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BIOENERGETICS OF PRODUCTIVITY AND PROSPECTS OF ENHANCING EFFICIENCIES OF PHOTOSYNTHESIS BY CO_2 CONCENTRATING MECHANISM AND OF PHOTOASSIMILATE PARTITIONING BY GENETIC ENGINEERING IN GROUNDNUT

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ABSTRACT

In the backdrop of the current understanding of bioenergetics, photosynthesis and photoassimilate partitioning, certain physiological and biochemical factors have been identified that hold the production barrier of groundnut. Computations indicate that in order to be bioenergetically more efficient, enhancement in the oil content of groundnut seeds should be approached at the expense of proteins rather than carbohydrates and enhancement in yield by improving HI rather than biomass productivity. Augmentation of enzyme sucrose phosphate synthase and suppression of expression of starch synthetase in groundnut leaves should be the possible targets for genetic engineering of groundnut plant for enhanced partitioning. Groundnut responds favourably to CO_2 enrichment around its canopy. Moreover, compared to unstressed crops, a much greater effect of CO_2 enrichment on dry matter production has been found in water-stressed crops. Hence future research efforts should be aimed at development of cheap and simple technology for CO_2 enrichment of the groundnut canopy for improving both productivity and water use efficiency of groundnut.

Key Words: Groundnut; *Arachis hypogaea* L., bioenergetics; partitioning; CO_2 enrichment; genetic engineering.

India is the largest producer of groundnut in the world and yet its productivity is one of the lowest (Table 1). In India, groundnut is regarded as an oilseed crop and bulk of the produce is channelized for oil expulsion. While the oil is used mostly for culinary purposes, the deoiled-cake is used partly as cattle feed supplement/concentrate and partly for export.

Groundnut is a unique plant in that it is adapted to a diversity of soil and temperature zones. Considerable improvement in groundnut productivity has been brought about by empirical process of plant breeding and optimizing the cultural practices. These processes, however, did not require specific knowledge of plant bioenergetics, biochemistry, or physiology. The increase in yield has been due to both a higher biomass productivity and an improvement in the partitioning of photosynthate in favour of harvest portion. The scope of the present paper is to identify certain physiological and biochemical factors that hold the productivity barrier of groundnut and evaluate the prospects of overcoming them in the backdrop of the current understanding of bioenergetics, photosynthesis and photoassimilate partitioning.

I. BIOENERGETICS OF GRAIN YIELD

It is common knowledge that the average yields of cereals are almost double that of oilseeds. Are then the oilseed crops less efficient in conserving the solar energy? The reason for the lower yields of oilseeds lies neither in the poor efficiency of oilseed crops in trapping solar energy nor a poor partitioning of the photosynthate. As a matter of fact the groundnut - a C3 crop, has been shown to be not only more efficient (Table 2) in trapping solar energy but also in energy partitioning compared to wheat - a C3 crop and even *C. dactylon*- a C4 grass (Dwivedi *et al.*, 1985).

The major constituent of the oilseeds is triglyceride while that of cereals is starch.

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Whereas it requires a plant to expend only 1.2 g of photosynthate to produce one gram of starch, it has to expend 2.5 and 3.3 g of photosynthate to produce one gram of protein and triglyceride, respectively (Penning de Vries *et al.*, 1974).

Consequently, while one gram of photosynthate can produce 0.7 g of seed biomass of cereals, it can produce only 0.65 and 0.45 g of grain legumes and oilseeds, respectively (Sinclair and de Wit, 1975, Mitra and Bhatia, 1979). Thus bioenergetic computations indicate that it is the chemical composition of the seed of a crop which to a major extent determines the grain yield. A comparison of seed biomass productivity of a few cereals, grain legumes and oilseeds is shown in Table 3.

Bioenergetics of manipulating biological yields vis-a-vis harvest index of groundnut.

The approach to increasing the productivity of a crop plant can be aimed at enhancing either its biological yield or its harvest index or both. The theoretical demand for photosynthate (in glucose equivalents) for the following four options have been worked out by Misra and Yadav (1995) to achieve an increment of 50% from the base pod yield of 900 kg ha^{-1}.

A. Increasing HI by 50% without affecting biological yield.

B. Increasing biological yield by 50% without affecting HI.

C. Increasing biological yield by 20% and HI by 25%.

D. Increasing biological yield by 100% at the same time reducing HI by 25%.

The calculations (Table 4) indicate that the option A would demand the least (10.4%) increment in photosynthate, followed by options C (26.2%), B (50.0%) and D (89.6%). It is thus clear that bioenergetically, the approach to increasing the pod yield through improving HI would be the most efficient one, whereas increasing the biological yield while lowering the HI would be the most inefficient.

Bioenergetics of increasing oil content in groundnut

Energetic cost of increasing seed-oil concentration in groundnut has been worked out by Mitra and Bhatia (1979). Any increase in oil percentage will have to be associated with a corresponding decrease in the percentage of other constituents of seed biomass. As proteins and carbohydrates are other two major constituents, the three approaches considered were:

A. Reduction in carbohydrates while keeping the percentage of proteins unaltered.

Table 1. Production of groundnut in the world and three leading groundnut producing countries

	Area ('000 ha)		Production ('000 MT)		Productivity (kg ha^{-1})	
	1991	1992	1991	1992	1991	1992
World	20333	20609	23975	23506	1179	1141
China	3060	2655	6389	5580	2088	2102
USA	816	684	2235	1943	2740	2842
India	8350	8600	7428	8200	890	953

Source: FAO Year Book (1992)

Table 2. Comparison of biomass productivity and solar energy conserving efficiency of groundnut, wheat and a common grass

Species	Phytomass productivity g m^{-2} day^{-1}	Energy conserving rate Kcal m^{-2} day^{-1}	Solar energy conserving efficiency %
		June - October *	
A. *hypogaea* (C3)	*12.1*	*58.5*	*2.921*
C. *dactylon* (C4)	16.7	56.8	2.835
		November-March **	
A. *hypogaea* (C3)	12.5	59.4	1.786
T. *aestivum* (C3)	13.2	47.1	1.419

* Low solar radiation intensity period
** High solar radiation intensity period

Source: Dwivedi *et al.* (1985)

Table 3. Seed biomass productivity of cereals, grain legumes, and oilseeds crops

Crop	Composition % of dry weight			Productivity
	Carbohydrate	Protein	Lipid	g^{-1} glucose
Cereals				
Maize	81	13.0	4.2	0.70
Rice	89	8.6	1.1	0.75
Wheat	83	13.5	1.7	0.71
Grain legumes				
Chickpea	72	19.0	1.7	0.65
Pea	72	23.5	1.3	0.66
Pegionpea	68	25.7	2.0	0.66
Oilseeds				
Groundnut	25	27	45	0.40
Rape	25	23	48	0.40
Sesame	19	20	54	0.39
Soybean	38	38	20	0.47

Source: **Adapted from Sinclair and de Wit (1975) and Bhatia and Mitra (1988)**

B. Reduction in proteins while keeping the percentage of carbohydrates unaltered.

C. An equivalent reduction in the percentage of both proteins and carbohydrates.

The energetic cost of increasing seed-oil percentage with the above three approaches is shown in Table 5. It would be energetically more economical to increase the concentration of oil in the seed at the cost of concentration of protein rather than carbohydrate. It has also been shown that there exits a negative correlation between the oil and protein content of groundnut genotypes (Tai and Young, 1975; Dwivedi *et al.*, 1990) and hence formulating breeding strategies for increasing oil content while lowering the percentage of protein will not only be bioenergetically efficient but also easier.

II. PHOTOSYNTHESIS *VIS-A-VIS* BIOMASS PRODUCTIVITY

Inorganic elements (C, H, O, N, and S) are incorporated in organic molecules via light dependent reactions. These are utilized for construction and turnover of plant organs. The new organs help further acquisition of nutrients. Hence, given all the nutrients in a required concentration and form, the plant growth should ultimately be dependent upon net CO_2 fixed i.e. photosynthesis. Studies have indeed indicated that there exists a linear relationship between the net photosynthesis of the entire canopy throughout the growing season and crop yield (Christy and Porter, 1983).

Photorespiration is converse of photosynthesis and results in loss of solar energy captured and conserved by plants and consequent loss of crop yield. In C3 plants, depending on temperature, in field conditions photorespiration causes a reduction in yield of crops by 25 to 50% (Canvin, 1990). Since groundnut is a C3 plant, enhancement of net photosynthesis or suppression of photorespiration should bring about a substantial increase in the productivity of groundnut.

Prospects of suppressing photorespiration vis-a-vis enhancing photosynthesis

The CO_2 fixing enzyme, ribulose-1, 5-bisphosphate carboxylase (Rubisco) also displays oxygenase activity. When ribulose-1, 5-bisphosphate (one of the substrates of Rubisco) is bound to an active site of Rubisco, it can react with either CO_2 and O_2. Thus the two processes of carboxylation and oxygenation are competitive. At air levels of CO_2 (0.03%) and O_2 (21%), two or three moles of CO_2 are fixed per mole of O_2, indicating that Rubisco has a higher affinity for CO_2 than O_2 (Jensen, 1990). This suggests that the Rubisco enzyme may have evolved at a time when the atmosphere contained much less O_2. Thus oxygenase activity of rubisco appears to be a chemical consequence of the carboxylation mechanism and then photorespiration to be a salvage operation (Canvin, 1990).

i) Genetic engineering of rubisco bisphosphate carboxylase / oxygenase (Rubisco) for improving its efficiency: The specificity factor of Rubisco which indicates the affinity of the enzyme for CO_2 has indeed been modified during the course of plant evolution. The values of specificity factor are about 80 for higher C3 and C4 plants, 62 for green algae, 48 for cyanobacteia and as low as 10 to 15 for some photosynthesis bacteria (Table 6) (Jordan and Ogren, 1981). Higher specificity factors indicate a greater affinity by the enzyme for CO_2. Thus there is a little scope for mobilizing an efficient Rubisco from any other photosynthetic species to groundnut by genetic engineering. Moreover, despite major advances towards comprehensive understanding of structure, mechanism, physiology and molecular biology of Rubisco, the feasibility of designing a more efficient enzyme remains problematic (Hartman and Harpel, 1994).

ii) CO_2 concentrating mechanism for enhancing carbon exchange rate (CER) : Research work done in the last three decades has shown that CO_2 enrichment in the ambience of crop canopy tends

Table 4. Bioenergetic efficiency of increasing crop productivity through varying HI and biological yield

Options	Biol. yield kg ha^{-1}	Pod yield kg ha^{-1}	HI %	Glucose required kg ha^{-1}	Increase over baseline %
Baseline	2250	900	40	3682	--
A	2250	1350	60	4064	10.4
B	3375	1350	40	5524	50.0
C	2700	1350	50	4648	26.2
D	4500	1350	30	6983	89.6

Source: Misra and Yadav (1995)

Table 5. Energetic cost of increasing oil content of groundnut seed

Composition C:P:O:M	Glucose requirement g 100 g^{-1} seed	Increase relative to standard %
Standard 28:27:45:3	248.12	--
High oil (LC) 23:27:50:3	258.82	4.3
High oil (LP) 28:22:50:3	252.34	1.7
High oil (LC , LP) 25.5:24.5:50:3	255.58	3.0

C:P:O:M = Carbohydrate Protein: Oil Mineral

LC = Low Carbohydrate; LP = Low Protein

Source: Mitra and Bhatia (1979)

Table 6. Specificity factor of Rubisco from various photosynthetic organisms

Type of organism		Specificity factor
C3 plants		80
C4 plants		80
Green algae		62
Cyanobacterria		48
Photosynthetic bacteria	I	62
	II	9-15

Source: Jordan and Ogren(1981)

to increase the growth rates and harvestable yields of most plant species (Kimball, 1983; Cure and Acock, 1986). Short term CO_2 enrichment increases CER, but the higher CER does not persist for long periods (Sage *et al.*, 1989).

The beneficial effect of CO_2 enrichment is brought about by enhancement of net photosynthesis by increasing carboxylation, reducing oxygenation and increasing temperature. It also brings down stomatal conductance resulting in reduced transpiration rate, thus CO_2 enrichment greatly enhances the water use efficiency of plants. The increase in yield under CO_2 conditions is achieved through an increase in the number and area of leaves and in the number of reproductive plant parts (Lawlor and Mitchell, 1991). In developed countries, CO_2 enrichment technique is already in vogue for greenhouse crops. In fields studies, encouraging results have been obtained with major crops like rice, wheat and maize. However, after an initial increase with CO_2 enrichment, the CER often declines. But this is not so with groundnut.

Response of groundnut to CO_2 enrichment: Poor seed fill and resultant seed-coat shriveling occur commonly in Virginia type peanut grown in Taiwan. The phenomenon has been linked to continuous forming of new pegs (excessive sink load) and low canopy CER, with a view to evaluating the effect of CO_2 enrichment (1000 µl CO_2 l^{-1} and depegging on CER and yield, experiments were conducted on pot-grown virginia-type peanut (Chen and Sung, 1993). Carbon dioxide enrichments were applied to the plants at pod filling. Depegging effect was examined contracting the controls and plants maintaining 30 to 40 pegs throughout the growing period. The short-term CO_2 enrichment (CO_2 treatment for 10 days) improved both leaf and canopy CER. Long-term CO_2 enrichment (CO_2 treatments throughout pod-filling) almost doubled the CER, reduced stomatal conductance and tended to ease leaf Rubisco (Table 7) and chlorophyll deteriorations. Biomass yield per plant increased with high CO_2 treatment applied at seed-filling period (Table 8), but the production of marketable seeds improved only in the plants receiving CO_2 enrichment and depegging treatments (Table 9).

In an another experiment conducted by Clifford *et al.*, (1993), stands of groundnut were grown in controlled-environment glass-houses at 28°C (± 5°C) under two levels of CO_2 (350 or 700 µ l CO_2 l^{-1} and two levels of soil moisture (irrigated weekly or no water from 35 days after sowing). Elevated CO_2 increased the maximum rate of net photosynthesis by up to 40%, with an increase in conversion coefficient for intercepted radiation of 30% (from 1.66 to 2.16 g MJ^{-1}) in well-irrigated conditions, and 94% (from 0.64 to 1.24 g MJ^{-1}) on a drying soil profile. In plants well supplied with water, elevated CO_2 increased dry matter accumulation by 16% and a pod yield by 25%. However, the harvest index (total pod dry weight/above ground dry-weight) was unaffected by CO_2 treatment. The beneficial effects of elevated CO_2 were enhanced under severe water stress, dry matter production increased by 112% and a pod yield of 1.34 t ha^{-1} was obtained in 700 µl CO_2 l^{-1}, whereas comparable plots at 350 µl CO_2 l^{-1} only yielded 0.22 t ha^{-1}. There was a corresponding decrease in harvest index from 0.15 to 0.05 (Table 10). Following the withholding of irrigation 35 days after sowing, plants growing in elevated CO_2 could maintain significantly less negative water potentials ($P< 0.01$) for the remainder of the season than comparable plants grown in ambient CO_2. Thus CO_2 enrichment allowed prolonged plant activity during drought. In plants which were well supplied with water, allocation of dry matter between leaves, stems, roots and pods was similar in both CO_2 treatments. On a drying soil profile, allocation in plants grown in 350 µl CO_2 l^{-1} changed in favour of root development far earlier in the season than plants grown at 700 µl l^{-1}, indicating that severe water stress was reached earlier at 350 µl CO_2 l^{-1} (Clifford *et al.*, 1993). And, hence it was concluded that the primary effects of elevated CO_2 on growth and yield of

Table 7. Effect of CO_2 enrichment on CER, stomatal conductance and Rubisco activity of groundnut

CO_2	Stage of the crop			
$\mu l\ l^{-1}$	R5	R6	R7	R8
	Canopy CER umol m^{-2} S^{-1}			
340	10.24	8.98	8.03	7.14
1000	14.33	10.25	15.72	15.25
	Leaf CER umol m^{-2} S^{-1}			
340	20.56	18.62	16.49	10.48
1000	43.85	42.67	38.75	37.00
	Stomatal conductance mol m^{-2} S^{-1}			
340	0.42	0.40	0.39	0.24
1000	0.21	0.23	0.24	0.21
	Rubisco umol m^{-2} S^{-1}			
340	28.50	27.40	27.60	21.70
1000	*28.50*	*29.80*	*30.10*	*25.30*

R5, R6, R7 and R8 refer respectively to beginning seed, full seed, beginning maturity, and harvest maturity stages of growth in the reproductive phase of the groundnut crop.

Source: Chen and Sung (1990)

Table 8. Effect of CO_2 enrichment and depegging on dry matter accumulation and yield of groundnut

CO_2	Dry matter g plant $^{-1}$			
$\mu l\ l^{-1}$	Leaves	Stem	Root	Pod
340	29.79	32.22	2.01	32.61
340 depegging	30.16	29.90	2.33	33.87
1000	34.97	33.89	2.79	36.97
1000 depegging	38.12	32.69	3.41	38.57
LSD (0.05)	1.60	2.29	0.14	2.28

Source: Chen and Sung (1990)

groundnut stands were mediated by increase in the conversion coefficient for intercepted radiation and the prolonged maintenance of higher leaf water potential during increasing drought stress.

Thus the preliminary short-and long-term CO_2 enrichment experiments have shown that groundnut responds favourably to CO_2 enrichment. And at elevated CO_2 levels more pods are formed and the canopy CER is able to meet the sink demand. As a result though pod yield is enhanced, the majority of pods produced are of unmarketable grade due to poor filling. It is, however, not clear whether the rate limiting factor is CER itself or the rate of sucrose synthesis or a feedback inhibition due to accumulation of starch.

III. PROSPECTS OF ENHANCING HARVEST INDEX BY GENETIC ENGINEERING

It is now known that the partitioning of photoassimilate into export-competent (sucrose) versus - incompetent (starch) forms in export leaves determines the source capacity (Sonnewald and Willmitzer, 1992; Huber and Huber, 1992). Several reports suggest that the amount of sucrose present in the source leaf is rate limiting with respect to its export capacity. Socrose is synthesized by the coupled action of enzymes sucrose phosphate synthase (SPS) and sucrose phosphatase. However, the importance of SPS in the regulation of carbon partitioning in leaves has now been confirmed using recombinant DNA technology (Worrel '*et al.*, 1991).

Groundnut leaves have a tendency to partition a greater proportion of the photoassimilate into starch than sucrose (Huber, 1981a) as they have a low level of SPS (Huber, 1981b). Therefore inhibition of starch synthesis and/or stimulation of sucrose synthesis in the source leaves would be the possible targets of manipulation for enhancing productivity of the crop. Recently, the potential of recombinant DNA technology has been demonstrated for enhancing the rates of sucrose production in tomato and suppression of starch synthesis in potato and tobacco (Sonnewald and Willmitzer, 1992).

CONCLUSIONS

Computations indicate that in order to be bioenergetically more efficient, enhancement in the oil content of groundnut seeds should be approached at the expense of proteins rather than carbohydrates and enhancement in yield by improving HI rather than biomass productivity. Augmentation of enzyme sucrose phosphate synthase and suppression of expression of starch synthetase in groundnut leaves should be the possible targets for genetic engineering of groundnut plant for enhanced partitioning.

CO_2 enrichment experiments in both controlled and field conditions indicate that groundnut responds favourably to CO_2 enrichment around its canopy. Moreover, compared to unstressed crops, a much greater effect of CO_2 enrichment on dry matter production has been found in water-stressed crops. Hence future research efforts should be aimed at development of cheap and simple technology for CO_2 enrichment of the groundnut canopy for improving both the productivity and water use efficiency of groundnut.

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Table 9. Effect of CO_2 enrichment and depegging on productivity and characteristics of seeds

CO_2 $\mu l\ l^{-1}$	Seed g plant^{-1}		100 seed weight g Marketable
	Marketable	Unmarketable	
340	17.12	4.69	61.12
340 depegging	18.81	2.95	72.35
1000	19.33	6.95	62.38
1000 depegging	24.42	4.34	84.21
LSD (0.05)	0.59	0.52	2.57

Source: Chen and Sung (1990)

Table 10. Effect of CO_2 enrichment and water availability on the above ground dry matter accumulation, pod yield and harvest index in stands of groundnut

Parameter	Treatment	CO_2 ($\mu l\ l^{-1}$)	
		350	700
Dry matter ($t\ ha^{-1}$)	Wet	13.79	16.03
	Droughted	4.13	8.87
Yield ($t\ ha^{-1}$)	Wet	2.73	3.42
	Droughted	0.22	1.34
Harvest Index	Wet	0.20	0.21
	Droughted	0.05	0.15

Source: Clifford *et al.* (1993)

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CHARACTER ASSOCIATION AND PATH ANALYSIS IN F_2 POPULATION OF GROUNDNUT

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ABSTRACT

Fifty-five genotypes of groundnut in the F_2 generation were evaluated for seventeen component characters. The character association studies indicated that kernel yield, number of kernels, number and length of seconuary branch, plant height, length of primary branch, nodes on primary and secondary branch, number of mature pods, mature pod per cent and number of pegs were strongly associated with pod yield. The path coefficient analysis revealed that nodes on main axis, nodes on primary branch and number of kernels were the main characters influencing pod yield directly as well as indirectly.

Key Words: Pod yield; correlation coefficients; path coefficient analysis; groundnut.

INTRODUCTION

Selection of superior genotypes based on yield *per se* will be less efficient because yield is a complex character and simultaneously contributed by many mutually related components. This assumes greater importance in groundnut compared to other crops due to the fact that the groundnut pods are formed underground and unless associations between the external plant characters and yield are established, it may not be possible to effect proper selection of plants prior to harvest. Hence, the present study was carried out to obtain information on the magnitude of relationship of individual yield components to yield, inter-relationships among them and to measure their relative importance.

MATERIALS AND METHODS

A crossing programme involving eight interspecific hybrid derivatives in the F_{10} generation and three cultivars of groundnut in a line x tester mating design was undertaken during August - December, 1992 at the Oilseeds Breeding Station, Tamil Nadu Agricultural University, Coimbatore. From the resulting hybrids 55 F_1 progenies were selected and advanced to F_2 generation. The details of the crosses are,

Chico/VB 78	(4 Progenies),		
VRI 2/VB 78	(4 Progenies),	CO2/VB78	(4 Progenies),
VRI 2/VR 60	(3 Progenies),	Chico/VB 72	(2 Progenies),
VRI 2/VB 72	(1 Progeny),	Chico/VB4	(1 Progeny),
VRI 2/VB 42	(1 Progeny),	CO 2/VB 42	(2 Progenies),
Chico/VR 4	(3 Progenies),	CRI 2/VR 4	(2 Progenies),
CO 2/VR 4	(6 Progenies),	Chico/VR 11	(2 Progenies),
VRI 2/VR 11	(1 Progeny),	CO 2/VR 11	(3 Progenies),
Chico/VB 51	(4 Progenies),	VRI 2/VB 51	(3 Progenies),
CO 2/VB 51	(4 Progenies),	Chico/VR 17	(1 Progeny),
VRI 2/VR 17	(1 Progeny) and	CO 2/VR 17	(3 Progenies).

The F_2 generation was raised during August - December, 1993, in randomized block design with three replications, adopting a spacing of 30 cm between rows and 15 cm between plants within the row. Data were collected on five randomly selected plants in each entry per replication on plant height (X_1), length of primary branch (X_2), length of secondary branch (X_3), number of primaries (X_4), number of secondaries (X_5), nodes on main axis (X_6), nodes on primary branch (X_7), nodes on secondary branch (X_8), number of mature pods (X_9), mature pod per cent (X_{10}), number of pegs (X_{11}), reproductive efficiency (X_{12}), kernel yield (X_{13}), shelling per cent (X_{14}), number of kernels (X_{15}), oil content

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(X_{16}) and pod yield (Y). Phenotypic and genotypic correlation coefficients were calculated using the method adopted by Johnson *et al.*, (1955). Path coefficient analysis was carried out in accordance with Dewey and Lu (1959).

RESULTS AND DISCUSSION

The nature and extent of association existing at both genotypic and phenotypic levels worked out in all possible combinations, are presented in Table 1. In the present study, the genotypic correlation coefficients were higher than the phenotypic correlations for most characters studied. This may be due to depressed phenotypic expression by environmental influence (Deshmukh *et al.*, 1987). The data revealed that pod yield had significant positive association with kernel yield, number of kernels, number and length of secondary branch, plant height, length of primary branch, nodes on primary and secondary branch, number of mature pods, mature pod per cent and number of pegs both at phenotypic and genotypic levels. Such positive association of pod yield with, number of secondary branch, number of mature pods (Lakshmaiah *et al.*, 1983), shelling per cent, number of pegs, number of primary branch (Swamy Rao *et al.*, 1988), plant height, kernel yield and number of kernels (Reddi *et al.*, 1991) were reported earlier. It was interesting to note that only oil content showed significant negative association with yield at genotypic level, confirming the reports of Chiow and Mynne (1983). Intercorrelation estimates for yield components revealed that length of primary branch length of secondary branch, number of secondaries, number of mature pods, number of pegs, kernel yield and number of kernels were significantly and positively associated with one another as well as pod yield which indicated that these are important components for improvement of pod yield in groundnut and also the possibility of simultaneous improvement of these traits by selection.

The path coefficient studies (Table 2) indicated that nodes on main axis had the highest positive direct effect on pod yield followed by number of primary branches while plant height exhibited the maximum negative direct effect on yield. This is in accordance with the reports of Lakshmaiah *et al.*, (1983). Pod yield was highly influenced by nodes on main axis, nodes on primary branch, number of kernels both directly and indirectly. The genotypic correlation coefficients for these characters were also positive and highly significant. Hence, an emphasis on these traits in selection for groundnut improvement may be rewarding. The low residual effect indicated that characters other than those considered in the present study did not exert significant influence on pod yield.

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Table 1. Phenotypic and genotypic correlation coefficients between yield and its components of groundnut in 55 genotypes of F_2 generation

		Y	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16
Y	P	1.000	0.326*	0.307*	0.400**	0.062*	0.421**	0.227	0.316*	0.284*	0.616**	0.328*	0.576**	0.181	0.847**	-0.179	0.769**	-0.159
	G	1.000	0.554**	0.913**	0.809**	0.836**	0.834**	0.834**	0.627**	0.982**	0.274*	0.710**	0.517**	0.416**	0.586**	0.421**	0.811**	-0.507**
X1	P		1.000	0.645**	0.445**	0.114	0.300*	0.516**	1.399**	0.437**	0.263	0.134	0.319*	0.002	0.309*	-0.020	0.299*	0.014
	G		1.000	0.795**	0.741**	0.157	0.327**	1.010**	0.400**	0.460**	1.140**	-0.180	1.096**	0.554**	0.780**	0.298*	0.956**	0.293*
X2	P			1.000	0.478**	0.140	0.389**	0.377**	0.301*	0.322*	0.211	0.046	0.309*	-0.016	0.305*	-0.020	0.256	0.046
	G			1.000	0.352**	0.270**	0.353**	0.792**	0.534**	0.164	0.420**	-0.736**	0.845**	0.661**	0.519**	-0.396**	0.742**	0.662
X3	P				1.000	0.131	0.575**	0.248	0.325*	0.694**	0.331*	-0.008**	0.541**	-0.068	0.400**	0.022	0.318*	0.048
	G				1.000	1.204**	0.547**	0.485**	0.570**	1.030**	1.062**	0.091	1.040**	0.382**	0.200	-0.333*	0.406**	0.092
X4	P					1.000	0.298**	-0.068	-0.026	0.168	0.021	0.073	0.081	-0.128	-0.120	-0.187	0.012	0.149
	G					1.000	1.063**	-0.123	0.420**	0.721**	0.820**	0.292*	1.981**	0.295**	0.399**	-0.808**	0.326*	0.202
X5	P						1.000	0.196	0.338**	0.553**	0.340**	-0.011	0.558**	-0.080	0.384**	-0.096	0.354**	0.026
	G						1.000	0.044	0.658**	0.621**	0.005	0.474**	0.080	-0.122	0.219	-1.461**	-0.106	0.291**
X6	P							1.000	0.429**	0.324**	0.164	0.076	0.255	0.013	0.230	0.135	0.274*	-0.049
	G							1.000	0.755**	0.197	1.189**	0.310*	1.002**	0.177	1.030**	0.372**	0.992**	0.139
X7	P								1.000	0.540**	0.274**	0.058	0.422**	0.072	0.326**	-0.038	0.317*	0.004
	G								1.000	0.979**	0.757**	0.324*	1.154**	0.472*	0.781**	0.094	0.611**	0.295**
X8	P									1.000	0.253	0.016	0.452**	-0.038	0.320**	0.002	0.295*	0.027
	G									1.000	2.467**	0.480**	1.704**	0.887**	0.918**	-0.174	0.439**	-0.073
X9	P										1.000	0.494**	0.725**	0.425**	0.617**	-0.099	0.729**	-0.070
	G										1.000	1.259**	-0.087	1.950**	0.759**	0.284**	1.163**	0.526**
X10	P											1.000	0.086	0.301	0.389**	-0.024	0.424**	-0.144
	G											1.000	0.344**	0.095	0.989**	0.190	1.014**	-0.216
X11	P												1.000	-0.018	0.548**	-0.032	0.588**	0.025
	G												1.000	1.590**	0.875**	0.032	0.752**	0.769**
X12	P													1.000	0.221	-0.027	0.283*	-0.093
	G													1.000	0.768**	0.223	0.814**	-0.282*
X13	P														1.000	0.167	0.816**	-0.158
	G														1.000	0.702**	1.169**	-0.422**
X14	P															1.000	-0.001	-0.130
	G															1.000	0.620**	-0.330*
X15	P																1.000	-0.161
	G																1.000	-0.320**
X16	P																	1.000
	G																	1.000

* p = 0.05; ** p = 0.01

Table 2. Direct (Diagonal) and Indirect effects of different characters on pod yield of groundnut in 55 genotypes of F_2 generation

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X16	Correlation with yield
X1	***-1.403***	0.102	0.511	0.055	-0.181	1.351	0.405	-0.337	0.295	0.046	-0.208	0.066	-0.193	-0.279	0.585	-0.260	0.554**
X2	-1.115	***0.128***	0.243	0.094	-0.196	1.059	0.492	-0.120	0.109	0.187	-0.160	0.078	-0.125	0.371	0.455	-0.588	0.913**
X3	-1.039	0.045	***0.689***	0.420	-0.303	0.649	0.525	-0.755	0.276	0.023	-0.197	0.045	-0.048	0.312	0.249	-0.082	0.809**
X4	-0.220	0.035	0.830	***0.349***	-0.589	-0.165	0.386	-0.529	0.472	-0.074	-0.375	0.035	-0.096	0.758	0.200	-0.180	0.836**
X5	-0459	0.045	0.377	0.371	***-0.555***	0.059	0.606	-0.455	0.001	-0.121	-0.015	-0.015	-0.053	1.370	-0.065	-0.259	0.834**
X6	1.416	0.101	0.334	-0.043	-0.024	***1.338***	0.695	-0.145	0.309	-0.079	-0.190	0.021	-0.241	-0.348	0.607	-0.123	0.788**
X7	-0.617	0.068	0.393	0.146	-0.365	1.010	***0.921***	-0.718	0.196	-0.082	-0.219	0.056	-0.189	-0.088	0.374	-0.261	0.627**
X8	-0.646	0.021	0.692	0.252	-0.344	0.264	0.902	-0.733	0.640	-0.122	-0.323	0.105	-0.223	0.163	0.269	0.065	0.983**
X9	-1.597	0.054	0.732	0.635	-0.003	1.591	0.697	-1.809	***0.259***	-0.320	0.016	0.232	-0.183	-0.267	0.712	-0.467	0.284*
X10	0.252	-0.094	-0.063	0.102	-0.263	0.415	0.298	-0.352	0.327	***-0.254***	-0.651	0.011	-0.239	-0.178	0.621	0.191	0.710**
X11	-1.537	0.108	0.717	0.692	-0.044	1.341	1.063	-1.250	-0.023	-0.087	***-0.189***	-0.189	-0.211	-0.030	0.461	-0.683	0.517**
X12	-0.777	0.084	0.263	0.103	0.068	0.237	0.434	-0.650	0.506	-0.024	-0.301	***0.119***	-0.185	-0.209	0.499	0.250	0.416**
X13	-1.123	0.066	0.138	0.139	-0.121	1.378	0.720	-0.673	0.197	-0.252	-0.166	0.092	***-0.243***	-0.658	0.716	0.375	0.586**
X14	0.418	-0.051	-0.229	-0.282	0.810	0.497	0.086	0.128	0.074	-0.048	-0.006	0.295	-0.170	***-0.938***	0.380	0.293	0.421**
X15	-1.341	0.095	0.280	0.114	0.059	1.327	0.563	-0.322	0.320	-0.258	-0.142	0.097	-0.282	-0.582	***0.612***	0.290	0.811**
X16	-0.411	0.085	0.064	0.071	-0.162	0.186	0.271	0.054	0.137	0.055	-0.148	-0.033	0.102	0.310	-0.200	***-0.888***	-0.507**

* p = 0.05; ** p = 0.01

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ADVANCES IN BREEDING FOR BASAL BRANCHING AND PRODUCTIVE LINES OF *Brassica juncea*

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ABSTRACT

An attempt was made to study the variability of basal and non-basal branching genotypes in F_3 and F_4 generations derived from nine crosses in Indian mustard (*Brassica Juncea*) [Czern & Coss (L)]. Sixty four F_3 families were studied for yield and yield attributes. Among them thirty two were selected and F_4 families of them were evaluated for yielding ability. The results revealed that there is sufficient variability available for all the plant type and yield parameters in the F_3 generation. A selection towards basal branching types is suggested to enhance the seed yield in *B. Juncea*.

Key Words: *Brassica Juncea*; basal branching; selection; variability.

INTRODUCTION

A pre-requisite for any selection programme is the existence of genetic variability. In Indian mustard (*Brassica Juncea*), the genetic variability is limited (Rai, 1989). A major advance was made in this respect by Prakash (1973), when a large number of ampidiploids were synthesized. Based on several studies it has been suggested that (Jain, 1984; Labana, 1984) the ideal plant for improved agronomic situations should be 1m tall with basal and compact branching having appressed pods and higher number of bold seeds. However, the studies relating to basal branching and its utilization are very scarce. Basal branching genotype has been defined (Vijayakumar *et al.*, 1994) as one in which at least one productive primary branch initiates within a height of 30 cm (H_1) from the ground.

The aim of this paper is to examine the variability, particularly for basal branching and its association with yield in F_3 and F_4 generations of some inter-varietal crosses made using cultivars and synthetic strains of *B.Juncea*.

MATERIALS AND METHODS

In the F_2 of nine crosses detailed below, 64 individual plants were selected for basal branching and other yield components during *rabi* 1989.

List of crosses and their pedigree

Cross	No. of Plants	Expanded pedigree
PBRN	10	PB = Pusa Bold
PBNN	6	RN = Synthetic *B.Juncea*
PBYS	8	(*B. campestris* ssp. *rapifera* x *B. nigra*)
JNRN	6	NN - Synthetic *B.Juncea*
JNNN	4	(*B. campestris* ssp. *narinosa* x *B. nigra*)
RNJN	8	YS = Yellow seeded *B.Juncea*
RNYS	8	(An accession from Poland)
NNRN	8	JN = Synthetic *B.Juncea*
RNNN	6	(*B. campestris* ssp. *japonica* x *B. nigra*)

F_3 families from the selected plants were raised during *rabi* 1990 on plant-to-progeny basis.

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Each family was sown in four rows of 3m length with a spacing of 75cm between rows and 10 cm between plants. Single plant data were collected on seven traits which included those indicative of basal branching, namely, number of primary (PBI) and secondary (SBI) branches within the height H_1, in addition to plant height (HT), seed yield (SY) and harvest index (HI) on per plant basis. An entry where, two thirds of the selected plants were basal branching were considered as basal branching entries, and the rest as non-basal branching.

Data collected on five randomly chosen plants was subjected to ANOVA. Using the method of Arunachalam and Bandyopadhyay (1984), the 64 families were grouped into four classes, H:High, M+: Medium above mean, M-: Medium below mean and L:Low using a performance score computed across the seven traits. The top 50% entries in each class was selected to give 32 families. The F_4 progeny of the selected F_3 plants from all the nine crosses was raised during *rabi* 1991 in a RBD, where each family was sown in a single row of 5m length in two replications with sacings mentioned earlier. The seed yield (g) per plot of each family was recorded.

RESULTS AND DISCUSSION

The variation between the 64 families was significant for all the traits. The coefficient of variation (C.V.) was greater for basal branching traits (Table 1) than others. However variation was subdued for the economically improtant traits, seed yield and harvest index. But the C.V. for SYI and HII were 4 and 5 times that of SY and HI, indicating that unutilised variability was abound for basal branching productivity traits. Though high variation for number of branches was recorded earlier (Paul, 1978), such variation for basal branching as observed in this study has not yet been reported. This was followed by significant differences in F_4 families for seed yield.

Data on mean seed yield of 32 selected families in F_3 and F_4 brought to light that all the productive families with high (H) or M+ overall status were basal branching. Despite some having M+ status, most of the non-basal branching families were of M-status. No basal branching families attained overall status 'L'. The mean seed yield (g) of families with high status was 23.3, followed M+ (21.4g), M-(16.8g) and low (11.9g). Since index selection was reported to be efficient in preliminary selection for single plant yield (Chatterjee and Bhattacharya, 1986; Teresa, 1987), the results of this study would add a modification that stable and high yields could preferentially be selected for using basal branching traits, PBI, SBI, SYI and HII.

The progress of yield improvement from F_3 and F_4 indicated that the mean seed yield of basal branching families in F_4 (320g) was lower to non-basal branching families (353g). The regression of F_4 seed yield on F_3 was negative and significant with respect to basal branching families, while for non-basal branching types, it was positive and signifcant. Basal branching families, while for non-basal branching types, it was positive and significant. Basal branching families segregated into 68% of non-basal branching plants in F_4, indicating high heterozygosity for basal branching. In contrast, non-basal branching families gave an average of 77% of non-basal branching plants in F_4 confirming high genetic uniformity of non-basal branching types. This could be a main reason for the comparatively low yields of basal brnaching F_4 famalies. In view of the above results it is advisable that individual selection be practised for basal branching types beyond F_3 generation. Nevertheless, the results gave a conclusive trend that it is possible to breed for basal branching and high productivity disproving contrary opinion by some physiologists (Bhargava and Tomar, 1982; Bhargava *et al.*, 1983; Chauhan *et al.*, 1987). A variety evolved with basal branching and high production of about 29.4 q/ha compared

to the yield of about 25 q/ha of the check, Pusa Barani is in All India Trials. This is an encouragig proof and it is time breeders invest sufficient efforts to evolve basal branching mustards, in future.

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Table 1. Mean (M), range (R) and coefficient of variation (CV) for seven traits in 64 families

Trait	M ± S.Em	R	CV (%)
HT: Plant height (cm)	218.5 ± 6.10	172.4 - 264.0	8.1
PB 1 : No. of primary branches at H1	0.8 ± 0.49	0 - 3.0	116.0
SB 1 : No. of secondary branches at H1	2.3 ± 1.62	0 - 7.3	121.3
SY1 : Seed yield (g) at H1	1.2 ± 1.03	0 - 7.3	134.4
SY : Seed yield (g) / plant	17.2 ± 3.37	6.2 - 34.0	33.7
HI 1 : Harvest index (%) at H1	0.8 ± 0.57	0 - 3.7	130.3
HI : Harvest index (%) / plant	13.8 ± 1.50	7.5 - 24.1	24.0

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PHENOTYPIC STABILITY OF SOME IMPORTANT YIELD COMPONENTS IN INDIAN AND EXOTIC GENOTYPES OF SOME OLEIFEROUS BRASSICAS

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ABSTRACT

The experimental material, comprising 54 selections belonging to four different oleiferous *Brassica* spp., viz., *B. juncea* L. (Czern and Coss.)., *B. campestris*, L., *B. carinata* Braun and *B. napus* L., was evaluated in six environments spread over two years with three sowing dates in each year. The selections showed differential response to the changing environmental conditions. There was preponderance of linear component for all the characters except 1000 seed weight. Both the linear and non-linear components were equally important for selection x environment (G x E) interaction for 1000-seed weight. The selections exhibiting higher 1000-seed weight were RH 30 and RH 8812. The former was stable for primary and secondary branches and 1000 seed weight while the latter was stable for all the characters studied. Largest number of stable selections were found for the character number of primary and secondary branches.

