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Shri V.L. NARASIMHA RAO
(1925-1991)

OBITUARY

Shri Vishnubhotla Lakshmi Narasimha Rao one of the councillors of the Indian Society of Oilseeds Research and former Joint Director of Vanaspathi Manufacturers Association's Oilseeds Research and Development Institute (VORDI) passed away in Hyderabad at 22.30 hours on June 22, 1991.

Shri V.L. Narasimha Rao was born on August 24, 1925 at Emani Village in Guntur district of Andhra Pradesh. After his schooling and early college education in Guntur district, Shri Rao studied in Banaras Hindu University at Varanasi and obtained his B.Sc (Ag.) degree in 1949 and M.Sc. (Ag.) degree in Plant Physiology in 1951 with a meritorius record. During his student days he took an active part in several cultural activities and sports. After working for a brief period in Hyderabad Agricultural Co-operative Association (HACA) in 1951, Shri Rao joined the team of Oilseeds Research Workers headed by Late Dr. L.G. Kulakarni at Himayat Sagar Agricultural Research Institute in Hyderabad. He worked as Assistant Oilseeds Specialist at the Agricultural Research stations at Kadiri and Yemmiganur in Andhra Pradesh during the period from 1960 to 1963, when he successfully demonstrated the feasibility of obtaining consistantly higher levels of productivity of groundnut. Subsequently he joined the Vanaspathi Manufacturers Association of India as Agronomist and rose to the position of Joint Director monitoring VORDI's Oilseed Programmes in Andhra Pradesh, Tamil Nadu, Karnataka and Orissa.

Shri Narasimha Rao contributed substantially in extending and popularising the cultivation of mustard in South India, particularly in Guntur district. He was a Fellow of Botanical Society and Published several scientific and popular articles on groundnut, castor and mustard.

He was an active member of the Executive of the Indian Society of Oilseeds Research and always contributed his best to strengthen the Society and its activities. He was an active participant in a number of wide ranging professional meetings, workshops and symposia on oilseeds research and development. Always forthright, frank and open minded, Shri Narasimha Rao unambiguously brought out various constraints and problems confronting the oilseeds sector in various meetings, seminars and workshops. Ever jovial, youthful and brimming with enthusiasm and quick wit, Shri Rao used to be a favourite of a wide circle of colleagues and friends who will sadly miss him. In his death, the Indian Society of Oilseeds Research has lost a very senior member, Councillor and a staunch and honest advocate of the cause of oilseed farmer.

Shri Narasimha Rao is survived by his wife, a son and a daughter. The Indian Society of Oilseeds Research conveys sincere condolences to the members of the bereaved family. May his soul rest in peace.

SHORT COMMUNICATIONS

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STABILITY OF SOME MUSTARD VARIETIES UNDER LATE SOWN CONDITIONS

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ABSTRACT

Twentysix genotypes of mustard were evaluated for stability parameters with respect to seed yield, plant height and plant height upto first branch over three successive years under late sown conditions. Prediction of performance across the environments was possible because of predominant role of predictable components. Stability in seed yield appeared to have been imparted by the stability for the yield components. The varieties viz. RLM-389, Varuna and RW-2367 which were found to be stable for seed yield were found to be stable for other characters also. RH-5610 was found to be a suitable variety for seed yield in favourable environments only. In the case of plant height, only RLM-82 was stable. The levels of stability were not common for all the characters for most of the genetypes

Key words: Stability, Mustard, Late sowing

INTRODUCTION

Indian mustard (*Brassica juncea* L) is one of the main oil seed crops grown in West Bengal. One of the reasons of low acreage and production of mustard in this state is the short span of sowing period, leading to delayed sowing of the crop. Therefore, identifying suitable genotypes for late sown condition is prerequisite to formulate a breeding programme. In this context, the implications of genotype X environment interaction in mustard under late sown condition has been explained earlier by Ghosh- dastidar *et. al*, (1988). In the present investigation, an attempt has been made to study the stability behaviour of twentysix genotypes of mustard under late sown condition over three successive years.

MATERIALS AND METHODS

In the present investigation, 26 strains of *Brassica juncea* L were tested over three successive years (1983 to 1985) under late sown conditions at 'C' Block District Seed Farm, Bidhan Chandra Krishi Viswavidyalaya. Seeds of all the strains were sown on 5th December in each year in a randomised block design with two replications. Each strain was sown in a single row of 2m length. Row to row distance was 30 cm. In 1985, another experiment was carried out with a close spacing of 22 cm. Therefore, three successive years along with one experiment on close spacing, altogether constituted four environments. Fertilisers like NPK were applied at the rate of 30:20:20 kg/ha and all other normal cultural practices were followed as and when required. Data were recorded on five randomly taken plants from each replication for three characters, viz., plant height, plant height uptothe first branch and seed yield per plant. Mean values of five plants per entry were used for statistical analysis. The Eberhart and Russell's model (1966) was followed for calculation of stability parameters.

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TABLE 2 ***Mean seed yield (g/plant) and parameters of stability of 26 genotypes of mustard under late sowing condition***

Genotypes	Mean seed yield	bi	S^2di
P-Rai 16	3.975	0.98	2.81**
RH-5610	4.412	2.05**+	-0.05
P-Rai 35	3.562	1.04*	0.29
KRV-Tall	3.300	0.59	0.13
B-85	2.100	0.67*	-0.12
RLM-612	2.562	0.64	0.13
RW-351	2.562	0.79	0.25
P-Rai 39	2.650	0.57*+	-0.22
Varuna	3.850	1.16*	0.19
P-Rai 36	3.587	0.95*	0.05
RW-2367	3.812	1.28*	-0.19
RH-7418	3.400	0.84	1.87**
RLM-82	2.988	0.91**++	-0.31
RH-7858	3.338	1.22*	0.59
P-Rai 18	2.676	0.66**++	-0.32
RH-786	3.763	1.47**++	-0.29
Raur-1	2.650	0.46*+	-0.20
RH-7857	3.175	1.20**	-0.19
RLM-785	3.412	1.14*	0.47
RLM-193	3.287	1.45*	0.47
RLM-389	3.912	1.59*	0.49
RLM-571	2.812	0.60	0.48
RIK-80-3	2.488	0.73**+	-0.27
KRV-Bala	3.112	0.88**	-0.24
RLM-528	4.763	1.10	5.52**
RH-7819	3.088	1.05*	0.02

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

+, ++ Significantly deviating from unity at 5% and 1% levels, respectively.

RESULTS AND DISCUSSION

Joint regression analysis (Table 1) showed that the mean differences between genotypes were highly significant revealing thereby the presence of genetic variability among genotypes included in the present investigation. Highly significant mean squares due to environment and genotype environment interactions revealed that the phenotypic expression of genotypes varied in different environments. Both linear and non-linear components of interactions were found to be significant in the case of seed yield and plant height upto first branch. On the other hand, in the case of plant height, only linear component was significant. However, in the case of plant height and seed yield, the linear components were significant against pooled deviations, revealing thereby the fact that the prediction of performance in different environments would be possible for all the three characters.

TABLE 1. Joint regression analysis in respect of three characters for 26 genotypes used in the stability analysis.

Source	d.f.	Seed yield	Plant height	Plant height upto 1st branch
		Mean squares		
Genotype (G)	25	1.6007**	1074.9834**	727.0763**
Environments (E)	3	142.8027**	14842.3934**	4269.1442**
G×E	75	1.2316**	102.1370*	121.7664**
E(Linear)	1	428.4082**	44527.1835**	12807.4326**-
G×E (Linear)	25	2.2605(a)**	202.0713**	245.9984(a)**
Pooled deviation	52	0.6896**	50.0713	57.3562*
Pooled error	104	0.3211	74.2175	32.6237

*, ** Significant against pooled error at 5% and 1% levels, respectively, (a) Significant against significant reminder at 1% level

Out of 26 genotypes investigated, three had significant S^2d and so were unstable for seed yield (Table 2). Thirteen genotypes yielded more than the population mean ($\bar{X}$ =3.20 gms per plant). Of these six genotypes (P-rai 16, RH-5610, Varuna, RW-2367, RLM-389 and RLM-528) constituted the top ranking group. Five genotypes had $b<1$, two genotypes had $b>1$ and ninteen genotypes had $b=1$. These genotypes can be categorised as below average, above average and average sensitive, respectively. A joint consideration of mean and stability parameters revealed that three genotypes, namely, RLM-389, Varuna and RW-2367, had higher seed yield, $b=1$*and $S^2d=O$. Accordingly, these genotypes appeared to be better adapted and as such could be utilized in breeding programmes. The genotype RH-5610 had high mean, above average sensitivity and deviation from regression not significantly different from zero ($S^2d=0$). Therefore, this genotype is especially suitable for favourable environmental conditions.

In the case of plant height (Table 3), eleven genotypes attained higher height than the population mean ($\bar{X}$ =121.24 cm). However, only three genotypes secured their position in the top ranking group (RLM-785, RLM-389 and RLM-82). Three genotypes recorded b>1, one genotype recorded b<a, and twentytwo genotypes had b=1. S^2di values were found to be insignificant for all the genotypes. Simultaneous consideration of mean and stability parameters revealed that only RLM--82 attained higher plant height coupled with b=1 and S^2di=O. Accordingly, this genotype showed better adaptation. The genotypes, RLM-785 and RLM-389 had high mean performance, above average sensitivity (b>1) towards environmental variations and deviations from regression not significantly different from zero (S^2di=0). Therefore, these two genotypes are specifically suitable for favourable envitonmental conditions.

In case of plant height upto first branch, three genotypes recorded S^2di=0 (Table 3). Therefore, these three genotypes were unstable for plant height upto first branch. Three genotypes had below average sensitivity (b<1) and twentyone genotypes had average sensitivity (b=1). Twelve genotypes had higher plant height upto first branch than the population mean ($\bar{X}$ =33.49 cm). Only three genotypes secured their position in the top ranking group (RLM-785, RLM-389 and RLM-528). From a joint consideration of mean and stability parameters, it was found that only RLM-389 had higher plant height up to 1st branch, b=1 and S^2di=0. Therefore this genotype is specially suitable for moderate environmental conditions.

Jatasra and Paroda (1980) showed that the stability in seed yield of wheat appeared to be imparted by the stability for the yield components. In the present experiment it is evident that high yielding genotypes, like RLM-389, Varuna and RW 2367 which were stable for seed yield were found to be stable, to some extent, for their components also. In this connection, RLM-389 can be recommended as a suitable variety under late sown conditions, as this variety was stable for seed yield and plant height upto the first branch. Varuna can also be suggested for wide adaptability, as it had average mean performance, b=1 and S^2di=0 for plant height and plant height upto the first branch. Similarly, RW-2367 was found to be stable for plant height only beside seed yield.

The levels of stability were not common for all the characters for most of the genotypes. In this respect, while RLM-389 and RLM-785 were suitable for rich environmental condition for plant height, were found to be stable for seed yield. Similarly, RLM-82 also behaved differently for different characters. Ghoshdastidar and Das (1981) reported such type of differences in stability for various characters in jute.

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TABLE 3. Stability parameters of two quantitative traits for 26 mustard genotypes grown under late sowing condition.

Genotypes	Plant height (cm)			Plant height upto first branch (cm)		
	m	bi	S²di	m	bi	S²di
P-Rai 16	119.40	0.86*	-28.13	30.12	0.29	33.78
RH-5610	115.86	0.94**	-67.91	30.92	0.04	32.75
P-Rai 35	112.75	1.38**	-74.17	31.10	1.37*	- 1.52
KRV-Tall	111.52	0.88**++	-64.84	26.15	0.09+	-18.67
B-85	78.07	0.04++	-50.92	14.63	-0.33+	- 7.82
RLM-612	104.95	0.97*	-44.86	29.35	0.93	10.59
RW-351	95.64	0.84*	-28.36	20.65	0.36	-12.52
P-Rai 39	121.05	0.89	18.25	40.50	1.18	- 7.23
Varuna	122.07	0.59	114.22	40.02	0.66	62.18
P-Rai 36	117.60	1.04*	-34.86	31.35	1.04*	-25.28
RW 2367	132.27	1.43*	-19.12	39.05	2.16**+	-24.22
RH-74128	124.06	0.89*	-55.74	44.95	1.55	- 7.89
RLM-82	141.34	0.98	-26.98	55.28	1.10**+	-32.47
RH-7858	121.77	0.65	21.28	40.78	0.46	61.71
P-Rai 18	119.31	0.98	-15.22	45.42	1.36*	- 4.34
RH-786	133.98	1.13**	-66.93	48.43	0.98*	- 9.67
Raur-1	105.85	0.76*	-23.23	25.02	0.52	- 5.96
RH-7857	114.25	1.13**	-59.89	30.87	0.47**++	-31.82
RLM-785	149.42	1.69**+	-58.72	67.75	2.34	301.11**
RLM-193	140.50	1.32*	19.86	56.92	1.94*	47.40
RLM-389	148.60	1.49**++	-71.63	62.10	1.24	11.56
RLM-571	139.56	1.25	121.42	50.40	1.70	197.03**
RIK-80-3	110.09	0.69*	-63.80	34.98	0.38	-13.73
KRV-Bala	115.55	0.74*	-42.88	30.85	0.84**	-29.08
RLM-528	139 06	1.37*	-38.43	61.42	2.21	109.99*
RH-7819	117.74	1.10*	16.18	37.80	1.11	7.17

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

+,++ Significantly deviating from unity at 5% and 1% levels, respectively.

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WEED MANAGEMENT STUDIES IN GROUNDNUT (*ARACHIS HYPOGAEA L.*) AND SUNFLOWER (*HELIANTHUS ANNUUS L.*) INTERCROPPING SYSTEM*

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ABSTRACT

A field experiment was conducted at Agricultural College, Farm, Dharwad, to study the effect of herbicides Viz: Pendimethalin and fluazifop-butyl applied alone, mixed or in combination with physical methods on groundnut and sunflower intercropping system. *Significant yield reductions were observed due to the weed competition.* Among the treatments tried, application of pendimethalin at the rate of 0.75 k.g a.i. per ha as pre-emergence spray supplemented with the interculture at 21 DAS was found to be effective and economical in controlling weeds.

Key words: Weedmanagement, Intercropping

INTRODUCTION

Sunflower and groundnut are the important *kharif* oil seed crops grown in Karnataka. Losses to the extent of 52 per cent and 18 per cent in yields of erect and spreading variety of groundnut and 26-50 per cent in case the of sunflower have been reported (Kulkarni *et al.*, 1963) due to weed competition. Hence, the present study was conducted to study the effectiveness of herbicides pendimethalin and fluazifop-butyl applied alone, mixed or in combination with physical methods.

MATERIALS AND METHODS

A field experiment was conducted under rainfed conditions during the *kharif* season of 1987 at the Agricultural College Farm, Dharwad. The experiment was laid out in randomized block design with four replications comprising 10 treatments. The soil was black clay with medium total nitrogen (0.053%) and available potassium (0. 0247%), but low in available phosphorus (0.003%). Seeds of groundnut (Var. DH-3-30) and sunflower (BSH-1) were sown in 3:1 row proportion by providing a spacing of 120 cm × 15 cm for sunflower and 30cm × 10cm for groundnut. The recommended doses of fertilizers were applied to groundnut (25:50:25 kg $N:P_2O_5:K_2O$ per ha) and sunflower (37.5:50:37.5 kg $N:P_2O_5:K_2O$ per ha).

Pendimethalin was applied as pre-emergence Spray one day after sowing and fluazifop-butyl as post-emergence (21 Days after sowing DAS). With regard to cultural practices, intercultures (IC) and hand weeding (HW) were done at 21 DAS and 45 DAS. These treatments were compared with the unweeded check.

RESULTS AND DISCUSSION

The predominent weeds observed in the experimental area were *Cynodon dactylon* Pers. *Cyperus rotundus* L., *Digitaria marginata*, *Echinochloa crusgalli* (L.), Beauv.,

* Part of M.Sc. (Agri.) thesis submitted to the University of Agricultural Sciences, Dharwad, by the first author.

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TABLE 1. Weed population as influenced by weed control treatments at different stages

Treatments	Number of monocot weeds/m²				Number of dic to weeds/m²			
	Day afer sowing			At harvest	Days after sowing			At harvest
	30	60	90		30	60	90	
1. Unweeded check	4.16 (17.25)*	3.18 (10.50)	3.80 (14.00)	3.62 (12.25)	4.88 (23.75)	4.67 (21.25)	5.01 (25.00)	5.49 (29.50)
2. Pendimethalin @ 1.0 kg a.i. per ha	1.60 (1.75)	2.33 (4.50)	2.56 (5.75)	2.42 (5.00)	2.25 (4.25)	2.88 (7.50)	4.21 (10.25)	3.47 (11.25)
3. Fluazifop-butyl @ 0.25 kg a.i. per ha	(1.78) 2.25	(1.72) 2.25	2.04 (3.50)	2.71 (6.50)	3.42 (10.75)	(14.75) 3.86	4.06 (16.25)	4.09 (17.00)
4. Pendimethalin @ 0.5 kg a.i per ha + Fluazifop-butyl 0.125 kg a.i. per ha	(2.05) (3.50)	(1.54) (1.50)	(1.95) (3.00)	2.06 (3.50)	2.45 (5.25)	(3.16) (4.25)	2.68 (6.75)	2.13 (9.00)
5. Pendimethalin @ 0.5 kg a.i. per ha + inter cultivation at 21 DAS** (IC)	2.20 (4.00)	1.87 (2.75)	1.90 (2.75)	2.20 (4.00)	2.36 (4.75)	2.29 (4.50)	3.00 (6.75)	2.88 (7.75)
6. Pendimethalin @ 0.75 kg a.i. per ha + Inter cultivation at 21 DAS (IC)	1.84 (2.75)	1.54 (1.50)	1.90 (2.75)	1.99 (3.00)	2.05 (3.25)	2.08 (3.50)	2.75 (7.50)	2.86 (8.25)
7. Fluazifop-butyl @ 0.225 kg a.i. per ha + hand weeding at 45 DAS (HW)	2.56 (6.50)	1.60 (1.75)	2.22 (4.00)	2.25 (4.25)	2.69 (6.25)	2.30 (4.50)	2.96 (8.25)	3.29 (10.00)
8. Fluazifop-butyl @ 0.187 kg a.i. per ha + hand weeding at 45 DAS (HW)	2.20 (4.00)	1.47 (1.25)	1.92 (2.75)	2.17 (3.75)	2.88 (7.00)	2.25 (4.50)	2.88 (7.75)	3.04 (8.75)
9. Inter cultivation at 21 DAS + hand weeding at 45 DAS	2.44 (5.00)	1.46 (1.25)	2.04 (3.25)	2.34 (4.75)	2.40 (5.25)	2.02 (3.25)	2.64 (6.00)	2.87 (7.25)
0. Hand weeding at 15, 30 and 45 DAS	1.25 (0.88)	1.46 (1.25)	1.68 (2.00)	1.68 (2.00)	1.68 (2.00)	1.47 (1.25)	2.01 (3.25)	2.22 (4.00)
S·Em±	0.34	0.31	0.25	0.23	0.25	0.36	0.33	0.38
CD.at 5%	0.99	0.90	0.72	0.68	0.72	1.05	0.96	1.11

* Figures in the parentheses indicates the original values. ** DAS = Days after sowing.

Ageratum conyzoides L., *Abutilon indicum* (L.), *Cocoulus hirstuus* (L.), *Commelina bengalensis* L., *Carchorus trilocularis* L., *Desmodium diffusum* D.C., *Oldenlandia affinis* (Roem and Schulf.) and *Phylanthus niruri* Auct. non. L.

