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SHORT COMMUNICATIONS

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Genetic improvement of oil yield in safflower: problems and prospects

M. Ramachandram
Directorate of Oilseeds Research, Hyderabad-500 030, India

ABSTRACT

Low seed oil content of about 28 to 32 per cent in all currently available varieties of safflower makes it a poor competitor under intensive cultivation. In an attempt to elevate the oil content of local varieties, thin, reduced and striped hull types were utilised in breeding programmes. The inherent defects of *th* and *rh* genes hindered the isolation of desirable recombinants in segregating populations. The derivatives of crosses involving one or the other allele of *stp* gene were found promising in initial evaluation trials.

The number of capitula per plant, seed weight, seed number per capitulum and proportion of hull are identified to be the principal components of oil yield. Highly significant negative correlations between the proportion of hull—oil per cent of whole seed, seed number—seed weight and yield per capitulum—capitula per plant are important from the point of selection criterion. Non-additive gene action predominated in the inheritance of seed yield and capitula per plant while additive component formed the major fraction in case of seed number, seed weight and proportion of hull. Based on the nature of gene action and available variability in breeding behaviour of the crop, future breeding strategies aimed at bringing simultaneous improvement in seed yield and oil content are suggested.

Key words : Seed yield; oil content; simultaneous selection; safflower; *Carthamus tinctorius*

INTRODUCTION

Low seed oil content of about 28 to 32 per cent in all local types makes safflower (*Carthamus tinctorius Linn*) a poor competitor despite its high yield potential to the extent of 32 q/ha under optimal agro-climatic conditions (Chowdhury, 1979). The genetic upgradation of ultimate product in safflower unlike major oilseed crops involves simultaneous improvement of seed yield and oil content. In our endeavours to achieve this goal, a thorough understanding of the genetic basis of constraints withholding the overall improvement of oil yield in the light of available information and experience so far gained would form prelude to reorient future breeding programmes.

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Problems encountered

Having realised the limitation of local improved varieties, the elevation of oil content by making use of the mutant hull types like thin, striped and reduced hull possessing 42 to 46 per cent oil content without altering the existing yield levels of local material formed the first step in the varietal improvement programmes of safflower in India. The sole objective of these programmes was to transfer the mutant genes responsible for low hull content to the local varieties through conventional breeding methods, i. e. pedigree and back cross breeding. Accordingly, the mutant hull types namely Th. 5, Th. 10, Rh. 4, AC. 1 and Frio as donor parents were extensively utilised in crossing programmes. The outcome has not been very encouraging for various reasons.

The pleiotropic effect of *th* gene on delayed anther dehiscence resulting in poor seed set and weak stems (Ebert and Knowles, 1966) hindered the isolation of desirable recombinants in segregating populations. Likewise, the association of *rh* gene with small seed size coupled with its low penetrance while attempting to combine it with the bold seed size of the local varieties made the crosses nearly total failure. The striped hull controlled by multiple alleles became the ultimate choice. The crosses involving purple and green striped hull types and A. 300, A. 1 and later on S. 144 as the local base were advanced by following pedigree as well as back cross breeding methods. A large number of striped hull types were isolated after every back cross cycle. Majority of these progenies got eliminated while stabilising by selfing generation after generation due to loss of initial vigour. Quite a few back cross derivatives evaluated in the Initial Evaluation Trial of Coordinated Project were found promising in some selected locations (Table 1). The improvement in oil yield to the extent of 41% in case of BLY.642 over the check variety, A.1 is commensurable with the objective of this programme.

Interrelations among principal components

The first partitioning of economic product in safflower is into seed yield and oil content, of which the former being a complex character (Ramachandram and Goud, 1981) is more influenced by genotype - environment interactions (Ranga Rao and Ramachandram, 1979). Accordingly further attempts to partition the seed yield (Ashri *et al.*, 1974; Khidir, 1974; Abel, 1976; Mathur *et al.*, 1976; Ranga Rao *et al.*, 1977; Makne *et al.*, 1979; Thombre and Joshi, 1981, Ramachandram and Goud, 1982 a) resulted in the identification of total capitula per plant and yield per capitulum as direct components, the latter being a function of seed weight and seed number. Other characters like plant height, height of branching, length of primary branch, stem girth and growth duration showed significant association with seed yield because of their indirect effects through total capitula per plant. The oil content of whole seed having a bearing on seed

Table 1 : Yield potential of some high oil derivates in selected locations (IET-II : Safflower Annual Report, AICORPO, 1983-84, Directorate of Oilseeds Research, Hyderabad.)

	Entry	Pedigree	Seed Yield (kg/ha)						Mean	
			Rajendranagar	Latur	Phaltan*	Bellary	Jalna	Mean	Oil per cent	Oil yield (kg/ha)
1.	BLY 625	AC.1 x A.1[3]	1755	741	1672	827	1679	1335	37.8	505
2.	BLY.616	,,	807	789	1881	1123	1751	1270	36.5	463
3.	BLY.642	,,	663	966	2213	918	2742	1500	35.4	531
4.	BLY.1080	S. 144 x VFstp.1	508	778	2318	1079	1655	1282	36.0	461
5.	HOP.22	A. 1 x VFstp.1[2]	753	623	2213	1245	2432	1453	35.4	514
6.	A. 1	—	1394	934	1278	929	1946	1296	29.0	376

* Irrigated trial

weight and seed number acting in opposite directions is influenced to a large extent by the proportion of hull (Claassen *et al.*, 1950; Elsaeed, 1966; Ranga Rao *et al.*, 1977; Sangale *et al.*, 1982).

It is evident that the number of capitula per plant, seed number per capitulum, seed weight and hull content are the principal components of oil yield per unit area. Breeding for higher yield through increased number of capitula has been and will probably continue to be important in arid and semi-arid areas. On the other hand, the plant type with fewer but larger capitula is expected to respond more to intensive crop management practices. A combination of all the four principal components in optimum proportion would constitute the most desirable plant type, for the reconstitution for which the inter-relations form the basis of selection (Grafius, 1964).

Selection criteria

Highly significant correlation between total capitula and yield per capitulum as well as one of its component character, the seed number per capitulum (Table 2) poses a serious problem to the indirect selection for seed yield through principal components. Thus simultaneous selection for yield per capitulum and total capitula needs to be based on appropriate weights. Alternatively, restricted selection of Kempthorne and Nordskog (1959) could be followed wherein the improvement has to be effected directly for yield per capitulum by keeping total capitula

Table 2 : Interrelations among principal components of oil yield in safflower

	Seed weight@	Seed number @	Oil content @	Hull content @@
Total capitula	0.16	—0.54**	—0.19	—0.01
Seed weight		—0.37**	—0.70**	0.51**
Seed number			0.38**	—0.16
Oil content				—0.83**

@ Genotypic correlations (Ramachandram and Goud 1982 a)

@@ Phenotypic correlations (Ranga Rao *et al.*, 1977)

as a constant variable. It is possible to increase the number of capitula per unit area by manipulating the population density. Ashri *et al.* (1974) and Ramachandram and Goud (1982 a) emphasized the potentiality of a plant type with fewer but larger capitula having maximum number of reasonably heavy seeds. The orientation of branches on the main stem in terms of angle and length of branch in such a plant type play an important role in increasing the response to population levels. Thus the desirable plant type should have shortest primary branches (less than 10 cm length) oriented at an angle of around 20° with highest yield per capitulum.

The improvement in yield per capitulum has to come through the manipulation of seed number and seed weight which are again negatively correlated. The oil content of whole seed is influenced by seed weight through the proportion of hull. Once the hull content is brought down, the size of the kernel and the seed number become the critical factors for yield per capitulum and the negative correlation between these two components calls for simultaneous selection based on appropriate weights.

Gene action and heritability

Limited information drawn from the studies of Ehdaie and Ghaderi (1978), Kotecha and Zimmerman (1978), Kotecha (1981), Deokar and Patil (1980), Channeshappa (1980), Ramachandram and Goud (1981, 1982 b, 1982 d) and Ranga Rao (1983) revealed the predominance of non-additive gene action in the inheritance of total capitula while the additive effects and the interactions involving additive component were equally important in case of seed weight and seed number per capitulum. Consequently, both additive and non-additive fractions of the genetic variance were found to control the seed yield, though the latter took an edge over the former. Accordingly, narrow sense heritability as per Ramachandram and Goud (1981) was lowest (22%) for seed yield followed by total capitula (45%), while the same estimates were 82% and 84% for seed weight and seed number respectively. The studies of Yazdi-Samadi *et al.* (1975), Deokar and Patil (1979), Ramachandram and Goud (1982 c) and Ranga Rao (1982) on the extent of heterosis confirmed the major role of non-additive gene action for seed yield. Depending on the genetic diversity of the parents involved (Ranga Rao *et al.*, 1980), the hybrids differed in the expression of heterosis, the indigenous improved varieties and the exotic types forming the best combinations (Table 3).

On the other hand, the seed oil content (Ramachandram and Goud, 1981; Vijayakumar and Giriraj, 1980) and its direct component character, the proportion of hull (Channeshappa, 1980) were predominantly under additive gene control. As a result, the narrow sense heritability was as high as 92% in the studies of Ramachandram and Goud (1981), In fact, the hull content of seed is controlled by independent mutant genes like *th, stp* and *rh*, which indirectly influence the oil content by bringing down the proportion of hull. The improved types, *viz.*, AC. 1, Frio, Rio, Royal and VFstp. 1 possessing one or the other alleles of *stp* are characterised by high general combining ability and form the potential lines for breeding programmes aimed at high oil content.

Breeding methodology

Though the nature of gene action indicated distinct advantage of heterogygosity in so far as seed yield is concerned, it is the existing variability in breeding behaviour of the crop that decides on the type of variety to be developed. Safflower is essentially a self-pollinated crop (Claassen, 1950), the extent of out crossing being dependent on the mode of anther dehiscence (Ramachandram and Ranga Rao, 1984) and the activity of insect pollinators (Karve *et al.*, 1981). Besides, the male sterility (Heaton and Knowles, 1982) and self-incompatibility identified in *Carthamus flavescens* (Imrie, 1969) are of immense use to the breeder in maintaining the heterozygosity, though not facilitates to produce hybrids on commercial scale.

Against the background of near failure of hybrid breeding progrommes utilising delayed anther dehiscence of *th* gene (Urie and Zimmer, 1970) and gamma ray irradiation of female parent, alternate breeding methods facilitating to exploit additive and non-additive components of genetic variances are advocated (Ramchandram and Goud, 1981). The appearance of high proportion, of

Table 3 : Parental diversity in the expression of heterosis and inbreeding depression for seed yield in safflower (Ramachandram and Goud, 1932 c)

Cross			Heterobelteosis (%)	Inbreeding depression (%)
Indian × Indian				
A. 1	×	S. 144	34.8	3.5
A. 1	×	MS. 49	10.6	—19.7
A. 1	×	6 Spl	22.1	11.4
Indian × Exotic				
A. 1	×	G. 1157	127.4	38.4
A. 1	×	VFstp. 1	179.1	40.1
MS. 49	×	AC. 1	280.1	26.0
MS. 49	×	VFstp. 1	164.8	0.4
Exotic × Exotic				
AC. 1	×	G. 1157	14.3	39.4
G. 1157	×	VFstp. 1	30.5	16.4
AC. 1	×	VFstp. 1	83.2	10.5

parental types in segregating populations of crosses involving high oil and low oil types, similar character association in parents and F_2 populations and high heterogenety for the estimates of genetic components together suggest the action of strong conservative force resulting from linkage in inhibiting the frequency of genetic recombination (Hanson, 1959). For such situations, breeding procedures which would maximise the opportunity of breaking up of the linkage blocks are needed. In this respect, biparental mating amongst the segregates rather than continued selfing or recurrent backcrossing encourages the release of concealed variability. Another method of working with such complex situation as encountered in the simultaneous improvement of seed yield and oil content is mutagenesis, which shifts the mean in the desired direction. The presence of high non-additive gene action for seed yield necessitates the maintenance of heterozygosity in the population. In the present context it is achieved by following either recurrent selection methods or maintaining the open pollinated population resulting from intercrossing the desirable genotypes possessing high general combining ability.

The intermating population involving all possible crosses of superior inbreds is subjected to biparental progeny selection as described by Murthy (1979). This approach of simultaneous introduction of more than two parents in the population though provides broad genetie base (Jensen, 1970) suffers from the complexity of selection procedure as the improvement involves more than two characters. In either case, the utilization of recently identified genetic male sterility facilitates large scale crossing in segregating population.

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Identification of risk efficient genotypes in toria

P. R. Kumar and N. P. Singh
All India Coordinated Research Project
on Oilseeds (Rapeseed-Mustard), Haryana Agricultural University,
Hisar-125 004, India

ABSTRACT

A study was undertaken to identify risk efficient genotypes in Indian rape (*Brassica campestris* L. var. *Toria.*) For this purpose, a wide array of genotypes of Indian rape tested at different agro-ecological conditions of the country during 1978-79 to 1981-82 under the All India Coordinated Research Project on Oilseeds were examined. To estimate the stability and adaptability components of variance, the analysis was carried out using the decision theoretic concept of risk aversion. It was observed that two components of variance were uncorrelated and the preference based ranking did not differ significantly from yield based ranking. in order to confirm the stable nature of selected genotypes and their response to different environments , the Eberhart and Russell (1966) model was used.

Key words : *Brassica campestris*; stability; adaptability; risk aversion

INTRODUCTION

During 1981-82, the oleiferous Brassicas occupied 12.439 million hectares and produced 14.319 million tonnes of oilseed in the world. India ranks first in acreage and third in production. The productivity of Brassica oilseed in India is quite low (545 kg/ha) compared to the world average (1151 kg/ha). An important reason for low productivity is that though Brassicas are energy rich crops, they are cultivated largely under the conditions of energy starvation, mostly on marginal and sub-marginal lands. These factors made these crops as highly uncertain in terms of net returns. Taking these facts into consideration, Kumar and Singh (1983) worked out the stability and adaptability components of variance in Indian mustard (*Brassica juncea* (Linn) Czern & Coss.). They identifed four risk efficient varieties, two each for rainfed and irrigated situations in the country. Realising the immediate need for having stable and adaptable varieties of Toria (*Brassica campestris* L.), an important cash crop of the country, a similar type of study was carried out. The results of these findings are presented in this paper.

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MATERIALS AND METHODS

In order to identify risk efficient genotypes of Toria, multi year and multi-locational data of the All India Coordinated Research Project on Oilseeds were computed. A set of nine strains of *Brassica campestris* L. var. Toria, viz., PT-303, PT-30, PT-507B, ITSA, Sangam, T-9, LUDHC-2, TH-11 and LUDHC-1 was selected out of a total of 140 strains tested at 18 locations in the country from 1979 to 1982 under irrigated conditions. A fertilizer dose of 50:25:25kg/ha NPK was given uniformly in all the experiments. The lay out of the experiments was randomized complete block design with 3-4 replications. The plot size varied from 1.5×5m for Initial Evaluation Trials (IET) and 0.05 hectares for minikits. The row to row distance was 30 cm while the plant to plant distance was maintained at 10 cm. The analysis of variance technique was used for such an analysis neglecting the replications. For some genotypes, if it was not tested at a particular location, the analysis of variance was carried out using the missing plot technique.

A farmer at any given location only experiences the average yield and stability as his level of risk. A ranking for selecting a strain by a farmer was established on the basis of the average yield and using the decision theory under risk. For risk analysis, the stability was measured by standard deviation and risk preferences by the trade-off between the standard deviation and mean seed yield. For a decision maker, this leads to a unique preference based ranking for selecting a strain with given risk preference level. For this purpose, the Expected Returns Variance Analysis (E-V analysis) given by Anderson *et al.* (1977) was used.

Taking into consideration the level of satisfaction of the farmers and average seed yield of selected set of genotypes and based upon the assumptions and findings of Binswanger (1980), utility curves for the utility functions were constructed. Here, the slope $\frac{\Delta S}{\Delta Y}$ of these utility curves was taken as a measure of risk aversion of the farmers (Fig. 1). The idea behind using this theory for identification of risk-efficient strains in Toria was the similarity of the economic conditions of farmers, mode of farming and other conditions of marginal and sub-marginal farmers interviewed by Binswanger (1980).

In order to confirm the stable nature of selected genotypes and their response to different environments, the Eberhart and Russell (1966) model was also used.

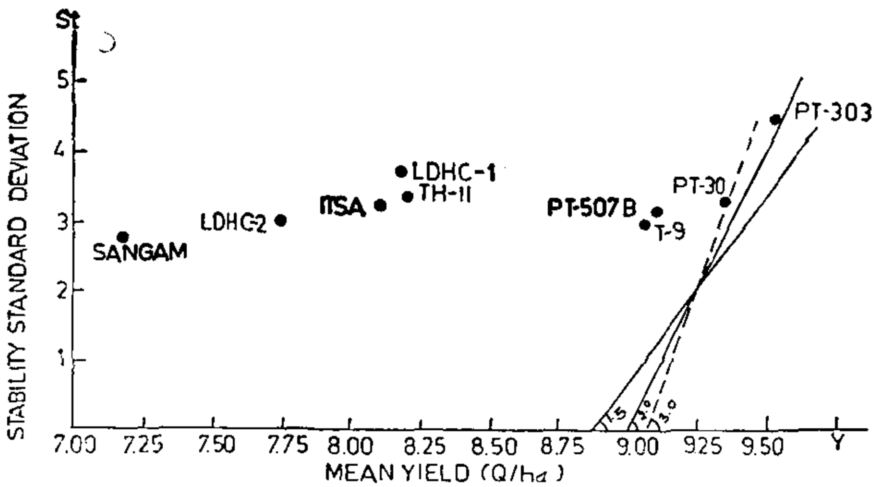
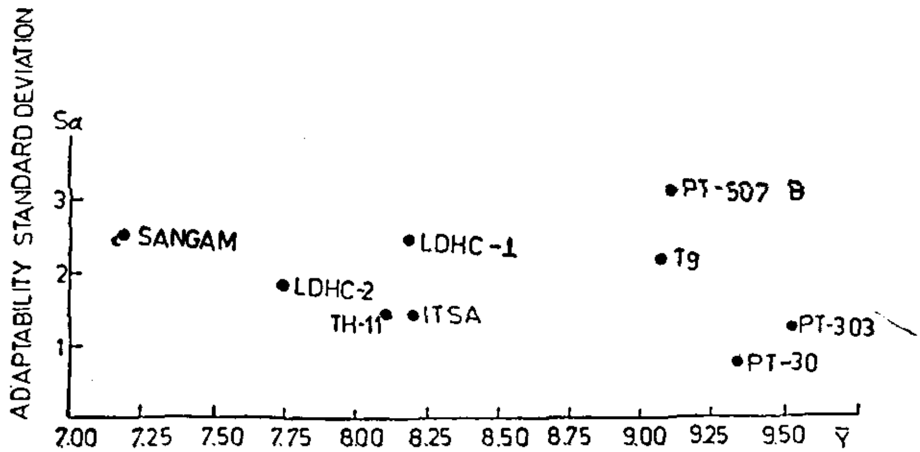


Fig. 1 : Ranking according to risk preference



MEAN SEED YIELD (Q/ha)

Fig. 2 : Scattered diagram of seed yield and adaptability standard Deviation

RESULTS AND DISCUSSION

According to Binswanger (1980), a genotype is risk efficient, (1) if no other genotype among the tested genotypes can achieve the same seed yield with lower standard deviation and (ii) the same standard deviation with higher seed yield. Likewise, adaptability efficiency of a genotype is (i) if no other genotype among the tested set of genotypes can achieve the same average seed yield with lower adaptability relevant standard deviation and (ii) same adaptability relevant standard deviation with higher seed yield. Based upon these criteria, a set of risk efficient strains (PT-303, PT-30, T-9 and Sangam) and adaptability efficient strains (PT-303 and PT-30) were identified. The strain PT-303 was higher in stability relevant standard deviation with the highest average seed yield. The higher standard deviation observed for this strain appears to be due to the highest seed yield. It shows that this particular high yielding strain is suitable for better environmental conditions. It is interesting to note that the same strain, PT-303 has the least adaptability relevant standard deviation showing thereby wider adaptability of this particular strain under different agro-ecological conditions of the country.

The stability relevant standard deviations were plotted against the mean seed yield of each strain at all locations over all the year (Fig. 1). The utility curves were also constructed for three levels of risk aversion, *viz.*, 1.5, 2.0 and 3.0.

It was observed that for two levels (2.0, 3.0,) the proposed strain with rank one was PT-303 while for level (1.5), the preferred strain was PT-30. Furthermore, the yield based ranking and the preference based ranking for two levels of risk aversion (2.0, 3.0) coincides for all the strains. For the third level, i.e., 1.5, the ranking differs with the average seed yield ranking These ranking are presented in Table 1. The adaptability relevant standard deviation was plotted against average yield (Fig. 2). In the absence of a choice-theoretic-criterion for trading-off the seed yield against adaptability variance, one can only infer from the figure that a particular genotype is more adaptive than the other in adaptability sense and average yield. In the present study, the strain PT-30 showed the least adaptability standard deviation. It is also noted that adaptability and stability efficients sets contain common strains. But these two components of standard deviation are not correlated. These findings are in conformity with the results of Evenson *et al.* (1978) and are of significance from crop improvement point of view. These two attributes are subject to selection by plant breeders who can achieve higher stability or wider adaptability by sacrificing other plant attributes.

When the Eberhart and Russell (1966) model was used in the same set of data, the mean sum of squares due to genotype × environment were found to be significant (Table 3). These results indicate that genotypes interacted significantly with evironments. The partitioning of sum of squares and reminder mean sum of squares also indicated their significance (Table 3). The magnitude of linear component (regression mean sum of squares) was high suggesting thereby possibility of prediction across the environments.

An attempt was also made to isolate an ideal variety possessing the high mean yield, average response ($b_i = 1$) and as small as possible the deviation

Table 1 : Ranking of Toria genotypes according to different device criteria and in different years under irrigated conditions

Genotype	4 years average yield (q/ha)	Ranking				Stability standard deviation	Adaptability standard deviation
		Yield based	Risk preference based				
			(1.5)	(2.0)	(3.0)		
PT-303	9.5208	1	2	1	1	4.5154*	1.3277**
PT-30	9.3666	2	1	2	2	3.3250*	0.7869**
PT-5078	9.1104	3	4	3	3	3.1735	3.1531
T-9	9.0738	4	3	4	4	3.0161*	2.1991
ITSA	8.2800	5	5	5	5	3.4030	1.5044
LDHC-1	8.1896	6	7	6	6	3.7441	2.4500
TH-11	8.1050	7	6	7	7	3.3045	1.4905
LDHC-2	7.7538	8	8	8	8	3.0074	1.7645
Sangam	7.1838	9	9	9	9	2.7779	2.5757

* Stability efficient set. ** Adaptability efficient set.

Table 2 : *Estimates of Stability parameters* in respect of seed yield in Toria

Sr. No.	Genotype	4 years average yield (q/ha)	b_i	Sd_i^2
1.	PT-303	9.5208	1.2660*	1.4279
2.	PT-30	9.3666	0.4489*	1.9889
3.	PT-5078	9.1104	1.5774*	—0.5362
4.	T-9	9.0738	1.2062*	—0.0790
5.	ITSA	8.2000	0.2325*	2.7597
6.	LDHC-1	8.1896	0.7728*	2.6608
7.	TH-1	8.1050	0.2250	1.0425
8.	LDHC-2	7.7538	1.4385	—1.5758
9.	Sangam	7.1838	1.1050	1.2971

* Significant at 5% level.

Table 3 : Pooled analysis of variance for seed yield in Toria

Source of variation	D. F.	M. S. S.
Varieties	8	5.5545*
Environment + (Var. × Envi.)	45	5.9962
Environment (Linear)	1	71.0372
Variety × Environment (Linear)	8	14.2572**
Pooled Deviation	36	2.3550*
Pooled Error	162	0.9412

* Significant at 5% level. ** Significant at 1% level.

around regression slope (i.e., Sd^2_i). A perusal of data presented in Table 2 indicated that genotype PT-303 possessed the highest seed yield, above average response and non-significant deviation around regression. Besides this, two more genotypes namely, PT-507B and T-9 also exhibited appreciably high seed yield, above average response ($b_i > 1$) and non-significant deviation around regression slope. These findings suggest that genotypes PT-303, PT-507B and T-9 are suitable only for better environments. The strain LDHC-1 was observed to possess average seed yield, below average response ($b_i < 1$) and non-significant deviation around regression slope indicating thereby the suitability of this strain to low yielding environments.

It is of interest to note that all the genotypes under the test attained non-significant Sd^2_i value. It suggests the suitability of genotypes over environment. Thus the strain PT-303 and T-9 were identified by both the methods as risk efficient, stable and having above average seed yield. The strain PT-30 and PT-303 were identified as adaptable by risk analysis while two other strains PT-507B and LDHC-1 were identified as stable by using Eberhart and Russell model.

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Cytological basis of self-incompatibility in toria

A. K. Trivedi and C. N. Chaubey*

Department of Biological Sciences, C. B. S. & H., G. B. Pant
University of Agriculture and Technology, Pant Nagar,
Nanital (Uttar Pradesh)

ABSTRACT

In *Brassica campestris* var. *toria*, the cytological mechanism of self-incompatibility was investigated by studying pollen germination and tube growth under self-pollination and cross pollination. Self incompatibility which was sporophytic in nature, manifested itself by poor germination of pollen grains on the stigmatic surface and by stunted growth of twisted, swollen pollen tubes in stylar tissue. Increase in protein content beyond a certain limit in incompatible flowers, specially in pistils, acted as inhibitor for self-pollinated pollen grains and tubes.

Key words : *Brassica campestris*; self incompatibility; cytology

INTRODUCTION

In the cruciferae including *Brassica,* self-incompatibility is sporophytic in nature (Bateman, 1955; Thompson, 1957). In *toria,* scratching or slicing of the upper layer of stigmatic papillae tissue increases fruit setting and seed formation in comparison to artificially selfed flowers (Singh, 1958) showing that the site of inhibition is located in stigmata and self-incompatibility is under sporophytic control. However, cytological investigations are required to study the behaviour of pollen tube growth in self-incompatible plants of *toria.* The present investigation is, therefore, an attempt to cytologically examine the mechanism of incompatibility as well as to find out if proteins work as inhibitor in this regard.

MATERIALS AND METHODS

A large number of floral buds (both young and developed) and open

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* At present Professor/Senior Breeder, Department of Genetics and Plant Breeding, N. D. University of Agriculture and Technology, Faizabad (U. P.) India.

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flowers of *toria*. T. 9 were self-and cross-pollinated. They were collected at 2, 4, 6, 8, 10, 12, and 24 hours after pollination in aceto-alcohol fixative and then were preserved in 70 per cent alcohol. A modification of Dionne's method (1958) was applied to study the length and shape of pollen tubes. This stain was prepared by adding 0.6 g safranine and 0. 08 g aniline blue powder in 100 ml hot 45 per cent acetic acid. The material was hydrolysed in 45 per cent acetic acid for over three and a half hours at 60° C. It was then squashed in the above mentioned stain. Pollen tubes stained blue against light bluish purple back ground of stylar tissue. Tube lengths were recorded in ocular micrometer units which were later transformed into microns. Thirty observations were recorded at each time interval after pollination.

Selfed floral buds and flowers of two self compatible (*Brown sarson*, var Suphla and Yellow sarson, var. YS 151) and two self-incompatible types (*Toria*, vars. T. 9 and M_3) of *Brassica campestris* were collected after 24 hours of pollination. Their protein content was estimated by the method used by Lowry *et al.* (1951). To estimate total proteins of floral buds, pistils and flowers, 0.5 g material was crushed in 10 ml distilled water and the crude suspension was centrifuged at 10,000 r p m for 15 minutes. The supernatant was taken out and diluted five times. Thereafter, 0.5 ml diluted sample was used for determination of total proteins.

RESULTS

Average pollen tube length in both selfed and crossed buds and flowers of self-incompatible type (var. T.9) has been presented in Table 1. Self and cross-pollination in young buds showed similar pattern. Thus crossing and selfing both were effective during young bud stage. In developed buds and open flowers, self pollination resulted in a lower rate of pollen tube growth than cross pollin-nation. The effect was more pronounced in case of open flowers. These open flowers collected at 24h after pollination revealed significant retardation in pollen tube growth on self pollination.

Pollen tubes also revealed variability in their shapes In developed buds and flowers soon after self-pollination the pollen tubes were either aborted or were swollen at their terminal ends. If some tubes penetrated the stylar tissue, they travelled only to a short distance in uneven zig zag pattern. On the other hand, selfing in young buds did not show such abnor-malities.

Protein content of selfed buds, flowers and pistils of both self-compatible and self-incompatible types has been presented in Table 2. Young as well as developed buds in both self-compatible and self-incompatible types on self pollin-ation revealed almost no difference in their protein content. However, this

Table 1 : Mean pollen tube length (in microns) in selfed and crossed flowers of T. 9 at various hours after pollination

Hour after pollination	Young buds		Developed buds		Open flowers	
	Self-pollination	Cross-pollination	Self-pollination	Cross-pollination	Self-pollination	Cross-pollination
2	26.38	35.16	15.55	45.33	7.56	55.75
4	63.83	94.66	28.96	97.51	13.75	99.33
6	102.15	101.66	30.98	129.25	23.91	132.00
8	111.08	123.75	50.16	152.08	27.83	140.50
10	112.41	140.58	63.91	173.83	39.16	180.58
12	133.08	144.23	87.16	179.25	60.65	106.75
24	165.58	158.25	108.75	197.91	67.91	239.25

C. D. (at 5% level) = 8.34 C. D. (at 1% level) = 10.76

Table 2 : Protein content of selfed buds, flowers and pistils in self-incompatible and self-compatible types of *B. campestris*

Varieties	Protien content (in mg. per ml)				
	Young buds	developed buds	Open flowers	Pistils of developed buds	Pistils of open flowers
A. Self-Incompatible					
1. Toria (T. 9)	0.76	0.87	1.48	0.56	0.80
2. Toria (M. 3)	0.81	1.00	1.50	0.63	0.82
Mean	0.785	0.935	1.49	0.595	0.81
B. Self-Compatible					
1. *Brown Sarson* (Suphla)	0.73	0.87	1.10	0.41	0.54
2. *Yellow Sarson* (YS 151)	1.81	0.03	1.17	0.51	0.56
Mean	0.77	0.95	1.14	0.46	0.55

difference was conspicuous in whole flowers and their pistils. The protein content in selfed open flowers and in their pistils of self-incompatible types was more (+0 35 and +0.26 mg per ml respectively) than in those of self-compatible types. In other words, out of a differential protein content of 0.35 mg per ml by whcih *selfed flower of self-incompatible types showed an excess quantity* over those of self-compatible types, pistils alone contributed a differential protein quantity of 0 26 mg per ml.

DISCUSSION

In self-incompatible *toria*, variety T. 9, crossing among plants during bud open flower stage resulted in effective germination and growth of pollen tubes. On the other hand, in developed buds and open flowers, pollen grains on self-pollination barely germinated and short twisted pollen tubes either did not penetrate the stigmatic surface or if penetrated, they travelled only to a very short distance in the stylar tissue, However, selfing was effective for proper growth of pollen tube during young bud stage only. This type of pollen tube behaviour indicated that self-incompatibility in *toria* is under sporophytic control. Similar observations have been reported by Lewis (1959), Odland (1962) and Thompson (1965).

The total protein content was conspicuously more in selfed flowers of self-incompatible types than in those of self-compatible types where as such a difference was absent between the two types in case of their self-pollinated floral buds. This suggests that in self-incompatible *toria*, increase in protein content of flowers beyond a certain limit acts as inhibitor for self-pollinated pollen grains and tubes to grow in the stylar tissue. Since the protein content in selfed young buds of self-incompatible plants is perhaps below a threshold limit of inhibition, self-pollination remains always effective by showing normal growth of pollen tubes and ultimately producing selfed seeds.

Nasrallah and Wallace (1967) have reported that self compatibility in young buds of cabbage (*B. oleracea var. capitata*) was on account of absence of one or more antigens (proteins) present in the stigmata of self-incompatible flowers. As one would expect, the major part involved in showing difference in total protein content between self-compatible and incompatible types, is pistil, in the present investigation.

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Control of *MELOIDOGYNE ARENARIA* on groundnut with nematicides and oil-cakes

Parwinder Singh Grewal, H. K. Chhabra and V. K. Kaul
Department of Plant Pathology,
Punjab Agricultural University, Ludhiana

ABSTRACT

Oil cakes of mustard, sesame and cotton @ 20 and 30 q/ha and nematicides, *viz*. aldicarb, carbofuran and phorate @ 1.5 and 3.0 kg/ha were applied before sowing groundnut (M-13) in a field heavily infested with *Meloidogyne arenaria*. Aldicarb, carbofuran and mustard oil cake were most effective in reducing the nematode population, root gall index and increasing the pod yields. Nematicides were more effective than the oil cakes.