Key words : Oleiferous Brassicas; GxE; yield components.

INTRODUCTION

Yield is a primary consideration in breeding programmes which is governed by polygenes and is greatly influenced by many physiological processes within a plant as well as environmental factors to which the plant is exposed. Selection for yield *per se* may not be effective since there may not be genes for yield *per se* (Grafius, 1956).

Information about phenotypic stability in a crop has substantial value in screening varieties for cultivation as well as for use in further breeding programmes. Therefore, it becomes necessary to assess the stability of desirable selections for important yield components. In the present study, phenotypic stability of 54 selections of 4 species of oilseed Brassicas have been estimated and reported.

MATERIALS AND METHODS

The present investigation was carried out during *rabi* season of 1992-93 and 1993-94 in the research farm of Department of Plant Breeding, Chaudhary Charan Singh Harayana Agricultural University, Hissar. The material consisted of 54 selections of four *Brassica* spp.

1. *B. juncea* L. (Czern & Coss) - 24 selections
2. *B. campestris* L. - 10 selections
3. *B. carinata* Braun - 10 selections
4. *B. napus* L. - 10 selections

Field experiment was conducted to assess stability of 54 selections by growing them in two seasons (*rabi* 1992-93 and 1993-94) with three sowing dates (30th September, 20th October and 10th November) in each season. Under each environment, three meter long four row plots were assigned to each of these selections, at a spacing of 30 x 15 cm in randomized block design with three replications. Normal recommended agronomical package of practices were followed to raise the crop. Plants from two central rows were used for recording the observations. The data recorded for primary branches, secondary

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branches, seeds per siliqua and 100 seed weight were subjected to stability analysis as per the model proposed by Perkings and Jinks (1968).

RESULTS AND DISCUSSION

The significance of mean squares due to selections in joint regression analysis (Table 1) indicated that a considerable variability existed among the selections for all the characters studied. The environmental mean squares were significant for all the characters which reflected that the environments varied markedly for all the characters. Significant mean squares due to G x E interactions indicated that the selections showed differential response to the changing environmental conditions. The G x E interaction was partitioned into two components namely, heterogeneity between regression and remainder, the former accounting for linear component whereas the latter for non-linear component. There was preponderance of linear component for all the characters except 1000 seed weight. For these traits, the G x E interaction could be predicted reliably based on linear regression which had considerable practical value. Both the linear and non-linear components accounted for G x E interaction for the 1000- seed weight. Hence predictions based on linear regression could be difficult for this character.

According to Perkins and Jinks (1968) a desirable selection should have high mean ($\bar{x}$) with βi and $\bar{S}^2_{di}$ values approaching to zero. But Paroda and Hayes (1971), Jatasra and Paroda (1979) and Becker (1981) suggested that linear regression (βi) could be regarded as a measure of response of a particular selection and deviation from regression $\bar{S}^2_{di}$ should be considered as a better measure of stability.

The stability parameters for various characters are presented in Table 2. For primary branches per plant, 24 selections had non significant βi and $\bar{S}^2_{di}$ values. The selection Ethiopian Sel, exhibiting highest number of primary branches with average responsiveness but it was unstable. Out of 31 stable selections, 24 exhibited average responsiveness, six exhibited above average responsiveness and one selection exhibited below average responsiveness. None of the stable selections was found to have higher number of primary branches per plant. For secondary branches, 26 selections showed non-significant βi and $\bar{S}^2_{di}$ values. Among 36 stable selections, 26, 7 and 3 were average, below average and above average responsive, respectively. The stable selections NC14 and HC 9006 expressed the above average mean performance. The stability parameters presented in Table 2 for seeds per siliqua revealed that both βi and $\bar{S}^2_{di}$ were non-significant for 15 selections. Out of 23 stable selections, 16 exhibited average response, 4 exhibited below average response and 3 selections exhibited above average response. Only one stable selections N 20-7-1 showed above average mean performance. Examination of stability parameters presented for 1000-seed weight in Table 2 indicated that both βi and $\bar{S}^2_{di}$ values were non-significant for 14 selections. Out of 26 stable selections, high mean performance was exhibited by six only (PCRS, Varuna, RIC 949, RJ 14, RH 30 and RH 8812). RH 30 and PCR 5 showed average and below average responsiveness, respectively. Varuna, RIC 949, RJ 14 and RH 9912 showed above average responsiveness.

The largest number of stable selections were found for primary and secondary branches. So these characters could be used as criterion of selection while breeding for phenotypic stability.

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Table 1. Regression analysis for yield components in rapeseed and mustard.

Source	d.f.	Primary branches	Secondary branches	Seeds per siliqua	1000-seed weight (g)
Selection	53	45.49**	232.31**	120.02**	8.76**
Environment (Joint regression)	5	23.99**	148.26**	38.03**	0.44**
Selection x environment	265	1.74**	7.74**	5.82**	0.17**
Heterogeneity between regression	53	2.71**++	12.59**++	10.94**++	0.18**
Ramainder	212	1.49**	6.53**	4.54**	0.24**
Pooled error	636	0.30	1.95	1.04	0.08

** Significant at 0.01 level.

++ Significant against remainder at 0.01 level of probability.

Table 2. Stability parameters of 54 Brassica selections for yield components in rapeseed and mustard.

S.No. Genotype	Primary branches			Secondary branches			Seeds per siliqua			1000 - seed weight		
	$(\bar{x})$	βi	S^2_{di}	$(\bar{x})$	βi	S^2_{di}	$(\bar{x})$	βi	S^2_{di}	$(\bar{x})$	βi	S^2_{di}
B. Juncea												
1. EC 126745	4.96	-0.06	0.43	9.01	0.82	3.72	12.99	-2.76	9.87**	2.92	-0.12**	0.06**
2. ZEM 1	9.78	-3.06**	3.28**	16.94	0.91	10.09**	11.50	-0.18	0.80	2.28	-0.15**	0.20*
3. Shiva 1	5.66	0.59	0.59	10.44	-0.17	0.96	12.02	-0.28	2.25*	2.73	0.59*	0.01
4. Vardhan	4.46	-0.65*	0.14	8.92	0.01	0.93	10.91	-0.28	2.35*	3.13	0.87**	0.09*
5. PCR 5	5.17	-0.02	0.40	11.98	-0.28	1.42	12.22	-0.24	1.40	4.24	-0.81**	0.03
6. Kranti	4.65	-0.58	0.60	9.66	-0.34	0.40	13.53	0.70	2.47*	3.55	1.03**	0.04
7. Varuna	4.71	-0.54	1.18**	9.02	-0.03	0.83	12.79	-0.93	7.05**	4.57	0.87**	0.04
8. RLC 1359	4.77	0.18	0.18	8.93	0.31	1.10	12.86	-2.12**	0.34	4.14	-0.40	0.03
9. JGM 9056	6.14	-0.24	7.14**	9.24	-0.84**	0.55	11.89	-0.64	2.74*	36.99	-0.98**	0.34**
10. RLC 949	4.56	-0.29	1.12**	9.06	-0.60	4.66*	13.02	-1.92**	0.57	4.23	0.83**	0.02
11. RJ 14	4.31	0.07	0.28	8.56	-0.14	2.27	11.28	0.74	1.17	4.61	0.66*	0.03
12. RH 30	4.82	0.63	0.53	11.68	0.79*	0.60	14.35	-0.18	5.56**	5.84	-0.36	0.03
13. Prakash	4.78	1.11	0.89**	10.64	-0.49*	0.09	11.51	-1.34	1.49	2.66	0.27	0.03
14. RH 781	4.64	-0.06	0.31	9.51	-0.57*	0.25	12.57	-1.74	2.99*	4.03	0.77**	0.01
15. RH 819	4.86	-0.37	0.58	9.42	-0.98**	0.66	13.04	0.32	1.22	4.70	-0.95**	0.31**
16. RH 8812	4.46	0.65	0.09	11.07	-0.46	0.42	14.12	-1.71*	1.68	5.18	0.55*	0.05
17. RH 8814	4.69	-0.24	0.04	9.77	-0.34	1.53	14.46	-0.12	2.17*	3.97	-0.97**	0.28**
18. RH 8315	4.79	0.94	0.75*	8.89	-0.22	-0.03	13.66	0.57	1.55	3.97	0.30	0.91**
19. RH 8701	5.61	0.39*	-0.03	9.42	-0.48	1.48	14.06	-0.25	1.61	4.21	-0.84**	0.38**
20. RH 7846	4.76	0.48	0.46	9.67	0.13	1.14	12.40	-1.76*	2.29*	3.52	-0.62**	0.13**
21. RH 8825	4.80	0.23	0.21	9.28	-0.27	8.77**	14.07	-0.62	2.68*	4.24	-0.75**	0.08*
22. Pusabold	4.47	0.44*	-0.01	10.05	-0.18	1.69	12.60	-0.28	2.62*	5.05	-1.03**	0.13**
23. Pusabarani	4.56	-0.76	0.37	8.36	0.45	0.43	13.00	0.36	0.51	5.52	1.04**	0.28**
24. Vaibhav	4.47	0.35	0.49	9.46	0.06	0.43	14.83	-1.35**	0.34	3.52	-0.37	0.01
B. Campestris												
25. Torch	6.64	0.61	1.76**	9.38	-0.18	-0.25	14.58	-2.73**	2.68*	3.32	0.62*	0.43**
26. Bele	6.24	2.25**	2.12**	9.29	0.35	0.17	15.80	3.09**	0.82	2.36	0.32	0.37**
27. YSPb 24	5.72	2.54*	3.21**	3.41	-1.47**	0.78	15.60	0.24	16.25**	3.35	0.63*	0.04
28. BSH 1	5.46	1.03*	1.39**	8.91	-0.39	1.60	14.88	-0.14	5.80**	3.27	-0.27	0.42**
29. BS 46	6.48	1.75*	1.02*	9.08	-0.51	0.67	13.62	-0.10	7.45**	3.48	0.79**	0.03

Contd...

S.No.	Genotype	Primary branches			Secondary branches			Seeds per siliqua			1000 - seed weight		
		$(\bar{x})$	i	S^2_{di}	$(\bar{x})$	i	S^2_{di}	$(\bar{x})$	i	S^2_{di}	$(\bar{x})$	i	S^2_{di}
30.	Sangam	5.68	1.58**	0.64	11.08	0.54	4.23*	14.30	2.26**	1.27	2.53	0.40	0.39**
31.	TH 68	5.46	-0.29	0.13	11.34	0.17	8.83**	14.32	-0.16	1.96	2.79	0.76**	0.03
32.	TL 15	5.17	0.34	0.22	10.13	-0.21	1.58	16.67	0.59	3.97**	2.48	0.61*	0.41**
33.	T 9	4.43	0.61**	-0.05	9.39	-0.24	8.08**	13.01	0.70	10.84**	3.06	0.61*	0.29**
34.	PT 303	5.21	0.90**	0.05	8.26	-0.52	4.23*	15.29	1.64	6.85**	2.66	0.66**	0.30**
B. Carinata													
35	CAR 4	12.24	-1.87	4.88**	25.67	2.98**	12.52**	12.92	-2.28**	1.68	2.82	-1.29**	0.11*
36.	CAR 5	11.51	-1.20	4.67**	22.00	0.76	46.28**	16.14	-3.78*	11.76**	3.10	0.06	0.03
37.	CAR 6	11.18	-1.07	1.85**	20.56	-0.74	8.91**	13.66	-1.06	1.25	2.73	-0.39	0.01
38.	C_6 YS_7B	9.61	1.28	2.06**	19.93	0.08	34.84**	15.07	0.08	2.61*	2.88	0.78**	0.08*
39.	Eth. sel.	14.43	-2.74	14.48**	33.49	3.35	21.24**	13.09	-0.73	0.36	3.87	0.80**	0.04
40.	HC 2	9.48	-1.60**	1.29**	20.33	-1.14	6.07**	13.33	-0.31	2.29*	2.61	-1.07**	0.32**
41.	HC 14	10.15	-0.54	2.23**	16.03	1.09*	2.11	13.60	-0.95	1.06	3.12	-1.19*	0.18*
44.	BC 2-2	11.05	-0.45	0.81*	18.86	2.37*	11.59**	14.49	-3.65**	3.27**	2.71	0.03	0.03
B. napus													
45.	Mldas	4.71	0.44	0.31	5.75	-0.31	7.46**	17.92	2.72	8.58**	2.60	-0.28	0.03
46.	Culliver	4.76	0.08	0.50	8.90	-0.71**	-0.38	17.02	2.72	10.01**	2.55	0.63*	0.33**
47.	N 20-1	5.06	0.07	0.46	8.13	-1.32**	1.35	18.08	1.80	7.04**	2.58	-0.29	0.01
48.	N 20-7-1	3.62	-0.23	0.23	9.48	-0.41	0.05	20.89	4.37**	1.24	2.85	0.32	0.01
49.	N 20-12-1	4.21	-0.01	0.75*	6.58	-0.86	9.93**	19.96	1.17	20.99**	2.68	-0.28	0.02
50.	Tower 5-2	3.59	-0.31	0.47	9.05	-0.71	2.81	20.07	2.52*	4.36**	3.17	-0.81**	0.41**
51.	Tower 6-1	3.92	-0.71	0.46	8.34	0.89*	1.33	18.08	3.01*	7.08**	3.41	0.21	0.03
52.	HNS 8	3.79	0.71*	0.20	6.74	-0.21	1.91	20.42	3.46	15.56**	3.16	0.63*	0.38**
53.	HNS 9006	3.50	0.52	0.15	5.74	-0.14	13.10**	16.79	0.90	1.29	2.89	-0.32	0.01
54.	Westor	5.76	0.75	1.44	5.38	-0.73	3.36	17.98	1.58	3.72**	2.51	0.15	0.01
Mean		6.50			12.26			15.20			3.25		
SE ± 1.20		0.81		2.13	0.68			1.44	1.12		0.40	0.18	

*, ** Significant at 5% and 1% level of probability.

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STABILITY ANALYSIS FOR YIELD AND ITS COMPONENTS IN MUSTARD (*Brassica juncea* L. Czern and Coss)

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ABSTRACT

Stability analysis of 25 mustard genotypes was made for six characters (plant, height, days to maturity, primary and secondary branches/plant, siliquae/plant and seed yield/plot), grown over eight environments. The G X E interaction, environment (linear) and environment (non linear) components were significant for all the traits except primary branches/plant. However, the predictable component was predominant, indicating the prediction of performance of genotypes over environment for these traits. Genotypes Kranti, PR 43, TM 21, RH 30, Krishna and RLM 619 were found suitable for timely sown situations whereas, varieties namely Krishna, DIRA 667, TM 21, PR 43 and TM 9 performed satisfactorily under late sown conditions .

Keys words : Mustard; *Brassica juncea*; genotype-environment; interaction; stability analysis.

INTRODUCTION

Rapeseed-mustard is the major *rabi* oilseed crop in Himachal Pradesh, covering 36 per cent of the total area and contributing to 45 per cent of the total oilseed production. Mustard, which is relatively a n ew crop to the state is catching the attention of farmers especially as a mixed crop with wheat. The state has a wide range of agro climatic conditions where wheat sowing is carried right from mid September to the end of December. The present investigation was undertaken to identify stable and high yielding varieties of mustard which could fit into different agro climatic conditions of Himachal Pradesh.

MATERIALS AND METHODS

Twenty five mustard genotypes were grown in a simple randomized block design for two years (1990-1991 and 1991-1992) at the Oilseed Research Station, Kangra. Four micro environments (Timely sown irrigated, Timely sown-rainfed, Late sown-irrigated and Late sown-rainfed) in each year, thus giving eight environments. Data were recorded on per plot basis in each of the replications. The data were analysed for stability parameters according to Eberhart and Russell (1966) and Perkins and Jinks (1968).

RESULTS AND DISCUSSIONS

Joint regression analysis showed that genotypes as well as environments differed significantly for all the six characters studied (Table 1). Significant G x E interactions for most of the characters indicated varied phenotypic expression of most genotypes in different environments. Both predictable and unpredictable components shared the G X E interactions the former being slightly predominant. Similar results were reported by Labana *et al.* (1989), Singh *et al* (1984) and Thakur *et al.* (1992). The environment (linear) interaction components were also significant for all the traits. However, higher magnitude of environment (linear) to genotype-environment (linear) interaction for all the characters might be responsible for high adoption of genotypes in relation to yield and its components in mustard.

Variances due to pooled deviation (non -

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linear) were also significant for all the traits except for primary branches, reflecting considerable genetic diversity in the material which supported the observations of Perkins and Jinks (G X E). Such non-linear deviation may be of practical value to construct and test the utility of multiple regression model to know critically the complex mechanism of adaption.

Assessment of genotypes on individual parameters (x_i, b_i and $\tilde{S}^2_{di}$) for seed yield revealed that the highest yielding genotype Krishna had good stability for this trait (Table 2). It is also stable for primary branches/plant.

Varieties Kranti and PR 43 both ranking second in seed yield exhibited average stability for this character. These varieties also performed consistently in respect of secondary branches and siliquae/plant. Variety RH 30, third highest yielder among the genotypes studied was stable for other traits as well. Further varieties DIRA 329 was found to be most stable for all the characters whereas, DIRA 18 showed maximum responsiveness for seed yield and was unstable for other traits RH 8602 and PR 8603 exhibited average stability.

All the genotypes could be classified as suitable for various environments (Table 3). Four genotypes namely, Kranti, RH 8563, PR 43 and TM 21 performed good under timely sown and irrigated conditions, whereas RH 30, DLM 6, Krishna and RLM 619 recorded better yields under timely sown rainfed conditions. For late sown conditions varieties RK 8602, Krishna, DIRA 128 and Kranti did well under irrigated situations, while under rainfed conditions genotypes DIRA 367, RM 19, TM 21 and PR 43 were most suitable.

Secondary branches and siliqua per plant showed significant positive correlation with seed yield (Table 4). These two characters also exhibited maximum direct effect on seed yield. Therefore, varieties with average stability for these traits can be predicted to perform consistently under varied environmental conditions.

Based on these characteristics described above, these genotypes could be used to evolve improved mustard varieties suitable for different agro climatic conditions of Himachal Pradesh.

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Table 1. ANOVA (MSS) for stability for seed yield and other attributes in mustard.

Source	df	Yield/ plot	Plant height	Days to maturity	Primary branches/ plant	Secondary branches/ plant	Siliquae/ plant
			Eberhart and Russel model (1)				
Genotypes (G)	24	874.6**	192.9**	2.85**	0.11	2.81*	281.1*
Environments (E)	7	206237.4**	12423.9**	37778.9**	2.97**	108.2**	64367.5**
G x E	168	721.7**	63.5**	2.96**	0.15	1.39*	305.4**
E x (G x E)	175	8942.3**	557.9**	154.0**	0.26	5.66**	2867.9**
E (linear)	1	1443661.7**	86965.0**	26450.6**	20.82**	757.3**	450576.0**
G x E (linear)	24	844.5**	81.5**	2.19**	0.20	1.99*	316.5**
Pooled Deviation	150	673.0**	58.1**	2.98**	0.14	1.24*	291.4**
Pooled Error	384	131.9	38.1	0.38	0.14	0.34	60.02
			Perkins and Jinks model (2)				
Genotypes (G)	24	874.6**	192.9**	2.85**	0.11	2.81**	281.1**
E/Joint Regression	7	206237.4	12423.9**	3778.7**	2.97**	108.2**	64367.5**
Hetro. bet. regression	24	815.6	81.5	2.19	0.20	1.99**	316.5
Remainder	144	701.0**	60.5**	3.11**	0.14	1.29**	303.5**

** and * : Significant at 5% and 1% levels, respectively.

Table 2. Genotypes with highest mean, maximum responsiveness and stability for different characters.

Character	Best performer	Most responsiveness	Most stable
1. Seed yield / plant	Krishna	DIRA-18	DIRA-329
2. Primary branches / plant	Krishna	Krishna	PR-8603
3. Secondary branches / plant	TM 4	TM 19	RM 619
4. Siliquae / plant	TM 4	DIRA-367	PR-8603
5. Plant height	TM 4	RK-8701	RK-8602
6. Days to maturity	Varuna	RK-8601	TM 21

Table 3. Mustard varieties with high mean performances under different agroclimatic conditions of Himachal Pradesh over years.

Environments	Varieties
Timely sown, irrigated	Kranti, RH-8553, PR-43, TM-21
Timely sown, rainfed	RH-30, DLM-6, Krishna, RLM-619
Late sown, irrigated	RK-8602, Krishna, DIRA-128, Kranti
Late sown, rainfed	DIRA-367, TM-19, TM-21, PR-43

Table 4. Direct (diagonal) and indirect effects of various attributes on seed yield

Characters	Days to flowering	Days to maturity	Primary branches / plant	Secondary branches / plant	Siliquae / plant	Genotypic correlation with seed yield
Days to flowering	-0.218	-0.032	-0.013	0.272	0.227	0.238
Days to maturity	-0.060	-0.116	-0.021	0.280	0.285	0.368
Primary branches / plant	-0.022	-0.020	-0.124	0.154	0.115	0.103
Secondary branches / plant	-0.110	-0.060	-0.035	0.538	0.272	0.604
Siliquae / plant	-0.126	-0.084	-0.036	0.373	0.392	0.519

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CHARACTER ASSOCIATION AND PATH ANALYSIS IN SESAME UNDER RAINFED ECOSYSTEMS.

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ABSTRACT

In 25 genotypes of sesame (*Sesame indicum* L.) the genotypic correlations were higher than the phenotypic ones. Seed yield had significant positive phenotypic and genotypic association with secondary branches per plant, capsules per plant, capsules per main shoot, seeds per capsule, biological yield and harvest index. Biological yield, harvest index and secondary branches per plant had positive direct effect on seed yield. The results revealed that due emphasis is to be given to harvest index, biological yield and secondary branches per plant while selecting plants for improving seed yield in sesame.

Key words : Sesame; correlation; path coefficient; rainfed.

INTRODUCTION

Sesame is an ancient oil crop grown in about 2.2 million hectares which is about 40% of the global area under this crop. However, India's share in the world's sesame pool is only about 27% with a very poor productivity of 225 kg/ha. Its cultivation in marginal lands under poor management and input starved conditions are the most important factors for its low productivity. Development of suitable genotypes of sesame under rainfed condition is an important objective in sesame breeding. Estimation of character association with seed yield and their direct and indirect effects on yield helps in the selection of desirable plant types and the present investigation was undertaken for this.

MATERIALS AND METHODS

The materials for the present investigation comprised 25 sesame (*Sesamum indicum* L.) genotypes received from the All India Co-ordinated Research Project on Oilseeds, Hyderabad. The genotypes studied belong to different agro-climatic zones of the country including the state of Maharashtra, Rajasthan, Punjab, Madhya Pradesh, Tamil Nadu, Orissa and Bihar. The genotypes were raised during *kharif* 1992 in R.B.D. with 4 replications under rainfed conditions at Dholi Research Farm, T.C.A., Dholi (Muzaffarpur) Bihar. Each genotype was raised in 7 rows of 5 meter length with30 and 10 cm row to row and plant to plant distance respectively. Observations were recorded on 5 randomly chosen plants for 13 quantitative characters except for days to 50% flowering and days to 75% maturity which were recorded on a plot basis. Correlation coefficient was computed using variance and covariance components (Singh and Chaudhary, 1977) and path coefficient analysis as elaborated by Deweny and Lu (1969).

RESULTS AND DISCUSSION

Correlation coefficient at genotypic and phenotypic level were computed per pair of all 13 characters and presented in Table 1. In general, the values of genotypic correlation were higher than their corresponding phenotypic correlation coefficient values. This may be due to the effect of environment in modifying the expression of the genotype thus altering the phenotypic expression. The seed yield was observed to be significantly and positively associated both at phenotypic and genotypic level with the harvest index, number of capsules per plant, number of capsules per main shoot, number of seeds per

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capsule, secondary branches per plant and biological yield. However with 1000 seed weight significant positive association was observed at phenotypic level only. Such results have also been reported by Chandrasekhara and Ramana Reddy (1993), Babu and Siva Subramanian (1992-93), and Zhan (1983) in a different set of material with one or the other character. The inter-relationship among various characters is presented in Table 1.

Correlation coefficients of yield per plant with other quantitative characters were (Table 2) partitioned into their direct and indirect effects through path coefficient analysis. The results indicated that positive association of yield per plant with biological yield and harvest index were mainly through their positive direct effect on yield per plant. While the positive association of yield per plant with 1000-seed weight, no. of seeds per capsule, no. of capsules per main shoot, and no. of capsules per plant was due to their positive direct effect on yield per plant but these traits had a negative direct effect on yield per plant. Indirect effect, mainly via harvest index of these characters was the main force to give the observed association of these traits with yield per plant. Similarly the positive direct effect of secondary branches per plant as well as positive indirect effect via harvest index were mainly responsible for positive association of secondary branches per plant with seed yield. Among all the characters, the indirect effect via harvest index was most important for giving the observed association of the different characters with seed yield. The results were in corroboration with the observations made by Chandrasekhara and Reddy (1993).

It is revealed that harvest index, biological yield as well as number of secondary branches per plant may be taken as the most important selection criteria during any selection programme of high yielding genotypes under rainfed situation.

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Table 1. Genotypic (G) and phenopypic (P) correlation coefficients among 13 characters in sesame.

		Days to 75% maturity	Plant height	No. of primary branches	No. of secondary branches	No. of capsules/ main shoot	No. of capsules/ plant	Capsule length	No. of seeds/ capsule	1000 seed weight	Biolog. yield	Harvest index	yield plant
Days to 50% flowering	G	-0.23	-0.27	-0.00	-0.13	-0.24	0.57**	-0.44**	-0.55**	0.41**	-0.21	0.16	0.05
	P	-0.19	-0.16	0.01	-0.02	0.14	0.40**	-0.25*	-0.42**	-0.26*	-0.186	0.14	0.05
Days to 75% maturity	G		0.08	-0.08	-0.20	-0.09	-0.08	-0.08	-0.02	-0.20	-0.16	0.03	-0.08
	P		-0.07	0.06	-0.17	-0.07	-0.07	-0.11	0.06	-0.14	-0.14	0.05	-0.06
Plant height	G	–	–	0.49**	-0.10	-0.34	-0.14	0.72**	0.11	0.15	0.36*	-0.38**	-0.18
	P	–	–	0.34**	0.12	-0.22	-0.08	0.40**	0.07	0.05	0.17	-0.19	-0.09
Primary branches	G	–	–	–	0.14	-0.28*	0.17	0.57**	0.27*	-0.01	0.62**	-0.21	0.12
	P	–	–	–	-0.05	-0.19	0.12	0.34**	0.24*	-0.03	0.37**	-0.15	0.08
Secondary branches	G	–	–	–	–	0.61**	-0.05	0.17	0.48**	0.56**	0.77**	0.11	0.54**
	P	–	–	–	–	0.41**	0.01	0.06	0.32**	0.25*	0.33**	0.12	0.35**
Capsules main shoot	G	–	–	–	–	–	0.42**	-0.35*	0.20	0.34*	0.26	0.39**	0.54**
	P	–	–	–	–	–	0.33**	-0.19	0.14	0.21	0.15	0.32**	0.46**
Capsule plant	G	–	–	–	–	–	–	-0.28*	-0.15	-0.05	-0.12	0.60**	0.68**
	P	–	–	–	–	–	–	-0.12	-0.12	-0.05	0.09	0.44**	0.56**
Capsule length	G								0.22	0.14	0.40**	-0.29*	-0.05
									0.19	0.03	0.26*	-0.23	-0.04
Seed / capsule	G									0.71**	0.38**	0.36*	0.53**
	P									0.45**	0.27*	0.28*	0.45**
1000 Seed weight	G										0.25	0.56**	0.68**
											0.17	0.36**	-0.04
Biological yield	G											-0.25	0.34*
	P											-0.41**	0.26*
Harvest index	G												0.82**
	P												0.76**

Table 2. Direct (diagonal) and indirect effects of different characters towards seed yield per plant

Characters	Days of 50% flowering	Days to 75% maturing	Plant height	Primary branches / plant	Secondary branches / plant	Capsules / main shoot	Capsule / plant	Capsule length	Seeds / capsule	1000 seed weight	Biological yield / plant	Harvest index (%)	Yield / plant
Days to 50% flowering	***-0.080***	0.010	-0.020	0.000	-0.020	-0.027	-0.010	0.027	0.051	0.056	0.124	0.186	0048
Days to 75% maturity	0.019	***-0.043***	-0.004	-0.003	-0.035	0.010	0.001	0.009	-0.02	0.031	-0.098	0.035	-0.008
Plant height	0.022	0.003	***0.073***	-0.019	-0.015	0.037	0.002	-0.043	-0.010	-0.020	0.218	-0.430	-0.183
Primary branches	0.000	-0.003	0.036	***-0.039***	0.022	0.030	-0.005	-0.034	-0.025	-0.001	0.370	-0.234	0.120
Secondary branches	0.010	0.009	-0.007	-0.005	***0.158***	-0.090	-0.001	-0.010	-0.094	-0.078	0.463	0.130	0.536**
Capsules main shoot	-0.020	0.004	-0.024	0.011	0.129	***-0.110***	-0.007	0.021	-0.019	-0.046	0.155	0.448	0.540*
Capsule plant	-0.045	0.002	-0.010	-0.007	0.007	-0.047	***-0.017***	0.017	0.014	0.006	0.074	0.682	0.676**
Capsule length	0.036	0.006	0.052	-0.021	0.027	0.038	0.003	***-0.060***	-0.021	-0.019	0.239	-0.328	-0.047
Seed / capsule	0.044	-0.001	0.006	-0.012	0.075	-0.022	0.033	-0.013	***-0.093***	-0.099	0.229	0.407	0.527**
1000 Seed weight	0.033	0.010	0.012	-0.000	0.089	-0.037	0.001	-0.008	-0.066	***-0.138***	0.152	0.640	0.688**
Biological yield	0.017	0.007	0.026	-0.024	-0.122	-0.028	-0.002	-0.024	-0.036	-0.035	***0.599***	-0.284	0.339*
Harvest index	-0.013	-0.001	-0.028	0.008	0.18	-0.043	-0.011	0.017	-0.0033	-0.078	0.150	***1.38***	0.824**

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GENOTYPE X ENVIRONMENT INTERACTION FOR COMBINING ABILITY ESTIMATES IN CASTOR (*Ricinus communis* L.)**

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ABSTRACT

Combining ability study was conducted over four environments to identify best parents and hybrids to develop high yielding varieties and hyrbids in castor. Four pistillate lines were crossed with 15 inbreds of castor in a L x T design. The resulting 60 hybrids along with 19 parents were evaluated for yield and its related traits in four environments (two locations and two seasons). Significant G x E interaction was observed for all the traits. Appreciable amount of additive x environment interaction for all traits was indicated. Variance due to gca and sca were significant for all the traits studied indicating importance of additive and non additive gene action. However non additivity was most striking for seed yield, capsules per plant and length of primary raceme. VP 1 and LRES 17 among lines and SH 63 among testers were good general combiners. LRES 17 x RC 1226 with high sca effects was identified for heterosis exploitation.

Key Words: Castor; *gca; sca*; G x E; combining ability.

INTRODUCTION

With a view to identify elite parents and appropriate cross combinations for improving the productivity of castor (*Ricinus communis* L.), the information on nature and magnitude of gene action on yield and related components is needed for plant breeders. To attain this goal, a line x tester analysis was useful to test a large number of parents at a time. Further, Singh and Narayan (1993) opined that in order to obtain accurate results the crosses have to be evaluated over several locations for two or three years. Hence the present investigation was taken up in four different environments consisting of two seasons and locations to obtain information on gene action and its interaction with environments for yield and its related attributes.

MATERIALS AND METHODS

The materials consisted of four pistillate lines and fifteen inbreeds of castor and their 60 hybrids produced in a line x tester mating design. The parents and their hybrids were evaluated in RBD with three replications at two locations, namely Oilseeds Research Station, Tindivanam (11.45° N, 79.46° NE, 45.6m MSL, temperature range from 24.1°C to 31.7°C, annual rainfall of 1228.6 mm, sandy loam soil with 7.4 pH) and Sugarcane Research Station, Cuddalore (12.56° N, 79.50°E, 4.60 m MSL, temperature range from 23.61°C to 32.80°C, annual rainfall of 1196.6 mm, sandy clay loam soil with 6.8 pH), in two seasons *viz.*, summer 1993 and *kharif* 1993. Each entry was raised in two rows, each accommodating ten plants each. A spacing of 90 cm between rows and 45 cm between plants was observed. Data were recorded on 10 randomly selected plants for five quantitative traits (Table 1). The combining ability analysis was carried out for individual environments followed Kempthorne (1957) and for pooled analysis as per Eberhart *et al.*, (1981). The proportional contribution of lines, testers and their interaction to total variance was calculated as per Singh and Chaudhary (1985).

RESULTS AND DISCUSSION

Analysis of variance for combining ability for individual environments (Table 1) and pooled over environments (Table 2) revealed that variance due

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to both *gca* and *sca* were significant for all the traits, suggesting that both additive and non-additive types of gene action were important for these traits. The predominance of variance due to *sca* for all the five traits at all the four environments and pooled over environments revealed that non-additivity was more important than additive component for all the traits under study, as observed by Singh and Srivastava (1982) and Dangaria *et al.*, (1993). Non-additive generation was most striking in the case of seed yield, capsules per plant and length of primary raceme.

Combined analysis of variance for seed yield and related traits (Table 2) revealed that the mean squares due to *gca* (overall) x environment, *gca* (lines) x environment, *gca* (testers) x environment and *sca* environment were significant for all the traits. This indicated the presence of additive variance along with appreciable amount of additive x environment interaction for all the traits (Rojas and Spraque, 1952).

The negative estimation obtained in the individual as well as in combined analyses in some traits for *gca* or *sca*, seems to be due to sampling error or genotype x environmental interactions causing additive genetic variation, or lack of

Table 1. Analysis of variance for combining ability in individual environments for yield and its components in castor

Traits	Environemnt	GCA			SCA	GCA/SCA
		Parents	lines	testers		
Length of	E1	-1.07	-2.70	5.28	60.81	-0.020
Primary	E2	-0.47	-0.13	-1.72	77.07	-0.006
raceme	E3	15.09	17.43	6.29	59.08	0.250
	E4	15.27	15.25	15.34	44.85	0.340
Racemes	E1	0.05	0.03	0.11	3.83	0.013
per	E2	0.13	0.16	0.05	3.76	0.037
plant	E3	-0.14	-0.20	0.09	5.45	-0.026
	E4	-0.14	-0.20	0.10	4.91	-0.28
Capsules	E1	49.41	-11.70	278.53	963.05	0.051
per plant	E2	-14.86	-17.06	-6.60	839.36	-0.018
	E3	38.73	-0.92	187.47	698.12	0.055
	E4	36.49	12.99	124.63	579.69	838.58
Seed yield	E1	47.64	6.33	202.57	838.58	0.060
per plant	E2	-0.87	-1.11	0.02**	670.68	0.001
	E3	45.13	9.87	177.38	599.81	0.070
	E4	59.11	46.83	105.14	523.53	0.110
100 - seed	E1	1.27	1.54	0.20	7.00	0.180
weight	E2	1.54	1.88	0.30	6.01	0.250
	E3	1.57	1.92	0.37	7.56	0.210
	E4	1.59	1.81	0.78	9.68	0.160

All significant at 1% level except ns, which is nonsignificant. E1 - Summer 1993 at Tindivanam

E3 - Kharif 1993 at Tindivanam E2 - Summer 1993 at Cuddalore E4 - Kharif 1993 at Cuddalore

random mating in the genetic design used, causing under estimation of male variance and over estimation of female variance and *vice versa*. (El-itriby, 1981).

The proportional contribution of lines, testers and line x testers (Table 1) showed that maximum (more than 57%) contribution came from line x tester interaction followed by testers and lines for all the traits. It indicated that the interaction of genes from both the parents played a major role in expression of these traits.

Considering the overall environment, the *gca* effects were similar to the *sca* effects in a majority of the environments for most of the parents for all the traits, indicating that the presence of additive effects observed for most of the traits had not been altered by the influence of environment.

The female parents VP 1 and LRES 17 showed significant *gca* effects for all the traits, except VP 1 for capsules per plant and LRES 17 for 100 seed weight (Table 3). The female line JP 65 showed maximum *gca* effects for yield and 100 seed weight. Among the male patents, SH 63 recorded significant *gca* effects for all the traits. Similarly, JH 120 and RC 1226 also showed significant *gca* effects for all the traits, except 100 seed weight. The testers USSR 2 and Salam local recorded significant *gca* effects for seed yield and capsules per plant.

The hybrid LRES 17 X RC 1226 displayed significant *sca* effects for all the five traits (Table 4). Further, 240 x JI 1, and 240 x SH 63 for four traits each and 240 x USSR 2 and JP 65 x

Table 2. Analysis of variance for combining ability pooled over environments for yield and its components in castor

Source	Length of primary raceme	Racemes per plant	Capsules per plant	Seed yield per plant	100 seed weight
GCA :					
Over all (O)	3.48**	-0.02**	24.68**	34.77**	1.48**
Lines (L)	3.18**	-0.16**	0.41*	18.46**	1.78**
Testers (T)	4.62**	0.15**	115.71**	96.94**	0.36**
SCA	33.72**	2.26**	290.26**	370.28**	6.83**
GCA: SCA	**0.10**	**0.02**	**0.08**	**0.09**	**0.22**
GCA (O) x Environment	3.72**	2.26**	2.76**	2.98**	0.02*
GCA (L) x Environment	4.26**	0.01**	-4.58**	-2.98**	0.01*
GCA (T) x Environment	1.68**	-0.06**	30.30**	25.33**	0.05**
SCA x Environment	27.74**	2.16**	479.80**	287.87**	0.73**
Proportional contribution of :					
Lines	11.68	4.43	4.12	5.97	19.03
Testers	28.35	25.24	34.74	33.87	23.87
Line x Testers	59.97	70.33	61.14	60.16	57.72

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

Table 3. General combining ability effects of parents, pooled over environments for different traits in castor

Parents	Length of primary raceme	Racemes per plant	Capsules per plant	Seed yield per plant	100 seed weight
LINES:					
VP 1	2.11**	0.32**	1.31	2.14**	0.25**
240	-3.64**	-0.01	-4.98**	-9.63**	-1.46**
JP 65	-0.23	-0.48**	-3.02**	6.59**	2.00**
LRES 17	1.76**	0.17**	6.69**	0.90*	-0.79**
TESTERS					
JI 1	-1.85**	-1.70**	-7.84**	-3.46**	0.33**
JI 52	0.01	0.14**	-5.38**	-9.89**	-1.48**
SH 63	2.53**	0.86**	22.60**	19.08**	0.20*
JH 120	4.99**	0.17**	22.33**	16.27**	-0.58**
RCG 43	-3.49**	0.53**	-9.7**	-2.96**	1.19**
RC 901	4.34**	-0.50**	-22.05**	-13.24**	1.16**
Rc 913	-4.46**	-0.63**	-12.80**	-21.00**	-2.11**
RC 1221	-5.46**	-0.82**	23.10**	-25.37**	-2.22**
RC 1226	7.12**	2.34**	21.39**	12.62**	-1.37**
RC 1356	-3.01**	-0.13**	3.47**	0.96	-0.05
RC 1378	2.14**	-0.18**	5.18**	0.51	-0.62**
60-16-11	-4.48**	-0.12**	-8.77**	-5.89**	1.08**
USSR 2	-1.24**	-0.27**	12.39**	27.07**	3.07**
Gingee	3.32**	-0.61**	-4.52**	-1.34*	1.47**
Salam local	-0.45	0.49	6.81**	6.61**	-0.07
SE (lines)	0.20	0.02	0.78	0.34	0.04
SE (testers)	0.40	0.04	1.52	0.67	0.08

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

Table 4. Hybrids showing significant sca effects for three or more traits with their *per se* performance pooled over environments in castor.