Effect of Weed Control Methods

I. On Weed Characteristics.

The observations on weed population recorded at different stages of crop growth are given in Table 1. The number of both monocot and dicot weeds at all stages viz., 30,60 and 90 DAS and at harvest differed significantly among the treatments. Hand weeded plot recorded the minimum weed count at all four stages. It was because the weeds were removed regularly (at 15,30 and 45 DAS). Similar results were obtained by Venkateswarlu and Ahlawat (1986) in pigeonpea based inter cropping system. Except unweeded check, the treatments were on par with each other in the number of monocot weeds at 30, 60 and 90 DAS. Pendimethalin (0.5 kg/ha) IC, Pendimethalin (0.75 kg/ha) IC, Fluazifop-butyl (0.187 kg/ha) + hand weeding (HW) showed significantly lower monocot weed population indicating that these treatments controlled monocots effectively.

At all the stages, hand weeding (thrice) recorded the lowest number of dicot weeds, while the unweeded check recorded the highest number of dicots (Table 1). Hand weeding, intercultivation+hand weding, pendimethalin (0.5 kg/ha)+intercultivation and pendimethalin (0.75kg/ha)+intercultivation recorded significantly lower dicot weeds as compared to unweeded check. It may be due to the activity of pre-emergence herbicide and removal of later emerged weeds by cultural methods.

The lowest biomass was recorded from the plots which received pendimethalin (0.75 kg/ha) coupled with one interculture (3.71 q/ha) closely followed by hand weeding (3.78 q/ha). Unweeded check recorded significantly higher weed biomass than that in all others (Table 2). The lower weed dry weight per unit area in the plots that received weed control treatments was due to the less number of weeds by rapid depletion of carbohydrate reserve of weeds with herbicidal application and through rapid respiration (Dakshinadasa, 1962) and also due to inhibition of photosynthetic activity (Hill *et al.*, 1963).

The influence of different weed control methods at harvest revealed that per cent control of weeds considerably improved with weed control treatments (Table 2). The highest weed control efficiency was noticed in pendimethalin (0.75 kg/ha) coupled with one interculture (21 DAS) (86.97%).

2. Effect on crop growth, yield and yield components of groundnut

At harvest, the highest dry matter production of groundnut was in hand weeding (26.72 g/plant) whereas the lowest in the unweeded check (18.40 g/plant) (Table 3). Hand weeding, pendimethalin (0.75 kg/ha) IC and fluazifop-butyl (0.187 kg/ha) +

TABLE 3· Effect of weed control treatment on dry matter production (g/plant) at harvest and yield components of groundnut and sunflower.

Treatment	Groundnut				Sunflower			
	Dry matter production per plant (g)	Pod number per plant	Pod wt. per plant (g)	100 pod wt (g)	Dry matter production (g/plant)	Number of seeds per plant	Wt. of seeds per head (g)	1000-seed weight (g)
1. Unweeded check	19.40	12.75	10.80	117.32	85.83	836.86	30.38	35.44
2. Pendimethalin @ 1.0 kg a.i. per ha	22.41	14.82	14.89	125.16	118.92	1042. 56	41.24	40.70
3. Fluazifop-butyl @ 0.25 kg a.i. per ha	21.03	14.38	13.12	123.08	102.51	956.12	38.05	39.10
4. Pendimethalin @ 0.5 kg a.i. per ha + Fluazfop-butyl @ 0.125 kg a.i. per ha	23.96	19.12	16.89	125.19	118.80	997.22	36.00	36.70
5. Pendemethalin @ 0.5 kg a.i. per ha + intercultivation at 21 DAS (IC)	25.04	16.11	18.30	117.94	123.93	1097.62	39.64	39.48
6. Pendimethalin @ 0.75 kg a.i. per ha +Intercultivation at 21 DAS (IC)	25.56	18.74	19.96	124.94	125.80	1156.30	42.36	40.72
7. Fluazifop-butyl @ 0.125 kg a.i. per ha + hand weeding at 45 DAS (HW)	23.50	15.23	16.07	121.03	98.54	964.55	40.28	40.46
8. Fluazifop-butyl @ 0.187 kg a.i. per ha + hand weeding at 45 DAS (HW)	25.32	17.80	18.12	125.06	110.64	1176.94	41.84	39.65
9. Intercultivation (21 DAS)+hand weeding (45 DAS)	21.50	14.50	13.94	120.43	114.28	1046.11	40.53	40.18
10. Hand weeding at 15, 30 and 45 DAS	26.72	18.40	18.41	125.56	132.83	1136.40	44.43	42.22
S.Em±	0.97	1.21	1.13	3.43	5.68	68.34	2.30	1.70
C.D. at 5%	2.82	3.66	3.27	NS	16.49	183.81	6.67	5.53

DAS: Days after sowing HW: Hand Weeding IC: Inter Cultivation NS: Not Significant.

TABLE 2. Weed dry weight, weed control efficiency and weed index as influenced by weed control treatments

	Treatments	Weed Weight (q/ha)	Weed control efficiency (%)	Weed index (%)
1.	*Unweeded check*	28.55	—	44.71
2.	*Pendimethalin @ 1.0* kg a.i. per ha	16.77	41.00	29.44
3.	Fluasifop-butyl @ 0.25 Kg a.i. per ha	19.24	32.60	24.86
4.	*Pendimethalin @* 0.5 Kg a.i. per ha Fluasifop-butyl @ 0.125 Kg. a.i. per ha	5.84	79.48	21.91
5.	Pendimethalin @ 0.5 Kg. a.i. per ha Intercultivation at 21 DAS (IC)	6.06	78.86	21.25
6.	Pendimehalin @ 0.75 Kg. a.i. per ha Intercultivation at 21 DAS (IC)	3.71	86.97	9.79
7.	Fluasifop-butyl @ 0.125 Kg a.i. per ha Hand weeding at 45 DAS (HW)	6.95	76.37	21.91
8.	Fluasifop-butyl @ 0.187 Kg. a.i. per ha Hand weeding at 45 DAS (HW)	5.55	80.56	17.69
9.	Intercultivation at 21 DAS Hand weeding at 45 DAS	7.36	73.67	22.16
10.	Hand weeding at 15, 30 and 45 DAS	3.78	86.54	—
	S.Em±	2.88	2.70	3.82
	C.D. at 5%	8.35	7.83	11.09

* DAS Days after sowing.

HW were superior to others in dry matter production per plant. Unweeded check recorded significantly lower dry matter as compared to all other treatments. This was because of a strong competition from weeds with crop for growth factors. This lends support to the findings of Naidu *et al.* (1985)

The highest pod yield (27.83 q/ha) was obtained with hand weeding (thrice) closely followed by pendimethalin (0.75 kg/ha)+IC (27.72 q/ha (Table 4). This was in consequence of increased pod number, pod weight per plant and 100-pod weight. The variation in pod yield of groundnut was due to the differential contribution of yield components towards pod yield as obtained with different treatments (Table 3).

3. Effect on crop growth, yield and yield components of sunflower

It was observed that dry matter produced per plant at harvest in hand weeding 132.83 g) and pendimethalin (0.75 kg/ha) + IC (125.80) (Table 3) was superior to others. Increase in dry matter production by weed control treatments may be attributed to effective control of weeds, thereby enabling sunflower crop to utilise larger amount of nutrients and moisture. Raju and Sankaran ra(1974) also reported decrease in sunflower dry matter production due to weed competition.

The variation in seed yield of sunflower (Table 4) was due to differential contribution of yield components towards yield in different treatments. The increase in seed yield due to weed control treatments may be attributed to the beneficial effects on yield components (Table 3) such as number of seeds and weight of seeds per head and 1000-seed weight. The highest seed yield was obtained from hand weeding (13.36 q/ha) closely followed by pendimethalin (0.75 kg/ha)+IC (13.47 q/ha) and fluazifop-butyl (0.187 kg/ha)+HW (13.27 q/ha).

4. Effect on total seed yield

Hand weeding, pendimethalin (0.75 kg/ha)+IC and flazifop-butyl (0.187 kg/ha)+HW resulted in higher total seed yield over the unweeded check. The increase in total seed yield due to weed control treatments was to the magnitude of 34.83 to 67.74 per cent over the unweeded check. The increase in total seed yield was to the extent of 67.74 per cent in hand weeding, 62.73 per cent in pendimethalin (0.75 kg/ha)+IC and 54.77 per cent in fluazifop-butyl (0.187 kg/ha)+HW. Similarly, Prasad *et al* (1985) obtained the highest yield of both the crops as well as total grain yield production in terms of arhar equivalent with manual weeding followed by fluchloralin in *arhar*+soybean intercropping system. The yield reductions of 44.71 per cent recorded in the unweeded check compared to hand weeding was significantly higher than in all other treatments (Table 2).

5. Economics of weed control

The highest net income was obtained in pendimethalin (0.75 kg/ha)+IC (Rs. 20268.03/ha). Based on the results of the investigation, pre-emergence application of pendimethalin (0.75 kg/ha) supplemented with one interculture at 21 DAS can be advocated for better weed control and high returns from groundnut and sunflower Intercropping system under rainfed condtitions (Table 4).

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TABLE 4. Effect of weed control methods on pod yield of groundnut, seed yield of sunflower, total seed yield and net return per ha

Treatment	Pod yield of groundnut (q/ha)	Seed yield of sunflower (q/ha)	Total seed yield (q/ha)	Net returns (Rs/ha)
1. Unweeded check	19.74	8.48	20.74	12911.18
2. Pendimethalin @ 1.0 Kg a.i. per ha	22.42	10.72	29.24	15439.02
3. Fluazifop-butyl @ 0.25 Kg a.i. per ha	20.37	10.08	27.88	13511.31
4. Pendimethalin @ 0.5 Kg a.i. per ha Fluazifop-butyl @ 0.125 Kg a.i. per ha	23.16	13.00	29.50	17251.65
5. Pendimethalin @ 0.5 Kg a.i. per ha Intercultivation at 21 DAS (IC)	22.87	11.56	29.70	16365.43
6. Pendimethaln @ 0.75 Kg. per ha Intercultivation at 21 DAS (IC)	27.22	13.47	33.75	20268.63
7. Fluazifop-butyl @ 0.125 Kg a.i. per ha hand weeding at 45 DAS (HW)	23.77	12.89	28.79	17509.06
8. Fluazfop-butyl @ 0.187 Kg a.i. per ha hand weedng at 45 DAS (HW)	26.56	13.27	32.10	19404.11
9. Intercultivation (21 DAS) Hand weeding (HW)	25.21	11.96	29.95	17949.47
10. Hand weeding at 15, 30 and 45 DAS	27.83	13.56	34.83	19912.50
S.Em±	0.98	0.94	1.42	
C.D. at 5%	2.85	02.78	4.14	

DAS Days after sowing

HW Hand weeding

IC Intercultivation

generation. Among the parents, differences were, however, not significant in respect of capsules/plant, 1000-grain weight and yield / plant in F_1. Variances due to crosses and parents *vs* crosses (F_1 and F_2) were also significant for all the charcaters except seed yield/plant and tillers/plant (F_2).

Analysis of variance for combining ability (Table 1) revealed that mean squares due to lines were significant for plant height and 1000-seed weight in F_1 and days to flowering in F_2 generation. Differences due to testers were also significant for days to flowering and maturity in both F_1 and F_2 and plant height, 1000-seed weight and seed yeld/plant in F_1 generation only. Mean squares due to lines x testers were significant in both the generations for days to flowering, plant height, capsules/plant but only in either of generations for days to flowering and maturity (F_2) and seed yield/plant (F_1). The specific combining ability (sca) variances for all the characters in both the generations except plant height were larger than the corresponding general combining ability (gca) variances for all the characters in both the generations except plant height in F_2. Similar results were obtained by Thakur and Rana (1987), Bhatnagar and Mehrotra (1980) and Budwal and Gupta (1970).

High magnitude of sca variances in one or both generations for most of the characters indicated predominance of non-additive gene action. The different estimates in F_1 and F_2 generations may be attributed to change in the distribution of gene in F_2 population or may be due to linkage disequilibrium. The results are in confirmity with those obtained by Singh and Srivastava (1987). The presence of predominantly large amount of non-additive gene action for yield and its components would necessitate the maintenance of heterozygosity in the population. Since this type of gene action is not fixable, breeding methods such as biparental mating followed by recurrent selection programme may accelerate the genetic improvement of these characetrs. Reported genetic cytoplasmic male sterility (Dubey and Singh, 1966, and Thompson 1977) may be utilized in recurrent selection programmes to accumulate favourable genes and facilitate breaking of undesirable linkage. Rao and Singh (1984 also suggested similar methodology for population improvement in this crop.

Estimates of gca effects (Table 2) revealed that among the female lines, KL-43 was good combiner for seed yield, plant height, days to flowering and maturity and capsules/plant. Besides being good combiner for yield, SPS 5/47-2, NPRR-463, EC-23239 were good general combiners for early maturity and TLP-1 being also good combiner for bold seededness. Similar results were also reported by Thakur *et al.* (1987) and Thakur and Rana (1987).

Among the testers, KL-1, a yellow-seeded variety, showed high general combining for seed yield/plant and early maturity whereas Flak-1, a late flax type genetype, exhibited high gca for plant height and seed yield in F_1 but significantly negative effect in F_2. Another tester, K_2 showed sgnificant negative gca effects for yield and other traits excepts for seed weight. In general a multiple crossing programme for intermating population involving all possible crosses among strains subjected to biparental mating may be expected to offer promise in breeding for high seed yield.

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LINE X TESTER ANALYSIS FOR COMBINING ABILITY IN LINSEED

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ABSTRACT

A line × tester analysis involving 9 lines and 3 testers in linseed (*Linum usitatissimum* L.) revealed that sca variances were relatively larger in magnitude for all the characters except plant height in F_2. Among lines, KL-43 was noted as the best general combiner for yield and its components but undesirable for days to flowering and maturity. The parents TLP-1, SPS 5/47-2, NPRR-463 and EC-23239 were good combiners for seed size, early maturity and TLP-1 being good combiner for seed size also. KL-1, a yellow seeded tester was good general combiner for seed yield and earliness and Flak-1 appeared to be good combiner for plant height.

The crosses of KL-1 with KL-43, EC-23239 and TLP-1; Flak-1 with SPS/23-5, NP-36, TLP-1 and K_2 with Neelam exhibited high sca effects for seed yield and some of its components. Multiple crossing followed by recurrent selection would provide better segregants for raising yield levels in linseed.

Key words: *Linum usitatissimum*, Combining ability,

INTRODUCTION

Linseed is one of the important oil and fibre crops in India as well as in other countries of the world. Our country being deficient in both these commodities, there is an urgent need of developing double purpose types of linseed. The present investigation was therefore, undertaken to assess the combining ability of twelve different oil and fibre types.

MATERIALS AND METHODS

The material comprised 27 F_1 and F_2 hybrids resulting from 3 testers (Flak-1, KL-1 and K_2) and 9 diverse lines (KL-43, EC-23239, EC-22494, SPS - 5/47-2, NPRR-463, SPS/23-5, NP-36, TLP-1 and Neelam). All the 27 F_1's alongwith parents were grown in a randomised block design with three replications. Each plot consisted of a single row of 5m long with row to row and plant to plant spacing within rows of 25 and 10 cm, resepectively. The F_2 was raised in similar fashion during the subsequent season. Metrical observations were recorded at maturity on a random sample of 5 plants in F_1 and F_2 from each plot for plant height (cm), tillers/plant, capsules/plant, seed yield (g) and 1000-seed weight (g). The days to flowering and maturity and yield in F_2 was recorded on plot basis. The observations on tillers/plant and seeds capsules in F_1 and 1000-seed weight in F_2 were not taken. The data were analysed for combining ability using the procedure of Kempthrone (1957).

RESULTS AND DISCUSSIONS

Analysis of variance showed significant differences among genotypes for all the characters studied in both the generations except tillers/plants and seeds/capsules in F_1

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TABLE 2. Estimates of gca eeffcts of 9 lines and 3 testers for characters in linseed

Parent	Days to flowering		Days to maturity		Plant height		Tillers/plant		Capsules/plant		Seeds/capsule		100 grain weight		Seed yield
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1
LINES															
Kl-43	3.02**	7.47**	1.04**	−2.20	6.21**	3.58*	—	0.13	12.43	9.88**	—	0.54	−0.39	−0.74*	26.98*
EC 23239	−0.42	−6.31**	0.93**	−1.53**	0.19	−0.40	—	−0.25	5.59	−3.06	—	0.10	0.47	0.33	4.75
EC 22494	0.47	5.03**	3.82**	1.80**	−1.32	1.98	—	0.00	−7.61	1.91	—	−0.18	−0.70	0.03	−5.80
SPS 5/47-2	−1.09**	2.20**	−1.84**	−1.31**	−5.45*	−3.25*	—	−0.08	−5.54	−3.69*	—	−0.06	0.30	0.32	−6.36
NPRR-463	1.09**	−4.31**	−1.73**	−0.42	−2.32*	−0.53	—	0.21	−6.54	−1.00	—	−0.60*	−0.42	−0.71	−10.25
SpS/23-5	0.35	−3.03**	0.49	0.03	1.61	2.68*	—	−0.03	4.26	1.20	—	−0.28	−0.06	1.09**	−7.53
NP-36	0.91**	4.58**	−0.90*	0.80**	−1.61	−2.67	—	0.26	−3.59	1.59	—	−0 08	−0.86	−0.93*	−7.47
TLP-1	−2.75**	−4.80**	−1.29**	0.80**	0.70	−0.39	—	−0.16	−5.45	−0.75	—	0.32	1.21*	−0.07	−6.4
Neelam	0.69*	−2.42**	−0.07	0.47	3.39**	2.96*	—	−0.13	6.46	−2.26	—	0.09	0.47	0.33	2.97
S.E (gi)	0.35	0.44	0.25	0.32	1.08	1.40	—	0.15	10.36	1.87	—	0.29	0.50	0.38	13.34
S.E. (gi-gj)	0.50	0.36	0.42	1.53	1.98	1.98	—	0.21	14.64	2.64	—	0.41	0.71	0.53	18.86
TESTERS															
Flak-1	5.65**	9.73**	2.19**	1.80**	11.47**	−58.23**	—	−0.03	7.23	−3.77**	—	−0.40*	−0.58*	0.69**	−9.86
KL-1	−2.85**	−5.72**	2.18**	0.80**	−4.25**	−76.04**	—	0.11**	10.26	1.27	—	0.30	−0.36	1.08**	18.26*
K2	−2.75**	−4.01**	1.52	−2.61**	−7.22**	−72.78**	—	−0.06	−17.48**	2.50*	—	0.10	0.95**	−0.61**	−8.40
S.E. (gi)	0.20	0.26	0.15	0.17	0.63	0.81	—	00 09	5.98	1.08	—	0.17	0.29	0.22	7.10
S.E. (gi-gj)	0.29	0.36	0.21	0.24	0.89	1.15	—	0.12	8.46	1.52	—	0.23	0.41	0.31	10.89

TABLE 1. Analysis of variance for combining ability in linseed

Source	Population	d.f.	Mean squares: Days to flowering	Days to maturity	Plant height	Tillers plant	Capsules plant	Seeds/ capsule	100 grams weight	Yield
Hybrids	F_1	26	64.64**	43.61*	259.66**	—	1070.66	—	3.20**	3.21
	F_2	—	27.31**	22.31*	30.32	0.20	194.87*	2.07	—	2607.50
Among lines	F_1	8	23.28	29.00	107.27**	—	472.22	—	4.43**	2.39
	F_2		229.35**	9.58	57.38	0.24	151.81	0.96	—	1232.72
Among testers	F_1	2	641.32**	280.80**	2724.23**	—	6252.15	—	18.54**	11.53**
	F_2		1936.08**	144.16**	2426.51	0.26	298.68	3.55	—	6775.31
Lines × tester	F_1	16	10.18**	21.28	29.23*	—	8810.53**	—	1.02	21.28**
	F_2		42.31**	10.23**	4828.17**	0.18	203.42**	2.44	—	1601.42
Error	F_1	76	1.11	50.20	10.59	—	188.85	—	2.24	1.27
	F_2		1.77	0.80	17.73	0.21	31.36	0.74	—	1601.42
^{2}gca	F_1	—	0.59	0.47	4.76	—	7.21	—	0.05	0.01
	F_2	—	3.80	0.20	4.08	—	—0.18	—0.01	—	—288.54
^{2}sca	F_1	—	4.02	6.90	6.21	—	177.78	—	0.20	0.44
	F_2		30.18	3.68	—0.37	—0.001	57.35	0.57	—	10354.45

* P=0.05, **P=0.01

Cross combinations KL-1 × KL-43, KL-1 × EC-23239 and KL-1 × TLP-1 exhibited high specific comnbining ability effects for Cross combinations KL-1 × KL-43, KL-1×EC–23239 and KL-1×TLP-1 exhibited high specific combining ability effects for seed yield in both the generations (Table 3). Besides yield these crosses also showed high sca effects for seeds/capsule, days to flowering and maturity and 1000-seed weight. Significant andpositive sca effects for seed yield were also obtained in the cross Flak-1 × NP-36, Flak-1 × TLP-1 and KL-1 × KL-43 in F_2.