Key words : Oil cakes; nematode control; groundnut; nematicides

INTRODUCTION

Root-knot nematodes pose a severe problem in almost all the groundnut growing tracts of the world. *Meloidogyne arenaria, M. hapla* and *M. javanica* have been reported to be associated with this crop under different climatic conditions (Eisenback *et al.*, 1981). These cause considerable losses to groundnut pods both qualitatively and quantitatively. A loss of about 8 per cent in yield has been reported with every ten-fold increase in the initial population of *M. hapla* infesting groundnut (Rickard *et al.*, (1977). The damage may be due to the direct feeding of the nematode on the roots or in the form of predisposition of the roots to other soil microflora otherwise non-pathogenic or week parasites or by hindering the nitrogen fixing ability of this legume crop (Germani *et al.*, 1980). *M. arenaria* was found to be severely damaging the groundnut crop in the Punjab (India) by Kang *et al.*, (1975) and Sharma *et al.* (1978). Control of root-knot nematodes on groundnut has been reported by various workers (Kang *et al.*, 1975 ; Rodriguez-Kabana *et al.*, 1980 and Sasser *et al.*, 1975.) However, Kang *et al.* (1975) and Sharma *et al.* (1978) suggested the use of nematicides for minimising the losses in yield of groundnut. The objective of the present investigation was to further evaluate the effectiveness of nematicides, aldicarb, carbofuran and

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phorate and oil-cakes of mustard, sesame and cotton for the control of *M. arenaria* on groundnut.

MATERIALS AND METHODS

The experiment was conducted in a farmer's field which was heavily infested with a natural population of *M. arenaria*. The soil was a sandy loam type. A randomised block design was followed and each treatment was replicated four times (plot size 4 x 4 m^2). An uniform dose of fertilizer was applied to all the plots and groundnut cultivar M-13 was sown.

The oil-cakes of mustard *(Brassica* spp.) ; sesame *(Sesamum indicum)* and cotton *Gossypium* spp) were powdered and broadcasted in the plots two weeks before sowing of groundnut at 20 and 30 q/ha. These were mixed in the soil with spade up to a depth of about 15 cm and a light irrigation was applied to allow the degradation of the organic matter.

Three nematicides, *viz.* aldicarb (Temik 10 G), carbofuran (Furadan 3 G) and phorate (Thimet 10 G) were applied to the soil in the furrows at the time of sowing of the crop at 1.5 and 3.0 kg a. i./ha.

The total population of *M. arenaria* in 250 cc of soil from each plot was recorded before planting, at the mid season and at pre-harvesting stage of groundnut crop following modified Cobb's sieving and decantation technique. Similarly, one gram of root sample was stained in hot lactophenol-acid fuchsin, destained, blended and counts for nematode population in various stages of development including eggs were recorded. The data were analysed statistically.

RESULTS

Oil-cakes

The application of oil-cakes to the soil improved the general growth of the plants as compared to the untreated controls. The data recorded on the population build-up (Table 1) show that a significant reduction in the nematode population in the roots took place with all the treatments up to 60 days after sowing and at harvesting. The larval population in the soil was also reduced significantly but the effect was not so pronounced at crop maturity. However, the mustard oil-cake at both dosages and sesame oil-cake at high dosage reduced the larval population in the soil significantly up to maturity of the crop. Root-gall index reduced significantly as compared to the controls with all the oil-cakes. The mustard oil-cake was most effective in controlling the nematode population both in the soil and roots followed by sesame and cotton-seed oil-cake respectively. However, the higher dosage of mustard oil-cake was comparatively better over its lower dosage in reducing the nematode population in the

Table 1 : Effect of oil-cakes on *Meloidogyne arenaria* population and yield of groundnut

Treatment	Dose q/ha	Nematode population (eggs and larvae/g of root)		Nematode population 2nd stage larvae/ 250 cc of soil		Yield kg/ plot	Yield q/ha	Gall index
		60 days after sowing	At harvesting	60 days after sowing	At harvesting			
1. Cotton-seed oil-cake	20	51236.14 (4.71)	58884.37 (4.77)	724.44 (2.86)	794.33 (2.90)	2.060	12.87	3.20
2. ,,	30	44668.36 (4.65)	50118.72 (4.70)	575.44 (2.76)	575.44 (2.76)	2.410	15.07	3.05
3. Sesame oil-cake	20	46773.52 (4.67)	53703.16 (4.73)	537.03 (2.73)	588.84 (2.77)	2.090	13.62	3.12
4. ,,	30	40738.02 (4.61)	50118.72 (4.70)	398.11 (2.60)	426.57 (2.63)	2.470	15.43	2.62
5. Mustard oil-cake	20	42657.95 (4.62)	51286.14 (4.71)	416 87 (2.62)	436.56 (2.62)	2.790	17.43	2.46
6. ,,	30	31622.08 (4.50)	40738.02 (4.61)	346.74 (2 54)	354.81 (2.55)	3.460	21.68	1.75
7. Control	—	91201.08 (4.96)	85113.80 (4.93)	812.83 (2.91)	1023.29 (3.01)	2.030	12.70	3.37
C. D. (p = 0.01)		(0.06)	(0.07)	(0.03)	(0.31)	0.490	—	0.06

Figures in the parentheses represent the means of log transformations of 4 replicates.

roots, however, there were no significant differences among the dosages of sesame and cotton-seed oil-cake.

The pod-yield of groundnut showed negative correlation with the nematode population. An increase of 37 and 70 per cent in yield was found with the application of mustard oil-cake @ 20 and 30 q/ha respectively. None of the other treatments could increase the pod-yield significantly over the control.

Nematicides

Nematicides also improved the crop stand, increased the pod-yield and decreased the nematode numbers. The data presented in Table 2, show a significant reduction in nematode population in soil and roots over control by

Table 2 : **Effect of nematicides on *Meloidogyne arenaria* population and yield of groundnut**

Treatment	Dose/ (kg ai/ ha)	Nematode population (eggs and larvae/g of root) 60 days after sowing	At harvesting	2nd stage larvae/ 250 cc of soil 60 days after sowing	At harvesting	Yield kg/ plot	q/ha	Gall index
1. Phorate	1.5	41686.94 (4.62)	48977.47 (4.69)	398.12 (2.67)	467.74	2.290	14.31	2.57
2. "	3.0	32359.37 (3.51)	38904.51 (4.59)	346.74 (2.54)	363.08 (2.56)	2.510	15.70	2.25
3. Carbofuran	1.5	31622.78 (4.50)	39810.72 (4.60)	295.12 (2.57)	346.74 (2.47)	0.040	19.00	2.56
4. "	3.0	28840.36 (4.34)	34673.69 (4.54)	223.87 (2.35)	257.04 (2.48)	3.460	21.62	2.22
5. Aldicarb	1.5	21877.52 (4.46)	27542.29 (4.44)	141.25 (2.15)	186.21 (2.27)	3.405	21.28	2.40
6. "	3.0	14791.08 (4.17)	19498.95 (4.29)	100.00 (2.00)	141.25 (2.15)	3.825	23.80	1.55
7. Control		83176.38 (4.92)	83176.38 (4.92)	812.83 (2.91)	1023.29 (3.01)	2.025	12.60	3.37
C. D. (p = 0.01)		(0.09)	(0.07)	(0.06)	(0.09)	1.000	—	0.09

Figures in the parentheses represent the means of log transformations of nematode population.

the application of nematicides, observed 60 days after sowing and at maturity of the crop. Aldicarb was the most effective nematicide followed by carbofuran and phorate respectively in reducing the nematode population. The higher dosages of all the nematicides except phorate were significantly better in reducing the nematode population in the roots and in the soil than the lower dosages. Root-gall index was also reduced significantly with all the nematicides.

The obervations on the pod-yield indicated that aldicarb and carbofuran were highly effective in increasing the yield over control. However, there was no significant differences among the dosages of these nematicides. Phorate could not increase the pod-yield significantly. The statistical analysis of the data further revealed that the pod yield was negatively correlated with the nematode population. An increase of 45 and 71 per cent in pod-yield was recorded with the application of carbofuran and 68 and 89 per cent with that of aldicarb at the lowar and higher dosages respectively over untreated cantrol.

DISCUSSION

In the present investigations, all the oil-cakes improved the general plant growth considerably and decreased the nematode population and root-gall index. These observations are supported by the work of Lall and Hameed (1969) and Sitaramaiah and Singh (1969), who reported that oil-cakes of mustard, margosa, castor, linseed and groundnut significantly reduced the intensity of root-galls on okra and tomato caused by *M. javanica* and increased the plant growth. Chhabra *et al.* (1978) reported that mustard oil-cake was most effective in reducing the larval population of *M. incognita* on okra followed by cotton-seed oil-cake. The present studies also revealed that the mustard oil cake was most effective in controlling the nematode population and increasing pod yield of groundunt followed by oil-cakes of sesame and cotton-seed respectively. The improvement in the growth may be due to the nutrients provided by the oil-cakes and production of phenolic contents and certain fatty acids having ditect toxic effect on the nematode (Alam *et al.*, 1979); Sitaramaiah and Singh, 1978) predatory fungi and certain other organisms (Dropkin 1980).

All the nematicides decreased the nematode population and root-gall index significantly over control and increased the pod-yield and also improved the growth of the plants. These findings are in conformity with those of Sasser *et al.* (1975) who reported that DBCP, diazinon, ethoprop, aldicarb, thionazin, phorate, phenamiphos and carbofuran increased the plant growth, yield and quality of groundnut significantly, in a field infested with *M. hapla*. However, phorate in the present investigations could not increase the yield significantly. Rodriguez-Kabana *et al.* (1980) reported that carbofuran did not reduce the juvenile numbers in the soil and failed to improve the general growth of groundnut plants at 2.2 kg ai/ha but at the higher dosage the yield increased considerably whereas in this study, carbofuran increased the pod yield of groundnut when applied @ 1.5 kg ai/ha or above. The differences may be due to different environmental conditions and soil type.

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Incidence of rust and Alternaria leaf spot in relation to plant population and fertility variation in Sunflower

Shaik Mahammad, R. Bener Raj and K. V. L. N. Dutt
Sunflower Project, Agricultural Research Institute,
Rajendranagar, Hyderabad-500 030, India

ABSTRACT

Lower planting densities and higher levels of nitrogen predisposed sunflowers to the infection of leaf spot caused by *Alternaria helianthicola* Narashimha Rao and Raj. Planting densities regulated by different spacings, however, had no influence on the rust infection caused by *Puccinia helianthi* Schw. Nitrogen fertilizer had a definite bearing as it enhanced the diseases, significantly with increasing levels of nitrogen upto 80 Kg N/ha. The micronutrients viz., Cu, Mn, Fe, Zn, Na and Borax had no influence on the infection of either of the diseases.

Key words : Rust; Alternaria leafspot; Sunflower

INTRODUCTION

The incidence of diseases on crops are known to be greatly influenced by the agro-cultural practices like planting geometry, planting density, mineral nutrition, drainage and time of sowing. Utilisation of these informations in sunflower disease management is lacking. Alternaria leaf spot, the most harmful agent of sunflower (Acimovic, 1979) and the rust infection are considered to be important diseases (Siva Prakasam *et al.*, 1977), causing heavy losses in yield. The Alternaria leafspot and rust have assumed epiphytotic proportions in India (Bhaskaram and Kandaswamy 1978 and Bhowmik and Singh; 1979). An attempt was, therefore, made to evaluate the incidence of these diseases in relation to the agronomic manipulations through plant population regulated by different spacings and fertility variation in sunflower.

MATERIALS AND METHODS

The introduced Soviet cultivars 'Armavirskji, during monsoon (August-November) and 'Peredovik during winter (December-March) 1979-80 were

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grown at the Agricultural Research Institute, Rajendranagar on black soils of medium fertility. Six spacings corresponding to differential plant population ranging 27,556 to 1,66,500 plants per hectare (Table 1) and four levels of nitrogen (0,40,80 and 120 Kg N/ha) in subplots were replicated thrice in a split plot design. Uniform dose of 60 Kg P_2O_5 and 40 Kg K_2O/ha was applied at the time of sowing.

Another experiment with six micronutrients and a control (Table 2) was also sown in a randomised block design with four replications. The crop was fertilized with 60 Kg N, 60 Kg P_2O_5 and 40 Kg K_2O per hectare. The micro elements copper ($CuSO_4$), Manganese ($MnSO_4$), Iron ($FeSO_4$) and Zinc ($ZnSO_4$) each at 10 Kg/ha, while, Sodium (Na Mo) and Boron (Borax) each at 5 Kg/ha were applied at the time of sowing. In both the experiements one-third nitrogen was applied at the time of sowing and the rest two third was top dressed at bud stage of the crop.

The parameters *viz*, percentage intesity and percentage incidence were used to evaluate the severity of diseases 70 days after sowing when the symptoms were highly manifested. Observations were made from bottom five leaves of five plants selected at random from each plot. The intensity was calculated by dividing the sum of percentage leaf area affected with the number of leaves in the sample whether they were infected or not. Incidence of the disease was computed as the number of leaves infected and expressed as percent per sample. The data were arranged concisely and subjected to angular transformation for statistical analysis.

RESULTS AND DISCUSSION

Effect of Plant population :

1. Alternaria leaf spot

The influence of plant population regulated by the spacial arrangements on disease intensity and incidence are furnished in Table 1. It could be well distinguished that plants sown in closer proximity were less affected than those sown at wider spacing. The percent intensity in Peredovik indicated a significant variation due to different spacings, while, in Armavirskij the differences were not significant though the decreasing trend with increased planting density was alike in both cultivars. In Peredovik the percent leaf spot intensity was significantly enhanced at the wider spacings of 60 x 60 cm (39.40%) and 60 x 45 cm (34.49%) while significantly least intensity (19.06%) was recorded in crop grown at the closest spacing of 30 x 20 cm. Garud *et al.* (1979) reported that the introduced Soviet cultivars of sunflower get severe infection covering more than 50% leaf area and the spots extend over the petioles, stem and floral parts.

Table 1 : Incidence of Alternaria leaf spot and rust on sunflower as influenced by plant population and levels of nitrogen

Treatment	Leaf spot				Rust	
	% intensity		% incidence		% intensity	% incidence
	Armavirskij	Peredovik	Armavirskij	Peredovik	Armavirskij	
Plants/ha						
27,556	10.45	40.47	68.00	97.33	8.59	66.33
(60 × 60 cm)	(18·12)	(39.40)	(58.76)	(84.74)	(16.61)	(56.61)
36,852	8.58	34.01	72.66	83.66	7.59	68.33
(60 × 45 cm)	(16.83)	(34.49)	(58.88)	(73.32)	(15.66)	(57.22)
55,278	8.28	20.92	63.66	87.33	9.12	63.33
(60 × 30 cm)	(16.47)	(26.49)	(53.29)	(73.50)	(16.86)	(53.11)
73,926	7.83	24.56	54.33	83.00	7.50	67.00
(45 × 30 cm)	(15.66)	(28.52)	(47.57)	(73.82)	(16.52)	(55.15)
83,000	8.35	27.48	61.33	88.33	8.37	65.33
(60 × 20 cm)	(15.50)	(30.63)	(52.12)	(76.24)	(16.33)	(54.59)
1,66,500	4.98	12.35	48.33	64.66	6.25	58.00
(30 + 20 cm)	(12.38)	(19.06)	(43.69)	(55.62)	(14.00)	(49.66)
SEm ±	1.07	3.06	2.55	4.22	1.22	4.38
CD 5%	NS	8.77	7.33	13.27	NS	NS
Nitrogen kg/ha						
0	4.85	18.02	47.55	71.55	5.23	49.33
	(12.46)	(23.20)	(43.33)	(61.45)	(12.81)	(44.61)
40	7.99	25.26	58.22	78.88	7.52	65.33
	(24.06)	(29.03)	(50.42)	(68.20)	(23.23)	(54.22)
80	9.26	26.64	68.38	90.44	9.86	76.22
	(26.17)	(30.20)	(57.33)	(78.61)	(27.13)	(61.53)
120	10.19	36.58	70.88	95.33	9.98	68.00
	(27.06)	(36.63)	(58.46)	(83.12)	(25.39)	(57.20)
SEm ±	0.79	1.51	2.54	3.23	0.79	1.97
CD (5%)	2.30	4.34	7.30	9.25	2.19	5.68

Figures in parantheses are percent Arcsine transformed values

The per cent incidence of leaf was significantly influenced by varying the planting densities of both the cultivars. It decreased from a maximum of 58.76 and 84.74% at the widest spacing of 60 x 60 cm in Armavavirskij and Peredovik to a miniumum of 43.69 and 55.62% respectively at the closest spacing of 30 x 20 cm.

2. Rust

The differential planting densities were not effective in altering the percent intensity and incidence of the disease (Table 1).

Table 2 : Incidence of Alternaria leaf spot and rust on sunflower as influenced by different micro-nutrients

Treatment	Leaf spot		Rust	
	% intensity	% incidence	% intensity	% incidence
$CuSO_4$ @ 10 kg/ha	8.49 (16.90)	65.00 (71.83)	9.07 (17.19)	68.00 (55.84)
$MnSO_4$ @ 10 kg/ha	7.93 (16.04)	57.00 (65.52)	6.34 (14.39)	61.00 (68.74)
$FeSO_4$ @ 10 kg/ha	6.41 (14.54)	59.00 (67.04)	11.53 (18.13)	66.00 (77.68)
$ZnSO_4$ @ 10 kg/ha	8.98 (17.17)	52.00 (61.55)	7.26 (15.17)	57.00 (65.40)
Na Mo @ 5 kg/ha	7.40 (16.25)	52.00 (61.55)	8.63 (16.96)	62-00 (69.66)
Borax @ 5 kg/ha	8.27 (16.67)	53.00 (62.56)	7.45 (15.05)	49.00 (69.46)
Control	8.61 (16.83)	63.00 (70.99)	9.64 (17.70)	64.00 (70.96)
SEm ±	1.51	5.02	2.79	7.31
CD (5%)	NS	NS	NS	NS

Figures in parantheses are percent Arcsine transformed values

Effect of nitrogen :

1. Alternaria leaf spot

The induced luxuriant vegetative crop grown with increasing levels of nitrogen played a significant role and conferred a predisposing factor for the infection of Alternaria leaf spot. The intensity of the disease increased consistently with every increment of added nitrogen ranging from a minimum of 12.46 and 23.20% in Armavirskij and Peredovik receiving no nitrogen to a maximum of 27.06 and 36.63% in the crop fertilized with 120 Kg N/ha. Similarly, the percent incidence was also significantly influenced by the increasing levels of nitrogen. It increased from 43.33 and 61.45% in no nitrogen treatment of Armavirskji and Peredovik to a maximum of 58.46 and 83.12% in the treatment receiving 120 Kg N/ha.

2. *Rust*

Fertility variation due to different levels of nitrogen significantly influenced the intensity of rust and its incidence. The intensity increased from a minimum of 12.81% in no nitrogen level to 23.23% with 40 Kg N/ha. Increasing the level of nitrogen to 80 Kg N/ha further aggravated the intensity to a maximum of 27.13% that remained statistically at par with that of 25.39% at 120 Kg N/ha. The incidence, similarly increased significantly upto 80 Kg N/ha and then levelled off with further increase to 120 Kg N/ha.

The interaction between planting density and levels of nitrogen had no marked influence on either of the diseases.

Effect of micronutrients

None of the six micro-nutrients studied (Table 2) showed any significant influence in predisposing sunflowers to either of the diseases.

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Correlations and path analysis in niger

S. N. Goyal [1] **and Sudhir Kumar** [2]
Department of Genetics and Plant Breeding,
Sukhadia University, Udaipur

ABSTRACT

Studies on variability, correlations and path analysis in 35 indigenous varities of niger (*Guizotia abyssinica* Cas.) revealed a wide range of variation for all the characters except for number of branches and seeds per capitulum. The accessions from Madhya Pradesh were found superior for yield and number of capitula per plant, whereas, accessions from Rajasthan, Karnataka and Maharashtra were conspicuous for earliness. Heritability estimates ranged from moderate to high and genotypic coefficient of variation was equal to phenotypic coefficient of variation in most of the cases. The yield was found to be significantly and positively associated with days to maturity, plant height, number of capitula and seeds per capitulum whereas its association was non-significant with regard to number of branches and number of days taken to commence flowering. Since the period to maturity, number of capitula per plant, number of seeds per capitulum and number of branches were found to have significant and positive effect on seed yield, due consideration should be given to these traits while making selection in niger.

Key words : Path analysis; niger; *Guizotia abyssinica*; variability

INTRODUCTION

Niger (*Guizotia abyssinica* Cass.) is a minor oilseed crop and its yield levels are very low. Inspite of its wide cultivation and adequate germplasm, investigations on its genetics have been rather meagre. Paucity of information exists as to the extent of variability, association of characters and their importance in relation to yield. The present study was, therefore, made to compute variability, correlations and path analysis in niger.

Present Address :

[1] Associate Research Scientist (Ag. Bot.) Gujarat Agril. University, Agril. Research Station, Amreli-364-601

[2] Visiting Professor, NEHU, Medziphema, Nagaland

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MATERIALS AND METHODS

After an initial evaluation of large indigenous collection of niger, 35 selected cultivars were planted at the Rajasthan College of Agriculture, Udaipur, in randomised block design with three replications. Each plot consisted of 3 rows of 3 m length which were placed at 50 cm apart. Observations on 5 randomly selected plants were recorded for the duration to commence flowering, number of days to maturity, plant height, number of capitula per plant, number of seeds per capitulum and seed yield per plant. Genotypic and phenotypic coefficients of variation were calculated according to the procedure laid down by Burton (1952) and heritability and genetic advance were arrived at using the formulae of Johnson *et al.* (1955). Correlations and path analysis were computed as per the method given by Panse and Sukhatme (1967) and Dewey and Lu (1959) respectively.

RESULTS

A significant difference was noticed among cultures for all the characters studied. The mean values obtained for each of the varieties for different characters indicated that cultures from Rajasthan, Karnataka and Maharashtra were significantly earlier in flowering and maturity, whereas those of Madhya Pradesh, Andhra Pradesh and Tamilnadu were late. For number of branches, cultivars from Maharashtra and Madhya Pradesh were superior. In general, varieties of Madhya Pradesh were found better for number of capitula and seed yield per plant, the notable ones being N 136, N 95, N 135, Composite-2 and Bilaspur. Though the varieties from Karnataka and Orissa were good for number of seeds per capitulum, they were poor in branching. Among the released varieties *viz*, Ootacamond and IGP 76, Ootacamond a long duration strain was found to be significantly high yielder in view of its possession of more number of seeds per capitulum. Singh *et al.* (1976) have also observed varietal differences among niger genotypes for eleven characters.

Range, mean, phenotypic and genotypic variances, their coefficient of variations, heritability and genetic advance are presented in Table 1. A wide range of variability was observed for all characters except for number of branches and number of seeds per capitulum where the range was comparatively narrow. Genotypic coefficient of variation was more or less equal to phenotypic coefficient of variation. High to moderate heritability estimates were observed for all the characters except for plant height. No linear relationship among genetic coefficient of variation, heritability and genetic advance was noticed but yield per plant was found to have a high genetic coefficient of variation alongwith high heritability and high genetic advance.

Table 1 : Range, standard error (SE), phenotypic, genotypic variances, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (h^2) and genetic advance as per cent of mean (GA) in niger

Characters	Range	Mean	±S.E.	Phenotypic variation	Genotypic variation	PCV	GCV	h^2	GA
Days to flower	49.67-88.67	65.78	±1.11	110.64	108.78	15.99	15.85	98.32	32.387
Days to maturity	83.67-123.00	100.58	±0.82	138.07	137.06	11.68	11.64	99.32	23.888
Plant height (cm)	107.67-170.66	134.40	±18.03	537.10	49.41	17.23	5.23	9.20	32.658
Number of branches	8.11-19.99	13.22	±2.07	13.60	7.16	27.88	20.24	52.64	30.249
Number of capitula	20.70-101.77	40.71	±7.57	255.76	169.68	32.29	32.00	66.34	53.685
Seed pers capitula	11.83-31.37	21.48	±2.89	34.61	22.05	27.39	21.86	63.71	35.945
Yield per plant (g)	0.496-4.441	1.772	±0.335	0.746	0.557	48.772	42.832	77.34	77.656

Genotypic, phenotypic and environmental correlation of coefficients (Table 2) reveal that genotypic correlations were higher than their respective phenotypic and environmental correlations. Seed yield was found to be significantly and positively associated with days to maturity, plant height, number of capitula per plant and seeds per capitulum, whereas with regard to days to flower and number of branches, the correlations were non-significant and positive. Further, all the characters were also found to be inter-related with each other. Similar relationship has also been observed by Kandaswamy (1973) and Sahu and Patnaik (1981). Since the pattern of phenotypic correlations were similar to genotypic correlations, the phenotypic values can very well be used as criteria for selection.

The importance of these characters was further analysed by computing their direct and indirect effects on seed yield (Table 3). The number of days taken to maturity having a high correlation with yield had the highest direct and indirect positive effect on it. It was followed by number of capitula per plant, number or seeds per capitulum and number of branches. The magnitude of direct and indirect effects of all these characters was more than their respective correlations with seed yield. Larger direct and indirect positive effects of days

Table 2 : Association of different characters with seed yield in niger

Characters		Days to maturity	Plant height	Number of branches per plant	Number of capitula per plant	Number of seed per capitulum	Yield per plant
Days to	P	0.930**	0.307*	0.547**	0.194	0.070	0.067
flower	G	0.925**	0.083	0.351*	0.187	0.076	0.063
	E	0.623**	—0.073	—0.488**	0.052	0.246	0.086
Days to	P		0.353*	0.710**	0.260	—0.176	0.684**
muturity	G		0.186	0.478**	0.234	—0.158	0.563**
	E		0.973**	—0.611**	—0.255	—0.324*	0.871**
Plant	P			0.916**	0.924**	—0.163	0.360*
height	G			0.285	0.527**	0.022	0.463**
	E			0.126	0.472**	0.030	0.811**
Number of	P				0.423**	0.341*	0.277
branches	G				0.587**	0.138	0.268
per plant	E				0.740**	0.809**	0.277
Number of	P					0.488**	0.979**
capitula	G					0.383*	1.000**
per plant	E					0.024	0.888**
Number of	P						0.682**
seeds per	G						0.477**
capitulum	E						—0.027

* Significant at 5 percent level   ** Significant at 1 percent level

to maturity and number of seeds per capitula on seed yield have also been observed by Sahu and Patnaik (1981) but the impact of number of capitula and primary branches was negative. The direct and indirect effect of days to flower and plant height on seed yield was negative. However they have positive effect on it *via* the number of branches, number of capitula and days to maturity. Thus plant height and days to flower appeared to be components of these traits and not of seed yield.

Thus for improving seed yield in niger, due emphasis should be placed on days to maturity, number of branches, number of capitula and seeds per capitulum. As all these traits had high heritability alongwith high genetic advance, it is possible to have rapid gain by mass selection.

Table 3 : Direct and indirect effects of different characters on seed yield in niger

	Days to flower	Days to maturity	Plant height	Number of branches	Number of capitula	Seeds per capitulum	Total correlation with yield
Days to flower	—5.016	4.829	—0.640	0.520	0.308	0.066	0.067
Days to maturity	—4.664	5.192	—0.736	0.675	0.412	—0.195	0.684
Plant height	—1.540	1.833	—2.085	0.870	1.466	—0.180	0.364
Number of branches	—2.743	3.686	—1.910	0.950	0.671	—0.377	0.277
Number of capitula	—0.973	1.350	—1.926	0.402	1.586	—0 540	0.979
Seeds per capitulum	*—0.301*	*—0.914*	*0.340*	*—0.324*	*0.774*	*1.107*	0.682

Diagonal values are direct effects of respective characters on seed yield and off diagonal are indirect effeets thorough respective characters on seed yield.

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Contributions of different items of the package of practices for increasing mustard yield

Kanchan Baral, R. K. Ghosh, B. Das Gupta, N. N. Mandal and B. N. Chatterjee
Research Project on Rapeseed and Mustard, Factulty of Agriculture,
Bidhan Chandra Krish Viswavidyalaya, Kalyani, West Bengal-741 235

ABSTRACT

An integrated/approach to increase mustard (*Brassica juncea* Linn. Czern and Coss) yield in the short and mild winter condition of West Bengal has been made at the University Farm and farmer's field during 1981—82 and 1983—84. It showed that both the local (B' 85) and improved ('Varana') varieties recorded highest increments in yield (92 and 89% over the control treatments, respectively), when they received all the inputs. Fertilizer contributes maximum (48%) closely followed by irrigation (21%). The yields increased mainly due to the increments in the number of siliqua/plant and test weight of grains. Unless the pest and disease incidences are high, use of costle insecticides and fungicides as per the prescribed doses, reduce wide margin of profit. Early variety 'B 9' (*Brassica campestris*) which escaped major incidence of aphid in some years in farmers field, with limited resources, could yield better than others.

Key words : Package of practices; Mustard; *Brassica juncea*

INTRODUCTION

Mustard (*Brassica juncea* Linn. Czern and Coss) is an important oilseed crop in North India. Scientists of different disciplines have separately reported that the yield of mustard can appreciably be increased through (1) the use of improved varieties (Yadava, 1976 ; Kumar, 1982) (2) application of fertilizers (Patil and De, 1978; Roy *et al.*, 1981) (3) adoption of improved agronomic practices (Rathi, 1978 ; Chatterjee, 1982) and (4) plant protection measures (Bhaketia, 1982; Kolte, 1982). In this paper the results of an integrated approach to increase mustard yield in the short and mild winter conditions of West Bengal, through the available scientific informations in different disciplines, have been presented.

MATERIALS AND METHODS

Field experiments were carried out during 1981-82 and 1982-83,

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at the University farm situated at 23°N and 89°E above 9.75 m sea level. The winter in this region is very short (15 Nov. to 15 Feb.) and mild (the mean maximum and minimum temperatures range from 17 to 20°C and monthly mean minimum temperatures remaining at 10°C in the month of January). The rainfall during the period of experimentation were 80.2 and 17.1 mm in 1981-82 and 1982-83 respectively. The aphid infestation commences from the end of December onwards. 'B 85' a short duration (100 days) variety is extensively grown in this area. The experiment was conducted in sandy loam neutral soil (Entisol), with 0.06% N, 35 and 114 kg of available P_2O_5 and K_2O/ha in Randomised Block Design with 11 treatments and 4 replications in 7.5 m x 3 m and 5 m x 4 m plots during 1981-82 and 1982-83 respectively.

The experiment was sown (using 6 kg/ha seed rate) on 10 and 5 November during 1981-82 and 1982-83 respectively, in lines 30 cm apart and later on (15 days after sowing) thinned out to 10 cm apart plants within the lines. The fertilized plots received 80 kg N (in two splits as urea), 40 kg P_2O_5 (as single super phosphate) and 40 kg K_2O (as muriate of potash). The crop received 4 sprays of metasystox against aphids at fortnight intervals starting from 45 days after sowing. The crop also received 3 sprays of Dithane M-45 (Mancozeb 0.2 %) at 60, 75 and 90 days after sowing, against *Alternaria* blight, as per treatments (Table 1). The crop was irrigated (3-4 irrigations) as per treatments as and when needed in different years.

The treatments were described in Table 1 where local variety 'B-85' and improved variety 'Varuna' have been designated as LV and IV and they are of 100 and 120 days duration. The legends F, P, D and I stand for fertilizer, pest control, disease control and irrigation treatments as described earlier.

A number of non-replicated trials were also conducted in farmers field, with improved package of practices as in the treatment No. 10 in 1500 sq.m plots with some other improved varieties as well, in different years as summarised in Table 3, to find out the yield potentiality of these varieties in large plots. The varieties 'Varuna', 'RW 351', 'Pusa Bold', 'B9' (Yellow sarson) and Composite 3 matured in 120, 110, 115, 95 and 100 days, respectively.

The cost of different inputs as scheduled in treatments stated earlier for fertilizer application (Rs. 716/ha), irrigation (Rs. 170/ha) insect control measures (Rs. 270/ha) and disease control measures (Rs. 210/ha) were calculated at the prevailing rate of 1983. The selling rate of mustard in the market was Rs. 6/kg.

RESULTS AND DISCUSSION

Seed yield:

The highest yield (1333 kg/ha) was recorded in the treatment where the

Table 1 : Seed yield (kg/ha) of mustard raised with different management practices

Treatments	Seed yield kg/ha 1981-82	1982-83	Mean	% increase in yield	Net profit in Rs/ha	Cost : benefit ratio
L V (B-85)	564	590	577		1458	
I V (Varuna)	725	686	706		1974	
I V + F	1151	933	1042	47.7	2708	1 : 2.2
I V + I	834	867	851	20.6	2394	1 : 3.6
I V + P	787	724	756	7.1	2054	1 : 1.7
I V + D	754	762	758	7.4	2032	1 : 1.0
I V + I + F	1414	1133	1274	80.5	3476	1 : 3.0
I V + I + P + D	1216	1159	1188	68.3	3422	1 : 4.0
I V + F + P + D	1205	1057	1131	60.3	2744	1 : 2.0
I V + I + F + P + D	1503	1162	1333	88.9	3392	1 : 2.3
L V + I + F + P + D	1059	1159	1109	92.2*	2496	1 : 2.0
S Em ±	146.9	28.6				
C D at 5%	306.5	66.7				

* as compared to L V ; others are compared with I V only

late variety 'Varuna' received all the inputs. The local improved variety 'B 85', maturing in 100 days, also yielded high (1109 kg/ha) when it received all the inputs. The contributions to yield of mustard from fertilizer, irrigation, aphid control and disease control, on an average appeared to be 47.7, 20.6, 7.1 and 7.4 percent respectively in normal years when the incidences of diseases and insects are not heavy. Taking into consideration of the cost benefit ratios it appeared that the most profitable factor of production, with existing price ranges, is to provide irrigation to the mustard crop, by which it can utilize available nutrients better than under unirrigated conditions. The cost of fertilizer being heavy, fertilizer application even to the tune of 80 kg N, 40 kg P_2O_5 and 40 kg K_2O, does not provide wide margin of profit although it is more potent to increase yield than other factors of production. Similarly, unless the pest and disease incidences are high, use of costly insecticides and fungicides according to the prescribed doses, do not provide wide margin of profit. But to overcome the risk of failure of the crop one has to do so. The incidences of pest and diseases were relatively less in the years of experimentation.