Hybrids	*Length of* primary raceme		*Racemes* per plant		*Capsules* per plant		*Seed yield* per plant		*100 seed* weight	
	sca	mean (cm)	*sca*	mean	*sca*	mean	*sca*	mean (g)	*sca*	mean (g)
LRES 17 x RC 1226	14.35	61.62	2.57	14.69	52.77	223.9	54.55	183.2	2.81	27.54
240 x JI 1	13.11	46.01	-0.97	6.93	20.83	151.1	37.86	139.9	4.16	30.01
240 x SH 63	6.17	43.45	3.28	13.75	22.56	183.3	23.19	147.8	1.03	26.65
240 x USSR 2	0.92**	35.02	-0.37	9.50	21.77	172.3	30.07	162.7	3.43	30.91
JP 65 x JH 120	5.05	40.41	2.74	12.03	14.20	176.6	20.71	158.7	1.62	29.91
SE (sca)	0.80		0.08		3.06		1.34		0.17	
Grand mean		38.39		10.44		144.5	112.8		26.86	

All significant at 1% level except **, which is nonsignificant

JH 120 for three traits each showed significant *sca* effects. Hence the hybrid LRES 17 x RC 1226 is considered to be promising for commercial utilization.

The specific combining ability effects attributed to dominant deviations and epistatic interactions are useful in a cross pollinated crop like castor, in which heterosis exploitation has paved way for greater productivity in building up of hybrids. In the present study, the predominance of *sca* effects for seed yield and most other yield components was encountered. The *sca* effects were positive and significant in 25 hybrids for seed yield over environments. However, considering each of the cross combination at each of the environments, the hybrids LRES 17 x RC 1226, 240 x USSR 2, 240 x JI 1, JP 65 x RCG 43 and JP 65 x JH 120 were found to posses significant and positive *sca* effects under all the environments. Similar results were also reported by Pallikondaperumal (1990) in sunflower.

In the present study, there was positive relation between *sca* effects for seed yield and one or more other component characters in most of the cross combinations (Table 4) as observed by Dangaria *et al.*, (1987).

Comparison of *gca* effects of parents and the *sca* effects of hybrids revealed that it may not be possible to find a uniform trend for all the traits in all the hybrids. However, it could be inferred that when both the parents possessed significant positive *gca* effects, there was a concomitant positive significant *sca* effect in certain hybrids for seed yield as observed in JP 65 x RCG 43 and LRES 17 x RC 1226 (Table 4).

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COMBINING ABILITY ANALYSIS FOR SEED YIELD AND ITS ATTRIBUTES IN NIGER UNDER RAINFED CONDITIONS

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ABSTRACT

A line x tester analysis involving ten promising female parents and four male parents was carried for six quantitative traits in niger under rainfed situations. The overall heterosis was significant for plant height only. The non-additive gene action was of greater importance for all characters including seed yield. Among parents, N 73 - 13, RCR - 64 and IGP-76 were appeared to be the best general combiners for seed yield per plant. The crosses GA-11 x No. 71, CHH-1 x UN - 5, N 73 -13 x IGP-76, RCR-64 x GA-10 and CHH-2 IGP-76 possessed superior specific combinations for seed yield and its attributing characters.

Key words: *Niger; seed yield; combining ability.*

INTRODUCTION

Information on nature of genetic control of seed traits is lacking in niger. Such information if gathered from the comparative study of parents and crosses may be helpful in genetic manipulation of seed traits. Keeping this in view the present study was conducted by adopting Line x tester analysis (Kempthorne, 1957).

MATERIALS AND METHODS

The materials consisted of ten lines and four testers (Table 2) and their 40 crosses. These were grown in randomized block design with three replications at the Zonal Agricultural Research Station, Chindwara (M.P) during *kharif* season of 1991-92 under rainfed conditions. The experiment was sown on 6.8.91. Each genotype was sown in a single row of 5 meter length with spacing of 30 x 12 cm. Observations were recorded on Six quantitative characters from five competitive plants selected randomly per plot. The mean values of each genotype were subjected to combining ability analysis (Kempthorne, 1957).

RESULTS AND DISCUSSION

The analysis of variance (Table 1) revealed highly significant differences among the entries for all the characters except for 1000 - seed weight. There were highly significant differences among parents for all the characters except for number of capsules per plant and 1000 seed weight which indicated existance of genetic diversity in parental materials. Variations among crosses were found to be highly significant for all the characters except for 1000-seed weight. This indicated that the genetic variability in parents was manifested in their crosses. Differences between parents and crosses were significant for only plant height which indicated presence of heterosis for this character. Variance due to males were significant for all the characters except for days to maturity and 1000-seed weight. For female it was non significant for all the characters. The mean Squares due to females were found to be smaller than those due to males except for days to maturity. The lower magnitude of variances in the female x male interaction, although highly significant for all characters except for 1000-seed suggested greater uniformity among the hybrids than among the parental varieties. The variance due to *SCA* was found to be considerably higher than that of *GCA* for all characters indicating greater importance of non-additive gene action. The characters controlled by non-additive gene action hold promise for the exploitation of heterosis. These results are in agreement with findings of

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Govinda Raju *et al.*, (1992) for days to 50 per cent flowering, days to maturity, plant height, number of filled achenes per capitulum and achene yield per plant in sunflower. Putt (1966), Setty and Singh (1977) also reported predominent role of non-additive component for achene yield in sunflower. Hence, the improvement of these traits might be possible by the bi-parental mating followed by recurrent selection.

Among parents the best general combiners were different for different characters (*Table 2*). For seed yield per plant N 73-13, RCR-64 and IGP-76 were appeared the best general combiners. Besides, seed yield IGP-76 was best general combiner for number of branches per plant. Parents No. -71, *RCR-238 and RCR-64* were best general combiners for plant height whereas CHH-1, N 73-13, UN-4 and UN-5 were best general combiners for early maturity.

Estimates of specific combining ability effects revealed a wide range of variation for all the characters (*Table 3*). *The crosses GA-11 x No.* 71, CHH-1 x UN-5, N 73-13 x IGP-76, RCR-64 x GA-10 and CHH-2 x IGP-76 were superior specific combinations for seed yield per plant. Besides yield RCR-64 x GA-10 was the best specific combination for plant height and days to maturity also. For number of capsules per plant and number of branches per plant ONS-8 x IGP-76 and GA-5 were found to be the best crosses. The former cross was the best specific combination for plant height and days to maturity also. The other best crosses for plant height were RCR-228 x IGP-76 and UN-4 x No. 71 and for days to maturity were CHH-2 x GA-10, DN-4 x GA-10 and CHH-1 x UN-5. The best hybrids GA-11 x No. 71 and CHH-1 x UN-5 with high SCA effect for seed yield involved both the parents which an average were the poor general combiner. So non-additive type of gene action seems to be involved in the inheritance of seed yield. Similar results of non-additive gene action for different traits in sunflower were reported earlier by Putt (1966), Setty and Singh (1977) and Sindagi *et al.*, (1979).

The results of current study have some bearing on breeding methodology to be followed in niger under rainfed conditions. The characters like seed yield showed predominent role of non-additive genetic variance which could be exploited through a hybrid breeding programme. For the improvement of characters like number of branches and capsules per plant and days to maturity which exhibited predominant additive genitive variance, simple selection procedure would be effective.

From the present set of parents, N 73-13, RCR-64, IGP-76, UN-5, CHH-1 and DN-4 were good parents and their exploitation in future breeding programme for rainfed areas may give desirable results.

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Table 1 . Analysis of variance (mean squares) for combining ability in niger

Source of variation	d.f.	Days to maturity	Plant height (cm)	No. of branches/ plant	No. of capsules/ plant	Seed yield / plant	1000 - seed weight
Entries	53	11.66**	119.78**	4.18**	64.98**	1.61**	0.06
Parents	13	10.67**	140.13**	2.31	28.75	0.61**	0.07
Crosses	39	12.28**	114.02**	4.87**	78.56**	1.98**	0.06
Parents v/s crosses	1	0.08	79.89*	1.49	6.02	0.46	0.11
Females	9	20.41	79.96	4.22	80.12	2.04	0.05
Males	3	5.10	490.50**	16.14*	224.24*	6.25*	0.11
Females x male	27	10.37**	83.54**	3.84**	61.86**	1.48**	0.06
Error	106	0.82	20.36	1.71	29.32	0.27	0.10
σ^2 gca	-	0.06	0.99	0.03	0.54	0.02	-
σ^2 sca	-	3.18	21.06	0.71	10.85	0.40	-

*, ** = Significant at 5 and 1 percent levels respectively.
Note : For 1000 - seed weight the analysis of variance was found non-significant hence, gca and sca effects were not calculated.

Table 2 . Estimates of general combining ability effects of parents in niger.

	Parents	Days to maturity	Plant height (cm)	No. of branches/ plant	No. of capsules/ plant	Seed yield/ plant
Females :	GA-5	1.38**	-3.65**	0.83*	0.53	-0.40**
	GA-11	0.08	1.60	0.72	3.65*	0.04
	ONS-8	1.63**	-0.73	-0.86*	-5.40**	-0.54**
	RCR-64	1.22**	3.52**	0.53	0.37	0.64**
	RCR-238	0.05	4.27**	0.29	2.75	0.10
	CHH-1	-2.12**	-1.23	0.19	-1.24	-0.21
	N73-13	1.78**	0.02	-0.53	0.35	0.71**
	DN-4	-0.95**	0.18	-0.37	1.83	-0.13
	CHH-2	-0.20	-0.65	-0.22	-0.87	0.10
	CHH-5	-0.03	-3.32*	-0.58	-1.97	-0.30*
Males :	IGP-76	0.35*	-4.48**	0.26	2.83**	0.58**
	UN-5	-0.45**	0.82	0.75**	1.85	0.11
	No.71	0.35*	5.12**	-0.02	2.08*	-0.48**
	GA-10	-0.25	-1.46	-0.99**	-2.60**	-0.20*
	SE(gi)lines	0.26	1.30	0.38	1.56	0.15
	SE(gi)Testers	0.17	0.82	0.24	0.99	0.09
	SE(gi-gi)Lines	0.37	1.84	0.53	2.21	0.21
	SE(gi-gi)Tester	0.23	1.17	0.34	1.40	0.13

*, ** = Significant at 5 and 1 percent levels respectively.

Table 3 . Estimates of specific combining ability effects of crosses in niger.

Crosses			Days to maturity	Plant height	No. of branches/ plant	No. of capsules/ plant	Seed yield/ plant
GA-5	x	IGP-76	-1.02*	-5.35*	-0.33	-4.33	-0.24
GA-11	x	IGP-76	-0.43	-5.60*	0.52	-1.91	-0.87**
ONS-8	x	IGP-76	-1.60**	7.73**	2.13**	7.68*	-0.32
RCR-64	x	IGP-76	0.15	-7.19**	0.71	5.37	0.40
RCR-228	x	IGP-76	-0.02	11.40**	-1.49*	-2.15	-0.20
CHH-1	x	IGP-76	0.48	-0.77	-0.29	-3.76	-0.62
N73-13	x	IGP-76	-0.52	-1.02	-0.63	-4.95	1.13**
DN-4	x	IGP-76	1.98**	-1.19	-0.06	-0.83	-0.46
CHH-2	x	IGP-76	0.57	-1.69	-0.81	1.87	0.79**
CHH-5	x	IGP-76	0.40	3.65	1.27	2.97	0.38
GA-5	x	UN-5	0.12	0.02	2.32**	6.40	-0.14
GA-11	x	UN-5	0.70	1.10	-0.23	2.40	0.01
ONS-8	x	UN-5	1.20*	-0.57	-0.26	0.38	0.71*
RCR-64	x	UN-5	0.62	-0.49	-0.12	-0.12	-0.41
RCR-238	x	UN-5	0.45	-5.90*	-0.01	-0.63	-0.04
CHH-1	x	UN-5	-3.05**	2.60	-0.31	5.82	1.23**
N73-13	x	UN-5	-1.38**	-4.65	-1.18	-3.03	-0.93**
DN-4	x	UN-5	1.45**	-2.15	-0.15	-4.85	0.11
CHH-2	x	UN-5	1.70**	3.68	-0.70	-5.75	-0.30
CHH-5	x	UN-5	-1.80**	6.35*	0.61	-0.65	-0.23
GA-5	x	No.71	-0.65	2.05	-1.10	0.71	0.42
GA-11	x	No.71	-0.77	2.46	0.80	3.60	1.29**
ONS-8	x	No.71	0.40	-2.54	-1.22	-4.35	-0.29
RCR-64	x	No.71	0.82	-1.12	-1.01	-6.45*	-0.87**
RCR-238	x	No.71	-0.68	-3.87	0.83	3.96	0.19
CHH-1	x	No.71	-0.85	0.96	0.96	-2.45	0.13
N73-13	x	No.71	-1.18*	2.71	1.19	3.90	-0.94**
DN-4	x	No.71	0.32	7.21**	0.69	5.55	0.65*
CHH-2	x	No.71	1.57**	-0.20	0.20	0.65	-0.14
CHH-5	x	No.71	-0.27	-7.62**	-1.29	-5.05	-0.35
GA-5	x	GA-10	0.25	3.28	0.12	-2.77	-0.05
GA-11	x	GA-10	0.50	2.03	-1.09	-4.08	-0.42
ONS-8	x	GA-10	0.00	-4.63	-0.65	-3.70	-0.10
RCR-64	x	GA-10	1.58**	8.76**	0.42	1.20	0.88**
RCR-238	x	GA-10	0.25	-1.63	0.67	-1.18	0.04
CHH-1	x	GA-10	3.42**	-2.80	-0.37	0.40	-0.64*
N73-13	x	GA-10	3.08**	2.95	0.62	4.08	0.74*
DN-4	x	GA-10	-3.75**	-3.88	-0.48	0.13	-0.31
CHH-2	x	GA-10	-3.83**	-1.72	1.31	3.23	-0.35
CHH-5	x	GA-10	1.67**	-2.38	-0.59	2.73	0.19
SE(sij)			0.52	2.61	0.75	3.13	0.30
SE(sij-skj)			0.74	3.68	1.71	4.42	0.42

*, ** = Significant at 5 and 1 percent levels respectively.

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GENETIC VARIABILITY, CORRELATION AND PATH ANALYSIS IN NIGER

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ABSTRACT

In fifteen genotypes of niger substantial genetic variability was observed for nine characters studied. Heritability estimate was low for primary branches/plant; moderate for seed yield/plant and high for remaining all characters. Significant positive and higher genotypic correlation of seed yield with seeds/capitulum, days to flower and days to maturity was observed; while it was moderate with 1000 seed weight and plant height. A positive phenotypic as well as genotypic correlation among days to flower, days to maturity, seeds/capitulum and 1000 seed weight and their positive association with seed yield was observed, indicating that these are the major yield components in niger. However, on the basis of correlation and path analysis, days to maturity, seeds/capitulum and 1000 seed weight were the major yield components. Since late maturity beyond certain limit is not desirable, greater emphasis should be laid on seeds/capitulum and 1000 seed weight.

Key Words: Niger; variability; interrelationship.

INTRODUCTION

Knowledge of heritability and correlation among components of productivity are valuable in selection. Path analysis of yield components brings out the relative importance of their direct and indirect influence and helps in understanding in their association with the seed yield. The present study was undertaken to analyse the variability and interrelationship of components of productivity in niger crop.

MATERIALS AND METHODS

The material consists of fifteen elite genotypes of niger, which were evaluated in coordinated varietal trial during *kharif* 1995-96 at Igatpuri. They were evaluated in randomized block design with three replications in a plot size of 2.10 x 5.00 m. The spacing was 30 cm x 10 cm. Observations were recorded for days to flower and days to maturity on plot basis and for plant height (cm), primary and secondary branches/plant, capitula/plant, seeds/capitulum and 1000 seed weight (g) from ten randomly selected plants per plot basis. The seed yield/plant (g) was worked out from the plot yield. The heritability and other variability parameters were estimated following Burton De Vane (1953). Genotypic and phenotypic correlations were worked out following Robinson *et al.*, (1951). The path analysis was done as per the procedure outlined by Dewey and Lu (1959).

RESULTS AND DISCUSSION

Significant differences among the genotypes of niger, suggested the presence of substantial variability for all characters studied. The variability parameters such as range, mean, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance as percentage of mean (GA) are presented in Table 1. The GCV was maximum for the secondary branches/plant (27.30), followed by capitula/plant (26.80). It was lowest for 1000 seed weight (6.80), primary branches/plant (5.40) and days to maturity (4.80). PCV revealed the same pattern of variability. The differences between GCV and PCV were very low for all characters, was mostly due to genetic factors. The presence of high genetic variability

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is an indication of good scope for their improvement through selection.

Days to flower had highest heritability (95.60) followed by days to maturity (92.10); whereas it was lowest for primary branches/plant (26.80). The highest GA was observed for secondary branches/plant (53.40) followed by capitula/plant (49.40). High heritability coupled with high GA was observed for secondary branches/plant and seeds/capitulum indicating the predominance of additive gene action for these two characters. For days to flower and days to maturity, high heritability coupled with low GA were observed, suggesting preponderance of non additive gene action. A low or moderate heritability with low GA was observed for primary branches/plant, suggesting that environment had a major role in their expression.

The seed yield/plant showed significant and higher genotypic correlation in positive direction with seeds/capitulum, days to flower, days to maturity and it was moderate with 1000 seed weight and plant height. It was negatively correlated with secondary and primary branches/ plant and capitula/plant, and was lower in magnitude. Similar was the pattern of phenotypic correlations. But the genotypic correlations were higher in magnitude than their respective phenotypic correlations, indicating that selection for the correlated characters could give a better yield response than would be expected on the basis of phenotypic correlations (Robinson *et al.*, 1951). Thus these present results are in general agreement with those of Sahu and Patnaik (1981), Goyal and Kumar (1985 and 1993) and Chennarayappa (1987).

Seventeen of the thirtysix phenotypic correlations among nine characters were significant, three of which were negative. The negative correlations were those of seeds/ capitulum, 1000 seed weight with primary branches/plant, and seeds/capitulum with plant height. Nineteen out of thirtysix genotypic correlations among nine characters were significant; four of which were in negative direction and fifteen were in positive direction. A phenotypic as well as genotypic correlation among days to flower, days to maturity, seeds/ capitulum and 1000 seed weight and their positive association with seed yield/plant was observed, indicating that these are major yield components in niger. A selection for these characters would possibly be helpful in improving the yield potential of this crop.

The contribution of these characters was further analysed by computing their direct and indirect effects on seed yield and are presented in Table 3. Path coefficient analysis based on genotypic and phenotypic correlations revealed almost similar pattern of direct and indirect influence of different characters on seed yield/ plant. Thus, the results based on genotypic correlations only are presented and discussed. Days to maturity, seeds/capitulum and 1000 seed weight had large and positive direct effects; whereas, secondary branches/plant had moderate

Table 1. Estimates of different variability parameters in niger.

Character	Range	Mean	PCV	GCV %	Heritability	GA % of mean
Days to flower	37-55	46	8.60	8.40	95.60	19.20
Days to maturity	97-111	104	5.10	4.80	92.10	9.70
Plant height (cm)	79.40-168.35	141	22.30	18.70	71.60	35.30
Primary branches/ plant	5-7	6	9.10	5.40	26.80	4.90
Secondary branches/	4-10	7	28.20	27.30	80.00	53.40
Capitula / plant	18-36	27	29.50	26.80	83.40	49.40
Seeds/capitulum	16-26	22	15.70	13.70	75.20	22.70
1000 seed weight (g)	3.55-4.70	4.19	6.92	6.80	70.10	10.40
Seed yield/plant (g)	144.260	189	15.60	13.40	61.00	18.40

direct effect on seed yield. The direct effect of remaining character was very small. The large direct effect of days to maturity, which has no direct bearing on yield is difficult to explain. The positive correlation of days to flower, plant height, 1000 seed weight and seed yield/plant were owing to their positive indirect effects via days to maturity and seeds/capitulum. But the high positive correlation of days to maturity and seeds/capitulum with seed yield/plant were owing to their large positive direct and indirect effects via each other. The low negative but nonsignificant correlation of primary branches/plant, secondary branches/plant and capitula/plant with seed yield were owing their low direct effects and cancellation of indirect effects via other characters.

From the foregoing discussion, it could be inferred that days to maturity, seeds/capitulum and 1000 seed weight are the major factors determining seed yield. Since late maturity beyond a certain limit is not desirable, greater emphasis should be laid on seeds/capitulum and 1000 seed weight.

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Table 2. Estimates of genotypic (above diagonal) and phenotypic (below diagonal) correlations in niger

Character	Days to flower	Days to maturity	Plant height (cm)	Primary branches/ plant	Secondary branches/ plant	Capitula/ plant	Seeds/ capit-ulum	1000 seed weight (g)	seed yield/plant (g)
Days to flower	1.00	0.94**	0.43*	0.13	-0.20	0.01	0.80**	0.55*	0.79**
Days to maturity	0.74**	1.00	0.28*	0.44*	-0.22	0.07	0.84**	0.38*	0.72**
Plant height	0.39*	0.24	1.00	-0.14	-0.12	-0.03	0.28*	0.22	0.35*
Primary branches/ plant	0.10	0.40*	-0.12	1.00	0.14	-0.04	-0.35*	-0.33*	-0.16
Secondary branches/ plant	-0.19	-0.20	-0.09	0.12	1.00	0.10	-0.32*	-0.10	-0.15
Capitula/prant	0.01	0.02	-0.02	-0.03	0.10	1.00	-0.25*	-0.11	-0.11
Seeds/capitulum	0.75**	0.79**	0.25*	-0.30*	-0.30*	-0.20	1.00	0.47*	0.89**
1000 seed weight	0.50*	0.34*	0.20	-0.31*	-0.09	-0.10	0.42*	1.00	0.44*
Seed yield / plant	0.70**	0.68**	0.31*	-0.12	-0.12	-0.10	0.81**	0.42*	1.00

*, ** Significant at five percent and one percent level, respectively.

Table 3. Direct (diagonal) and indirect effects of component traits in niger

Character	Days to flower	Days to maturity	Plant height (cm)	Primary branches/ plant	Secondary branches/ plant	Capitula/ plant	Seeds/ capit-ulum	1000 seed weight (g)	Genotypic correlations with seed yield/plant (g)
Days to flower	*-0.04*	0.57	0.01	-0.03	-0.02	-0.01	0.34	-0.03	0.79**
Days to maturity	-0.05	*0.62*	0.07	-0.11	-0.01	-0.05	0.33	-0.08	0.72**
Plant height	-0.01	0.23	*0.01*	-0.01	-0.03	0.05	0.12	-0.01	0.35*
Primary branches/ plant	*-0.01*	*0.17*	*-0.01*	*-0.21*	0.02	0.02	-0.16	0.02	-0.16
Secondary branches/ plant	0.02	-0.28	-0.01	-0.01	*0.24*	-0.04	-0.09	0.02	-0.15
Capitula/plant	0.00	0.02	-0.01	0.01	0.01	*-0.09*	-0.08	0.01	-0.11
Seeds/capitulum	-0.25	0.51	0.03	0.09	-0.09	0.35	*0.45*	-0.20	0.89**
1000 seed weight	-0.15	0.05	0.01	0.07	-0.15	0.10	0.11	*0.40*	0.44*
Residual effect = 0.34									

*, ** Significant at five percent and one percent level, respectively.
Diagonal figures denotes direct effects.

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PERFORMANCE OF SOYBEAN GENOTYPES UNDER DIFFERENT PLANT POPULATION LEVELS IN THE KRISHNA - GODAVARI ZONE OF ANDHRA PRADESH

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ABSTRACT

A field experiment was conducted during the rainy seasons of 1990 and 1991 at Regional Agricultural Research Station, Lam, Guntur to study the performance of different genotypes under varying population levels. The genotypes exhibited significant variation among the yield and yield attributing characters studied. PK 472 gave the highest seed yield followed by KB 60 and Hardee. The high seed yield in PK 472 and KB 60 was due to better 100 seed weight and seed-production efficiency. Increasing the plant population from 2 to 4 lakh plants/ha resulted in a significant yield increase in all the genotypes. However, there were no significant differences between 4 and 6 lakh plants/ha. PK 472 and KB 60 can be recommended at 4 lakh plants/ha to harness the yield potentials in the black soils of Krishna-Godavari zone of Andhra Pradesh.

Key Words: - Soybean genotypes; plant population.

INTRODUCTION

The cultivation of soybean is on the increase in the black soils of Krishna-Godavari zone of Andhra Pradesh. The introduction of soybean to this zone with a meagre technical know - how resulted in low productivity of 1000 kg/ha which is much below the world average of 1900 kg/ha (FAO, Rome 1990). One of the major constraints affecting the yield is inadequate plant population. Further, the cultivation of several new varieties by the farmers warranted research on their optimum plant population to harness optimum yield potentials of soybean. Hence a study to assess the performance of soybean genotypes at varying levels of plant population was undertaken.

MATERIALS AND METHODS

A field experiment was conducted at Regional Agricultural Research Station, Lam, Guntur during the rainy seasons of 1990 and 1991. The treatments comprising 7 genotypes (PK 472, SH 84-14, UGM 30, MACS 63, KB 60, Hardee and KHSb 2) in main plots and 3 plant populations (2.0, 4.0 and 6.0 lakh plants/ha) in subplots were replicated thrice in a split-plot design. Net-plot size was 3.0 m x 5.0 m with rows spaced 30 cm apart. The soils were black clayey (60%) and low in available nitrogen (185.0 kg/ha) and available phosphorous (12.6 kg/ha) and high in potassium (557.0 kg/ha). The crop was sown on 14th July 1990 and 17th June 1991. A basal application of N and P_2O_5 @ 30 and 60 kg/ha respectively was made and the seeds were inoculated with *Rhizobium japanicum* culture prior to sowing. A total of 576.2 and 848.5 mm rainfall was received during the 1990 and 1991, respectively in the cropping season. Seed production efficiency was calculated as seed yield/number of days to physiological maturity, and expressed as kg/ha/day. Observations on yield attributing characters were recorded on ten random plants/plot. Yield was recorded and expressed as q/ha. The results of pooled analysis were presented in the manuscript.

RESULTS AND DISCUSSION

Effect of genotype

Genotype MACS 63 flowered significantly early followed by UGM 30 as compared to the other genotype / varieties (Table 1). MACS 63 also

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matured early (98 days) as compared to 105 to 111.5 days taken by the rest. Minimum height (28.0 cm) was recorded in PK 472 whereas UGM 30 was the tallest (67.2). Though highest pods/plant were recorded in KB 60, it was on par with the SH 84-14 and MACS 63. PK 472 and KHSb2 had significantly more 100- seed weight than the other varieties while MACS 63 had significantly lower 100- seed weight. Seed production efficiency in terms of seed yield/ha/day was significantly higher in PK 472 (19.8 kg/ha) than the other genotypes/varieties tested.

A wide variation (12.0 to 21.1 q/ha) in seed yield was noted amongst the genotypes/varieties tested. PK 472 recorded significantly higher seed yield (21.1 q/ha) than all the genotypes owing to more 100-seed weight and seed production efficiency. This was followed by KB 60 and the major yield contributing component could be the number of pods per plant. Chandel *et al.*, (1087), Khandait *et al.*, (1991) and Halvankar *et al.*, (1993) reported similar varietal differences for seed yield.

Effect of plant population

An increase in planting density from 2 to 6 lakh plants per hectare resulted in progressive increase in plant height (Table 1). In contrast, number of branches/plant and number of pods/plant showed a reverse trend. This can be due to competition among the plants for sunlight. The results are in concurrence with the findings of Chandel *et al.*, (1987) and Halvankar *et al.*, (1993).

The seed yield also increased with increase in population levels studied. This may be attributed to the seed production efficiency at increasing plant population levels. Even though highest seed yield wasrecorded in 6 lakh plants/ha it was on par with the 4 lakh plants/ha. Perhaps the no. of pods/unit area and seed production efficiency might have contributed for higher yields as reported by Balyan and Mohta (1985) and Sheelavantar and Patil (1988).

Interaction effect

All the varieties gave significantly higher seed yield at 4 and 6 lakh plants/ha than 2 lakh plants/ha. Similarly, at each level of plant population PK 472 recorded significantly higher yield than all the genotypes tested. This was followed by KB 60 (Table 2).

To conclude, it can be stated that PK 472 was the best choice in terms of 100-seed weight and seed production efficiency for obtaining better yields. Further, a population of 4 lakh plants/ha was sufficient to reap significantly higher yields with all the genotypes studied in Krishna-Godavari zone.

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Table 1. Effect of genotype and planting density on growth parameters and seed yield of soybean (pooled data of 2 years)

Treatment	*Growth parameters*							Seed yield (q/ha)
	Days to 50% flowering (No.)	Days to maturity (No.)	Plant height cm)	Branches/ plant (No.)	Pods/ plant (No.)	100 seed weight	Seed production efficiency (kg/ha/day)	
Genotype								
PK 472*	42.5	106.5	28.0	3.3	51.8	12.6	19.8	21.1
SH 84-14	45.0	107.0	37.6	3.7	66.9	11.3	13.9	15.0
UGM 30	39.5	105.0	67.2	3.1	49.6	10.4	13.6	14.3
MACS 63	37.0	98.0	47.6	2.1	66.4	9.1	14.4	14.2
KB 60	46.5	109.0	44.5	3.4	77.7	10.7	16.3	17.8
Hardee*	42.0	111.0	44.2	3.4	63.0	11.0	14.3	15.9
KHSb2*	46.0	111.5	40.4	3.9	60.9	12.7	10.7	12.0
CD (0.05)	4.2	5.5	4.6	0.6	11.5	0.6	3.3	1.1
Plant Population (lakh plants/ha)								
2.0	42.6	106.8	39.0	4.3	79.1	11.6	13.2	14.2
4.0	42.6	106.8	45.4	3.2	60.2	11.1	15.3	16.4
6.0	42.6	106.8	48.3	2.4	47.6	10.6	15.6	16.7
C D (0.05)	NS	NS	1.3	0.2	4.0	0.2	0.7	0.3

* released varieties

Table 2. Seed yield (q/ha) of soybean as influenced by genotypes x plant population (pooled data of 2 years)

Genotype	Plant Population (lakh plants/ha)		
	2.0	4.0	6.0
PK 472*	20.0	21.9	21.4
SH 84-14	12.6	15.3	16.9
UGM 30	12.8	14.5	15.5
MACS 63	13.2	14.5	14.9
KB 60	15.4	18.8	19.2
Hardee	14.5	16.5	16.5
KHSb2	10.5	13.0	12.5
CD (0.05)			
Between 2 plant population in same genotype			1.03
Between 2 genotypes at same level of plant population			1.6

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EFFECT OF LEVELS OF NUTRIENTS ON SUNFLOWER AND THEIR RESIDUAL EFFECT ON PRODUCTIVITY, ECONOMICS, LAND USE AND PROFIT EFFICIENCY OF *RABI* CROPS IN SEQUENCE

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ABSTRACT

A field experiment was conducted to study the effect of different NPK levels (50, 100 and 150% recommended dose of NPK (RDF) on to *kharif* sunflower and their residual effect on the productivity and monetary returns on succeeding *rabi* crops like sorghum, safflower, groundnut, sunflower and chickpea on red sandy loam soils of Hyderabad during 1992-93 and 1993-94. The pooled seed yield of sunflower was found highest (1503 kg/ha) at 150% RDF which was higher by 27% and 10% over 50% and 100% RDF respectively. Higher yields of all the *rabi* crops except groundnut were realized from sunflower which received recommended dose. The sunflower seed equivalent yields and returns were highest in sunflower-groundnut sequence (Rs. 15,050/ha) followed by sunflower-sunflower sequence. Sunflower-safflower sequence resulted in higher land use efficiency while profit efficiency was maximum in sunflower-sunflower sequence.

Key Words: Sunflower; nutrient; crop sequence; land use efficiency; net returns; profit efficiency.

INTRODUCTION

The area under sunflower has been increasing in recent years due to its merits of fitting in to the various cropping systems. In Telangana area of Andhra Pradesh, it has emerged as the most remunerative *kharif* crop. Several *rabi* crops are grown under irrigation. The average productivity of sunflower in Andhra Pradesh (614 kg/ha) in particular and India (750 kg/ha) in general is low, largely due to poor nutritional management and improper crop rotations. Besides, building up of pests and diseases was observed in recent years, especially when the crop was grown continuously on the same land apart from deleterious effects on the productivity (AICORPO, 1990). When the preceding crop was groundnut, the productivity of sunflower was more irrespective of the nutrients applied to sunflower (Reddy *et al.*, 1994). In order to identify suitable sequential *rabi* crops for *kharif* sunflower raised under varying fertilizer levels, the present study was taken up.

MATERIALS AND METHODS

The field experiments were conducted during 1992-93 and 1993-94 on red sandy loam soil of the Narkhoda research farm of the Directorate of Oilseeds Research at Hyderabad to evaluate the performance of various *rabi* crops as sequence crops after *kharif* sunflower as base crop raised at 50, 100 and 150 per cent recommended fertilizer levels (70:90:30 kg $N:P_2O_5:K_2O$/ha). The succeeding *rabi* crops viz., sorghum (CSH-13 R), safflower (A-1), groundnut (ICGS-11), sunflower (MSFH-17) and chickpea (ICCV-38) were grown on the same plots at their respective recommended fertilizer levels. The soil was low in fertility status with low in nitrogen (organic carbon 0.38%), medium in available phosphorus (16.5 kg/ha) and high in available potassium (396 kg/ha) with slightly acidic pH (6.2). Urea, super phosphate and muriate of potash were the sources of N, P_2O_5 and K_2O respectively. The base crop raised with three fertilizer levels and 15 replications was sown in the last week of June during 1992 and 1993. Randomized block design was followed for the base crop with 3 fertilizer levels and 15 replications. The succeeding irrigated *rabi* crops formed the main plots and 3 residual fertility levels, the sub-plots of split-plot design with 3

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replications. The *rabi* crops were sown during the 3rd week of October 1992 and 1993. The plot size of the sub-plot was 4.8 m x 5.4 m. *Kharif* sunflower was grown as rainfed as the rainfall distribution was optimum. The total rainfall received during 1992-93 and 1993-94 were 593 and 538 mm respectively. Recommended agronomic practices were followed. The wholesale market price of the crops that prevailed during crop harvest were considered for working out gross returns. Seed equivalent yield of sunflower was computed by using the market prices of the crops tried. The land use efficiency was worked out as suggested by Pal *et al.*, (1985) and profit efficiency values were obtained by total net returns in a sequence divided by total duration of crops in that sequence.

RESULTS AND DISCUSSION

Crop Productivity: Sunflower yield as base crop during *kharif* season was significantly influenced by fertilizer levels (Table 1). The seed yield of sunflower showed an increasing trend with successive increase in fertilizer levels during both the years. Seed yields did not differ significantly between 50% and 100% as well as between 100% and 150% recommended fertilizer levels. Significantly higher seed yield was recorded where 150% of the recommended fertilizer was applied over 50% of the recommended dose. On an average, the crop receiving 150% of the recommended dose of fertilizer registered 27 and 10 per cent increase in yield compared to 50% and 100% recommended dose respectively.

The seed yield of *rabi* crops showed year to year fluctuations due to variation in residual fertility from the *kharif* sunflower crop. However, on an average, the seed yield of sorghum, safflower and chickpea increased up to residual fertility from 10% recommended dose (3046, 1123, and 1082 kg/ha, respectively), whereas highest yield of groudnut and sunflower (2002 and 1366 kg/ha respectively) was obtained at 150% recommended fertilizer applied to sunflower. It indicates that though the base crop of sunflower does not respond beyond 100% recommended fertilizer level, the succeeding crop of groundnut and sunflower can effectively utilize the unutilized residual fertility effectively. Superiority of groundnut in utilizing the residual fertility from preceding wheat crop has been reported by Pasricha *et al.*, (1987) in groundnut - wheat cropping sequence and in groundnut - summer sunflower cropping system by Reddy and Sudhakara Babu (1996). Higher nutrient requirement of sunflower for growth and yield may be attributed for its response up to 150% recommended dose in succeeding *rabi* season also. However, sorghum, safflower, and chickpea could utilize residual fertility only up to 100% recommended dose applied to preceding sunflower. thus there is variation among the *rabi* crops in utilizing the residual fertility.

Sunflower seed equivalent yield: Residual fertility from 100% recommended dose to preceding sunflower was sufficient to get higher sunflower seed equivalent yields from safflower and chickpea where as the highest sunflower seed-equivalent yield was obtained at 150% recommended dose from sorghum and groundnut. Maximum mean seed equivalent yield of sunflower (2398 kg/ha) was registered from groundnut at 150% recommended dose. Want and Fam (1987) reported similar beneficial effect of legumes in sunflower based cropping systems. Yield advantage in sunflower with groundnut as sequence crop in summer sunflower based crop sequence was reported by Reddy and Sudhakara Babu (1996).

Economics: Sunflower - groundnut sequence gave the highest net returns of Rs. 15,050/ha (Table 3) due to higher productivity of both the crops coupled with better market price inspite of higher cost of cultivation with this system. The next best remunerative system was sunflower - sunflower followed by sunflower - sorghum. Sunflower - safflower system gave the lowest net returns. The sunflower - sorghum sequence had comparable net return with two sequence crops of sunflower due to higher productivity of sorghum as well as

Table 1. Seed yield (kg/ha) of *karif* sunflower and succeeding *rabi* crops as influenced by fertilizer levels to *kharif* sunflower.

Crops	Nutrient levels ($N:P_2O_5:K_2O$ Kg/ha)								
	37.5 : 45 : 15			75 : 90 : 30			112.5 : 135 : 45		
	1992	1993	Pooled	1992	1993	Pooled	1992	1993	Pooled
Kharif Sunflower	1095	1169	1132	1270	1336	1303	1433	1433	1433
Succeeding *rabi* Crops									
Sorghum	3737	2356	3046	4205	2295	3250	3208	2558	2883
Safflower	823	1304	1063	841	1406	1123	1021	1359	1190
Groundnut	698	2137	1417	1446	2358	1902	1551	2454	2002
Sunflower	1420	940	1180	1600	1026	1313	1713	1020	1366
Chickpea	1322	599	960	1276	889	1082	1070	908	989

		C.D. (P = 0.05)	
		Crops X fertiliser	Fertiliser
For base Crop	1992	---	244.3
	1993	---	178.1
	Pooled	---	203.2
For succeeding *rabi* crops	1992	N.S	104.5
	1993	N.S	96.4
	Pooled	N.S	154.3

Table 2. Sunflower equivalent seed yield (kg/ha) of *rabi* crops as influenced by nutrient levels to preceeding *kharif* sunflower

Crops	Nutrient levels ($N:P_2O_5$: K_2O Kg/ha)								
	37.5 : 45 : 15			75 : 90 : 30			112.5 : 135 : 45		
	1992	1993	Pooled	1992	1993	Pooled	1992	1993	Pooled
Sorghum	1308	1060	1184	1355	1033	1194	1123	1151	1137
Safflower	679	1013	846	694	1181	937	842	1141	992
Groundnut	558	2607	1583	1157	2876	2016	1081	2994	2038
Sunflower	1423	940	1182	1600	1029	1315	1713	1020	1367
Chickpea	1223	652	938	1180	1175	1178	990	1278	1134

	C.D. (P = 0.05)		
	Crops	Fertiliser	Crops x fertiliser
1992-93	342	NS	NS
1993-94	279	77	a) for sub within same main = 172
			b) for sub within same/diff main = 289
Pooled	NS	118	NS

its fodder value.