The *per se* performance seems to be more realistic for selecting the best crosses as compared to sca effects. In contrast to the results of Patil and Chopde (1983), no association was observed between *per se* performances of crosses and sca effects. All the superior specific combinations involved high × high, high and low or low × low general combiners. It appeared that the desirable sca effects of any cross combination need not necesarily depend on the level of gca effects of the parents involved. Exploitation of heterosis in self-pollinated crops like linseed has not become commercially feasible. Non-additive type of gene action in this crop could be utilized if we resort to multiple crossing procedure involving KL-43, KL-2, TLP-1, Flak-1, EC-23239 and SPS 5/47-2.

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TABLE 3. Promising crosses exhibiting high sca effects for seed yield in F_1 and F_2 generations for different traits, alongwith mean performance and gca effects of the parents involved in the crosses.

Cross	Mean Performance	sca Effects	gca effect P_1	P_2	Other traits for which the cross showed desirbale sca effect
F_1					
Flak-1 X SPS 23-5	.99	1.66*	0.69*	1.09	Days to flowering and maturity, capsules/ plant and 1000 grain weight.
Flak-1 X Neelam	5.39	0.75	0.69*	0.33	Capsules/plant
KL-1 X KL-43	4.52	1.98**	1.08**	0.74*	Capsules/plant
KL-1 X EC-23239	5.66	1.54*	1.08**	0.33	Days to flowering and maturity
KL-1 X SPS 23-5	4.85	0.53	1.08*	1.09*	Seed weight
KL-1 X TLP-1	4.26	2.17**	1.08**	-0.07	Days of heading and maturity, capsules/ plant, seed weight.
K_2 X TLP-1	4.14	1.77**	-0.62**	-0.07	Days to maturity and seed weight
F_2					
Flak-1 X NP-36	126.7	16.10*	-0.88	-7.47	Days to flowering and maturity and seeds capsules
Flak-1 X TLP-1	128.0	36.00**	-9.88	-6.91	Days to flowering and maturity and capsules/plant
Flak-1 X Neelam	137.0	23.95**	-9.88	-2.47	Days to maturity, seeds/capsules
KL-1 X KL-43	180.00	6.68	18.27*	26.98*	Days to maturity seeds/capsules
KL-1 X EC-23239	161.7	13.83	18.27**	4.75	Days to flowering, tiller/plant, capsules/plants
KL X NPRR 463	145.0	8.27	18.27**	-10.25	Days to flowering, seeds/capsules
KL-1 X TLP-1	150.4	28.95**	18.27**	-6.91	Days to flowering maturity, capsules/plant
KL-1 X Neelam	103.3	9.38	18.27**	-2.47	Days to maturity capsules/plant, seeds / capsules
K_2 X KL-43	170.0	43.77**	8.4	26.98**	Days to flowering, plant height, days to maturity (early) capsues/plant.

there were three rates of nitrogen (O, 40 and 80 kg ha^{-1}) and three rates of potassium (0, 30 and 60 kg ha^{-1}). Further, each main plot is sub-divided into two sub-plots in which feitilizei was applied (i) full at the time of sowing, (ii) half at the time of sowing and (iii) remaining half after 40 days or first irrigation. Finally, each sub-plot was again devided into two ultimate plots to adjust the presence and absence of CCC (2-chloroethyl trimethyl ammonium chloride) treatment. Thus, within a replication, the total treatment combinations were thiity six and in the trial the total number of plots were one hundeied eight. Double split plot design with three replications and 4.6m×1.8m= 8.28 m^2 net plot size was adopted for the tria'.

Nitrogen, phosphorus and potassium were applied through urea, single super phosphate and muiiate of potash repectively. 2-chloroethyl trimethyl-- ammonium chloride was sprayed at the rate of 2 kg ha^{-1} in 2 per cent water solution. The plants of the variety Varuna (T-59) of mustard were maintained at 45 cm × 20cm apart. Phosphorus was applied at the rate of 40 kg ha^{-1} at the sowing time The crop was sown on 29-11-82 and 10-11-83; and harvested on 29-3-83 and 12-3-84 during 1982-83 and 1983-84, respectively. One irrigation was given at 40 days after sowing.

For the growth analysis studies, mean total accumulated plant weight (biological yield), mean leaf area and mean dry weights of plant including weight of economically important parts were obtained at the beginning and end of the period of plant growth and abslolute growth rate (AGR) relative growth rate (RGR), net assimilation rate (NAR), leaf area ratio (LAR) and leaf area duration (LAD) were calculated as described by Watson (1952), Radford (1967) and Joseph (1973). The dry weight of root was not included in these calculations.

Chlorophyll 'a', 'b' and total chlorophyll content of the leaves at 80 days after sowing were estimated as advocated by Witham *et al.* (1971). For sugar analysis, the clearing of plant extracts was done as per Loomis and Shull (1937) and the total reducing sugars and sources were determined by Somogyi phosphate reagent method (Somogyi, 1946).

Nitrogen was determined by micro-kjeldahl method (Humphries, 1956) and phosphorus was determined colorimetrically by the modified method of Troug and Meyor (1929) as described by Bertramson (1942). The potassium and oil content in seed were analysed flame photometrically (Jackson, 1967) and by Soxhlet method (Sankaran, 1966), respectively. The data were analysed with the help of computer at Indian Agricultural Statistical Research Institute New Delhi and the significance was tested at 0.05 probability and only the significant data are reported.

RESULTS AND DISCUSSION

Growth analysis:

Two factor interaction of N×K at the rate of 80 kg ha^{-1} and 60 kg ha^{-1}, significantly increased the AGR as compared to the rest of the treatments (Table 3). Increa-

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RESPONSE OF SEED AND OIL YIELD AND SOME PHYSIOLOGICAL ATTRIBUTES OF MUSTARD TO DIFFERENT LEVELS AND METHODS OF NUTRIENT APPLICATION

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ABSTRACT

Split application of nitrogen and basal application of potassium together when combined (N×K) at the rate of 80 kg and 60 kg ha^{-1} to mustard (*Brassica juncea*) significantly increased the absolute growth rate and leaf area at all the growth stages and total accumulation of nitrogen, phosphorus and potassium at maturity stage in seed and stem in both the years. Thus, the seed yield by this interaction was also significantly influenced due to enhancement of photosynthesizing organs. Relative growth rate and leaf area ratio leading to higher grain yield. Net assimilation rate registered a decrease because of senescence of lower leaves. Similarly, leaf sugars at 80 days decreased due to which the seed oil content decreased in plots fertilized with higher ntrogen levels. Increased potassium levels enhanced the percent seed oil content. Chlorophyll 'b' and total chlorophyll of the leaves were found to be higher as a result of interaction due to the application of higher levels of nitrogen and potassium.

Key words: Mustard, Nitrogen, Potassium, N×K interaction.

INTRODUCTION

Adequate nitrogen supply increased the amount of cell-plasma and chlorophyll which is a vital factor for growth of mustard crop (Kuo and Chen, 1980), whereas fertilization of phosphorus helps in improvng the seed weight as also development of deeper and proliferous root system leading to extraction of water and nutrients from deeper layers of soil profile. Potassium application is responsible for translocation of photosynthates from different plant parts to the seat of accumulation (Mengel and Kirkby, 1980). Interaction of nitrogen and potassium during formative phases and seed filling stage gives higher yield (Majumdar *et al.*, 1988). Similarly, cycocel retards the growth of plant at earlier stages and translocate the photosynthates towards reproductive organs promoting the synthesis of oil at later stages. Taking above facts into consideration the present experiment was planned to examine whether magnitude of response in combination of both the factors would prove beneficial than their seperate effects due to positive interaction.

MATERIAL AND METHODS

The field experiment on mustard (*Brassica juncea*) was carried out during *Rabi* season of 1982-83 and 1983-84. The soil of the experimental plot was neutral in reaction and sandyloam in texture. The available nitrogen, phosphorus and potassium contents of the soil at the initial stage were 210 kg N, 36 kg P_2O_5 and 215 kg K_2O ha ha^{-1}, respectively. In actual practice, within a replication, the whole field is devided into nine main plots, to accomodate nine interactions of N×K. In this interactions,

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TABLE 1. Contd.

N and K leves (kg hs^{-1})	(iii) Leaf area (cm^2)				(iv Leaf area ratio (cm^2 g^{-1})		
	Days 30th	after 60th	sowing 90th	Maturity Days	30th to 60th Days	after 60th-90th	sowing 90th to Maturity
N^0	264.90	301.20	151.58	50.42	105.70	25.73	6.15
N^{40}	403.63	454.73	213.97	66.20	123.94	38.46	6.26
N^{80}	566.81	650.18	359.01	115.90	192.39	49.07	10.85
S.Ed±	34.97	33.22	31.42	4.76	24.60	8.35	0.72
C.D. at 5%	74.14	91.63	66.72	10.10	52.16	18.37	N.S.
K^0	458.26	503.45	241.96	65.26	174.51	36.51	7.52
K^{30}	388.85	454.26	265.28	90.38	129.50	45.77	8.54
K^{60}	388.23	448.41	217.33	76.87	118.02	30.98	7.21
S.Ed.±	34.97	33.22	31.47	4.76	24.60	8.36	0.72
C.D. at 5%	N.S.	N.S.	69.23	10.10	N.S.	N.S.	N.S.

N.S. stands for non-significant.

TABLE 1. **Main effects of N and K separately at different stages of growth analysis of mustard. (pooled of two years)**

N and K evels (kg ha-1)	(i) Absolute growth rate (g day-1)				(ii) Relative growthrate (g g-1 day -1)	
	Days after sowing			Days after sowing		
	3oth to 60th	60th to 90th	90th to Maturity	30th to 60th	60th to 90th	90th to maturity
N_0	0.120	0.247	0.152	0.039	0.032	0.028
N_{40}	0.172	0.268	0.210	0.042	0.029	0.020
N_{80}	0.174	0.331	0.219	0.042	0.036	0.021
S.Ed±	0.013	0.021	0.012	0.0013	0.0013	0.002
C.D. at 5%	0.027	0.045	0.027	N.S.	0.0028	0.005
K_0	0.150	0.268	0.178	0.041	0.030	0.021
K_{30}	0.139	0.302	0.203	0.041	0.032	0.022
K_{60}	0.177	0.276	0.200	0.043	0.033	0.025
S.Ed±	0.013	0.021	0.012	0.0013	0.0013	0.002
C.D. at 5%	0.027	0.045	0.027	0.0028	0.0028	0.005

N.S. stands for not significant.

Table 1 contd.

N and K levels (Kg ha^{-1}	(v) Leaf area duration (cm2 day-1 plant-1)			(vi) Net assimilation rate (g cm^2 day^{-1})		
	Days	after	sowing	Days	after	sowing
	30th to 60th	60th to 90th	90th to Maturity	30th to 60th	60th to 90th	90th to Maturity
N_0	84.91	67.77	30.26	0.0019	0.0016	0.0023
N40	128.73	100.31	42.02	0 0009	0.0012	0.0022
N80	181.93	152.21	71.23	0 0005	0.0009	0.0018
S.Ed±	10.93	8.15	5.16	0 00011	0.00025	0.00035
C.D. at 5%	23.18	17.29	10.96	0 00028	0.00058	N.S
K_0	144.24	111.67	46.07	0.0009	0.0011	0.0018
K_{30}	126.46	108.77	53.33	0.00092	0.0013	0.0022
K_{60}	124.87	99.86	44.10	0.0016	0.0013	0.0023
S.Ed±	10.93	8.15	5.16	0.00011	0.00025	0.00035
C.D. at 5%	N.S.	N.S.	11.36	N.S.	0.00058	N.S.

N.S. stands for non-significant

TABLE 2. Effect of N and K on chlorophyll (mg/g fresh leaf weight) and sugar (mg/100g fresh leaf weight) contents of mustard leaves at 80 days after sowing

N and K levels (kg ha^{-1})	Chorophyll 'a'	Chlorophyll 'b'	Total chlorophyll	Reducing sugar	Non-reducing sugar	Total sugar
N_0	18.98	15.07	33.95	219.53	256.71	476.28
N_{40}	18.69	16.89	35.65	159.70	189.01	346.95
N_{80}	19.03	18.58	37.41	167.84	202.17	365.85
S.Ed±	0.14	0.09	0.26	0.33	0.26	4.09
C.D. at 5%	0.31	N.S.	0.56	0.70	0.56	8.67
K_0	19.15	17.25	36.25	222.98	260.46	479.28
K_{30}	18.85	16.55	35.36	163.09	199.49	360.81
K_{60}	18.69	16.74	35.41	161.00	187.94	348.98
S.Ed.±	0.14	0.09	0.26	0.33	0.26	4.09
C.D. at 5%	0.31	0.19	0.56	0.70	0.56	8.67

N.S. stands for non-significant

TABLE 3. Effect of N x K interactions on growth analysis at different stages of observations (pooled of two years)

(i) Absolute growth rate (g day^{-1})

Nitrogen levels (kg ha-1)	30th to 60th day			60th to 90th day			90th to maturity stage		
	K_0	K_{30}	K_{60}	K_0	K_{30}	K_{60}	K_0	K_{30}	K_{60}
0	0.09	0.10	0.016	0.19	0.27	0.24	0.12	0.19	0.13
40	0.19	0.17	0.14	0.27	0.27	0.29	0.18	0.19	0.24
80	0.15	0.14	0.22	0.34	0.35	0.29	0.22	0.21	0.21
S.Ed.±		0.02			0.03			0.02	
C.D. at 5%		0.04			0.08			0.04	

Table 3 contd.

(ii) Leaf area (cm2)

Nitrogen levels (kg ha^{-1})	30th day (1982-83)			60th day (1982-83)			90th day (1982-83)			Maturity stage (pooled)		
	K_0	K_{30}	K_{60}	K_0	K_{30}	K_{60}	K_C	K_{30}	K_{60}	K_0	K_{30}	K_{60}
0	608.61	315.42	555.42	648.69	361.96	602.09	165.31	84.93	73.18	39.61	61.70	49.94
40	774.67	576.04	632.85	858.20	636.22	673.58	208.87	203.87	117.63	64.17	53.82	80.61
80	937.85	1038.47	794.09	975.00	1096.30	840.97	159.40	276.66	171.96	92.03	155.63	100.04
S.Ed.±		98.74			98.62			23.22			8.24	
C.D. at 5%		209.33			209.08			49.23			17.49	

sed crop growth rate by separate application of nitrogen and potassium at the rate of 120 kg and 60 kg ha^{-1} at flowering to 15 days after flowering in sesamum was also reported (Majumdar *et al.*, 1988).

Relative growth rate was also found to be significant for N×K interactions in between 30th to 60th days and from 90th day to maturity stage. With regard to leaf area, a combined application of nitrogen and potassium at the rate of 80 kg and 30 kg ha^{-1} was also found beneficial at all the growth stages of observations.

Higher combined levels of nitrogen and potassium upto 80 kg and 60 kg ha^{-1} markedly enhanced the leaf area at most of the growth stages, whereas higher leaf area was associated with $N_{80} \times K_{30}$ interaction (Table 3). Majumdar *et al.*, also observed the higher leaf area with N×K interaction in sesame crop.

Leaf area duration registered a significant increase by N×K interaction in between 30th to 60th days and from 90th day to maturity stage of the observations. An increase in the LAD of barley crop due to potassium application was reported by Ralph (1976).

In spite of enhancement of all the growth parameters, the net assimilation rate was found to reduce with higher level of N×K interaction because, NAR may result in its decline with the increase in leaf area. This is probably due to the lower degree of light interception by lower leaves. Thus, the total photosynthate production became less.

Chlorophyll 'a', 'b' and total chlorophyll content:

Higher levels of N and K upto 80 and 60 kg ha^{-1}, respectively, increased the chlorophyll 'a', 'b' and total chlorophyll of the leaves at 80 days after sowing (Table 2). Increase in the total chlorophyll of the leves due to nitrogen application in yellow mustard was also reported by Nordestgaard (1979).

Reducing, non-reducing and total sugars:

Higher levels of nitrogen and potassium ($N_{80} \times K_{60}$), significantly decreased the reducing, non-reducing and total sugars of the leaves at 80 days after sowing.

Nitrogen, phosphorus and potassium accumulation by seed and straw:

Higher levels of N×K from 0 to 80 kg and 60 kg ha^{-1} significantly increased the nitrogen, phosphorus and potassium accumulation in seed and straw (Table 5). Increased accumulation of nitrogen, phosphorus and potassium accoumulation in seed and straw at maturity stage is also reported by Kuo and Chen, 1980; Bishonoi and Singh, 1982 and Patel and Khatri, 1983.

TABLE 4. Combined and separately application of N and K on seed yield and seed oil content of mustard (pooled of two years)

Nutrient levels (kg ha^{-1})	Seed yield (q ha-1)				Seed oil(%)			
	K_0	K_{30}	K_{60}	Mean	K_0	K_{30}	K_{60}	Mean
N_0	5.76	5.33	5.70	5.59	33.25	33.75	35.00	**34.66**
N_{40}	**10.81**	13.40	13.36	12.52	33.00	33.75	34.50	**33.75**
N_{80}	17.48	16.28	21.55	18.43	25.00	28.25	33.66	**28.97**
S.Ed.±	N or K separately	= 0.17	N x K interaction	= 0.29	N or K separately	= 0.52	N x K interaction	= **0.90**
C.D. at 5%		0.36		0.63		1.10		**1.90**

TABLE 5. Response of basal or split method of N and K application on seed yield of mustard (pooled of two years)

Nitrogen evels (kg ha^{-1})	Seed yield (q ha-1)		Potassium levels (kg ha^{-1})	Seed yield (q ha^{-1})	
	Basal application	Split application		Basal application	Split application
N_0	6.33	4.87	K_0	9.83	12.87
N_{40}	12.72	12.33	K_{30}	11.54	11.79
N_{80}	16.61	20.26	K_{60}	14.27	12.80
S.Ed.±	0.22	0.21	S.Ed.±	0.22	0.21
C.D. at 5%	0.48	0.44	C.D. at 5%	0.46	0.45

Seed yield:

It is clear from the Table 5 that N × K interaction at the rate of 80 kg and 60 kg ha^{-1} in which N through split and K through basal application resulted in significantly higher seed yield in both the years of experimentation. The yield was influenced significantly due to increase in AGR, leaf area, LAD at the most of the stages and NAR at some of the stages of observations. These growth parameters were enhanced by increased levels of chlorophyll 'a', chlorophyll 'b' and total chlorophyll in the leaf during their growth stages. The total accumulation of nitrogen, phosphorus and potassium were also significantly affected by this interaction.

Seed oil:

Combined application of N and K at the rate of 80 kg and 60 kg ha^{-1} respectively increased the seed oil content as compared to 80 kg N ha^{-1} alone (Table 4). Decrease in seed oil percentage of rapeseed following higher rates of nitrogen was directly related to the rise in protein content. The increase in seed yield due to nitrogen application, could compensate for reduction in oil content, as it leads to higher per hectare yield of oil (Kuo and Chen, 1980).