Table 2: Yield components of mustard grown under different management practices

Treatments	No. of Siliqua/plant		No. of seeds/pod		1000 seed weight (g)	
	1981-82	1982-83	1981-82	1982-83	1981-82	1982-83
L V (B-85)	80	92	12	9	2.618	2.69
I V (Varuna)	84	98	10	10	3.212	3.69
I V + F	100	108	11	10	3.788	3.63
I V × I	105	109	10	9	3.585	3.51
I V + P	99	114	10	11	3.583	3.60
I V + D	105	115	9	9	3.015	2.99
I V + I + F	99	107	13	13	3.677	3.55
I V + I + P + D	114	110	11	11	4.375	4.50
I V + F + P + D	111	114	11	12	4.676	4.24
I V + I + F ÷ P + D	175	171	13	13	4.763	4.55
L V + I + F + P + D	128	131	9	11	3.093	3.17
S Em ±	10.8	6.8	0.86	0.70	0.28	0.33
C D at 5 %	22.5	14.1	1.79	1.46	0.58	0.69

Yield components

From the results summarised in Table 2 it is apparent that the number of siliqua/plant and test weight of grains are the most important factors that are influenced due to cultural treatments. The influences of different factors on the number of siliqua/plant were in the descending order D>P>I>F whereas the trends of differences in No of seeds/siliqua and test weights were in the order of F>P>I>D.

On farm trials

The results of 'on farm' trials revealed very interesting feature in 1983-84. The highest yield with package of practices was received from the early maturing variety 'B 9' (maturing in 95 days) which escaped severe aphid incidence. In 1983-84 the crop was badly damaged due to improper timings of the applications of the prescribed doses of insecticides, because of some unavoidable circumstances (non-availability of metasystox). Under West Bengal conditions with high humidity and short to mild winter, perhaps the most appropriate technology for the poor farmers is to provide them with very early maturing varieties of mustard

Table 3 : Yield of oilseeds in kg/ha and net profit in Rs/ha recorded 'on Farm' trials

Name and address of farmers	Variety	1981-82 Yield (kg/ha)	1981-82 Net profit (Rs/ha)	1982-83 Yield (kg/ha)	1982-83 Net profit (Rs/ha)	1983-84* Yield (kg/ha)	1983-84* Net profit (Rs/ha)
Balen Mandal	'Varuna'					510	40
Jhingra, Nadia	'RW 351'					570	280
	'Pusa Bold'					830	1320
	'B 9'					930	1720
Md. Anwar Hussain	'Varuna'	1650	2785				
Village Singa,	'RW 351'	1680	2875				
Nadia	'B 9'	1500	2335	1470	2209		
	'B 85'			1208	1290		
S. P. Mazumdar,	'Varuna'					525	100
Hapania, Nadia	'RW 351'					488	Nil
	'Pusa Bold'					540	160
	'B 9'					840	1360
Shri Dhirendra Nath	'Varuna'	1875	3575			319	Nil
Mondal, Nagarukhra,	'RW 351'	1800	3350			413	Nil
Nadia	'B 9'	1650	2900			2190	6260
	'Composite 3'**			1552	3073		
	'B 54'			1489	2853		
	'Pusa Bold'					380	Nil
Satyendra Nath Mondal	'Varuna'			1433	2309		
Nagarukhra, Nadia	'RW 351'			1088	1102		
Prabhat Chandhra Mandal	'Composit-3'			1609	3216		
Simulpukur, Nadia	'B 54'			1733	3650		
Ashoke Dey,	'Varuna'			1358	1616		
Village Suigr, Nadia	'RW 351'			908	42		
Gopal Ch. Bhabak	'B 85'			1411	2373		
Nagarukhra, Nadia	'B 9'			965	1294		

Cost of cultivation of mustard (per hectare) in cultivators field ranged from Rs. 1855 to Rs. 2000 in 1981-82, Rs. 1605 to Rs. 1764 in 1982-83 and Rs. 2000 to Rs. 2500 in 1983-84.

* Heavy infestation of aphids (except in early maturing varieties); this could not be effectively controlled due to non-availability of metasystox in the local market.

** Material received from Pulses and Oilseeds Research Station, Berhampore, W. Bengal.

which can escape aphid incidence. From Table 3 it may be persued that all the varieties ('B 54', 'B 85' and 'B 9') which matured within 100 days, provided very good yields. As a matter of fact the sequence *Kharif* rice-mustard (early variety) - *boro* rice has become very popular these days.

The cost of mustard seed and oil, has increased recently to a very high extent and this provides a good scope to the farmers to increase production. Application of fertilizers, even under rainfed condition, to the tune of 80 kg N/ha, provides a good margin of profit. To avoid risk it is always safe to protect crop with plant protection measures, particularly when the crop is irrigated and adequately fertilized.

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Studies on intercropping of groundnut

O. P. Mehta, A. L. Bhola, D. P. S. Tomar and T. P. Yadava*
Department of Plant Breeding, Haryana Agricultural University,
Hisar-125 004.

ABSTRACT

Field experiment was conducted to find out a suitable crop combination with groundnut (cv. MH-2 as the principal crop. Intercropping increased the total production. Highest monetary return was obtained from groundnut + *arhar* grown in the ratio of 6 : 1. The mean LER was maximum (1.25) in groundnut + *sesamum* grown in the ratio of 3 : 1.

Key words : Intercropping; Groundnut; *Arachis hypogaea*

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is the most important *kharif* oilseed crop grown in north India. High seed rate (150 kg/ha) and cost of groundnut seed make a common farmer reluctant to increase the area under this crop. The seed rate can be reduced if another suitable crop is introduced as intercrop. Keeping this in view and to increase land-use efficiency, total productivity and return per unit area per unit time, a field experiment was conducted to study the feasibility of growing pulse, other oilseed and grain crops in combination with groundnut in proportions of 3 : 1, 6 : 1 and 9 : 1.

MATERIALS AND METHODS

The experiment was carried out at the Haryana Agricultural University Research Farm, Hisar during the *Kharif* seasons of 1982 and 1983. The soil was sandy loam in texture with pH 7.9, low in nitrogen (136 kg/ha), medium in phosphorus (18 kg/ha) and high in available potassium (357 kg/ha). The experiment was conducted in a randomised block design with four replications. Thirteen treatment combinations *viz.* T_1 = sole crop of groundnut; T_2 = sole

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* Present Address : Project Director, Directorate of Oilseeds Research, Hyderabad-500 030

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crop of *bajra*; T_3 = sole crop of *Sesamum*; T_4 = sole crop of *arhar*; T_5 = groundnut + *bajra* (3:1); T_6 = groundnut + *Sesamum* (3:1); T_7 = groundnut + *ahar* (3:1); T_8 = groundnut + *bajra* (6:1); T_9 = groundnut + *Sesamum* (6:1); T_{10} = groundnut + *arhar* (6:1); T_{11} = groundnut + *bajra* (9:1); T_{12} = groundnut + *Sesamum* (9:1) and T_{13} = groundnut + *arhar* (9:1) were tested.

Recommended doses of fertilizers were applied to groundnut (15 kg N + 50 kg P_2O_5/ha), *bajra* (120 kg N + 60 kg P_2O_5), *Sesamum* (35 kg N/ha) and *arhar* (15 kg N + 40 kg P_2O_5/ha). A uniform dose of N and P_2O_5 at the rate of 15 and 50 kg/ha, respectively, was applied to all other treatment combinations. Verieties of groundnut (*Arachis hypogaea* L.), *bajra* (*Pennisetum typhoides*), *Sesamum* (*Sesamum indicum*) and *arhar* (*Cajanus cajan*) used in the experiment were MH-2, BJ-104, HT-1 and Prabhat respectively. All the crops were sown simultaneously on July 6, 1982 and July 14, 1983.

Irrigations were applied to the treatment plots as and when required depending on the rainfall (three irrigations during 1982 and two during 1983). The monthly rainfall is given in table 1. For comparative efficiency of different treatments, the produce of main crop as well as the intercrops were converted into monetary value.

Table 1 : Total monthly rainfall and mumber of rainy days during crop period of 1982 and 1983

Month	1982		1983	
	Rainfall (mm)	No. of rainy days	Rainfall (mm)	No. of rainy days
July	106.0	6	148.0	12
August	100.8	10	110.2	11
September	0.0	0	91.9	5
October	0.0	0	0.5	1
November	0.4	1	0.0	0
Total	207.2	17	350.6	29

RESULTS AND DISCUSSION

The pod yield of groundnut was significantly higher in sole crop than its combinations with intercrops at all the proportions. Reduction in yield of groundnut, when intercroped, has been reported by Almeida *et al.* (1976). Yield of groundnut was affected differently by various intercrops. The maximum reduction in yield of groundnut at all the proportions was in *bajra*. Extensive tillering, shallow root system and high depletion of nutrients by *bajra* might be the factors responsible for decreasing the yield of groundnut. *Sesamum* reduced the yield of main crop to a lesser extent than *bajra*. Minimum reduction in yield was caused by *arhar*, which being a deep rooted and non-depletive crop did not compete strongly. Regarding sole crop of different crops, *arhar* yielded maximum followed by groundnut, *bajra* and *Sesamum* during both the years. The results are presented in table 2.

The yield of intercrops was highest when grown with groundnut as a base crop in a proportion of 3:1 followed by 6:1 and 9:1, irrespective of the type of intercrop (Table 2). The highest yield was realised by *arhar* at all the proportions, followed by *bajra* and *Sesamum* during both the years of experimentation. Singh and Singh (1983) reported similar yield of *arhar* in an intercropping experiment.

The data on total pod and grain yield presented in table 2 revealed that *arhar* was the best intercrop in groundnut. Groundnut + *arhar* yielded maximum followed by groundnut + *bajra* and groundnut + *Sesamum* at all the proportions during both the years of experimentation. However, the maximum mean total yield (3637.5 kg/ha) was obtained when groundnut and *bajra* were grown in a ratio of 6:1. This was closely followed by groundnut + *arhar* (3:1) yielding 3548 kg/ha of total produce.

The data presented in table 3 indicated that mean LER was maximum (1.25) in treatment groundnut + *Sesamum* in proportion of 3:1. This was followed by mean LER 1.18 in treatments groundnut + *Sesamum* and groundnut + *arhar* both in proportions of 6:1. Nikam *et al.* (1984) also reported mean LER to be maximum when groundnut and sunflower were grown in proportion of 3:1.

Economics of production is the ultimate criterion for selecting the best crop combination. In the present study, combination of groundnut with *arhar* gave significantly higher monetary return than its combination with *bajra* or *Sesamum* at all the proportions during both the years of experimentation (Table 3). However on the basis of mean monetary returns of two years, groundnut and *arhar* grown in proportion of 6 : 1 was the best treatment. Nikam *et al.* (1984) reported net monetary returns increased due to intercropping of groundnut with sunflower. Highest profit was obtained from intercropping soybean with groundnut by Satyanarayana and Reddi (1979). Comparing pure stand of different crops, groundnut gave the highest return followed by *arhar*, *Sesamum* and *bajra*.

Table 2 : Yield of groundnut and intercrops as affected by various treatments

Treatment	1982			1983			Mean		
	Groundnut dry pods (kg/ha)	Intercrops grain yield (kg/ha)	Total yield (kg/ha)	Groundnut dry pods (kg/ha)	Intercrops grain yield (kg/ha)	Total yield (kg/ha)	Groundnut dry pods (kg/ha)	Intercrops grain yield (kg/ha)	Total yield (kg/ha)
Pure groundnut	3090	—	3090	2867	—	2867	2978.5	—	2978.5
Pure *bajra*	—	2704	2704	—	2447	2447	—	2575.5	2575.5
Pure *Sesamum*	—	583	583	—	702	702	—	642.5	642.5
Pure *arhar*	—	3126	3126	—	3205	3205	—	3165.5	3165.5
G + B (3 : 1)	597	2510	3107	890	2043	2933	743.5	2276.5	302)
G + S (3 : 1)	842	612	1457	1228	531	1759	1035	571.5	1606.5
G + A (3 : 1)	693	2690	3383	1157	2156	3313	925	2623	3548
G + B (6 : 1)	1103	1715	2818	1434	1166	2600	1268.5	1440.5	2709
G + S (6 : 1)	1360	520	1880	1594	341	1935	1477	430.5	1907.5
G + A (6 : 1)	1566	2330	3896	1666	1713	3379	1616	2021.5	3637.5
G + B (9 : 1)	1439	1567	3006	1715	1242	2957	1577	1404.5	2981.5
G + S (9 : 1)	1584	363	1947	1931	215	2146	1757.5	289	2046.5
G + A (9 : 1)	1961	1418	3379	1860	1269	3129	1910.5	1343.5	3254
S Em ±	124.1			127.4					
C. D. 5%	360.3			369.7					

G = Groundnut; B = *Bajra*; S = *Sesamum* A = *Arhar*

Table 3 : Land equivalent ratio (LER) and monetary return as influenced by various treatments

Treatment	LER			Total monetary return (Rs/ha)		
	1992	1983	Mean	1982	1983	Mean
Pure groundnut	1.00	1.00	1.00	15450.00	12901.00	14175.50
Pure *bajra*	1.00	1.00	1.0)	3785.00	2936.00	3360.50
Pure *Sesamum*	1.00	1.00	1.00	2915.00	5265.00	4090.00
Pure *arhar*	1.00	1.00	1.00	10941.00	11859.00	11400.00
G + B (3:1)	1.12	1.14	1.13	6498.00	6460.00	6479.00
G + S (3:1)	1.32	1.18	1.25	7273.00	9510.00	8391.50
G + A (3:1)	1.08	1.07	1.075	12880.00	13185.00	13532.50
G + B (6:1)	0.99	0.97	0.98	7968.00	8451.00	8209.50
G + S (6:1)	1.33	1.04	1.18	9202.00	9738.00	9470.00
G + A (6:1)	1.25	1.11	1.18	15985.00	13833.00	14909.00
G + B (9:1)	1.04	1.10	1.07	9389.00	9208.00	9298.50
G + S (9:1)	1.13	0.98	1.05	9736.00	10308.00	10022.00
G + A (9:1)	1.08	1.04	1.06	14770.00	13070.00	13920.00
S Em ±				587.72	516.19	
C. D. at 5%				1692.25	1492.06	

	Market rates (Rs/q)	
	1982	1983
Groundnut	500	450
Bajra	140	120
Sesamum	500	750
Arhar	350	370

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Yield and quality of groundnut as affected by some production factors

J. S. Saini and A. S. Dhillon
Department of Plant Breeding,
Punjab Agricultural University, Ludhiana

ABSTRACT

The effect of some recommended factors of groundnut production *vis-a-vis* the farmers' practices was studied in a field trial on a spreading groundnut cultivar PG I for four years (1977—1980). The approved package of practices enhanced the pod yield by 156 per cent, the hulm yield by 95 per cent, shelling by 5.9 per cent and total oil yield by 194 per cent over those obtained under the adoption of farmer's practices. The important production factors were control of early and late leaf spots, weed control, protective irrigation and fertilizer application. The omission of any of these factors from the package of practices reduced the mean pod yield by 31, 27, 26 and 20 per cent respectively.

Key words : Production factors; leaf spots control; termite control; weed control; protective irrigation

INTRODUCTION

Groundnut cultivar PG1 (spreading), released in 1953 still covers the major groundnut area in the Punjab. Dalal *et al.* (1967) found that application of about 20 kg P_2O_5/ha through single superphosphate to rainfed crop of PG1, enhanced the pod yield by 33 per cent. In another study with this variety, Dalal and Saini (1968) reported an increase of 35 per cent in pod yield with 28 kg N/ha (through ammonium sulphate) over no nitrogen. Later studies revealed that a fertilizer dose of 20 kg N + 40 kg P_2O_5/ha was conducive to high yields (Saini *et al.* 1973). A spacing of 30 x 22.6 cm (1,45,000 plants/ha) and a crop duration of about 130 days were found to be optimum for PG I (Singh *et al.*, 1968). Depending upon the seasonal rainfall, one to two irrigations at flowering and fruiting enhanced the pod yield of semi-spreading variety C 501 by 10 to 19 per cent and its shelling by 3 to 4 per cent (Saini and Sandhu, 1973). Chohan, (1971) found the treatment of groundnut seed with thiram 75% (0.5%) as the

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most effective against the seed-rot and seedling diseases The control of early and late leaf spots with three sprays of carbendazim (0.05%) resulted in an average yield increase of 44 6 per cent (Anonymous, 1977).

The optimum levels of various production factors for groundnut, determined through separate experiments in the Punjab, were integrated into a comprehensive experiment initiated in 1977 to ascertain the contribution of each factor in the package of recommended practices, to the yield and quality of cultivar PG1, *vis-a-vis* the farmers' practices.

MATERIALS AND METHODS

An experiment was conducted at the Research Farm, Punjab Agricultural University, Ludhiana for four *Kharif* seasons 1977 to 1980, on the predominantly grown groundnut cultivar PG1. Nine treatments (Table 1) were arranged in a randomized block design, with four replications. Treatment A (farmers' practices) comprised the sowing of crop with 25 per cent less seed than the recommended rate of 85 kg kernels/ha, and removing the weeds once through hand hoeing after three weeks of sowing. Treatment B, the approved package of practices recommended by the University consisting of the pre-sowing application of 25 kg/ha of aldrin (5% dust), treatment of seed with thiram @ 5 g/kg kernels, use of 85 kg/ha kernels sowing at 30 x 22.5 cm spacing, application of 15 kg N + 40 kg P_2O_5/ha through urea and single superphosphate at sowing, two hoeings and weedings, 3 and 6 weeks after sowing, application of protective irrigations whenever needed, control of early and late leaf spots with three sprays of carbendazim (0.05%) and harvesting the crop at full maturity period of about 130 days. The other treatments were derived by omitting individual factor from treatment B at a time. The crop was sown in the last week of June after the pre-sowing irrigation and received zero, two, three and zero irrigations during 1977, 1978, 1979 and 1980 respectively. After harvesting, the crop was allowed to sun-dry in the respective plots and the pods were separated, when fully dried, by hand picking, 10-12 days after harvesting. The plotwise data of pod yield were subjected to statistical analysis. The shelling and oil content were determined from the component samples of each treatment. The data of ancilliary characters were recorded on the basis of five plants drawn at random from each plot and subjected to statisitical analysis. The gross plot size was 13.65 m^2 and the yield was recorded from 8.25 m^2.

The soil of the experimental field was loamy sand, with pH 8.3, 0.26% organic carbon (low), 18 kg/ha available P (medium) and 138 kg/ha available K_2O (medium).

Table 1 : Effect of various factors on pod yield and other characters

Treatment	Pod yield (kg/ha) 1977	1978	1979	1980	Mean	Shelling %	Total Oil yield (kg/ha)	Straw yield (kg/ha)
A. Farmers' Practices	1234	1020	670	1030	988	62.6	306	2309
B. Approved pack. of practices	2380 / 98	2377 / 133	2182 / 226	3167 / 207	2526 / 156	68.5	899 / 194	4500 / 95
C. B except seed treatment and termite control	2018 (15.2)	2062 (13.2)	2091 (4.2)	2955 (6.7)	2281 (9.7)	68.2	778 (13.4)	4469 (0.6)
D. B except 1/4th seed rate	2123 (10.6)	2207 (7.1)	2061 (5.5)	2818 (11.0)	2303 (8.8)	66.5	775 (13.3)	4031 (10.4)
E. B except fertilizers	1667 (30.0)	1874 (21.2)	2076 (4.9)	2485 (21.5)	2025 (19.8)	65.8	671 (25.4)	3640 (19.1)
F. B except weed control	1750 (26.5)	1863 (21.6)	1833 (16.0)	1894 (40.2)	1835 (27.4)	67.8	621 (30.9)	4265 (5.2)
G. B except protective Irri.	1976 (25.4)	2203 (7.3)	1333 (38.9)	2121 (33.0)	1858 (26.4)	65.3	606 (32.6)	3495 (22.3)
H. B except tikka control	1388 (41.7)	1740 (26.8)	1970 (9.7)	1909 (39.7)	1752 (30.6)	68.2	597 (33.6)	3343 (25.7)
I. B except harvesting at full maturity.	1872 (21.3)	1932 (18.7)	2015 (7.6)	2652 (16.3)	2118 (16.1)	66.4	711 (20.9)	3765 (16.3)
C. D. at 5%	251	509	383	448	204			
Seasonal rainfall (mm)	651	441	226	717				

'figures below the line indicate per cent increase over treatment A, *viz.* farmers' practices

* figures in parenthesis indicate per cent decrease from treatment B, *viz.* approved package of practices

RESULTS AND DISCUSSION

Effect on pods and straw yield

The approved package of practices significantly influenced the pod yield in all the years of experimentation as well as in the pooled analysis. The increase in pod yield with the approved package of practices (treatment B) over farmers' practices (treatment A) was in the order of 93, 133, 226 and 207 per cent in 1977, 1978, 1979 and 1980 respectively.

Omitting the control of leaf spots, the protective irrigations and control of weeds from the approved package of practices significantly reduced the pod yield in three seasons out of the four seasons of experimentation. The reduction in yield due to omission of leaf spots control was (9.7 to 41.7 per cent) followed by 16.0 to 40.2 per cent reduction with the omission of weed control and 7.3 to 38.9 per cent reduction with the omission of protective irrigations. The impact of omission of fertilizers and pre-mature harvesting was significant in two seasons and the reduction was of the order of 4.9 to 30.0 per cent and 7.6 to 21.3 per cent respectively. The reduced seed rate had no significant effect on pod yield while the influence of seed treatment and termite control was observed in first season only.

On the average of four years, the approved package of practices, with a mean pod yield of 2526 kg/ha showed a superiority of 156 per cent over the farmers' practices, which produced only 988 kg/ha. With the omission of individual factors from the approved package of practices, there was a decrease in yield from 8.8 to 30.6 per cent. The highest reduction of 30.6 per cent was observed with the omission of leaf spots control, followed by 27.4 per cent reduction for omission of weed control, 26.4 per cent reduction for omission of protective irrigations and 19.8 per cent reduction for omission of fertilizers from the approved package of practices. The lowest reduction of 8.8 per cent occured when the seed rate was reduced by one-fourth. The loss in yield, resulting from the omission of other factors namely immature harvesting and the treatment of seed alongwith the control of termites were 16.1 and 9.7 per cent respectively.

It is interesting to note that in 1979 when very low rainfall (226 mm) was received, the increase in yield of pods resulting from the adoption of package of practices over the yield obtained in farmers' practices was as high as 226 per cent compared to 93 to 207 per cent in the remaining years when good seasonal rainfall ranging from 441 to 717 mm was received. With the omission of protective irrigation in the low rainfall year of 1979, the reduction in yield was 38.9 per cent as against 4.2 to 16.9 per cent with the omission of other factors. Evidently limited soil moisture drastically reduces the efficacy of other inputs. The hulm yield also increased from 2309 kg/ha under the farmers' practices to 4500 kg/ha (95 per cent). These results confirm the earlier findings of Saini and Sandhu (1973), Cheema *et al.* (1977) and Saini and Dhillon (1981).

Effect on quality

Shelling percentage increased from 62.6 per cent in farmers' practices to

68.5 per cent (5.9 per cent more) in approved package of practices. The most important factors influencing the shelling were, protective irrigation and fertilizers. These factors when omitted from the approved package of practices caused a reduction of 3.2 and 2.7 per cent in shelling respectively.

The total oil yield showed a substantial increase from 306 kg/ha under the farmers' practices to 899 kg/ha under the approved package of practices i.e. an increase of 194 per cent. With the omission of early and late leaf spots control from the approved package of practices, the highest reduction of 33.6 per cent was observed closely followed by 32.6 per cent with the omission of weed control. These findings are partly in agreement with the earlier findings of Sandhu *et al.* (1972), Saini and Sandhu (1973) and Saini and Dhillon (1981).

Effect on ancilliary characters

The values of all the ancilliary characters were significantly enhanced with the adoption of approved package of practices compared to those under the farmers' practices (Table 2). The number of secondary branches per plant

Table 2 : Effect of treatments on ancilliary characters of groundnut plant

Treatment	Height (cm)	Secondary branches (No.)	Pod bearing pags (No)	Mature pods (No.)	100-kernel wt. (g)
A. Farmers' Practices	14.3	7.4	30.1	18.2	34.7
B. Approved package of practices	21.4	10.2	36.3	27.7	40.7
C. B except seed treatment and termite control	19.8	8.8	34.0	21.0	40.0
D. B except 1/4th seed rate	16.3	9.4	30.8	20.7	38.0
E. B except fertilizers	16.4	8.0	23.2	16.4	38.0
F. B except weed control	20.7	7.4	24.5	15.4	39.7
G. B except protective irrigation	15.7	7.2	27.2	16.3	37.0
H. B except leaf spots control	21.1	8.8	24.5	17.0	39.7
I. B except harvesting at full maturity	19.7	10.0	27.4	17.5	40.3
C. D. at 5%	3.7	2.1	5.9	4.2	—

increased from 7.4 to 10.2 (38 per cent), the pod bearing pegs per plant from 30.1 to 36.3 (21 per cent), the number of mature pods per plant from 18.2 to 27.7

(52 per cent) and 100-kernel weight from 34.7 to 40.7 (17 per cent), as a result of the approved package of practices. The number of mature pods per plant which were recorded as 27.7 in approved package of practices were drastically reduced to 15.4, 16.3, 16.4 and 17.0 with the omission of weed control, protective irrigation, fertilizers and leaf spots control respectively showing a decrease of 44.4, 41.2, 40.8 and 38.6 per cent. The values of other attributes also showed almost the same trend with the omission of these production factors. Evidently the reduced values of these important yield attributes were reflected in lowering the ultimate pod yield when these factors were omitted from the approved package of practices.

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Stability analysis for protein and oil content in soybean

O. Singh and B. D. Chaudhary
Department of Plant Breeding,
Haryana Agricultural University, Hisar-125 004

ABSTRACT

To identify ideal genotypes in soybean, 32 promising strains were evaluated under 3 artificially created environments in a randomized block design with 4 replications. Significant environment and genotype environment interaction (GE) indicated variable response of varieties to wide range of environments. Similarly, significance of linear component of environment and GE indicated the predictability of regression coefficients pertaining to various genotypes on environmental means. Out of 11 genotypes with above average performance, all were stable except SH2 for oil content (%). Two genotypes, HM49 and PK73—94 were unpredictable. All the remaining 8 genotypes were adaptable to favourable environment. All the 3 stable genotypes with above average protein content were stable except Bragg. Interestingly both the remaining genotypes were adaptable to favourable environment due to above average response. Thus, HM44, SH3, SH4, PK71--6, PK73—64, PK73—86, Ankur and Bragg for oil content and HM49 and HM90 for protein content, with above average performance, will be responsive during favourable years. However, these will not perform poor under stress conditions.

Key words : Stability analysis; soybean; *Glycine max*; protein and oil content

INTRODUCTION

The presence of GE creates difficulties in assessing the performance of different cultivars. This is especially so in case of food legumes, which are often cultivated under varying agro-climatic, edaphic and management conditions. It is, therefore, necessary to identify the cultivars which are high yielding and stable in their performance, before these are released for commercial cultivation. With this objective in view, the present investigation was undertaken to identify ideal genotypes in 32 elite strains of soybean for quality characters, *Viz.*, Oil content (%) and protein content (%).

MATERIALS AND METHODS

Thirty two promising strains of soybean (*Glycine max* L. Merrill) were sown in a randomized block design with 4 replications under 3 artificially created

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environments. Two environments were created by following 2 sowing dates at an interval of a month, (7th July and 5th August, 1978) whereas third was induced by the application of fertilizer dose (20 : 80 : 60 NKP kg/ha) and nitragine culture in 1 of the 2 experiments sown on the later date (7th August, 1978). The rows 4.5 meters long were spaced 45 cm whereas, plants within rows were 5 cm apart. All the recommended cultural practices were used to raise a good crop. Five competitive plants were selected at random to estimate protein and oil content (%) as per specifications outlined in AOAC (1961). Mean data were analysed for stable genotypes following Eberhart and Russell (1966).

RESULTS AND DISCUSSION

Mean squares due to varieties were significant for oil content (Table 1) indicating sufficient variablity among the 32 genotypes. It was confirmed by the mean data of this character (Table 2). On an average, varieties had 15.8% in HM1 and as high as 17.9% in PK 73-94. Though mean square due to varieties for protein content was non-significant, yet the character was analysed.

Table 1 : Mean squares in pooled analysis of variance for oil content and protein content in soybean

Source	d. f.	Oil content (%)	Protein content (%)
Genotypes (G)	31	6.51*	11.02
Environment (E)	2	138.60*	30.56*
G + (G x E)	64	7.51*	9.45
E (linear)	1	277.20*	61.11
G x E (linear)	31	4.68*	8.72
Pooled deviation	32	1.83	8.73
Pooled error	279	3.23	13.75

* Significant at 5%

The mean squares due to environments were significant for both the characters (Table 1). It indicated the presence of variability in these created environments. The environmental indices were 2.40, -1.10 for oil content and -0.80, 1 30 and-0.50 for protein content for environments 1,2 and 3 respectively. The mean squares due to linear portion of environment was also significant and that too with higher magnitude. It indicated that prediction will be valid

Table 2 : Stability parameters for oil and protein content (%) in soybean

S.No.	Genotypes	Oil content (%)			Protein content (%)		
		Mean	b_i	$S^2_{d_i}$	Mean	b_i	$S^2_{d_i}$
1.	HM1	12.85	—0.12	—0.33	40.70	—0.63	—0.69
2.	HM8	14.12	—0.28	0.20	30.74	—2.64*	51.62*
3.	HM10	13.61	0.94*	—0.72	38.71	—2.48*	—1.09
4.	HM11	15.93	1.65*	—0.81	37.82	—1.32	9.72
5.	HM12	13.46	0.07	0.84	40.82	1.17	—0.60
6.	HM25	14.37	0.14	0.96	39.38	3.64*	—3.18
7.	HM33	16.00	1.46	0.02	40.98	2.17	11.86
8.	HM42	14.82	0.47	—0.24	38.35	2.02	1.78
9.	HM44	17.74	1.87*	3.97	38.95	2.01	14.40
10.	HM49	17.19	0.80	1.86	46.43	1.49*	—2.93
11.	HM78	15.60	1.84*	—0.80	41.66	—3.93	7.87
12.	HM90	16.28	2.26*	—0.80	44.53	2.23*	—0.47
13.	HM112	15.95	0.59*	—1.81	39.85	2.47	5.38
14.	HM93	14.32	0.32	—0.04	39.39	1.80	16.12
15.	SH1	16.28	1.63*	—0.76	41.17	1.53*	—3.15
16.	SH2	17.20	1.64	13.27	39.98	3.93*	—3.06
17.	SH3	17.88	1.53*	—0.09	41.71	1.03*	—3.43
18.	SH4	17.75	2.24*	—0.56	40.25	2.68	1.95
19.	SH5	13.80	0.16	3.03	40.18	1.57	0.94
20.	DS73—16	14.90	0.45*	—0.80	30.03	2.70	6.52
21.	DS74—20—2	15.28	1.00*	0.04	41.18	0.73*	—3.41
22.	JS72—395	14.18	0.50	—0.23	41.86	3.81*	—3.44
23.	PK321	15.47	0.79	1.09	41.51	3.28*	16.82
24.	PK71—6	17.48	1.68*	—0.72	40.28	1.78*	—2.69
25.	PK71—21	14.91	—0.19*	—0.48	39.01	—1.79	2.57
26.	PK73—64	17.13	1.80*	5.05	40.03	1.84	5.58
27.	PK73—86	17.42	1.26*	0.24	42.29	0.28	—0.96
28.	PK73—92	15.62	0.70*	0.41	41.81	—2.54	32.10
29.	PK73—94	17.94	1.19	4.69	37.99	—2.00	3.22
30.	PK74—262	16.38	1.67*	4.24	37.59	3.38*	—1.23
31.	Ankur	16.78	1.39*	0.48	38.45	1.02*	—3.40
32.	Bragg	17.29	1.15*	—0.05	42.93	—0.21	11.46
	Mean	15.81 ± 0.96			40.48 ± 2.09		

* Significant at 5%

in the present experiment. It was confirmed by the significant values of the most of regression coefficients (Table 2).

Testing newly evolved varieties under varying environments provides the information for their performance over several locations for one or more reasons. But though useful, it is not always possible. Under such circumstances, it may be more convenient to increase environments by manipulating agronomic treatments at existing experimental sites. The present investigation indicated that the agronomic treatments, dates of sowing and fertility levels provided different environments for both the characters. The environments were created by extending dates of sowing from 7th July to 5th August and inclusion and exclusion of fertilizer dose and nitragine culture.

The significance of mean squares due to GE indicated the variable response of these 32 genotypes in the 3 artificially created environments. The linear component of GE was also significant and that too with higher magnitude. It indicated that the differences in the regression coefficient, b_i, pertaining to various genotypes on environmental mean were real and predictable.