Land use efficiency and profit efficiency: Sunflower - safflower sequence achieved the highest land use efficiency (0.65) followed by sunflower - groundnut (0.61) and sunflower - chickpea (0.59) sequences (Table 3). It was lowest in sunflower - sunflower sequence (0.55). It is mainly due to duration of the winter crops, wherein safflower took longer time to mature followed by chickpea and groundnut.

The profit efficiency was highest in sunflower - sunflower sequence (Rs. 73/ha/day) because of short duration, higher productivity and better market prices. Sunflower - safflower sequence was the lowest in terms of profit efficiency (Rs. 53/ha/day). The sunflower - groundnut sequence with a higher profit efficiency of Rs. 67/day is ideal both in terms of providing land coverage for a longer period, efficient utilization of fertility in a system and yielding highest returns. Among the various sunflower based cropping systems, sunflower - groundnut was found most productive as well as more remunerative besides being efficient in utilizing the residual fertility from sunflower. This system imparts greater sustainability on a long term in terms of meeting fodder needs and improving soil fertility, with optimum utilization of resources.

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Table 3. Economics, land use and profit efficiency as influenced by fertiliser levels to *kharif* sunflower based Cropping systems. (Mean of 1992-93 and 1993-94)

Cropping system	Net returns (Rs. /ha)				Land use efficiency (%)	Profit efficiency Rs. / day / ha
	37.5 : 45 : 15	75 : 90 : 30	112.5 : 135 : 45	Mean		
		(N : P_2O_5 : K_2O Kg/ha)				
Sunflower - Sorghum	13473	14698	13515	13895	56	68
	(8508)	(9727)	(10905)	(9713)		
Sunflower - Safflower	11509	12515	13189	12404	65	53
	(8581)	(9780)	(1095)	(9773)		
Sunflower - Groundnut	11726	16161	17263	15050	61	67
	(10930)	(12085)	(13283)	(12099)		
Sunflower - Sunflower	12979	14720	15452	14384	55	73
	(10141)	(11340)	(12538)	(11340)		
Sunflower - Chickpea	11765	13404	12646	12605	59	61
	(8435)	(9634)	(10832)	(9634)		

Figures in parenthesis indicate the cost of cultivation of the system (Rs./ha)

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EFFECT OF WEED CONTROL ON NUTRIENT UPTAKE, WEED WEIGHT AND YIELD OF GROUNDNUT

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ABSTRACT

A field experiment was conducted on alfisols at the Regional Research Station, Raichur of the University of Agricultural Sciences, Dharwad, during *rabi*/summer season of 1994 to study the effect of weed control on nutrient uptake, weed weight and yield of groundnut under irrigated conditions. The treatments viz., weed-free check, trifluralin @ 1.5 kg a.i./ha + intercultivation (IC) @ 30 DAS and 45 DAS, alachlor @ 3 kg a.i./ha + hand weeding 30 DAS + IC 45 DAS and trifluralin @ 1.5 kg a.i./ha + IC 30 DAS resulted in significantly higher nutrient uptake by crop, while the uptake by weeds was minimum. In unweeded control uptake of nutrients by groundnut crop was significantly lowest and the nutrients removed by weeds was maximum. Weed free check recorded highest pod yield (28.55 q/ha) and was on par with trifluralin @ 1.5 kg a.i./ha IC 30 and 45 DAS (23.63 q/ha). Significantly lowest pod yield of 9.91 q/ha was recorded in unweeded control.

Key Words: Weed management; groundnut; irrigated; nutrient uptake.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop of India. The productivity of groundnut under irrigated conditions in command areas of Karnataka during *rabi*/summer conditions is not stable due to various reasons, weed infestation is one such problem. Yield loss due to weed infestation amounts to 70 per cent (Kalaiselvan *et al.*, 1989). Weeds not only compete with crop for the resources like moisture, nutrients, light and space but also interfere with pegging, pod development and harvesting of groundnut. The critical period of weed competition was found to be 4 to 8 weeks after sowing (Hamada, 1988).

Cultural weed control is a common practice in groundnut. It is time consuming, expensive and tedious. Continuous use of herbicides might result in soil and ground water pollution in the long run. The integrated weed management offers a suitable alternative. Hence, the present investigation was undertaken to evaluate integrated weed management in groundnut.

MATERIALS AND METHODS

A field experiment was conducted on the alfisols in plots of 5.0 x 3.6 m in a randomised block design with three replications to know the effect of weed control on nutrient uptake, weed weight and yield of groundnut, during *rabi*/summer 1994-95 at Regional Research Station, Raichur. The experiment comprised of 12 treatments (Table 1). The soil of experimental plot was low in available nitrogen (156.8 kg/ha), medium in available phosphorus (25 kg/ha) and potassium (312 kg/ha). For uniform mixing of trifluralin throughout the soil profile and for better efficacy of herbicide, trifluralin was sprayed using high volume sprayer a day prior to sowing on light irrigated plots. Spraying of herbicide on light irrigated plots reduce herbicide loss. Alachlor was sprayed on the same day after sowing (27.12.84) with the help of high volume sprayer as pre-emergent herbicide. Interculturing at 30 and 45 DAS (days after sowing) was done with the help of a hoe.

After the harvest of the groundnut, weeds present in the gross plot were sun dried and later

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dry weight in kg per gross plot was converted to quintal per ha. Same weed samples were analysed for nitrogen, phosphorus and potassium by following standard procedures. Groundnut variety (R. 8808) was dibbled at spacing of 30 x 10 cm. A uniform quantity of 25:75:25 N, P and K kg/ha was applied as basal dose. For calculation of correlation coefficient all the three replications with twelve treatments were considered.

RESULTS AND DISCUSSION

Predominant mono-cotyledonous weeds observed were *Cynodon dactylon* (L.) Pers, *Cypress rotundus* L. *Panicum* spp., *Echinochioa crusgalli* (L.) Beau. and *Digitaria marginata* Link., while common dicotyledonous weeds observed were viz., *Amaranthus viridis* L., *Euphorbia hirta* L., *Phillanthus niruri* L., *Tridax procumbense* L., *Tribulus terestris* L., and *Trichodesma indicum*. Trifluralin weedicide controlled dicotyledonous weeds viz., *Amaranthus viridis* L., *Euphorbia hirta L., Tridax procumbense L., Tribulus terestris* L. and also monocotyledonous weeds like *Panicum* spp., *Echinochioa crusgalli* (L.) Beau. and *Digitaria marginata* link.

The data on weed weight (dry), pod yield and nutrient uptake by crop and weeds are presented in Table 1. Integrated weed control practices recorded the lower weed dry weight as compared to cultural treatments, was perhaps due to lower number of germinated weeds and their growth. Similar results were obtained by Sudhakar and Muniappa (1990). The highest weed weight (22.83 q/ha) was recorded in unweeded control treatment. Among the integrated weed management practices, trifluralin @ 1.5 kg a.i./ ha + IC at 30 and 45 DAS recorded significantly lower weed weight (3.48 q/ha) and was on par with trifluralin @ 1.5 kg/ha a.i./ha + IC at 30 DAS (4.63 q/ha) and Alachlor @ 3.0 kg a.i./ha + HW 30 DAS + IC 45 DAS (3.89 q/ha). Lower weed weight in the above treatments was due to efficient control of weeds, which reduced the total weed population and in turn reduced the weed dry weight at all the stages of crop.

Significantly highest nutrient removal by weeds was observed in unweeded control (71.23, 21.46 and 29.91 kg/ha of N, P and K respectively) due to the highest weed weight (22.83 q/ha) and higher weed population starting from sowing till harvest whereas, groundnut crop recorded the lowest nutrient uptake (29.65, 7.64 and 32.09 kg/ ha of N, P and K respectively. This was due to higher weed density (40.67 weed/m^2) and weed dry matter (213.53 g/m^2). Weeds which competed with crop for various growth resources depleted greater amounts of nutrients and thus deprived the crop for nutrients. Soundar Rajan (1985) reported that nutrient removal by weeds was maximum in unweeded control in which crop uptake was minimum.

Among the integrated weed management practices, the groundnut crop under the treatments viz., trifluralin @ 1.5 kg a.i./ha + IC (intercultivation) at 30 and 45 DAS, removed significantly higher amounts of N, P and K (86.91, 23.34 and 80.88 kg/ha respectively), while nutrient removed by weeds was minimum (15.36, 5.52 and 1.74 kg N, P and K kg/ha). Pannu *et al.*, (1989) reported that the uptake of N, P and K by the crop depended mainly on the dry matter accumulation by weeds. On an average, in integrated weed management practices (T1 to T7), weeds removed 18.19, 6.32 and 6.38 kg N, P and K per ha respectively whereas weeds under cultural treatments (T8, T9 and T12) removed higher N, P and K (22.14, 7.54 and 9.80 kg/ha) which was 12.84, 20.44 and 5.36 per cent higher than the corresponding values in integrated methods. On the contrary nutrients removed by crop in integrated weed management practices (T1 to T7) was higher viz., 75.68, 20.14 and 79.85 kg/ha of N, P and K respectively, whereas, it was 66.57, 16.24 and 67.97 kg N, P and K respectively under cultural treatments (T6, T8 and T12). This was mainly attributed to efficient control of weeds in early stages by herbicides and later by cultural treatments which reduced the weed population and dry matter accumulation by weeds and ultimately led to lower uptake of nutrients by weeds and on contrary led to higher uptake of

nutrients by groundnut crop. Similar results were obtained by Nimje (1992).

Correlation matrix (Table 2) was worked out by comparing the yield data with respective characters of all the three replications. Correlation matrix indicated that there was positive correlation between weed weight and nutrient uptake by weeds (r = 0.914, r = 0.857 and r = 0.990 for N, P and K respectively). On the contrary there was a negative relationship between weed weight and nutrient uptake by crop (r = -0.880, r = -0.987 and r = -0.949 for N, P and K respectively). Pod yield was negatively correlated with N, P and K uptake by weeds (r = -0.794, r = -0.719 and r = -0.841 respectively) and positively correlated with N, P and K uptake by crop (r = 0.841, r = 0.868 and r = -0.983 respectively).

CONCLUSION

Integrated weed management practices controlled weeds efficiently and increased the crop yields over the cultural methods and unweeded control. Among the integrated weed management practices, trifluralin @ 1.5 kg a.i./ha + IC at 30 and 45 DAS controlled the weeds efficiently and recorded higher pod yield. Higher nutrient uptake by crop and lower by weed was noticed in integrated weed management practices than the cultural methods, whereas in unweeded control reverse trend was observed.

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* Original not seen.

Table 1. Effect of weed control treatments on nutrient uptake by crop and weeds (kg/ha), dry weed weight (q/ha) and pod yield (q/ha)

Tr. No.	Treatment	Nutrient uptake by weeds			Nutrient uptake by crops			Dry weed weight (q/ha)	Pod yield (q/ha)
		N	P	K	N	P	K		
T1.	Trifluralin @ 0.5 kg a.i./ha - IC at 30 DAS	22.72	7.41	14.58	59.28	15.33	64.05	12.15	14.96
T2.	Trifluralin @ 1.0 kg a.i./ha - IC at 30 DAS	19.45	6.30	6.76	72.12	17.73	76.95	7.68	18.38
T3.	Trifluralin @ 1.5 kg a.i./ha - IC at 30 DAS	8.43	5.89	3.00	84.26	22.81	86.01	4.63	22.03
T4.	Trifluralin @ 0.5 kg a.i./ha - IC at 30 & 45 DAS	23.48	8.01	11.46	68.20	17.61	71.92	10.42	16.31
T5.	Trifluralin @ 1.0 kg a.i./ha - IC at 30 & 45 DAS	21.15	6.11	4.82	75.03	21.50	79.86	6.33	20.30
T6.	Trifluralin @ 1.5 kg a.i./ha - IC at 30 & 45 DAS	15.36	5.52	1.75	86.91	23.34	90.88	3.49	23.63
T7.	Alachlor @ 3 kg a.i./ha - HW 30 DAS - IC 45 DAS	16.77	4.85	2.34	83.98	22.64	88.30	3.89	22.76
T8.	Hand weeding 30 DAS - IC at 45 DAS	21.45	6.43	9.96	68.14	15.18	69.25	9.05	16.79
T9.	Inter cultivation at 30 and 45 DAS	20.46	7.64	14.00	58.28	14.16	60.54	10.77	14.31
T10.	Weed free check	0.00	0.00	0.00	93.83	29.14	94.24	0.00	26.55
T11.	Unweeded control	71.23	21.46	29.91	29.65	7.64	32.09	22.83	9.91
T12.	Hand weeding 20 DAS - IC 30 and 45 DAS	24.50	8.54	5.45	73.29	19.38	74.13	5.67	19.35
	SEm ±	1.09	0.73	0.74	1.44	0.60	1.51	0.63	1.15
	CD at 5%	3.18	2.13	2.18	4.22	1.77	4.33	1.84	3.36

Table 2. Correlation matrix

		Pod yield	Weed weight	N uptake by weeds	P uptake by weeds	K uptake by weeds	N uptake by crop	P uptake by crop	K uptake by crop
1.	Pod yield	1.000**	-0.953**	-0.794**	-0.719**	-0.941**	0.941**	0.968**	0.983**
2.	Weed weight		1.000	0.914**	0.857**	0.990**	-0.990**	-0.987**	-0.949**
3.	N uptake by weeds			1.000	0.979**	0.891**	-0.891**	-0.893**	-0.828**
4.	P uptake by weeds				1.000	0.825**	-0.825**	-0.825**	-0.759**
5.	K uptake by weeds					1.000	-1.000	-0.986**	-0.930**
6.	N uptake by crop						1.000	0.986**	0.930**
7.	P uptake by crop							1.000	0.961**
8.	K uptake by crop								1.000

** Significant at 5%

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WEED MANAGEMENT STUDIES IN *RABI*-SUMMER GROUNDNUT (*Arachis hypogaea* L.) GROWN AFTER RICE

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ABSTRACT

A field experiment was conducted at the Research Farm, College of Agriculture, Raipur for two seasons during rabi-summer (Dec. - May) of 1990-91 and 91-92 to study the efficiency of different herbicides compared with interculture with hand weeding at 30 day followed by hand weeding at 50 days after sowing and unweeded control. The study revealed that the infestation of weeds reduced the mean pod yield by 54.75 per cent. Interculture with hand weeding at 30 days followed by hand weeding at 50 days after sowing recorded maximum weed control efficiency of 89.5% in 90-91 and 93.4% in 91-92, respectively. The crop produced significantly higher pod yield (2068 and 1717 kg/ha, respectively) than due to herbicide treatments. Among the herbicides the pre-planting incorporation of fluchloralin @ 1.0 kg a.i./ha showed higher mean weed control efficiency of 67.2 and 55.7 per cent with mean pod yield of 1557 and 1424 kg/ha, respectively. Lowest weed index value (17.33%) was recorded with the pre-planting incorporation of fluchloralin @ 1.0 kg a.i./ha followed by the application of pendimethalin @ 1.0 kg a.i./ha (24.70%) as pre-emergence spray.

Key Words: Weed control efficiency; weed index; herbicides; groundnut.

INTRODUCTION

Groundnut is an important oilseed crop grown after rice in "Chhatisgarh" region of Madhya Pradesh. The crop weed competition at early stage of groundnut is maximum because of its slow initial growth as the sowing of rabi-summer groundnut is done during winter in the month of December. The critical period of crop weed competition was reported to be first 45 days after sowing (Singh *et al.*, 1985) and the competetive stress of weeds cause reduction in pod yield by about 13-75 percent (Kondap *et al.*, 1989). Weed management through chemical herbicides is one of the important approaches to reduce the crop weed competition at early stage. Therefore, the present experiment was conducted to study the performance of different herbicides to manage the annual weeds in groundnut grown after rice.

MATERIALS AND METHODS

An experiment was conducted during rabi-summer of 1990-91 and 91-92 at the Research Farm, IGAU, College of Agriculture, Raipur. The treatments (Table-1) were tested in a randomized block design with four replications. Fluchloralin was sprayed and incorporated into the soil before sowing and other herbicides were sprayed as pre-emergence, 24 hrs after sowing. The groundnut variety JL-24 was sown at a distance of 30 cm between the rows and 10 cm between the plants within a row during last week of December and harvested during second week of May in both the years. The soil of the experimental field was clay loam in texture, having 220, 9.5 and 340 kg/ha available N, P_2O_5 and K_2O respectively with 7.6 pH. The crop was fertilized with 30 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha through urea, single super

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$$\text{Weed control efficiency (\%)} = \frac{\text{Weed dry weight in control - Weed dry weight in treatment}}{\text{Weed dry weight in control}} \times 100$$

$$\text{Weed index (\%)} = \frac{\text{Yield of weed free plot - yield of treated plot}}{\text{Yield of weed free plot}} \times 100$$

phosphate and muriate of potash, respectively. The weed control efficiency and weed index were calculated by using the formulae suggested by Somani (1992).

RESULTS AND DISCUSSION

The predominant weed species observed in the experimental field were *Cynodon dactylon* Pers., *Echinochloa crusgalli* (L.), *Echinochloa colonum* (L.), *Chenopodium album* (L.), *Melilotus sp.* and *Cyperus rotundus* (L.).

The highest mean weed control efficiency of 91.4 per cent was recorded with interculture with two hand weedings i.e. interculture and earthing followed by hand weeding at 30 days after sowing and only hand weeding at 50 days after sowing. Among the different herbicides tested, the application of fluchloralin @ 1.0 kg a.i./ha as pre-planting incorporation registered maximum weed control efficiency of 63.0 and 71.4 per cent during first and second year, respectively followed by the application of pendimethalin @ 1.0 kg a.i./ha as pre-emergence with a weed control efficiency values of 52.2 and 59.2 per cent. On the mean basis 67.2 and 55.7 per cent weed control efficiency was observed with the application of fluchloralin and pendimethalin, respectively. Lowest mean weed control efficiency of 33.4 per cent was observed with the pre-emergence application of butachlor @ 0.75 kg a.i./ha. Murthy *et al.*, (1992) also reported pre-sowing incorporation of fluchloralin @ 1.0 kg a.i./ha supplemented with interculativations at 15, 30 and 45 days after sowing for effective control of weeds and increasing pod yield of groundnut.

Significantly higher dry pod yield of groundnut i.e. 2068 and 1717 kg/ha during 90-91 and 91-92, respectively were harvested with interculture followed by hand weeding at 30 days after sowing and only hand weeding at 50 days after sowing over other treatments which accounted for 126.8 per cent increase in pod yield over unweeded control. Yield reduction due to weed infestation was also reported by Kondap *et al.*, (1989) and Murthy *et al.*, (1992).

On the mean basis pre-planting incorporation of fluchloralin @ 1.0 kg a.i./ha and pre-emergence spray of pendimethalin @ 1.0 kg a.i./ha recorded significantly higher pod yield (1557 and 1424 kg/ha, respectively) when compared to butachlor (1311 kg/ha), thiobencarb (1230 kg/ha), alachlor (1034 kg/ha) and anilophos (1080 kg/ha). On an average these two herbicides accounted for 86.7 and 70.7 per cent increase in yield over control. Rathi *et al.*, (1986) and Guggari *et al.*, (1995) also obtained higher pod

Table 1. Weed control efficiency at 30 DAS, pod yield and weed index of groundnut as influenced by different weed control treatments

Treatments	Weed control efficiency (%)			Pod yield (kg/ha)			% yield increase over control	Weed index (%)		
	90-91	91-92	Mean	90-91	91-92	Mean		90-91	91-92	Mean
1. Fluchloralin @ 1.0 kg a.i./ha	63.0	71.4	67.2	1628	1487	1557	**86.7**	21.28	13.39	17.33
2. Butachlor @ 0.75 kg a.i./ha	29.3	37.6	33.4	1441	1182	1311	**57.2**	30.32	31.16	30.74
3. Thiobencarb @ 0.75 kg a.i./ha	41.0	46.0	43.5	1186	1275	1230	**47.5**	42.65	25.74	34.19
4. Alachlor @ 1.0 kg a.i./ha	53.0	47.4	50.2	1029	1040	1034	**24.0**	50.24	39.43	44.83
5. Pendimethalin @ 1.0 kg a.i./ha	52.2	59.2	55.7	1552	1297	1424	**70.7**	24.95	24.46	24.70
6. Anilophos @ 0.4 kg a.i./ha	32.8	42.0	37.4	1068	1092	1080	**29.5**	48.35	36.40	42.37
7. Interculture with hand weeding at 30 DAS + hand weeding at 50 DAS. (Weed free)	89.5	93.4	91.4	2068	1717	1892	**126.8**	–	–	–
8. Unweeded check (control)	–	–	–	679	990	834	–	67.17	42.34	54.75
S.Em. ±	–	–	–	104	72	82	–	–	–	–
CD(5%)	–	–	–	302	209	238	–	–	–	–

DAS - Days after sowing

percentage reduction in yield was maximum (54.75%) in unweeded control compared to the application of herbicides. Minimum weed index value (17.33%) was recorded with the application of fluchloralin @ 1.0 kg a.i./ha followed by pendimethalin @ 1.0 kg a.i./ha (24.70%), whereas maximum weed index value of 44.83 per cent was observed with the application of alachlor @ 1.0 kg a.i./ha as pre-emergence spray.

Thus, the present study indicated that among the herbicides fluchloralin @ 1.0 kg a.i./ha as pre-planting incorporation and pendimethalin @ 1.0 kg a.i./ha as pre-emergence spray were equally effective in managing the annual weeds in rabi-summer groundnut grown after rice. But, interculture with hand weeding at 30 days followed by hand weeding at 50 days after sowing was significantly superior to the herbicide

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AVAILABILITY OF NUTRIENTS TO [illegible] AND REMOVAL OF NUTRIENTS BY WEEDS

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ABSTRACT

The data from the field experiments conducted during *rabi* 1986-87 and 1987-88 at J.N. Krishi Vishwa Vidyalaya, Jabalpur (M.P.) revealed that higher NPK utilization in seed was noted under two irrigations than no irrigation. The higher fertility (F2-60:30:15 NPK kg/ha) also resulted higher utilization of NPK in seed and straw than lower fertility (F1-40:20:10 NPK kg/ha). Maximum utilization of NPK utilization under different herbicidal treatments was almost similar. The uptake of NPK by weeds increased significantly under two irrigations as compared to one irrigation and no irrigation and was not affected by fertility levels. Different weed control treatments influenced the NPK utilization by weeds. It was significantly higher under weedy check and lowest under weeding. There was significant reduction in NPK under different herbicidal treatments as compared to weedy check.

Key words: Irrigation; fertility; weed control; linseed.

INTRODUCTION

With the availability of assured irrigation, grassy weeds are becoming problematic (Malik *et al.*, 1984). Simultaneous emergence and rapid growth of weeds lead to severe crop weed competition for light, moisture, space and nutrient. Crop-weed competition for nutrients in general and for nitrogen in particular is a serious factor in limiting the yield of field crops (Mukhopadhyay, 1974; Pandey and Singh, 1983; and Yadav *et al.*, 1985). Mani (1975) also reported that about 80% of nitrogen depletion by weeds was attained with in the 5-6 weeks after sowing. Thus, the control of weeds is important not only to check the losses caused by weeds, but also to increase the efficiency of the fertilizer applied to the crops. Therefore the present investigation was carried out to study the effect of irrigation, fertility and weed control methods on the availability of nutrients to linseed (*Linum usitatissimum* L.) crop and removal of nutrients by the associated weeds.

MATERIALS AND METHODS

Field experiment was conducted at J.N.Krishi Vishwa Vidyalaya, Jabalpur (M.P.). It was laid out in split plot design with three replications. Irrigation levels (I0-no irrigation, I1 - one irrigation at 0.4 IW/CPE ratio, I2-two irrigations applied at 0.8 IW/CPE ratio) and fertility levels (F1 - 40:20:10 kg NPK/ha and F2 -60:30:15 NPK/ha) were assigned to main plots. The nutrients were applied through urea, superphosphate and muriate of potash, respectively. The basis for such type of NPK levels was the recommended practice in the area of Jabalpur region, hence no control plot was included. Weed control methods (W1-weed check, W2-hand weeding 20+50 days after sowing. W3-isoproturon @ 1.0 kg/ha pre-emergence (2 days after sowing), W4-isoproturon @ 1.0 kg/ha post emergence (20 days after sowing and W5-pendimethalin @ 1.0 kg/ha post emergence (20 days after sowing) were in sub-plots. Linseed C.V., JL-23 was sown on November 15, 1996 and November 5, 1987. The soil of the experimental field was medium black in texture having 255 kg N, 13.5 kg P and 434 kg K/ha, in available form. The NPK utilization by straw, seed and weeds in linseed were determined by adopting standard methods as suggested by Jackson (1967).

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RESULTS AND DISCUSSION

The major weeds in the experimental area were viz; *Cypress rotundas* L., *Digitaria adscendens* Henr., *Phalaris minor* Retz., *Melilotus alba* Desf., *Anagallis arvensis* L., *chenopodium album* L., *Cichorium intybus* L., *Vicia sativa* L., *Medicago denticulata* Willed., *Trifolium flagiferum* L. *Portulaca oleraces* L., and *Convolvulus arvensis* L.

The NPK uptake in seed increased under irrigated condition during second year. Higher uptake in seed under two irrigations was attributed to more utilization efficiency of NPK in crop plants. The higher NPK utilization in seed under high fertility (F2) was noted as compared to lower fertility (F1) during both the years. It clearly revealed that if more nutrients are available in soil, they are utilized more by the plants and results in greater seed production. These results are in conformity with those of Agarwal *et al.*, (1994). The utilization of NPK was the lowest under weedy check. It was attributed to the sharing of nutrients by the weeds. The maximum utilization of NPK was under hand weeding which was obviously due to the weed free situation. The NPK utilization under different herbicidal treatments was almost similar during both the years (Table 1).

The NPK accumulation in straw of the linseed also had similar trends under different treatments as noted for seed. In weeds, the NPK utilization increased significantly under irrigated plots as it was higher with two irrigations as compared to one irrigation and unirrigated condition. Pandey *et al.*, (1970) also reported greater utilization of NPK in weeds under irrigated conditions as compared to unirrigated. The NPK utilization in weeds under higher fertility reduced as compared to lower fertility. This might be due to more utilization by crop plants and increased vegetative growth. The increased crop growth might have suppressed the weed growth. However, the increased utilization of NPK by weeds under higher fertility was reported by Yadav *et al.*, (1986). The influence of different weed control treatments on NPK utilization in weed biomass revealed significantly higher value under weedy check. It was attributed to greater weed biomass production in weedy check. The lowest NPK utilization in weed biomass under hand weeding was obviously due to more clean situation as also noted by Yadav *et al.*, (1986). The significant reduction in NPK under different herbicidal treatments as compared to weedy check is a clear evidence of the effectiveness of herbicides.

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Table 1. Influence of different treatments on NPK utilization (kg/ha)

Treatment	Seed			Straw			Weed biomass		
	N	P	K	N	P	K	N	P	K
	1987-88	87-88	87-88	87-88	87-88	87-88	87-88	87-88	87-88
Irrigation levels									
I0 (No irrigation)	37.2 - 31.6	3.5 - 3.2	9.1 - 6.7	26.8 - 22.5	5.0 - 4.1	89.7 - 80.6	31.2 - 23.2	1.1 - 0.9	22.5 - 21.1
I1 (0.4 IW/CPE ratio)	35.4 - 39.3	4.7 - 4.8	12.1 - 9.0	28.1 - 26.2	5.9 - 4.3	96.0 - 91.4	40.1 - 28.6	1.3 - 1.1	28.1 - 25.0
I2 (0.8 IW/CPE ratio)	37.7 - 42.0	5.4 - 5.0	13.0 - 9.5	27.8 - 25.9	5.9 - 4.3	94.7 - 88.8	39.8 - 34.4	1.9 - 1.3	28.9 - 3.7
CD = P (0.05)	NS 3.89	0.6 - 0.8	0.6 - 0.7	NS 3.4	NS NS	6.3 - 6.1	2.0 - 2.2	1.0 - 2.0	5.1 - 5.6
Fertility levels									
F1 (40:20:10 NPK kg/ha)	33.4 - 32.8	4.0 - 4.1	10.3 - 7.6	25.0 - 23.7	4.1 - 90.4	90.4 - 84.1	36.8 - 29.0	1.4 - 1.1	26.7 - 29.0
F2 (60:30:15 NPK kg/ha)	40.2 - 42.0	5.8 - 4.9	11.0 - 9.8	29.8 - 26.1	5.3 - 5.1	102.1 - 10.9	36.0 - 27.6	1.4 - 1.0	26.9 - 26.0
CD = P (0.05)	6.7 - 6.1	0.8 - 0.7	NS 0.9	4.1 - NS	0.9 - 0.7	9.1 - NS	NS NS	NS NS	NS NS
Weed control methods									
W1 (Weedy check)	29.6 - 29.9	3.7 - 3.4	8.7 - 7.1	23.8 - 20.7	4.3 - 3.3	83.6 - 76.0	75.9 - 50.0	3.8 - 2.5	67.3 - 44.3
W2 (Hand weeding at 20 + 50 DAS)	42.3 - 45.4	5.9 - 5.7	14.0 - 10.3	29.0 - 28.5	5.9 - 5.9	97.4 - 98.5	10.3 - 9.2	0.4 - 0.9	9.3 - 8.2
W3 (Isoproturon 1.00 kg/ha) pre-emergence	35.8 - 39.7	4.3 - 4.4	11.0 - 8.9	28.8 - 24.8	5.9 - 4.2	98.0 - 86.9	51.9 - 27.9	2.1 - 1.1	27.4 - 24.8
W4 (Isoproturon 1.00 kg/ha) post -emergence	37.7 - 38.3	4.9 - 4.1	11.4 - 8.3	27.7 - 25.2	5.8 - 4.3	94.0 - 87.0	30.3 - 33.0	1.2 - 1.3	14.4 - 29.2
W5 (Pendimethalin 1.00 kg/ha) post-emergence	39.8 - 35.4	4.4 - 4.1	11.7 - 8.1	28.9 - 25.9	5.9 - 4.5	97.9 - 87.2	35.8 - 27.4	1.4 - 1.1	14.3 - 24.4
CD = P (0.05)	5.53 - 4.37	0.51 - 0.58	0.59 - 0.62	3.53 - 3.27	0.82 - 1.0	7.17 - 8.57	2.71 - 6.3	0.23 - 0.41	5.76 - 6.1

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FACTORS AFFECTING VIABILITY AND GERMINATION OF UREDINIOSPORES OF *Puccinia arachidis* Speg

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ABSTRACT

Laboratory experiments were conducted to study the germination of Urediniospores of *Puccinia arachidis* Speg as a function of some biometerological parameters as this process is cardinal to infection and subsequent process of disease development. Laboratory experiments showed that the germination of urediniospores access freely at 100 percent Relative Humidity(RH) and temperature at 25° ± 2° C within 2 hrs. Maximum percentage of germination occurred within 25 hr. at the temperature range between 20°C. Temperature below 10°C and above 30°C were unsuitable. RH 80 percent was prerequisite for good germination of urediniospores although a few did germinate over 55-75 per cent RH. The viability of urediniospores of groundnut rust was normally of short duration but was modulated by environmental conditions. At low temperature (5°C) the urediniospores remained viable for 65 days but at 40°C temperature the viability was lost rapidly. During the non host period the urediniospores were found to remain viable for 60 days in infected crop debris though started decreasing after 10 days.

Key Words: *Puccinia arachidis;* urediniospores; viability; germination; temperatur; relative humidity.

INTRODUCTION

Puccinia arachidis Speg. the causal organism of groundnut rust disease is heteroecious and the pycnial and aecial stages were not found on groundnut plant. The rust was found to occur exclusively in the form of uredinia though Chahal and Chohan (1971) observed teleutospores in Punjab in green house plants, this was not confirmed either in Punjab or elsewhere in India through subsequent studies. In Brazil, development of teleutospores within media on artificial inoculated groundnut plant in green house has been reported (Hennen *et al.*, 1976). Survival and rapid germination of infective propagules (urediniospores) is an important factor in causing rapid infection to host tissues and thus assuring perpetuation. For effective aerial dissemination of urediniospores of groundnut rust, long duration viability is likely to help in spatial spread of the disease. However, the two aspects viability and germination of urediniospores have not received sufficient attention (Mallaiah & Rao, 1979; Subrahmanyam & Mc Donald, 1984). This paper reports the influence of selected biometeorological parameters in viability under different conditions of laboratory and field, germination and the cardinal functions of a pathogen that determine disease development.

MATERIALS AND METHODS

(1) Preparation of Spores

In order to determine the conditions and time required for germination of urediniospores, freshly harvested spores from developing urediniospori (72 hr. old pustules) was suspended in sterile distilled water. The suspension was centrifuged at 5000 rpm for 10 min. to remove water soluble germination inhibitor (Foudin and Macko, 1974). The supernatent was suspended in fresh sterile distilled water to a dilution to provide 20-30 spores/microscopic field.

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(2) Viability of urediniospores

The effect of different storage temperatures on subsequent germination of urediniospores was studied. The urediniospores were harvested from 72 hr. old pustules and were kept in small sterilized glass vials and maintained at different temperatures ranging from 5° to 40 °C at different interval. Over 75 days interval, a batch of urediniospores was drawn, suspension was prepared and trials were set up to record the incubation time required for germination. Observations were recorded after 48 hr. of incubation.

(3) Survival on crop debris

To study the duration of viability of urediniospores the infected crop debris was collected 15 days before harvest and kept at different storage temperature conditions. Before storing, the viability of spores was also recorded. One set of crop debris was kept in sterile petriplates at 5°C in a BOD incubator, another kept in room temperature (25° - 30°C), a third was kept in cloth bag in the field (temperature range, 25° - 37°C), a fourth set was kept as open heap in the field and the fifth set was maintained *in vivo* on living plants. The whole experiment was conducted during March to April 1988. Urediniospores were collected from these sets and suspension was prepared as described earlier. A thin film of suspension was placed in sterile grooved slide and kept in a BOD incubator at 25° ±2°C and 100% RH After 48 hr of incubation the slides were observed under microscope at 400 x magnification and germination percentage recorded.

(4) Germination vs. temperature

To study the effect of temperature on germination, the spore suspension was placed in grooved slides in a thin film of water with a sterile pipette and was incubated in a BOD incubator at various temperature over a range of 5° - 45°C.

(5) Germination vs. relative humidity

For studying the effects of different humidities on germination of urediniospores, humidity chambers were specially prepared following Winston and Batis (1960) using glycerol and distilled water in different proportions. In all these trials the present spore germination was recorded after 24 hr. and 48 hr. under 400 x magnification after fixing and staining spores.

(6) Duration of incubation for germination

In order to determine the time required for germination the experiments were set up in a BOD incubator at a temperature 25° ±2°C and 100% RH. Observations were recorded every 2 hr. under 400 x magnification.

RESULTS

(1) Viability of urediniospores

(a) Effect of storage temperature

Results (Fig. 1) indicated that urediniospores could be stored for 65 days at 5°C without loss in viability, though after 35 days of storage the viability percentage was markedly reduced to 21.1% and after 55 days and 65 days a germination percentage was only 9.0% and 2.0% respectively. At 40°C storage temperature, germination percentage was zero after 5 days. At 30° - 35°C storage, germination was less than 50% within 5 days. Et $_{50}$ at temperatures from 5° to 25°C were 36, 35, 28.5; and 25 days respectively at 5°C intervals. The spores at these temperatures did not germinate after 65 and 55 days respectively.

(b) Viability on crop residues

Maximum germination was recorded when the crop debris was stored at 5°C temperature (Table 1). In crop residues left at room temperature (at 20° - 30°C) the urediniospores remained viable for 60 days though after 55 days urediniospores released from the old pustules were remarkably low in viability. In the field, urediniospores remained viable for 15 days in crop debris left in open heap. Viability markedly started decreasing after 10 days (6.0%). However when the crop

debris was kept in bags left in the field, the urediniospores remained viable for 20 days. Here also after 15 days a marked reduction in viability was noticed (9.1%). These results revealed that with increasing age of pustules the percent of germinability of spores declined significantly.

(2) Urediniospores germination

(a) Effect of temperature

A temperature between 20° to 25° was found to be optimum giving 68.7 to 82.1% germination after 24 hr. of incubation and 78.8 to 80.4% after 48 hr. of incubation. The maximum percentage of germination was obtained at 25°C (Fig. 2). It was evident from this experiment that below 10°C and above 30°C were unsuitable for spore germination. The pattern of germination at 24 hr. and 48 hr. of incubation showed little change and most spores had germinated within 24 hr.

(b) Effect of relative humidity

Results in Fig. 3 showed that a constant temperature of 25° ±2°C increase in RH led to increased percentage of germination. The maximum germination percentage was recorded at highest RH level (100%) while a low percentage of germination of urediniospores (4-10%) was recorded at 55-75%. Rate of increase in germination was found to accelerate rapidly between 85 to 100 percent RH. Thus it was found that increasing the RH had significant positive influence on urediniospores germination.

(c) Incubation time

Results in Fig. 4 indicated that a minimum incubation time 2 hr. was necessary for germination of urediniospores 25° ±2°C and 100% RH. It also appeared that with increase in time there was an increase in germination percentage of urediniospores. Fifty percent germination was recovered after 7 hr of incubation. Maximum percentage of germination was recorded after 25 hr of incubation. It was also found that after 9 hr of incubation the percentage increase as a function of time became very low.

DISCUSSION

Unlike the wheat rust pathogen, the urediniospores of *Puccinia arachidis* did not remain viable for long periods and their viability, perpetuation and spread were modulated by environment. Low temperature (5°C) permitted spores to remain viable for 65 days. The spores were not viable at a temperature of 40°C. Subrahmanyam *et al.*, (1982) reported that urediniospores lost viability within 4 weeks on exposed infected crop debris under post harvest conditions at ICRISAT. In the urediniospores released from old pustules viability declined significantly.

In order to infect, the urediniospores have to germinate on the host surface and this process is also modulated by biometeorological parameters. Controlled conditions experiment showed that these spores germinate in 2 hr at 100% RH and a temperature of 25 ± 2°C and maximum germination occurred within 25 hr. Ideal temperature for germination was over the range of 20 - 25°C and temperatures below 10°C were optimum for Urediniospores germination. The optimum temperature for germination of urediniospores was reported to be 24.5°C to 28°C and no germination occurred below 8°C (Zhou Liang-gao, 1984). Foudin and Macko (1974) reported that optimum temperature for urediniospore germination of *P. arachidis* was 18°C in USA. Thus variation of temperature influenced significantly the spore germination of this pathogen. Statistical analysis using a two way analysis showed the treatments to be significant. Cochrane (1958), Mallaiah and Rao (1974) suggested that a thin film of water was essential for germination of urediniospores of *Puccinia arachidis*.