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COMBINING ABILITY ANALYSIS OF RESISTANCE TO MUSTARD APHID *LIPAPHIS ERYSIMI* (KALT.) IN INDIAN MUSTARD, *BRASSICA JUNCEA* (L. CZERN & COSS

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ABSTRACT

In a 6×6 complete diallel cross involving three mustard aphid resistant parents viz; T 6342, RH 7846 and RC 1425 and three susceptible parents namely, Kranti, Varuna and RH 785 reciprocal effects were not observed. T 6342 and RH 7846 were the best general combiners for resistance. T 6342×RH 7846 and Kranti×T 6342 as well as their reciprocal crosses exhibited desirabe sca effects for resistance.

Key words: *Lipaphis erysimi* (Kalt.), Indian mustard, Inheritance, combining ability.

INTRODUCTION

Among various insect-pests affecting and restricting yield potential of various cultivars of Indian mustard, mustard aphid, *Lipaphis erysimi* (Kalt) is the most important. This pest alone can cause the losses in yield ranging from 10 to 75 per cent depending upon its intensity and prevailing environmental conditions (Singhvi *et al*, 1973; Prasad and Phadke, 1983; Bakhetia, 1983 and Malik and Anand, 1984). While varietal differences in resistance to mustard aphid in this crop have been reported by many researchers (Dutta and Saharia, 1984; Angadi *et al*, 1987; Kalra *et al.*, 1987 and Chatterjee and Sengupta, 1987), no systematic efforts have been made to identify parents and crosses based on their combining ability effects which are otherwise essential for urther breeding programme to evolve high yielding aphid resistant cultivars. The present study was, therefore, carried out in this direction by involving aphid resistant and susceptible lines of good genetic background.

MATERIALS AND METHODS

For the present study the mateiral comprised three resistant parents viz; T 6342, RH 7846 and RC 1425 and three susceptible parents viz; Kranti, Varuna and RH 785 crossed in a 6x6 complete diallel fashion. The six parents and their 30 F_1 progenies were grown in a randomised block design with three replications at the experimental farm of Haryana Agricultural University, Hisar during 1986-87. Each entry was represented by a single row of 5m length and distance between rows was kept at 30cm and the plant to plant distance within row was maintained at 10-15 cm by thinning after three weeks of planting. After every three entries, single row of *Brassica campestris* var. BSH-1 which is highly susceptible to mustard aphid attack was planted as infector row. The experiment was conducted under no insecticidal spray so as to get adequate aphid incidence. At complete flowering stage, the entires were scored on 0-5 scale for aphid infestation index as suggested by Bakhetia and Sandhu (1973). Five plants from each entry were taken for recording the date for aphid incidence. The

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TABLE 1. ANOVA for combining ability for mustard aphid reaction in Indian mustard.

Source	d.f.	S.S.	M.S-		
gca	5	5.068	Mg	=	1.0136**
sca	15	5.961	Ms	=	0.3974**
Reciprocal	15	0.350	Mr	=	0.023 Ns
Error	70	70 –	Me	=	0.0120

** P–0.01

TABLE 2. General combining ability effects (diagonal), specific combining ability effects (above diagonal) and reciprocal effects (below diagonal) in Indian mustard.

	Parents	P_1	P_2	P_3	P_4	P_5	P_6
Kranti	P_1	*0.140*	3.168	3.885	–0.214	–0.143	–0.744
RH 7846	P_2	–0.220	*–0.063*	–0.578	0.229	0.0859	–0.516
RH 785	P_3	0.000	0.035	*0.121*	–0.314	0.141	0.461
Varuna	P_4	–0.015	0.135	0.135	*0.084*	–0.172	–0.612
RC 1425	P_5	–0.135	0.100	–0.030	–0.050	*0.264*	0.218
T 6342	P_6	0.085	0.150	–0.130	0.015	0.100	*-0.556*

TABLE 3. *Per se* performance of the parental material in respect of seed yield and mustard aphid infestation

Parents	P_1 (Kranti)	P_2 (RH-7846)	P_3 (RH-785)	P_4 (Varuna)	P_5 (RC-1425)	P_6 (T-6342)
Seed yield (g/plant)	5.70	4.60	5.20	5.30	4.90	4.80
Average aphid infestation index	1.90	0.75	2.00	1.30	0.90	0.90

data was first averaged and then transformed by arc sin transformation. The transformed data were then analysed as per Griffing (1956) Model I and Method II.

RESULTS AND DISCUSSION

The results of analysis of variance for combining ability for mustard aphid resistance are presented in Table 1. The mean squares due to general combining ability (gca) and specific combining ability (sca) effects were highly significant. This reflects the genetic variability in the material for general and specific combining ability for the aphid reaction. It was further evident that mean squares due to gca were two and a half times greater than sca. This infers the fixable nature of the reaction to aphid incidence. Another interesting point in Table 1 indicated that the differences among genotypes to aphid incidence were controlled by the nuclear genes as the reciprocal differences were not significant.

General and specific combining ability effects and *Per se* performance are presented in Table 2 and 3, respectively. The perusal of the tables reveal that T 6342 followed by RH 7846 possessed high gca effects for aphid resistance (negative sign). RC 1425, Kranti and RH 785 were the poor general combiners for aphid tolerance as was evident from their high positive values for gca. T 6342 is the potential available source of tolerance to aphid (Bakhetia and Sandhu, 1973; Brar and Sandhu, 1978 and Bakhetia, 1983). This source has been extensively utilised in hybridization programme as donor parent with a view to incorporating aphid resistance. RH 7846 which is number two in combining ability had been developed from a cross of Prakash xT 6342. All other parental lines showed low gca effect for aphid resistance.

Among the crosses RH 7846xT 6342, Kranti x T 6342 and their reciprocal crosses showed lower values of sca and hence most desirable for aphid resistance. These crosses involved one or both the parents having high and desirable gca effects. This also indicated the additive genetic nature of resistance to mustard aphids. The base material of these two crosses will be effectively utilized through pedigree selection for developing aphid resistant genotypes with high yield.

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GENETIC ANALYSIS OF RUST RESISTANCE IN GROUNDNUT *ARACHIS HYPOGAEA* L.

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ABSTRACT

Analysis of generation means of six crosses involving susceptible and resistant genotypes of groundnut for rust resistance indicated that resistance is controlled by both additive and non-additive gene action. Among the non-additive gene interactions, additive x dominance (j) type was substantial. Breeding methodology to combine the high yield, quality and rust resistance is suggested.

Key words: *Arachis hypogaea*, Rust resistance, gene action.

INTRODUCTION

Groundnut rust caused by *Puccinia arachidis* Speg. is one of the important foliar diseases affecting the crop in India. In semi arid tropics, this disease was reported to cause yield losses exceeding 50%. Although the disease can be controlled effectively by certain fungicides, non availability of these chemicals at appropriate time and the cost involved in application, restrict their use. Consequently, the disease assumes higher magnitude which also provides a high inoculum source to the succeeding crop. Genotypes possessing resistance to rust were reported by Subrahmanyam *et al.* (1982). But these accessions have other disadvantages namely thick pericarp, shrivelled kernels and poor shelling out turn. Recombination breeding to transfer the favourable resistant genes from these donars, to the adapted varieties will be an ideal approach to evolve suitable varieties for the disease in endemic areas. As the knowledge of the gene action is an essential per-requsite for formulating the resistance breeding programmes, a preliminary study was undertaken at the Agricultural Research Station, Aliyarnagar, a location endemic for rust disease of groundnut.

MATERIALS AND METHODS

The material consisted of six generations PI, P2, F1, F2, BC1 and BC2 of the six combinations involving the adapted varieties Co 2 and JL 24 as ovule parents and the resistant donars NcAc 17090, PI 414331 and PI 414332 as pollinators. The segregating progenies and non segregating parental populations were raised in a randomised block design with three replications. The material was scored for rust disease. The crop was sown on 20th April 1987 in a special season and on 15th July 1987 in the *Kharif* season and the mean data subjected to scaling test following Jinks and Jones (1958). The known susceptible cultivar Kadiri-3 was sown in the infector rows 14 days prior to the sowing of the test populations. Besides, the uredospore suspension was also sprayed at weekly intervals from 45 days after sowing(DAS)to provide sufficient incolum and obtain high disease pressure. A sample size of 50 plants in parents and F1, 100 in backcrosses and 200 in F2 were utilised for scoring the disease just before

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TABLE 2. Estimates of the additive dominance and interaction Parameters for rust score in groundnut.

Crosses	Components of generation means					
	m	d	h	i	j	l
Co 2 × Nc Ac 17090	4. 7** ± 0.67	2.16** ± 0.09	1. 8 ± 1.62	-0.36 ± 0.66	-0.96* ± 0.44	-1.40 ± 0.99
Co 2 × PI 414331	6.24** ± 0.87	1.05 ± 0.56	-2.68 ± 2.30	-1.84 ± 0.67	-2.0* ± 0.97	1.44 ± 1.45
Co 2 × PI 414332	5.31** ± 0.64	2.15** ± 0.09	6.45** ± 1.60	-1.06 ± 0.64	-1.0* ± 0.46	00.06 ± 1.01
JL 24 × Nc Ac 17090	5.55** ± 0.92	2.55** ± 0.13	1.05 ± 2.17	-0.60 ± 0.91	-2.1** ± 0.56	-1.1 ± 1.31
JL 24 × PI 414331	7.30** ± 0.98	3.00** ± 0.13	-3.70 ± 2.32	-2.20* ± 0.97	-4.6** ± 0.60	2.2 ± 1.41
JL 24 × PI 414332	6.88** ± 0.66	2.88** ± 0.14	-2.93 ± 1.78	-1.80** ± 0.65	-3.55** ± 0.58	1.95 ± 1.15

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

TABLE 1. Mean rust score of segregating and non segregating populations of six cross combinations in groundnut.

Crosses	$\overline{P_1}$	$\overline{B_1}$	$\overline{F_1}$	$\overline{F_2}$	$\overline{B_2}$	$\overline{P_2}$
1. Co 2 × Nc Ac 17090	6.50 ± 0.15	6.00 ± 0.11	5.10 ± 0.10	5.25 ± 0.13	4.32 ± 0.17	2.18 ± 0.09
2. Co 2 × PI 414331	6.80 ± 0.18	5.50 ± 0.12	5.00 ± 0.09	5.26 ± 0.14	4.10 ± 0.14	2.00 ± 1.10
3. Co 2 × PI 414332	6.40 ± 0.16	5.80 ± 0.17	5.20 ± 0.13	5.24 ± 0.12	4.15 ± 0.12	2.10 ± 1.09
4. JL 24 × Nc Ac 17090	7.50 ± 0.21	6.40 ± 0.18	5.50 ± 0.15	5.80 ± 0.19	4.90 ± 0.17	2.40 ± 0.15
5. JL 24 × PI 414331	8.10 ± 0.19	5.80 ± 0.17	5.80 ± 0.17	6.00 ± 0.20	5.10 ± 0.21	2.10 ± 0.19
6. JL 24 × PI 414332	7.95 ± 0.20	6.00 ± 0.20	5.90 ± 0.10	5.90 ± 0.10	4.90 ± 0.16	2.20 ± 0.18

P_1 and P_2 refers to succeptible and resistant genotypes respectively.

harvest following 1 to 9 rating (1=free from rust and 9=50 to 100% defoliation due to rust infection) suggested by Subrahmanyam *et al.*, (1982).

RESULTS AND DISCUSSION

The mean rust grades for the six generations in each of the six combinations studied are presented in Table 1. The additive, dominance and interaction parameters estimated are presented in Table 2.

The additive component (d) was significant for all the crosses except Co 2xPI 414331. Both additive and dominance components were significant in the cross Co 2xPI 414332. Among the non-allelic gene interactions, additive x dominance gene effects were substantial and large for this trait. However, additive x additive (i) type of interaction was also observed in the crosses JL 24 × PI 414331 and JL 24xPI 414332. As varied results on the inheritance of rust resistance have been reported (Middleton and Shorter, 1984; Bromfield and Bailey, 1972; ICRISAT. 1982 and Hammons, 1984), Reddy *et al.* (1984) emphasized the need for further studies in this line in order to precisely evolve a breeding strategy. The present study confirms the importance of additive genes in all the crosses evaluated. Due to a greater magnitude of additive gene action, resistant progenies could be isolated by pedigree breeding or mass pedigree selection from segregating populations. The interference by the non-allelic interaction (j) involving additive x dominance components observed, can be partially or fully overcome by other non-conventional methods like convergent hybridisation (Norden, 1980); or intermating segregants in early generations or subjecting the hybrid pods to gamma irradiation at low doses of less than 20 krad for breaking the linkages between rust resistance and the undesirable traits viz. thick shell and low recovery of kernels.

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EFFECT OF CONSERVATION TILLAGE PRACTICES AND NITROGEN LEVELS ON MOISTURE AND RESIDUAL NITROGEN IN ALFISOL UNDER RAINFED CASTOR*

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ABSTRACT

A field experiment was conducted on alfisol during *kharif* 1988-89 to study the effect of different tillage practices viz., deep tillage, broad bed and furrows, dead furrows, ridges and furrows and flat bed (control) at varying levels of Nitrogen viz., 0, 20, 40, 60. and 80 kg N ha^{-1} on moisture storage during the growth period of castor under rainfed conditions. Broad-bed and furrows followed by dead furrows resulted in higher moisture storage compared to the other tillage treatments. The stored soil moisture was the highest at No. gradually decreased with an increase in level of Nitrogen The residually available Nitrogen content after the crop's harvest was high in broad bed and furrows followed by dead furrows. The lowest Nitrogen content was recorded in the flat beds.

Key words: Conservation tillage, soil moisture, residual nitrogen, castor.

INTRODUCTION

The importance of increasing the moisture storage through different management practices under rainfed conditions hardly needs any emphasis. Castor is a fairly deep-rooted crop and its growth is influenced by the soil physical properties including soil moisture storage etc. Castor crop in Andhra Pradesh is mostly grown under rainfed conditions in alfisols (locally called *chalka* soils), which are shallow in depth, low in moisture storage, prone to crusting and poor in fertility status. The mean annual rainfall in castor growing region of Andhra Pradesh is around 700mm per annum which is unpredictable, highly erratic and often interspersed with long dryspells. The farmers generally do not apply any fertilizer to castor. The crop is often subjected to moisture and nutrient stresses resulting in low and unstable yields. The effect of different conservation tillage practices like deep ploughing, ridges and furrows, maintaining broad bed and furrow, dead furrow etc. on *in situ* moisture conservation and-response to applied nitrogen needs to be evaluated in order to step up the productivity of castor in Andhra Pradesh. The interaction effects between the soil moisture storage and applied nitrogen were well established in the case of other rainfed crops like *jowar*, *bajra*, maize, redgram, and wheat (AICRPDA 1980 and 1983, CRIDA 1984 AICRP on SP CIP, Ludhiana Centre, 1987, Prihar and Gajri, 1988). Such information on castor crop, however, is lacking though its response to nitrogen fertilization is well established (Sarma, 1985, Madhusudhana Rao and Venkateswarlu 1988). In the light of the above, a field experiment was conducted with a view to assessing the effect of different tillage practices coupled with different levels of nitrogen fertilization on the soil moisture storage and also on soil fertility in terms of residually available nitrogen.

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MATERIALS AND METHODS

A field experiment was conducted with castor variety 'Aruna' at the Agricultural Research Institute, Rajendranagar during *kharif* 1988-89. The soil is a shallow, gravelly sandy loam in texture with 2 percent slope, neutral in reaction, low in organic casbon, available N, K and high in available P.

The experiment was conducted in a strip plot design with five conservation tillage practices viz., deep tillage, broad-bed and furrows, dead furrows, ridges and furrows, ridges and furrows and flat bed (control) as main treatments, and five N levels (0, 20, 40, 60 and 80 Kg ha^{-1}) as sub-plot treatments with four replications.

The cultivation was done along the contours with the aid of vegetative contour key lines ("Khus" grass: *Vetiveria zizanioides*) which were established earlier. Experimental area was uniformly ploughed once after summer showers in June with tractor drawn cultivator, and later with disc harrow, across the slope before sowing. Deep tillage was done by using a sub-soiler after the preparatory cultivation and before sowing to a depth of about 30 cm. In the case of broad bed and furrows, a bed of 75 cm width and a furrow of 75 cm width, and 15 cm depth was formed, 30 days after sowing (DAS) with the help of spade. Dead furrows of 15cm depth were opened 30 DAS with the help of a ridge plough at 150 cm intervals along the contours. Ridges and furrows were formed with a ridge plough along the contours 30 DAS in between the plant rows. In case of flat bed (control), no tillage, other than the one given before sowing of crop, was done. Nitrogen in the form of urea was applied in bands as per the treatments in two equal splits, half at 30 DAS and remaining at 50 DAS. Potassium, at 30 kg ha^{-1} was applied for all the plots as basal dose before sowing. Sowing was done along the contours by hand dibbling behind the plough at a depth of 5 cm with a spacing of 75×30 cm on 5-8-1988. Total rainfall of 417 mm spread over in 27 rainy days was received during the crop period. Dry spell prevailed from the first week of October, till the harvest of the crop except for a single shower of 17mm during the second week of December.

Moisture content was determined gravimetrically at periodical intervals from 59 to 124 DAS, eleven times at 0-15 and 15-30 cm depths in all the treatments. In the broad bed and furrows and ridges and furrows-treatment, moisture estimations were done both on the beds/ridges and furrows separately and their average values were taken. After harvest of the crop, soil samples from all the treatments were analysed for their residual nitrogen content by alkaline permanganate method (Subbaiah and Aziza, 1956).

RESULTS AND DISCUSSION

The different conservation tillage practices adopted in the present study significantly increased the soil moisture storage both in surface (0-15cm) and sub surface (15-30cm) soil compared to control (Table 1). Among the tillage practices, broad beds and furrows resulted in higher moisture storage during the entire crop growth

TABLE 1. Mean soil moisture content (%) at periodical intervals during the crop growth period as affected by different tillage practices at different depth.

Date	Days After sowing	Deep Tillage T_1		Broad bed furrows T_2		Dead furrows T_3		Ridges & furrows T_4		Flat bed T_5	
		0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 c,m	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm
3.10.1988	59 DAS	8.3	10.6	10.9	14.3	10.5	13.2	7.1	9.4	6.9	9.9
8.10.1988	64 DAS	6.1	8.1	9.2	13.3	8.2	11.4	5.0	7.3	5.4	8.6
15.10.1988	71 DAS	3.2	5.8	6.5	10.1	4.7	6.9	2.6	5.8	3.2	4.7
21.10.1988	77 DAS	3.4	4.6	6.5	8.8	6.0	8.3	2.7	4.7	3.1	5.3
26.10.1988	82 DAS	3.0	4.4	4.1	7.7	3.2	5.6	2.5	4.5	2.3	3.6
1.11.1988	88 DAS	2.7	4.5	4.7	7.5	4.8	5.7	2.7	3.5	2.1	4.1
7.11.1988	94 DAS	2.8	5.9	5.8	8.8	3.6	5.2	2.3	3.9	2.0	4.0
16.11.1988	103 DAS	2.7	4.1	5.3	7.3	5.0	6.6	2.8	4.3	2.3	3.8
23.11.1988	110 DAS	2.7	4.2	4.4	7.5	3.0	5.4	1.4	3.1	1.5	3.9
30.11.1988	117 DAS	2.5	4.0	4.7	8.3	4.0	6.4	2.0	3.2	1.7	2.9
1.12.1988	124 DAS	3.9	4.9	6.2	8.9	5.3	6.0	2.9	4.2	2.8	4.1
	Mean	3.75	5.55	6.21	9.32	5.30	7.34	3.09	4.90	3.03	4.99

TABLE 2. Mean soil moisture content (%) at periodical intervals during the crop growth period as affected by different nitrogen levels at different depth.