The regression approach, initiated by Yates and Cockerham (1938), was extended by Eberhart and Russell (1966), who defined ideal variety as one, which has the highest yield over a broad range of environment, a regression coefficient value of unity (b_i) and deviation from mean squares equal to zero. 11 genotypes, *viz.*, HM44, HM49, SH2, SH3, SH4, PK73-86, PK73-64, PK73-94, PK73-6, Ankur and Braggs, showed significantly higher oil content than mean oil content of 16 77 (15 81 + 0.96). Out of these 11 genotypes, HM49, SH2 and PK73 94 were unpredictable due to nonsignificant regresssion coefficient. However, all the 11 genotypes were stable as revealed by non-significant deviation from the regression except SH2 (Table 2). These 11 above average performing genotypes need to be analysed for prediction, response and stability. Three genotypes, HM49, SH2 and PK73-94 were unpredictable and as such adaptation cannot be defined. Similarly SH2 was unstable. Remaining 8 genotypes having above average response were suitable in favourable environment, I, which was normal sowing with normal cultural practices.

For protein content (%), 3 genotypes were found having significantly higher protein content than the average 42.57% (40.48 + 2.09). Regression coefficient was nonsignificant in 19 genotypes and as such these unpredictable genotypes can not be classified for adaptation. Interestingly all the genotypes were stable due to nonsignificant deviation from regression except HM8 (Table 2). Genotypes with below average performance are of little or no practical utility, even if these are stable and predictable. Hence, responsiveness and stability of 3 genotypes with above average performance need to be discussed. All these 3 genotypes with non-significant deviation from regression were termed stable, Only 1 genotype, Bragg, having nonsignificant regression coefficient was unpredicatable and as such can not be classified for adaptability. Both the remaining genotypes were classified on the basis of response. Interestingly, both the genotypes, HM49 and HM90 with above average response and stability were adaptable to favourable environment, I_2, normal cultural practices.

From the above discussion, 8 genotypes for oil content and 2 genotypes for protein content with above average performance, stability and predictability need to be retained in the breeding programmes. These genotypes, HM49, SH3, SH4, PK71-6, HK73-64, PK73-86, Ankur and Bragg for oil content and HM49 and HM90 for protein content will be advantageous in the favourable years. However, these will not perform poor under stress conditions.

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Influence of soil fertility status and primary nutrients (N, P, K) application on chemical composition and oil production of major oilseeds in vertisols of Madhya Pradesh

S. A. Jaipurkar and Girish Puri
Department of Soil Science & Agricultural Chemistry,
J. N. Agricultural University, Jabalpur-482 004 (M. P.)

ABSTRACT

Significant influence of varying degree of soil fertility status on nutrients concentration in (N, P) in grains of safflower, niger, and potassium concentration in linseed grains were denoted. Besides, significant variation in sulphur content in grains of linseed and safflower were noted. Relative mean seed concentrations of major nutrients were in the following order : N(%)—niger (3.87)> linseed (3.13)> safflower (2.05); P(%)—Niger (0.51)> linseed (0.40)> safflower(0.33); K (%)—Niger (1.81)> linseed (1.09)> safflower (0.98); Ca (%) — Niger (5.19)> safflower (0.48)> linseed (0.47); Mg(%) —safflower (0.23)> niger (0.19)> linseed (0.18), and S(%) —Linseed (0.14)> niger (0.13)≥ safflower (0.09). The P and K contents in seeds of niger and linseed were significantly affected by the levels of fertilisation (N, P, K) and their effect was significant and obviously seen in nitrogen content of safflower seeds. The oil content in niger and safflower were significantly effected by varying degree of soil fertility status. Significant correlation coefficient of Olsen's—P with oil content in linseed (r = 0.4267*) and oil production (kg/ha) in safflower (r = 0.3876*) and linseed (r = 0.5816*) were observed. Oil content and oil production of these crops were significantly affected by various levels of N, P, K fertilisation. The mean oil production (kg/ha) was in order of : linseed (926.7) safflower (450.6) niger (80.4). Comparative studies on profitability maximised oil production by these crops revealed that the treatment combination $N_{45}P_{45}$, $N_{80}P_{40}K_{20}$ and $N_{45}P_{60}$, were adjudged to be best for niger, safflower and linseed respectively. Linseed and safflower were equally prolific crops in terms of profit, benefit cost ratio and yardstick value of oil production.

Key words : Soil fertility; primary nutrients; oil composition

INTRODUCTION

There is acute shortage of edible and drying oil in India. The oil production is unstable due to fluctuation in the yield of groundnut, which is the major oilseed crop. The vegetable oil resources can be broadbased by growing crops

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like linseed (*Linum usitatissimum* Linn.) niger (*Guizotia abyssinica* Cass.) and safflower (*Carthamus tinctorius* Linn.). Therefore, standardised conditions, i.e., agro-technique, fertilizer management, soil and water management and pest management for a specific agro-climatic-soil complex, has to be exploited in view to raise the oil productivity. Thus the present communication hinges around two objectives, i.e., comparative performance of niger, safflower and linseed under varying soil fertility status and influence of N,P,K fertilization on the nutrient concentration (N,P,K) and oil productivity of these crops.

MATERIALS AND METHODS

Field experiments were conducted from June, 1980 to March, 1982 at livestock farm, College of Agriculture, JNKVV, Jabalpur. The soil belongs to fine, montmorillonitic hyperthermic family of Typic chromustert (USDA Hand book No. 436). It is clayey (sand 21.5%, silt 23.5% and clay 55%). Three main experiments on linseed (R-17), niger (Ootakmund) and safflower (JSF-1) were conducted on four fertility gradient strips created by applying graded doses of nitrogen, phosphorus and potassic fertilizers so as to get sufficient range in their soil fertility. A preparatory crop of fodder maize was grown in the preceding season of each main experiment so that the fertilizers get stabilised in the soil by reaction with soil, plant and microbes. The graded doses of nutrients; N:0, 75, 150, 300; P_2O_5: 0, 85, 170, 340; and K_2O:0, 75, 150, 300 kg/ha each) were applied to create a fertility gradient before sowing of an exhaust crop-maize. The fertilizers used were urea, superphosphate and muriate of potash. After the harvest of fodder maize, the main experiments each on linseed, niger and safflower were superimposed on the four strips on which, fertility gradient had already been obtained (table 1). In general, on account of availability of primary nutrient (N,P,K) under varying soil fertility status revealed that available nitrogen varied from low to medium, available phosphorus from low to very high and available potassium from medium to high. A fractional factorial combination of 21 treatments ($5\times4\times3$; levels of N P_2O_5 and K_2O) were allotted at random, in each of the four strips with eight control plots (3×8 m^2). The fertilizer schedule is given below.

Level	Dose (Kg/ha)								
	Niger			Safflower			Linseed		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
0	0	0	0	0	0	0	0	0	0
1	15	15	15	20	20	20	25	20	20
2	30	30	30	40	40	40	50	40	40
3	45	45	—	60	60	—	75	60	—
4	60	—	—	80	—	—	100	—	—

Table 1 : Level of available nutrient status in different fertility gradient strips (kg/ha)

Crop and nutrients	Soil fertility gradient strips							
	L_0		L1/2		L_1		L_2	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Niger								
Nitrogen	190-257	228	246-347	301	258-369	326	336-436	392
Phosphorus	4-5-16.0	9.4	11.6-24.9	17	14.2-35.6	24	24.0-53.9	36
Potassium	291-494	366	358-538	445	403-538	472	493-627	563
Safflower								
Nitrogen	224-280	250	246-336	285	268-336	310	302-403	341
Phosphorus	6.2-17.8	11	15.1-24.3	20	25.9-59.6	42.4	41.8-67.6	54.7
Potassium	313-470	393	313-582	468	358-716	447	448-716	546
Linseed								
Nitrogen	213-268	238	268-358	296	268-392	337	324-425	366
Phosphorus	1.8-12.4	4.3	9·6-52.5	28.4	15.1-42.4	28.4	12.4-67.6	39.2
Potassium	325-582	490	313-582	440	313-538	443	313-672	484

Plant populations were maintained and standard agronomic practices followed.

A composite soil sample from 0-15 cm depth was drawn from each plot before sowing of each main experiment. The soil samples were dried in shade, ground, passed through 20 mesh sieve. Primary plant nutrients, i.e., available nitrogen, available phosphorus, available potassium and secondary nutrients i.e. available calcium + magnesium and available sulphur were determined by (Jackson, 1973).

Digestion of seed (0.5 g) was done in diacid mixture of nitric acid and perchloric acid (5:2) and the volume was made upto 100 ml. This digest was used to determine phosphorus (Koening and Johnson, 1942), potassium (Chapman and Pratt, 1961), calcium and magnesium (Piper, 1967), sulphur (Blanchor *et al.*, 1965) and nitrogen (Piper, 1967). Oil per cent was determined by soxhlet extraction method.

RESULTS AND DISCUSSION

The mutrient concentration with respect to nitrogen, phosphorus and potassium in seeds of niger and safflower increased significantly with rise in fertility status (Table 2). The P and K concentrations in seeds of linseed were found to be non-significant. Similarly, the concentration of secondary plant nutrients (Ca, Mg, S) in niger had non-significant effect due to varying degrees

Table 2 : Influence of soil fertility status on the nutrient concentration (%) in seeds of various oilseed crops

Crop	Nutrient	Fertility gradient status				Mean	S Em. ±	CD (5%)
		L_0	L1/2	L_1	L_2			
Niger	N	3.6	3.9	3.9	4.1	3.87	0 04	0.08
	P	0.45	0.49	0.54	0.59	0.51	0.01	0.02
	K	1.55	1.70	1.95	2.35	1.88	0.06	0.13
	Ca	0.401	0.480	0.603	0.593	0.519	0.054	NS
	Mg	0.174	0.223	0.176	0.186	0.189	0.026	NS
	S	0.126	0.127	0.148	0.146	0.136	0.18	NS
Safflower	N	2.0	2.0	2.1	2.1	2.05	0.038	0.079
	P	0.31	0.33	0.34	0.35	0.33	0.01	0.023
	K	0.85	0.90	1.00	1.15	0.98	0.04	0.08
	Ca	0.450	0.476	0.501	0.532	0.489	0.092	NS
	Mg	0.248	0.230	0.236	0.217	0.232	0.155	NS
	S	0.072	0.085	0.098	0.114	0.092	0.013	0.027
Linseed	N	2·6	2.6	0.27	3.0	3.13	0.04	0.08
	P	0.39	0.40	0.40	0.41	0.40	0.01	NS
	K	0.85	0.85	1.05	1.00	1.09	0.06	NS
	Ca	0.511	0.552	0.443	0.409	0.470	0.035	0.072
	Mg	0.168	0.161	0.186	0.248	0.19	0.040	NS
	S	0.147	0.118	0.150	0.180	0.148	0.040	0.084

of soil fertility gradient. Significant variation in sulphur and calcium content with degree of soil fertility gradient was recorded in safflower and linseed. Significant fertility gradient in soil for available sulphur and calcium were observed prior to sowing of niger, linseed and safflower but this was not observed in case of available soil magnesium. Therefore, it revealed that nutrient composition of grain and soil for available status of these nutrients, maintained functional relations (Jaipurkar, 1984). Shinde *et al.* (1982) have also reported the increase in sulphur concentration of soybean due to high availability of soil sulphur. Relative nutrient concentrations present in each oilseed crop were in order Nitrogen (%) — niger (3.87) > linseed (3.13) > safflower (2.05); phosphorus (%) – niger (0.51) > linseed (0.40) > safflower (0.33); potassium (%) — niger (1.81) > linseed (1.09) > safflower (0.98); calcium (%) — niger (5.19) > safflower (0.48) > linseed (0.47); magnesium (%) — safflower (0.23) > niger (0.19) > linseed (0.18) and sulphur (%) — linseed (0.14) > niger (0.13) > safflower (0.09).

Earlier workers Mahajan and Bisen (1980) have also inferred that increase in soil fertility status have positive and perceptible impact on the nutrient concentration (N,P,K) in major oilseeds and cereal crops.

The influence of N,P and K fertilization (Table 3) on seed composition with regard to nitrogen, phosphorus and potassium, showed non-significant effect in niger and linseed, whereas, treatment $N_{60}P_{60}K_{40}$ has yielded the highest and significant nitrogen content (2.35%) in safflower. Significant effect on phosphorus was recorded by treatments $N_{60}P_{30}K_{30}$ and $N_0P_{20}K_{20}$ in niger and linseed respectively. Potassium concentration was significantly affected by the treatment $N_{60}P_{45}K_{15}$, whereas, non-significant affect on K concentration by fertilisation was recorded in safflower and linseed.

The mean oil per cent (Table 4) was in order of : linseed (43.4) > niger (33.6) > safflower (23.9). Oil content in niger and linseed varied significantly with varying degrees of soil fertility status and apparently, a curvilinear pattern was observed in niger, safflower and it was vitiated and followed positive linear trend in linseed. Significant variation in mean oil production was noted due to varied soil fertility gradients and curvilinear pattern was observed in niger and safflower, whereas, linseed did not follow positive and linear trend.

The correlation studies (Table 5) have shown that oil percentage of all the oilseed crops under study, had non-signiftcant relation with the quality parameters like seed-N, seed-Mg and seed-Mg+S contents. The available soil phos phorus had significant ($r = 0.4267^*$) relation with the oil content and production ($r = 0.5816$) in linseed. In case of safflower, oil production was positively correlated ($r = 0.3876$) with Olsen's-P. Sulphur and magnesium contents of

Table 3 : Influence of fertilisation on chemical composition (nitrogen, phosphorus and patassium) in the seeds of various oilseeds

Sl. No.	Nutrients N-P-K	Niger N (%)	Niger P (%)	Niger K (%)	Safflower N (%)	Safflower P (%)	Safflower K (%)	Linseed N (%)	Linseed P (%)	Linseed K (%)
1.	0-0-0	3.87	0.518	1.88	2.05	0.333	0.98	3.13	0.400	1.09
2.	0-1-1	4.02	0.523	2.05	2.27	0.323	1.05	2.93	0.425	1.05
3.	1-0-1	4.00	0.500	1.91	2.23	0.333	1.15	3,00	0.418	1.25
4.	1-1-0	4.02	0.520	1.78	2.32	0.333	1.05	3.03	0.413	1.08
5.	1-1-1	4.05	0.535	1.91	2.17	0.333	1.11	3.08	0.413	1.26
6.	2-0-0	4.12	0.523	1.86	2.30	0.345	1.06	3.13	0.407	1.23
7.	2-0-1	4.10	0.515	1.93	2.25	0.323	1.11	3.20	0.412	1.29
8.	2 1-0	4.02	0.553	1.87	2.35	0.333	1.04	3.08	0.410	1.29
9.	2-1-1	4.22	0.508	2.02	2.20	0.348	1.11	3.03	0.412	1.21
10.	2-2-0	4.05	0.520	2.17	2.12	0.358	1.04	3.15	0.412	1.26
11.	2-2-1	4.05	0.548	2.17	2.22	0.353	1.10	3.03	0.415	1.29
12.	2-2-2	4.15	0.555	2.11	2.35	0.340	1.04	2.98	0.412	1.34
13.	3-0-0	4.22	0.510	1.80	2.22	0.348	0.99	3.10	0.418	1 28
14.	3-1-1	4.18	0.533	2.06	2.27	0.353	1.15	2.98	0.418	1.31
15.	3-2-2	4.15	0.548	2.23	2.22	0.360	1.23	3.05	0.412	1.33
16.	3-3-0	4.15	0.548	2.03	2.20	0.355	1.10	3.05	0.412	1.38
17.	3-3-1	4.10	0.543	1.83	2.35	0.360	1.06	3.03	0.405	1.36
18.	3-3-2	4.15	0.565	2.07	2.20	0.355	1.11	3.05	0.413	1.38
19.	4-2-1	4.10	0.528	2.25	2.17	0.353	1.14	3.25	0 415	1.34
20.	4-2-2	4.10	0.585	2.23	2.25	0.360	1.06	3.05	0.410	1.38
21.	4-3-1	4.02	0.575	2.30	2.17	0.363	1.03	3.25	0.413	1.34
22.	4-3-2	4.12	0,573	2.27	2,18	0.358	1.08	2.73	0.410	1.28
	Mean	4.09	0.537	2.04	2.24	0.347	1.08	3.05	0.412	1.27
	S.Em. ±	NS	0.013	0.09	0.55	0.013	0.24	0.08	0.007	0.04
	CD 5%	NS	0.037	0.26	0.15	NS	NS	NS	0.018	0.11

Table 4 : Influence of varying soil fertility status on oil content (%) and oil production (kg/ha) of niger, safflower and linseed

Fertility status	Niger		Safflower		Linseed	
	Oil content (%)	Oil production kg/ha	Oil content (%)	Oil production (kg/ha)	Oil content (%)	Oil production (kg/ha)
L_0	32.3	60.4	23.3	220.7	42.3	710.0
L 1/2	34.4	71.3	24.4	408.2	43.0	778.6
L_1	34.4	75.6	24.0	425.1	43.5	822.3
L_2	33.4	59.6	24.0	368.0	44.8	1030.6
Mean	33.62	66.7	23.9	355.4	43.4	855.3
S. Em. ±	0.58	1.77	0.58	26.3	0.74	44.3
CD at 5%	1.21	3.70	NS	54.8	1.55	92.2

Table 5 : Correlation of oil content (%) with various parameters of oilseed crops

Sl. No.	Parameters	Correlation coefficient (r)		
		Niger	Safflower	Linseed
1.	Seed-N content	—0.1659	0.1374	—0.0040
2.	Seed-S content	—0.2337	—0.0883	0.2949
3.	Seed-Mg content	0.1354	—0.0192	0.3393
4.	Seed-Mg + S	0.0391	—0.0619	0.0320
5.	Soil-P	0.2800	0.1118	0.4267*
6.	Soil-Mg	0.0851	0.3448	0.2107
7.	Soil-S	0.0140	0.0817	0.3167
8.	Soil-P - oil production	—0.0560	0.3876*	0.5816*

* Significant at 5% level

Table 6 : Influnce of fertilisation (N,P,K) on the content (%) and production (kg/ha) of oil in various oilseed crops

Sl. No.	Treatments (N-P-K)	Niger		Safflower		Linseed	
		Oil (%)	Oil (kg/ha)	Oil (%)	Oil (kg/ha)	Oil (%)	Oil (kg/ha).
1.	0-0-0	33.63	66.7	23.92	355.4	43.40	835.2
2.	0-1-1	33.57	84.2	23.85	375.4	41.88	832.0
3.	1-0-1	33.23	73.4	23.20	404.1	41.58	903.0
4.	1-1-0	33.88	85.0	23.55	453.6	42.25	856.5
5.	1-1-1	32.60	31.6	23.44	413.5	42.03	929.9
6.	2-0-0	32.35	67.2	24.00	420.8	41.48	922.2
7.	2-0-1	33-13	67.1	23.87	493.3	41.03	85.88
8.	2-1-0	33.85	76.7	23.82	441.1	41.73	904.9
9.	2-1-1	33.55	81.7	23.77	472.7	40.93	912.7
10.	2-2-0	33.73	65.9	24.05	473.5	40.40	944.2
11.	2-2-1	34.65	77.4	24.35	460.3	43.00	962.9
12.	2-2-2	35.23	79.2	24.07	453.6	41.35	902.5
13.	3-0-0	32.88	81.9	23.82	421.2	41.25	931.5
14.	3-1-1	33.38	68.1	24 07	421.2	41.93	941.5
15.	3-2-2	34.83	86.2	23.72	460.3	43.53	979.9
16.	3-3-0	34.30	103.7	24.27	481.3	43.93	1004.2
17.	3-3-1	34.95	86.5	23.87	465.7	43.20	986.0
18.	3 3 2	34.35	89.7	24.90	496.5	42.70	945.8
19.	4 2-1	33.80	87.1	24.80	523.4	42.98	894.0
20.	4-2-2	34.30	79.0	24.42	483.9	42.28	982.5
21.	4-3-1	34.28	86.8	25.55	481.4	43.53	994.7
22.	4-3-2	34.60	91.2	25.42	471.2	43.05	991.0
	Mean	33.77	80.4	24.13	450.6	42.24	926.7
	S. Em. ±	0.52	6.12	0.37	31.7	0.72	37.3
	CD at 5%	1.46	17.0	1.03	87.9	2.02	103.3

Table 7 : Profitability of maximised oil production due to fertilisation in various oilseed crops

Crop Treatments	Mean oil yield of control (plot kg/ha)	Oil production of treated plot (kg/ha)	Response of oil production	Profit Rs./ha	Benefit : cost ratio	Yard stick value
Niger $N_{45}K_{45}$	66.7	103.7	37.0	152	0.42	0.41
Safflower $N_{80}P_{40}K_{20}$	355.4	523.4	168	1867	3.84	1.20
Linseed$N_{75}K_{60}$	835.2	1004.2	169	1829	3.40	1.25

Rate : Oil @ Rs. 14.00/kg; N @ Rs. 3.30/kg; P_2O_5 @ Rs. 4.84;
K_2O @ Rs. 1.37

oilseeds individually or collectively did not show significant correlation with oil per cent. The magnitude and extent of correlation coefficient revealed that magnesium content was more closely related to oil content than S content in linseed. On the contrary, Subramaniam *et al.* (1976) also reported increase in seed oil content of groundnut by magnesium application and it was infererred that magnesium probably increases the efficiency of phosphorus in plant towards oil synthesis.

Signtficant effect of levels of fertilisation on oil content and oil production was noticed (Table 6). The mean oil production (kg/ha) were in order of : linseed (926.7) > safflower (450.6) >niger (926.7). Oil content and production increases with the increase in fertilizer levels. The juxtaposition of treatments N_{45} P_{45} K_{45} and N_{60} P_{45} K_{15} revealed that reduction in oil percentage in niger from 32.92 to 34.28 was probably ascribed to higher level of nitrogen. Ramaswami *et al.* (1974) reported significant increase in oil content upto 50 kg N/ha level. A higher dose of nitrogen, however, reduced the seed oil content. In contrast, linsed and safflower failed to yield such trend. In general, the treatments N_{45} P_{45} K_0, N_{80} P_{40} K_{20} and N_{75} + P_{60} had exploited the highest oil production in niger, safflower and linseed respectively. The data on profitability of maximised oil production indicated linseed as the most prolific, oil producing crop, having oil production and profit to be 1004 kg/ha and Rs. 1829/ha, as compared to safflower and niger. The safflower and linseed had yielded approximately equi-magnitude of benefit : cost ratio (3.40:3.80) and yardstick value (1.20). Thus, it can be inferred that niger is a poor oilseed crop in view of yield potential, response yardstick and other economic measures like benefit : cost ratio and profit, whereas, safflower and linseed are the most profitearing and responsive crops to fertilisation and can be grown in Madhya Pradesh.

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Spray schedule decision model for management of leaf spots of groundnut

V. D. Sondge, C. D. Mayee and S. A. Karpe
Marathwada Agricultural University, Parbhani-431 402

ABSTRACT

One spray of carbendazim was not sufficient to give prolonged protection against subseqent leaf spots infections of groundnut. A minimum of two early sprays (beginning at 30 days) reduced disease severity, apparent infection rates and enhanced pod yield. However, spray scheduled at various growth stages gave differential responses indicating the possibility of decision making under conditions of resource contraints. When resources of a grower permits for only two sprays, the best profits could be obtained by undertaking the applications at 30 and 42 days after sowing. The optimum decision in case where only one spray is permissible in the cost of cultivation, should be taken at 42 days after sowing to derive maximum profit by the management practices.

Key words : Leaf spots; carbandazim; management; decision making; profit function

INTRODUCTION

Early and late leaf spots generally referred as 'tikka' disease of groundnut induced by *Cercospora arachidicola* Hori and *Cercosporidium personatum* (Berk. and Curt.) Deighton respectively are the most widely distributed and destructive foliar diseases (Smith and Littrell, 1980, Subrahmanyam *et al.,* 1982). In India, yield losses due to early and late leaf spots are substantial (Subrahmanyam *et al.,* 1980; Ghuge *et al.,* 1981). Carbendazim, a systemic fungicide, is currently advocated for leaf spots management as it has proved highly effective against the early and late leaf spot pathogens in multilocational experiments over a period of three years (Kolte *et al.*, 1978; Ghuge *et al.*, 1981). However, the limitations of finance in the semi-arid tropics in which the crop is mostly grown imposes certain restrictions over the number of spray applications.

The present investigations were aimed to determine the critical stages of spary applications that were effective for management of the disease and also to

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work out the profit function that dicides it's acceptability when cost constraints are operative.

MATERIALS AND METHODS

A field experiment was conducted using leaf sopts susceptible groundnut variety, JL-24. It was sown in 4.5 m × 4.5 m plots with 30 cm × 15 cm spacing in a randomized block design with three replications

Conidia of *C. arachidicola* and *C. personatum* initially multiplied on detached leaves of JL-24 at 29°C were removed from the sporulating lesions of both the leaf spots and suspended in sterile water containing 0.2 ml of Trition X 100 per litre of water. The concentration of the mixture of spores was adjusted to approximately 2.5×10^4 sporesl/ml. The inoculations were performed during the evening hours. Actively growing 25-day old plants in each plot were inoculated by spraying the mixed conidial suspension to cover all the leaves.

Different carbendazim (Bavistin 50 WP, 0.1%) spray treatments were started on the appearance of the disease. Treatment schedules consisted of one to five sprays beginning from 30 days after sowing (DAS) and one to four sprays beginning from 42 DAS at an interval of 12 days. The quantity of carbandazim used in spray varied from 0.5 kg/ha each on 30 and 42 DAS to 0.6 kg/ha each on 54, 66 and 78 DAS (Table 1).

Leaf spots incidence (% infected leaves) and intensity (number of spots per compound leaf) were recorded periodically seven times during the growth period and apparent infection rates based on the initial and final intensities were calculated according to Van der Plank (1963). Ten individual plants per plot were labeled and used for scoring the disease. To avoid interference from natural infection of rust, three uniform sprays of 0.07% tridemorph (Calixin 80 EC) were undertaken as it selectively inhibits rust (Ghuge *et al*, 1981).

The dry pod yield was observed to be the function of quantity of carbandazim (kg/ha) sprayed at identified pathologically sensitive growth stages of the crop. Thus, the crop stages were divided in different niji growth periods (30-42, 42-54, 54-66, 66-78, days after sowing) i.e. $y = f\ (xi)$ .... (1)
Where, y = yield of dry pods, xi = ith quantity of the fungicide in kg/ha at jth stage, $i = 1,2,3, \ldots\ldots$ n in kg/ha and $j = 1,2,3$ .... n stages of crop.

The objective yield function of the following type was developed by least square technique :

Table 1 . Effect or carbendzim spray schedules on tikka disease of groundnut

Number of spray	Sprays DAS	Total *quantity* of chemical (kg/ha)	Final disease avaluation		
			% incidence (arcsine)	*Intensity* (spots/leaf)	*Infection* rate (r) (units/day)
Water spray	Control	0.0	74.6	14.7	0.091
5	30—78	2.8	21.7	2.5	0.028
4	30—66	2.2	25.1	2.5	0.031
3	30—54	1.6	29.2	2.8	0.038
2	30—42	1.0	40.4	4.7	0.054
1	30	0.5	62.0	11.0	0.070
4	42—78	2.3	31.0	2.8	0.043
3	54—78	1.8	50.8	7.6	0.058
2	66 . 78	1.2	56.5	8.8	0.059
1	78	0.6	68.8	11.3	0.072
SE ±			3.2	1.5	
CD (P = 0.5)			9.4	4.3	

DAS = Days after sowing

$Y = b_o + \sum b_i x_i$ .... (2). Where, Y = Yield in kg/ha, bi = regression coeficients of spraying xi quantity at each stage, i = 1,2,3 n and bo = intercept of the objective yield function.

The yield function (eq-2) was converted into profit function after introducing the cost elements for conditional maximization of profit (P) as : $P = s\text{-}q + \sum x_i (b_i s - r)$ . . (3) with the constraints.

$D < x_i < 3, \sum x_i r + q < f$ and $P > O$

Where : P = Profit in rupees/ha

q = Cost of cultivation, Rs. 1200/ha excluding cost of chemical

s = Selling price of dry pods, Rs. 4/kg

f = Funds available in Rs/ha (variable)

r = Cost of chemical, Rs. 440/kg

x = Quantity of chemical kg/ha

The optimum solutions for maximization of profits under different constraints (resources availabilities) were obtained by the simplex method (Anand, 1981).

RESULTS AND DISCUSSION

Carbendazim reduced early and late leaf spots severity on groundnut nearly one month after first application. One early spray, however, was not enough to keep disease levels significantly below those in unsprayed check plots. Supplementary sprays given at 54 to 78 days reduced disease severity. When the first application of fungicide was delayed until 78 DAS, it was not effective in reducing the disease levels. However, four applications beginning from 42 DAS did keep disease magnitude significantly below that in check plots (Table 1). The apparent infection rates declined substantially in plots receiving a minimum of two early sprays.

Reduced disease levels resulted in increased pod yield (Table 2). Early schedules of three to five spray applications or four late sprays gave significantly higher pod yields over other treatments. The date further revealed a differential impact of early and late sprays at fixed growth stages. On assuming the yield to be function of quantity of chemical sprayed at different stages, the resultant yield equation was:

$$Y = 1120.9 + 487 X_1 + 637 X_2 + 240.83 X_3 + 236.67 X_4 + 200.83 X_5 \qquad (4)$$

$$R^2 = 0.6767, \; SEY \pm 66.30$$

Where ; Y = Yield (kg/ha) and X_1 to X_5 = Quantity of the fungicide sprayed at each stage (kg/ha)

The R^2 of the function showed that the fit was good and it explained 67.67, per cent variation in between the expected and observed yields. It was precisely accurate and meaningful (SEY = 66.30 kg/ha). The persual of equation 4 revealed that the magnitude of response of crop to spray differed at different stages and thereby indicated a differential impact of disease on yield. The most sensitive stage of crop to disease was during 42 to 54 DAS and 66-78 DAS.

The response of the crop to carbendezim increased upto second application at 42 days and thereafter it gradually declined. This is probably because of longer persistence of the chemical in host tissues as it is a known systemic fungicide.

The differential impact of conditional spray application coupled with prolonged persistance suggested that a suitable spray decision for maximization

Table 2: Dry pod yield of groundnut in various spray Schedule treatments

Number of early spray	Spray DAS	Yield (kg/ha)	Number of late spray	Spray DAS	Yield (kg/ha)
5	30-78	2057	4	42-78	1846
4	30-66	1969	3	54-78	1485
3	30-54	1904	2	66-78	1460
2	30-42	1640	1	78	1241
1	30	1363	Water spray	Control	1088
SE ±		139.1	CD (P = 0.05)		413.1

DAS = Days after sowing.

Table 3: Optimum decision, schedule priorities and maximum profit under constraints

Case	Available resource		Schedule	Resource in balance		Profit
	Chemical (kg/ha)	Funds (Rs/ha)	priority DAS	Chemical (kg/ha)	funds (Rs/ha)	(Rs/ha)
A	0.5	1700	42	—	280	4338
B	2.0	1800	30,42	1.0	200	5092
C	2.5	2000	30,42,54	0.9	96	5406
D	3.0	2200	30,42,54,6	0.8	32	5710
E	3.0	2500	30,42,54,66,78	0.2	68	5930

DAS = Days after sowing

of profit under resource constraints was possible. Therefore, the yield function was converted to profit function (eq.5) of linear programming i.e. activity analysis for conditional maximization of profit under imposed constraints. The resultant equation was $P = 3283.6 + 1508\ X_1 + 2108\ X_2 + 523.32\ X_3 + 506.68\ X4 + 363\ 32X_5$ (5) With constraints; $O < X_1 < 3$, $\lesssim X$ ir $+ q < F$; and $P > O$ The profit function indicated that profits were higher than the investments and the spray applications were economical. Hence, optimum decision were developed, which are given in Table 3. The data revealed that under unlimited resource availability (Case E) the decision was to take sprayings at all specified stages to get maximum net profit of Rs. 5927.59/ha. Under limited resources (cases A to D), the appropriate decision shall be to take sprayings at 30 and 42 days after sowing for getting highest profit. If only one spray is to be applied then it should be given at 42 DAS instead of 30 DAS. Depending on the availability of funds, the repeat sprays could be extended on 54 and 66 DAS on priority basis for getting maximum profits under these conditions.