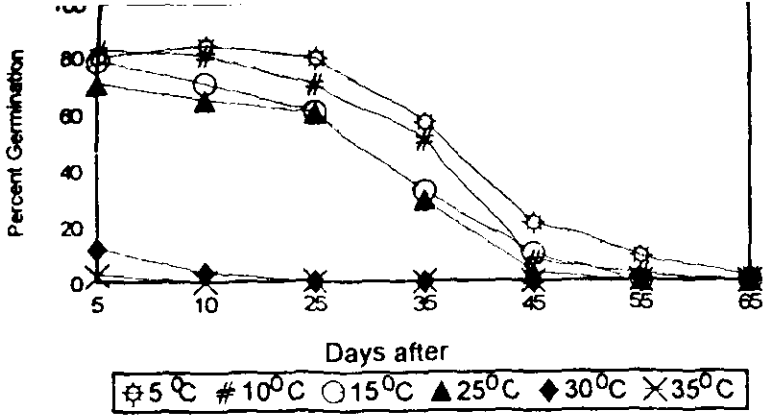

Fig. 1. Effect of storage temperature on viability of urediniospores of *Puccinia arachidis*

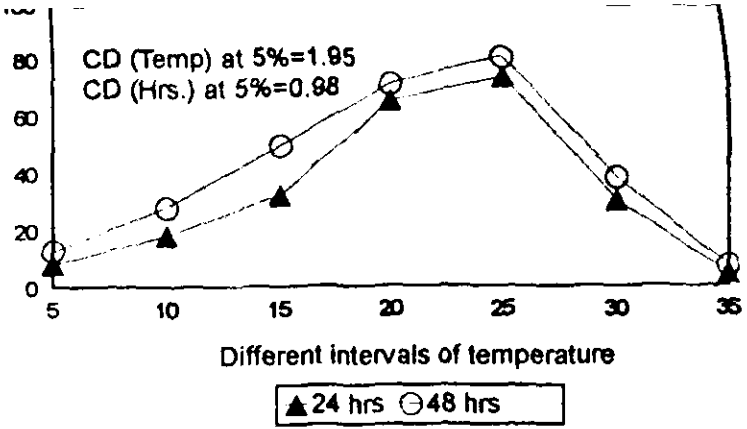

Fig. 2. Effect of temperatures on germination of urediniospores of *Puccinia arachidis*

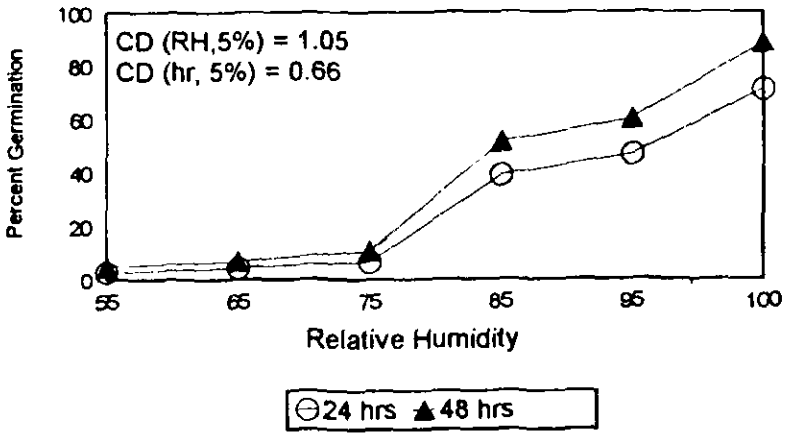

Fig. 3. Effect of relative humidity on germination of urediniospores of *Puccinia arachidis*

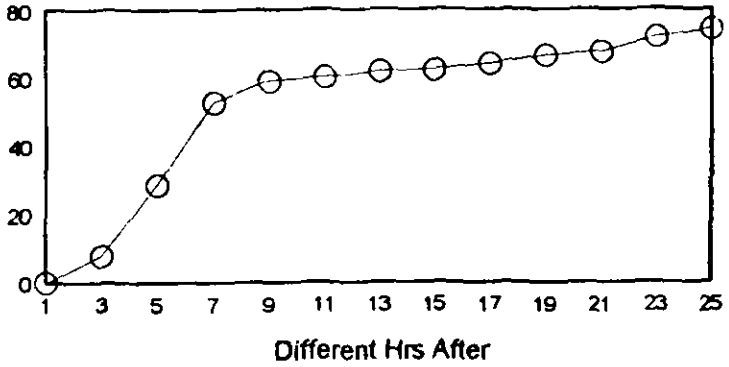

Fig. 4. Germination of urediniospores of *Puccinia arachidis* as function of incubation time

Mallaiah and Rao (1979) also observed that at 25°C temperature germination starts within 2 hr and reaches a maximum level in 6 hr

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Table 1. Viability of urediniospores of groundnut rust exposed to different conditions of storage (average 425 spores).

Different days after storage	At 5°C incubator	Room temp. (20-30°C)	Bagged & left in field	Open heap	Living plant
5	81.4	61.2	71.2	60.6	84.5
10	83.7	42.3	60.0	56.4	90.1
15	86.5	--	25.4	6.0	92.4
20	88.3	--	19.1	--	88.8
25	90.0	--	0.0	--	86.5
30	84.4	--	--	--	84.2
35	80.1	--	--	--	77.1
40	50.2	--	--	--	76.0
45	58.8	--	--	--	75.8
50	43.6	--	--	--	74.6
55	30.2	--	--	--	74.3
60	15.6	--	--	--	72.6
Initial average	87.1	87.1	87.1	87.1	87.1

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EFFECT OF SIMULATED RUST EPIDEMICS IN GROUNDNUT ON DRY MATTER AND YIELD

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ABSTRACT

The effects of simulated conditions of epidemics of rust in groundnut under field conditions during the 1988 crop season at different growth stages revealed significant variations in dry matter and yield losses over uninoculated control. When inoculum was provided at flowering, peg development and pod formation stages, highest dry matter (54.6%) and yield (54.5%) losses due to rust were recorded. However, when inoculations were performed at peg development and pod formation or at flowering and pod formation, rust did not cause substantial losses in dry matter and pod yield. The simulated rust epidemics were linearized using different transformations. Gompertz transformation was found to fit the multiple regression model best in linearization of disease progress data. The simulation of rust epidemic in groundnut thus appeared reliable for studying their effects on growth and yield.

Key Words: Epidemics; *Puccinia arachidis;* growth stages; Environment; *Arachis hypogaea.*

INTRODUCTION

Rust of groundnut *(Arachis hypogaea)* is a well established disease and is known to cause significant reduction in crop yields in many areas of the world (Mayee, 1986: Subrahmanyam and McDonald, 1983). Yield reductions are highly influenced by the time of occurrence of rust and the stage of crop growth. Early infections and continuous availability of inoculum during the crop period results in heavy losses. Moreover, the epidemic growth is also influenced by the prevailing environment. Rust often appears in epiphytotic forms (Mayee, 1987; Mayee and Datar, 1988) but limited information is available on effects of rust epidemics on crop yield at various growth stages. The present paper reports the result of artificial inoculations carried out during vital crop growth stages as well as the levels of rust inoculum on dry matter and crop yield. Transformation models were applied to linearize the disease progress data and the epidemic parameters estimated by multiple regression analysis.

MATERIALS AND METHODS

Seeds of groundnut cultivar JL 24 were sown on 25th June 1988 in a randomized block design with 3 replications in blocks of 4.5m x 3.0m each and spaced 30cm x 15cm apart. The treatments included artificial inoculations with rust urediniospores at growth stages of flowering (30 days after planting - DAP), peg development (50 DAP), pod formation (70 DAP), flowering + peg development + pod formation, flowering + peg development, flowering + pod formation and peg development + pod formation. In each treatment, plants were inoculated with urediniospore suspension of 5 x 10^{-4} spores ml^{-1} supplemented with a surfectant "Sandovit" during evening hours with a hand sprayer (Mayee, 1983). The remaining treatments were kept rust-free by spraying tridemorph 100 E.C. at 0.07% at periodic intervals (Ghuge *et al*, 1981) until inoculation stages. The differences between plant's fresh weight and dry weight were used to calculate per cent dry matter obtained for each treatment. The pod yields harvested from each treatment plots were sun dried and converted into kg ha^{-1}, and these were considered to calculate per cent yield losses over uninoculated control. The rust severity was evaluated at weekly intervals from the time of first appearance of pustules as per the standard evaluation scale (Mayee and Datar, 1986).

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The sigmoidal disease progress curves were studied for the suitability of correct transformation model to linearize the data in the estimation of epidemic parameters. For this, the proportion of disease (y) at any assessment time was linearized by using the Vanderplank's (1963) logit transformation.

Logit (Y) = ln (y / (1 - y))

and the Gompertz transformation (Kranz, 1974),

Gompit (Y) = -ln (-ln (y)).

This enables linear regression to be performed for fitting the models to data sets and to obtain a reasonable estimate of the epidemic rate. The Logit and the Gompit Y values consisted of transformed disease proportion in the range $O < Y < 1$.

The environmental parameters used for studying the effects of weather parameters on disease progress included maximum and minimum temperature (^{0} C), maximum and minimum relative humidity (%), total rain fall (mm), wind velocity (KMPH), sunshine period (hours day^{-1}) and the biological parameter of previous level of disease (PLD). The averages of these variables for the specific period of desease assessment except for total rainfall and PLD were worked out for statistical analysis. The weather parameters and PLD were considered as concomittant variables, whereas, disease severity was the dependant variable. Linear multiple regression analysis was performed for analyzing the correct transformation model as evaluated by the coefficient of multiple determination (R2), residual sum of squares (RSS) and standard error (SE) as suggested by Madden (1986) and Cornell and Berger (1987).

RESULTS AND DISCUSSION

Significant differences occurred in for dry matter produced and yield losses in all treatments over uninoculated control (Table 1). Dry matter losses were higher for inoculations made during growth stages of flowering + peg development + pod formation (54.6%) followed by flowering + peg development (45.75%), flowering (44.69%), peg development (35.22%), flowering + pod formation (34.2%), pod formation (30.59%) and peg development + pod formation (24.69%). Yield losses over uninoculated control were higher for inoculations made for combination of all growth stages (54.51%) followed by peg development (52.8%), flowering + peg development (49.8%), pod formation (39.94%), flowering (39.4%), peg development + pod formation (27.56%) and flowering + pod formation (26.75%).

Dry matter and yield reductions caused due to simulated rust epidemics were greatly influenced by infection at different growth stages of groundnut plants and also by frequency of inoculation. Rust progressed fast and was highest when inoculum was provided during combination of all the growth stages of groundnut followed by inoculations made during flowering, peg development and pod formation and combination of these stages. It may be presumed that inoculations made during flowering stage contributed to little reduction in dry matter and yield since the assimilate of subsequent vegetative growth compensated adequately for early losses. These differences in the level of reduction can be attributed to the amount of photosynthate available for the growing plant which in turn is related to the level of infection present and the growth stage during infection. Ghuge *et al.*, (1981) reported 34.94% and 48.24% dry matter and yield losses, whereas, Subrahmanyam and McDonald (1983) reported upto 50% pod yield losses when rust inoculations were made during seedling stage (upto 30 DAP) under field conditions. Mayee and Baheti (1983) observed yield reductions due to rust between 4.6% to 71.9% using controlled rust inoculum spray schedules from seedling to pod formation stages. It is clear that inoculations or appearance of rust at early growth stages contributed much more to yield losses than

Table 1. Dry matter, yield and yield losses in groundnut cultivar JL 24 as influenced by simulated rust epidemics.

Sr. No.	Inoculations at Growth Stages	% Dry matter Produced	Yield (Kg/ha) Produced	% Losses over uninoculated Control	
				Dry matter	Yield
1.	Flowering	42.91	703.69	44.69	39.40
2.	Peg Development	50.26	543.20	35.22	52.80
3.	Pod Formation	53.86	753.08	30.59	39.94
4.	Flowering + Peg Development + Pod Formation	35.22	518.51	54.60	54.51
5.	Flowering + peg Development	42.08	580.24	45.75	49.80
6.	Flowering + Pod Formation	51.83	851.84	34.20	26.75
7.	Peg Development + Pod Formation	58.43	827.15	24.69	27.56
8.	Uninoculated Control	77.60	1148.14	–	–
	SE+/- =	0.18	100.04	0.24	5.90
	CD AT 5% =	0.56	303.46	0.89	18.18

Table 2. Characteristics of multiple regression analysis for inoculations at different growth stages and environmental parameters in the groundnut cultivar JL 24.

Inoculation Stages	Untransformed			Logit Transformed			Gompit Transformed		
	R2	RSS	SE	R2	RSS	SE	R2	RSS	SE
1.Flowering	0.99	26.46	0.99	0.85	14.38	0.73	0.91	1.08	0.20
2.Peg Development	0.99	6.91	0.62	0.89	6.05	0.58	0.97	0.11	0.08
3.Pod Formation	0.99	1.04	0.34	0.99	0.26	0.17	0.91	0.23	0.16
4.Flowering + Peg Development + Pod Formation	0.99	11.05	0.64	0.85	14.38	0.73	0.90	1.19	0.21
5.Flowering + Peg Development	0.99	11.03	0.64	0.85	16.42	0.78	0.90	1.19	0.21
6.Flowering + Pod Formation	0.98	71.73	1.63	0.84	15.59	0.76	0.90	1.08	0.20
7.Peg Development + Pod Formation	0.99	0.01	0.03	0.98	0.58	0.18	0.99	0.04	0.05
8.Uninoculated Control	0.99	7.30	0.52	0.83	16.00	0.77	0.86	1.08	0.20

severity of rust at late stages even though inoculations were done twice during later growth stages. However, repeated availability of inoculum during all growth stages is detrimental and can cause heavy losses.

Linear transformations of disease progress data avoids erroneous interpretation of epidemic parameters and effectively utilize the least square regression analysis. According to Kranz (1974), it is essential to check the suitability of transformation model so that the epidemic analysis can be used in forecasting studies. In the present investigation, non transformed disease progress curves were effectively linearized by logistic and Gompertz transformation in the range of $0.05 < Y < 0.6$ and allowed application of regression models to experimental data sets.

Although R^2 values of non transformed analysis were higher than the transformed data, Gompertz transformation best fitted the regression models than the logistic and untransformed data for linearization as evaluated by low RSS and SE values (Table 1). The Gompertz transformation was also found to linearize disease progress curves effectively indicating its suitability for current transformation in epidemic growth studies. Similar results have been reported by Hau and Kranz (1974) for wheat leaf rust. The suitability of Gompertz transformation as reported earlier (Mayee *et al.*, 1990) was confirmed again and thus the simulation of rust epidemics carried out in the present investigation is considered reliable to know their effects on dry matter and yield.

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INSECTICIDAL PROPERTY OF INDIGENOUS PLANTS AGAINST *Dactynotus carthamii*, H.R.L. AND ITS PREDATOR, *Chrysoperla carnea* l.

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ABSTRACT

Effects of a few indigenous plants against safflower aphid, *Dactynotus carthamii* HRL and its natural predator, *Chrysoperla carnea* L. were studied at the University of Agricultural Sciences, Dharwad (India) during 1993-94. Extracts of eight plants were evaluated along with two new chemical insecticides. Against aphids, *Parthenium hysterophorus, Lantana camara, Stachytarphita indica, Vitex negundo and Calotrophis gigantea* were as effective as synthetic insecticides, polytrin and profenofos. S. *indica, P. hysterohorus* and *V. negundo* were found to be safe to the eggs, larvae and adults of potential predators *C. carnea*. The study indicated the utilization of biowaste for pest management and conserving useful insects in agricultural eco-system.

Key Words : Botanical pesticides; safflower aphids; *Chrysoperla carnea* L.

INTRODUCTION

The use of botanicals for pest management is gaining importance in view of their selectivity, low cost and safety to ecosystem. Botanicals have different modes of action like antifeeding, repelling and growth inhibitory effects against insect pests. Chopra (1933), Puttarudriah and Bhatia (1979), Panigrahi (1983), Pandey *et al.* (1983) Patil *et al.* (1980) have identified some plant materials worth using and testing against various crop pests and stored grain pests. Screening of 84 Indian plant products has indicated the superiority of many plants against green peach aphid *Myzus persicae* Sluzer (Hiremath, 1984). With a view to search and explore indigenous plant material of toxic nature an attempt has been made in the present study to know the insecticidal activity of commonly available plant materials of this region against safflower aphid, *Dactynotus carthamii* HRL and a potential predator of aphid *Chrysoperla carnea* L.

MATERIALS AND METHODS

Studies were carried out at the University of Agricultural Sciences, Dharwad during 1993. The plant materials were collected in the vicinity of Dharwad. The list of plants and other products used is presented in Table 1. The test insects of uniform age were collected from the field and were preconditioned before conducting the experiment. The plant extracts were prepared by crushing 100g plant parts with 100 ml of water, the extract was filtered through fine muslin cloth. The filtered extract was made up to 200 ml by adding distilled water. This product was considered as 50 per cent concentration and the desired concentrations were prepared by adding distilled water and used against safflower aphid and egg, larva and adults of *C. carnea*. One ml of different plant products and the insecticides were sprayed on excised safflower leaf bits with the help of atomizer, the leaves were kept for drying for 15 minutes then 25 uniform aged safflower aphids were released on sprayed excised leafbits. Each treatment was replicated thrice. The mortality was recorded at 24 and 48 hours after the spray.

Similarly for *Chrysoperla* eggs, these different plant products and chemicals were sprayed on 25 eggs in each treatment replicated thrice and the per cent hatchability was recorded. For larval mortality the *Chrysoperla* larvae were fed with treated safflower apphids. In each treatment 10 larvae were taken and larval mortality was recorded at 48 and 72 hr after

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treatment. In order to know the contact toxicity of these botanicals to adults one ml solutions of each treatment was uniformly smeared on the inner surface of the glass tube (10 cm x 1.0 cm) by gently rolling the glass tubes. Then 10 adult *Chrysoperla* were released in each treatment by giving 10 per cent honey as food for adults. The per cent mortality was recorded at 48 and 72 hr. after exposure to different treatments.

RESULTS AND DISCUSSION

The data on toxicity of different plant extracts (Table 1) against safflower aphid revealed that *T. accidentalis, V. rosea, S. indica, V. negundo, L. camara* and *C. gigantea* were as effective as chemical control with polytrin and profenophos at 24 hr after treatment. *P. hysterophorus* and *A mexicana* recorded only 14.80 and 41.11 per cent mortality at 24hr and 82.76 and 85.38 per cent at 48 hr after treatment respectively. All the remaining crude extracts caused cent percent mortality of *D. carthami* at 48 hr after treatment. The leaf extracts of *L. camara* and *P. hysterophorus* which exhibited insecticidal activity against the test insects in the present investigation has also been reported to be toxic (Patel *et al.*, 1990). Pandey *et al.* (1983 and 1987) have reported leaf extracts of *L. camara* to be toxic against *Aphis gossypii* Glover and *Lipaphis erysimi* Kalt. The present study clearly proved *L. cemara* crude extracts to be highly toxic. Patel *et al* (1990) reported alcohol extract of *P. hysterophorus* to be more toxic than *L. camara* based on the LC_{50} values. The variation may be due to the differences in the methods of extraction.

The bio-assay studies on *C. carnea* indicated the superiority of the plant products over chemical insecticides in conserving the predator. The egg hatchability of *C. carnea* varied from 30 to 63 percent among the plant products, whereas it varied from 3 and 20 per cent in profenophos and polytrin respectively. Among the plant products *V. negundo* recorded 60 per cent larval mortality of *C. carnea*, followed by *L. Camara* (46%), *V. rosea* (40%), *S. indica* (33.33%), *A mexicana* (26.60%) and *P. hysterophorus* (20.00%). While cent per cent mortality was recorded in synthetic insecticides, it is interesting that the some level of adult mortality was noticed with Thuja. It is likely that this plant extract may be useful against same plant pests where natural enemies have little role to play and an insecticide with shorter persistence is preferred. Number of other plants namely *S. indica, A. mexicana* and *P. hysterophrous* also appear to be safe with least mortality of adults. However a high mortality (86.66 and 60 per cent) was exhibited in *V. rosea* and *L. camara* respectively, indicating their toxic nature on this universal predator.

Some of the plant products tested have shown a high level of toxicity towards the pest and at the same time low toxicity to its natural enemy. Hence the promising plant products like *S. indica*, the pest *P.hyoterophorus, A. mexucana* and *V. negundo* can possibly be utilized in managing or in developing IPM package for most destructive pest of safflower in peninsular India.

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Table 1. Effect of different plant products on safflower aphid, *D. carthomic* and on its natural predator *C. carnea*

Plant Products	Safflower aphid		*Chrysoperla carnea*				
			Egg hatchability (%)	Larvel Mortality (%)		Adult mortality (%)	
	24 hr.	48 hr.	48 hr.	48 hr.	72 hr.	48 hr.	72 hr.
Parthenium hysterophorus 2%	41.11 (39.83)	82.76 (66.46)	46.66 (42.99)	13.33 (17.71)	20.00 (26.51)	6.66 (8.83)	13.33 (17.71)
Vitex negundo 2%	90.03 (75.35)	100.00 (88.19)	63.00 (40.78)	20.00 (26.51)	60.00 (50.77)	40.00 (33.84)	46.66 (42.70)
Vinca rosae 2%	99.10 (84.98)	100.00 (88.19)	56.66 (48.93)	6.67 (8.85)	40.00 (38.85)	66.66 (59.39)	86.66 (71.68)
Calotrapis gigantea 2%	91.30 (75.29)	100.00 (88.19)	40.00 (39.14)	6.67 (8.85)	13.33 (17.71)	40.00 (33.84)	53.33 (51.31)
Stachytarpheta indica 2%	95.26 (79.11)	100.00 (88.19)	40.00 (39.14)	20.00 (26.51)	33.33 (35.01)	0.00 (0.00)	0.00 (0.00)
Lantana camara 2%	88.98 (76.06)	100.00 (88.19)	46.66 (42.99)	26.66 (26.15)	46.66 (43.07)	40.00 (38.85)	60.00 (55.55)
Argemone mexicana 2%	14.80 (22.53)	85.38 (74.96)	40.00 (39.14)	13.33 (17.77)	26.66 (30.79)	13.33 (17.71)	13.33 (17.71)
Tuja occidental is 2%	100.00 (88.19)	100.00 (88.19)	30.00 (31.92)	20.00 (26.51)	20.00 (26.51)	100.00 (88.19)	100.00 (88.19)
Polytrin	100.00 (88.19)	100.00 (88.19)	20.00 (26.07)	100.00 (88.19)	100.00 (88.19)	100.00 (88.19)	1000.00 (88.19)
Profenofos 20 EC (2 al/1tr)	100.00 (88.19)	100.00 (88.19)	3.33 (6.14)	100.00 (88.19)	100.00 (88.19)	100.00 (88.19)	1000.00 (88.19)
Water Spray	0.00 (0.00)	0.00 (0.00)	83.33 (66.14)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
S.Em. ±	6.63	7.69	9.12	10.97	7.89	14.76	11.31
C.D. (5%)	13.84	16.06	18.82	22.75	16.88	30.47	23.36

Note : Figures parenthesis are angular transformed values

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ACCELERATED AGEING - A RELIABLE TOOL FOR PREDICTING STORABILITY OF SUNFLOWER*

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ABSTRACT

Studies on the prediction of relative storability of sunflower Cv. EC - 68414 revealed close association of germination percentages obtained at 3, 6, 9 and 12 months under ambient storage with those subjected for ageing for 3, 4, 5 and 6 days respectively. Seeds from outer concentric whorls had highest germination at all periods of storage and showed decreasing trend towards the centre of the capitulum. Similar was the trend in accelerated ageing and controlled deterioration. The seeds from outer whorls showed better storability.

Key Words: Sunflower; storability; accelerated ageing.

INTRODUCTION

Seeds are seldom used after harvest and at the places of their production. Thus they are stored for varying periods and sunflower is no exception. It is impossible to judge the storability of any seed based on physical appearance. Delouche and Baskin (1973) developed 'accelerated ageing technique' for predicting the storability of various crop seeds in a relatively short time. According to Desai (1976), the seed lots that maintain germination well after accelerated ageing also record good germination when stored under normal conditions. Gidrol *et al.*, (1989) also observed 25 per cent reduction in germination of sunflower Cv. Rodeo kept for ageing for 1-8 days. With these stated facts in view, a study was conducted to know the relative storability of sunflower Cv EC - 68414.

MATERIALS AND METHODS

Seeds of sunflower Cv. EC-68414 obtained from 1 to 25 concentric whorls of several capitula were grouped into five lots L1, L2, L3, L4 and L5; each comprising seeds respectively from five whorls from exterior to interior. Although seeds were formed upto 30th whorl in a capitulum, those from 26th to 30th whorl were not included in the study as they were of negligible quantity. Storability of each lot of the seeds stored under ambient conditions for a period of twelve months was observed by conducting standard germination test at quarterly intervals as per ISTA rules (Anon., 1985).

Moisture content of some seeds of the lots L1 through L5 was raised to nine per cent and subjected to accelerated ageing at 10°C temperature and a relative humidity of 95 ± 5 per cent. After 3, 4, 5 and 6 days of exposure periods (P) the seeds were removed from the ageing chamber and subjected to standard germination test. Similarly controlled deterioration for some seeds of these lots L1 to L5 was carried out by raising the moisture content from 9 to 20 per cent by the addition of calculated quantity of water (i.e., 1.25 ml water added to 10 g seed to raise the moisture content by 1 per cent), and kept in the

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ageing chamber for 3, 4, 5 and 6 days and standard germination test conducted. Angular transformations were done to the germination percentages and statistical analysis carried out using completely randomized design.

RESULTS AND DISCUSSION

Data in Table 1, reveals that L1 comprising seeds from outer whorls showed highest germination percentage. Germination for lots L2 - L5 showed significantly decreasing values and the trend continued till the end of the storage period. The results are in agreement with Singh *et al.*, (1990) who reported higher germination and viability of seeds from outer florets and decreased values for the inner florets.

Germinability of seeds showed decreasing trend with increased periods of exposure to ageing and also in controlled deterioration (Table 2). The germination values obtained in controlled deterioration test were lower than the values obtained under ambient storage and ageing tests. This may be due to higher seed moisture content (20%). Fast decrease in germination of seeds having higher seed moisture content during storage has also been reported by Haldar *et al.*, (1983).

The germination results of seeds stored in ambient conditions and seeds subjected for ageing as well as controlled deterioration showed their association. Percentage germination for different lots recorded after 3, 6, 9 and 12 months ambient storage coincided with those obtained after 3, 4, and 6 days of ageing and are in agreement with Delouche and Baskin (1973).

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Table 1. Germination of seeds stored under ambient conditions

Seed lot (L)	Storage periods (P) months					Mean
	0	3	6	9	12	
L 1	90.5 (72.1)	88.3 (70.0)	86.1 (68.1)	824 (65.2)	80.3 (63.7)	85.5
L 2	84.9 (67.2)	83.0 (65.7)	78.9 (62.7)	75.9 (60.6)	72.1 (58.1)	79.0
L 3	78.9 (62.7)	73.0 (58.7)	70.1 (56.9)	65.9 (54.3)	62.1 (52.1)	70.0
L 4	70.1 (56.8)	60.4 (51.0)	58.0 (49.6)	52.6 (46.5)	48.8 (44.3)	58..0
L 5	63.0 (52.5)	55.9 (48.4)	47.1 (43.3)	42.3 (40.6)	33.5 (35.4)	48.4
Mean	77.5	72.1	68.0	63.8	59.4	

	S.Em. ±	C.D. at 5%
Seed lot (L)	0.084	0.233
Storage period (P)	0.084	0.233
Interaction (L x P)	0.188	0.521

Figures in parenthesis indicate angular transformed values.

Table 2. Seed germination as influenced by accelerated ageing and controlled deterioration

Seed lot (L)	Accelerated ageing						Controlled deterioration					
	P0	P1	P2	P3	P4	Mean	P0	P1	P2	P3	P4	Mean
L 1	90.0 (71.6)	88.3 (70.0)	85.7 (67.8)	82.7 (65.4)	79.7 (63.2)	85.3 (67.6)	90.0 (71.6)	87.3 (69.2)	81.7 (64.7)	79.3 (63.0)	78.0 (62.0)	83.3 (66.1)
L 2	84.7 (67.0)	82.0 (64.9)	78.0 (62.0)	75.7 (60.4)	72.3 (58.3)	78.5 (62.5)	84.7 (67.0)	79.7 (63.2)	74.7 (59.8)	71.7 (57.8)	66.7 (54.7)	75.5 (60.5)
L 3	78.7 (62.5)	73.7 (59.1)	70.3 (57.0)	67.0 (55.0)	63.7 (53.0)	70.7 (57.3)	78.7 (62.3)	71.7 (57.8	66.7 (54.7))	63.0 (52.5)	56.7 (48.8)	67.3 (55.3)
L 4	70.3 (57.0)	62.7 (52.3)	58.7 (50.0)	55.0 (48.2)	51.3 (45.8)	59.6 (50.7)	70.3 (57.0)	61.3 (51.6)	56.3 (48.6)	50.3 (45.2)	44.0 (41.5)	56.5 (48.8)
L 5	63.0 (52.5)	56.0 (48.4)	48.7 (44.2)	42.3 (40.6)	35.3 (36.5)	49.1 (44.5)	63.0 (52.5)	52.7 (46.5)	46.0 (42.7)	38.3 (38.3)	32.0 (34.4)	46.0 (42.7)
Mean	77.3 (62.1)	72.5 (59.0)	68.3 (56.2)	64.5 (53.9)	60.5 (51.3)		77.3 (62.1)	70.5 (57.7)	65.1 (54.1)	60.5 (51.4)	55.5 (48.3)	
			S.Em. ±		C.D. at 5%				S.Em. ±		C.D. at 5%	
Seed lot (L)			0.750		2.077				0.743		2.058	
Storage period (P)			0.750		2.077				0.743		2.058	
Interaction (L x P)			0.340		0.942				0.330		0.914	

Figures in parenthesis indicate angular transformed values.

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CHLOROPHYLL MUTATION FREQUENCY AND SPECTRUM INDUCED BY CHEMICAL MUTAGENS IN LINSEED *(Linum usitatissimum L.)*

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ABSTRACT

Dry Seeds of linseed cultivars *LC 185* (yellow, small seeds) and Shubhra (brown, bold seeds) were treated with diethy sulphate (DES) in addition to Shubhra treated with hydroxylamine (HA), using 1, 2, 3 and 4% concentrations of both the mutagens. Mutation frequency (MF) induced by DES was higher than HA. MF increased with increase in mutagenic concentration, being the highest at 4% concentration. On M_2 seedling basis, the highest MF induced in Shubhra by HA and DES were 0.766 and 1.65%, respectively. LC 185 was more mutable than Shubhra with the highest MF of 2.099%. Mutation spectrum consisted of 12 types with *viridis* followed by *albo-viridis* and red tip being the most frequent mutants. Induced by .4% DES, frequencies of *Viridis* and *albo-viridis* were 30.6 and 18.5 per cent, respectively in Shubhra against 40.0 and 10.6 per cent in LC 185. HA (0.4%) induced 25 per cent *viridis*, followed by red tip (20.0%) and red spots (15.0%) mutants in Shubhra. Mutagenic efficiency and effectiveness of DES were higher than HA. Effectiveness of DES was higher in LC 185 than Shubhra at higher concentrations.

Key Words : *Linseed, mutation frequency, mutation spectrum, effectiveness, efficiency.*

INTRODUCTION

Mutations are important from both, theoretical and applied points of view and mutation breeding technique is one of the most effective techniques of plant improvement. In linseed, which is an important industrial crop, mutational work done is mostly related to physical mutagens (Bianu and Marki, 1970; Beard, 1971; Rai and Das, 1975; Shorov, 1982). Information on chemical mutagenesis in this crop is however, sporadic. The present experiment was therefore, undertaken to study the mutagenesis induced through chemicals in linseed.

MATERIALS AND METHODS

A yellow, small seeded cultivar LC 185 (100 seed weight = 0.41g ; oil content = 45.7%) and a brown, bold seeded cultivar Shubhra (100 seed weight = 0.84g; oil content = 45%) of linseed (*Linum usitatissimum* L.) were taken for the present study. Dry seeds of both the cultivars were treated with diethylsulphate (DES) in addition to Shubhra treated with hydroxylamine (HA) with their 0.1, 0.2, 0.3 and 0.4 per cent concentrations for 2 hours at 22°C, followed by washing. The treated seeds alongwith control were grown in the laboratory as well as in the field. From every treatment, 250 M_1 plants were harvested individually and grown as plant-to-progeny row in M_2, the row length being 2m. Chlorophyll deficient seedlings (mutants) were identified on cotyledonary leaves according to Gustafsson (1940) in field conditions in M_2 generation. Mutation frequency was calculated on M_1 plant and M_2 seedling basis. Segregation frequency was calculated as :

$$\frac{\text{Average number of mutant seedlings/plant}}{\text{Average number } M_2 \text{ seedlings/plant}} \times 100$$

Mutagenic efficiency (regarding seedling injury, pollen sterility and ovule sterility) and mutagenic effectiveness were calculated according to Konzak *et al.* (1965) and Nilan *et al.* (1965), by the following formulae.

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$$\text{Mutagenic efficiency} = \frac{\text{MF (\%)}}{\text{Seedling injury (\%), pollen sterility (\%) or ovule sterility (\%)}}$$

$$\text{Mutagenic effectiveness} = \frac{\text{MF (\%)}}{\text{Concentration of mutagen (millimoles) x hours of treatment}}$$

RESULTS

Mutagens caused reduction in seedling growth and fertility in M_1. Reduction increased with increasing concentrations of mutagens. DES caused more deleterious effect than HA on growth and fertility (Table 1). The highest seedling injury in Shubhra caused by HA was 53.9 per cent and that caused by DES was 65.8 per cent. In the cultivar LC 185, DES caused the highest seedling injury of 88.0 per cent. Pollen sterility in untreated population was 9.5 per cent in Shubhra and 9.7 per cent in LC 185, while the ovule sterility was 19.3 per cent in Shubhra and 29.5 per cent in LC 185. The highest pollen and ovule sterilities caused by HA (0.4%) in Shubhra were 22.8 and 13.3 per cent, respectively. The highest pollen and ovule sterilities caused by DES (.4%) were 46.5 and 25.5 per cent, respectively in Shubhra, while 55.1 and 16.3 per cent, respectively in LC 185 (Table 1).

Chlorophyll mutation frequency (MF)

MF was determined on M_1 plant and M_2 seedling basis. It was found to increase with increase in concentration of the mutagen (Table 2). DES induced higher MF as compared to HA. On M_1 plant basis, the highest MF induced by the highest concentration (0.4%) of DES was 31.2 and 32.0 per cent in Shubhra and LC 185, respectively, while it was 28.0 per cent in Shubhra in the case of HA. On M_2 seedling basis, 0.628 per cent MF induced in Shubhra by DES at 0.1 per cent increased upto 1.65 per cent at 0.4 per cent concentration. The highest MF induced by HA was 0.766 per cent. At higher concentration, DES induced higher MF in LC 185 than Shubhra. The highest MF induced by DES in LC 185 was 2.099 per cent.

Segregation frequency

Segregation frequency of DES induced mutants was greater than that of HA. It ranged from 2.7 to 4.1 per cent in HA and 3.9 to 5.6 per cent in DES induced mutants in Shubhra (Table 2). Comparatively, LC 185 had higher segregation frequency which ranged from 3.7 to 8.9 per cent.

Mutation spectrum

A total of 12 types of chlorophyll mutants were induced by both the mutagens, DES and HA (Table 3). Mutation spectrum was wider at higher concentration. In general, *Viridis* was the most frequent mutant in all the treatments. *Virido-albina, xantho-viridis* and yellow spot mutants were comparatively less frequent and were observed in a few treatments only. At the highest MF (induced by 0.4% DES), the mutants *albina, viridis, xantha and albo-viridis* were 2.8, 30.6, 20.3 and 18.5 per cent, respectively in Shubhra, while 3.5, 40.0, 16.5 and 10.6 per cent, respectively in LC 185. Thus *viridis* was more frequent while *albo-viridis* was less frequent in LC 185 as compared to Shubhra. *Xantha* seedlings did not appear in HA treatments. There were 5 per cent *albina*, 25 per cent *viridis* and 10 per cent *albo-viridis* mutants induced by 0.4% H.A. It induced a high frequency of certain mutants, such as red spot and yellow tip, while DES induced these mutants with a very low frequency (Table 3).

Mutagenic efficiency and effectiveness

Mutagenic efficiency was studied in relation to seedling injury, pollen sterility and ovule sterility. On M_1 plant basis, HA was found more efficient than DES in Shubhra, except at 0.2% concentration in relation to seedling injury

Table 1. Seedling injury, pollen and ovule sterilities in M1 generation of hydroxylamine (HA) and diethlsulphate (DES) treated linseed varieties.

Mutagen	Concentration (%)	Concentration (mM)	Seedling injury (%)	Pollen sterility (%) Observed	Pollen sterility (%) Caused by mutagen	Ovule sterility (%) Observed	Ovule sterility (%) Caused by mutagen
Cultivar Shubhra :							
HA	0.0	0.0	0.0	9.5	0.0	19.3	0.0
HA	0.1	14.38885	25.7	10.9	1.4	20.5	1.2
HA	0.2	28.7770	41.0	15.1	5.6	23.1	3.8
HA	0.3	43.1655	46.2	19.7	10.2	29.4	10.1
HA	0.4	57.5540	53.9	32.3	22.8	32.6	13.3
DES	0.0	0.0	0.0	9.5	0.0	19.3	0.0
DES	0.1	6.4935	39.5	15.3	5.8	27.7	8.4
DES	0.2	12.9870	63.2	27.4	17.9	30.2	10.9
DES	0.3	19.4805	63.2	55.5	46.0	38.2	18.9
DES	0.4	25.9740	65.8	56.0	46.5	44.8	25.5
Cultivar LC 185 :							
DES	0.0	0.0	0.0	9.7	0.0	29.5	0.0
DES	0.1	6.4935	12.0	15.2	5.5	34.2	4.7
DES	0.2	12.9870	20.0	25.9	16.2	39.8	10.3
DES	0.3	19.4805	52.0	49.4	39.7	42.4	12.9
DES	0.4	25.9740	88.0	64.8	55.1	45.8	16.3

(Table 2). On M_2 seeding basis, DES was found more efficient than HA, especially at higher concentrations. Efficiency of DES in relation to seedling injury at lower concentrations and of pollen and ovule sterility at higher concentration was higher in LC 185 than Shubhra.

Regarding induction of mutations, DES was found more effective than HA on both, M_1 plant and M_2 seedling bases (Table 2). At 0.4 per cent concentration, effectiveness of DES (.318) was about 5 times greater than HA (0.0066). Varietal differences regarding effectiveness were also observed, the effectiveness of DES was greater in LC 185 (0.0404) than shubhra (.0318) at 0.4 per cent concentration.

DISCUSSION

Reduction in seedling growth and fertility is generally observed in mutagenic treatments. The seedling injury is possibly due to inhibition of auxin synthesis (Gordon, 1954), auxin destruction (Sideris *et al.*, 1969, 1971), failure of assimilatory mechanisms and inhibition of mitosis in growing points (Gunckel, 1957). Sterility may occur due to inactivation of certain genes, upset in genetic-physiological equilibrium, physiological disturbances, chromosome structural changes and point mutations (Rana and Swaminathan, 1964; Gaul, 1977).

Mutagens differ in frequencies of induced

mutations. In the present study, MF was higher in DES than HA treatments and increased with increasing concentration of mutagens. Marki and Bianu (1969) found that MF induced by TEM was very low as compared to that induced by EMS and NMU in linseed. In barley, Prasad and Tripathi (1987) found that DES induced higher MF as compared to HA. Marki and Bianu (1969) and Galkin (1982) also observed differential response of linseed genotypes in MF induced by chemical mutagens. The findings of Galkin (1982) that yellow-seeded variety with high oil content to be more mutable than others corroborate the results of the present study. LC 185 is characterized by small seeds (0.41g/100 seeds), while Shubhra has bold seeds (0.84 g/100 seeds). Thus MF may be inversely related to the seed size. Observed segregation frequency of mutants was less than expected (25%). It was greater in DES as compared to HA. In other crops also, segregation frequency was reported to be less than expected (D'Amato, 1965; Frydenberg and Jacobsen, 1966; Constantan, 1975; Prasad and Tripathi, 1987). Generally, segregation frequency of mutants induced by physical mutagens is higher than that induced by chemical mutagens.