Date	Days after sowing	N_0		N_{20}		N_{40}		N_{60}		N_{80}	
		0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm	0–15 cm	15–30 cm
3.10.1988	59 DAS	9.2	12.2	9.1	12.3	8.6	11.5	8.6	10.6	8.3	10.8
8.10.1988	64 DAS	6.9	11.2	7.2	9.7	6.3	9.7	6.7	9.2	6.9	8.9
15.10.1988	71 DAS	4.5	7.6	4.7	8.3	3.8	5.9	3.8	5.6	3.3	5.9
21.10.1988	77 DAS	4.9	7.1	4.5	6.9	4.2	6.8	3.4	5.0	4.7	5.8
26.10.1988	82 DAS	3.0	5.0	2.9	6.2	2.6	4.9	3.2	4.8	[illegible].3	5.0
1.11.1988	88 DAS	4.0	5.5	3.7	5.3	3.6	5.8	2.7	4.1	3.1	4.6
7.11.1988	94 DAS	3.4	6.5	4.0	6.1	3.1	5.3	3.0	4.6	2.9	5.3
16.11.1938	103 DAS	3.7	5.8	4.5	6.5	3.8	4.8	2.7	4.3	3.3	4.7
23.11.1988	110 DAS	2.9	5.7	2.8	4.8	2.5	4.5	2.5	4.1	2.2	5.0
30.11.1988	117 DAS	2.9	5.0	3.5	5.6	3.2	5.2	2.3	4.0	3.1	5.0
7.12.1988	124 DAS	4.8	6.7	4.0	5.8	4.6	5.0	3.9	5.1	3.8	5.4
	Mean	4.56	7.11	4.62	7.05	4.21	6.31	3.89	5.58	4.08	6.04

period closely followed by dead furrow. Deep tillage and ridges and furrows were the next best compared to the flat bed (control). The efficiency of broad bed and furrows and dead furrows in conservation of moisture was also reported by Haranath (1980), All India Coordinated Research Project for Dryland and Agriculture, Anantapur centre (1980), All India Coordinated Research Project for Dry and Agriculture, Hyderabad centre (1983) and the pilot project for Watershed Development in rainfed area of Maheshwaram (1988).

Deep tillage was given before sowing of the crop, while broad bed and dead furrows were imposed subsequently 30 DAS. It is possible that the rains during the first few days after ploughing have disturbed the surface texture of the soil, which is known to be prone for crusting, in such a way that it blocked them icropores and reduced the infiltration during the subsequent rains. On the other hand the broad bed and dead furrows, which were opened 30 DAS, could store more moisture because of the breaking of surface crust. In addition, there was higher drymatter production in deep tillage and ridges and furrows, compared to broad bed and dead furrows, which might have resluted in higher evapotranspiration (ET) in the post rainy period leading to more soil moisture depletion, and less moisture storage. In the case of the ridges and furrows, exposure of increased surface area to the atmosphere might have also resulted in higher evaporation leading to less storage of moisture. Soil moisture storage under the deep tillage and the flat bed (control) was compared and the efficiency of former was established by several workers (Bhushan *et al.*, 1977; Dixit *et al.*, 1981; Vittal, 1987). So far, work was reported comparing the relative efficiency of broad bed, dead furrows, *vis-a-vis* the deep tillage in light textured shallow soils, which are known to be prone to surface hardening due to crusting.

The data on mean soil moisture content, as influenced by nitrogen levels, are presented in Table-2. The soil moisture storage gradually decreased with an increase in level of N. It may be mentioned in this connection that application of nitrogen resulted in higher growth upto 80 Kg N ha^{-1}, leading to higher water requirement for plant metabolism and evapotranspiration. Singh *et al* (1975) and Prihar and Gajri (1988) also reported similar trend of variation between soil moisture storage and applied nitrogen levels. However different nitrogen levels could cause variation of low magnitude in soil moisture stored, compared to that of tillage practices (Table 1). Obviously, the physical properties of the soil have perceptible influence on the storage of rain water rather than the nutritional status. The available N content in the surface (0-15 cm) and sub surface (15-30cm) soil after the harvest of the crop as the N content before sowing of the crop are presented in Table 3. Available N in the surface soil(0-15cm) was very much depleted during the cropping. In general, higher residual N was observed in the sub-surface layer than in the surface layer. It decreased from about 244 kg N ha^{-1} in 0-15cm layer to 103 to 212 kg N ha^{-1} in different treatments. Similarly, the N content in soil after the harvest of castor crop in the sub-surface soil layer (15-30cm) was reduced from about 432 kg N ha^{-1} to 130 to 256 kg N ha^{-1} in the different treatments. The residual nitrogen content was significantly influenced by the tillage treatments and in the both surface (0-15cm) and sub-surface (15-30cm) layers. The broad-bed and furrow resulted in a relatively higher mean residual N content.

TABLE: 3. Available nitrogen content (kg ha^{-1}) in soil after harvest, at different depth as affected by different tillage practices and nitrogen levels

Main treatmets	Sub treatments											
	Depth 0-15 cm						Depth 15-30 cm					
	N_0	N_{20}	N_{40}	N_{60}	N_{80}	mean	N_0	N_{20}	N_{40}	N_{60}	N_{80}	Mean
T_1 Deep tillage	165	170	167	186	173	172.2	176	176	190	181	191	182 8
T_2 Broad bed and furrows	212	193	198	190	197	198.0	256	218	227	219	232	230.4
T_3 Dead furrows	179	172	170	172	181	174.8	199	198	184	191	195	193.4
T_4 Ridges and Furrows	103	161	150	158	147	143.8	143	176	167	168	168	164.4
T_5 Flat bed	128	136	129	111	158	132.4	156	151	150	130	179	153.2
Mean	157.4	166.4	162.8	163.4	171.2		186.0	183.8	183.6	177.8	193.0	
CD at 5% T						17.18						9.14
N						8.67						NS
T at same N						23.80						21.76
N at same T						18.60						23.00

Data on available nitrogen status of initial soil

Depth (cm)	Available N kg ha^{-1}
0–15	244
15–30	432

Dead furrow and deep tillage were the next best while flat bed (control) recorded the lowest residual N content. Among N levels, highest residual available N content was recorded in the plots which received 80 kg N ha^{-1} and the lowest in the plots without N application. So, broad bed and furrows and dead furrows had higher nitrogen which could be utilized by the next crop.

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TRACER STUDIES ON P USE EFFICIENCY BY MUSTARD (*BRASSICA JUNCEA* L.), SAFFLOWER (*CARTHAMUS TINCTORIUS* L.) AND CHICKPEA (*CICER ARIETINUM* L.)

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ABSTRACT

Mustard and Chickpea derived a large fraction of their P requirement from applied phosphate compared to safflower crop at flowering. Consequently mean per cent P utilization was maximum in mustard (17.7) followed by chickpea (13.0) and safflower (9.5). However, P uptake at maturity was higher for oilseeds than for the pulse. Grain yield response per kg of applied P was higher at lower rate of P application regardless of the crop.

Key words P use efficiency - ^{32}P tracer - Mustard, Safflower, Chickpea

INTRODUCTION

Pulse and oilseed crops have a higher P requirement per unit yield among various grain crops. On an average, P_2O_5 required to produce one tonne of yield may be 2 kg for tubers, 10 kg for cereals, 14 kg for pulses and 24 kg for oilseeds (Annon. 1988). Therefore, P is the most important nutrient limiting pulse and oilseeds production. Since it is a very costly input, the evaluation of these crops for their P use efficiency needs to be worked out. However, plant genotypes and their cultivars are known to differ in their feeding capacities on applied as well as native P (Clark, 1983; Joshi et al., 1977; Rao et al. 1984). The knowledge of crop species based on scientific approach has an important value for choosing an appropriate cropping sequence for effecting economy in fertilizer use. Hence, the present investigation reports the efficiency of chickpea mustard and safflower to utilize P from applied as well as native soil sources.

MATERIALS AND METHODS

Field experiments were conducted with chickpea (*Cicerarietinum*) var. *BG*-231 mustard (*Brassica juncea*) var. *Pusa Bold* and safflower (*Carthamus tinctonius*) var. A-300 for two successive *rabi* seasons (1982-83 and 1983-84) on alluvial loam soil (Typic, Ustocrept) at the farm of the Indian Agricultural Research Institute, New Delhi. The important properties of soil varied as organic carbon, 0.55-0.59 per cent; available P, 13.2-14.4 kg/ha; P fixing capacity, 35.9-36.8 per cent; clay, 17.2-17.6 per cent and pH 8.2-8.3.

The treatments for each crop consisted of three levels of phosphate (30,60 and 90 kg P_2O_5/ha) replicated thrice in a completely randomised design with one control. In each main plot, an area of 2.75×0.66 m was earmarked as microplot. Potash was applied to each crop at the rate of 40 kg K_2O/ha through muriate of potash.

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Chickpea received 20 kg N/ha as basal application and a recommended dose of 50 kg N/ha as urea was applied to safflower and mustard in two splits, half as basal and the rest top dressed before flowering. In this way, main plot as well as micro-plot both received the same rate of nitrogen, potash and phosphorus as well as other cultural operations. The only difference was that ^{32}P labelled superphosphate (sp. activity, 0.4 m Ci/g P_2O_5) was used in the microplot.

Plant samples were collected at the flowering stage (95 days growth for safflower) from the microplot receiving 32 tagged fertilizer. The plant material was dried in the *sun and subsequently in hot air oven at 70°C and ground. All the samples were ana*lysed for P by vanadomolybdate method (Koenig and Johnson, 1942) and radioassay of the plant material as well as fertilizer was done following the method described by Mackenzie and Dean (1948). Counting was done in an end window G.M. counter. At maturity the seed and stalk of the crops were harvested separately.

RESULTS AND DISCUSSION

The data on dry matter yield, P content and P uptake at flowering and maturity are presented for one season only as the result for these parameters were almost similar for both the years.

Dry matter yield, P content and total P uptake at flowering and maturity

Phosphate application upto 60 kg P_2O_5/ha significantly increased the P uptake at flowering as well as maturity in Chickpea. However, P levels did not cause significant variation in the dry matter yield, P concentration in plant, grain and stalk yield (Table 1,2 and 3).

An increasing trend in the dry matter accumulation, P content and P uptake at flowering and maturity in mustard with increasing levels of phosphate is evident from the Tables 1 and 2. Yet significant difference existed with respect to P absorption only due to phosphate levels up to 60 kg P_2O_5/ha. Variation in grain and stalk yield due to different P levels was not significant (Table 3).

Phosphate application did produce significantly higher dry matter yield, P uptake both at flowering and maturity, grain and stalk yield in safflower over control but the levels were significant with respect to P uptake only upto 60 Kg P_2O_5/ha (Table 1,2 and 3).

P concentration in plants was higher in chickpea as compared to mustard and safflower thereby resulting in higher P uptake at flowering in chickpea than in safflower despite the lower dry matter yield of the former than the latter. Mustard showed maximum P uptake at flowering, but at maturity, mustard and safflower were comparable with respect to total P uptake but both were greater than chickpea in this respect.

TABLE 1. Effect of phosphorus levels on dry matter yield and P content

Crop	Dry matter yield (q/ha)				C.D. at	P content (mg/g)				C.D. at
	P_2O_5 levels (kg/ha)				5% level	P_2O_5 levels (kg/ha)				5% level
	0	30	60	90		0	30	60	90	
Chickpea	22.2	25.9	27.8	27.5	2.81	3.38	3.56	3.53	3.53	N.S.
Mustard	40.8	43.8	46.1	45.9	3.27	2.41	2.59	2.72	2.75	0.28
Safflower	34.4	41.5	42.9	42.7	3.58	2.08	2.16	2.24	2.18	N.S.

TABLE 2. Effect of phosphorus levels on P uptake at flowering and maturity.

Crop	Dry matter yield (q/ha)				C.D. at	P content (mg/g)				C.D. at
	P_2O_5 levels (kg/ha)				5% level	P_2O_5 levels (kg/ha)				5% level
	0	30	60	90		0	30	60	90	
Chickpea	7.48	9.18	9.79	9.67	0.52	11.29	13.44	14.21	14.38	0.87
Mustard	9.82	11.35	12.90	12.63	0.77	13.89	16.12	16.98	17.51	1.43
Safflower	7.36	8.93	9.60	9.31	0.44	12.81	17.35	17.67	17.47	1.96

TABLE 3. Effect of phosphorus levels on grain and straw yield

Crop	Grain yield (g/ha) P_2O_5 levels kg/ha 0	30	60	90	C.D. at 5% level	Straw yield (g/ha) P_2O_5 levels kg/ha 0	30	60	90	C.D. at 5% level
Chickpea	16.28	18.96	19.86	19.77	2.16	30.3	34.4	35.4	35.3	4 48
Mustard	15.82	18.28	18.92	18.85	2.10	91.2	105.0	107.6	106.0	7.73
Safflower	13.57	16.14	16.89	16.70	2.25	79.5	94.7	98.2	97.6	11.56

TABLE 4. Effect of phosphorus levels on % P derived from fertilizer and % P utilization

Crop	Pdff (%) P_2O_5 levels (kg/ha) 30	60	90	C.D. at 5%	% P utilization P_2O_5 levels (kg/ha) 30	60	90	C.D. at 5%
Chickpea	22.7	29.2	29.8	4.39	18.2	12.5	8.3	2.56
Mustard	23.2	32.5	33.2	5.64	23.0	17.8	12.2	3.67
Safflower	17.5	21.1	22.0	3.10	13.7	8.8	6.0	1.78

Field experiment rabi 1982 - 1983

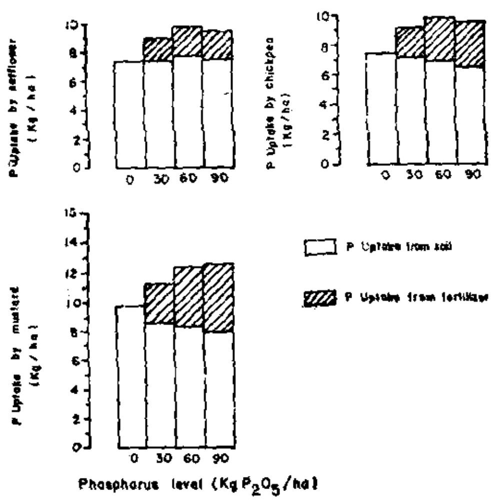

Fig:1 Effect of phosphorus levels on soil and fertilizer P uptake by chickpea, mustard and safflower crop.

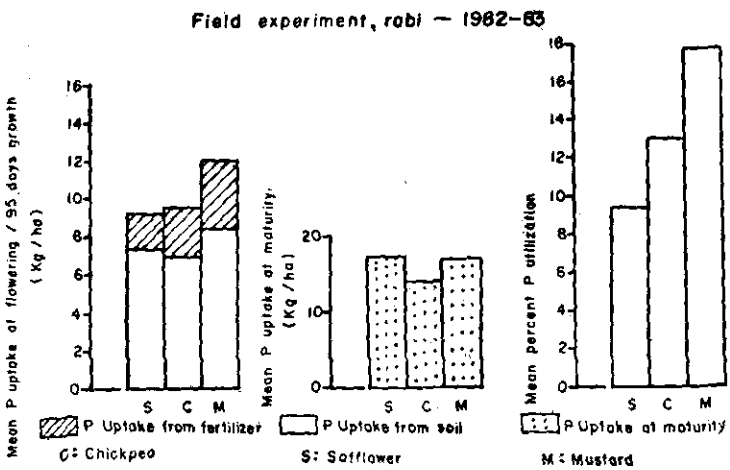

Fig. 2: Relative efficiency of utilization by chickpea, mustard and safflower crops.

As observed by other workers (Sharma and Verma 1982; Gangasaran and Kinra, 1979) in this investigation also, grain yield response per kg of applied P was higher at lower rate of P application invariably in all the three crops. The data further showed that all the three crops responded to application of phosphate, though the magnitude of response varied from crop to crop. Positive yield response of these crops to phosphate fertilisation have been reported by many workers (Panwar et al. 1977, Holmes and Aimsley, 1978).

Per cent Pdff, soil and fertilizer P uptake and per cent P utilization

Per cent P utilization declined steadily and significantly from 23.0 to 12.2 in mustard, 18.2 to 8.3 in chickpea and 13.7 to 6.0 in safflower with increasing levels of phosphate from 30 to 90 kg P_2O_5/ha. However, per cent P derived from fertilizer (%Pdff) as well as fertilizer P uptake increased significantly in each crop following the application of phosphate upto 60 kg P_2O_5/ha (Table 4 and Fig. 1). Nevertheless, crop species showed considerable difference in their ability to exploit applied source. Consequently, mean fertilizer P uptake and mean % P utilization were the highest in mustard followed by chickpea and safflower (Fig. 2).

The results from the radiochemical analysis further showed that mustard had the highest mean soil P uptake and the chickpea the least, while safflower was the intermediate in this respect (Fig. 2). These observations thus confirm that the plant species differ markedly in their capacity to extract P from the available pool of the soil. Such differential behaviour of crop species could be attributed to the differences in the nature of crop plant, duration of crop and extent of root development and other plant root parameters like CEC, root supplying power etc. (Kalra and Soper, 1968; Clark, 1983). Evidently mustard utilized applied phosphorus more efficiently whereas safflower utilized native soil source better as compared to chickpea. The findings from this investigation may be used in the selection of crops in a cropping sequence for effecting economy in fertilizer use.

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RESPONSE OF *TORIA* TO IRRIGATION AND NUTRIENTS

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ABSTRACT

A field experiment on toria was conducted during 1988-89 and 1989-90 to evaluate the effect of different levels of irrigation and nutrient application. Application of three irrigations at 20, 40 and 60 days after sowing contributed significant increase in yield, yield attributes and oil content. The highest net returns (Rs. 3244/ha) were also obtained with three irrigations. Application of 80,40,20 and 30 kg/ha N, P_2O_5, K_2O and sulphur gave significant increase in yield, and oil content of toria and the highest net returns of Rs. 2930/ha were also obtained with this treatment.

Key words: Irrigation, Nutrient application, *Brassica compestris* var. *toria*.

INTRODUCTION

Toria (*Brassica compestris* var. *toria* Duth and fully) is an important mid season (semi-*rabi*) oilseeds (40 to 44% oil) crop in north India. Average yield of *toria* in India is very low as compared to other oilseeds because it is mostly grown rainfed without or very little fertilization. Response of *toria* to sulphur in addition to major nutrients has been reported by many workers (Singh 1986, Rai and Kumar 1980 and Choudhary and Sharma 1983). Therefore, the present investigation was undertaken to evaluate the effect of irrigation and nutrient application on the yield of *toria*.

MATERIALS AND METHODS

The experiment was conducted in split plot design with four replications during *rabi* seasons of 1988-89 and 1989-90 at the Jawahatlal Nehru Krishi Vishwa Vidyalaya, Regional Agricultural Research station, Tikamgarh (M.P.). Soil was clay loam in texture, slightly alkaline in reaction (PH 7.7.), Medium in available nitrogen and potash (315 kg/ha N and 240 kg/ha k_2O) and low in available phosphorus and sulphur (8 kg/ha P_2O_5 and 9 ppm sulphur). Average value of field capacity, permanent wilting point and bulk density in 0-30 cm. soil layer were 30.2%, 15.2%, and 1.4g/cc respectively. Four levels of irrigation in main plots (no irrigation, one, two and three irrigations 20,20 and 40 and 20, 40 and 60 days after sowing) and five levels of nutrient application (control, 80:0:0, 80:40:0, 80:40:20 and 80:40:20:30 NPKS kg/ha) in sub plots were on a plot size of 15 m^2. *Toria* (CV.T-9) was sown in 30cm apart in rows on 16 and 18 September and harvested on 16th December during both years. The entire dose of fertilizer as per treatments was applied basally. Required quantity of sulphur was applied through single super phosphate and application of nitrogen and phosphorus was adjusted through urea and Diammonium phosphate.

The land received sufficient rainfall in both the years during land preparation just before sowing, so no pre-sowing irrigation was applied for germination. A measured

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quantity of 75 mm of water was applied in each irrigation. The rainfall of 81.4 mm and 44.1 mm was received in the month of September in the two years respectively.