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Table 1 : Phenotypic (above diagonal) and genotypic (below diagonal) correlation coefficient among 14 characters during *Kharif* (K), *Rabi* (R) and *Zaid* (Z) season in sunflower

Character		X_1	X_2	X_3	X_4	X_5	X_6
Seedling	K	—	0.76**	0.80**	0.38*	-0.36*	0.21
height (X_1)	R	—	0.67**	0.56**	-0.16	-0.20	0.07
	Z	—	0.85**	0.87**	0.34	0.28	0.49**
Seedling	K	0.91	—	0.90**	-0.18	-0.15	0.48**
fresh weight	R	0.87	—	0.95**	0.24	0.22	0.51**
(X_2)	Z	0.99	—	0.99**	0.40*	0.32	0.57**
Seedling dry	K	1.11	0.93	—	-0.20	-0.14	0.42*
matter	R	0.72	0.99	—	0.22	0.19	0.41*
weight (X_3)	Z	1.02	0.93	—	0.43*	0.35	0.59**
Days to	K	-0.39	-0.17	-0.22	—	0.94**	0.52**
heading (X_4)	R	-0.19	0.41	0.35	—	0.98**	0.83**
	Z	0.43	0.62	0.67	—	0.97**	0.91**
Days to	K	-0.40	-0.12	-0.11	1.00	—	0.57**
flowering	R	-0.26	0.36	0.32	0.99	—	0.79**
(X_5)	Z	0.32	0.48	0.52	0.98	—	0.89**
Number of	K	0.26	0.72	0.81	0.57	0.62	—
leaves (X_6)	R	0.08	0.71	0.58	0.88	0.84	—
	Z	0.53	0.70	0.74	0.98	0.94	—
Plant height	K	0.43	0.80	0.97	0.66	0.64	0.86
at flowering	R	0.43	0.90	0.81	0.71	0.66	0.88
(X_7)	Z	0.72	0.87	0.90	0.92	0.87	0.91
Plant height	K	0.47	0.73	0.87	0.64	0.63	0.83
at maturity	R	0.45	0.89	0.80	0.71	0.66	0.87
(X_8)	Z	0.77	0.92	0.95	0.88	0.83	0.89
Stem	K	0.55	0.80	1.12	0.41	0.46	0.77
diameter	R	0.16	0.68	0.84	1.05	1.02	0.74
(X_9)	Z	0.50	0.64	0.68	0.77	0.79	0.86
Head	K	0.70	0.86	1.10	-0.07	-0.10	0.50
diameter	R	0.78	1.40	1.42	0.58	0.55	0.71
(X_{10})	Z	0.43	0.64	0.70	0.45	0.54	0.62
Seed Yield	K	0.82	0.95	1.18	0.01	-0.02	0.51
(X_{11})	R	0.47	0.76	0.72	0.66	0.64	0.73
	Z	0.72	0.74	0.78	0.31	0.36	0.48
1000 seed	K	0.45	0.53	0.89	0.19	0.16	0.41
weight (X_{12})	R	0.47	0.79	0.98	0.15	0.16	-0.01
	Z	0.28	0.15	0.14	-0.01	0.03	-0.02
Oil content	K	-0.21	-0.01	-0.03	-0.24	-0.26	-0.18
(X_{13})	R	-0.05	-0.36	-0.41	-0.29	-0.23	-0.25
	Z	0.02	0.00	-0.01	-0.12	-0.08	-0.02
Protein	K	-0.03	-0.16	0.31	0.19	0.20	0.02
Content (X_{14})	R	0.05	-0.06	-0.05	-0.11	-0.09	-0.25
	Z	0.20	0.36	0.36	-0.17	-0.20	0.03

* Significant at $P = 0.05$ K = *Kharif* R = *Rabi* Z = *Zaid*

** Significant at $P = 0.1$

Table 1 : (Contd.)

X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}
0.37*	0.43*	0.40*	0.55**	0.67**	0.38*	—0.15	—0.02
0.36*	0.38*	0.11	0.51**	0.33	0.29	—0.04	0.04
0.64**	0.65**	0.50**	0.40*	0.62**	0 13	0.08	0.11
0.52**	0.53**	0.46**	0.58**	0.64**	0.32	0.03	—0.13
0.66**	0.65**	0.48**	0.80**	0.54**	0.37*	—0.23	—0.04
0.71**	0.74**	0.51**	0.35	0.53**	0.11	0.01	0.25
0.48**	0.50**	0.50**	0.57**	0.60**	0.44*	0.02	0.18
0.58**	0.58**	0.50**	0.76**	0.53**	0.42*	—0.27	—0.03
0.72**	0.76**	0.54**	0.38*	0.55**	0.10	—1.01	0.25
0.59**	0.54**	0.33	—0.07	—0.01	0.12	—0.22	0.18
0.68**	0.67**	0.70	0.41*	0.50**	0.06	—0.28	—0.11
0.86**	0 82**	0.66**	0.34	0.25	—0.02	—0.10	—0.15
0.61**	0.54**	0.37*	—0.09	—0.02	0.14	—0.25	0.18
0.63**	0.62**	0.69**	0.41*	0.47**	0.09	—0.22	—0.09
0.84**	0.80**	0.70**	0.42*	0.29	0.03	—0.07	—0.19
0.82**	0.81**	0.58**	0.44*	0.48**	0.34	—0.15	0.01
0.85**	0.84**	0.59**	0.57**	0.62**	0.01	—0.24	—0.25
0.89**	0.87**	0.78**	0.48**	0.41*	—0.02	—0.01	0.02
—	0.98**	0.71**	0.49**	0.61**	0.50**	—0.32	0.11
—	0.99**	0.63**	0.62**	0.77**	0.23	—0.40*	—0.19
—	0.99**	0.77**	0.54**	0.56**	0.14	—0.08	0.05
1.00	—	0.75**	0.56**	0.68**	0.54**	—0.36	0.13
1.00	—	0.62**	0.61**	0.76**	0.24	—0.40*	—0.18
0.99	—	0.75**	0.52**	0.56**	0.15	—0.09	0.11
0.89	0.88	—	0.71**	0.70**	0.68**	—0.17	0.30
0.80	0.77	—	0.73**	0.68**	0.35	—0.29	0.17
0.85	0.83	—	0.83**	0.73**	0.23	0.18	0.03
0.53	0.59	0.82	—	0.86**	0.64**	—0.04	0.05
0.81	0.77	0.67	—	0.66**	0.48**	—0.11	0.06
0.70	0.68	0.98	—	0.84**	0.46*	0.26	0.14
0.67	0.73	0.81	0.95	—	0.62**	—0.29	0.05
0.90	0.87	0.80	0.84	—	0.26	—0.39	—0.03
0.66	0 66	0.82	0.02	—	0.53**	0.21	0.13
0.56	0.62	0.85	0.72	0.69	—	—0.24	0.48**
0.35	0.34	0.39	0.57	0.31	—	—0.09	0.19
0.18	0.18	0.31	0.61	0.68	—	—0.05	0.15
—0.35	—0.37	—0.19	—0.05	—0.34	—0.27	—	0.04
—0.40	—0.41	—0.40	—0.11	—0.45	—0.10	—	0.18
—0.09	—0.10	0.20	0.32	0.23	—0.06	—	—0.37*
0.11	0.13	0.36	0.05	0.06	0.53	0.05	—
—0.19	—0.18	0.25	0.08	—0.03	0.27	0.18	—
0.07	0.13	0.04	0.21	0.16	0.18	—0.37	—

Table 2 : Direct (diagonal) and indirect effects (off diagonal) of various characters on seed yield

Character		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	r_i* with seed yield
Seedling	K	1.08	—6.40	4.73	—1.15	1.62	0.36	2.48	—1.78	—0.77	0.18	0.53	—0.14	0.08	0.82
height (X_1)	R	0.02	—0.23	0.35	0.67	—0.76	—0.10	1.78	—1.07	0.15	0.19	—0.48	0.00	0.00	0.47
	Z	1.88	1.20	—1.66	—1.54	0.64	0.46	4.48	—5.18	0.35	0.20	—0.08	—0.01	—0.02	0.72
Seedling	K	0.98	—7.02	3.96	—0.51	0.50	1.02	4.66	—2.73	—1.14	0.22	0.62	—0.01	0.40	0.95
fresh weight	R	0.02	—0.32	0.49	—1.41	1.08	—0.89	3.74	—2.09	0.64	0.35	—0.83	—0.02	0.00	0.76
(X_2)	Z	1.85	1.21	—1.61	—2.24	0.97	0.60	5.47	—6.18	0.45	0.30	—0.05	0.00	—0.03	0.74
Seedling dry	K	1.20	—6.54	4.25	—0.65	0.46	1.14	5.67	—3.28	—1.59	0.28	1.04	—0.02	—0.78	1.18
matter weight	R	0.02	—0.32	3.48	—1.25	0.94	—0.73	3.35	—1.88	0.79	—0.36	—1.02	—0.02	0.00	0.72
(X_3)	Z	1.90	1.20	—1.62	—2.41	1.05	0.64	5.64	—6.37	0.48	0.33	—0.04	0.01	—0.03	0.78
Days to	K	—0.42	1.21	—0.93	2.97	—4.06	0.82	3.84	—2.40	—0.59	—0.02	0.22	—0.16	—0.47	0.01
heading (X_4)	R	0.00	—0.13	0.18	—3.48	2.93	—1.10	2.95	—1.66	0.98	0.15	—0.15	—0.02	0.01	0.66
	Z	0.80	0.75	—1.08	—3.62	1.97	0.84	5.73	—5.90	0.54	0.21	0.00	0.06	0.01	0.31
Days to	K	—0.43	0.87	—0.48	2.98	—4.05	0.87	3.76	—2.37	—0.66	—0.03	0.19	—0.18	—0.49	—0.02
flowering	R	—0.01	—0.11	0.15	—3.44	2.96	—1.04	2.75	—1.55	0.95	0.14	—0.16	—0.01	0.01	0.64
(X_5)	Z	0.59	0.58	—0.84	—3.53	2.02	0.81	5.48	—5.60	0.55	0.25	—0.01	0.04	0.02	0.36
Number of	K	0.28	—5.07	3.45	1.71	—2.49	1.41	5.00	—3.11	—1.09	—0.13	0.48	—0.12	—0.06	0.52
leaves	R	0.00	—0.22	0.29	—3.06	2.48	—1.25	3.65	—2.04	3.69	0.18	0.01	—0.01	0.01	0.73
(X_6)	Z	0.98	0.85	—1.20	—3.53	1.89	0.86	5.69	—5.97	0.60	0.29	0.01	0.01	0.00	0.48

Character		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	r* with seed yield
Plant height	K	0.46	—5.59	4.13	1.95	—2.60	1.21	5.84	—3.74	—1.26	0.13	0.66	—0.23	—0.29	0.67
at flowering	R	0.01	—0.28	0.40	—2.47	1.97	—1.10	4.15	—2.34	0.74	0.20	—0.37	—0.02	0.01	0.90
(X_7)	Z	1.34	1.06	—1.46	—3.31	1.75	0.78	6.26	—6.68	0.60	0.33	—0.05	0.05	—0.01	0.66
Plant height	K	0.51	—5.11	3.72	1.89	—2.56	1.17	5.81	—3.76	—1.25	0.15	0.73	—0.25	—0.32	0.73
at maturity	R	0.01	—0.28	0.39	—2.45	1.96	—1.08	4.13	—2.35	0.72	0.19	—0.36	—0.02	0.01	0.87
(X_8)	Z	1.44	1.11	—1.54	—3.18	1.68	0.77	6.22	—6.73	0.58	0.32	—0.05	0.05	—0.01	0.66
Stem diameter	K	0.59	—5.62	4.77	1.23	—1.88	1.08	5.18	—3.30	—1.42	0.20	1·00	—0.13	—0.89	0.81
(X_9)	R	0.00	—0.22	0.41	—3.65	3.02	—0.92	3.30	—1.81	0.93	0.17	—0.40	—0.02	—0.01	0.80
	Z	0.94	0.77	—1.11	—2.79	1.59	0.75	5.30	—5.59	0.70	0.45	—0.09	—0.10	0.00	0.82
Head diameter	K	0.76	—6.03	4.69	—0.22	0.41	0.07	3.08	—2.20	—1.16	0.25	0.84	—0.04	—0.13	0.95
(X_{10})	R	0.02	—0.44	0.70	—2.01	1.63	—0.88	3.38	—1.82	0.63	0.25	—0.60	—0.01	—0.01	0.84
	Z	0.81	0.77	—1.14	—1.64	1.08	0.54	4.38	—4.58	0.69	0.47	—0.18	—0.16	—0.02	1.02
1000 seed	K	0.49	—3.68	3.78	0.56	—0.65	0.58	3.29	—2.33	—1.21	0.18	1.17	—0.18	—1.31	0.69
weight (X_{11})	R	0.01	—0.25	0.48	—0.51	0.46	0.02	1.46	—0.80	0.37	0.14	—1.05	0.00	—0.02	0.31
	Z	0.53	0.18	—0.23	0.05	0.06	—0.02	1.10	—1.20	0.21	0.29	—0.30	0.03	—0.02	0.68
Oil content	K	—0.22	0.05	—0.13	—0.70	1.05	—0.25	—2.02	1.38	0.28	—0.01	—0.32	0.67	—0.12	—0.34
(X_{12})	R	0.00	0.11	—0.20	0.99	—0.66	0.31	—1.68	0.96	—0.38	—0.03	0.10	0.04	—0.01	—0.45
	Z	0.03	0.00	0.02	0.42	—0.17	—0.02	—0.58	0.68	0.14	0.15	0.02	—0.49	0.03	0.23
Protein	K	—0.03	0.13	1.33	0.56	—0.80	0.03	0.67	—0.49	—0.50	0.02	0.61	0.03	—2.50	0.06
content (X_{13})	R	0.00	0.02	—0.03	0.38	—0.26	0.31	—0.80	0.43	0.23	0.02	—0.28	0.01	—0.06	—0.03
	Z	0.36	0.44	—0.58	0.60	—0.41	0.03	0.42	—0.87	0.03	0.10	—0.06	0.18	—0.08	0.16

Residual effects : *Kharif* (K) = 0.25, *Rabi* (R) = 0.07 and *Zaid* (Z) = 0.39

* Genotypic Correlation Coefficient

important character like days to flowering was positively correlated with days to heading, number of leaves and plant height. Number of leaves had positive correlation with plant height, stem diameter and head diameter. Relationship of plant height at flowering was positive with plant height at maturity, stem diameter and head diameter. Likewise there was positive association of plant height at maturity with stem and head diameter. Head diameter was found to show strong positive correlation with stem diameter and 1000 seed weight, Seedling height manifested positive association with seedling fresh and dry matter weight, plant height and head diameter. Considering the relationship of seedling fresh and dry matter weight, it was observad that these two seedling characters were positively correlated with number of leaves, plant height and stem and head diameter.

Studies on the direct and indirect effects (Table 2) revealed that days to flowering and plant height at flowering had maximum direct contribution towards seed yield as compared to other charecters. Besides this, seedling height and head diameter also contributed directly to seed yield. The direct effect of rest of the characters on seed yield varied with the season. Considering the indirect effects, it was observed that except oil content all the characters had direct effects via plant height flowering. The other important components were seedling height and head diameter through which fresh and dry weight of the seedling, number of leaves, plant height (both at flowering and maturity), stem dinmeter and 1000 seed weight indicated enhancing effects on seed yield. Therefore, days to flowering, number of leaves and head diameter are the important traits which affected the seed yield directly and Indirectly and should be given emphasis during selection for the improvement of seed yield in sunflower.

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Relationship of maturity with seed characteristics and their implications in selection of Linseed

S. K. Rao and S. P. Singh
Department of Plant Breeding and Genetics
J. N. Agricultural University, Jabalpur-482 004

ABSTRACT

A wide range of genetic variability was obtained for days to maturity, period of flowering to maturity, seed length, seed width, 1000 seed weight, oil (%) and oil yield per plant. Heritability estimates were high for all characters. Significant positive correlation coefficients were observed for character combination *viz.*, days to maturity *vs.* period of flowering to maturity, days to maturity *vs.* oil yield per plant, 1000 seed weight *vs.* oil (%), seed length *vs.* 1000 seed weight, period of flowering to maturity *vs.* 1000 seed weight, period of flowering to maturity, and seed length vs. seed width. Significant negative associations were observed for days to maturity with seed length seed width and 1000 seed weight, seed width with oil yield per plant. Path coefficient analysis revealed the direct contribution of days to maturity, seed length and 1000 seed weight on oil (%) whereas days to maturity, seed length and oil (%) had direct influence on oil yield per plant. Multiple linear regression analysis also showed similar results.

Key words : Seed size, oil yield, developmental traits

INTRODUCTION

The association analysis is helpful in determining the oil yield factors but it does not provide an exact picture of relative importance of direct and indirect influence of each component towards oil yield. The inclusion of more variables in this analysis shows complexity of indirect association. No information is available exclusively on relationship of development traits with seed components and oil content in linseed. Hence, this investigation was undertaken to find out the genetic variation and inter-relationships of these traits in linseed through correlation, multiple linear regression and path coefficient analysis.

MATERIALS AND METHODS

The experimental material comprised of 48 F_1 populations of linseed

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(*Linum usitatissimum* L.) generated by 16 divergent parents collected from various linseed growing parts of India and abroad. These 15 parents were crossed in a partial diallel mating design IV given by Fyfe and Gilbert (1963). Thus, in the present investigation, total number of crosses were n=48. These were planted at dusty acres farm of JNKVV during *rabi* season of 1978-79. Each entry was grown in two continuous rows plots, each of three meters long with the row to row distance of 35 cm and plant to plant distance of 5 cm within rows. In each row 5 competitive plants were tagged to record observations on days to maturity and period of flowering to maturity. From bulked samples of each entry in each replication, ten representative samples were drawn and used to measure 1000 seed weight (g), seed length and seed width (mm). The oil content was estimated by the Soxhlet extraction method.

Genotypic, phenotypic and environmental variances and their coefficients of variation, heritability and genetic advance were calculated by the method given by Johnson *et al.* (1955). Correlation coefficients of all characters in all possible combinations had been worked out. The multiple regression analysis was carried out as per the procedure suggested by Panse and Sukhatme (1967). Path coefficient analysis was done as per the procedure suggested by Dewey and Lu (1959) taking seed yield and oil (%) as an effects and other characters as all the possible causes.

RESULTS AND DISCUSSION

Parameters of variation for all characters are given in Table 1. Oil yield per plant had the maximum range of variation followed by 1000 seed weight and period of flowering to maturity. Phenotypic and genotypic variances were sufficiently high for all characters. Genotypic and phenotypic coefficients of variation were determined to have better picture of relative amount of variation of different characters. The highest genotypic coefficient of variation was observed for oil yield per plant followed by 1000 seed weight and period of flowering to maturity. The oil (%) recorded the lowest genotypic coefficient of variation. All characters showed high heritability estimates varied from 0.89 to 0.99 per cent. The expected genetic advance expressed as percentage of mean ranged from 7.53 from oil (%) to 74.07 for oil yield per plant. Although, all characters had high heritablity estimates but oil yield per plant, 1000 seed weight and period of flowering to maturity recorded the maximum expected genetic advance as percentage of mean. The high expected genetic advance associated with high heritability estimates might be due to substantial contribution of additive gene effects (Panse, 1957). The remaining characters showed high heritability estimates but they are associated with low genetic advance indicating the major role of non-additive genetic variation governing these characters.

Correlation coefficients among differant characters combinations are given in Table 2. Days to maturity had significant positive association with period of

Table 1 : Genetic parameters of variation for maturity, seed characters and oil content in linseed

Parameter	Days to maturity	Period of flowering to maturity	Seed length (mm)	Seed width (mm)	1000 seed weight (g)	Oil (%)	Oil yield/ plant
Mean	107	49	5.14	2.77	8.25	43.72	1.080
Range : Maximum	95	24	4.17	2.11	5.34	39.76	0.394
Maximum	113	66	5.94	3.08	10.32	47.25	2.413
Variance :							
Phenotypic	39.92	42.42	0.123	0.036	1.549	3.09	0.191
Genotypic	38.91	42.16	0.118	0.034	1.527	2.83	0.171
Environmental	1.006	0.259	0.005	0.002	0.022	0.26	0.0201
PCV	5.9	13.29	6.82	6.85	15.09	4.02	40.47
GCV	5.83	13.25	6.68	6.67	14.98	3.85	38.29
h^2B	0.97	0.99	0.95	0.94	0.98	0.91	0.89
G. A.	12.63	13.28	0.68	0.37	2.51	3.29	0.80
G. A. as % of mean	11.8	27.10	13.23	13.36	30.42	7.53	74.07

flowering to maturity and oil yield per plant, whereas it had negative association with seed length, seed width and 1000 seed weight. Period of flowering to maturity had positive association with 1000 seed weight. Seed length had positive association with seed width. However, seed width itself had negative association with oil yield per plant. 1000 seed weight had positive association with oil (%). The most desirable association observed in this study is, that days to maturity had positive association with oil yield per plant.

Multiple regression analysis of oil yield/plant on various characters are presented in Table 3. The contribution of various characters towards oil yield per plant was obtained by squared value of multiple correlation coefficient. The multiple regression of oil yield/plant on other components together accounted for 32.69 per cent of variability. Elimination of variable days to maturity drastically reduced the variation in oil yield/plant. Multiple regression equation of oil (%)

Table 2 : Correlation coefficients of days to maturity, seed characters with oil content in F_1, population of linseed

	Period of flowering to maturity	Seed length	Seed width	1000 seed weight	Oil (%)	Oil yield/ plant
Days to maturity	0.3486*	—0.4452**	—0.3572*	—0.3148*	—0.0216	0.4585**
Period of flowering to maturity		—0.1290	0.0084	0.3172*	—0.1668	0.0856
Seed length			0.5090**	0.4747**	0.2243	—0.1178
Seed width				0.4641	0.1492	—0.3098*
1000 seed weight					0.4864**	—0.1275
Oil (%)						0.2210

** Significant at 1% level; * Significant at 5% level

Table 3 : Multiple regression equation, multiple correlation coefficients and contribution of different characters to variation in oil yield/plant

Regression equation	R	Contribution towards oil yield/plant
$Y = -2.219 - 0.1266 X_5 + 0.996 X_6$	0.3382	12.12
$Y = -0.2103 - 0.5863 X_4 - 0.0964 X_5 + 0.0852 X_6$	0.4121	16.98
$Y = -0.3710 + 0.0540 X_3 - 0.7999 X_4 - 0.0711 X_5 \times 0.0916 X_6$	0.4312	18.59
$Y = -3.0444 + 0.0165 X_2 + 0.1889 X_3 - 0.7179 X_4 - 0.1652 X_5 + 0.1281 X_6$	0.5003	25.03
$Y = -3.2713 + 0.0200 X_1 + 0.0046 X_2 - 0.2574 X_3 - 0.6433 X_4 - 0.0703 X_5 - 0.0857 X_6$	0.5718	32.69

X_1 = Days to maturity; X_2 = Period of flowering to maturity; X_3 = Seed length; X_4 = Seed width; X_5 = 1000 seed weight; X_6 = Oil %; Y = Oil yield/plant

Table 4 : Multiple regression equation, multiple correlation coefficient and contribution of different characters to variation towards oil %

Regression equation	R	Contribution towards oil (%)
$Y = 37.6137 - 0.8022 X_5 + 1.1922 X_6$	0.5665	32.09
$Y = 46.2951 - 1.9683 X_4 + 0.7284 X_5 - 0.9629 X_6$	0.9938	98.76
$Y = 9.6698 - 2.4386 X_3 - 16.2641 X_4 + 11.9361 X_5 - 1.1037 X_6$	0.8661	75.01
$Y = 60.7075 - 0.0985 X_2 - 1.9716 X_3 - 4.5689 X_4 + 1.6069 X_5 - 0.0756 X_6$	0.7684	59.04
$Y = 34.1551 + 0.1004 X_1 - 0.1332 X_2 - 0.0820 X_3 - 0.5171 X_4 + 1.3555 X_5 - 1.0099 X_6$	0.9989	99.78

X_1 = Days to maturity; X_2 = Period of flowering to maturity; X_3 = Seed length; X_4 = Seed width; X_5 = 1000 seed weight; X_6 = Oil yield/plant; Y = Oil %

Table 5 : Path coefficients showing direct and indirect effects of different characters on oil (%) in linseed

Characters	Days to maturity	Period of flowering to maturity	Seed length	Seed width	1000 seed weight
Days to maturity	0.4060	—0.2030	—0.3026	0.0281	—0.2681
Period of flowering to maturity	0.1415	—0.5823	—0.0877	—0.0007	0.2702
Seed length	—0.1808	0.0751	0.6797	—0.0400	0.4043
Seed width	—0.1450	—0.0049	0.3460	—0.0786	0.3953
1000 seed weight	—0.1278	—0.0744	0.3227	—0.0365	0.8517

Residual effect : 0.5972

Table 6 : Path coefficients showing direct and indirect effect of different characters on oil yield per plant in linseed

Characters	Days to maturity	Period of flowering to maturity	Seed length	Seed width	1000 seed weight	Oil (%)
Days to maturity	0.3821	0.0304	—0.0874	0.0865	0.0537	—0.0069
Period of flowering to maturity	0.1332	0.0871	—0.0253	—0.0020	—0.0541	—0.0532
Seed length	—0.1701	—0.0112	0.1963	—0.1233	—0.0810	0.0715
Seed width	—0.1365	0.0007	0.0099	—0.2423	—0.0792	0.0476
1000 seed weight	—0.1203	0.0276	0.0932	—0.1125	—0.1707	0.1551
Oil (%)	—0.0083	—0.0145	0.0440	—0.0362	0.0830	0.3189

Residual effect : 0.8205

on various characters are presented in Table 4. The regression equation of oil (%) on all other variables together account for 99.78 per cent variability in oil (%). Almost similar amount of variation was observed in case of seed width, 1000 seed weight and oil yield/plant. As other variables are added to this combination, there was a decrease in contribution towards oil (%).

The correlation coefficients had been partitioned into direct and indirect effects and contribution of each component to oil (%) are presented in Table 5. 1000 seed weight exerted direct positive influence (0.8517) on oil (%) followed by seed length and days to maturity. Period of flowering to maturity had high magnitude of negative direct influence on oil (%). Indirect effects of all the variables via seed width with the exception of days to maturity were found to be negative. Similarly, indirect effects of all variables except days to maturity via 1000 seed weight were positive and considerably high. The direct and indirect effects and contribution of each component towards oil yield per plant had been worked out and are presented in Table 6. Days to maturity had high magnitude of positive direct effects on oil yield per plant followed by oil (%) and seed length. The direct effects of 1000 seed weight and seed width were negative. The positive correlation coefficients of days to maturity with oil yield per plant was also of high magnitude to direct effects of days to maturity on oil yield per plant.

An overall observation of the results of genetic variation, correlation, multiple regression and path analysis revealed that there was a sufficient scope for the improvement of oil yield in linseed by selecting the genotypes with longer maturity span, high oil (%) and larger seed length. The selection criteria based on the above findings will definitely be useful to improve the linseed oil production.

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Short Communications

Observations on some new pests of sesamum from India

Y. K. Mathur, Basant Singh and J. P. Verma*
Department of Entomology, C. S. Azad University of
Agriculture & Technology, Kanpur-2 (U. P.)

Sesamum (*Sesamum indicum* L) one of the major oilseed crops of this country, occupies a cultivated area of 24,42,500 ha with an annual production of 4,37,100 metric tonnes. Although it is a short seasonal crop but is known to suffer heavy losses from pest ravages in different parts of the country (Singh 1970; Vevai, 1970; Abraham *et al.*, 1973). An intensive study on the incidence of pests of this crop at its different stages of growth was undertaken under All India Co-ordinated Research Project on Oilseeds (Sesamum) in Rajasthan and under routine survey of the crop in Uttar Pradesh.

Regular collections of various insect pests were made from different agro-climatic regions of Rajasthan and Uttar Pradesh during 1969-73 and 1978-80, respectively. The identities of insects were confirmed from Commonwealth Institute of Entomology, London, Forest Research Institute, Deharadun and Zoological survey of India, Calcutta.

Details of the new insect pests, particularly, with regard to their systematic position, economical status, damaging stage of the pest and nature of damage to host plant have been presented in Table 1.

Amongst the pests reported herein (Table 1), a thorough search of the available literature reveals that sesamum is a new host record for *Zonitomorpha melanontera* Fabr. *Chaetocnema basalis* Blay, *Oxycetpnia versicolor* Fabr., *Bagrada cruciferarum* Kirk., *Agonoscelis nubila* F., *Hermolaus* sp., *Nesidiocoris tenuis* Reut. *Campyloma* sp., *Halticus* sp. *Pyrogomorpha conica desrti* Bli-

* Regional Research Station, Durgapura (Rajasthan)

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Table 1 : New insect pests of sesamum

	Name of the insect	Systematic Position	Economical status of pest (major/minor)	Parts of the plant effected	Damaging stage of the pest	Remarks
1.	*Eurproctis lunata* M.	Lymantridae : Lepidoptera	Sporadic	Leaves	Caterpillar	Only early instar larvae could be observed feeding gregariously.
2.	*Zonitomarpha melanonnera* Fabr.	Meloidae : Coleoptera	Minor	Flowers	Adult	
3.	*Ozycetonia versicolour* Baly	Scarabaeidae : Coleoptera	Minor	Flowers & leaves	Adult	
4.	*Chaetocnema besalis*	Halticidae : Coleoptera	Sporadic	Leaves	Adult	
5.	*Cberia* sp.	Cerambycidae : Coleoptera	Sporadic	Stem	Grub	
6.	*Bagrada cruciferarum* Kirk.	Pentatomidae : Heteroptera	Minor	Leaves & Succulant foliage	Nymps & adult both	
7.	*Agonoscelis nubila* F.	-do-	Minor	Leaves	-do-	Generally confined to upper leaves.
8.	*Hermolaus* sp.	-do-	Minor	Leaves	-do-	
9.	*Lygeus militiaris*	Lygaeidae : Heteroptera	Sporadic	Leaves & Pods	-do-	
10.	*Elasmolomus sordicus* Fabr.	-do-	Minor	Pods	-do	
11.	*Nesidiocoris tenuis* Reut.	Miridae : Heteroptera	Minor	Leaves	-do-	
12.	*Halticus* sp.	Miridae : Heteroptera	Minor	Leaves	Nymps & adult both	
13.	*Campyloma* sp.	-do-	Minor	Leaves	-do-	
14.	*Pyrogomorpha conica deserti* Bli-Botanko	Pyrogomorphidae : Orthoptera	Minor	Leaves	Nymps & adult	
15.	*Monomorium salonomis* L.	Formicidae : Hymenopetera	Minor	Flowers	Adult	

Botanko, *Monomorium salonomis* L. from this country. In Rajasthan and Uttar Pradesh, besides these pests, *Lygeus militiaris*, *Elasmolomus sordicus* Fab., *Euproctis lunata* M. and *Oberia* sp. have also been recorded for the first time infesting the crop. It would be worthy to mention that the other pests of economic importance recorded by the present authors are *Antigastra catalaunalis* Dup., *Amsacta moorei* Butl., *Layphgma exigua* Hubn., *Asphyndylia sesami* Felt., *Microtermes obesi* Holmgr and *Orosius albicinctus* Dist.

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Control of seedling wilt of safflower caused by *SCLEROTIUM ROLFSII* Sacc.

A. L. Siddaramaiah

Assistant Plant Pathologist, Department of Plant Pathology, College of Agriculture, Dharwad-580 005

Safflower (*Carthamus tinctorius* Linn.) is one of the most important oilseed crops in Northern parts of Karnataka and being cultivated commonly under rainfed condition in *Rabi* season. Several soil-borne diseases have been reported on safflower. Among them Sclerotium root rot caused by *Sclerotium rolfsii* Sacc. is causing considerable damage. The pathogen can infect any stage of the crop growth. However, author observed young seedlings being most susceptible when moisture level was less. Siddaramaiah *et al* (1978) reported seedling blight of safflower caused by *Phytopythora palmarum* Butler can be effectively controlled by seed treatment with Captan at the rate of 2.5 g/kg seed. Siddaramaiah and Desai (1980) reported that Thiram, Brassicol and Panoctine (2.5 g, 2.5 g and 1 ml/kg of seed respectively) gave good control of foot rot of linseed both as seed dresser and soil dernch. Since no information is available for control of seed rot and seedling wilt of safflower caused by *Sclerotium rolfsii* an attempt was made to control the disease and the data are presented in this note.

Sclerotium rolfsii pathogenic to safflower, grown on corn meal sand medium for two weeks and mixed at the rate of 5 per cent (by weight) to the black soil collected from safflower field and filled in pots. The following fungicides *viz*, Bavistin (Carbendazim) 50 WP, Brassicol (Pentachloronitrobenzene) 75 WP, Baytan (Triodimefon) 15 DS; Captan (N—trichloromethlyl—thio—4 cyclohexene 1, 2 dicarboximide) 75 WP, Ceresan (Ethyl mercary chloride) 2.5%, Daconil (Tetrachloro iso phthalonitri) 75 WP; Dithane M-45 (Manganese + Zinc ethylene bis-dithio-carbamate)75 WP and Thiram (Tetra methyl thiuram disulphate) 75 WP were used both as seed treatment and soil drench. For seed dressing, these fungicides were used at the rate of 2.5 g/kg of seed except Dithane M-45 which was used at the rate 3 g/kg seed. Seed dressing was done by slurry method. Drenching of fungicides was done 4 days after mixing the inoculum. For soil

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drenching, 200ml of 0.3 *per cent* (Commercial formulation) solution of respective chemicals were applied to pot of three replications. Appropriate control was maintained in both the methods. Observations were recorded both for pre-emergence and post-emergence death of seedlings.

100 per cent protection was recorded from pre-emergence death by Bavistin and Thiram. Maximum pre-emergence death was recorded in control (43.33%). In soil drenching treatment, none of the fungicides showed cent per cent protection from pre-emergence death. The incidence varied from 10 to 43.33 per cent.