Types of mutants and their frequencies vary according to mutagen, its concentration, genotype, method of treatment, ploeiotrapy and linkage (Borojevic *et al.* 1977). In this experiment, *viridis* was the most frequent mutant in all the treatments. *Xantha* was absent in HA, while *xantho-viridis* was absent in DES treatment of Shubhra. Marki and bianu (1969) found wider mutation spectrum in EMS and NMU than TEM with albina as the most frequent mutant in linseed. *Xantho-viridis* was lacking in Shubhra, while yellow sport was absent in LC 185 having *viridis* as more frequent. Genotypic differences with regard to spectrum and frequencies of chlorophyll mutations have been reported in different crops such as linseed (Bianu and Marki, 1970; Rai, 1973), barley (Nilan *et al.*, 1975) and castor (Athma and Reddy, 1984).

Mutagenic efficiency helps free from undesirable changes (Konzak *et al.*, 1965). DES was found more efficient than HA at higher concentrations. Mutagenic effectiveness measures the mutations per unit dose per unit time of treatment (Konzak *et al.* 1965; Constantans, 1975). In the present experiment, DES was found more effective than HA. Effectiveness of DES in LC 185 was greater than Shubhra at higher concentrations. Prasad and Singh (1986) found that mutagenic effectiveness was higher for EMS, while efficiency was higher for gamma rays in *Brassica juncea*. Prasad and Thripathi (1987) found that DES was more effective than HA, while SA was superior to both the mutagens in barley.

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Table 2. Induced chlorophyll mutation frequency and mutagenic effieiency and effectivencess in linsed.

Mutagen	Conc. (%)	Segr. M_1 Plants	M_2 Seedlings		Segr. freq. (%)	Mutation freq. per 100		Efficiency in relation to						Effectivence	
								Seedling injury		Pollen Sterility		Ovule Sterility		M_1	M_2
			Total	Mutants		M_1 Plants	M_2 Seedlings	M_1	M_2	M_1	M_2	M_1	M_2		
Cultivar Shubhra															
HA	0.0	0	10,880	0	-	-	-	-	-	-	-	-	-	-	-
	0.1	30	10,067	50	4.1	12.0	.497	.497	.019	8.571	.355	10.000	.414	.4170	.0173
	0.2	48	10,042	58	3.0	19.2	.577	.468	.014	3.429	.103	5.053	.152	.3336	.0100
	0.3	52	9,838	74	3.6	20.8	.752	.450	.016	2.039	.074	2.059	.074	.2409	.0087
	0.4	70	10,436	80	2.7	28.0	.766	.520	.014	1.228	.034	2.105	.058	.2432	.0066
DES	0.0	0	10,880	0	-	-	-	-	-	-	-	-	-	-	-
	0.1	36	9,068	57	4.4	14.4	.628	.405	.016	2.483	.108	1.714	.075	1.1088	.0483
	0.2	75	8,679	102	3.9	30.0	1.175	.549	.019	1.676	.066	2.752	.108	1.1550	.0452
	0.3	60	5,607	75	5.6	24.0	1.338	.422	0.21	.522	.029	1.270	.071	.6160	.0343
	0.4	78	6,546	108	5.3	31.2	1.650	.506	.025	.671	.035	1.223	.065	.6006	.0318
Cultivar LC 185															
DES	0.0	0	13,140	0	-	-	-	-	-	-	-	-	-	-	-
	0.1	42	13,082	82	3.7	16.8	.627	1.400	.052	3.054	.114	3.574	.133	1.2936	.0483
	0.2	56	11,420	126	4.9	22.4	1.103	1.120	.055	1.383	.068	2.175	.107	.8624	.0425
	0.3	45	8,978	144	8.9	18.0	1.604	.358	.030	.453	.040	1.395	.124	.4620	.0412
	0.4	80	8,098	170	6.6	32.0	2.099	.345	.024	.581	.038	1.963	.129	.6160	.0404

Table 3. Types and frequencies of chlorophyll mutants induced by HA and DES in linseed.

Mutagen	Conc. (%)	Mutant Seedlings	Mutant types* and frequencies (%) A	V	X	AV	VA	XV	YT	RT	WT	WS	RS	YS
Cultivar Shubhra :														
HA	.1	50	–	40.0	–	18.0	–	–	22.0	12.0	4.0	–	4.0	–
HA	.2	58	–	31.0	–	20.7	–	–	10.3	17.3	6.9	–	13.8	–
HA	.3	74	2.7	32.5	–	8.1	2.7	–	10.8	18.9	5.4	–	16.2	2.7
HA	.4	80	5.0	25.0	–	10.0	–	2.5	12.5	20.0	7.5	2.5	15.0	–
DES	.1	57	–	14.0	7.0	28.0	–	–	19.3	26.4	–	–	5.3	–
DDES	.2	102	–	32.4	–	47.1	–	–	–	8.8	8.8	–	2.9	–
DES	.3	75	–	6.4	4.0	8.0	–	–	–	8.0	4.0	4.0	4.0	4.0
DES	.4	108	2.8	30.6	20.3	18.5	11.1	–	–	5.6	8.3	2.8	–	–
Cultivar *LC* 185 :														
DES	.1	82	2.4	70.8	19.5	4.9	–	–	–	2.4	–	–	–	–
DES	.2	126	–	61.9	9.5	4.8	–	–	6.3	11.1	–	3.2	3.2	–
DES	.3	144	–	71.5	6.2	6.9	1.4	1.4	2.8	2.8	1.4	–	5.6	–
DES	.4	170	3.5	40.0	16.5	10.6	2.4	–	4.7	4.7	8.2	9.4	–	–

* A = *albina;* V = *viridis;* X = *xantha;* AV = *albo-viridis;* VA = *virido-albina;* XV = *xantho-viridis;* YT = yellow tip; RT = red tip; WT = wite tip; WS = white spots; RS = red spots; YS = yellow spots.

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COMPARATIVE EFFICACY AND ECONOMICS OF NUCLEAR POLYHEDROSIS VIRUS (NPV) FOR THE CONTROL OF *Helicoverpa armigera* (HUBNER) ON GROUNDNUT

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ABSTRACT

A field experiment was conducted to compare the efficacy and economics of three doses of HaNV (500, 250 & 150 LE/ha) for the microbial control of *Helicoverpa armigera* (Hubn.) in groundnut at the Gujarat Agricultural University Campus, Janagadh for two consecutive years (1992-94). The results revealed that the HaNPV application at 250 LE/ha was found to be the most effective in reducing the larval population of Helicoverpa and increased yield, with the highest ICBR of 1:3.82 in comparision to high and low doses of HaNPV when four sprays of the virus were applied at 5 days interval starting from the pest appearance.

Keywords : Groundnut, *Helicoverpa*, HaNPV.

INTRODUCTION

The groundnut (*Arachis hypogaea* L.) is attacked by a number of insect pests including the gram pod borer, *Helicoverpa armigera* - Ha (Hubn.) It feeds on leaves and causes considerable damage by defoliation. Since insecticides resistance has been reported in *H. armigera* (Mehrotra, 1989), the NPV has been used as a microbial insecticides against this pest on chickpea (Rabindra and Jayaraj, 1988), pigeonpea (Muthiah and Rabindra, 1991; Natarajan *et al.* 1991), cotton (Dhandapani *et al.* 1987) and sunflower (Rabindra *et al.* 1986; Bijjur *et al.* 1991). With exception of recent report of Dhandapani *et al.* (1993) and Muthuswami *et al.* (1993) the control of this pest through virus has previously not been attempted so far on groundnut. Hence the present study was made.

MATERIALS AND METHODS

The crude suspension of indigenous HaNPV was prepared by the fresh NPV propagated in fourth instar larvae of *Helicoverpa*. The virus was harvested in distilled water from fresh virosed cadavers and partially purified by filtration through the fine muslin. The experiment was laid out in a randomized block design with a plot size of 200 m^2. HaNPV was tested at three doses *viz.*, 500 LE, 250 LE and 150 LE with unsprayed controls. Six replicates were maintained for each treatment (Table 1). The virus was applied as a foliar spray at an interval of five days and repeated four times, starting from the pest appearance, when the crop was normally 30-35 days old. The treatment were imposed with a knapsack sprayer using a spray fluid of 450 litres/ha. The number of *Helicoverpa* larvae were recorded from one sq.m. area in each plot before spray and after 1,2,3 and 4 days of spraying. Pod and fodder yields were also recorded in each treatment. For studying the larval mortality due to treatments, groundnut leaves treated with HaNPV were picked up from each plot after 24 hr. of each spray and ten third instar *Helicoverpa* larvae were on this materials. This treatment was replicated six times. The control was kept as untreated groundnut leaves. The larval mortality was recorded in each treatment. The data thus obtained were analysed statistically and presented in Table 1 and 2.

RESULTS AND DISCUSSION

Cumulative effect of NPV

Date on commulative effect of different doses of HaNPV at 5 days in field tests (Table 1) showed the significant reduction in larval population over

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the control. Lowest population was recorded in HaNPV 500 LE/ha, followed by HaNPV 250 LE/ha, while in control it was recorded highest (3.96 larvae/m^2). In laboratory test the larval mortality was significantly higher in all three treatments over control. Highest mortality was recorded in HaNPV 500 LE/ha (68.04%), followed by HaNPV 250 LE/ha (62.83%) and 150 LE/ha (52.20%). Thus the results of laboratory tests on larval mortality due to three doses of HaNPV confirmed the effect of HaNPV on field population of the pest.

Effect on pod and fodder yields

The pod and fodder yields in all three doses of HaNPV were significantly increased over control (Table 1). Higher yield of pod and fodder was obtained in HaNPV 500 LE/ha (1617 kg pod and 2867 kg fodder/ha), followed by HaNPV 250 LE/ha (1412 kg pod and 2608 kg fodder/ha). In control it was recorded as lowest (1099 kg pod and 1738 kg fodder/ha).

Economics

The economics of three doses of HaNPV (Table 2) revealed that highest net realization/return over control was obtained due to application of HaNPV @ 500 LE/ha (Rs. 6262/ha), followed by HaNPV 250 LE/ha (Rs. 3878/ha). However, highest incremental cost benefit ratio (ICBR) was observed with HaNPV 250 LE (1:3.82), followed by HaNPV 500 LE (1 : 3.55) and 150 LE (1 : 2.09).

The study concluded that the HaNPV 250 LE/ha was found to be effective and economical application for the control of *Helicoverpa* in groundnut. Muthuswami *et al.* (1993) used a baculovirus mixture for the control of mixed populations of *Helicoverpa* and *Spodoptera* in groundnut and reported that the populations of both the pests could be successfully controlled by applying the NPV mixture @ 250 LE/ha either with an adjuvant cotton kernal extract 10% and crude sugar 10% or chlorpyriphos @ 125 g a.i./ha. Dhandapani *et al.* (1993) also reported that the NPV 250 LE/ha with crude sugar @ 2.5 kg/ha as effective in reducing the larval population of *Helicoverpa* and *Spodoptera* in groundnut. These reports support the finding of the present investigation.

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Table 1. Efficacy of HaNPV sprays on field population and larval mortality of *Helicoverpa armigera* on groundnut (Pooled of two years, 1992 and 1993).

Treatment	No. of larvae/sq.m				Larval mortality (%)				Mean
	1st spray	2nd spray	3rd spray	4th spray	1st spray	2nd spray	3rd spray	4th spray	
HaNPV 500 LE	1.79	1.59	1.34	1.10	50.44	57.51	28.55	55.77	55.57
	(3.20)	(2.53)	(1.80)	(1.21)	(59.45)	(71.15)	(72.78)	(68.36)	(68.04)
HaNPV 500 LE	1.84	1.57	1.52	1.23	47.53	50.79	56.18	55.26	52.44
	(3.28)	(2.45)	(2.32)	(1.51)	(54.41)	(60.04)	(69.01)	(67.53)	(62.83)
HaNPV 500 LE	1.83	1.73	1.59	1.35	41.34	47.04	48.73	47.09	46.26
	(3.35)	(2.99)	(2.53)	(1.82)	(43.63)	(53.55)	(56.50)	(53.65)	(52.20)
Control	2.06	2.12	2.06	1.99	20.94	22.53	21.75	20.94	21.55
	(4.24)	(4.49)	(5.00)	(3.96)	(12.75)	(14.55)	(13.40)	(12.750	(13.48)
S. Em. +	0.07	0.08	0.09	0.07	2.22	2.92	2.88	3.41	3.35
C.D. at 5%	N.S	0.25	0.26	0.27	6.42	8.45	8.34	9.85	9.70
C.V. %	14.14	18.25	20.20	19.21	19.23	22.81	21.60	26.39	18.38

Figures in the parentheses indicate retransformed values.

Table 2. Yields, economics and ICBR in HaNPV treatments for the control of Helicoverapa armigera on groundnut

Treatment	Yield (kg/ha)		Total Quantity (Rs.)	Cost of HaNPV (Rs./ha)	Labour charge (Rs./ha)	Cost of treatment over control	Gross realization	Net realization	ICBR
	Pod of HaNPV used	Foodder (Rs.)							
HaNPV 500 LE	1617	2867	1.250	1500	264	1764	19220	6262	1:3.55
HaNPV 500 LE	1412	2608	0.625	750	264	1014	16836	3878	1:3.82
HaNPV 500 LE	1217	2121	0.375	450	264	714	14448	1490	1:2.09
Control	1099	1738	–	–	–	–	12958	–	–
S.Em. +	37.28	63.06	–	–	–	–	–	–	–
C.D. at 5%	107.70	182.12	–	–	–	–	–	–	–
C.V. %	9.61	9.36	–	–	–	–	–	–	–

Labour charge = Rs. 22 per labour
Price : HaNPV = Rs. 120/100 LE
Groundnut pods = Rs. 11/kg.
Groundnut fodder = Rs. 0.5/kg.

The interest of the plant breeders during recent years has been directed mainly towards developing varieties of hybrids to suit the diverse agro-climatic conditions in Indian mustard. Diverse genetic stocks are available but their performance over the locations and agro-climatic conditions are yet to be exploited. In the present investigation eleven lines, six testers (varieties) and their 66 hybrids of Indian mustard have been taken up to evaluate phenotypic stability under different environments.

Eighty three genotypes were evaluated for yield and its component traits in three replications, at four locations viz., Plant breeding farm, RCA, Udaipur, Main Castor-Mustrad Research Station, G.A.U., S.K. Nagar, Oilseeds Research Sub Station, Talod and Main Sorghum Research Station, Surat. The trial was sown in the second fortnight of October, 93. The germination of the trial was good and hence plant stand maintained properly. Generally season was favorable for crop growth. Each plot consisted of a single row of 3 meter length. The inter and intra row distance was 45 X 15 cm, respectively. Fertilizer was applied at the rate of 50 kg nitrogen and 50 kg phosphorus per hectare with five irrigations. The observations were recorded on ten randomly selected competitive plants of each entry for number of siliquae/plant, seeds/siliqua, 1000 seeds weight and seed yield/plant. The stability parameters were computed using the model of Eberhart and Russell (1966).

The mean sum of squares with regards to different traits on the basis of pooled data are presented in Table 1. The mean sum of squares due to genotypes including both parents and hybrids were highly significant for most of the characters except seed weight, when tested against pooled deviation. The G X E interactions were also significant for all the characters. Mean squares due to environment G X E interaction were also significant for all the characters. The mean squares due to G X E (linear) and pooled deviation (non-linear) were significant for seed yield/ plant and seeds/siliqua. This suggested that both linear and non linear components played important role in building up total G X E interaction for these traits. The results are in agreement with those of Singh and Patra (1989) in Indian rape and Sharma and Roy (1993) in toria.

The stability parameters, such as regression co-efficient (bi) and deviation from regression ($\bar{S}^2_{di}$) alongwith mean performance of genotypes (parents and hybrids) for various characters were computed to assess the stability of performance over locations. These parameters are presented in Table 2. According to Eberhart and Russell (1966), an ideally adaptable variety would be the one having high mean value, unit regression coefficient and a deviation from regression as small as possible ($\bar{S}^2_{di} = 0$).

The parental line Kranti and RH 7513 were stable for siliquae/plant, Lalpur 17, RSK 76 and BIO 902 for seeds/siliqua and RSK 78, RSK 77 and Varuna for 1000 seed weight. However, none of the parents was stable for seed yield. Likewise, the six crosses viz., RSK 16 x Varuna, RSK 76 x Varuna, RSK 16 x Kranti, RSK 16 x Vardan, RSK 28 x Vardan and RH 7513 x Varuna were stable for seed yield, three for siliquae/plant, 22 for seeds/ siliqua and 15 for 1000 seed weight. The present results are also in agreement with the results obtained by Henry and Deulay (1990).

The parent RLC 1359 was suitable for

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significant deviation. Likewise, four crosses viz., BIO 902 x Vardan, RSK 69 x Varuna, RSK 77 x Kranti, RSK 28 x Kranti were suitable for better environment for seed yield and three for seeds/ siliqua. While, each of one cross showed better performance in poor environment for siliquae/ plant and seeds/siliqua, as they has low mean over

displayed an important role of both linear and non-linear components in building up total G x E interactions. None of the parents was found stable over locations for seed yield. This suggested that the parental lines were relatively more sensitive to environments as compared to their hybrids.

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Table 1. Analysis of variance for phenotypic stability with regards to different traits in Indian Mustard

Source	D.F.	Seed Yield/ Plant	Silique/ Plant	Seeds/ silique	1000 seed weight
Genotypes (G)	82	55.00**	4231.30**	5.20**	3.62**
Environments (E)	3	1386.05**	11846.67**	4.31**	0.15
G + (G x E)	246	15.72**	1470.32**	0.33**	0.07**
E + (G x E)	249	32.23**	1595.34**	0.38**	0.07**
E (Linear)	1	4158.10**	35542.49**	12.96**	0.44**
G x E (Linear)	82	19.34 *	1355.24	0.49**	0.06
Pooled deviation	166	13.74**	1509.44**	0.25**	0.08**
Pooled error	656	0.96	45.99	0.07	0.01

Where, * and ** are significant at P=0.05 and P=0.01 levels, respectively.

Table 2. Estimation of stability parameters of individual genotype for seed yield and its component traits

Sl. No.	Seed yield per plant			Siliquae per plant			Seeds per Siliqua			*1000* seed weight		
	X	bi	$\bar{S}^2_{di}$	X	bi	$\bar{S}^2_{di}$	X	bi	$\bar{S}^2_{di}$	X	bi	$\bar{S}^2_{di}$
1 2	3	4	5	6	7	8	9	10	11	12	13	14
Famale												
1. RSK 16	15.6	0.42	25.88**	284.8	0.25	-12.35	13.6	0.67	-0.06	4.5	4.35	0.02
2. RSK 28	14.7	0.57	1.97	281.8	-0.88	1611.44**	13.5	1.96	2.59**	4.1	0.50	-0.01
3. RSK 69	15.5	0.66	2.50	318.9	2.09	692.96**	12.8	-1.18	0.17	5.0	-3.07	0.18**
4. RSK 76	20.8	1.77	18.88**	283.1	0.35	1680.40**	15.1	-0.94	0.19	4.9	4.71	0.05 *
5. RSK 77	19.5	-0.09	6.96**	258.9	-0.29	591.02**	13.8	2.21	0.05	5.8	4.26	0.03
6. RSK 78	16.8	0.84	11.76**	284.7	-1.57	1087.93**	12.7	-5.93	2.66**	6.0	2.30	0.02
7. Lalpur 17	12.9	0.53**	-0.86	282.4	2.46	247.68 *	17.8	1.04	-0.05	2.3	7.74	0.05 *
8. RJ 9	15.9	1.04	11.22**	277.7	-1.78	3119.13**	15.5	-3.04	0.58**	5.1	-2.97	0.20**
9 CSR 164	14.3	1.12	1.24	301.0	2.65	246.32 *	15.1	3.45	1.10**	3.1	1.23	0.02
10 BIO 902	16.1	1.30	31.14**	273.9	3.25	163.87 *	14.9	142	0.03	6.3	7.03	0.10**
11. RH 7513	15.0	0.92	10.50**	300.1	0.19	12.47	12.5	-0.32	-0.07	3.2	0.71	0.00
Males												
1. GM 1	17.8	0.75	10.67**	315.6	-1.42	321.90**	13.5	1.98	0.00	4.3	4.08	0.08**
2. PM 67	14.3	1.70	24.49**	320.1	1.56	3963.60**	15.1	3.50	0.47**	3.3	8.94	0.18
3. Varuna	16.6	0.61	5.87	270.1	1.22	194.79 *	14.2	0.09	-0.05	4.6	1.47	0.01
4 Kranti	14.7	1.17	13.02**	304.2	1.06	28.91	14.7	1.05	-0.05	4.2	1.37	0.00
5 RLC 1359	17.2	0.99	10.64**	366.8	3.29**	62.78	14.6	4.25	0.27 *	6.1	0.85	0.07**
6. Vardan	12.1	0.88	28.58**	329.5	2.55	1271.18**	14.3	-0.93	0.02	4.2	0.04	-0.01
Hybrids												
1. RSK 16 X SM1	23.0	1.00	6.11**	266.6	1.11	7.90	13.5	0.31	-0.04	5.0	0.80	0.09**
2 RSK 16 X PM 67	25.5	1.95	5.25 *	292.3	2.53	1579.04**	14.8	2.18	0.07	4.0	-0.29	0.07**
3. RSK 16 X Varuna	27.1	1.32	2.77	302.3	2.24	3420.62**	14.6	2.88	0.13	5.6	-2.87	0.02
4 RSK 16 X Kranti	21.0	0.53	0.99	272.0	0.09	13.77	14.7	0.43	0.01	5.1	-4.86	0.10**
5. RSK 16 X RLC 1359	15.9	0.95	6.80**	222.9	0.54	261.23**	13.9	2.09	0.23	5.0	0.98	0.45**
6. RSK 16 X Varuna	20.9	1.20	-0.22	270.3	2.19	498.41**	14.5	1.64	-0.06	4.5	-1.82	0.08**
7. RSK 28 X BM1	15.5	0.00	23.12**	228.7	-2.79**	144.85	14.5	-0.65	0.39 *	4.4	-1.60	0.01
8. RSK 28 PM1	24.4	0.24	40.41**	247.0	0.85	397.15**	17.0	-1.38	0.29 *	3.7	1.27	0.01
9. RSK 28 Varuna	15.8	0.06**	-0.80	235.5	1.97	7.80.01**	15.4	4.01**	-0.07	4.5	0.42	0.35**
10. RSK 28 Kranti	20.7	1.60**	0.76	294.6	2.84	1017.73**	15.2	3.28	0.04	4.1	0.80	0.15**
11. RSK 28 X RLC 1359	18.9	0.10**	-0.89	302.7	-0.15	55.95	14.3	-1.40	0.33 *	4.7	1.80	0.01
12. RSK 28 X Vardan	20.8	0.39	2.33	281.6	-0.58	291.10**	14.5	2.56	0.21	4.3	6.10	0.17**

1	2	3	4	5	6	7	8	9	10	11	12	13	14
13.	RSK 69 X GM 1	21.1	0.31	29.50**	297.8	-0.37	215.15 *	13.7	1.98	0.03	5.0	4.14	0.04**
14.	RSK 69 X PM 67	24.4	0.40	11.19**	323.1	0.25**	35.52	15.0	2.65 *	-0.03	3.7	-1.06 *	-0.01
15.	RSK 69 X Varuna	21.8	1.48 *	0.09	2.88.1	0.93	219.99 *	13.9	-2.60	0.26 *	5.3	5.79	0.03
16.	RSK 69 X *Kranti*	25.2	0.77	21.86**	261.5	-0.92	1351.36**	14.2	0.80	-0.02	4.5	-0.81	0.01
17.	RSK 69 x RLC 1359	22.7	2.09	16.31**	271.5	0.03**	-44.69	13.7	1.36	0.02	5.4	-0.25	0.15**
18.	RSK 69 X Vardan	18.3	0.40**	-0.53	232.3	1.70	20.68	13.4	0.05	0.02	4.4	-0.25	0.00
19.	RSK 76 X GM 1	91.8	0.98	12.23**	285.3	3.80	1295.69**	16.4	0.71	-0.01	4.9	2.33	0.14**
20.	RSK 76 X PM 67	18.6	1.05	-0.01	242.5	0.04 *	-6.21	15.6	0.30	0.00	3.8	-0.22	0.01
21.	RSK 76 X Varuna	22.0	0.84	2.77	327.0	1.95	1058.88**	13.9	-1.50	-0.01	5.4	0.56	0.03
22.	RSK 76 X Kranti	29.9	1.77	21.94**	397.4	1.78	4060.02**	14.5	0.74	0.09	4.6	-245	0.00
23.	RSK 76 X RLC 1359	21.6	0.50	5.33 *	283.7	-1.13**	70.44	15.8	0.96	-0.04	5.5	-1.14	0.20**
24.	RSK 76 X Vardan	20.8	0.81	17.42**	313.7	1.07	13.74	15.5	0.12	0.26 *	4.4	1.92	0.01
25.	RSK 76 X *GM 1*	19.2	0.57 *	0.05	290.3	0.61	185.05 *	16.1	1 63	-0.04	5.2	-0.43	0.05 *
26.	RSK 77 X PM 67	28.1	2.25	83.76 *	378.4	1.45	237.36 *	15.9	3.49	0.38 *	3.8	-0.99	0.01
27.	RSK 77 X Varuna	19.4	-0.30	130.98**	294.8	0.16	2810.94**	14.1	3.35	0.01	4.8	-4.02	0.03
28.	RSK 77 X Kranti	20.8	1.75**	-0.87	297.8	-0.24	224.07 *	15.8	0.34	0.24	4.8	-2.80	0.19**
29.	RSK 77 X RLC 1359	20.3	0.82	11.20**	287.4	-0.13	7307.06**	17.0	0.36	-0.05	5.8	3.03	0.02
30.	RSK 77 X Vardan	20.1	0.54	0.42	262.9	-0.65	1320.85**	16.7	1.10	0.04	4.2	0.77	0.00
31.	RSK 77 X GM1	18.2	0.30	4.19 *	290.5	-4.84	5916.21**	14.8	3.30	0.05	5.6	0.95	0.01
32.	RSK 77 X PM 67	22.0	0.67	9.91**	249.6	3.12**	43.80	15.5	2.82**	0.05	3.9	2.52	0.00
33.	RSK 78 X Varuna	25.8	1.51	31.49**	285.3	1.28	5954.31**	13.2	0.03	0.03	5.5	-3.05	0.03
34.	RSK 78 X *Kranti*	20.2	1.76	30.82**	223.2	2.94	2.7.30**	14.2	2.64	0.01	5.3	-2.11	0.01
35.	RSK 78 X RLC 1359	21.8	1.52	20.89**	318.7	2.76	148.78	13.5	-0.18**	-0.06	6.6	-4.29	0.09**
36.	RSK 78 X Vardan	22.6	1.13	3.55**	285.6	1.31	181.14 *	14.7	1.90	-0.05	5.1	-1.22	0.01
37.	Lalpur 17 x GM 1	18.9	0.22**	-0.39	269.2	4.67	2165.98**	14.1	2.82	0.12	2.8	1.85	-0.01
38.	Lalpur 17 x PM 67	20.8	1.13	5.99	301.2	5.47	919.58**	14.1	2.82	0.12	2.7	1.85	-0.01
39	Lalpur 17 X Varuna	16.2	0.71	3.74 *	299.5	0.93	319.63**	16.4	3.30	0.58**	2.7	-0.18	-0.01**
40.	Lalpur 17 X Kranti	18.2	1.06	4.57 *	266.8	3.84	446.16**	13.7	-0.07	0.01	2.8	5.15	0.13
41.	Lalpur 17 X RLC 1359	14.1	0.19	0.21	276.2	1.18	5412.11**	15.2	2.63	0.37 *	3.2	3.70	0.00
42.	Lalpur 17 X Vardan	14.0	-0.13**	0.74	279.3	-0.42	7080.95**	13.4	2.33	0.24	2.8	2.74	0.04**
43.	*RJ 9 X GM 1*	22.2	1.67	29.20**	316.6	1.81	2257.44**	13.7	0.71	-0.05	5.2	-5.98	0.29**
44.	RJ 9 X PM 67	22.3	2.01	8.99**	311.7	3.09	4092.74**	15.9	2.75	0.02	3.9	0.19	0.00
45.	RJ 9 X Varuna	20.4	0.97	0.94**	281.5	0.39	236.96 *	14.6	-0.39	0.00	5.0	-0.52	0.04**
46.	RJ 9 X Kranti	17.9	0.43	4.55**	274.6	0.98	573.70**	15.9	1.04	-0.03	4.6	-2.22	0.00
47.	RJ 9 X RLC 1359	24.5	1.58	20.32**	309.0	-0.42	6858.04**	14.4	1.56	0.05	5.6	-1.86	0.19**
48.	RJ 9 X Vardan	26.0	2.29	36.87**	342.9	0.69	1429.38**	13.5	0.15**	-0.07	4.2	2.52	0.00
49.	CSR 164 X GM 1	19.2	0.87	4.93 *	306.0	0.97	3425.51**	14.2	1.12	0.09	3.8	**0.80**	**0.02**

1	2	3	4	5	6	7	8	9	10	11	12	13	14
50.	CSR 164 X PM 67	20.6	0.54	9.97**	3.3.3	1.57	4746.17**	12.8	-0.10 *	-0.05	3.0	6.25	0.12**
51.	CSR 164 X Varuna	16.5	0.80	5.94**	286.1	-0.61	549.19**	13.8	-0.78	0.05	3.8	-2.24	0.07**
52.	CSR 164 X Kranti	19.3	1.29	2.39	290.9	1.11	49.33	12.7	1.52	0.18	3.8	-2.37	0.05**
53.	CSR 164 X RLC 1359	21.4	1.44	14.32**	336.1	2.17	1591.98**	14.1	2.42	0.07	4.3	10.72	0.13**
54.	CSR 164 X Vardan	22.7	1.96	9.13**	3.7.2	2.49	3691.57**	12.8	-2.03	0.13	3.5	8.08	0.16**
55.	BIO 902 X GM1	16.9	0.27	4.90 *	297.4	-0.68	336.16**	13.5	0.53	-0.02	5.3	10.33	0.41**
56.	BIO 902 X PM 67	23.8	1.22	14.78**	324.6	1.27	1856.79**	15.7	-2.35	0.12	4.3	3.21	0.17**
57	BIO 902 X Varuna	21.9	1.46	16.85**	322.4	1.13	3354.97**	16.0	2.13	0.08	5.6	-4.73	0.04**
58.	BIO 902 X Kranti	19.3	1.69 *	1.28	279.2	-0.14**	-38.22	13.2	1.93	0.33 *	5.0	2.50	0.01
59.	BIO 902 X RLC 1359	23.8	1.82	5.08 *	305.7	1.71	1916.09**	14.5	1.33	-0.03	6.6	0.33	0.06**
60.	BIO 902 X Vardan	23.7	2.13**	0.02	336.6	1.09	1073.25**	16.3	-0.88	0.19	4.5	-2.05	0.02
61.	RH 7513 X GM 1	20.5	0.70	12.55**	314.5	1.11	1129.20**	13.3	2.12	0.15	4.1	-0.71	0.04**
62.	RH 7513 X PM 67	26.1	1.25	5.80**	337.4	-2.30	2234.56**	13.0	1.69	1.64**	3.4	2.17	0.06**
63.	RH 7513 X Varuna	20.4	1.63	2.21	323.9	-1.03	3191.36**	13.8	1.53	0.08	3.8	0.88	-0.01
64.	RH 7513 X Kranti	23.1	0.55	14.25**	316.5	-0.65	881.72**	13.5	1.25	-0.04	3.6	3.09	0.06 *
65.	RH 7513 X RLC 1359	24.2	2.17	28.54	347.5	5.92	1730.92**	14.5	2.58	0.06	4.3	0.72	0.11**
66.	RH 7513 X Vardan	18.2	0.36	18.98**	295.0	3.34	1401.44**	13.4	4.46	0.00	3.2	-0.28	0.00
Mean of Parents		16.2	297.3	14.3	4.5								
Mean of Hybrids		21.2	293.0	14.5	4.5								
Population mean		20.1	293.9	14.5	4.5								
S.E of bi		0.52	1.88	1.26	3.85								

Where, * and** are significant at P = 0.05 and P = 0.01 levels, respectively.

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PHENOTYPIC STABILITY FOR YIELD AND YIELD CONTRIBUTING CHARACTERS IN INDIAN RAPESEED (*Brassica campestris* VAR. YELLOW SARSON)

Seed yield and oil content in oilseed *Brassicas* fluctuate depending upon the variety and climatic conditions, under which they are grown (Singh and Patra, 1989 and Quddus *et al.*, 1991). Therefore, in the present study an attempt was made to collect information as to whether promising selections of Indian rapeseed respond differentially when grown in different environment and on genotype-enviroment interactions for seed yield and major yield contributing characters.

In the present investigation, 32 genotypes were grown in randomized block design replicated thrice under irrigated ($E1$) and rainfed (E_2) conditions at Instructional Farm of N.D.U.A.T., Kumarganj, Faizabad and under irrigated condition at Crop Research Station, Masodha (E_3). Each entry was grown in three rows per plot of three meter length. All the recommended cultural practices were followed for raising the crop under irrigated and rainfed conditions. Data were recorded on five competitive randomly taken plants from each replication for four characters and mean values were used for statistical analysis. The G X E interactions were analysed following Eberhart and Russell (1996) for the characters after verifying homogeneity of error variances.

Joint regression analysis (Table 1) showed that mean squares due to genotypes as well as environments were highly significant revealing thereby the presence of substantial diversity among genotypes as well as environments. The G X E components was highly significant for number of siliqua/plant against pooled deviation and number of primary branches/plant and seeds/ siliqua against pooled error. The E (linear) and G X E (linear) components were significant for all the characters, indicating considerable influence of environment on all the characters and existence of genetic differences among genotypes for their regression on environmental index, respectively. Significant estimate of pooled deviation for all the characters except primary branches/plant showed the importance of non-linear effect as well but its magnitude was lower than corrsponding G x E (linear) component. Similar results have been reported earlier (Singh and Patra, 1989; Quddus *et al.*, 1991).

An examination of parameters, bi and $\bar{S}^2_{di}$ for individual genotypes revealed that only one genotype for seed yield, two each for number of primary branches/plant and seeds/siliqua and three genotypes for number of siliqua/plant had significant regression mean squares. This showed that linear regression accounted for only limited number of genotypes. However, a large number of genotypes exhibited absence of G X E interaction.

A simultaneous consideration of all adaptation parameters (X, bi and $\bar{S}^2_{di}$) for individual genotypes indicated that NDYS 44 was high yielder and unstable although it was highly responsive (bi>1) to better management conditions. The genotypes NDYS 36 and YST 151 were average responsive and highly unstable. The strains NDYS 7 and NDYS 9 showed above average seed yield (8.16 g/plant and 8.06 g/plant), average responsiveness and stable performance. Amongst other genotypes, NDYS 39 and NDYS 42 also exhibited above average X and stability for seed yield. Stability of NDYS 7 for seed yield was also accompanied by stability for primary

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branches/plant and seeds/siliqua and that of NDYS 9, all three component traits showed stability in their expression. These two genotypes, offer promise for wide adaptation with superior performance.

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Table 1. Pooled analysis of variance (M.S.) for seed yield and its three components in Indian rapeseed.

Source of variation	D.F.	Number of primary branch/plant	Number of siliquae/plant	Number of seeds/siliqua	Seed yield/ plant
Genotype (G)	31	3.24@@	1861.50@@	46.42@@	2.44 **
Environment (E)	2	10.22@@	3646.58@@	268.21 **	2.61 **
G X E	62	0.70 **	294.21 ++	10.55 **	0.11
E + (G X E)	64	1.00 **	352.10 ++	50.66 ++	0.18
E (linear)	1	20.48 **	7288.32 ++	536.32 ++	17.28 ++
G X E (linear)	31	0.90 **	469.27 ++	12.28 ++	1.85 ++
Pooled deviation	32	0.46	115.42 **	8.54 **	1.22 **
Pooled error	*186*	*0.44*	*99.67*	*3.99*	*0.53*

@,@@, Significant at 5% and 1% probability level against G X E
*,** Significant at 5% and 1% probability level against pooled error
+,++ Significant at 5% and 1% probability level against pooled deviation.

Table 2. Estimates of stability parameters for four quantitative characters in Indian rapeseed for some selected genotypes with above average perfomance for seed yield.

	Number of primary branch/plants			Number of Siliquae/ plant			Number of seeds/ Siliqua			Seed yield/plant		
	$\bar{X}$	bi	$\bar{S}^2_{di}$	$\bar{X}$	bi	$\bar{S}^2_{di}$	$\bar{X}$	bi	$\bar{S}^2_{di}$	$\bar{X}$	bi	$\bar{S}^2_{di}$
1	2	3	4	5	6	7	8	9	10	11	12	13
NDY-7	7.80**	1.13	0.25	114.89**	0.30	223.17**	26.53	1.40	-2.21	8.16	1.30	0.33
NDYS-8	7.02	1.44	-0.04	75.38	0.52	-94.72	31.29	1.99	-1.55	7.57	-2.15	-0.49
NDYS-9	5.98	0.59	-0.43	104.17	-0.71	-59.19	33.60**	0.56	7.04	8.06	1.87	0.33
NDYS-17	7.01	2.60	-0.43	75.22	1.41	-47.97	35.45**	0.77	4.21	7.24	0.11	1.16
NDYS-22	8.12**	1.07	-0.05	139.35**	0.42	34.13	25.93	2.55**	3.94	7.52	2.07	0.63
NDYS-30	6.51	1.18	0.17	97.98	0.61	-90.31	31.82	0.21	7.68	7.68	-1.19	-0.26
NDYS-33	5.82	1.03	-0.42	79.29	1.31	-75.67	34.11 *	1.07	-1.19	7.41	1.85	-0.01
NDYS-36	8.12**	1.28	-0.01	115.56**	0.35	-29.21	31.70	-0.07	1.27	8.30	-1.91	1.85 *
NDYS-38	6.97	0.28	0.05	82.98	0.41	-94.92	34.42 *	0.34	-0.46	7.19	-0.28	-0.44
NDYS-42	7.80**	3.08 *	2.80**	121.13**	3.90	-11.57	31.31	0.07	9.23	7.89	2.07	-0.43
NDYS-43	5.83	1.59	-0.43	67.31	1.67	-80.18	33.80 *	0.71	9.23	7.89	2.07	-0.43
NDYS-44	7.31	1.59	8.28	120.13**	2.54 *	-102.70	32.24	1.18	-2.17	8.85 *	5.80**	8.57**
NDYS-47	7.41 *	1.71	-0.34	132.67**	3.02**	181.19**	23.82	1.67	0.05	7.07	3.93	-0.33
NDYS-48	7.37	0.96	-0.42	126.18**	1.87	73.21	28.10	1.79	-1.04	-7.47	-1.91	0.25
YS-875	6.91	0.69	-0.45	118.96**	22.4	-87.12	21.97	1.52	-1.51	-7.24	1.07	-0.47
YST-151	7.30	1.08	1.35**	138.33**	0.29	40.55	24.21	1.20	4.13	7.89	-0.48	2.12**
Population mean	6.60	1.01	--	97.04	0.99	--	29.24	0.98	--	7.09	0.98	--
SE (m) ±	0.48	0.85	--	7.60	0.71	--	2.07	0.71	--	0.78	1.50	--

*, ** Significant at 5% and 1% probability level, respectively.