RESULTS AND DISCUSSION

In both the years, the effects of irrigation and levels of nutrient application were found statistically significant and the interaction was not significant.

Effect of irrigation

The differences in seed yield due to irrigation were significant over no irrigation in both years. The data (Table-2) indicate that three irrigations at 20,40 and 60 days after sowing gave significantly higher yield than two irrigation at 20 and 40 days after sowing and one irrigation at 20 days after sowing due to combined effect of increased number of siliquae, number of seeds per siliqua and 1000 seed weight which resulted in higher seed yield under three irrigations. Two irrigations gave significantly higher yield over one irrigation which inturn was also significantly superior as compared to no irrigation in 1988-89. In 1989-90, two irrigations gave significantly higher yield over no irrigation and was at par with one irrigation. Three irrigations contributed significantly more to height, primary and secondary branches per plant, siliquae per plant, seeds per siliqua and 1000 seed weight over no irrigation in both years. Application of one (20 DAS) and two irrigations (20 and 40 DAS) treatments also contributed significantly to the yield attributing characters in both the years except primary branches per plant during 1988-89 (Table-1). Samui *et. al.* (1986) observed that supply of water in requisite amounts improved the yield attributing characters of mustard which finally increased the seed yield over no irrigation.

Oil percent (Table-2) in seeds had also significant variations due to irrigation treatments in both years. However, irrigation applied at 20, 40 and 60 days after sowing gave the highest oil content (42.9%) followed by two and one irrigations. Without irrigation the oil content was the lowest (41.45%). Probably due to the fact that lipid synthesis was better with optimum moisture supply. Samui *et al.* (1986) reported that oil content of mustard seed was improved due to irrigation.

Effect of nutrient application:

All the levels of nutrient application recorded significantly higher yield of *toria* than control in both the years (Table-2). Application of 80,40,20 and 30 kg/ha N, P_2O_5, K_2O and S respectively enhanced the yield significantly over the rest of nutrient levels in both years. Application of 30kg sulphur with NPK treatment gave 29 percent in 1988-89 and 28 percent in 1989-90 higher yield over 80,40 and 20kg/ha, N, P_2O_5 and K_2O level respectively. Application of nitrogen, phosphorus, potash and sulphur 80+40+20 +30 kg/ha respectively also contributed significantly to yield attributing characters of *toria*. Singh *et al.* (1970) and Pathak (1975) reported that growth and yield attributes increased with the application of sulphur with nitrogen and phosphorus.

TABLE 1. Effect of irrigation and nutrient application levels on height, primary, secondary branches per plant and siliqua per plant of toria.

Treatments	Height		Primary branches per plant		Secondary branches per plants		Siliquae per plant	
	1988–89	1989–90	1988–89	1989–90	1988–89	1989–90	1988–89	1989–90
A. Irrigation								
No irrigation	82.62	75.66	7.75	3.18	8.85	9.67	65.93	61.00
One irrigation (20 DAS)	92.67	85.66	7.66	6.18	11.49	11.20	101.50	88.33
Two irrigations (20, 40 DAS)	101.75	97.83	8.43	8.96	15.75	14.39	123.73	113.82
Three irrigations (20,40,60 DAS)	111.75	105.00	8.69	10.71	21.73	18.23	189.50	136.16
S.E. (m) ±	1.39	4.76	.95	0.47	1.42	1.36	9.70	6.11
C.D. (5%)	4.86	14.62	NS	1.47	4.27	4.08	33.57	18.29
B. Nutrient application (N P K S kg/ha)								
0 : 0 : 0	81.12	76.26	6.65	5.88	10.65	9.27	81.00	87.00
80 : 0 : 0	96.97	80.12	7.15	7.39	11.49	10.69	109.00	96.44
80 : 40 : 0	99.99	82.12	7.86	8.37	13.80	10.84	134.75	112.00
80 : 40 : 20	101.28	85.67	8.74	8.77	15.75	11.49	138.00	119.22
80 : 40 : 20 : 30	105.41	105.12	8.95	9.85	18.15	14.67	162.00	149.04
S.E. (m) ±	0.71	3.38	0.04	0.99	0.19	0.07	4.63	6.83
C.D. (5%)	2.23	11.14	0.14	2.97	0.69	0.24	13.60	20.49

TABLE 2. Effect of irrigation and nutrient application levels on the yield, seeds per siliqua, test weight and oil per cent of toria.

Treatments	*Yield kg/ha*		*Number of seeds per siliqua*		*Test weight (g)*		*Oil %*	
	1988–89	1989–90	1988–89	1989–90	1988–89	1989–90	1988–89	1989–90
A. Irrigation								
No irrigation	298	282	20.37	14.60	2.25	2.80	42.30	40.60
One irrigation (20 DAS)	399	489	25.37	19.47	2.56	3.00	42.45	40.96
Two irrigations (20,40 DAS)	598	680	27.37	21.24	2.68	3.10	42.65	41.58
Three irrigations (20,40,60 DAS)	990	998	30.31	26.49	2.95	3.32	43.86	41.95
S.E. (m) ±	13.91	68.27	1.23	1.30	0.05	0.09	0.12	0.05
C.D. (5%)	45.13	213.00	3.67	3.93	0.16	0.29	0.30	0.16
B. Nutrient applications (NPKS kg/ha)								
0 : 0 : 0	299	389	21.32	21.92	2.13	2.75	42.01	41.02
80 : 0 0 :	449	495	23.83	24.00	2.55	2.99	42.44	41.30
80 : 40 : 0	628	679	26.58	25.05	2.60	3.08	42.89	41.83
80 : 40 : 20	688	732	30.83	27.45	2.63	3.22	43.19	41.92
80 : 40 : 20 : 30	889	937	35.85	28.35	2.80	3.29	44.09	42.14
S.E. (m) ±	16.44	35.52	1.64	0.87	0.027	0.04	0.18	0.072
C.D. (5%)	48.16	95.54	4.77	2.70	0.059	0.14	0.47	0.226

DAS = Days after sowing

TABLE 3. Economics of irrigation and nutrient application treatments

Treatments	Yield kg/ha	Cost of cultivation Rs/ha	Gross return Rs/ ha	Net return Rs/ha
A. Irrigation				
No irrigation	290	1970	1740	— 230
One irrigation	439	2220	2634	+ 414
Two irrigations	639	2470	3834	+1364
Three irrigations	994	2720	5964	+3244
B. Nutrient application				
0 : 0 : 0	344	1872	2064	+ 192
80 : 0 : 0	472	2272	2832	+ 560
80 : 40 : 0	653	2509	3918	+1409
80 : 40 : 20	710	2530	4260	+1751
80 : 40 : 20 : 30	913	2548	5478	+2930

Sale rate of toria - Rs. 6/kg

(—) Not profitable

(+) Profitable

Whereas application of 80+40+0 kg of N, P_2O_5, K_2O respectively resulted in an increase in grain yield by 40 percent in 1988-89 and 37 percent in 1989-90 over 80+0+0kg/ha N, P_2O_5 and K_2O respectively. The beneficial effect of phosphorus on seed yield is also reported by Mudholkar and Ahlawat (1981). An addition of 20 kg/ha K_2O with 80+40 kg/ha N and P_2O_5 respectively showed significant effect on yield of *toria* in 1988-89. This shows that to exploit full yield potential, balanced nutrition is necessary. The importance of balanced fertilization in mustard is also emphasised by Pathak *et al.* (1963) and Tomar *et al.* (1980).

The oil content in seed is greatly influenced by nutrient application. Application of 80+40+20+30 kg/ha N, P_2O_5, K_2O and S respectively gave significantly higher oil content over all the treatments. Singh (1986) reported that sulphur contributed significant increase in oil content of oil seeds.

Economics:

In average, data of two years it was observed that (Table-3) the three irrigations gave the highest net return (Rs. 3244/ha) followed by two irrigation (Rs. 1364/ha) and one irrigation (Rs. 414/ha). Without irrigation *toria* is not profitable. Application of 80:40:20:30 kg/ha NPK and S respectively gave the highest net return (Rs. 2930/ha) followed by 80:40:20 (Rs. 1751/ha), 80:40:0 (Rs. 1409/ha), 80:0:0 (Rs. 360/ha) NP and k respectively and without fertilizer (Rs.192/ha).

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WHAT CATAPULATED THE VEGETABLE OILSEEDS SECTOR FROM OUT OF ITS DECADE OLD INERTIA? TWO SUCCESSIVE GOOD MONSOONS OR WONDER TECHNOLOGIES.....?

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The green revolution which swept food crops in late sixties and early seventies and brought in its wake dramatic improvements in their output, left the oilseed group of crops totally untouched and unaffected (Table-1). Between 1967-68 and 1986-87 the aggregate output of 9 annual oilseeds comprising the 7 edible oilseeds namely, groundnut, rapeseed mustard, sesame, niger, sunflower, safflower and soybean and the two industrial oilseeds namely, castor and linseed registered only 2.79 million tonnes increased output which works out to a mere 1.8 per cent increase per annum. As against this, the production of wheat and rice went up nearly three and two fold respectively and the aggregate output of all food crops shot up from 95.05 million tonnes in 1967-68 to as much as 143.42 million tonnes by 1986-87. Equally impressive was the growth in the productivity of food crops which increased at an annual compound growth rate of 2.10% per annum since late sixties (production: +12.68%). The performance is even more impressive in crops such as wheat whose per hectare yields registered more than 74% increase during the last two decades.

The continued stagnation in one of the country's crucial sectors namely vegetable oilseeds even 40 years after country's independence in the face of rapidly widening demand-supply gap and the burgeoning import bill which touched a staggaring figure of Rs. 3844 crore. between 1981-86 has no suprise, prompted many a quarter attribute the worsening situation to non-existence of any worthwhile and innovative technological breakthroughs on oilseeds front akin to the one witnessed in cereals more particularly wheat and rice.

Contrary to the wide spread scepticism, the situatuion on the oilseed front however, improved dramatically since 1987-88. For the first time, the country's total output of oilseeds moved out of the decade old ceiling of 11-12 million tonnes and staged a record level of around 18 million tonnes by 1988-89 which infact marks an increase of 41% over the previous best of 13 million tonnes registered in 1983-84 and 44% over that of 1987-88. What is most imporatnt, the positive tempo in oilseeds production unleashed by the mission-mode approach of Technology Mission on Oilseeds cutting across departmental brarriers continued unabated for the second (16.7 million tonnes) and 3rd successive years i.e. 1990-91 (estimated production: 16.9 million tonnes).

The positive signs of transformation in the vegetable oilseeds scenario are visible in almost all important annual oilseeds (Table-2) and major oilseeds growing states

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TABLE 1. Growth of oilseeds vis-a-vis food crops during 1967-68 to 1986-87

Crop	Area in million Ha		Production in million tonnes		Productivity Kg/ha	
	1967–68	1986–87	1967–68	1986–87	1967–68	1986–87
Rice	36 44	41.17	37.61	60.56	1032	1471
Wheat	15.00	23.13	16.54	44.32	1103	1916
Cereals	98.77	104.04	82.95	131.71	840	1266
Pulses	22.65	23.16	12.10	11.71	534	506
Foodgrains	121.42	127.19	95.05	143.42	783	1128
Groundnut	7.55	6.98	5.73	5.87	759	941
Rapeseed	3.24	3.72	1.57	2.61	483	700
Total Oilseeds	16.65	18.63	8.48	11.27	509	605

TABLE 2. Growth of oilseeds output prior to and after 1986: A comparative analysis*

Crop	Production in lakh tonnes (1)	(2)	Area in lakh *hectares* (1)	(2)	% increase in production	%*increase due to* Area	Yield	Joint effect
KRF. Groundnut	45.76	58.24	61.95	66.27	27.28	6.98	18.98	1.32
R/S Groundnut	16.38	19.69	10.82	13.49	20.16	24.64	-3.59	-0.88
TOT. Groundnut	62.14	78.09	72.77	79.75	25.67	9.58	14.68	1.41
Soybean	8.64	14.14	11.40	18.03	63.56	58.17	3.40	1.98
Sesame	5.27	6.35	21.79	23.36	20.49	7.20	12.40	0.89
KRF. Sunflower	2.04	2.99	5.73	7.21	46.33	25.77	16.35	4.21
Rabi Sunflower	1.36	2.64	3.04	5.66	93.87	86.09	4.18	3.60
TOT Sunflower	3.40	5.66	7.61	12.86	66.31	68.99	-1.59	-1.09
Castor	3.94	3.69	6.44	6.14	-6.51	-4.56	-2.04	0.09
Niger	1.72	1.74	6.08	6.20	1.36	1.97	-0.60	-0.01
Rapeseed	27.87	40.69	39.47	48.08	45.98	21.81	19.84	4.33
Safflower	4.55	4.34	8.86	8.98	-4.62	1.35	-5.89	-0.08
Linseed	4.03	3.65	14.35	11.79	-9.51	-17.88	10.19	-1.82
KRF Oilseeds	67.70	85.90	112.30	125.90	26.88	12.11	13.18	1.60
RABI Oilseeds	53.80	71.67	75.60	89.37	33.21	18.21	12.69	2.31
All nine annual Oilseeds	121.50	158.30	187.90	215.27	30.29	14.56	13.72	2.00
Cottonseed	23.96	25.02	75.45	69.73	4.40	-7.59	12.96	-0.98

(1) = *Pre-mission period (Average of 1983-86)

(2) = Post mission period (Average of 1989-90)

TABLE 3. **Changing scenario on the indigenous oilseed front in different states: Recent trends in the area and production***

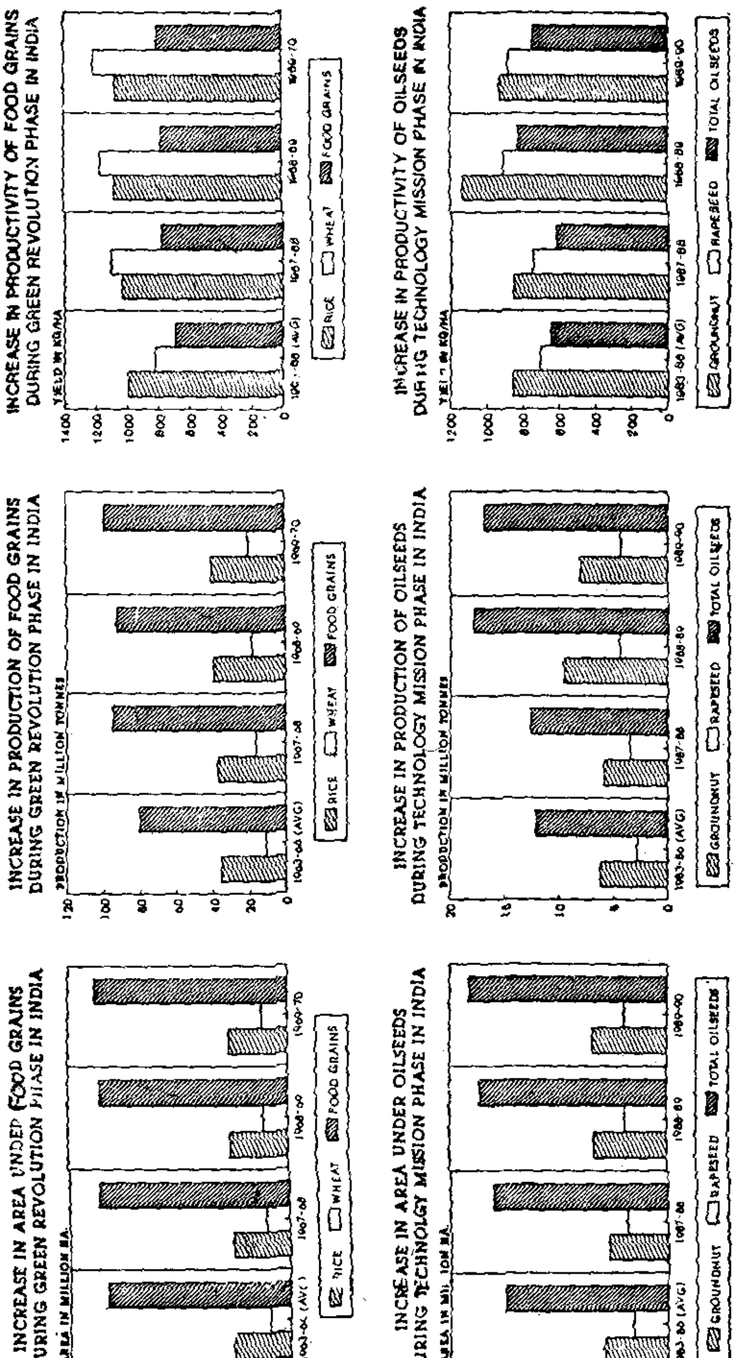
State	Production in lakh tonnes		Area in lakh hectares		%increase in production	% increase due to		
	(1)	(2)	(1)	(2)		Area	Yield	Joint effect
Andhra Pradesh	15.49	22.04	22.27	28.35	42.31	27.32	11.77	3.22
Assam	1.47	1.83	3.25	3.65	24.55	12.42	10.78	1.34
Bihar	1.37	1.27	2.41	2.27	-7.06	-5.82	-1.32	0.08
Gujarat	18.24	21.57	25.62	22.12	18.25	-13.66	36.96	-5.05
Haryana	2.51	4.09	2.95	3.79	62.82	28.36	26.84	7.61
Karnataka	11.42	14.85	17.06	24.26	30.00	42.18	-8.57	-3.62
Madhya Pradesh	13.30	20.70	25.93	31.45	55.63	21.30	28.29	6.03
Maharashtra	12.72	16.18	22.27	26.12	27.14	17.26	8.43	1.45
Orissa	7.71	8.47	9.66	10.88	9.85	12.63	-2.47	-0.31
Punjab	1.72	2.24	1.87	2.28	30.49	22.14	6.83	1.51
Rajasthan	10.18	16.55	17.85	21.76	62.66	21.90	33.44	7.32
Tamil Nadu	11.05	12.47	10.98	12.70	12.88	15.70	-2.43	-0.38
Uttar Pradesh	11.01	10.84	21.25	18.65	-1.51	-12.24	12.22	-1.50
West Bengal	2.22	4.40	3.73	5.41	98.35	44.95	36.84	16.56

* (1) = Pre mission period (Average of 1983-86)

(2) = Post mission period (Average of 1987-90)

TABLE 4. **Behaviour of monsoons and their impact on aggregate oilseeds output during the period 1983-1990.**

Year	No. of meterological sub-divisions with normal/excess rainfall	Total of production of oilseeds (in lakh tonnes)
1983–84	91	126.9
1984–85	74	129.5
1985–86	74	108.3
1986–87	60	114.5
1987–88	40	123.8
1988–89	94	178.9
1989–90	83	169.5


INCREASE IN AREA UNDER FOOD GRAINS DURING GREEN REVOLUTION PHASE IN INDIA
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YIELD IN KG/HA
RICE
WHEAT
FOOD GRAINS
INCREASE IN AREA UNDER OILSEEDS DURING TECHNOLOGY MISSION PHASE IN INDIA
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INCREASE IN PRODUCTIVITY OF OILSEEDS DURING TECHNOLOGY MISSION PHASE IN INDIA
GROUNDNUT
RAPESEED
TOTAL OILSEEDS
1987-88
1988-89
1989-90

FIGURE - 1

(Table-3 . The improvement in the aggregate output of oilseeds are however, more pronounced in crops like rapeseed-mustard, soybean whose annual output rose by 18.1 (=69.4% increase over 1986-87) and 9.5 lakh tonnes (=107% increase over 1986-87) respectively within a span of 2-3 years only. Similarly, some of the states like West Bengal, Rajasthan, Haryana, Madhya Pradesh and Andhra Pradesh surpassed a numbei of other Important oilseed growing states in their performance.