Baytan was found to be highly effective and gave 100 per cent protection from post-emergence rot. Less than 20 per cent rot was recorded in Thiram, Ceresan, Brassicol and Captan treated pots. Though Bavistin was found effective for protection from pre-emergence rotting of seed, it failed to protect the seedlings

Tabte 1 . Effect of fungicides for control of pre-emergence and post-emergence death of safflower

Fungicides	% mortality							
	Seed treatment				Soil drench			
	Pre-emergence		Post-emergence		Pre-emergence		Post-emergence	
Bavistin	00.00	(00.00)	23.86	(16.66)	28.78	(23.33)	17.98	(26.08)
Baytan	20.00	(26.07)	00.00	(00.00)	26.07	(20.00)	32.52	(16.66)
Brassicol	20.00	(26.07)	13.39	(08.33)	26.07	(20.00)	17.68	(12.50)
Captan	03 33	(21.14)	12.97	(10.34)	15.00	(13.33)	19.53	(19.23)
Ceresan	6.14	(13.33)	18.77	(07.69)	21.14	(10.00)	25.64	(11.11)
Daconil	37.22	(36.66)	49.61	(57.89)	26.57	(20.00)	35.17	(33.33)
Dithane M-45	33.00	(30.00)	40.69	(42.85)	39.23	(40.00)	51.51	(61.11)
Thiram	00.00	(00.00)	12.29	(06.66)	17.21	(13.33)	20.04	(17.53)
Control (with inoculum)	41.07	(43.33)	63.32	(76.47)	41.07	(43.33)	67.48	(76.47)
Control (without inoculum)	6.14	(03.33)	00.00	(00.00)	12.29	(03.33)	00.00	(00.00)
C. D. at 1% level	16.27		22.02		27.03		23.39	

Data in parenthesis are angular transformed values of percentage from post-emergence death. Daconil and Dithane M-45 failed to give any protection. None of the fungicides gave satisfactory protection from post-emergence death in soil drench treatment. However, the pre-emergence death in soil drench was quite less in Ceresan (11.11%) and Brassicol (12.50%) treated pots as compared to other fungicides. All the fungicides protected the seeds and seedlings from wilt causing pathogen of Safflower at various levels (Table 1). From the results, it is clear that treatment of seeds with Thiram or Captan (2.5 g/kg) could be effectively used to protect from seed rot and seedling blight of safflower caused by *S. rolfsii*.

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Effect of aerial application of quinalphos and phosphamidon on the infestation of groundnut leaf miner

H. N. Vyas* and V. J. Patel
Main Oilseeds Research Station, Gujarat Agricultural University,
Junagadh Campus, Junagadh

Groundnut (*Arachis hypogaea* Linn.) is an important oilseed crop in India. In recent years groundnut is also being cultivated during *rabi*/summer season in about 0.2 million hectares in Gujarat.

During the last 3-4 years groundnut leaf miner (*Aproaerema modicella deventor*) has become damaging in Saurashtra region (Kapadia *et al.*, 1982) probably due to availability of groundnut crop throughout the year because of large scale cultivation of rainy as well as *rabi*/summer groundnut.

Ground spraying of quinalphos was reported to be effective against this pest at the rate of 0.025 per cent (Abdul Kareem and Subramanium, 1976; Urs and Kothai, 1976) and 0.05 per cent (Singh, 1978);

Sangappa and Ali (1977) have tried phosphamidon (0.03%) against groundnut leaf miner at Raichur (Karnataka) and found to be superior. Longiswaran and Rao (1982) also obtained the superiority of phosphamidon (0.05 percent) to control groundnut leaf miner.

In the present investigation, attempts were made to determine the efficacy of quinalphos and phosphamidon applied by air craft.

Quinalphos (Ekalux EC 25% and 45% EC) was applied by an aircraft (Basant fixed wing VT EDI) in selected fields at Kadodara village near Kodinar (Dist. Amreli) @ 187.5 and 250 gi. /ha Thus in all there were 6 treatments. The area covered under each quinalphos treatment was 6 hectares Observations were recorded for phosphamidon from the groundnut fields covered under normal aerial spraying programme organised by the State Department of Agriculture against aphids and other pests. Similarly

* Dy. Director of Research (zone), Gujarat Agricultural University, Junagadh Campus, Janagadh-362 001

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observations for control (untreated) were recorded from the adjacent insecticide free groundnut fields.

Pre- and post-treatment level of leaf miner damage were recorded from 5 different spots of 2 m^2 area from each plot. The data on larval mortality were recorded 3 hours, 1 day, 3 days, 4 days and 10 days after the application of the insecticides and the percentage were worked out. Zero and cent per cent data on mortality were replaced by using the formula $1/4n \times 100$. The percentage figures were subjected to arcsin transformation and then analysed statistically.

Pre-treatment level of leaf miner population and the mean per cent larval mortality of groundnut leaf miner at various intervals after aerial spraying of the insecticides are presented in Table 1.

Table-1 : Initial population and larval mortality of groundnut leaf miner, *A.modicella* at various intervals after aerial spraying

Treatments	Initial population count	Mean percent larval mortality after				
		3 hours	24 hours (1-day)	72 hours (3-days)	86 hours (4-days)	10 days
Quinalphos 25 EC 187.5 g.a.i/ha	16.2	36.44* (35.29)	63.31 (79.82)	69.51 (87.75)	67.66 (85.53)	77.09 (95.00)
" " 250 " "	15.2	43.74 (47.80)	77.08 (95.00)	66.02 (83.71)	77.08 (95.00)	77.08 (96.00)
Quinalphos 45 EC@ 187.5 " "	17.8	38.26 (38.33)	69.69 (87.95)	77.08 (95.00)	77.08 (95.00)	77.08 (95.00)
" " 250 " "	16.6	53.04 (63.85)	77.08 (95.00)	74.84 (93.16)	77.03 (95.00)	77.08 (95.00)
Phosphamidon @ 200 ml/ha	16.2	4.04 (00.93)	46.89 (53.30)	53.86 (65.22)	57.77 (71.55)	19.99 (11.70)
Control (Untreated)	19.4	12.92 (5.00)	12.92 (5.00)	12.92 (5.00)	12.92 (5.00)	12.92 (5.00)
S. Em. ±		2.785	3.84	9.22	5.66	2.57
C.D. at 5%		8.22	11.33	27.20	16.70	7.58
C.V.%		18.73	14.77	35.29	10.49	8.13

* Arcsin percentage tranformation; Figures in paranthesis are retransformed value

The leaf miner population (larvae and pupae) prior to aerial spraying of quinalphos and phosphamidon ranged from 15.2 to 19.4 in various plots. The data on per cent larval mortality of leaf miner immediately after 3 hours of aerial spraying were found to be highly significant. The larval mortality was recorded to be highest (63.85%) in quinalphos @ 250 g ai. / ha, 3 h after aerial spraying. Quinalphos @ 187.5 and 250 g ai. / ha exhibited 35.29%, 47.80% larval mortality of the pest, respectively. Whereas, phosphamidon @ 200 g ai. / ha showed only 0.93% mortality of the pest.

At 24 hours of application, both the quinalphos formulations @ 250 g ai / ha observed to be significantly superior than rest of the treatments. Similarly the lower dosage (187.5 g ai./ha) of both the formulation of quinalphos showed 79.82% and 87.95% larval mortality, respsctively and found statistically at par with each other in reducing the pest population. Phosphamidon 0.03% gave only 53.30% larval mortality which may be due to the systemic action of the chemical.

Both the formulations as well as dosages of quinalphos were observed to be highly significant and at par among themselves in controlling the pest after 72 hours of aerial application and exhibited 83.71 to 100 per cent larval mortality. Phosphamidon gave 65.22% mortality of the pest. There were no significant differences among various treatments in respect of larval mortality after 4 days of aerial application.

Quinalphos formulations (Ekalux 25% EC and 45% EC) tested @ 187.5 g ai. / ha showed 100 per cent larval mortality of leaf miner pest, 10 days after their application in groundnut crop.

Published information on aerial spraying of quinalphos or phosphamidon against groundnut leaf miner is not available, however, the results of the present investigations are comparable with similar studies carried out through ground application of these insecticides in controlling the leaf miner pest of groundnut.

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CGS 1-19 : A new spanish bunch groundnut cultivar with fresh seed dormancy

P. S. Reddy, V. R. Zade and S. N. Deshmukh
Project Coordinating Unit (Groundnut), Panjabrao Krishi Vidyapeeth,
Akola-444 104, Maharashtra

Lack of seed dormancy in the Spanish Bunch varieties has been reported to be one of the major problems of groundnut in Argentina, Indonesia and Zimbabwe, besides India (Cummins and Jackson, 1982). A short period of dormancy is a desirable attribute in the case of Spanish Bunch varieties. These varieties, when grown in the summer, are likely to get caught in the pre-monsoon rains when they are ready for harvest, resulting in a considerable yield losses due to germination of seed *in situ*. Ramachandran *et al.* (1967) and Varasai Mohammad *et al.* (1970) reported some success in the isolation of Spanish Bunch cultivars with short period of dormancy of about 20 days; but those cultivars have not been released for general cultivation so far.

Out of the Spanish Bunch groundnut varieties released in India, only TG 17 was reported to possess a short period of dormancy. The period of dormancy in this variety was reported to be 10-15 days by Patil (1977) and 15-20 days by Patil and Mouli (1978). When this variety was tested in comparison with six other cultivars at Tindivanam centre, 90% seeds did not germinate in TG 17 up to 30th day after maturity (Anonymous, 1984).

Recently an attempt has also been made to breed a Spanish Bunch cultivar possessing fresh seed dormancy at the Groundnut Coordinating Unit of the All India Coordinated Research Project on Oilseeds, Panjabrao Krishi Vidyapeeth. Akola. The derivative of the cross, J 11 x Robut 33-1, was found to possess seed dormancy for a period of about 35 days. This note describes briefly about the development of this cultivar and its dormancy period in relation to 17 released groundnut varieties belonging to Spanish and Valencia botanical groups.

The cross, J 11 x Robut 33-1, was effected by the senior author in 1977. Four sister lines of the cross viz., 1-4, 1-7, 1-17 and 1-19, were brought to

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Akola and planted for yield testing in the F_5 generation. The line 1-19 showed delayed germination which lead to suspecting of dormancy. While the remaining three lines germinated normally, 1-19 took over 30 days to complete germination. The late germinated plants in this line were peg marked and bulk harvested. This bulk (CGS 1-19) was tested for dormancy in comparison with TG 17 popularly

Table 1 : Germination percentages in the released groundnut varieties and CGS 1-19

Varieties	Botanical group	Germination percentages 10 DAS	15 DAS	25 DAS	35 DAS
1. AK 12-24	Spanish	58	65	67	71
2. Co 1	Spanish	48	55	59	62
3. Dh 3-30	Spanish	59	63	65	72
4. GAUG 1	Spanish	58	63	66	71
5. Gangapuri	Valencia	51	61	69	77
6. J 11	Spanish	37	45	47	55
7. JL 24	Spanish	71	82	89	91
8. Jyoti	Spanish	47	53	58	68
9. Kisan	Spanish	59	67	67	70
10. KRG 1	Spanish	38	49	53	60
11. Kopergaon 3	Valencia	59	69	77	81
12. Pollachi 2	Spanish	41	54	57	63
13. Spanish improved	Spanish	45	56	61	67
14. TMV 2	Spanish	51	59	63	65
15. TMV 7	Spanish	37	51	55	65
16. TMV 9	Spanish	50	56	63	69
17. TMV 12	Spanish	43	53	56	61
18. CGS 1-19	Spanish	6**	17**	21**	26**
General Mean		47.7	56.5	60.9	66.4
S.E.m		3.9	4.3	4.2	3.9
C.D. at 1%		14.2	15.8	15.2	14.2
C.V.%		7.1	13.3	11.9	10.2

DAS = Days after sowing; ** Significant at $P = 0.01$

grown Spanish and Valencia varieties during *Kharif*, 1983. CGS 1-19 and the IG 17 released varieties under test were harvested from the summer crop on 30-4-1983. The fully matured pods were hand shelled and the Dithane M-45 treated kernels were planted on 2-5-1983 in a Randomised Block Design replicated three times, by using a spacing of 30 x 10 cm. 100 kernels were sown in a single row in each treatment. The trial was irrigated immediately after sowing and also at weekly intervals of 35 days till the germination counts were completed. Germination counts were recorded on 10th day, 15th day, 25th day and 35th day after sowing. The data on germination percentage are presented in Table 1.

Data showed that more than 50 per cent of the kernels germinated in the released varieties by 10th day while in CGS 1-19 the germination was only 6 per cent, which was significantly different at 1 per cent level. On 15th, 25th and 35th day, the germination percentages in CGS 1-19 were 17, 21 and 26 respectively, which were significantly lower than the corresponding values recorded by the released varieties. By 35th day the germination in the released varieties ranged from 55 per cent in J 11 to 91 per cent in JL 24. Thus, while three-fourths of the kernels germinated in the released varieties, in CGS 1-19 three-fourths of the kernels did not germinate upto 35th day after sowing which clearly proved the presence of fresh seed dormancy for a period of 5 weeks in CGS 1-19. The dormancy in this culture was also tested and confirmed by the Groundnut Physiology Division of the International Crop Research Institute for the Semi-Arid Tropics, Hyderabad (R.C. Nageswara Rao, per. comm.) and also by the Tindivanam centre (Anonymous, 1984). The culture CGS 1-19 under the name CGC 7 has been entered in the Initial Evaluation Trial during Rabi-Summer 1983-84, under the All India Coordinated Research Project on Oilseeds, for its yield evaluation at different locations.

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Effect of Rhizobium inoculation on germination and yield of groundnut

G. Ramakrishnan and G. A. Palanisamy
Agricultural Research Station, Aliyarnagar-642 101, India

Groundnut plants fixed most of its notrogen requirement when nodulated with effective nitrogen fixing bacteria (*Pettitt et al.* 1975). Inoculation with effective *Rhizobium* strains have increased pod yield in fields where groundnut had not been previously grown (Burton, 1976). However, there are few reports that inoculation resulted in decreased yield in fields where groundnut has been raised previously (Subba Rao, 1976). Direct application of *Rhizobium* to seed is most common form of inoculation and the shelled groundnuts are too fragile to be inoculated directly which may result in germination failures. Direct seed inoculation was found to decrease seed germination (Nambiar and Dart, 1982). With a view to study the effect of *Rhizobium* treatment on germination and yield of groundnut pods, trials were conducted at Agricultural Research Station, Aliyarnagar and the results are presented in this paper.

Two field trials were conducted during *Kharif* 1982 and 1983. Three cultivars *viz.*, POL. 2, JL. 24 and Robut 33-1 and two *Rhizobial* strains NC. 92 and 5a/70 received from ICRISAT were utilised in the studies. The following were the treatments.

1. Seeds treated with Rizobia individually
2. Seeds treated with thiram alone
3. Seeds treated with *Rhizobium* + thiram
4. No treatment

The experiment was laid out in randomised block design replicated four times and for each treatment 80 seeds were sown. The germination count was taken on 10th day after sowing. The yield per plots was recorded.

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Table 1 : Effect of *Rhizobium* inoculation on germination and yield of groundnut

Treatments	Mean per cent germination						Yield of pods/plot (kg)					
	Kharif 1982			*Kharif* 1983			*Kharif* 1982			*Kharif* 1983		
	POL.2	JL.24	R.33-1	POL.2	JL.24	R.33-1	POL.2	JL.24	R.33-1	POL.2	JL.24	R.33-1
1. *Rhizobium* NC 92	89.9	70.4	47.9	81.3	78.2	66.9	0.23	0.38	0.41	0.25	0.38	0.38
2. *Rhizobium* 5a/70	88.8	69.7	60.7	85.6	82.2	68.1	0.22	0.36	0.49	0.26	0.38	0.41
3. **Thiram @ 4g/kg seeds**	85.0	73.5	60.1	88.5	85.9	70.4	0.18	0.43	0.52	0.27	0.44	0.43
4. *Rhizobium* NC 92 + **Thiram**	86.9	76.0	54.1	84.7	80.7	81.3	0.21	0.40	0.46	0.26	0.46	0.45
5. *Rhizobium* 5a/70 + **Thiram**	94.1	70.3	56.3	89.1	80.7	80.7	0.23	0.43	0.42	0.25	0.46	0.48
6. **Control**	91.6	80.3	66.9	87.8	79.7	64.7	0.21	0.44	0.59	0.25	0.44	0.47
C D at 5%	9.07			6.53			0.11			0.34		

In respect of germination it may be seen that though the results were statistically significant, all the treatments were at par during both the seasons (Table 1). Three cultivars showed distinct differences in the germination while the interaction between varieties and treatments was not significant.

For yield, significant differences were observed among the three cultivars in *Kharif* 1982 when JL 24 and R 33-1 gave better yields than POL 2. However during *Kharif* 1983 the yield differences were not appreciable and all the three cultivars were at par.

Interaction of the treatments and varieties was not significant either for the pod yield.

The trials on inoculation with *Rhizobium* in groundnut have given contradictory results. Sundara Rao (1971) obtained higher yields with *Rhizobium* inoculation. Nambiar and Dart (1982) reported increase in yield in the range of 2.8 to 40% (60 to 1000 kg pods/ha) over the control with a combination of the cultivar Robut 33-1 and *Rhizobium* strain NC. 92. However, in the present study there was no response to the *Rhizobial* strains used in respect of yield. Arora *et al.* (1970) reported no increase in pod yield while Subba Rao (1970) observed a reduction in the yield due to *Rhizobium* inoculation. Van Der Merwe *et al.* (1974) also suggested a negative response to *Rhizobium* inoculation. The results of the studies conducted under AICORPO at ICRISAT, Ludhiana and Tirupati indicated no significant differences in yield of groundnut pods. At Durgapura, *Rhizobium* strains did not affect plant population, number and weight of nodules, but significant differences were obtained in the pod yield (Anon. 1982). The present study indicated that direct seed inoculation with *Rhizobium* has not adversely affected the seed germination and plant stand.

Possibly continuous cropping with groundnut in the experimental fields might have influenced in the built up of native *Rhizobia* which might have resulted in the failure to obtain a positive response to the *Rhizobial* strain of NC. 92 and 5a/70 in the present studies.

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Nitrogen nutrition of mustard under rainfed condition of West Bengal

R. L. Nayak and S. S. Mondal
Department of Agronomy, Bidhan Chandra Krishi Viswavidyalya, Kalyani-741 235, Nadia, West Bengal

Mustard (*Brassica campestris* L) is one of the most important edible oil seed crops grown in *Rabi* season in West Bengal. The total annual seed production of mustard is about 40 thousand tonnes which meets hardly 4-5% of State's annual demand of oil. In West Bengal mustard is generally grown under rainfed condition after *Kharif* rice to utilise the residual moisture. But the yield is quite low. Dalal *et al.* (1962) stated that the grain yield of mustard increased almost proportionate to the doses of nitrogen application under unirrigated condition. Prakash Vir and Verma (1979) reported that the increase of N affected favourably the yield attributes, seed yield and per cent N content in seed and stover under rainfed condition of Agra Region. Yield of rainfed mustard in West Bengal can also be increased through use of improved variety and nitrogen nutrition. Therefore, the present experiment was conducted to find out the suitable varieties of mustard under rainfed conditions and its optimum nitrogen requirement to get maximum yield.

The experiment was conducted at Bidhan Chandra Krishi Viswavidyalaya Farm, Kalyani in 1979-80 and 1980-81 with six promising varieties - Toria B-54, Rai-B-85, Rai-T/2/8, Rai-T-59, yellow sarson and appresed mutant in main plot and four levels of nitrogen, O, 30, 60 and 90 kg N/ha in sub-plot with three replications on sandy loam soil with O. 5% organic carbon, 15 kg P_2O_5 /ha and 150 kg K_2O/ha having pH 6.8 to study the effect on nitrogen fertilization on yield of different mustard varieties under rainfed condition. Uniform basal dose of 30 kg each of P_2O_5 and K_2O/ha was applied to all the plots, at the time of land preparation before sowing. The crop received rainfall of 23.46 mm in 1979-80 and 145. 51 mm in 1980-81 during its growing period. Seeds were sown in line of 30 x 10 cm spacing in the middle of October after harvest of *Kharif* rice with adequate soil moisture to get proper germination and crop establishment. Crop was harvested during the middle

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Table 1 : Grain yield attributes of mustard varieties to N-levels under rainfed condition

Treatments	Grain yield (kg/ha)			Oil yield (kg/ha)			No. of pods/plant		No. of grains/pod	
	1979 80	1980-81	Av.	1979 80	1980-81	Av.	1979-80	1980-81	1979-80	1980-81
Variety										
Tori B-54	498	1688	1093	174	607	309.5	154	240	10	13
Rai B-85	714	1771	1242	271	681	476.0	168	250	11	15
Rai T-2/8	620	2042	1331	235	788	511.0	155	270	11	14
Rai T-59	615	1667	1141	234	643	438.5	150	245	11	14
Yellow sarson	503	834	668	176	297	236.5	113	225	15	15
App. Mutant	472	865	669	165	307	236.0	70	210	15	14
S. Em (±)	11	74	—	—	—	—	—	—	—	—
C D at 5%	33	233	—	—	—	—	—	—	—	—
N-levels (kg N/ha)										
0	411	1084	747	136	359	247.5	126	210	11	11
30	523	1702	1112	168	546	357.0	131	245	14	14
60	751	1799	1275	236	567	401.5	139	255	13	15
90	595	1327	961	184	411	297.5	138	250	12	14
S Em (±)	9	44		—	—		—	—	—	—
C D at 5%	28	129		—	—		—	—	—	—

of February in both the years. Adequate measures were taken to control the attack of insect-pest and diseases. Weeding was done as and when it was necessary upto 40 dadys after sowing.

Effect of variety : The variety, Rai-B-85 produced highest yield (714kg/ha) followed by Rai T-2/8 (620 kg/ha) during 1979-80 and the variety Rai T-2/8 produced highest yield (2042 kg/ha) followed by Rai B-85 (1771 kg/ha) during 1980-81 (Table 1). The yields were higher in 1980-81 than in 1979-80 due to higher rainfall during the growth period in 1980-81. Pooled data revealed that the variety Rai T-2/8 with duration of 85-90 days recorded highest yield (1331 kg/ha) followed by Rai-B-85 (1242 kg/ha). Chatterjee and Bhattacharyaya (1981) reported that under rainfed condition Pant Rai 35 gave the highest yield of 837 kg/ha closely followed by Pant Rai-34. No other strains tried in the present investigation indicated any significant improvement in yield over the National check, Varuna under rainfed condition. As regards to maturity durition, all the four earlier mentioned strains indicated more or less similar duration ranging from 108-112 days The state check B-85, however, matured within 82 days under rainfed condition. Prakash Vir and Verma (1979) found that the mustard variety T-59 showed the better result under rainfed condition in Agra region. Results indicated that Rai B-85 and Rai T 2/8 are suitable under rainfed condition in Gangetic alluvial tracts of West Bengal.

Table 2 : Interaction of mustard varieties with N-fertilization on yield (kg/ha) under rainfed condition (Av. of two years)

Variety		N-level kg N/ha				
		0	30	60	90	Mean
Tori B-54		717	1427	1271	957	1093
Rai B-85		783	1399	1709	1078	1242
Rai T-2/8		1168	1374	1645	1136	1331
Rai T-59		772	1045	1395	1353	1141
Yellow sarson		410	680	904	680	668
App. mutant		636	748	726	564	669
Mean		747	1112	1275	961	
C D at 5%	Varieties		133			
	nitrogen		78			
	Nitrogen within a variety		52			
	Varieties within N-level		125			

Effect of nitrogen : During both the years the yield of mustard under rainfed condition increased (748 kg/ha in 1979-80 and 1646 kg/ha in 1910-81) upto 60 kg N/ha and beyond that the yield was drastically reduced (Table 1). From the pooled data the maximum yield (1197 kg/ha) was found at 60 kg N/ha. This result is in agreement with the findings of Singh and Prasad (1975) and Prakash Vir and Verma (1979). Nitrogen fertilization at 60 kg N/ha increased the yield contributing characters over a dose of 30 kg N/ha. This may be attributed to better growth and development of individual plant which in turn resulted in production of more seed yield per hectare. Similar results have also been recorded by Sandhu and Singh (1960).

Effect of interaction of nitrogen with variety : Pooled data (Table 2) revealed that the variety Rai B-85 produced highest yield (1709 kg/ha) under rainfed condition at 60 kg N/ha The variety Rai T-2/8 was equally good to Rai B 85 at 60 kg N/ha. Varieties B-85, Rai T-2/8, Rai T-59 and yellow sarson showed response upto 60 kg N/ha, but Tori B 54 and App. mutant responded only upto 30 kg N/ha. Varieties B-85 and T-2/l (maturing in 90 days) are suitable for growing with 60 kg N/ha under rainfed condition. Similar restlts were only recorded by Singh and Prasad (1975).

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Intercropping studies in linseed with wheat and gram

R. S. Rathore and G. L. Mishra
Regional Agricultural Research Station, J.N.K.V.V.,
Tikamgarh-472 001, Madhya Pradesh

Linseed (*Linum usitatissimum* Linn) is an important oil seed crop in most rainfed areas of Madhya Pradesh, especially in Bundelkhand region. In Bundelkhand linseed is generally sown with gram and wheat under mixed cropping system with an object to cover the risk against adverse weather. But systematic information about its economic aspect and more remunerative row combinations is not available. Therefore, the present experiment was formulated to find out economically viable associate crops of linseed and their system of planting.

The experiment was conducted at Regional Agricultural Research Station, J. N. K. V. V., Tikamgarh (M. P.) during *rabi* 1982-83, The soil of experimental field was black having pH 7.8, organic carbon 0.90 per cent, EC 0.20 mmhos/cm, available N, P_2O_5 and K_2O @ 315, 8.0 and 240 Kg/ha respectively. The region receives an annual rainfall of about 800-900 mm. The experiment was conducted in a randomized block design with four replications involving sixteen treatments. The seed was drilled on 18th November, 1982 at the rate of 100, 80 and 30 kg/ha for wheat, gram, and linseed respectively.

It is evident from table 1 that all the intercrop combinations gave a land equivalant ratio (LER) of more than one and high monetary return over pure cropping was obtained in most of the intercrop combinations. Linseed-gram combinations of 3:1, 2:1 and 1:1 gave monetary return of Rs. 9333, 9081, and 7900 respectively, which was significantly superior over pure gram which gives a monetary return of Rs. 6047. Regarding linseed-wheat intercrop all the combinations *viz.*, 3:1, 2:1, 1:2, 1:1 and 1:3 gave significantly higher monetary return of Rs. 7628, 7106, 6378, 6244 and 5886 respectively over pure wheat which gives monetary return of Rs. 3378. Intetcrop combinations of linseed-gram (3:1 and 2:1) gave significantly higher monetary return of Rs. 9333 and 9081 respectively over pure linseed (regular). Similarly, linseed-wheat combi-

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nations of 3:1 and 2:1 gave sufficiently higher income of Rs. 7628 and 7106 as compared to linseed pure (regular).

Therefore, wheat, gram and linseed growing farmers of Bundelkhand region can improve the production and consequently their economic status by adopting best intercrop combinations over sole crops.

Table 1 : Grain yield, land equivalent ratio (LER) and total monetary return as influenced by different cropping systems

	Treatments	Grain yield (kg/ha)		LER	Total monetary raturn (Rs./ha)
		Main crop	Intercrop		
1.	Linseed pure (regular)	1347	—	1.00	6736
2.	Linseed pure (border)	1792	—	1.00	8958
3.	Gram pure (regular)	3023	—	1.00	6047
4.	Gram pure (border)	2458	—	1 00	4917
5.	Wheat pure (regular)	2111	—	1.00	3378
6.	Wheat pure (border)	2708	—	1.00	4333
7.	Linseed-gram (1:1)	1000	1426	1.21	7853
8.	Linseed-gram (2:1)	1384	1079	1.37	9081
9.	Linseed-gram (3:1)	1528	842	1.40	9333
10.	Linseed-gram (1:2)	843	1704	1.18	7900
11.	Linseed-gram (1:4)	732	1746	1.11	5761
12.	Linseed-wheat (1:2)	833	1113	1.13	6244
13.	Linseed-wheat (2:1)	1190	722	1.22	7106
14.	Linseed-wheat (3:1)	1330	597	1.26	7628
15.	Linseed-wheat (1:2)	778	1555	1.30	6378
16.	Linseed-wheat (1:3)	653	1638	1.25	5886
	SEm ±				642.00
	C. D. at 5%				1851.00

Prevailing Market rate of crops :

Linseed — Rs. 5.00/Kg

Wheat — Rs. 1.60/Kg

Gram — Rs. 2.00/Kg

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Performance of some herbicides on weed control in Sesamum

A. S. Rao and K. Narayana Rao
Weed Science Division, A.P.A.U., Agricultural College,
Bapatla-522 107

Sesamum (*Sesamum indicum* L.) is one of the important oil seed crops in India next only to groundnut and mustard. The weeds heavily infest the crop and ultimately reduce crop yields ranging from 17 to 41 per cent. The critical period of crop weed competition was found to be from 2nd to 5th week after sowing (Kondap *et al.*, 1984). Weed control by using herbicides in the early stages is one of the alternatives as manual weeding is costly. Several workers (Gaur and Tomar, 1978; Ghosh and Mukhopadhyay, 1980; Vishnu Shukla, 1984) have reported the effective control of weeds with herbicides. In this study new herbicides along with the earlier chemicals have been chosen to find out their effectiveness for weed control in sesamum.

A field trial in a randomized block design with 4 replications comprising 5 treatments was conducted at the Agricultural College Campus, Bapatla to study the comparative efficiency of fluchloralin (N-Propyl-N(2' chloroethyl)-2, 6-dinitro-N-Propyl-4 (trifluoromethyl) aniline); fluazifop-butyl (Butyl 2-(4-(5 trifluoromethyl-2-pyridyloxy) phenoxy) propionate); Oxyfluorfen (2-chloro-1-(3-ethoxy-4-nitrophenoxy) 4-(trifluoromethly) benzene) and thiobencarb (S-4-chlorophenyl)-diethyl thiocarboamothioate) for weed control in sesamum grown in summer season (January-April) of 1984. All the herbicides were applied as pre-emergence spray one day after sowing except fluchloralin which was applied as pre-sowing spray. These herbicide treatments were compared with unweeded control. The soil of experimental plot was sandy loam with moderate fertility. Weed population per unit area (0.25 m^2) were recorded at 15 days interval upto 45 days after sowing. Number of pods per plant, seed yield and weed dry weight from the net plots were recorded at the time of harvest.

The mojor weed species occured in the experimental plot in order of their abundance were *Cyperus rotundus* L., *Cynodon dactylon* (L.) Pers., *Panicum miliare* Lamk., *Dactyloctenium aegyptium* Beauv. (among sedges and grasses),

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Table 1 : Effect of herbicides on weed population, weed dry weight, number of pods per plant and seed yield in sesamum

Treatment (kg a.i./ha)	Weed population per 0.25 m^2 (days after spraying)						Weed dry weight (kg/ha)	Mean number of pods per	Seed yield (kg/ha)
	15		30		45				
Unweeded control	8.00	(2.82)	14.75	(3.81)	13.75	(3.68)	806.25	29.00	453.10
Fluchloralin @ 1.25	4.50	(2.01)	4.75	(2.13)	5.25	(2.22)	234.37	42.25	750.00
Fluazifop-butyl @ 0.5	4.50	(2.05)	7.25	(2.59)	6.25	(2.47)	313.00	35.75	528.12
Oxyfluorfen @ 0.25	1.75	(1.25)	3.00	(1.71)	5.00	(2.17)	200.00	23.00	206.25
Thiobencarb @ 1.75	2.25	(1.45)	4.50	(2.10)	4.25	(2.00)	429.37	26.75	415.62
S. Em ±		0.34		0.32		0.37	62.98	4.94	64.82
CD at 5%		0.74		0.70		0.87	151.86	10.60	140.64

Figures in parenthesis are square root transformed values

Gyanondropsis pentaphylla (L.) Merr., *Portulaca oleracea* L., *Boerhaavia difffusa* L , *Cassia tora* L., *Euphorbhia hirta* L., (among broad leave weeds).

The status of weed population revealed that pre-emergence application of oxyfluorfen @ 0.25 kg/ha had significantly reduced the weed population (Table 1) over all other treatments except thiobincarb at 15 DAS (days after sowing). At 30 DAS oxyfluorfen was significantly superior to fluazifopbutyl @ 0.50 kg/ha and unweeded control in recording lower weed population. At 30 DAS the treatments fluchloralin and thiobencarb were at par as revealed from weed population per unit area. There was no significant difference between the herbicide treatments at 45 DAS but all are significantly superior to unweeded control in recording lower number of weed population,

The effect of different herbicide treatments on weed dry weight (Table 1) revealed that pre-emergence application of oxyfluorfen @ 0.55 kg/ha significantly reduced weed dry weight (200 kg/ha) compared to thiobencarb and unweeded control. There was no significant difference between fluchloralin and fluazifop-butyl. Oxyfluorfen @ 0.25 kg/ha had severely effected germinatton and ultimately resulted in poor plant population. Even the germinated seedlings showed scorching effect on leaves in the early stages. Though oxyfluorfen recorded lowest weed dry weight (200 kg/ha) but it has recorded lower number of pods per plant (23) and seed yield (206.25 kg/ha) due to the toxicity. Fluchloralin @ 1.25 kg/ha recorded maximum number of pod per plant (42.25) and significantly superior to oxyfluorfen, thiobencarb and unweeded control. In case of seed yield also fluchloralin recorded maximum yield (750 kg/ha) and significantly superior to all other treatements. The results obtained are similar to that of Ghosh and Mukhopadhyay (1980).