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INBREEDING DEPRESSION IN SAFFLOWER *(Carthamus tinctorius L)* HYBRIDS BASED ON GENETIC MALE STERILITY

Several experimental hybrids were developed in safflower, using recessive genetic male sterility system evolved at the Directorate (Prasad *et al.*, 1995). Some of these hybrids showed distinct advantage for seed and oil yields over high yielding checks at the national level for two years in coordinated trials. If the farmer prefers to go in for cultivation of their home grown F_2 populations of F_1 hybrids, the information on loss in seed yield due to inbreeding is very useful. Therefore, the present study was undertaken to estimate the effect of inbreeding on seed yield, oil yield and their component characters.

The experiment consisting of two F_1 hybrids viz., DSH 116 and DSH 128, their F_2 populations, three check varieties (A1, HUS 305 and Manjira) and a high oil line (VI-92-2-4) was laid out in a randomized block design with three replications in 1995-96 crop season in a red sandy soil. Each individual plot consisted of ten rows and each row was 5m long at 45 x 20 cm spacing. Crop received four irrigations. Twenty plants were randomly selected for recording total capitula per plant, seed number per capitulum and plant height in each replication. Seed yield, oil yield, oil content and days to flowering were recorded from each plot. The mean values of each treatment over replications were used for estimation of inbreeding depression.

The magnitude of inbreeding depression (Table 1) for seed yield (23-26%) indicates high seed loss in the first generation of selfing of safflower hybrids. Considerable inbreeding depression for seed yield was also reported by Muhammed *et al.* (1969) and Ramachandram and Goud (1982) in first and second generations of safflower varieties. The effect of inbreeding was high on the two main yield components *viz*, total capitula per plant (16-34%) and seed weight. Yield loss in F_2 could be due to high inbreeding depression for seed number and total capitula. High inbreeding depression was also observed for oil yield (23-32%), whereas inbreeding depression for plant height, oil content, seed weight and days to flowering was low or negligible. Similar low or negligible inbreeding depression on these attributes was also reported by Yazdi-Samadi *et al.* (1975) in majority of selfed progenies. The high and low magnitudes of inbreeding depression for various attributes studied indicate preponderance of non-additive gene action for seed yield, total capitula and seed number while additive gene action for the remaining attributes.

This study indicated that there was considerable reduction in seed yield and oil yield from F_1 hybrids to their capital F_2 populations. However, oil yield of both F_2 populations did not differ significantly from check varieties. The highest yielding hybrid, DSH 128, was derived from a cross between a moderately yielding recessive genetic male sterile line MS 6(0) possessing high oil content (33%) and a high yielding national check variety (A1). The reduction in seed yield of F_2 population of this hybrid was at par with check varieties. The magnitude of reduction in seed yield of F_2 population of the heterotic hybrid, DSH 128, was comparable with that of yield increase in F_1 hybrid over the check varieties. This suggests preponderance of non-additive gene interaction in manifestation of heterosis for seed yield.

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Table 1. Mean values and inbreeding depression for different attributes

Entry	Seed yield (kg/ha)	Oil yield (kg/ha)	Oil content (%)	100 seed weight (g)	No.of seeds/ capitulum	Total capitula/ plant	Days to flowering	Plant height (cm)
DSH 116								
F_1	1827.29	623	33.8	5.7	36.1	34.0	90	78.5
F_2	1344.19	422	32.0	5 8	32.1	22.3	90	73.0
IB (%)	26.0	32	5.3	0.0	11.0	34.0	0.0	7.0
DSH 128								
F_1	2140.73	644	30.0	6.2	40.5	28.6	90	80.2
F_2	1634.29	495	30.0	6.9	30.2	23.6	89	75.3
IB (%)	23.0	23	0.0	0.0	25.0	16.0	0.0	6.1
HUS 305	1503.80	472	27.7	6.9	29.3	27.8	90	82.9
Manjira	1535.18	443	27.6	7.1	28.3	26.9	89	75.4
A1	1675.27	460	25.9	7.7	29.0	24.7	90	87.8
VI-92-2-4	1280.99	400	31.4	5.1	33.6	26.8	89	83.4
GM	1617.72	494	29.7	6.4	32.6	27.2	89.6	77.1
CV (%)	11.2	13.7	4.3	7.9	16.7	18.3	1..9	7.1
CD (0.05%)	319.6	118.7	2.2	0.9	9.8	3.0	NS	9.5

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EFFECT OF FYM AND SAND APPLICATION ON TORIA IN A DRY TEMPERATE HILI ZONE OF H.P.

The productivity of rapeseed - mustard (1993-94) in Himachal Pradesh is much less 359 kg/ha as compared to Punjab (1143 kg/ha) or Gujarat (901 kg/ha). The soils of Spiti Valley are low in organic carbon and are silty loam in texture. Among the various means of increasing productivity on these soils, use of organic manures and improvement in soil texture may be a good approach. The present study was, therefore, undertaken to investigate the effect of FYM and sand application on toria.

A field experiment was conducted during summer 1994 at HPKV, Research Sub - Station, Lari farm in Lahaul and Spiti (Latitude 30° - 42'N, Longitude 77° - 37'E and altitude of 3247 metres). Spiti valley is characterised by sloppy desert mountains. The growing season is only from April to September. The area lying in the rain-shadow of Himalaya receives very low precipitation (<300 mm) largely in the form of snow. The summer is characterised by high day temperature reaching up to 40°C. During, 1994 average temperature was 21° C (April to October) with a range of 10 - 40°C. In general, in Spiti valley, cold desert winds with 25 to 30°C blow during winters. The annual snowfall ranges from 1 to 2 metres. The treatments viz. FYM @ 20 t/ha, sand @ 20 t/ha, sand @ 50 t/ha, FYM @ 10 t/ha + sand @ 25 t/ha, FYM mulching @ 20 t/ha and control were tested in a randomized block design, with four replications. In case of FYM mulching treatment, after the sowing of toria, FYM was spread on the soil surface like mulch. The crop was sown on May 27, 1994 and harvested on September 6, 1994 taking DK-1 variety. Fertilizers were applied as per recommendations. The experimental soil was having PH 8.5, EC 0.28 dsm^{-1}, organic carbon 4.5 kg ha^{-1} available N 245 kg/ha, available P 85 kg/ha and available K 542 kg/ha, CEC 7.2 C mol (p^+)/kg, $CaCO_3$ 1.4% with silty loam texture.

The results revealed significant influence of different treatments on plant height, secondary branches, length of siliqua (Table 1). FYM incorporation, FYM mulching, sand application alone and in combination, with FYM significantly increased the plant height, secondary branches and length of siliqua over control. The highest plant height was recorded in FYM+sand treatment. In contrast to this these treatments were statistically same as FYM incorporation and FYM mulching when their effect was studied on secondary branches of the crop. Ponikia *et al.* (1993) also reported that the water uptake at a given time and total water absorption by seeds and diffusibility of seed increased with compaction levels, which ultimately increased groundnut yield. In an another study, Moitra *et al. (1996)* reported that grain yield of yellow sarson increased due to mulching in a sandy loam soil of Eastern India.

Significant increase in seed and straw yield of toria was recorded due to the application of different treatments over control (Table 1). The increase in seed yield over control was 34.4, 54.3, 62.0 and 46.3 and the increase in straw yield was 25.4, 29.3, 35.2 and 26.8% due to FYM incorporation, sand application, FYM + sand application and FYM mulching, respectively. Maximum seed yield (1567 kg/ha) was obtained in sand + FYM treatment was significantly superior over FYM mulching and FYM incorporation treatment. The increase in seed and straw yield of toria was due to increase in various growth and yield attributing characters of *toria* in these treatments. The response to FYM may be due to the fact that experimental site was deficient in organic carbon and nitorgen. The imporvement brought about in soil health due to FYM has a long term bearing on crop production (Singh and Dwivedi, 1996). Singh *et al.* (1990)

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reported that mulching has positive influence on mustard yield in the soil of Barapani and Meghalaya. Similar increase in mustard/ *toria* yield due to FYM application was also reported by other workers (Sardana and Sidhu, 1994).

The results revealed that the effect of FYM and sand application was significant on *toria*. Maximum seed yield (1567 kg/ha) was recorded in the treatment where sand @ 25t/ha+FYM @ 10 t/ha were applied and was significantly (1300 kg/ha) but was at par with sand application alone (1492 kg/ha). The straw yield was not affected due to different treatments.

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Table 1. Effect of farmyard manure on growth, yield attributing characters and yield of toria.

Treatments	Plant height (cm)	Primary branches	Secondary branches	Length of siliqua (cm)	Number of seeds siliqua^{-1}	1000 seed weight (g)	Yield (kg/ha) seed	Yield (kg/ha) straw
FYM @ 20 t/ha	68.4	4.2	8.0	5.8	17	3.60	1300	3385
Sand @ 50 t/ha	74.2	5.1	8.7	7.1	19	4.15	1492	3490
FYM @ 10t/ha + sand @ 25 t/ha	76.6	5.7	9.1	7.2	20	4.50	1567	3650
FYM mulching @ 20 t/ha	70.2	5.3	8.4	6.0	18	3.90	1415	3425
Control	60.0	3.0	7.3	5.0	15	3.00	967	2700
L.S.D. (P=0.05)	2.0	NS	1.2	1.0	NS	NS	168	379

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INTEGRATED WEED MANAGEMENT IN MUSTARD

Integrated weed management is a preferable practice that aims at reducing the dosage of herbicide to be applied to soil in combination with cultural method or other herbicide, thereby alleviating the residue and pollution problems besides providing and effective and acceptable means of weed control to the farmer. It is the best way of managing weeds for releasing high production in mustard (Panwar *et al.*, 1987 and Brar *et al.*, 1991). Hence, the present investigation was carried out during *rabi* 1994-95 at the Student's Farm, Rajendranagar, Hyderabad to find out optimum dose of herbicide, its time and number of hand weedings in an integrated manner to achieve good control of weeds for releasing higher yields of mustard. Fourteen treatments comprising four pre-emergence herbicides viz., butachlor, metolachlor, pendimethalin and fluchloralin and the combination at three-fourth dose of these herbicides with one hand weeding (HW) at 30 DAS and similarly with one post-emergence herbicide parquat at 0.15 kg/ha at 21 DAS twice hand weeding at 20 and 35 DAS and one unweeded check were tested in a randomised block design with three replications. The experimental site was sandy loam having 250, 33 and 361 kg/ha available nitrogen, Phosphorus and Potassium, respectively with pH 8.1 and organic Carbon 0.36%. The test variety TM-4 was sown on 1st November, 1994 at 30 cm apart in solid rows. Thinning was done at 10-15 DAS to maintain intra row spacing of 10 cm. The crop was fertilized with 50 kg N, 60 kg P_2O_5 and 40 kg K_2O per hectare as basal and another 50 kg N/ha was top dressed after first irrigation (30 DAS).

Monocot and Dicot weeds in experimental site accounted for 40 and 60 percent of the total weed flora, respectively, the dominant weeds being *Cyperus rotundus, Cynodon dactylon,* among monocots and *Parthenium hysterophorus, Amaranthus viridis, Digera arvensis, Euphorbia hirta, Cleome viscosa, Portulaca oleracea, Trichodesma indicum*, and *Melilotus indica* under dicot weeds.

Number of siliquae/plant and number of seeds/siliqua were found to increase considerable under hand weeding twice treatment followed by butachlor + HW which was on par with fluchloralin + HW. All the cultural and herbicidal weed control treatments markedly reduced the weed dry matter accumulation. Maximum weed dry weight (55.2 g/m^2) was recorded at harvest in unweeded check. This was obvious since weeds were allowed to grow unchecked in these plots. The treatments with butachlor + HW (10.1 gm/m^2) closely followed by fluchloralin + HW (10.1 gm/m^2) registered lower weed dry weights next only in hand weeding twice (8.1 g/m^2) treatment. Seed yields obtained from the cultural as well as herbicidal weed control treatments were significantly higher than under unweeded check, the highest closely followed by fluchloralin + HW (14.2 q/ha), butachlor + HW (14.2 q/ha), metolachlor + HW (13.6 q/ha) the latter three treatments remained at par with one another. The weed dry matter under these treatments was less than under other treatments.

Higher net returns (Rs. 16616/ha) were obtained due to twice HW followed by butachlor +HW (Rs. 1674 /ha) and fluchloralin + HW (Rs. 20772/ha) but the benefit cost ratio was highest (3.7) under butachlor + HW treatment. These findings conclude that pre-emergence application of either butachlor or fluchloralin each at 1.0 kg/ha followed by one hand weeding at 30 DAS proved to be a better integrated weed management system than twice hand weeding.

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Table 1. Yield and yield attributes of mustard under different weed management practices.

Treatments	Number of siliqua/plant	Number of seeds/siliqua	Weed dry weight (g/m^2)	Seed yield (q/ha)	Net returns (Rs/ha)	Benefit cost ratio
Butachlor @ 1.5 kg/ha (Pre - E).	138	11.34	31.4	10.86	11781	2.61
Metolachlor @ 1.0 kg/ha (Pre -E)	131	10.88	35.0	9.80	10086	2.19
Pendimethalin@ 1.0 kg/ha (Pre - E)	117	10.51	39.9	8.43	7413	1.42
Fluchloralin @ 1.5 kg/ha (PPI)	137	11.30	31.3	10.84	11084	2.14
Butachlor @ 1.0 kg/ha (Pre-E) + hand weeding 30 DAS	222	13.15	10.2	14.20	16764	3.70
Metolachlor @ 0.75 kg/ ha (Pre-E) + hand weeding 30 DAS	208	12.88	12.5	13.68	15864	3.41
Pendimethalin @ 0.75 kg/ha (Pre-E) + hand weeding 30DAS	198	12.20	15.0	11.83	12619	2.46
Fluchloralin @ 1.0 kg/ha (PPI) + hand weeding 30 DAS	221	13.11	10.1	14.18	20772	4.17
Butachlor @ 1.0 kg/ha (Pre-E) + paraquat @ 0.15 kg/ha (Post-E)	178	12.09	19.7	12.04	13538	2.99
Metolachlor @ 0.75 kg/ha (Pre-E) + paraquat @ 0.15 kg/ha (Post - E).	160	11.86	22.8	11.80	13058	2.81
Pendimethalin @ 0.75 kg/ha (Pre-E) + paraquat @ 0.15 kg/ha	142	11.50	26.9	10.23	10233	2.00
Fluchloralin @ 1.0 kg/ha (PPI) + paraquat @ 0.15 kg/ha	117	12.00	19.7	12.02	13064	2.63
Unweeded check	103	9.16	55.2	7.20	6836	1.72
Handweeding twice (20&30 DAS)	244	13.23	8.1	15.00	16616	2.82
CD at 5%	8	1.95	2.3	1.26	-	-

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INFLUENCE OF SOWING METHOD OF PARENTAL LINES AND NITROGEN RATES ON SYNCHRONIZATION OF FLOWERING, YIELD AND SEED QUALITY OF SUNFLOWER HYBRID APSH-11

The evolution of hybrids has opened new vistas in augmenting the sunflower production levels. The hybrid APSH-11 has a high yield potential in addition to the induced resistance to Alternaria leaf spot and rust. However, seed production for this hybrid need considerable skill in the management of its parental lines for synchronised flowering. The pollen parent (RHA 271) is known to flower earlier than the seed parent (CMS 7-1A) by about a week. Hence, a field experiment was conducted to study the effect of simultaneous and staggered sowings and nitrogen rates for synchronised flowering of the two parents for effective pollination.

The experiment was conducted in an Alfisol (pH 8.1) at Agricultural College Farm, Rajendranagar, Hyderabad (AP) during summer 1996. The soil was low in available nitrogen (169 kg ha^{-1}), phosphorus (3.6 kg ha^{-1}) and potassium (134 kg ha^{-1}). The experiment was laid out in a RBD. The treatments comprised a combination of two sowing dates (simultaneous and staggered sowing) and four nitrogen rates (100, 125, 150 and 100 kg/ha + 2% urea as foliar spray). In staggered sowing, the pollen parent was sown 5 days after the seed parent. Foliar spray of urea was done at preflowering stage. One row of pollen parent and four rows of seed parent were sown at 60 cm X 30 cm spacing on February, 2 1996. Application of 40 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha was made as basal. Rest of the nitrogen was top dressed 30 days after sowing as per treatment. The crop was irrigated four times. The seed yield and biometric observations were recorded at harvest in addition to the visual record on flowering. Oil content in seeds was estimated using NMR technique. The seed quality test was done 30 days after harvest for its germinability, vigour index, root and shoot length using paper towels in 3 replications and incubated at 25 +1°C and 95 +2 percent relative humidity for 7 days (ISTA , 1985).

The results showed that pollen parent was short statured having less stem girth, head diameter and flowered about 5 days earlier than the seed parent. The staggered sowings had no significant influence in altering the plant height, stem girth and head diameter of both the parental lines. However, the staggered sowing of pollen parent was very effective for synchronisation in flower initiation and 50 per cent flowering (Table 1). This confirms the findings of Agarwala (1994). The resultant hybrid had significantly higher 1000 seed weight and seed yield per plant (Table 2) which may be due to effective pollination and thus increased hybrid seed production. In simultaneous sowing much of the pollen grain perhaps lost unutilised as it is known to be viable for only 8 hours (Dangi *et al.*, 1982). The nitrogen rates had a significant influence on the crop growth. The two parents responded to grow significantly tall, attain more stem girth and large head size at 150 kg N/ha over the recommended rate of 100 kg N/ha. However, it delayed the days needed both to initiate and 50 percent flowering. The foliar spray of urea had no significant influence. The 1000 grain weight of pollen parent improved significantly while the yield per plant at 100 and 150 kg N/ha was on par. The per hectare production of both the parental lines was significantly more at 150 kg N/ha. Agarwala (1994) reported that the seed yield of APSH-11 hybrid increased significantly with additional 20 kg over 100 kg N/ha. The oil percentage was not influenced either by the staggered sowing or nitrogen rate.

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The germination percentage, root and shoot length of the hybrid was not influenced by the staggered sowings. However, the seed was significantly superior in its quality with a high vigour index due to simultaneous sowing of two parental lines (Table 3). Additional 50 kg N/ha significantly improved the germination percentage and vigour index of the hybrid as well as the root and shoot length of the seedlings compared to 100 kg N/ha. The seed quality of the pollen parent also improved by this treatment. Sowing of pollen parent (RHA 271) could thus be staggered for 5 days after the seed parent (CMS 7-1A) for synchronised flowering and a dose of 150 kg N/ha be applied for higher yields of the hybrid APSH-11.

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Table 1. Influence of sowing method and nitrogen dose on morphological characters and flowering behaviour of parental lines of APSH-11 sunflower hybrid.

Treatments	Plant height (cm)		Stem girth (cm)		Head diameter (cm)		Number of days to initial flowering		Number of days to 50% flowering	
	Pollen parent	Seed parent	Pollen parent	Seed parent	Pollen parent	Seed parent	Pollen parent	Seed parent	Pollen parent	Seed parent
Sowing method										
Simultaneous	104.8	113.0	3.4	3.8	7.2	9.1	47.3	52.0	54.8	59.9
Staggered	105.0	115.7	3.5	3.8	7.3	9.4	52.9	53.0	59.1	60.8
SE±	0.5	0.4	0.02	0.01	0.01	0.01	0.5	0.7	0.5	0.5
CD 5%	NS	NS	NS	NS	NS	NS	1.0	NS	1.1	NS
Nitrogen kg/ha										
100	102.4	108.7	3.2	3.6	6.5	8.8	49.1	49.8	55.3	59.2
125	105.1	117.1	3.6	3.8	7.6	9.6	50.2	54.0	58.2	60.8
150	108.6	120.1	3.6	4.1	7.6	9.7	51.3	55.3	58.8	62.0
100 + 2% Urea spray	103.4	111.5	3.3	3.7	7.2	8.9	49.8	51.0	55.5	59.5
S.E ±	0.7	0.6	0.03	0.02	0.02	0.02	0.7	1.0	0.7	0.7
CD 5%	*1.5*	*1.4*	*0.06*	*0.05*	*0.05*	*0.05*	*1.4*	*2.3*	*1.5*	*1.4*
Interaction										
SE ±	1.0	1.0	0.04	0.03	0.03	0.03	0.9	1.5	1.0	1.0
CD 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2. **Influence of sowing date and nitrogen dose on yield attributes, yield and oil percentage of parental lines of APSH-11 sunflower hybrid.**

Treatments	1000 Seed weight (g)		Seed yield/plant (g)		Seed yield (kg/ha)		Oil percent	
	Pollen parent	Hybrid	Pollen parent	Hybrid	Pollen parent	Hybrid	Pollen parent	Hybrid
Sowing method								
Simult aneous	22.09	23.21	9.12	9.27	78.00	339.00	32.6	30.1
Staggered	22.75	27.35	9.47	16.15	81.00	609.00	32.7	30.0
SE±	0.70	1.43	0.60	0.82	2.00	29.00	0.2	0.1
CD 5%	NS	3.06	NS	1.77	NS	62.00	NS	62.00
Nitrogen kg/ha								
100	21.10	24.33	8.80	11.35	75.00	417.00	33.7	30.9
125	22.68	25.16	9.15	12.95	79.00	476.00	32.0	29.8
150	23.71	26.83	10.35	13.95	87.00	537.00	32.0	29.0
100 + 2% Urea spray	22.20	24.82	8.91	12.62	76.00	466.00	33.0	30.5
S.E ±	0.99	2.02	0.84	1.16	3.00	41.00	1.6	1.2
CD 5%	2.12	NS	NS	2.50	6.00	88.00	NS	NS
Interaction								
SE ±	1.40	2.86	1.20	1.65	4.00	58.00	1.3	0.9
CD 5%	NS	NS	NS	NS	NS	124.00	NS	NS

Table 3. Influence of sowing method and nitrogen dose on seed quality parameters of parental lines of APSH-11 sunflower hybrid.

Treatments	Germination percent		Vigour index		Root length (cm)		Shoot length (cm)	
	Pollen parent	Seed parent	Pollen parent	Seed parent	Pollen parent	Seed parent	Pollen parent	Seed parent
Sowing method								
Simultaneous	92.4	90.6	11.2	19.2	10.9	12.6	8.6	9.6
Staggered	95.8	91.8	13.7	21.5	13.7	14.0	9.1	10.2
SE±	1.5	1.3	0.7	0.5	0.2	0.6	0.05	0.2
CD 5%	3.2	NS	1.4	1.0	0.4	NS	0.1	NS
Nitrogen kg/ha								
100	91.0	88.8	6.2	16.0	10.9	11.4	8.3	9.3
125	93.1	92.1	11.6	21.7	12.6	14.8	9.1	10.0
150	95.9	93.3	13.8	23.6	13.6	14.9	9.8	10.4
100 + 2% Urea spray	93.3	90.4	11.6	20.2	12.0	12.2	8.3	9.9
S.E ±	2.5	1.4	0.9	0.6	0.2	0.9	0.1	0.3
CD 5%	4.6	3.0	2.0	1.4	0.5	1.9	0.2	0.6
Interaction								
SE±	3.0	1.9	1.3	0.9	0.3	1.2	0.1	0.1
CD 5%	NS	NS	NS	NS	NS	NS	NS	NS

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PERFORMANCE OF SESAME CULTIVARS AT DIFFERENT FERTILITY LEVELS UNDER RAINFED CONDITIONS

The yield of sesamum is low mainly due to lack of high yielding varieties and inadequate application of fertilizers. Maiti and Jana (1985) and Itnal (1993) reported that with application of nitrogen and phosphorus the yield of sesame increased significantly, while, potassium has no significant influence on the yield (Rao *et al*, 1985). The present study was, therefore, laid out in *kharif* season of 1990, to find out the response of sesame cultivars to different fertility levels under rainfed conditions at Rahuri (Maharashtra).

Field experiment was conducted on shallow black soil (30 cm) in a factorial randomized block design with three replications during *kharif* season at Instructional farm of Post Graduate Institute, M.P.K.V., Rahuri. The cultivars tested were JLT-7 (Tapi), Phule Til No.1 and Hawari (local). The fertility levels have been indicated in Table 1. The crop was sown on 16th June, 1990 at 30 cm spacing with 2.22 lakh plants / ha. Rainfall of 417 mm was received during the crop growth period.

The varieties JLT-7 and Phule Til No. 1 were at par but recorded higher yield than local by 45.14 and 42.61 per cent, respectively. JLT-7 and Phule Til No. 1 recorded 32.92 and 27.68 per cent higher number of capsules per plant, respectively than local variety. The grain weight per plant was higher by 46.77 and 44.47 per cent in the above two varieties when compared to local variety.

The grain yield increased significantly with every successive increase in level of fertility and was the highest (9.93 q/ha) with 37.5 + 18.5 kg $N+P_2O_5$/ha which was 39.28 per cent higher than control. These results are in agreement with the findings of Sasikumar *et al.* (1989). The increase in capsule number and seed weight per plant to fertilizer application contributed towards the increase in seed yield. The plant height, spread, number of functional leaves and dry matter accumulation per plant increased significantly with increased levels of fertilizer. The straw to grain ratio widened with increase in fertilizer levels. However, the harvest index was maximum in the absence of fertilizer use. The interaction effect of nitrogen and phosphorus was non-significant.

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Table 1. Influence of different dates of sowing and fertility levels on growth and yield of soybean.

Treatments	Plant height at 75 DAS (cm)	Total dry Matter (g)		Seed yield (q / ha)
		75 DAS	90 DAS	
Sowing dates				
D1	55.82	16.78	19.00	20.7
D2	63.58	19.80	22.07	25.07
D3	50.19	13.85	16.00	17.37
D4	44.67	11.00	12.30	4.48
Fertility levels				
F1	32.09	12.19	13.55	13.73
F2	50.19	14.81	17.00	17.08
F3	60.55	16.40	18.89	17.99
F4	71.43	18.02	21.00	18.86
C.D. (0.05)	0.68	0.47	0.49	1.08

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POWDERY MILDEW DEVELOPMENT IN MUSTARD UNDER DIFFERENT PRODUCTION FACTORS

Powdery mildew caused by *Erysiphe ruciferarum* opiz. ex Junell, is becoming a serious disease of rapeseed-mustard in different parts of India (Saharan, 1992, Mayee, 1995). Damage to the crop is more severe when infection takes place in early stages of plant growth. Studies were conducted on the development of this disease in mustard crop sown under different production factors in mid hill conditions of Himachal Pradesh.

A field experiment was conducted during *rabi* 1993-94 and 1994-95 at Oilseeds Research Station, Kangra in randomized block design with three replications. Production factors such as improved variety, fertilizer, irrigation, disease control, pest control alone and in combination with each other and minus weed control were compared with recommended package for intensity of powdery mildew. Recommended package (RP) included improved variety Varuna of mustard *(Brassica juncea L.)* Czern and Coss, fertilizer NPK (60:40:40), two irrigations (Pre sowing and 30 days after sowing), hand weeding, control of *Alternaria* blight and white rust by foliar sprays of Mancozeb (0.2%) and aphids by need based sprays of Metasystox (1 ml/lit.). Plant stand was maintained by keeping a spacing of 30 x 10 cm. Sowing was done on October 28, during both the years. Percent disease intensity was calculated on 0-5 scale at the time of crop maturity (8.4.94 and 29.3.95) as per the formula described by Saharan and Chand (1988). Weather parameters like temperature, humidity and rainfall were also recorded for both the crop seasons.

Powdery mildew appeared in all the treatments except in T2 (RP-improved variety) during 1993-94 (Table 1). The disease did not appear in this treatment because local variety used matured one month earlier and escaped the disease.

The disease intensity was maximum in T10 (RP- irrigation and plant protection) followed by T4 (RP-irrigation). The treatments without irrigation favoured the maximum development of disease. Minimum disease intensity was recorded in T9 (RP-fertilizer and plant protection) which was statistically on par with T3 (RP-fertilizer), T1 (RP) and T5 (RP-disease control). Decease did not appear in any of the treatment during 1994-95.

Weather data (Table 2) indicated that though temperature for the disease development was almost the same during February and March in both the years, higher rainfall and relative humidity during January, February and March did not favour the outbreak of powdery mildew in 1995.

It is evident from the above that rainfed situations as well as no or low rainfall during February and March favours the development of disease under mid hill conditions of Himachal Pradesh. Saharan (1992) has also mentioned that for the epidemic build up of powdery mildew, moderate temperature (mean 16.28°C, Low relative humidity (less than 60%) and minimum or low rainfall during February and March were congenial.

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Table 1. Effect of different production factors on development of Powdery mildew in mustard.

	Treatments	Disease intensity (%)	
		1993-94	1994-95
T1 :	Recommended package (RP)	20.0(26.5)	-
T2 :	RP-improved variety	0.0(0.0)	-
T3 :	RP- fertilizer	18.4(25.3)	-
T4 :	RP-irrigation	62.4(52.2)	-
T5 :	RP-disease control	20.0(26.5)	-
T6 :	RP-pest control	21.(27.7)	-
T7 :	RP-disease & pest control	20.8(27.1)	-
T8 :	RP-fertilizer & irrigation	60.0(50.8)	-
T9 :	RP-fertilizer & plant protection	17.6(24.8)	-
T10 :	RP-irrigation & plant protection	64.0(53.1)	-
T11 :	RP-weed control	22.4(28.3)	-
CD (P=0.05)		2.0	-

Figures in parentheses are angular transformed values
- indicates no disease.

Table 2. Weather data for the crop season of 1993-94 and 1994-95

Month	1993-94				1994-95			
	Temperature °C		RH	Rain fall	Temperature °C		RH	Rain fall
	Max.	Min.	(%)	(mn)	Max.	Min.	(%)	(mn)
Oct.	26.8	18.1	65	-	27.0	19.3	64.8	-
Nov.	23.8	13.1	96	10.2	22.8	14.9	68.8	-
Dec.	20.3	10.1	67	-	18.3	10.8	67.0	41.0
Jan.	22.7	10.7	67	41.6	18.6	10.6	68.8	52.3
Feb.	20.1	12.3	64	66.9	19.7	10.1	66.6	152.0
March	28.1	17.6	61	-	29.8	13.7	65.0	46.0
April	31.3	20.4	57	47.7	30.7	16.5	57.0	54.1
Total rainfall				168.4				346.4

- indicates no rainfall.

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INCREASED SUSCEPTIBILITY OF SUNFLOWER GENOTYPES TO SUNFLOWER MOSAIC VIRUS ON PRIOR-INOCULATION WITH THE SPORES OF *Alternaria helianthi*.

Sunflower mosaic virus occurring naturally on sunflower was reported by Nagaraju *et al.* (1995). In their study, the virus was found to be mechanically sap and also aphid transmitted. Further, its transmission through any means was limited and never increased beyond 40 per cent, in any of the genotypes tested by changing buffers, their pH, molarity; abrasives, anti-inhibitors and also by inoculating with different age group of test plants. Gill (1965) reported that four viruses (tobacco necrosis, cucumber mosaic, artichoke latent and cabbage mosaic), multiplied more extensively in leaves infected with sunflower rust caused by *Puccinia helianthi*. Further, he observed that more virus recovered from rusted than from non-rusted tissues, whether infection on normal tissue was systemic or local and concluded that susceptibility to virus infection was usually pre-requisite to infection of rusted tissue. Gupta *et al.* (1977) also studied the synergism between *Alternaria alternata* and sunflower mosaic virus and reported that there was no interference of *A. alternata* with the infection and spread of the virus except in blighted portions. In the present investigation, an attempt was made to increase the susceptibility of the test seedlings for virus infection by spraying the spore suspension of *Alternaria helianthi* before inoculation.

Twenty nine sunflower genotypes which includes germplasm lines and cultivars/hybrids were sown in two sets in earthen pots under insect proof glasshouse conditions at GKVK campus of the University of Agricultural Sciences, Bangalore. Standard inoculum of the sunflower mosaic virus maintained in the glasshouse was prepared using sodium phosphate buffer (0.067M, pH 7.00) containing 0.5 per cent sodium sulphite, @ of 1 ml/g of infected leaf tissue by macerating and squeezed through double layered muslin cloth. 10-12 days after sowing, to one set of sunflower genotypes, inoculation was made with the standard inoculum by holding the leaves on the left hand fore and middle fingers and rubbing with the right hand fore finger by dipping in the standard inoculum. The inoculated leaves were then washed with a jet of water to remove the excess inoculum left on the leaves before drying.

On the same day, another set of the same genotypes were inoculated with the spores of *A. helianthi*. The *A. helianthi* was freshly isolated from the infected leaves of sunflower using Potato Dextrose Agar. The spores of the pathogen was multiplied in the laboratory on the same media. Seven day old, well sporulated pathogen was washed in sterile water and a spore suspension was prepared so that 15-20 spores of *A. helianthi* were present under each low power microscopic fields. By adding a few drops of Tween-20 to this spore suspension and with the help of an atomizer, spraying was done on to the test plants and covered with polythene bags to create and maintain high relative humidity for 24 hours. To this set, one week after spraying with the spores *A. helianthi*, inoculation was made with the standard inoculum of the sunflower mosaic virus as described earlier. The test plants in both the sets were kept for observations under glasshouse conditions for the expression of the virus symptoms.

The results (Table 1) revealed that the per cent transmission of the virus among the tested genotypes in the first set where only virus inoculation was made ranged from 16.7 to 50.0. The highest per cent of 50.0 was observed in the genotype Acc. No. 58 and L101 only. In the other set where spores of *A. helianthi* was sprayed, a week before inoculation with the virus, the

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transmission (more than 60%) was obtained in the genotypes Acc. Nos. 10, 208, 333, 430, Morden and KBSH 1. Lamey and Everet (1967) reported that the increased susceptibility of *Hoja blanca* virus infected with rice leaves to enhancement of the transmission of sunflower mosaic virus through mechanical sap inoculation, by prior inoculating the test plants with the spores of *A. helianthi*.

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Sl. No.	Genotypes	Normal procedure			a week prior to inoculation		
		Ino.	Inf.	%	Ino.	Inf.	%
1.	Acc. No. 4	10	3	30.0	10	8	90.0
2.	Acc. No. 14	8	3	37.5	16	7	43.8
3.	Acc. No. 33	12	3	25.0	7	5	71.0
4.	Acc. No. 40	9	4	44.4	6	4	67.0
5.	Acc. No. 43	14	5	35.7	6	2	33.3
6.	Acc. No. 58	16	7	50.0	9	7	78.0
7.	Acc. No. 60	11	3	27.3	8	4	50.0
8.	Acc. No. 61	22	5	22.7	8	4	50.0
9.	Acc. No. 179	7	2	28.6	15	9	60.0
10.	Acc. No. 194	18	5	27.8	13	8	61.5
11.	Acc. No. 200	20	6	30.0	7	5	71.0
12.	Acc. No. 206	17	7	41.2	10	7	70.0
13.	Acc. No. 208	10	2	20.0	10	8	80.0
14.	Acc. No. 328	10	3	30.0	8	6	75.0
15.	Acc. No. 333	12	4	33.3	7	6	86.0
16.	Acc. No. 351	15	3	20.0	20	9	42.3
17.	Acc. No. 430	23	4	16.7	12	10	83.3
18.	Acc. No. 810	17	4	23.5	12	8	66.7
19.	Acc. No. 886	7	2	28.6	6	4	66.7
20.	Acc. No. 887	16	5	31.3	18	8	44.4
21.	Acc. No. 1029	9	3	33.3	6	3	50.0
22.	Acc. No. 1386	21	7	33.3	19	6	31.6
23.	Acc. No. 1442	12	4	33.3	17	8	47.1
24.	Acc. No. 1464	10	4	40.0	11	8	72.7
25.	L 51	15	4	26.7	12	8	66.0
26.	L 101	10	5	50.0	10	7	70.0
27.	EC 68414	10	3	30.0	13	5	38.5
28.	Morden	15	6	40.0	20	16	80.0
29.	KBSH 1	15	7	46.7	18	15	83.3

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EFFECTIVENESS OF THE PUPAL PARASITOIDS, *Brachymeria nephantidis* GAHAN AND *Brachymeria lasus* WALKER AGAINST *Opisina arenosella* WALKER

The bethylids, *Brachymeria nephantidis* Gahan and *Brachymeria lasus* Walker were found important among nine pupal parasitoids of the coconut caterpillar, *Opisina arenosella* Walker at the Coconut Plantation, Mahuva (Gujarat), however, *B. nephantidis* dominated to *B. lasus in* nature (Kapadia, 1987; Kapadia and Mittal, 1995). They could parasitize the pest to ascertain extent due to the intracompititive behaviour. Field evaluation of both the bioagents against this pest has not yet been studied. The present investigation on biological control was therefore, undertaken to evaluate the effectiveness of these bethylids.

Both the parasitoids were mass reared in laboratory as per rearing technique of Raghwani *et al.* (1995). Accordingly, females (50) and males (25) of parasitoid were confined in a horizontally placed glass jar (20 X 16 cm) and honey was provided as food. The jar with adult parasitoids was kept in subdued sunlight for 10-15 minutes daily for 3-4 days after which 100 fresh *Corcyra* pupae kept in open petridish were exposed for oviposition. The parasitized host were replaced daily by the fresh ones. The adult emergence commenced normally 12-14 days after oviposition. Five days old adult females parasitoids were released in a selected coconut orchard of 200 palms, infested with the suitable stage of the pest. The number of parasitoid females was released in proportion of 30 per cent of *Opisina* pupae. The field releases were made during three years, 1985-87 and 1990-91. The observations on the level of parasitism in the released and non-released coconut orchards were recorded after 15 days of release. The control orchard was located 2 Km. away from the released orchard. Both the parasitoids were liberated separately in the differed orchards. Twenty five infested coconut palms were selected at random from the experimental orchard for determining the parasitism. The data obtained were analysed using "t" test.

Releases of *B. nephantidis* were made twice in each of three years and results (Table 1) showed that the percentage parasitism over the control varied from 5.94 to 10.00 except a highest (60%) obtained in May, 1986. The average parasitism was 19.34 per cent. Release of *B. lasus* was made once in each of three years. The parasitism over the control ranged from 6.81 to 9.00 with an average of 8.11 per cent. Thus the parasitism by *B. nephantidis* was obtained higher (19.34%) than the parasitism by *B. lasus* (8.11%). In both cases, there was no marked difference (except during May) in the level of parasitism by the parasitoids which were released in different months. Thus the seasonal conditions did not favour the parasitoids to cause the parasitisation above 9-13 per cent. Pillai and Nair (1981) reported 13.90 per cent parasitism by *B. nephantidis* and only 0.62 per cent parasitism by *B. lasus*. *B. nephentidis* maintained a more or less same population throughout the year (Pillai and Nair, 1981; Kapadia and Mittal, 1995).

The study summarized that the recovery by the field released *B. nephantidis* and *B. lasus* against *O. arenosella* was found to be 19.3 and 3.1 per cent, respectively. Thus *B. nephantidis* field releases proved to be a more potential bioagent to suppress the pest.

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Table 1. Field releases and effectiveness of *B. nephantidis* and *B. lasus* against *O. arenosella* during different years (1985-87, 1990-91).