Data presented in Tables 2 and 3 indicate that increase in acreage is not wholly responsible for the observed improvements in the output of oilseeds. In fact, more than 50% of the increased output over the pre-mission era (1983-86) owes to improvements in per hectare yields *per se* and its interaction with area. For instance, when compared to 1985-86 the national average productivity of crops such as rapeseed-mustard, soybean, groundnut in the year 1988-89 went up by 35% (=907 kg/ha); 18.7% (=907 kg/ha) and 57% (=1132 kg/ha) which by any standards is a remarkable feat.

The silent revolution in oilseeds front which in fact, compares closely to what was witnessed on food front two decades ago, went unnoticed and unsung unlike their cereal counterparts like wheat (% irrigated area: 51% in late 60's to 77.3% in 80's) and rice (% irrigated area: 38% in late 60's & to 43.4% in 80's) bulk of whose production comes from irrigation (=oilseeds: 6.1% in late 60's to 18.8% in 80's) and favourable moisture and input conditions (*See fig*.1).

The exceptionally good harvest of oilseeds the countiy could reap during the last two successive years has a significant impact on the country's export earnings. By 1988-89 and 1989-90 the country's imports of vegetable oilseeds plummeted from 18 lakh tonnes valued at Rs. 1060 croies in 1987-88 to as low as 3-4 lakh tonnes (value=Rs. 250-260 crores) by 1988-89 thereby resulting in a net saving of Rs. 800 crores in the annual outgo of foreign exchange reserves. Simultaneously, foreign exchange earnings from exports of oilseeds and oilseeds extractions shot up from Rs. 223 crores in 1986-87 and Rs. 231 crores in 1987-88 to as much as Rs. 496 crores and above in 1988-89 and more than Rs. 840 crores in 1989-90. During the current year, the total export earnings from oilseeds extractions are expected to touch a staggering figure of Rs. 1000 crores or so.

The remarkable achievements of the country's vegetable oilseeds front did not receive the aclaim the food crops received. Far from it there has been utter disbelief at the reported performance on account of continuous skyrocketing and run away prices. More often than not the impressive performance the oilseeds sector staged ovei a short span of 2-3 years it could not achieve foi more than 40 years is a asscribed to the fortuitous and exceptionally favourable and well tailored monsoon the country has been blessed with both in space and time.

Tne above contention is however, not borne out by the past performance of oilseeds under similar situations. Interestingly, the country has experienced an equally favourable monsoon in 1983-84 and to a lesser extent during 1984-85 (Table-4). Notwithstanding the prevalence of such exceptional and bountiful monsoons the output of oilseeds in neither of the above two years exceeded 12.5 to 13 million tonnes.

TABLE 5. **Wholesale prices of some major annual oilseeds vis-a-vis their minimum support prices for the period 1983-1990.**

Crop	Year	Support price (Rs/Q)	Whole sale price (Rs/Q)*
Groundnut in shell	1983-84	315	656
	1984-85	340	619
	1985-86	350	632
	1986-87	370	828
	1987-88	390	1025
	1988-89	430	790
	1989-90	500	923
Rapeseed	1983-84	360	482
	1984-85	385	447
	1985-86	400	447
	1986-87	415	667
	1987-88	430	748
	1988-89	460	615
	1989-90	510	720
Soybean yellow	1985-86	275	280
	1986-87	290	342
	1987-88	300	552
	1988-89	320	525
	1989-90	370	...
Sunflower	1985-86	335	417
	1986-87	350	546
	1987-88	390	662
	1988-89	450	503
	1989-90	530	...
Safflower	1985-86	400	419
	1986-87	415	685
	1987-88	415	822
	1988-89	440	808
	1989-90	490	...
Sesame	1983	...	717
	1984	...	740
	1985	...	694
	1986	...	872
	1987	...	1420
	1988	...	1020
	1989	...	977

* Average prices prevailing during the 1st 3 months after normal harvest.

Source : Agricultural Prices in India and various issues of Agri. situation in India published by Ministry of Agric. and Cooperation.

What is important, the production of oilseeds was maintained close to the previous best of 12.95 lakh tonnes (1984-85) even in one of the most hostile crop growing conditions of 1987-88 when more than 60% of the metereological sub divisions in the country received subnormal rainfall. Obviously, weather was not the sole factor that cliqued in the breakthroughs. What then triggered the remarkable transformation in oilseeds? While no doubt, the country has developed 70 and odd high yielding varieties of various oilseed crops since the setting up of Technology Mission on Oilseeds in May, 1986, it would however, be too premature to except them make any significant dent on oilseeds production within such a short span of two years considering the long gestation period involved between release of varieties and their actual spread to farmers, fields. Nevertheless, there has never been a dearth of improved cultivars. Between early seventies and mid eighties the country has released as many as 162 high yielding varieties and hybrids of specific regional and multi-regional importance which are capable of giving 20-40% more yields than the corresponding regional or national checks. Besides these, researches launched since early seventies under the co-ordinated research project also resulted in the identification and development of a large number of low cost and cash options for stepping up the production of oilseeds through vertical as well as horizantal means. Until 1986, bulk of these imporved technologies were however, found languishing in the laboratories for want of takers because of a multitude of factors viz. (1) unfavourable pricing policy and fluctuations in oilseeds prices in space and time to the disadvantage of the farmers (2) limited developmental support in oilseeds (3) non-availability of quality seed of high yielding varieties in sufficient quantities at the right time (4) low investment capacity of bulk of the oilseed farmers who are marginal and submarginal (5) predominant cultivation of oilseeds under rainfed (=86%) and input starved conditions. Since 1987-88 the climate for oilseeds production has turned out to be highly favourable thanks to the series of integrated and mutually synergistic policies and measures the Technology Mission on Oilseeds has initiated viz., declaration of support prices to oilseeds with assured market support and intervention mechanism, (2) availability of easy credit, supplies and other farmer support services (3) progressive phasing out of imports of vegetable oils and (4) building up of buffer stocks for effective market intervention to prevent steep fall or rise in price below and beyond specific price bands stipulated for major oilseeds. All these measures had a cumulative and favourable effect on the open market prices of oilseeds which always ruled much above the minimum support prices declared by the Government of India from time to time (Table-5). The supply and distribution of certified and quality seed of various high yielding varieties of oilseeds which were less than 6 lakh quintals prior to 1986 went up to 10.73 lakh quintals (=79%) in 1988-89. As a result of various concerted positive measures initiated by the state and Central Governments, the oilseeds farmers received in 1988-89 twice the inputs and services than they had in 1986-87 (=35 crores; 1988-89=67 crores).

Evidently, favourable pricing climate backed up by effective market intervention mechanism is the single most decisive factor which has for the first time enthused farmers shift more and more area from low yielding millets and cereals to oilseeds and resort to increased use of inputs like fertilizers, plant protection, irrigation in conjunction with other low cost inputs like timely planting, choice of right varieties, quality seed etc. The result of the synergistic interplay of right choice of crops, varieties, production and protection technologies, attractive prices, concerted developmental efforts and technologies on the hitherto neglected group of oilseeds, strong farmer support services and above all the remarkable versatility of the Indian farmer to raise to the challenges and opportunities is a bumper harvest in oilseeds combined with increasing resilience in their output.

Judging from the recent track record, ability to maintain oilseeds out-put even under adverse seasonal conditions close to what was realised under the most favourable monsoonal years in the past namely 1983-84 and the extraordinary resilience the oilseed group of crops displayed in recent years to harness fully and effectively the bounties of wayward monsoon there is no room whatsoever, for any scepticism on the country's potentials and capabilities to achieve the much elusive self-reliance in not too distant a future.

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EFFECT OF SALINE WATER IRRIGATION ON INDIAN (*BRASSICA JUNCEA L.* CZERN AND COSS) VARIETIES

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A B S T R A C T

The study on the effect of saline water irrigation on mustard carried over for four years in well drained sandy loam soil indicated that upto EC iw10 dSm^{-1} siliquae/plant and seed yield increased by 6 and 7 percent respectively over the control. Increased level of ECiw beyond 10 dSm^{-1} however, decreased seed yield and at ECiw 18 dSm^{-1}, siliquae/main shoot and seed yield plot decreased to the extent of 7.5 and 14.9% respectively. Among the varieties of mustard, 'Kranti' was found significantly superior when irrigated with saline water of ECiw 10 but beyond that there was no significant difference in yield. Salt accumulation in soil profile was more with high saline water used twice for irrigation during the crop period. Appreciable decrease in salinity was observed before the commencement of the subsequent *rabi* season due to efficiency of sub surface drainage system and leaching of salts from soil profile.

Key words: *Brassica juncea*, Saline water irrigation

INTRODUCTION

In the semiarid areas of the country Indian mustard is grown either as rainfed or with protective irrigation using underground brackish water present at very shallow depth leading to low yields. The information pertaining to critical growth stage and suitable variety tolerant to saline water irrigation is limited. Therefore, the present experiment was undertaken to identify critical growth stage susceptible to saline water irrigation and identify mustard varieties tolerant to salinity.

MATERIALS AND METHODS

Field studies were conducted for 4 years starting from *rabi* 1985-86 to *rabi* 1989-90 at Sampla (Rohtak), the experimental farm of the Central Soil Salinity Research Institute where sub surface tiled drainage system at 1.75 depth was provided. Sampla is semi-arid location with highly erratic mean annual rainfal of about 650 mm. The soil was sandy loam in texture with hydraulic conductivity of 1.15 m/day. The average soil salinity (ECe) at the start of experiment ranged from 2.0 to 3.8 dSm^{-1}. The experiment was planned in split-split design and replicated 3 times. The treatments in addition to presowing irrigation with best available water (BAW, EC 0.8 dSm^{-1}) comprised in the first 2 years, 2 qualities of saline drainage water of EC_{iw} 6 and 10 dSm^{-1} and BAW as control in main plots; flowering (S_1) siliquae formation (S_2) and both flowering and siliquae formation (S_3) of growth stages for irrigation in sub plots and 5 high yielding varieties of Indian mustard namely Pusa Barani, Pusa Bold, Varuna, Kranti and Prakash were randomly placed in sub-sub plots. In the later 2 years (1987-88 and 1988-89 however, two kinds of saline drianage water (EC_{iw} 6 and 10 dSm^{-1}) was replaced by highly saline drainage water of EC_{iw} 12 and 18 dSm^{-1}. The mustard

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variety Prakash was replaced by CS 50. The every year crop was sown in the first week of November after presowing irrigation with BAW and fertilized with N 100 kg/ha as basal dose. Each variety was sown in one row 3.0 m length and spaced 30 cm apart (net plot area $0.9m^2$). After two weeks of sowing plants were thinned to 15 cm spacing. The saline irrigation water of EC_{iw} 6, 10, 12 and 18 dSm^{-1} were prepared by mixing BAW (EC 0.8 dSm^{-1}) with saline drainage water (EC 27 dSm^{-1}, Na^+ 160 meq/lit, $Ca^{++}+Mg^+$ 180 meq/l and Cl^- 321 meq/l.). Soil samples were collected from sub-sub plot from 0-15, 15-30 cm depth at sowing time and upto 60 cm at crop maturity. Data on seed yield and yield parameters (Table 1 and 2) were collected from 3 randomly selected plants. In the later two years however, data on siliquae/main shoot was recorded instead on siliquae/plant. The mean values of 2 years data were subjected to statistical analysis.

TABLE 1. Effect of saline water irrigation on seed yield and yield attributes of raya crop

Treatment	Plant height (cm)	Branches/ plant (NO)	Siliquae/ plant (NO)	Siliqua length (cm)	Seeds/ siliqua (NO)	1000seed wt. (g)	Seed yield (q/ha)
Saline Irrigation water (dSm^{-1})							
0.8 (control)	179	17.2	216	5.1	13.0	4.40	12.7
6.0	182	17.4	205	4.9	12.4	4.35	11.9
10.0	181	16.0	229	5.2	12.9	4.35	13.6
CD P 0.05	NS	NS	NS	NS	NS	NS	NS
Stages of irrigation							
Flowering (s_1)	183	16.7	242	5.1	12.0	4.37	12.3
Siliquae formation (S_2)	180	28.1	280	4.9	12.7	4.32	12.4
Flowering and Siliquae formation (S_3)	179	16.5	235	5.2	12.6	4.40	12.9
CD P 0.05	NS	NS	NS	NS	NS	NS	NS
Varieties							
Pusa-Barani	165	14.4	185	5.6	12.7	5.68	12.7
Pusa Bold	166	15.5	180	5.8	12.8	5.22	12.7
Varuna	174	15.8	188	5.0	11.8	4.57	12.2
Kranti	184	16.9	234	5.0	13.3	3.69	13.8
Prakash	212	22.4	289	4.1	13.0	2.75	12.1
CD at P 0.05	147	4.0	8.91	0.58	0.9	0.69	0.9

Note: All other interactions were insignificant.

RESULTS AND DISCUSSION

Data on yield parameters and seed yield/ha (table-1) revealed that none of the parameters was adversely affected by saline irrigation water upto EC_{iw} 10 dSm^{-1}. Siliquae/plant and seed yield/ha rather increased by 6 and 7 percent respectively over control. However, when salinity of irrigation was more than EC_{iw} 10 dSm^{-1}, a declining trend in parameters was observed (Table 2). The number of siliquae/mainshoot decreased significantly (7.5%) over control with EC_{iw} 18 dSm^{-1}. Seed yield decreased, though, not significantly by 8.0 and 14.9% as compared to EC_{iw} 0.8 when irrigated with EC_{iw} 12 and 18 dSm^{-1} respectively. At moderate to higher salinity levels (ECe

TABLE 2. Effect of high saline water irrigation on growth stages and seed yield of raya varieties.

Treatment	Plant height (cm)	Branches/ plant (NO)	Siliquae/ mainshoot (NO)	Siliquae length (cm)	Seeds/ siliqu (NO)	Seed yield main shoot (g)	1000seed wt. (g)	Seed yield (q/ha)
Saline irrigation water (dSm^{-1})								
0.8 (control)	159	12.4	39.2	5.6	13.2	2.34	5.38	17.8
12.0	165	12.2	37.2	5.5	13.3	2.21	5.31	16.4
18.0	161	12.1	36.3	5.5	13.2	2.01	5.31	15.2
CD at 0.05P	NS	NS	1.45	NS	NS	NS	NS	NS
Stages of irrigation								
Flowering (S_1)	167	11.2	36.4	5.4	13.1	2.13	5.48	16.4
Siliquae formation (S_2)	152	14.3	38.2	5.5	13.3	2.22	5.19	16.8
Flowering and siliquae formation (S_3)	166	11.2	38.2	5.6	13.3	2.21	5.32	16.1
CD	5.2	1.83	NS	NS	NS	NS	0.20	NS
Varieties								
Pusa-Barani	156	11.4	35.8	5.7	13.6	2.45	6.34	16.1
Pusa Bold	155	11.0	33.6	5.7	13.4	2.09	5.34	16.0
Varuna	159	12.0	34.2	5.6	12.3	2.12	5.60	15.9
Kranti	167	13.2	42.3	5.3	13.8	2.17	4.80	16.4
CS 50	171	13.4	42.0	5.2	13.1	2.06	4.51	18.0
CD at 0.05P	6.47	1.70	2.6	0.32	0.62	0.24	0.36	NS

Note: None of the interaction was significant.

4 to 8 dSm^{-1}) salt induced positive effect on yield parameters in mustard has been reported (Narain et al 1979, Rai 1977, 1980, Kumar 1984). Indian rape (*B. Compestris L.* var. *Sarson* Prain) has been reported to be fairly tolerant to saline water irrigation (Ram Deo and Ruhal 1971) and good crop of *raya* could be grown in sandy loam soil with EC_{iw} upto 12 dSm^{-1} (Narain et al 1979). In the present study, no significant adverse effect on seed yield was observed even when the crop was irrigated with EC_{iw} 18 dSm^{-1} possibly because of the presence of Calcium in high concentration which mitigate the adverse effect of sodium chloride on the growth of many crops (Lauchi and Epstein 1984).

The data (Table 1 and 2) clearly showed that when the crop was irrigated with saline water either at S_1 stage or S_2 or S_3 none of the growth stages was adversely affected. The irrigations at growth stages did not influence seed yield also. In mustard high EC water of 12 dSm^{-1} has been reported determental initially and decreased germination by 70% but beneficial later as the seed yield/plant was higher than the control (Rai 1980).

Varieties exhibited significant difference in seed yield upto EC_{iw} 10 dSm^{-1} (Table 1). Mean seed yield in the first two years revealed that the variety Kranti gave significantly high seed yield over others. The difference in seed yield among the varieties could be attributed to genetic variation for tolerance to salinity. Variability with regard to salinity tolerance and increase in seed yield in saline soil in Indian mustard over normal has been reported (Sinha 1986). The interaction effects between saline irrigation water and variety, growth stages and varieties and among all the three factors were insignificant . In the latter two years when the salinity of the irrigation water was increased, seed yield of the varieties did not differ significantly.

TABLE 3. Salt build up in soil profile (0-0cm) with saline water irrigation on mustard crop.

	Soil Salinity (dSm^{-1})			
EC_{iw} of Irrigation water (dSm^{-1})	Initial	Harvest		
		Irrigation stages		
		Flowering	Siliquae formation	Flowering & Siliquae formation
0.8	2.0	3.5	3.4	4.2
6.0	2.8	5.8	4.7	6.7
10.0	2.2	4.4	5.5	5.3
12.0	2.0	4.7	5.8	6.3
18.0	2.3	4.7	6.5	8.5

The average salt accumulation in soil profile (0-30cm layer) was found to be increasing with increasing salinity in irrigation water and further, salt accumulated more where two irrigation of saline water were given to crop (Table-3). The salinity was the highest with EC_{iw} 18 dSm^{-1} water. The salinity however, decreased appreciably before commencement of the following *rabi* season due to efficiency of sub-surface drainage through out the year and presowing irrigation with good quality water which also help in desalinization.

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SUNFLOWER - PIGEONPEA INTERCROPPING

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ABSTRACT

A field experiment on intercropping comprising 3 sunflower and 2 pigeonpea genotypes in different row proportions was conducted to identify suitable combinations of row proportions and genotypes for efficient land utilisation and better economic returns reinfed conditions during kharif 1985 and 1986. Genotypic differences were observed for identifying remunerative sunflower-pigeonpea intercropping system. Short statured and short duration sunflower variety Morden, medium tall and mid durationed sunflower hybrid BSH-1 were found to be more suitable for inter cropping with long durationed pigeonpea variety TTB-7. BSH-1 sunflower hybrid and TTB-7 pigeonpea intercropping in 1:1 row proportion optimal series was found to be highly remunerative. Differental response of the component crops in the intercropping system for the rainfall were observed. The optimal series was found to be advantageous over replacement series.

Key words: Inter-cropping proportions, genotypic selection.

INTRODUCTION

Sunflower has established its place as a newly introduced commercial *kharif* oilseed crop in India and southern states accounts for its major area and production. Pigeonpea is the most important pulse crop of southern India and is largely grown as a mixed crop with other dryland crops ilke *Jowar, bajra,* groundnut and *ragi.* The main constraint for crop production under drylands is the low and poor distribution of rainfall during crop growth periods. Mixed cropping acts as insurance against total failure under aberrant weather (Kaushik *et al.,* 1980 and Venugopal *et al.,* 1990) and may even improve economic returns compared to their sole crops if the moisture conditions are favourable to both components. Success of intercropping mainly depends on crop compatability and moisture availability during crop growth periods. Willey (1981) suggested to select crops of varying duration, so that quick maturing crop completes its life cycle before the grand growth of the other crop starts. Therefore selection of suitable genotypes of crop combination and their planting ratio greatly influences the performances and economic returns of the intercropping systems.

In view of the slow growth rate of pigeonpea in initial stages, it may offer a scope to grow a short duration intercrop like sunflower. With this information in background an experiment on Sunflower-Pigeonpea intercropping under rainfed conditions was conducted to study the performance of component crops, land equivalent ratio and net returns of sunflower-pigeonpea intercropping as influenced by genotypes and planting ratios.