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Inheritance of non-waxy trait in Indian mustard and its reaction to the aphids

A. K. Yadav, Harvir Singh and T. P. Yadava*
Department of Plant Breeding (Oilseeds)
Haryana Agricultural University,
Hisar-125 004

Inheritance studies

The spontaneous non-waxy (lack of superficial waxy bloom) mutant (RC-1425) of Indian mustard (*Brassica juncea* (L) Czern & Coss.) was identified during the year 1975 in the germplasm collection maintained at Haryana Agricultural University, Hisar. This mutant has non-waxy stem and aerial parts like leaves, branches, siliqua, etc. The selfed progenies showed that the mutant bred true for this trait. To elucidate the inheritance, this mutant was crossed with waxy cultivar namely, Prakash, during 1981-82. All F_1 plants were waxy showing the dominance of waxy trait. In the next season the F_2 and BC_2 generations showed segregation for waxy and non-waxy phenotypes. Statistically the observed ratio did not deviate from the Mendelian expected ratios, 3:1 and 1:1 in F_2 and BC_2, respectively (Table 1).

In BC_1 generation all the individuals were of waxy phenotype. Thus *the results clearly demonstrated that the non-waxy trait is recessive and controlled by single gene.*

Table 1 : Segregation ratios of waxy and non-waxy phenotypes in F_2 and BC generations of Prakash (waxy) X RC-1425 (non-waxy)

Generations	Number of plants		Ratios	P
	Waxy	Non-waxy		
F_1	245	—	—	—
F_2	215	75	3:1	0.05
BC_1 (F_1 x Prakash)	220	—	—	—
BC_2 (F_2 x RC-1425)	80	72	1:1	0.05

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* Project Director, Directorate of Oilseeds Research, Rajedranagar, Hyderabad A. P.

Reaction of waxy and non-waxy genotypes to the incidence of aphids

Non-waxy plants of *Brassica* species were reported to be resistant against mustard aphid, *Lipaphis erysimi* (Kalt,) in India (Srinivasachar and Malik, 1972; Nath and Mukhopadhyay, 1976) as well as in U. K. (Thompson, 1963; Way and Murdie, 1965) to cabbage aphid, *Brevicoryne brassicae* L. as compared to their waxy counterparts. Such genotypes can prove advantageous to the plant breeders to breed aphid resistant/tolerant varieties.

During the years 1980-81 and 1981-82 there was a heavy incidence of mustard aphid, *L. erysimi* on brown 'sarson', *Brassica campestris* and on Indian mustard (Var. Prakash). *Brassica campestris* (brown 'sarson') was taken as a standard check as it is the most susceptible to the mustard aphid, (Pathak, 1961). The waxy genotypes of *B. campestris* (BSH-1) and *B. juncea* (Prakash) were found heavily infested with mustard aphid as the average number of aphids varied from 250-1500 and 150-800 aphids per plant respectively and were categorised as susceptible. Whereas, non-waxy plants of *B. campestris* and the genotype of *B. juncea* (RC-1425) had fairly low number of aphids i. e. 10-15 and 5-10 aphids per plant respectively and were categorised as resistant (Table 2). Similar

Table 2 : Incidence of mustard aphid, *Lipaphis erysimi* (Kalt.) and green peach aphid, *Myzus persicae* (Sulzer) on *Brassica* crops

Genotypes	* Average number of aphids per plant (peak incidence of aphids)	
	Lipaphis erysimi	*Myzus persicae*
Brassica campestris		
Waxy	250-1500	10-50
Non-waxy	10-15	15-140
Brassica juncea (Prakash)		
Waxy	150-800	10-15
Brassica juncea (RC-6425)		
Non-waxy	5-10	20-150
F_1 Waxy	60-450	20-15
BC_1 Waxy	50-480	10-15

* The figures are the range of aphids present on 20 plants

reactions were observed in F_2 and BC_2 generations of the cross, Prakash x RC-1425 on waxy and non-waxy plants, seperately. However, in F_1 and BC_1 generations (waxy plants) showed the intermediate reactions to *L. erysimi* incidence and were categorised as tolerant. On the other hand non-waxy plants of *B. campestris* and *B. juncea* (RC-1425) harboured comparatively more number of green peach aphid, *Myzus persicae* (Sulzer) as 15-140 and 20-150 aphid per plant were observed as against 10-50 and 10-15 aphids per plant on the waxy plants of *B. campestris* and *B. juncea* (Prakash) which showed their susceptability to green peach aphid. These studies clearly indicated that the non-waxy trait of the plants contributed for the tolerance against mustard aphid, but this was not true against the incidence of green peach aphid. Way and Murdie (1965) practically demonstrated that the non-waxy plants of 'brussels sprout' were least preferred by *Brevicoryne brassicae* L., whereas, these were heavily infested with *M. persicae*. They explained that non-waxy plants are less readily recognised by colonising alate aphids of *B. brassicae*, or the alate are deterred from such plants after alighting or perhaps the apterous progeny develop less well on non-waxy plants. The present findings fully coroborate with these studies.

It is worth mentioning that the colour of alates of *L. erysimi* is pale green with mealy covering of wax, whereas, *M. persicea* is pale-green/red devoid of the waxy coating. It gives an idea that waxy plants are more preferred by *L. erysimi* than *M. persicae* because glossiness of the host provided some sort of immediate precursors of wax or wax itself which are essential for the development of *L. erysimi*. Thompson (1963) also observed that the non-waxy plants of (*Brassica oleracea* var. *acephala*) were less preferred by *B. brassicae* and *Aleuroides brassicae* walk. He further mentioned that both these insects secrete a white mealy covering of wax over their bodies and it, therefore, seems possible that the absence of wax or its immediate precursors in such plants may be the cause of non preferences.

The spontaneous non-waxy mutant (RC-1425) of Indian mustard was identified at Haryana Agricultural University, Hisar. The non-waxy trait was found to be recessive and governed by single gene which can be incorporated into a genotype through traditional breeding method like back crossing followed by selfing. Non-waxy progenies of *Brassica juncea* (L.) Czern & Coss (RC-1425) and *B. campestris* were fonnd fairly tolerant to the incidence of mustard aphid, *Lipaphis erysimi* (Kalt). At the same time these plants were found to be susceptible to the incidence of green peach aphid, *Myzus persicae* (Sulzer).

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Intercropping in sesamum with legumes

S. M. Kondap, A. R. Rao, W. A. Mirza and G. Bhojireddy
Department of Agronomy, College of Agriculture,
A.P. Agricultural University, Hyderabad 500 030

The per capita availability of fats and oils (15 and 47 g) in India is far below the minimum requirement of 38 and 120 g respectively, primarily because of the low productivity of oil seeds. The crops are mainly confined to marginal lands of low fertility and dependent upon erratic rainfall. Sesamum is grown extensively in the Telangana region of Andhra Pradesh often with low yields during the aberrant monsoon season. To enhance the agricultural production in rainfed tropical areas, a more organised approach of intercropping has captured the attention of research workers recently. Legumes have an important role in the intercropping system because of its potential to transfer the excreted nitrogen to the associated non-legumes (Virtanen *et al.* 1937; Ruschel *et al.* 1979). An experiment was, therefore, planned to work out the feasibility of enhancing the production potential from an intercropping system of sesamum associated with the pulses commonly grown in this region.

The experiment was conducted in *Kharif* 1979 and 1980 at the Agricultural College Farm, A.P.A.U., Hyderabad. The soil of the experimental site was a sandy loam, well drained with 0.86% organic carbon, 220.5 kg/ha available phosphorus and 10.62 kg/ha available potassium. The trial comprised of sesamum (*Sesamum indicum* L) c.v. T-85, intercropped with pigeonpea (*Cajanas cajan* L) c.v. Hy-3c, blackgram (*Vigna mungo* L) c. v. T-9 and greengram (*Vigna radiata* L) c.v. PS 16 at 1:1. 2:1 and 3:1 row proportions (replacement series) with a constant 50 cm between rows. Pigeonpea was also added to normally planted sesamum after every second and every third row of sesamum (2+1 and 3+1 in an additive series). Sole crops of sesamum, pigeonpea, blackgram and greengram were planted as per the same row spacings. These 15 treatments were replicated four times in a Randomised Block Design. Fertilizers were applied at the rate of 60 kg N, 30 kg P_2O_5 and 20 kg K_2O/ha uniformly to all the treatments prior to sowing. The crop were sown on July 24 and 23 in 1979 and 1980 and harvested on October 18 and November 10 respectively. The average rainfall during the crop period of 1979 and 1980 was 367.6 and 386.0 mm.

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The influence of intercropping teratments on growth and yield of sesamum is presented in Table 1. Sole crop sesamum surpassed the intercrops in plant height and there were singificant differences between intercrope in reducing the height of intercropped sesamum. Reduction in height was greater with blackgram and greengram than with pigeonpea as a component of the crop mixture. Sesámum branched more profusely when it was intercropped with blackgram, greengram or pigeonpea in 1 : 1 proportion than when sown as a sole crop. The number of pods produced per plant were also enhanced significantly when greengram or blackgram was the component sown in 1 : 1 proportion, but this effect was not observed in the pigeonpea 1 : 1 pattern. Sesamum with pigeonpea as an intercrop in the additive treatments (2+1 and 3+1) grew taller and produced less pods than in the replacement treatments probably because of more competition in these treatments.

Sole crop of sesamum recorded significantly higher yield than intercropped. In all intercropped treatments, there was reduction in sasamum yield below that expected on the basis of planted area. For example in the 1 : 1 mixture of sesamum: pigeonea, 40% of the sole sesamum crop yield was realized, whereas, 50% yield would be expected if intercrop competition was equal to monoculture competition. This indicates that competitive effects of the pulse on the sesamum were of primary importance in this study whereas other effects such as the transfer of N (as reported by Virtanen *et al.* 1937) may be of less importance.

Sole treatments of the pulses also out yielded the intercrops in all cases, and pigeonpea gave the highest pulse yield of all patterns. The total grain yields of the intercrops were higher with sesamum intercropped with pigeonpea followed by that with blackgram and greengram in 1 : 1 ratio. The superiority of the 1 : 1 patterns was due to the higher yields of the intercropped pulses and despite higher yield of sesamum in the 3 : 1 row arrangement. However, pigeonpea sole crop gave the maximum yield.

Sesamum grain equivalents and net return are shown in Table 2. Sole crop of pigeonpea produced the highest sesamum grain equivalent almost twice that of sesamum sole crop. This was due to the higher yield of the former and in spite of the lower price of pigeonpea compared with sesamum. The blackgram and greengram sole and intercrops gave significantly lower sesamum grain equivalent yields than either sesamum or pigeonpea or any of the sesamum : pigeonpea com binations. The 1:1 sesamum and pigeonpea combination was better than the other intercrop patterns and would be recommended where an intercrop is desired. Sesamum and pigeonpea combinations gave between 75% and 152% greater net return than growing sesamum alone, indicating the practical superiority of this combination when the choice is between sesamum sole crop and an intercrop.

Table : 1 Effect of intercropping of different pulses on the grain yield and ancillary characters of Sesamum

Treaments	Plant height (cm)		No. of branches/Plant		No. of Pods/Plant		Grain yield (q/ha)			
	1979	1980	1979	1980	1979	1980	1979		1980	
							Sesamum	Pulse	Sesamum	Pluse
1. Sesamum + Redgram 1:1	110.7	105.6	4.6	4.2	38.0	25.2	1.52	8.84	1.43	8.51
2. Sesamum + Redgram 2:1	116.0	106.8	4.1	3.9	38.5	24.1	2.07	7.14	1.81	6.13
3. Sesamum + Redgram 3:1	119.3	109.9	4.0	3.7	32.3	22.4	2.36	6.08	2.25	4.50
4. Sesamum + Redgram (Red gram sowing after every 2nd row of Sesamum) 2 + 1	124.0	110.7	3.3	2.9	29.4	20.6	1.97	8.36	1.76	6.88
5. Sesamum + Redgram (Redgram sowing after every 3rd row of sesamum 3 + 1)	124.1	114.5	3.6	3.2	32.2	23.1	2.40	6.45	2.19	4.82
6. Sesamum + Blackgram 1:1	105.6	99.9	5.1	4.1	49.2	30.2	1.69	2.74	1.49	2.60
7. Sesamum + Blackgram 2:1	108.3	100.2	4.3	3.8	42.0	29.2	2.20	1.98	1.91	1.89
8. Sesamum + Blackgram 3.1	111.6	101.7	4.8	3.5	39.1	25.9	2.42	1.55	2.27	1.59
9. Sesamum + Greengram 1:1	105.6	105.0	5 0	4.4	45.1	30.9	1.65	2.61	1.55	2.09
10. Sesamum + Greengram 2.1	108.1	107.6	4.3	4.0	43.7	28.4	2.12	2.06	2.02	1.19
11. Sesamum + Greengram 3:1	113.2	109.3	4.0	3.8	40.4	27.7	2.37	1.32	2.36	0.81
12. Sole Crop of Sesamum	133.8	117.6	3.7	3.9	39.2	26.8	3.77	—	3 36	—
13. Sole crop of Redgram	—	—	—	—	—	—	—	13.02	—	13.26
14 Sole crop of Blackgram	—	—	—	—	—	—	—	6.76	—	6.07
15. Sole crop of Greengram	—	—	—	—	—	—	—	6.28	—	4.83
S. Em ±	1.70	2.34	0.11	0.10	1.04	0.80	0.06	—	0.04	
C.D. at 5%	5.10	6.85	0.31	0.30	3.06	2.40	0.17	—	0.12	

Table 2 : Effect of Intercropping of different pulses on grain equivalent and net returns of Sesamum

Treatments	Sesamum grain Equivalents		Mean	Net Return (Rs/ha)		Mean
	1979	1980		1979	1980	
1. Sesamum + Redgram 1:1	6.22	5.95	6.09	2997.88	2759.04	2878.46
2. Sesamum + Redgram 2:1	6.48	5.06	5.77	3186.35	2184.71	2 85.58
3. Sesamum + Redgram 3:1	5.59	4.63	5.11	2603.14	1914.42	2258.78
4. Sesamum + Redgram (*Redgram sowing after* every 2nd row of Sesamum 2 + 1)	6.40	5.41	5.90	3097.45	2387.42	2742.43
5. Sesamum + Redgram (Redgram sowing after every 3rd row of Sesamum 3 + 1)	5.69	4.74	5.21	2656.48	1970.74	2313.61
6. Sesamum + Blackgram 1:1	2.93	2.68	2.81	860.60	638.15	749.37
7. Sesamum + Blackgram 2:1	3.08	2.77	2.92	970.84	705.71	838.27
8. Sesamum + Blackgram 3:1	3.13	2.99	3.06	1002.85	852.11	927.48
9. Sesamum + Greengram 1:1	2.83	2.50	2.67	800 14	521.78	660 96
10. Sesamum + Greengram 2:1	3.06	2.56	2.81	956.62	570.58	763.60
11. Sesamum + Greengram 3:1	2.86	2.73	2.80	825.04	679.43	752.23
12. Sole crop of Sasamum	3.77	3.35	3.56	1429.59	1092.35	1260.97
13. Sole crop of Redgram	6.90	7.03	6.96	3684.22	3723.77	3703.99
14. Sole crop of Blackgram	3.07	2.76	2.91	1219.78	968.48	1094.13
15. Sole crop of Greengram	2.85	2.19	2.52	1077.53	596.85	837.19
S. Em ±	0.29	0.17		181.18	112.61	-
C.D. at 5%	0.83	0.49		544.10	326.13	

In conclusion, sesamum combinations with blackgram or greengram had no yield or monetary advantage and sesamum: pigeonpea combinations produced more yield and gave higher net return than sole sesamum but were not as great as sole redgram. Under circumstances where an intercrop is desired for yield stability to reduce risk or for yield diversity, a 1 : 1 sesamum and pigeonpea combination is recommended.

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Phenological behaviour and yield of sesamum cultivars under different dates of sowing and row spacings

A. R. Rao, S. M. Kondap, G. Bhoji Reddy and W. A. Mirza
Department of Agronomy, College of Agriculture,
Rajendranagar, Hyderabad-500 030

Sesamum (*Sesamum indicum* L) is third largest oil seed crop and is extensively grown in India occupying an area of 2.4 lakh ha contributing 14% of total oilseed area with a production of 4.77 lakh metric tonnes of seeds (Sharma and Reddy 1983; Rai *et al.* 1984). The demand often outstrips the supply position due to its lowest average yield (2 77 q/ha) among all major field crops. With the introduction of short duration varieties and also intensive cultivation under multiple cropping system, there is need to have some flexibility in sowing dates, so that farmers could adjust sesamum sowings in relation to their crop rotational requirements. These aspects bring forward the need for a choice of more than one date of sowing and also choice of varieties to adjust the sowings and also to avoid the undesirable influence of climate on yield potential of sesamum. Keeping these things in view, the present trial was carried out.

The experiment was conducted at the Agricultural College Farm, Hyderabad during the rainy seasons of 1979 and 1980. The treatments consisting of four date of sowing (July 10, July 25, August 10 and August 25), three row spacing (15, 30 and 45 cm) with intra row spacing of 15 cm and three cultivars (N 62-39, Gouri and Madhavi). These treatments were replicated four times in a split plot design with four dates of sowing as main plots, 3 varieties as sub plots and 3 row spacings as sub sub plots. The soil of the experimental field was sandy loam with pH 8.0, 0.12% organic carbon, 20.6 kg/ha of available P_2O_5 and 378.6 kg/ha of exchangeable K_2O. An uniform dose of 60 kg N, 40 kg P_2O_5 and 30 kg K_2O/ha in the form urea, single super phosphate and muriate of potash respectively were applied as basal dose. The data on weather parameters during the crop seasons up to 50% flowering and maturity were recorded. The cumulative temperature units for each phenophase was calculated as a summation of the daily mean temperature. The overall season was normal with average rainfall of 368 and 386 mm in crop period during 1979 and 1980 respectively.

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Sowing dates : Sowing dates had significant effect on growth and development. The yield attributing characters (Table 2) such as plant height and number of pods/plant were maximum under first date of sowing (July 10) and significant reduction of these attributes were noticed with progressive delay in sowing. The numder of branches/plant were not influenced significantly between 10th and 25th July and 10th and 25th August. July sowings recorded significantly higher number of branches/plant than August sowings. The cumulative temperature, days to 50% flowering and maturity were also progressively reduced with subsequent sowing dates after 10th July in both the years (Table 1). Similarly the

Table 1 : Days to 50% flowering, maturity and cumulative temperature at phenophases under different dates of sowing of sesamum varieties

Treatments	Days to 50% flowering		Days to maturity		Cumulative temperature (C°)			
					Up to 50% flowering		Up to maturity	
	1979	1980	1979	1980	1979	1980	1979	1980
N 62—30								
July 10	45	44	103	101	1197	1154	2775	2659
July 25	40	39	99	98	1046	1000	2604	2485
August 10	35	33	93	91	913	855	2406	2304
August 25	32	30	89	86	856	769	2266	2096
Mean	38.00	36.50	96.00	94.00	1003.00	944.80	2515.80	2386.00
Gouri								
July 10	51	48	89	87	1360	1263	2363	2261
July 25	49	47	85	84	1280	1207	2252	2143
August 10	43	42	78	75	1134	1032	2031	1983
August 25	40	40	75	74	1060	1625	1951	1865
Mean	45.75	44.25	81.75	80.00	1208.50	1144.30	2149.00	2063.00
Madhavi								
July 10	38	37	80	79	1018	973	2137	2056
July 25	36	36	76	75	936	923	2018	1916
August 10	33	32	72	71	860	829	1883	1812
August 25	29	29	67	68	781	743	1774	1717
Mean	34.00	33.50	73.25	73.25	898.75	867.00	1953.00	1875.25

highest seed yield was obtained on July 10 sowing in **all the cultivars and** the mean yield declined progressively by 17, 35 and 43 **per cent** with **subsequent** delay in sowings.

Table 2 : Yield and yield attributing characters of sesamum under different treatments

Treatments	Plant height (cm)		Number of branches/plant		No of capsules/ plant		Seed yield q/ha		Mean
	1979	1980	1979	1980	1979	1980	1979	1980	
A. Date of sowing									
D_1 July 10	108.43	88.14	5.18	4.68	67.82	65.76	3.56	3.34	3.45
D_2 July 25	99.84	78.52	5.12	4.62	46.88	44.92	2.99	2.72	2.86
D_3 August 10	88.61	69.41	4.21	3.71	33.41	31.41	2.44	2.08	2.26
D_4 August 25	70.68	54.03	4.25	3.78	30.54	28.61	2.15	1.77	1.96
S. Em ±	0.52	0.70	0.18	0.06	0.62	0.63	0.04	0.06	
C. D at 5%	1.80	2.44	0.62	0.21	2.16	2.18	0.12	0.22	
B. Varieties									
V_1 N 62-39	101.39	81.25	4.57	4.07	45.54	43.55	2.75	2.42	2.58
V_2 Madhavi	70.85	53 28	4.31	3.81	39.14	37.17	2.45	2.10	2.28
V_3 Gouri	102.68	83.04	5.19	4.69	49.30	47.30	3.17	2.90	3.04
S E. m ±	0.81	0.76	0.10	0.12	0.13	0.52	0.02	0.06	
C. D. at 5%	2.43	2.27	0.30	0.37	0.38	1.55	0 06	0.19	
C. Spacings									
S_1 15 × 15 cm	95.78	76.48	3.91	3.41	34.52	32.52	2.79	2.48	2.64
S_2 30 × 15 cm	91.02	72.27	4.69	4.19	44.12	42.20	3.05	2.76	2.91
S_3 45 × 15 cm	88.12	68.83	5.47	4.97	53.35	53.31	2.52	2.18	2.35
S. Em ±	0.59	0.79	0.08	0.08	0.45	0.49	0.09	0.06	
C. D. at 5%	1.63	2.19	0.22	0.22	1.25	1.36	0.25	0.16	

Genotypes : The height of the plant of cultivars N 62-39 and Gouri were at par with each other and significantly taller than Madhavi in both the years (Table 2). But the number of branches and number of capsules/plant were maximum in Gouri in both the years followed by N 62-39 and Madhavi respectively. Though the number of branches/plant in these two varieties (N 62-39 and Madhavi) were at par with each other, Madhavi recorded the lowest number of branches/plant in both the years. Similarly the number of capsules/plant were minimum in Madhavi, consequently Gouri recorded the maximum mean seed yield (3.04 q/ha) while the lowest was recorded in Madhavi (2.28 q/ha).

The cultivar N 62-39 has taken comparatively more days for maturity ie. 14 and 22 days more than Gouri and Madhavi respectively. But Gouri has taken the maximum number of days to 50% flowering under different dates of sowing compared to the other two varieties. Similarly, the cumulative temperature upto 50% flowering was also maximum in Gouri compared to the other two varieties, probably this might have facilitated to develop better balanced source and sink relations leading to highest seed yield among all the varieties under all the dates of sowing due to its largest vegetative phase. Therefore, Gouri seems to be most flexible cultivar because of maintaining longer vegetative phase under all the sowing dates compared to other varieties.

Row spacing : Significant increase in plant height, was observed with subsequent decrease in row spacing. The narrow row spacing produced tallest plants in both the years whereas, the number of branches and number of capsules/plant progressively increased with increase in row spacing. However, the seed yield was maximum in medium row spacing (30 x 15 cm) compared to the rest of the spacings. Under wider spacing (45 x 15 cm), though the number of branches and number of capsules/plant were maximum, it could not compensate the yield loss because of less population while it was vice versa under narrow row spacing. Thus, 30 x 15 cm spacing seems to be optimum for getting higher seed yield of sesamum followed by narrow spacing of 15 x 15 cm. The percentage of seed yield in 30 x 15 cm spacing was 9 and 19% over 15 x 15 and 45 x 15 cm spacings respectively.

The interactions of cultivars x dates of sowings, dates of sowing x spacings and cultivars x spacings were found significant during both the years. The highest seed yield of sesamum was recorded in cultivar Gouri with optimum (30 x 15 cm) spacing in July 10 sowing. Under delayed conditions of sowing, narrow spacing of 15 x 15 cm may be preferred. These results are also in confirmatory with the results reported by Sanyasi Rao *et al.* (1977).

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Performance of sesamum genotypes over seasons at Coimbatore

S. Krishnaswami and R. Appadurai
School of Genetics, Tamil Nadu Agricultural University,
Coimbatore-641 003

Sesamum (*Sesamum indicum* L) is photo and thermosensitive and is a short day plant. Hence stability of a genotype over seasons is a prerequisite in breeding for improved varieties in this oilseed crop. A study was, therefore, taken up to assess the stability of a few genotypes.

The experimental material consisted of 20 genotypes evolved through single and multiple crosses including standard Co.1. These genotypes were tested for yield and yield attributes over three seasons *viz.* Monsoon 1982, Summer 1983 and Monsoon 1983. The materials were sown in a RBD with four replications. Date on plant height, number of branches, number of capsules per plant and seed yield per hectare were collected and were subjected to analysis of variance to test the significance of genotype x environment interactions. The stability parameters *viz*, 'b' and S^2d values were estimated using the model proposed by Eberhart and Russell (1966).

Table 1 : 'Anova' details of four traits

Source	df	Mean squares			
		Plant height (cm)	Branches	Capsules per plant	Seed yield kg/ha
Genotype	19	62.44	0.364*	119.8	14461.16
Season (linear)	1	12850.84*	3.358*	7416.20*	782317.76*
Genotype × season (linear)	19	34.09	6.538*	84.09	18250.01
Pooled derivation	20	43.89	0.225	90.54	13318.22
Error	171	47.33	0.214	84.24	10091.72

* Significant

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The Anova (Table 1) revealed the genotypic differences were significant for number of branches alone and not for plant height. capsule number and seed yield. The differences due to seasons were significant for all the four traits and the interaction of genotype x season was significant for number of branches and seed yield only.

The date on seed yield of the genotypes over seasons along with regression (b) values and the deviations from regression S^2d are given in Table 2.

Table 2 : Seed yield (kg/ha) of 20 genotypes of sesamum over three seasons

Genotype		Monsoon 1982	Summer 1983	Monsoon 1983	Mean	'b'	S^2d
1.	7828/1-15-1-4-1	437	924	832	731	1.849	—9750.72
2.	7722/1-1	736	780	619	712	—0.074	3574.79
3.	7722/10-8-1	438	787	695	695	1.283	—9023.50
4.	7722/4-5	692	708	594	664	—0.016	—2987.23
5.	7722/3-9-2	484	803	626	638	1.025	—136.75
6.	7732/6-1	492	677	718	629	0.824	—7506·50
7.	7725/11-1-1	225	909	736	623	2.526*	—6741.09
8.	7725/21-4-1	384	667	837	603	1.756*	17574.07
9.	7725/3-20-1	563	450	753	589	0.016	36847.68*
10.	7722/1-20-3-5	323	880	541	581	1.743	28789.07
11.	7725/5-3-1	447	530	682	553	0.573	5107.13
12.	7725/6-4-1	354	672	613	547	1.209	—9973.19
13.	7722/3-14-2	389	693	551	544	1.018	—4491.59
14.	7722/1-18-7-2	347	593	683	541	1.151	—1384.54
15.	7828/1-15-1-3-2	481	539	597	539	0.330	—7683.86
16.	7722/3-23-2-1	325	514	776	538	1.191	37079.82*
17.	KRR. 1/P.64-5-2	354	679	559	530	1.41	—6976.38
18.	7725/3-19-1	300	597	645	514	1.291	—5580.48
19.	7738/3-1	367	657	451	491	0.859	5512.17
20.	Co. 1	427	591	420	479	0.401	2281.84
	Seasonal Mean	424	682	646	588		
	SE	64.9	83.2	107.5	81.6		
	CD at 5%	183.8	235.5	NS	161.6		

* Significant

Among the genotypes, the culture 7828/1-15-1-4-1 recorded the highest yield followed by culture 7722-1-1 and the culture 7722/10-8-1. The regression values of all the three cultures are not significant from unity and the S^2d values also around zero showing them to be stable in their performance. Lack of significant differences among genotypes for all the traits other than number of branches may be ascribed to adoption of a constant selection criteria to advance superior genotyes from segregating generations to comparative trials. Number of capsules and seed yield are generally given much importance in this regard. The interaction of genotypes with the seasons is significant for number of branches and seed yield. Number of branches, therefore, seems to be differentially valnerable to environmental fluctuation in the various genotypes. Murugesan *et al.* (1978) have indicated the importance of the character, number of branches for selection. Multilocational testing of the genotypes in as many locations and seasons as possible is, therefore, very essential for sesamum.

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Residual toxicity of synthetic pyrethroids against *EUPROCTIS FRATERNA* Moore on castor

S. V. Singh, K. Mohan and B. Singh
Department of Entomology, C. S. Azad
University of Agriculture & Technology, Kanpur-208 002

The synthetic pyrethroids have been recently developed as potent insecticides against many of the serious crop pests (Elliott *et al.*, 1978). The compounds are also known to possess more photostability (Elliott *et al.*, 1973) and their efficacy is enhanced by rain (Ruscoc, 1977). Residual toxicity of these chemicals was, therefore, tested against hairy caterpillar (*Euproctis fraterna* Moore) on castor crop.

Permethrin 50 EC, cypermethrin 25 EC, decamethrin 2.5 EC, fenvalerate 20 EC, carbaryl 50 WP and endosulfan 35 EC were sprayed in two concetrations (Table 1) on January 18, 1983. The treatments were randomized in three replications. An untreated control was also maintained to observe natural mortality of the pest. For assesement of toxicity, leaves from the treated as well as untreated plants were randomely collected and brought to the laboratory after 1 h, 1, 3, 7, 11, 17 and 24 days of treatment. Laboratory reared 10 third instar larvae were released in each petridish and mortality counts were made after 24 h of treatment. The moribund larvae were also considered as dead.

The data were subjected to statistical analysis for PT indices with the method adopted by Sarode and Rattan Lal (1981). This method was also followed for calculating LT 50 with regression equation $Y = a + b\,x$, where, Y was taken as probit kill and x as log days (Goulden, 1959).

It is observed from Table 1 that synthetic pyrethroids are more pesristent and effective against *E. fraterna* in comparison to endosulfan and carbaryl PT indices of permethrin, fervalerate, cypermethrin and decamethrin were 2.37-2.83, 2.32-280, 1.86-2.70 and 1.36-1.58 times more than that of endosulfan (0.05%) respectively. Meanwhile, their LT 50 values also indicate slower rate of dissipation *viz.*, 8.45-10.73 days for cypermethrin, 8.11-9.21 days for permethrin, 7.57-9.30 days for fervalerate, 4.99-6.67 days for decamethrin, 3.48-5.56 days for

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Table 1 : Residual toxicity and persistence of various insecticides

Chemicals	Conc %	Percent mortality after							P T Index		L T 50 (days)	
		1 h.	1 day	3 days	7 days	11days	17 days	24 days	Values	Relative residual toxicity	Values (days)	Relative persistence
Permethrin												
	0.005	100.00	96.29	93.33	63.33	63.33	33.33	10.00	1530.10	2.37	3.11	3.31
	0.010	100.00	100.00	93.33	86.87	70.00	50.00	33.33	1828.56	2.83	9.21	3.76
Cypermethrin												
	0.005	100.00	92.96	90.00	80.00	43.33	16.67	0.00	1198.39	1.86	8.45	3.45
	0.010	100.00	95.59	93.33	90.00	63.33	50.00	16.67	1744.87	2.70	10.73	4.38
Decamethrin												
	0.00125	100.00	62.22	60.00	63.33	26.67	6 67	0.00	875.19	1.33	4.99	2.04
	0.00150	100.00	80.00	66.66	63.33	36.67	13.33	0.00	1019 97	1.58	6.68	2.73
Fenvalerate												
	0.010	100.00	89 67	83.33	80.00	53.33	20.00	10.00	1497.12	2.32	7.27	2.97
	0 015	100.00	100.00	86.33	83.33	73.33	50.00	33.33	1804.53	2.80	9.30	3 80
Carbaryl												
	0.100	100.00	75.92	63.33	43.33	6.67	0.00	0.00	636.35	0.97	3.48	1.42
	0.15	100.00	93.33	80.00	50.00	23.33	0.00	0.00	762.65	1.18	5.56	2.27
Endosulfan												
	0.05	100.00	93.33	73.33	23.33	3.33	0.00	0.00	645.30	1.00	2.45	1.00
	0.07	100.00	95.59	90.00	40.00	3.33	0.00	0.00	723.62	1.12	2.99	1.22

Relative residual toxicity and persistence were calculated by considering endosulfan 0.05 percent as Unity
There was no mortality in control

carbaryl and 2.35-2.99 days for endosulfan. These results are in confirmatory with those of Agnihotri *et al.* (1980) but do not corroborate with views of Nibalkar and Ajri (1981) who reported less persistence of permethrin than other pyrethroids. Regarding less toxicity of carbaryl and endosulfan the findings also differ from Batra *et al.* (1979) where they found that these two are the most effective insecticides against this pest. The retention of pyrethroids in leaf cuticle may be responsible for their slower degradation due to their lipophilicity (Ruscoc, 1977).

Total weekly rainfall 19.3 and 11.80 mm in the successive weeks of treatment was found to be more detrimental to endosulfan and carbaryl than decamethrin, cypermethrin, fenvalerate and permethrin. The results of Ruscoc (1977) are also in agreement with the present findings.