Year of study	Experimental orchard no.	No.of parasitoid adult released	Month of release	Parasitism (%) after 15 days of release		Parasitism (%) over control
				Experimental orchard	Control orchard	
A. Brachymeria nephantidis						
1985-86	1	312	December	9.48 (236)	3.54 (162)	5.94
	2	135	March	10.85 (58)	0.00 (50)	10.85
1986-87	1	78	May	60.00 (15)	0.00 (15)	60.00
	2	672	September	10.00 (10)	0.00 (10)	10.00
1990-91	1	365	October	11.62 (450)	1.72 (450)	9.40
	5	1562		20.39 (769)	1.05 (697)	19.34
"t" test significant at 5% (t = 1.95)						
B. Brachymeria lasus						
1985-86	1	194	December	8.57 (47)	0.00 (72)	8.51
1986-87	1	525	August	13.00 (60)	4.00 (25)	9.00
1990-91	1	315	September	8.33 (410)	1.52 (410)	6.81
	3	834		9.97 (517)	1.86(5.07)	8.11

"t" test significant at 1% (t = 4.25)

Figures in parentheses indicate the number of *Opisina* pupae observed.

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ASSOCIATION OF VARIOUS ROOT TRAITS WITH POD YIELD IN GROUNDNUT (*Arachis hypogaea*) UNDER DROUGHT CONDITIONS.

The local released varieties of peanut are susceptible to drought at the flowering stage. Importance of various root traits of plants for adaptation in rainfed areas needs no emphasis. The present experiment was conducted at Dryland Agriculture Research Sub-Station, Dhiansar Jammu (32°-39'N, 70°-55'E) during the spring and rainy season of the year 1990. This station is located at an elevation of 332 meters above the sea level with an annual rainfall of 927 mm, 73% of which falls during the summer (Fig. la and lb). One hundred breeding lines were maintained and evaluated for their nitrogen fixation and yield. Eight cultivars viz., TG-1, TG-2, TG-3, TG-9, TG-17, TG-23, TG-24 were selected which represent the overall variability. These cultivars were grown on two different dates of planting (15th March and 15th July) in randomized block design with three replications. A basal dose of 100 kg of DAP containing 18% nitrogen and 48% P_2O_5 was given at the time of sowing. The crop was sown using hand seed drill with a spacing of 30 cm between and 22.5 cm within rows. The experimental area was lightly hand raked and hoed shortly after the emergence of crop. At the termination of the vegetative phase, five randomly selected plants from each plot were uprooted, gently washed and recorded for various traits viz., root length (cm) root mass (g), nodule mass (g), pod yield (g) and nodule number. The crop was harvested on 28th October. Path co-efficient analysis was performed as per the method proposed by Dewey and Lu (1959). The analysis of variance of the pooled data indicated significant differences between varieties and seasons for root mass, root length, nodule mass, nodule number and pod yield (Table 1 and 2). The varieties TG-17 (March sown) and TG-3 (July sown) recorded longest root with high nodule mass, nodule number, root mass and pod yield. The correlations at the phenotypic level are presented in Table 3. The pod yield per plant was positively correlated with nodule number only in March sown crop. All the characters exhibited positive correlation among them in both the March and July sown crop, association being significant for root mass with root length, nodule mass and nodule number, root length with nodule number in March sown crop whereas in July sown only nodule mass has a positive and significant correlation with root length. Path co-efficient analysis (Table 4a and 4b) revealed that all the root traits studied had negative direct effect in March sown crop whereas in July sown nodule mass and nodule number had positive and direct effect on pod yield. Viands *et al.* (1981) and Pungle (1983) have also reported the association of root mass with different physiological parameters and yield components. Although the traits which exhibited the negative direct effect contributed positively to pod yield per plant via other traits most pronounced being the root mass. Thus for a model plant of peanut under drought condition, cultivar having deep and long root with high nodule mass is desirable.

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Table 1. Analysis of variance.

Source	d.f	Mean squares				
		Root mass	Root length	Nodule mass	Nodule number	Pod yield
Replications	2	0.0025M	57.902M	0.013M	66.24M	14.91M
		0.057J	116.660J	0.009J	73.50J	4.63J
Varieties	7	0.244*,**M	46.277 **M	0.238 **M	764.00 **M	160.10 **M
		0.334**J	12.988 **J	0.156 **J	278.16 **J	17.73 **J
Error	14	0.003M	4.311M	0.017M	17.65M	12.48M
		0.022J	1.136J	0.019J	15.145J	6.04J

M : March sown crop; J : July sown crop.

Table 2. Analysis of variance for pooled data.

Source	d.f	Mean squares				
		Root mass	Root length	Nodule mass	Nodule number	Pod yield
Varieties	7	0.113 **	47.56 **	0.222 **	681.8 **	89.06
Seasons	1	1.755 **	429.00 **	0.089 **	3915.05 **	15066.90 **
Replications/Seasons	2(3-1) = 4	0.03	87.28 **	0.011	69.89 **	10.48 **
Varieties x Seasons	7	0.369 **	11.70	0.172 **	360.35 **	89.17 **
Error	28	0.036	6.42	0.019	18.28	9.16

*, ** Significant at 5 and 1% levels, respectively.

Table 3. Correlation co-efficient for March sown (above diagonal) and July sown (below diagonal) crops for different traits.

Characters	Root mass	Root length	Nodule mass	Nodule number	Pod yield
Root mass	-	0.766 *	0.770 *	0.770 *	0.262
Roat length	0.446	--	0.639	0.885 **	0.525
Nodule mass	0.519	0.795 *	--	0.613	0.048
Nodule number	0.008	0.113	0.390	--	0.731 *
Pod yield	0.062	0.325	0.568	0.580	--

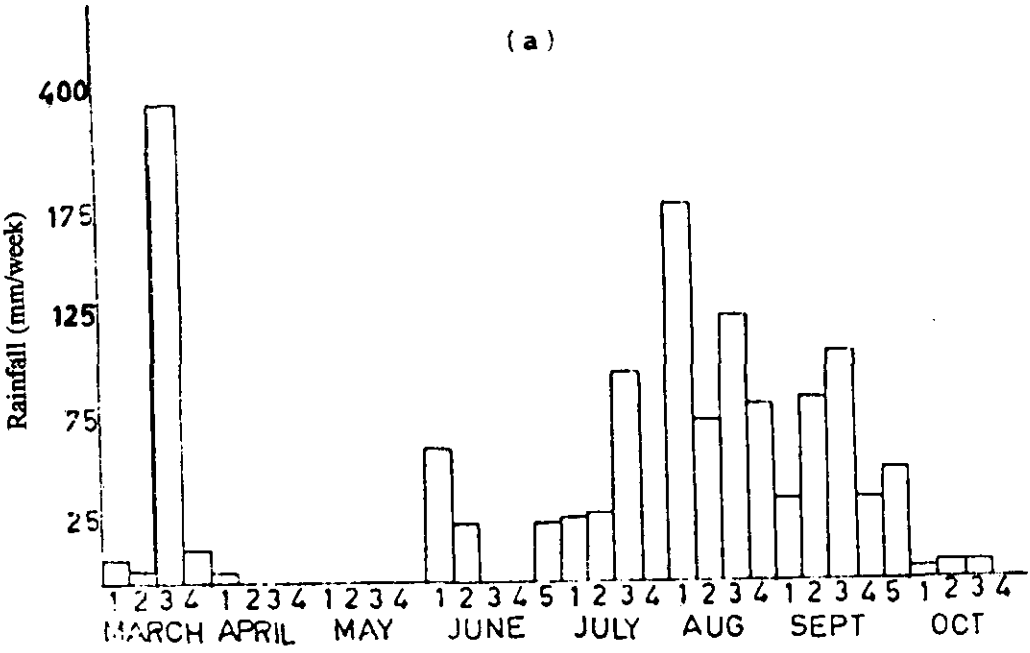
*, ** Significant at 5 and 1 per cent levels, respectively.

Table 4a. Direct and indirect effects of different root characteristics on pod yield in peanut (July sowing)

Characters	Root mass	Root length	Nodule mass	Nodule number	Pod yield
Root mass	-0.222	- 0.063	0.343	0.003	0.062
Roat length	- 0.099	- 0.141	0.526	- 0.038	0.325
Nodule mass	- 0.115	- 0.112	0.662	0.132	0.567
Nodule number	- 0.002	- 0.115	0.258	0.337	0.579

Table-4b. Direct and indirect effects of different root characteristics on pod yield in peanut (March sowing)

Characters	Root mass	Root length	Nodule mass	Nodule number	Pod yield
Root mass	- 0.392	- 0.207	- 0.325	1.186	0.262
Roat length	- 0.269	- 0.300	- 0.269	1.363	0.525
Nodule mass	- 0.442	- 0.302	- 0.172	0.944	0.048
Nodule number	1.540	- 0.302	- 0.239	- 0.259	0.740*



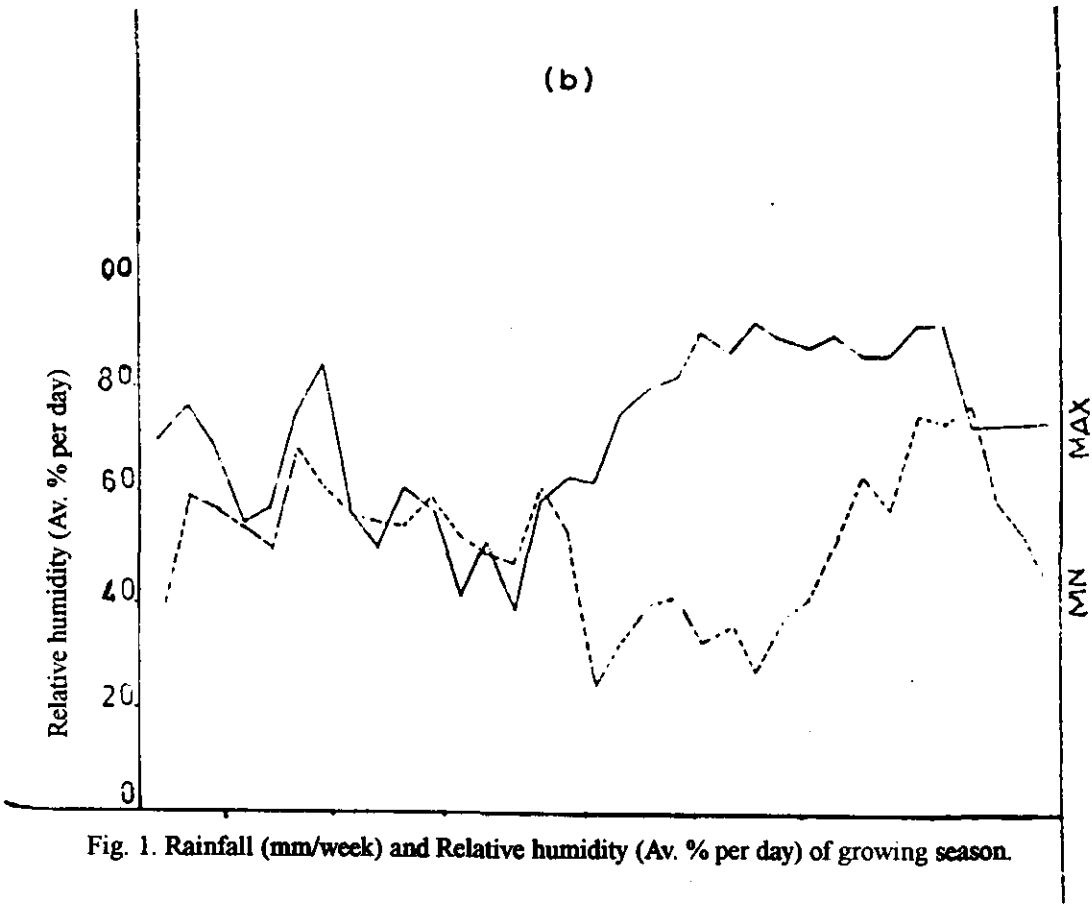


Fig. 1. Rainfall (mm/week) and Relative humidity (Av. % per day) of growing season.

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EFFECT OF DES AND EMS ON FIELD GERMINATION AND SURVIVAL IN GROUNDNUT

Chemical mutagens offer several advantages over the physical mutagens since chances of structural alterations of chromosomes and the resulting genetic deleterious consequences are less (Nayar and Jachuck, 1968). Groundnut is predominately a self pollinated crop species with limited genetic variation for both qualitative and quantitative traits. Mutagenesis offers an excellent scope for increasing the spectrum of variation (Mouli *et al.*, 1989).

In the present study an attempt was made to study the effect of different doses of two mutagens viz. DES (diethylsulphate) and EMS (ethyl methane sulphate) individually and in combinations on field germination and survivality at different stages of crop growth and to decide the LD_{50} with these two mutagens. The 10 treatments consisting of (i) 0.05, 0.10 and 0.20 per cents of each of DES and EMS individually, and the other (ii) 0.05% DES + 0.05% EMS (iii) 0.10% DES + 0.10% EMS, (iv) 0.05% DES + 0.10% EMS, and (v) 0.10% DES +).05% EMS. The genotype used was a Spanish bunch cultivar-Girnar 1 (X14-4-B-19-B x NCA c 17090) possessing good bearing and multiple biotic/abiotic resistances.

The dry seeds were pre-soaked in water for 12 hours and then were transferred to the desired concentrations of DES and EMS in aqueous medium and kept for 4 hours. For combination treatments of DES and EMS, the pre-soaked seeds were soaked with individual mutagen in sequence for 4 hours each. Treated seeds were washed for half an hour in running water and immediately sown in the field directly along with the untreated control in a randomized block design with three replications. The plot size was three rows of 3 m length with a spacing of 45 cm between rows and 10 cm between plants. The observations were recorded on per cent field germination and per cent survival of plants at 15, 30, 45 and 60 days after sowing (DAS) and at harvest.

None of the concentrations of EMS used in the experiment were having high lethality on groundnut seed, though all the concentrations of DES expressed significant mortality over control at harvest. The lethality at 0.20% DES exceeded LD_{50}. The exact LD_{50} of DES should be somewhere between 0.10 and 0.20 per cent. Similarly, the LD_{50} of EMS alone would be above 0.20%. Though germination percentages of combined treatments of 0.10% DES + 0.10% EMS and 0.10% DES + 0.05% EMS were significantly lower than the control, their differences with other two combined lethal effects of DES and EMS on survivality were continuous with the crop age. The survivalities of all those treatments at 45 DAS onward were significantly lower than the corresponding control. Similarly, at harvest stage the survivality of plants in all the doses of DES treatment alone were significantly lower than the control. This was perhaps due to accumulation and/or assortments of the chromosomal alterations caused by the radiomimitic compound used in this experiment was gradual over crop age. In earlier experiments involving most of the plant species, it was established that higher the mutagenic dose beyond LD_{50} lower is the chance of recovery of mutations due to increased lethality caused by gross chromosomal alterations. The combined doses of DES and EMS used in this study were also lower than the dose required for LD_{50} and it is expected to recover more of point mutations than gross chromosomal alterations in those combined treatments in later generations. The single treatment of EMS is likely to produce less mutants since all the doses used were much below LD_{50}. Similarly for DES, all the doses are likely to produce mutants in later generations because all the tested doses were around LD_{50}. Hence, it is

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evident from the present study that LD_{50} of groundnut is above 0.2% for EMS and between 0.1 and 0.2% for DES. Thus DES appear to be more lethal than EMS for groundnut.

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Table 1. Effect of different doses of DES and EMS on field germination and survivality in groundnut

Treatments	Field germination %	Plant survival at (DAS)					
		15	30	45	60	Harvest	Pooled
DES							
0.05%	88.15	87.78	86.30	85.93	85.19	84.08**	85.86
0.10%	87.41	87.04	86.30	84.07	83.33**	82.22**	84.59**
0.20%	25.81**	24.81**	23.33**	22.22**	21.48**	20.00**	22.37**
EMS							
0.05%	95.37	95.26	94.67	93.70	92.59	90.00	93.24
0.10%	94.45	94.45	92.96	91.11	89.26	88.85	91.33
0.20%	90.74	90.37	88.89	86.30	85.93	83.33**	86.96
DES + EMS							
0.05% + 0.05%	87.04	87.04	85.04	82.22**	80.37**	77.41**	82.42**
0.01% + 0.01%	81.11**	80.74**	80.00**	77.41**	75.93**	75.19**	77.85**
0.05% + 0.01%	87.41	86.67	84.07**	78.52**	76.30**	74.45**	80.00**
0.10% + 0.05%	81.11**	80.74**	79.63**	75.56**	73.70**	70.74**	76.07**
Untreated control	98.30	98.00	97.55	96.70	96.70	96.70	97.13
C.D. at 5%	12.8	12.6	13.0	13.1	12.6	11.5	12.6

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SOME MACRO AND MICRO NUTRIENTS IN SESAME SEEDS

Nutrient stress is one of the key factors that lowers the yield of crops. Sesame is cultivated mostly in marginal soils having low organic matter and poor soil fertility. Monitoring nutritional balances both in the plant and soil are imperative for an efficient nutrient management to realize higher seed yield. Plant analysis reveals the level of nutrients, which in turn helps in assessing the nutrient availability in a soil. Analysis of nutrient content in the economic part i.e. seed, gives an indication of overall nutrient requirement and its proportion. Remobilization of macronutrients from various plant parts of the pods of sesame cultivars during the reproductive phase was observed by Balakrishna Reddy and Narayanan (1983). In the present paper macro and micro nutrient contents in the sesame seeds have been examined.

Seeds of sesame varieties (Madhavi, Rajeswari, Gowri, Rama, TC-25 and RT-54) grown in different soils of low to medium fertility status in the agro-climatic conditions at Yelamanchili, Berhampur (Eastern cost plains and Hills), Jagityal (Southern plateau and Hills), Gurudaspur (Trans-Gangetic plains) and Mandore (Western dry region) respectively were collected. The matured seeds of these were analyzed for macro nutrients phosphorus (P), potassium (K) and micro nutrients zinc (Zn), iron (Fe), manganese (Mn) and copper (Cu) by following standard procedures (Jackson 1965). Oil percentage (NMR method) and thousand seed weight were also recorded. Statistical analyses for the individual nutrient content, oil per cent and thousand seed weight were computed following the standard statistical procedures (Table 1).

Macro nutrients P and K in the seeds of different sesame varieties varied from 4968 to 5991 mg/kg and 3375 to 5875 mg/kg, respectively (Table 1). The micronutrients Zn, Fe, Mn and Cu content ranged from 28.3 to 72.8. 58.6 to 375.3, 14.4 to 24.4 and 47.9 to 61.9 mg/kg, respectively. Thousand seed weight and oil per cent were found to vary significantly among the varieties tried. Minimum and maximum thousand seed weight and oil percentage recorded were 2.68 (Madhavi) to 3.63 g (TC-25) and 43.28 (RT-54) to 50.77 per cent (TC-25), respectively. Among the different sesame varieties, the total nutrient content of Madhavi was found to be higher while RT-54 had lower content. Potassium, Zn, Fe, Mn, and Cu content were recorded relatively higher in Gowri and Madhavi varieties and they were statistically significant. The mean P content was higher than K and micronutrient content followed the order Fe>Cu>Zn>Mn. There was a significant variation in the concentration of the micronutrients and potassium, and variation in the P content was found non significant. Balakrishna Reddy and Narayanan (1983) observed that sesame cultivars didn't show differences in absolute concentrations of macro nutrients in various plant parts. Accumulation of Mn in seeds was relatively low, probably due to its less mobile nature in the plant (Wittwer and Teubner 1959) or due to the antagonistic nutrient interactions (Hewitt 1948, Tandon 1995). Information on deficient, sufficient and toxicity levels of essential nutrients in oilseeds is scanty under field conditions. Threshold levels of deficiency for P (2-10 mg/kg), K (2-20 mg/kg), Zn and Cu (0.0001 to 0.005 mg/kg), Mn (0.005 to 0.02 mg/kg) and Fe (0.05 to 2 mg/kg) based on culture trails on a wide variety of crops were reported by Agarwala and Sharma (1976). Though perceptable deficiency was not observed for these nutrients, significant responses to the soil application of macro and micro nutrients in increasing the sesame seed yield in pot culture and under field conditions were reported by researchers (Singh and Tiwari 1985, Muralidharudu and Mev Singh 1990, AICORPO Annual Reports 1990-95).

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Gowri and Madhavi varieties of sesame were found to have higher nutrient requirement of macro and micronutrients. RT-54 showed in general, low nutrient content in seeds than the other varieties tested.

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Table 1. Nutrient content, seed weight and oil per cent in sesame varieties

Variety	P	K	Zn	Fe	Mn	Cu	Total nutrient content (mg/kg)	1000 seed Wt (g)	Oil %
	mg/kg								
Madhavi	5937	5750	70.9	375.3	24.4	61.9	12219.5	2.68	50.0
Gowri	5506	5875	72.8	218.8	20.2	57.6	11750.4	2.82	50.3
Rama	4968	5250	46.8	114.7	14.4	59.4	10453.3	2.96	44.6
Rajeswari	5453	5000	43.7	89.5	15.8	58.5	10660.5	3.39	48.4
RT-54	3567	3375	28.3	58.6	15.3	47.9	7092.1	2.98	43.3
TC-25	5991	5250	56.6	115.0	15.1	60.8	11488.5	3.63	50.3
Mean	5237	5083	53.2	162.0	17.5	57.7		3.08	47.9
S.E. (mean)	761.12	202	3.57	28.66	0.88	1.00		0.0007	0.15
C.D. (5%)	NS	610	10.78	86.40	2.67	3.03		0.0021	0.47

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CHEMICAL COMPOSITION OF SILIQUA CELL WALL AND POSSIBLE RELATIONSHIP WITH POD SHATTERING IN RAPESEED-MUSTARD

Direct harvesting of rapeseed is usually associated with significant loss of seeds (>30%), because of pod shattering in the hot, dry environment at the time of harvest (Labana *et al.*, 1992). Shatter resistance is determined by recessive alleles at two or three gene *loci* which appeared to interact in a dominant epistatic manner (Kadkol *et al.*, 1986), and it is possible to introgress resistance to pod shattering in *Brassicas* (Prakash and Chopra, 1988), though significant differences in pod shattering was observed in various cultivars of *Brassicas*, information on siliquae cell wall constituents and their role on pod rupture/ shattering is scanty. Hence, the present study was taken up to find out the chemical composition of siliqua cell wall consituents of different cultivars of Rapeseed-Mustard and their possible relationship to shattering.

Among the different cultivars of Rapeseed-Mustard grown in Himachal Pradesh, pod shattering is maximum in *B. campestris* (cv. Tobin) followed by *B. napus* (cv. Culture 2), *B. juncea* (cv. RCC 4) and *B. carinata* (cv. HPC 1). Seeds from mature siliquae of different cultivars were separated and the husk was analyzed for cell wall constituents following the method of Goering and Van Soest (1970). Nitrogen was estimated by conventional microkjeldahl's method and crude protein was calculated (A.O.A.C. 1990).

The amount of crude protein was maximum in HPC 1 (8.97%) and minimum in Tobin (4.23%). The Neutral Detergent Fibre (NDF) comprising lignin, cellulose, hemicellulose in siliqua was maximum in Tobin (64.48%) and minimum in HPC 1 (51.58%), whereas Culture 2 and RCC 4 had average values. Therefore, amount of crude protein tends to have inverse relationship with NDF. Lignocellulose (Acid Detergent Fibre, ADF) and cellulose also showed definite pattern, being maximum in Tobin followed by Culture 2, RCC 4 and HPC 1 (Table 1). Acid Detergent Lignin was minimum in HPC 1 (5.18%) and in others it did not differ much. The ash contains silica and minerals and it was maximum in Tobin (12.42%) and HPC 1 (11.95%).

These observations indicate that high crude protein content of siliqua cell wall coupled with low amount of lignin and cellulose may impart resistance to pod shattering in rapeseed mustard.

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Table 1. Cell wall constituents in various cultivars of different Brassicas. (% dry matter).

Constituents	Cultivars			
	Tobin	Culture 2	RCC 4	IIPC 1
Crude Protein	4.23	4.91	7,59	8,97
Acid Detergent Fibre (ADF)	54.95	48.50	48.90	46.40
Neutral Detergent Fibre (NDF)	64.48	58.70	57.70	51.58
Acid Detergent Lignin (ADL)	12.77	8.10	6.75	7.55
Ash	12.42	7.72	9.20	11.95
Hemicellulose	9.53	10.20	9.61	5.18
Cellulose	42.53	40.78	38.89	34.45

* Each value is mean of three determinations.

ADF = Lignin + Cellulose

NDF = Lignin + Cellulose + Hemicellulose + Silica

ADL = Lignin

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EFFECT OF HUMIC ACID COMPLEX WITH BORAX ON AVAILABLE BORON NUTRITION AND YIELD OF SUNFLOWER

Humus plays an important role in the retention of boron by soil and its release to plants. In the present study, an attempt has been made to understand the efficacy of humic acid complex with borax on nutrition and yield of sunflower.

A field experiment was conducted at ARS, Bhavanisagar, Tamil Nadu with sunflower (hybrid BSH-1) during *kharif*, 1992-93 in a non-saline, sandy loam soil. The seven treatments laid out in a randomised block design replicated four times, comprised of control (T1), humic acid complex (HAC) 100 ml (T2), HAC 400 ml (T3), borax at 10 kg ha^{-1} (T4), T4 + HAC at 100 ml (T5), T4 + HAC at 400 ml (T6) and borax @ 2 kg ha^{-1} +HAC 100 ml (T7). A basal dressing of 60:90:90 kgha^{-1} of N, P_2O_5 and K_2O respectively was given uniformly to all the plots as urea, single superphosphate and muriate of potash respectively. Biometric observations were recorded. Oil content was estimated using NMR and the oil yield was computed. Soil organic carbon and hot water soluble - B were estimated by Walkely and Block (1935) and Jackson (1973) methods respectively. The total boron content in plant and seed samples were estimated by following the method of Berger and Trough (1939) and the uptake was computed. The results of biometric observations (Table 1 and 2) indicated the humic acid complex applied at 100 ml (T2) and 400 ml (T3) significantly increased the vegetative growths of sunflower crop, while borax as soil application 10 kg/ha^{-1} did not. HAC at either level in combinations with borax as basal dressing resulted in the highest plant growth and the effect of boron was significantly expressed in presence of HAC. Borax 2 kg ha^{-1} applied as dust at heading (T6) stage was as good as HAC at 100 ml alone (T2), though significantly better than control. This might be due to the role of humic materials as suppliers of good regulators of plant materials and also due to uptake of humic substances to crop itself (Rauthan and Schnitzer, 1982).

Sunflower head diameter increased significantly at HAC 400 ml level. In the presence of boron at both the levels of HAC there was significant improvement in head formation compared to control, the largest beeing in the treatment boron plus 400 ml HAC (T6). Kononova (1966) reported that humic compounds being additional sources of polyphenols which were found to increase respiration rates and metabolism and growth of plants, borax @ 2 kg ha^{-1} level has again recorded results on par with 100 ml HAC level, though significantly higher than control. The beneficial effect was that boron on the enlargement of sunflower head was significantly expressed when HAC applied was at 400 ml level.

The percentage of heads set on the head varied from 84.6 to 90.3. HAC at higher dose only significantly improved the seed set, while borax alone did not influence the seed set. In the presence of borax, the effect of HAC was significant at both the levels and in the presence of HAC borax treated plots significantly improved the percentage seed set. This trend is in line with the findings of Narkhede and Patil (1989). Similarly Kernel to hull ratio (K:H ratio) improved significantly by application of both borax and HAC application either alone or in combinations.

Seed yield of sunflower was significantly increased by HAC application only at higher level and borax alone did not show any improvement. Borax application in the presence of HAC at 400 ml level significantly increased the seed yield by 18.3 per cent. In the presence of boron, significant increase in seed yield was recorded by increasing the HAC from 100 to 400 ml, the percentage increase being 20.2. Chandrasekaran (1992)

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reported increase in grain yield of I.R. -20 Paddy and pod yield of groundnut by urea addition in the presence of HAC or nitrohumic acid. A similar trend was recorded in stover yield also. Increased dry matter yield may be due to the humic acid-induced hormonal effect on the respiratory catalytic activity, cell permeability and increased nutrient uptake (Swayam Prabha *et al.*, 1989).

There was significant improvement in the oil content by the different treatments except in T6 (Borax in combination with 400 ml HAC),. where there was an increase of 7.1 percent in oil content over control. Oil yield was significantly increased by treatments with boron either alone or in combinations with HAC at both the levels.

In view of the above, it can be concluded that application of borax along with organic matter to sunflower is helpful in achieving higher productivity and increased oil yields.

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Table 1. Effect of humic acid complex and boron on biometric and yield parameters

	Treatments	Plant height (cm)	Head Diameter (cm)	Percent Seedset	K : H ratio
T1.	Control	121	11.3	84.6	0.88
T2.	Humic acid complex 100 ml	129	13.2	86.3	1.18
T3.	Humic acid complex 400 ml	130	13.5	88.2	1.40
T4.	Borax at 10 kgha^{-1}	124	12.0	85.4	1.54
T5.	T4 + HAC at 100 ml	136	13.6	87.4	1.32
T6.	T4 + HAC at 400 ml	135	15.8	90.3	1.46
T7.	Borax at 2kgha^{-1} at heading + HAC 100 ml	132	14.1	89.3	1.59
	CD ($P = 0.05$)	5	2.1	1.9	0.10

Table 2. Effect of humic acid Complex and boron on seed and oil content of sunflower, available OC and B content in soil

	Treatments	Seed Yield (kgha^{-1})	Stover Yield (kgha^{-1})	Oil Content (%)	Oil Yield (kgha^{-1})	Orgenic Carbon (%)	Hot water Soluble-B (ppm)
T1.	Control	780	1871	38.1	297	0.07	0.4
T2.	Humic acid complex 100 ml	954	2292	38.7	369	0.13	0.5
T3.	Humic acid complex 400 ml	1030	2490	39.2	404	0.14	0.7
T4.	Borax at 10 kgha^{-1}	925	2208	40.4	374	0.14	1.8
T5.	T4 + HAC at 100 ml	1013	2417	40.2	407	0.15	4.1
T6.	T4 + HAC at 400 ml	1218	2845	40.8	497	0.17	3.1
T7.	Borax at 2kgha^{-1} at heading + HAC 100 ml	869	2452	39.5	383	0.22	1.3
	CD (P = 0.05)	181	350	2.4	65	0.02	0.6

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STUDIES ON OIL BUILD UP IN DEVELOPING SAFFLOWER SEED *(Carthamus tinctorius)*

The oil build up in the developing achenes of safflower is known to be influenced by several biotic and abiotic factors. Besides safflower oil is considered to be the best for its quality in view of higher amount of polyunsaturated fatty acids. As the post anthesis assimilates support the seed development and oil buildup (Canner and Cawood, 1978) it is very important to know the critical stage of oil build up to ensure both quantity and quality of the oil. In the present investigation only the quantitative accumulation of oil at different stages of seed development is studied.

Six different safflower cultivars comprising three varieties A-1, A-2, 1000-2 and three hybrids DSH-107, DSH-116 and DSH-129 were grown under uniform fertility conditions in a randamized block design with three replication at the Agricultural Research Station, Annigeri during *rabi* 1995-96. Recommended spacing of 45 cm and 20 cm between inter and intra rows, respectively was provided to raise a good crop. In each replication 25 plants that flowered on the same day (zero day) for any cultivar were selected and tagged. Sampling was done at seven day intervals from the day after anthesis (DDA) up to 42 days by which time the capitulum turned golden yellow in colour. Seed samples investigated at a particular stage of maturity corresponded to the seeds in the outermost two to three whorls of the capitulum. Each sample contained seeds from all the three replications of the respective genotype. Soon after removal from the plants the seed samples were dried in an oven at 55-60 °C for 48 hours. The oil content of various samples was determined using NMR spectrometer.

The maturation of achene occurs over a period of several days after the anthesis during which oil accumulates in the developing endosperm. It could be seen that (Table 1) oil synthesis and accumulation started as early as zeroeth day. The accumulation of oil has been gradual both in varieties and hybrids from '0' DAA to 14 DAA but between the interval of 114 DAA to 21 DAA there was quantum jump in the oil accumulation. Similar spurt in oil build up between the interval of 15 DAF and 20 DAF has been reported by Lakshminarayan *et al.* 1984 in sunflower. From 21 DAA onwards till the harvest again the oil build up was gradual. However, a slight decline in the oil build up between 42 DAA and harvest was noticed in certain cultivars.

The genotype differences were observed for oil build up at a particular stage of development of the seed. In respect of variety, A-2 recorded lower oil content at zeroeth day as compared to A-1 and 1000-2 but surpassed them at 7 DAA and maintained its superiority even at later stages. Similar pattern of oil build up was noticed in case of hybrid DSH-107 surpassing the other two hybrids at 14 DAA. There were no appreciable differences between varieties and hybrids as regards to oil build up at different stages.

It is concluded that oil build up in safflower occurs over a period of 42 days from anthesis of the capitulum and middle of this period is considered to be crucial for protecting the crop from any stress conditions.

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Table 1. Oil content (%) of different safflower cultivars at different stages of seed development

Days after anthesis	Varieties				Hybrids				Grand maan
	A-1	A-2	1000-2	Mean	DSH-107	DSH-116	DSH-129	Mean	
0	10.02	8.96	11.77	10.25	10.55	15.89	10.54	12.33	11.29
	(31.72)	(26.39)	(38.45)	(32.19)	(31.57)	(47.05)	(31.59)	(36.74)	(34.47)
7	12.95	16.20	12.55	13.90	16.86	17.84	12.56	15.75	14.83
	(41.00)	(47.71)	(40.99)	(43.23)	(50.45)	(52.83)	(46.98)	(46.98)	(45.11)
14	15.66	16.79	14.38	15.61	24.14	17.96	13.01	18.37	16.99
	(49.08)	(49.46)	(46.98)	(48.51)	(72.23)	(53.18)	(38.99)	(54.80)	(51.66)
21	26.89	26.27	22.18	25.11	30.00	26.88	25.78	27.55	26.33
	(85.14)	(77.38)	(72.46)	(78.33)	(89.77)	(79.61)	(77.28)	(82.22)	(80.28)
28	28.65	28.74	24.68	27.36	31.24	28.82	28.26	29.44	28.40
	(90.75)	(84.65)	(80.63)	(85.33)	(93.48)	(85.34)	(84.72)	(87.85)	(86.59)
35	29.42	31.48	27.21	29.37	32.62	30.26	30.78	31.22	30.29
	(93.16)	(92.72)	(88.89)	(91.59)	(97.61)	(89.61)	(92.27)	(93.16)	(92.38)
42	31.58	33.23	29.90	31.57	33.42	32.62	33.16	33.07	32.32
	(100.00)	(97.88)	(97.68)	(98.52)	(100.00)	(96.59)	(99.42)	(98.67)	(98.60)
Harvest	30.93	33.95	30.61	31.83	33.04	33.77	33.36	33.39	32.61
	(97.94)	(100.00)	(100.00)	(99.31)	(98.86)	(100.00)	(100.00)	(99.62)	(99.47)

Figures in parentheses are relative percentages

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EFFECT OF CROPPING SYSTEMS AND NITROGEN ON OIL CONTENT AND NODULATION IN *Kharif* GROUNDNUT.

Groundnut, which ranks first among the oilseed crops, is becoming popular among the farmers as a cash crop. Intercropping is considered as one of the attempts for achieving maximum production per unit area per unit time. Grasses, preferably mixed with legumes, have been reported to build up soil fertility to economise the requirement of fertilizers and to improve and enrich the quality of herbage. Instead of taking sorghum (forage) as a sole crop with higher doses of N application, sorghum and groundnut combination give higher return with moderate level of nitrogen whereform both green forage and oilseed may be obtained for cattle feed as well as for human consumption.

The present study was conducted at the Central Research Farm, Gay-espur, Bidhan Chandra Krishi Viswavidyalaya, West Bangal, India, located at 23°N latitude, 89°E longitude and at an elevation at 9.75 m above sea level, during the summer (March to June) of 1988 and 1989. The experimental soil was sandy loam with 0.663%N, 15.72 kg/ha available P, 152.87 kg/ha available K and pH 6.8. The experiment was laid out in split plot design with three replications. The main plot treatments consisted of 4 nitrogen levels (0, 40, 80 and 120 kg/ha) and each main plot was divided into sub-plots with 5 cropping systems (viz, sole sorghum, sole groundnut, sorghum+ groundnut at 1:1 planting ratio, sorghum+groundnut at 2:1 planting ratio, sorghum+groundnut at 1:2 planting ratio). Inter and intra row spacing was maintained at 30 and 10 cm respectively in both sorghum (MP chari) and groundnut (JL 24). In pure stand, the seed rate of sorghum and groundnut was 50 and 100 kg/ha, respectively whereas the seed rate used for component crops in inter crop systems were based on land use by different crops. Nitrogen was applied as per treatment in the form of urea. Whereas phosphorus and potash was applied @ 60 and 40 kg/ha, respectively, in the form of single super phosphate and muriate of potash. Half of nitrogen and full doses of P and K were applied as basal before sowing and rest half of N was topdressed at 30 days after sowing. The total rainfall was 1577.5 and 1200.4 mm during 1988 and 1989, respectively. A standard sampling technique was adopted for root nodules where randomly selected groundnut plants were uprooted with a block of soil measuring 15 cm x 15 cm. The percentage of oil was determined by solvent-extraction method in soxhlet apparatus with petroleum either (BP 40-60°C) as solvent.

The number of nodules/plant significantly increased with 40 kg N/ha compared with control upto 45 DAS during both the years (Table 1) At 60 DAS control treatment recorded significantly higher number of root nodules compared with other treatments and thereafter declined with the increasing rate of nitrogen supply (80 and 120 kg/ha). It might be attributed to the shading of groundnut canopy by tall up with higher levels of nitrogen. Reddy and Chatterjee, 1973; Franco, 1977 and Nambiar and Dart, 1980 opined alike. The legumes grew better at lower levels of nitrogen compared with higher does (80 and 120 kg N/ha) and a greater advantage from inter cropping and nitrogen economy at lower level compared with higher level was obtained.

The number of nodules/plant of groundnut in sole as well as all inter cropped plots increased upto 45 DAS and declined afterwards during both the years of experimentation (Table 1). Sole crop of groundnut recorded higher number of nodules/ plant from 45 DAS on wards compared with intercropped groundnut plots. Higher number of nodules/plant in pure crop than in mixed crop than in mixed crop was also reported by Reddy and Chatterjee, 1973.

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Oil content in groundnut kernel significantly increased upto 40 kg N/ha during both the years (Table 1). A decreasing trend in oil content was found with increasing levels of N supply (80 and 120 kg/ha) Krishnanada et al., also obtained similar results.

Groundnut in 1 : 2 planting ratio of sorghum+groundnut recorded significantly higher oil content compared with other inter cropped groundnut but statistically at par with sole crop of groundnut.

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Table 1. Effect of nitrogen and cropping systems on number of nodules/plant and oil content (%) in *groundnut during kharif.*

Treatment	Number of nodules/plant of groundnut						Oil content (%)	
N levels (kg/ha)	30 DAS		45 DAS		60 DAS			
	1988	1989	1988	1989	1988	1989	1988	1989
N0	112	96	168	168	201	193	46.43	46.44
N40	147	138	223	196	180	166	50.13	49.14
N80	112	105	173	172	157	150	48.47	47.69
N120	92	95	142	147	82	70	47.77	46.85
S.Em(+)	6.86	7.47	4.79	11.13	5.44	8.6	5 0.05	0.03
C.D. at 5%	16.78	18.29	11.72	27.23	13.32	21.16	0.12	0.08
Cropping Systems								
Groudnut	118	115	197	190	170	162	48.35	47.60
S + G (1:1)	116	104	170	158	151	135	48.08	47.44
S + G (2:1)	100	91	149	144	137	127	48.22	47.34
S + G (1:2)	130	124	191	186	163	165	48.16	47.74
S. Em (+)	8.38	8.42	8.31	8.41	6.19	7.66	0.05	0.07
C.D. at 5%	17.29	17.39	17.16	17.36	12.79	15.81	NS	0.14

S=Sorghum; G=Groundnut, NS = Not Significant.

INFORMATION FOR CONTRIBUTORS

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