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Response of sunflower genotypes to time of nitrogen application

S. Narsa Reddy, B. Bucha Reddy, M. V. Sudhakar and M. S. Raju
Department of Agronomy, College of Agriculture,
Rajendranagar, Hyderabad-500 030

Oilseed crops are mostly grown under rainfed condition with uncertainty in their production level leading to shortage of edible oil. To bridge the gap in shortage, there is need to exploit the yield potential under irrigation. Among oilseed crops, sunflower (*Helianthus annuus* L) can be well fitted in multiple cropping system because of its short duration and photo-insensitiveness. The extent of response of sunflower genotypes to fertiliser management in particular to nitrogen under irrigation needs to be explored. Rational application of nitrogen at right stages of the crop growth is necessary for increasing the nitrogen use efficiency. Keeping these in view, the present investigation was carried out at Agriculture College Farm, Rajendranagar, Hyderabad in *rabi* 1983-84.

The treatments consisted of three genotypes (EC 68414, Morden and APSH-3) and application of 90 kg N/ha in six varying proportions as basal and top dressing at 30 and 45 days after sowing (Table 1). The treatments were arranged in a split plot design with genotypes as main plots and times of nitrogen application as sub plots with three replications. The soil was sandy loam with 7.4 pH, 0.58% organic carbon, 325 kg/ha available nitrogen, 25 kg/ha available P_2O_5 and 448 kg/ha available K_2O. The crop was sown on November 3 1983. The varieties Morden and APSH-3 were harvested after 92 days and EC-68414 after 100 days. A uniform dose of 60 and 40 kg of P_2O_5 and K_2O per hectare respectively were given.

Genotypes did not differ significantly in respect to leaf area index and flower head diameter, whereas, number of filled seeds per head, percentage of illfilled seed, test weight and seed yield were markedly varied. Highest seed yield of 18.2 q/ha was recorded in APSH-3 registering an increase of 12.5 and 19.6% over EC-68414 and Morden respectively. This increase in seed yield was mainly due to more number of filled seeds (659.4) and less percentage of illfilled

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seeds/head (13.5%). Although the test weight was low in APSH-3, it out yield other two genotypes because of considerable increase in number of filled seeds/ head (Table 1).

Table 1 : Growth and yield of sunflower as influenced by genotypes and time of N application

Treatments			LAI 60th day	Flower head diameter (cm)	Number of filled seed per head	Percentage of illfilled seeds per head	Test weight (g)	Seed yield (q/ha)
Genotypes								
EC. 68414			1.836	13.29	611.5	14.1	44.15	16.2
Morden			1.801	12.44	529.2	15.9	44.84	15.2
APSH.3			1.594	13.14	659.4	13.5	38.93	18.2
C. D. at 5%			NS	NS	55.98	1.03	3.239	1.50
Time of N application (90 kg N/ha)								
Basal	*30 DAS*	*45 DAS*						
T_1 Full	—	—	1.533	11.47	473.0	17.9	34.49	13.5
T_2 1/2	1/2	—	2.189	14.56	695.0	12.1	47.85	19.6
T_3 1/2	—	1/2	1.609	81.88	564.9	15.5	41.73	14.7
T_4 1/3	1/3	1/3	1.692	13.58	655.5	13.9	43.99	17.2
T_5 1/3	2/3	—	1.908	13.99	720.4	11.5	49.58	19.9
T_6 1/3	—	2/3	1.530	12.26	491.5	16.1	38.21	14.3
C.D. at 5%			0.194	0.79	49.57	0.80	2.997	1.08

N.S. = Non significant; DAS = Days after sowing

Application of 1/2 N as basal + 1/2 N at 30 days after sowing (T_2), and 1/3 N as basal + 2/3 N at 30 days after sowing (T_5) resulted in maximum Leaf Area Index (LAI), flower head diameter, number of filled seeds per head and test weight compared to all other times of nitrogen application.

Maximum seed yield of 19.91 and 19.61 q/ha were recorded by T_5 and T_2 treatments respectively. The increase in seed yield due to T_5 was 47.6, 39.1

35.0 and 15.9 per cent over basal application of all nitrogen (T_1), 1/3 N as basal+2/3 N at 45 days after sowing (T_6), 1/2 N as basal+1/2 N at 45 days after sowing (T_3), and 1/3 N each at basal, 30 and 45 days after sowing (T_4), respectively. Three equal split application of N at basal, 30 and 45 days after sowing (T_4) recorded 17.18 q/ha as against 13.49 14.75 and 14 31 q/ha recorded by T_1, T_3 and T_6 treatments respectively. The lowest yield due to basal application of all N (T_1) might be due to low availability of N at later stages of crop growth, as considerable amount of application of N might have lost through leaching. Similarly, delayed application of N at 45 days after sowing in the treatments T_3 and T_6 recorded decreased seed yield, due to poor initial vigour of the crop as evident from plant height, LAI and shoot dry matter at 45 DAS (Table 2). The findings of Sindagi (1982) and Vijay Kumar *et al.* (1973) are in agreement with the results of the present experimentation.

Table 2 : Growth as influenced by genotypes and time of N application at 45 days of crop growth

Treatments	Plant height (cm)	LAI	Shoot dry matter (q/ha)
Genotypes			
EC—68414	74.5	1.439	15.0
Morden	63.8	1 427	13.6
APSH—3	68 6	1.650	15.5
C.D. at 5%	4.53	NS	NS
Time of N application (90 kg N/ha)			
Basal 30 DAS 45 DAS			
T_1—Full — —	66.8	1.573	1 ,8
T_2— 1/2 1/2 —	78.2	2.011	18.3
T_3— 1/2 — 1/2	61.3	1.090	11.0
T_4— 1/3 1/3 1/3	70.3	1.587	12.7
T_5— 1/3 2/3 —	73.4	1.791	17.0
T_6— 1/3 — 2/3	64.0	0.990	12.0
C.D. at 5%	4.38	0.192	2.72

The seed yields as influenced by interaction of genotypes and time of N application was not significant, eventhough there is a variation of 8 days in duration among the genotypes.

The results suggest the application of 1/3 or 1/2 N as basal + 2/3 or 1/2 N at 30 days after sowing is the best time of nitrogen applcation to sunflower and the genotype APSH-3 was superior to other genotypes.

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Effect of season and plant densities on growth, yield and yield components of sunflower

T. N. Ashok Kumar, Gangadharaiah, K. T. Krishne Gowda and K. Seenappa
Sunflower Scheme, University of Agricultural Science,
G. K. V. K., Bangalore-560 065

Seed is a key input for increasing agricultural production. Sunflower (*Helianthus annuus* L) being a cross pollinated crop, seed production assumes greater importance and significance. Agronomic practices followed for the commercial crop aim at higher quantity of seeds. Whereas for a seed production crop, the quality of produce obtained is of importance in realising higher seed yield in subsequent planted crop. In order to develop package of practices for the seed production crop, the present study on EC. 68415 sunflower was initiated.

A field trial was carried out during *kharif* and *rabi* 1982 and during summer 1983 at the Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bangalore on red sandy loam soil under irrigated conditions. The sunflower variety EC. 68415 was sown on July 28, 1982, October 11, 1982 and on January 20, 1983 with a fertilizer dose of 80N, $60P_2O_5$ and $30K_2O$ kg/ha during *Kharif rabi* and summer seasons respectively, with plant populations of 37,000 (60cm x 45cm), 55,555 (60cm x 30cm) and 74,000 (45cm x 30cm) plants per ha. The agronomic operations were attended to as per schedule. Although the total rainfall received in 1982 was nearer to normal, but distribution was very erratic as a result, drought conditions prevailed for about 30 days immediately after sowing of the crop. The temperature observed was above normal by 1 to 2°C during *kharif*. There was no precipitation during summer 1983. Leaf area estimation per plant on five random plants were made as per Trehan *et al*. (1975). From this, leaf area duration (LAD) was computed (Power *et al*., 1967). Seed yield from net plots were recorded. Oil per cent was determined by Nuclear Magnetic Resonance spectrometer (NMR Model Minispec 20 Pi). From the seed yield and oil per cent, oil yield per ha was worked out.

Seed yield obtained in different seasons and plant densities differed significantly (Table 1). Higher seed yield was obtained in summer (2078 kg/ha) and

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Table 1 : Yield and yield components as influenced by seasons and plant densities

Treatments	Seed yield (kg/ha)	Test weight (g)	Oil (%)	Oil yield (kg/ha)	LAI at different stages of crop growth: Bud	Full bloom	Seed filling	Harvest	LAD
Seasons									
Kharif	1543	55.9	40.5	626	0.962	2.698	2.815	1.509	163
Rabi	2000	63.9	41.7	835	1.072	2.889	2.873	1 541	159
Summer	2078	76.2	42.7	885	1.286	2.610	2.173	1.513	139
Plant density per ha									
37,037 (60 × 45 cm)	2030	74.9	41.48	823	0.958	2.801	2.558	1.491	149
55,555 (60 × 30 cm)	2041	63.2	42.37	858	1.114	2.855	2.955	1.801	165
74,074 (45 × 30 cm)	1554	58.0	42.13	656	1.248	2.228	2.349	1.286	147
CD 5%	161	3.53							
Seasons vs Plant density									
Kharif									
60 × 45 cm	1642	60.8	39.6	651	0.868	2.721	2.813	1.476	160
60 × 30 cm	1639	53.4	41.0	672	0.992	2.964	3.154	1.735	179
45 × 30 cm	1362	53.5	40.8	556	1.026	2.409	2.477	1.317	150
CD 5%	NS	NS							
Rabi									
60 × 45 cm	2161	80.9	40.8	884	0.948	2.882	2.810	1.487	153
60 × 30 cm	2208	61.0	42.0	945	1.040	3.082	3.190	1.746	170
45 × 30 cm	1625	50.0	41.7	678	1.229	2.705	2.620	1.391	155
CD 5%	296	5.52							
Summer									
60 × 45 cm	2281	83.0	41.0	935	1.06	2.740	2.050	1.510	134
60 × 30 cm	2277	75.2	43.3	986	1.31	2.520	2.520	1.940	146
45 × 30 cm	1676	70.5	43.8	734	1.49	2.570	1.950	1.050	137
CD 5%	325	5.52							

it was on par with *rabi* yield (2000 kg/ha) while significantly lower yield was realised during *kharif* (1548 kg/ha). Similar trend was observed in respect of oil per cent and oil yield per ha. Seeds with higher test weight resulted in summer (76.2 g) followed by *rabi* (63.9 g) whereas seeds with low test weight were obtained during *kharif*. Thus the results indicated the suitability of summer season for gathering higher seed yield with better quality seeds. Krishnegowda (1984) also obtained higher yield with higher test weight from the summer crop than the *kharif*.

Leaf Area Index (LAI) worked out at bud stage was slightly higher during summar (1.286) than the other seasons and slightly decreased during flowering and seed filling stage. At maturity it was almost the same in all the seasons. However, because of disease free condition and also due to better solar radiation higher seed yield during summer was obtained. Further the crop matured 8-10 days earlier in summer as indicated by lower LAD (139 days) as compared to *Kharif* (163 days) and *rabi* (159 days).

Seed yield from 37,000 pl/ha (2030 kg/ha) and 55,555 pl/ha (2041 kg/ha) did not differ significantly. Whereas, seed yield was the lowest at 74,000 pl/ha (15554 kg/ha). On the basis of test weight, seeds with higher test weight accrued from a lower plant population of 37,000 pl/ha (74.9 g) than from 55,555 pl/ha (63.2 g) although seed yield obtained was on par at these two population levels. The test weight of seeds got from the higher population level of 74,000 pl/ha was the lowest (58 g), thus indicating the desirability of a lower population of 37,000 pl/ha. The oil per cent was lowered at the lower population (41.48%) than at higher level (42.13%) thus indirectly indicating the higher per cent of protein in seeds in the former, which is one of the criteria for quality seeds. Similar observations were made by Trepaceu (1954) and Kilmore (1968). Renea and Olteann (1960) also observed decrease in the quality of seeds with an increase in plant population. LAI recorded at lower plant population levels at flowering was higher than at the highest level, thus enabling the plants for higher photosynthetic activity.

Season and plant density interactions revealed that in all the seasons higher plant population gave the lowest yield with seeds of lower test weight. Seeds obtained from summer crop with lower plant population (37,000 pl/ha, 60cm x 45 cm) had higher test weight (83 g) than in any other seasons and plant densities. The test weight of seeds now recorded was higher than that (60 g) suggested by Giriraj *et al.* (1979). Thus, it is advisable to raise the seed production crop of sunflower during summer with a plant population of 37,000 pl/ha (60cm x 45cm) to obtain quality seeds

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Fungicidal control of Alternaria blight of mustard

B. Das Gupta, B. N. Chatterjee, S. Chowdhury, R. K. Ghosh and K. Baral
Department of Agronomy and Plant Pathology,
Bidhan Chandra Krishi Viswavidyalaya, Kalyani, West Bengal-741 235

Alternaria blight of Oleiferous brassicae is caused by two species of *Alternaria* namely *Alternaria brassicae* (Berk) Sacc. and *Alternaria brassicicola* (Schw) Wilts. *Alternaria brassicicola* is the predominantly occurring species in West Bengal and is responsible for substantial yield loss in both rape seed (*Brassica campestris* Linn.) and mustard (*Brassica juncea* Linn. Czern. & Coss) due to recurrent epidemics. Results of a filed experiment on fungicidal control of the disease is presented here.

In one set of experiments, four common fungicides, available to farmers, were evaluated as prophylactic spray against the disease. The fungicides used were Difolatan (Cis-N-(1, 1, 2, 2-tetrachloroethylthio)-4-cyclohexene-1, 2-dicarboximide) 80 WP, Dithane M 45 (zinc, manganese ethylene-bisdithiocarbamate 80 WP, Captan (N-trichloromethyl mercapto-4-cyclohexene-1, 2-dicarboximide) 83 WP and Blitox (Cu-oxychloride) 50 WP. Difolatan, Dithane M 45 and Captan were used at 0.2 % concentration of the trade product. The same for Blitox was 0.4 %. Four spraying of high volume suspension were applied at intervals of 15 days from 50 days after sowing (DAS). In another set of experiments, number of sprays required to provide adequate disease control was evaluated with Dithane M-45 as the fungicide, applied between 50-95 days of crop growth. Both experiments were laid out in Randomized Block Design with crop variety 'Varuna' sown during the last week of October with recommended package of practices. Observations on disease intensity were recorded 15 days after last spray on a 0-5 scale, where 0=no infection; 1=1-10% leaf/pod area damage; 2=11-25% leaf/pod area damage; 3=26-50% leaf/pod area damage; 4=51-75% leaf/pod area damage and 5= more than 75% leaf/pod area damage. Data on yield ond other yield factors were recorded at harvest at 115-126 DAS. Per cent disease intensity was calculated (Townsend and Heuberger, 1943) as : (sum of all numerical ratings x 100) / (Total number of leaf or pod X maximum score).

Effect of fungicides

Fungicides significantly reduced (Table 1) leaf infections due to *Alternaria*.

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Among the fungicides, Dithane M-45 gave highest reduction of leaf blight symptom but its effect was not significantly different from that of Difolatan. While Blitox and Difolatan gave comparable control of leaf and pod infections. Dithane M-45 and captan gave lesser amount of control of infections in pod than in leaf. Difolatan was most effective in controlling pod infections. Yield increase due to treatment was significant for all fungicides, the highest being with Dithane M-45. Per cent increase in yield showed an almost direct relationship with per cent reduction in disease intensity in the leaves (r = 0.942) and also in the pods (r = 0.96). Number of pods per plant and number of seeds per pod did not differ significantly due to treatments. But 1000 seed weight registered significant increases with fungicidal treatments characteristically in the order of increase in total yield. Cost-benefit ratio was also highest for Dithane M-45.

Table 1 : Effect of different fungicides as **prophylactic** spray on *Alternaria* blight and yield of mustard

Name of the fungicide	Percent Disease intensity		Yield (kg/ha)	1000 seed weight (g)	Cost benefit ratio
	Leaf	Pod			
Blitox-50	51.2 (45.7)*	13.7 (21.7)	683	4.08	1 : 1
Dithane M-45	35.1 (36.0)	12.6 (20.8)	960	4.94	1 : 5
Difolatan	42.6 (40.7)	10.8 (19.1)	890	5.01	1 : 4
Captan	47.4 (43.5)	15.6 (23.3)	750	4.53	1 : 1.2
No fungicide (Check)	66.8 (54.9)	17.8 (24.9)	518	3.63	
S Em ±	(3.15)	(0.97)	25.46	0.41	
C. D. at 5%	(6.87)	(2.12)	55.99	0.89	

* Figures in the parenthesis are the angular transformed values of per cent disease intensity

Effect of number of sprayings on disease control

Three (65, 80 and 95 DAS) and four (50, 65, 80 and 95 DAS) sprays of Dithane M-45 gave statistically comparable control of disease intensity in leaves and pods and the results were significantly different from that of two (80 and 95 DAS) sprays and no spary. Total yield and 1000 seed weight registered significant increases over 2 sprays and no spry (Table 2).

Table 2 : Effect of number of sprays with dithane M-45 on *Alternaria* blight and yield of mustard

Treatments	Percent disease intensity		Yield	1000 seed	Cost benefit
	Leaf	Pod	kg/ha	weight (g)	ratio
4 Sprays	39.99 (39.20)*	13.33 (21.36)	1070	5.59	1 : 2.5
3 Sprays	35.13 (42.18)	15.27 (22.96)	952	5.11	1 : 2
2 Sprays	56.13 (48.52)	18.92 (25.77)	933	5.42	1 : 2
No spray (Check)	63.40 (52.81)	22.82 (28.52)	613	4.13	
S. Em ±	(2.12)	(1.05)	62.11	0.261	
C.D. at 5%	(4.62)	(2.29)	135.35	0.569	

* Figures in the parenthesis are the angular transformed value of percent disease intensity

The above results, thus, showed that Dithane M-45 among the common fungicides available to farmers as a prophylactic fungicide against Alternaria blight of mustard in West Bengal, was most efficient. Under annual recurrence of epidemics, a schedule of three sprays between 65-95 DAS at 15 days interval appears to be optimum for reducing disease intensity and increasing yield. Kolte (1982) has, however, reported effective disease control at Pantnagar and Ludhiana with 2-3 sprays starting at 75 days after sowing. Shorter crop growth period and abundant humidity under West Bengal conditions may the reasons for this difference. Sarkar and Sen Gupta (1978) earlier observed that at 60 DAS mustard crop is most vulnerable to be infected by *Alternaria brassicicola* under West Bengal conditions.

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Evaluation of Spanish bunch groundnut varieties for spring season planting in the Punjab

K. S. Labana, Mohinder Singh and A. S. Sangha
Department of Plant Breeding, Punjab Agricultural University,
Ludhiana-141 004

Ever since the introduction of groundnut crop in the Punjab, it is being raised as *Kharif* crop and that too as a rainfed crop. With the spread of irrigations facilities, introduction of high yielding paddy varieties and its procurement at remunerative price by Govt. Agencies, the paddy has encroached the area under groundnut. In addition, during *Kharif* groundnut is confronted with a number of diseases like Collar rot, Bud rot (Necrosis), Leafspots (Early and Late) insect pests like white-grub, hairy caterpillar etc. leading to drastic reduction in yield. Consequently the area under groundnut is dwindling in the state. However, Labana and Singh (1979) explored the possibility of raising a successful groundnut crop in Spring (February) and reported that short duration Spanish bunch varieties are suitable for growing during this season. Evaluation of short duration varieties to fit into relay cropping and adoption of improved production technology has given a push to Spring season for taking a catch and cash crop before the main *Kharif* season.

The objectives of the present study were to find a suitable genotype, optimum date of sowing and spacing requirement for Spring groundnut.

The experiment was conducted at the Oilseeds Experimental Area, PAU, Ludhiana, during 1982 and 1983 under irrigated conditions. During Spring 1982, six Spanish bunch varieties *viz.* ICGS-1, RSHY-1, RG-17, J 11 and JL24 were tested against AK-12-24 as a standard. The varieties were sown on two dates *viz.* February 26 and March 12. Each variety was sown in a paired row of 3 m length with a spacing of 30 cm x 15 cm. A basal dose of 15 kg N and 20 kg P_2O_5/ha was applied at the time of sowing, Four to five irrigations were given during a season to raise the crop.

The experimental crop was harvested after 120 days of first date of sowing

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and sun dried for 5 days before picking the pods. The date on pod yield, shelling percentage and 100 kernel weight were recorded.

During Spring 1983, the experiment was sown with six varieties keeping AK 12-24 as standard. The experiment was laid out in a split plot design with three dates of sowing (February 19, March 2 and March 11) in the main plot, the six varieties in the sub plots and six spacing treatments (22.5 cm x 10 cm (S_1) 22.5 cm x 15 cm (S_2), 30 cm x 10 cm (S_3), 30 cm x 15 cm (S_4), 45 cm x 10 cm (S_5) and 45 cm x 10 cm plus earthing up (S_6) in sub-sub plots. There were two replications for each plot occupying an area of 2 73 square meter.

The crop was harvested after 122 days of first date of sowing. Data were recorded on days to first flowering, number of mature pods, number of pod bearing needles, shelling percentage, 100 kernel weight and pod yield. The oil percentage for each treatment was determined from the composite samples.

The analysis of variance showed that the mean squares due to varieties, date of sowing and their interactions were significant. This means that varieties and dates of sowing differed in yielding capacity and that varieties responded differently in different dates.

Varieties and dates of sowing :

The mean pod yield of the varieties, their performance in different dates and their interactions are presented in Table 1. Variety ICGS-1 recorded the mean yield of 1572 kg/ha as compared to 845 kg per ha given by the standard variety AK 12-24. The yield increase in favour of ICGS-1 was 86 per cent. Two other varieties names RSHY-1 and RG-17 were also significantly superior to AK 12-24 in pod yield.

As regards to the dates of sowing, the first date, February 27 proved to be far superior than the second date of March 12. The mean pod yield obtained in the first date was 1398 kg/ha as against only 500 kg/ha in the second date (Table 1). Variety ICGS-1 has given highest pod yield of 2367 ko/ha when sown on February 27 which is 1067 kg or 82 per cent more than 1300 kg/ha of AK 12-24

During the second year of testing, ICGS-1 maintained its superiority over the standard variety by recording a mean pod yield of 2194 kg/ha which was 64 per cent higher than that of the standard variety Table 1). Sowing done on February 19 (1687 kg ha) or March 2 (1698 kg/ha) had similar performance but both had significantly better results over the last date i e. March 11 (1397 kg/ha). The differential response of the varieties over different dates of sowing is evident. Here again, ICGS-1 proved to be the best performing variety with highest pod yield of 2441 kg/ha when sown on February 19 as against 1407 kg/ha of the standard variety, thus surpassing by 73 per cent in pod yield.

Table 1 : Effect of the date of sowing on varietal performance during Spring 1982 and Spring 1983

Variety	Pod yield kg/ha (1982)			Pod yield kg/ha (1983)			
	February 27	March 12	Mean	February 19	March 2	March 11	Mean
1. ICGS-1	2367	778	1572	2241	2287	1855	2194
2. RSHY-1	1542	458	1000	1605	1778	1432	1605
3. RG-17	1532	700	1116	1651	1824	1361	1612
4. J-11	1461	441	951	—	—	—	—
5. JL-24	1391	424	908	1512	1488	1250	1417
6. TG-14	1044	320	682	1506	1278	1420	1401
7. AK 12-24(Std.)	1300	391	845	1407	1534	1061	1334
Mean	1398	500	949	1687	1698	1397	1594

C. D. 5% Variety	: 121 kg/ha	C. D. 5% Variety	= 154 kg/ha
Date of sowing	: 49 kg/ha	Date of sowing	= 92 kg/ha
Variety × Dates	: 171 kg/ha	Variety × Dates	= 225 kg/ha

Table 2 shows the effect of date of sowing and spacing on pod yield. It is observed that pod yield varied with different dates of sowing and different spacing treatment combinations. However, closer spacing of seeds within a row (10 cm) tended to give higher yield than wider spacing (15 cm). The mean performance of the varieties over the three dates of sowing shows that spacing of 22.5 cm x 10 cm and 30 cm x 10 cm gave significantly more pod yield of 1735 kg/ha and 1760 kg/ha respectively than rest of the spacing treatments. Surprisingly the spacing of 45 cm x 10 cm when reinforced with periodical earthing up of the plants resulted into lowest yield. This could be attributed to more exposed surface area which led to increased water evaporation from the soil, consequently reducing pod yield as compared to other spacing treatments.

The above results clearly demonstrate that ICGS-1 is the most suitable variety for Spring planting in the Punjab. Early sowing *viz.* second fortnight of February coupled with a spacing of 30 x 10 cm were optimum for obtaining high yield.

Quality characters

The data in respect of some quality characters showed that during Spring 1982 both shelling percentage and 100 kernel weight were higher than those obtained during Spring 1983. Excessive rains during the months of March and April 1983, caused more vegetative growth which was at the expense of reproductive phase of the crop. This ultimately resulted into reduced shelling percentage and 100 kernel weight. The overall mean shelling percentage nda

100 kernel weight recorded during 1982 were 67.5 per cent and 42.1 g respectively while these were 55.5 per cent and 31.9 g respectively during 1983. Early sown crop tended to have higher shelling percentage and bolder kernels.

Table 2 : Effect of date of sowing and spacing on yield of groundnut, spring 1983

Date of sowing	Pod yield kg/ha						
	22.5 cm × 10 cm	22.5 cm × 15 cm	30 cm × 10 cm	30 cm × 15 cm	45 cm × 10 cm	45 cm × 10 cm	Mean
19.2.83	1809	1815	1821	1617	1815	1247	1687
2.3.83	1923	1565	1907	1642	1858	1283	1698
11.3.83	1472	1528	1571	1407	1173	1228	1397
Mean	1735	1636	1766	1556	1615	1256	

C. D. 5% Dates of sowing = 92 kg/ha
spacing = 124 kg/ha
Date × spacing = 225 kg/ha

The effect of spacing within and over the three dates of sowing on oil content was variable. However, early sown crop had higher mean oil content (49.4%) as compared to late sown crop (46.8%). Among the varieties, TG 14 had the highest oil content (50.3%) when sown on February 19, while RSHY-1 possessed more oil content when sown on March 2 (50.1%) and March 11 (48.0%).

Ancilliary characters

The data on some ancilliary characters were also recorded during 1983 which showed that the early sown crop (February 19) took longest time (53.5 days) while the late sown crop (March 11) took approximately 19 days less to come to first flowering. Due to low temperature prevailing at the time of first two dates of sowing, the crop/seeds did not germinate and emerge out of soil till rise in temperature during mid-March when all the varieties sown on all the three dates germinated and came out of soil simultaneously. That is why early flowering by the late sown crop did not have any advantage in yield.

Early sown crop had more number of pod bearing needles, and also more number of mature pod, which ultimately resulted into higher yield. High yield produced by ICGS-1 could be attributed to more number of pod bearing needles and mature pods as well as boldest kernels as compared to rest of the varieties.

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Intercropping in groundnut through border method

A. N. Srivastava and K. P. Verma
C. S. Azad University of Agriculture & Technology, Kanpur

Due to high prices and shortage of fertilizer and quality seed of groundnut farmers are unable to use full doses of fertilizers and quality seed in groundnut cultivation. It has been successfully proved here that groundnut crop can be grown by border method without reduction in pod yield while saving both fertilizer and seed to the extent of 25% (Srivastava and Prasad, 1984). The terminology 'Border method' has been assigned to a system of planting seed regularly in 3 rows while leaving every 4th row vacant (unseeded). Srivastava and Prasad (1984) also reported that one additional crop may also be grown in each 4th vacant row. Keeping this in view the experiment of intercropping in groundnut through border method under rainfed condition was conducted to utilize the vacant space and also to cover the risk of failure of crop rather than increasing the productivity.

A field study was carried out at Crop Research Farm, Kalianpur of the C. S. Azad University of Agriculture & Technology, Kanpur in R. B. D. design with three replications during 1983-84. The treatments included pure crops of groundnut, arhar and bajra. Groundnut was planted in rows 45 cm apart by both regular (with 100% seed) and border (with both 100% and 75% seed) method. Bajra was sown in rows 45 cm and 180 cm apart. Arhar T-21 was planted at 60 cm while arhar T-17 was sown at 90 cm and 180 cm apart in regular rows. Under intercropping system three rows of groundnut with two seed rates i.e. 100% and 75% seed + one row of intercrops *viz.*, arhar/bajra were planted. Groundnut var. Chandra, arhar, T-21, T-17 and bajra, B. J. 104 were used. Crops were sown on 7th July, 1983 with the onset of monsoon. A fertilizer dose of 10 kg N + 30 kg P_2O_5 in arhar, 40 kg N + 20 kg P_2O_5 in bajra and 15 kg N + 30 kg P_2O_5 + 45 kg K_2O/ha in groundnut was applied as basal in furrows 2-3 cm below the seed at sowing. Bajra crop was harvested in October, groundnut and arhar T-21 were harvested in the months of November and December respectively, whereas arhar T-17 was harvested in the end of April. The pH of the experimental plots was 7.8 with organic carbon at 0.33%, available P_2O_5 at 13.5 kg/ha and available k_2O at 215 kg/ha.

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The intensity and distribution of rainfall was normal which helped in better growth and development of each crop. Good rains upto the month of February, coupled with frostless season was also in favour of arhar T-17, although, bajra crop was affected by rains at flowering stage resulting in poor yield.

Table 1 : Pod/seed yield (q/ha) and gross income (Rs/ha) as affected by different cropping systems

Cropping systems	Groundnut		Intercrop	Gross income (Rs/ha)		
	yield	reduction %	yield	Groundnut	Intercrop	Total
1. Groundnut at 45 cm (Regular)	18.52	—	—	8334.0	—	8334.0
2. Groundnut at 45 cm (Border, 100% seed)	17.78	5.00	—	7969.5	—	7969.5
3. Groundnut at 45 cm (Border, 75% seed)	16.55	11.00	—	7447.5	—	7447.5
4. Arhar T-17 at 90 cm	—	—	34.74	—	13896.0	13896.0
5. Arhar T-17 at 180 cm	—	—	2 .66	—	10664.0	10664.0
6. Groundnut 100% seed + Arhar T-17 (3:1)	7.99	57.00	24.07	3595.5	9628.0	13223.5
7. Groundnut 75% seed + Arhar T-15 (3:1)	6.94	63.00	24.99	3123.0	9996.0	13119.0
8. Bajra at 45 cm	—	—	15.19	—	3037.0	3037.0
9. Bajra at 180 cm	—	—	10.00	—	2000.0	2000.0
10. Groundnut 100% seed + Bajra (3.1)	14.47	22.00	9.53	6513.5	1906.0	8419.5
11. Groundnut 75% seed + Bajra (3:1)	14.00	25.00	9.44	6300.0	1888.0	8188.0
12. Arhar T-21 at 60 cm	—	—	21.76	—	8704.0	8704.0
13. Groundnut 75% seed + Arhar T-21 (3:1)	13.66	27.00	9.63	6147.0	3852.0	9999.0
C. D. at 5%	4.3					1276.5

Market rates Rs/q, Groundnut : 450, Arhar : 400 and Bajra : 200

As regards the suitability of crop for intercropping with groundnut, arhar T-17 showed the most adverse effect on the yield of groundnut, while bajra crop showed the least, perhaps due to its early removal and less shading effect in comparision to arhar crop. As an intercrop the yield of arhar T-17 was maximum. Table 1 also revealed that among all the pure cropping systems, arhar T-17 as pure crop yielded highest followed by arhar T-21 and bajra respectively. This might be due to normal and frostless season for late arhar. The yield of groundnut in regular and border method was at par. The groundnut crop did not affect any intercrop.

A perusal of data (Table 1) revealed that arhar T-17 pure or intercropped with groundnut gave maximum gross return (Rs. 13896 and Rs 13223 respectively).

Table 2 : Land equivalent ratio (L. E. R.) as affected by different cropping systems

Cropping systems	Groundnut	Bajra	Arhar T-17	Arhar T-21	Total
1. Groundnut at 45 cm (Regular)	1.0	—	—	—	1.00
2. Groundnut at 45 cm (Border, 100% seed)	0.96	—	—	—	0.96
3. Groundnut at 45 cm (Border, 75% seed)	0.89	—	—	—	0.89
4. Arhar T-17 at 90 cm	—	—	1.00	—	1.00
5. Arhar T-17 at 180 cm	—	—	0.77	—	0.77
6. Groundnut 100% seed + Arhar T-17 (3:1)	0.43	—	0.69	—	1.12
7. Groundnut 75% seed + Arhar T-17 (3:1)	0.38	—	0.72	—	1.10
8. Bajra at 45 cm	—	1.00	—	—	1.00
9. Bajra at 180 cm	—	0.66	—	—	0.66
10. Groundnut 100% seed + Bajra (3:1)	0.78	0.63	—	—	1.41
11. Groundnut 75% seed + Bajra (3:1)	0.76	0.62	—	—	1.38
12. Arhar T-21 at 60 cm	—	—	—	1.00	1.00
13. Groundnut 75% seed + Arhar T-21 (3:1)	0.74	—	—	0.44	1.18

Giri and Upadhyay (1979) and Bhan and Khan (1984) reported highest gross return from groundnut when intercropped with cotton and maize respectively. It may be ascribed to more pod/seed yield with highest market value as compared to bajra.

Results presented in Table 2 reveals that land equivalent ratio differ remarkably due to different cropping systems. Groundnut intercropped with each crop gave higher L. E. R than pure cropping. Groundnut with full seed in border method intercropped with bajra (3:1) gave highest L E. R. and lowest was in the system where bajra and arhar T-17 were sown 180 cm apart in regular rows and pure groundnut sown in border method with 75% seed.

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