MATERIAL AND METHODS

Field experiments were conducted at the University of Agricultural Sciences, GKVK, Bangalore, under rainfed condition of *kharif* 1985 and 1986, on red loam soil.

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The soil had a pH of 7.1 and electrical conductivity of 0.07 m mohs/cm. The soil was low in organic carbon (0.35%), medium in available K (153 kg/ha) and high in available P (31 kg/ha).

The recommended genotypes of sunflower for Karnataka are EC. 68415 (Tall statured with 100 to 105 days duration) and BSH-1 (Tall statured with 95 to 100 days duration). The former two are open pollinated varieties and BSH-1 is a hybrid. The pigeonpea varieties recommended for Karnataka are Hy-3C (150 to 170 days duration) and TTB-7 (160 to 210 days duration).

Three sunflower genotypes (EC. 68415, Morden and BSH-1) and 2 pigeonpea genotypes (Hy-3C and TTB-7) were tried in 4:2 and 2:4 replacement series combination. These alongwith sole crop of each genotype resulted in 17 treatments. An additional treatment of 1:1 row with optimum population was included with BSH-1 and TTB-7.

In sole croppings, inter-row spacing adopted for Morden was 45 cm and 60 cm for all other genotypes of sunflower and pigeonpea. The intra-row spacing followed was 22.5 cm for pigeonpea and 30 cm for sunflower in both sole and intercroppings. The fertilizer doses followed were 40-50-40 and 25-50-25 kg of N, P_2O_5 and K_2O/ha for sole croppings of sunflower and pigeonpea respectively. The intercroppings received the same fertilizer dose as that of sole sunflower. The N was given in two equal splits to sunflower and entire N at basal dose itself to pigeonpea. The second split of N was given as top dressing to a month old crop of sunflower. In intercroppings, the top dressing of N was restricted only to sunflower component. The crops were sown on 27th and 21st July during 1985 and 1986 respectively. The plot size adopted was $7.2 \times 3.6m = 25.92m^2$. The routine cultural operations and necessary plant protection measures were adopted.

RESULTS AND DISCUSSION

Performance of sunflower and pigeonpea as sole crops

The weekly rainfal distribution during crop growth periods for the years 1985-86 and 1986-87 are presented graphically in Fig. 1. Though the total amount of rainfall was more in 1986-87, the crop yields of both sunflower and pigeonpea were higher in 1985-86 mainly because of better distribution of rainfall. Higher amount of rainfall (152.6mm) in 1985-86 provided better moisture conditions during preflowering state to sunflower as compared to that of 1986-87 (140.1mm). On the other hand, during post-flowering stage of sunflower, the rainfall in 1985-86 (229 mm) was less compared to that of 1986-87 (297 mm). These conditions must have helped for its better performance during 1985-86 (Fig. 1). The better moisture conditions of 1985-86 due to December-January rains (137.8mm) against 53.8mm in 1986-87 helped in growth and yield of pigeonpea. Based on net returns, the performance of sunflower was more stable because of assured normal seasonal rains.

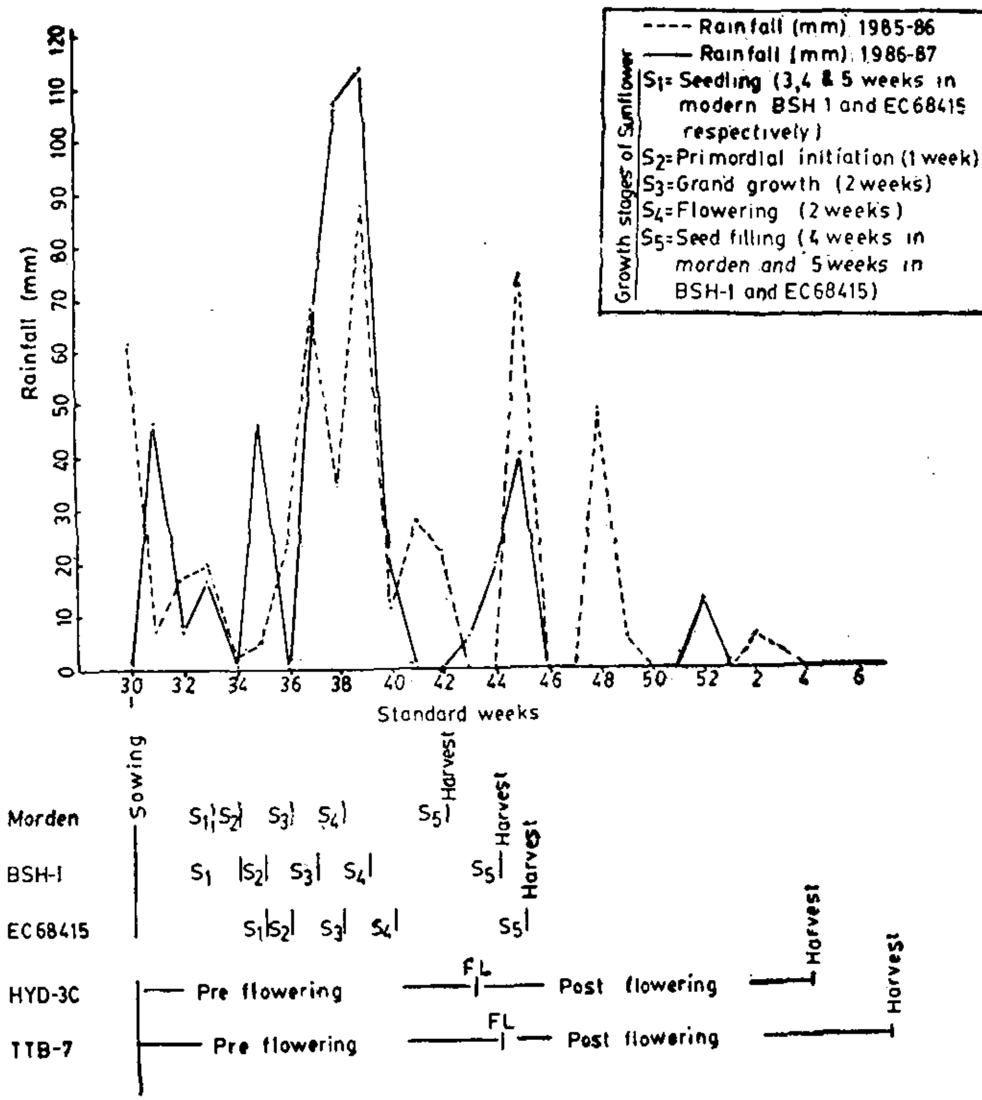

FIG.1. WEEKLY DISTRIBUTION OF RAINFALL DURING CROP GROWTH PERIODS OF SUNFLOWER AND PIGEONPEA

Performance of genotypes as sole crops

On an average of two year EC. 68415 gave 20 per cent higher yield over the mean of genotypes (Table 1).

Pigeonpea genotype TTB-7 gave 10 per cent higher yield over the mean of genotypes (Table 1).

Performance of sunflower-pigeonpea intercroppings

In both the years inter croppings reduced the yields of both components as compared to their respective sole crop yields (Table 2). The yield reductions of sunflower and pigeonpea were 31 and 63 per cent in 4:2 row proportion and 59 and 30 per cent 2:4 row proportions respectively.

When net returns were considered during 1985, the returns were on par between two sole crops and between the intercroppings, but both row proportions were significantly superior over the sole croppings. In 1986 sole sunflower (Rs. 1905/ha) and Sunflower+Pigeonpea (SF+PP) in 4:2 row proportion (Rs. 1978/ha) were on par and both were superior over sole pigeonpea (Rs. 1299/ha) and SF+PP in 2:4 row proportion (Rs. 1451/ha). In general SF+PP in 4:2 row proportion was the advantageous over 2:4 row proportion and sole croppings. Such benefits of higher yields and stable returns in general under intercropping system was also reported by Trenbath (1974). Studies of intercropping sunflower with pulses like cowpea and greengram at Jodhpur (Singh and Singh, 1977), greengram and cluster bean at Hissar (Narwal and Malik, 1986) and blackgram at Belgaum (Umapathy *et al.*, 1980) were also reported to give stable returns.

Sunflower-Pigeonpea genotypes in intercropping systems

The interaction effects with respect to seed yields of sunflower and pigeonpea, net return and LER were significant and the data on these are presented in Table 3. Short statured and short duration sunflower variety Morden, medium tall and mid duration sunflower hybrid BSH-1 were found to be more suitable for intercropping with long duration pigeonpea genotype TTB-7. The intercropping combinations in 4:2 row proportions namely Morden+TTB-7 (Rs. 3201/ha) and EC. 68415+TTB-7 (Rs. 3783/ha) significantly produced higher net returns as compared to their sole crops viz., EC. 68415 (Rs. 3014/ha), Morden (Rs. 1019/ha) and TTB-7 (Rs. 2706/ha) during 1985 which was a favourable rainfall year. In the subsequent year, in general though net returns were higher in the above intercropping system as compared to their sole crops, the differences were not significant.

Incidentaly an optimal series of inter cropping Combination comprising only BSH-1 among sunflower genotyeps with TTB-7 in 1:1 row proportion tried was found to be significantly superior over all other treatments. This optimal series combination during both the years produced significantly the highest net returns (Rs. 5273

TABLE 1. **Productivity and net returns of recommended genotypes of sunflower and pigeonpea.**

Genotypes	Seed yield (kg/ha) 1985 Kharif	1986 Kharif	Mean	Net return (Rs/ha) 1985 Kharif	1986 Kharif	Mean
A. **Sunflower**						
EC. 68415	1046	921	984	3014	2603	2809
BSH-1	880	780	830	2167	1839	2003
Morden	614	644	629	1019	1274	1147
C.D. (P=0.05)	78	106		451	590	
B **Pigeonpea**						
TTB-7	1215	956	1086	2706	1684	2195
Hyd-3C	1007	764	886	1876	915	1396
C.D. (P=0.05)	82	120		451	590	
C. **Averaged over genotypes**						
Sunflower	847	782	815	2066	1905	1986
Pigeonpea	1111	860	986	2291	1299	1795
C.D. (p=0.05)	-	-		NS	341	

Economics based on selling rates of sunflower seed @ Rs. 475 and 500 per quintal during 1985 and 1986 respectively and Pigeonpea seed @ Rs. 375 per quintal during both the years.

TABLE 2. **Productivity and net returns of sunflower (SF) + Pigeonpea (PP) intercropping in two row proportions compared to their sole croppings.**

Parameter	Sole SF.	Sole PP.	SF+PP in 4:2 rows	SF+PP in 2:4 rows	C.D. (P=0.05)
Seed yield (kg/ha)					
Sunflower					
1985	847	—	559	304	55
1986	782	—	568	306	75
	815	—	564	305	
Pigeonpea					
1985	—	1111	505	889	41
1986	—	860	302	496	98
Mean	—	986	404	693	
Net returns (Rs/ha)					
1985	2066	2291	2615	2890	319
1986	1905	1299	1978	1451	351
Mean	1986	1795	2297	2171	

TABLE 3. Productivity, net return and land equivalent ratio of sunflower + pigeonpea as influenced by genotypes and row proportions

		Seed yield in kg/ha						Net Return (Rs./ha)			LER		
		Kharif 1985		Kharif 1986		Mean		Kharif	Kharif		Kharif	Kharif	
		SF	PP	SF	PP	SF	PP	1995	1986	Mean	1985	1986	Mean
Sole Morden		614	—	644	—	629	—	1019	1274	1147	1.000 •	1.000	1.000
Sole EC. 68415		1046	—	921	—	984	—	3014	2603	2809	1.000	1.000	1.000
Sole BSH-1		880	—	780	—	830	—	2167	1837	2002	1.000	1.000	1.000
Sole Hyd-3C		—	1007	—	764	—	886	1876	915	1396	1.000	1.000	1.000
Sole TTB-7		—	1215	—	956	—	1086	2706	1684	2195	1.000	1.000	1.000
Morden + Hyd-3C	4:2	432	300	460	316	446	308	1265	1399	1332	1.001	1.093	1.047
	2:4	323	685	296	508	310	597	2217	1448	1833	1.208	1.135	1.172
Morden + TTB-7	4:2	546	671	562	279	554	475	3201	1930	2566	1.449	1.186	1.318
	2:4	225	997	252	499	239	748	2951	1225	2088	1.195	0.932	1.064
EC. 68415 + Hyd-3C	4:2	603	257	620	269	612	263	1893	2121	2007	0.834	1.161	0.998
	2:4	285	547	327	437	306	492	1486	1305	1396	0.817	0.941	0.879
EC. 68415 + TTB-7	4:2	613	743	572	329	593	536	3783	2130	2957	1.201	1.024	1.113
	2:4	346	1084	289	539	318	812	3818	1506	2262	1.226	0.917	1.072
BSH-1 + Hyd. 3C	4:2	630	392	608	270	619	331	2488	2028	2258	1.109	1.136	1.123
	2:4	271	830	354	484	313	657	2562	1694	2128	1.134	1.090	1.112
BSH-1 + TTB-7	4:2	527	669	586	347	557	508	3058	2262	2660	1.158	1.128	1.143
	2:4	371	1188	316	507	344	848	4308	1525	2917	1.408	0.958	1.183
	1:1	735	990	648	499	692	745	5273	3130	4203	1,653	1.370	1.512
C.D. (P=0.05)		78	82	106	120	143	170	451	590	942	0.13	0.21	0.28
C.V. (%)		8.90	6.34	12.3	15.4	14.0	14.0	9.97	19.98	21.58	6.65	12.04	12.85
C.D. (P=0.05) Between years						51	62			314			0.09

and 3130/ha in 1985 and 1986 respectively) and greater Land Equivalent ratio (LER) (1.65 and 1.37 in 1985 and 1986 respectively) over other intercroppings and sole croppings. Such improvements in returns and Land Equivalent ratio (LER) in sunflower+groundnut intercropping in different patterns under rainfed conditions were also reported by Nikam *et al* (1986) and in sunflower+pigeonpea intercropping in seasons favourable to one of the crop component only by Venugopal *et al.* (1990).

Conclusion and Recommendations

The above results clearly indicate that intercropping combinations of either BSH-1/Morden sunflower genotypes with TTB-7 pigeonpea genotype in 4:2 row proportions can be recommended for efficient utilisation of land and rainfall and for obtaining higher net returns.

Incidentally an optimal series of intercropping combination of BSH-1 with TTB-7 in 1:1 row proportion was found to be significantly superior over all other treatments. However, this needs further investigation in comparison with Morden for further confirmation.

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EFFECT OF DIFFERENT SEED DRESSING FUNGICIDES AGAINST CERTAIN SEED-BORNE FUNGI OF GROUNDNUT*

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ABSTRACT

Out of the five fungicides tested *in vitro*, Carbendazim was proved to be the most effective in inhibiting the growth of four fungi viz., *Aspergillus niger*, *A. flavus*, *A. terreus* and *Rhizoctonia bataticola* followed by carbendazim + thiram, and captan. But *in vivo* studies on seedling vigour revealed that carbendazim + thiram was effective in enhancing seed germination, shoot and root growth and total dry weight per plant as composed to other treatments

Key words: Seed borne fungi, Seed treatments, Groundnut.

INTRODUCTION

Disease is one of the constraints of production in groundnut. Mycoflora associated with groundnut seeds are assuming importance since they play an important role in causing seed rots, roots rots, seedlings blight and leaf spot diseases. In view of serious yield losses caused by seed-borne fungi due to reduced plant stand and seedling vigour in groundnut, many systemic and non-systemic fungicides were tested for their efficacy in inhibiting the growth of seed-borne fungi *in vitro* and *in vivo* (Krishnamurthy, 1975; Lalitha Kumari *et al.*, 1970; and Patil and Rane, 1982). Present investigation was carried out to assess the effect of different seed-dressing fungicides against seed-borne fungi of groundnut.

MATERIALS AND METHODS

Fungicidal treatments used in the present investigation are carbendazim, carbendazim + thiram (25% a.i. + 75% a.i.) thiram (75% WP), Captan (75% WP) and cooper oxychloride (50% Wp). All the five fungicides were tested against the following seed-borne fungi viz., *Aspergillus niger*, *A. flavus*, *A. terreus* and *Rhizoctonia bataticola in vitro* and *in vivo*.

Inhibition zone technique was adopted for *in vitro* testing of fiungicides. Fungal suspensions of *A. niger*, *A. flavus*, *A. terreus* and *Rizoctonia bataticola* were prepared by adding 10 ml of sterile water to 10 day old culture tubes. One ml each of the suspesnions was poured and spread uniformly over the hardened surface of PDA medium. The groundnut seed treated with respective test fungicides @ 2 g/kg of seed was kept in the centre of the petriplate and incubated at room temperature. Three replicates were maintained for each treatment. Suitable controls were also maintained. Inhibition zone developed around the treated seed in each plate was measured in cms after 72 hours of incubation.

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In vivo effect of fungicides was carried out by treating seeds of groundnut variety Kadiri-3 with respective test fungicides @ 2 g/kg of seed. The treated seeds were sown in pots containing autoclaved soil in green house with suitable controls. Three replicates were maintained for each treatment. Germination percentage was recorded upto fifteen days of sowing Percent increase in germination over control was calculated by using the formula

$$I = \frac{100\,(T\text{-}C)}{C}$$

Where

I = Percent increase

T = Percent germination in treatment

C = Percent germination in control

Twenty days after sowing, the seedlings were uprooted and observations on root and shoot elongation and toral dry weight were recorded. Percent increase of shoot length, root length and total dry weight over control was calculated by using the above formula.

RESULTS AND DISCUSSIONS

The data revealed that carbendazim was found to be most effective and significantly superior in inhibiting the growth of *Asperqillus niger*, *A. flavus*, *A. terreus* and *Rhizoctonia bataticola* with an inhibition zone of 2.9, 2.8, 3.6 and 4.8cm respectively followed by carbendazim + thiram with an inhibition zone 1.9, 2.3, 3.3, and 4.5 cm respectively. Copper oxychloride was found to be in-effective in inhibiting the growth of four fungi tested and was on par with control (Table 1). The inhibition of four fungi by carbendazim treatment reveals the ability to kill such seed-borne pathogens. Sole treatment of thiram (Lalitha Kumari *et al*, 1972) and of carbendazim, (Rao, 1972) have been reported earlier in controlling seed-borne pathogens of groundnut more effectively.

From the data presented (Table 2) it is evident that germination, shoot length, root length and total dry weight per plant increased significantly in all the fungicides tested. Carbendazim + thiram was found to be the most effective in increasing the germination, shoot length, root length and total dry weight by 20,21,43,24.41 and 47.72 percent over control respectively, followed by carbendazim, thiram, captan and cooper oxychloride.

In the present studies, a combination of carbendazim + thiram (systemic fungicide + non-systemic fungicide) was found to be the most effective than the other

TABLE 1. *In vitro* effect of fungicides against seed-borne fungi of groundnut

S. No.	Fungicide and concentration	*Inhibition zone in cms after 72 hours of inoculation with				* F. test	C.D.
		Aspergoillus rizer	*A. flavus*	*A. terreus*	*Rhizoctonia bataticola*		
1.	Carbendazim + thiram (2 g/kg of seed)	1.9	2.3	3.3	4.5	Sig	0.19
2.	Carbendazim (2 g/kg of seed)	2.9	2.8	3.6	4.8	Sig	0.19
3.	Thiram (2 g/kg of seed)	1.1	0.1	2.8	1.7	Sig	0.19
4.	Captan (2 g/kg of seed)	2.2	0.5	1.3	1.3	Sig	0.19
5.	Copper oxychloride (2 g/kg of seed)	None	None	None	None		
6.	Control (Untreated)	None	None	None	None		
	'F' test at 5% level	Sig	Sig	Sig	Sig		
	C.D. at 5% level	0.233	0.233	0.233	0.233		

* Mean of 3 repliactions. Interaction C.D. = 0.46 at 5% level.

TABLE 2. *In vivo* effect of fungicides on germination and seedling vigour of K_3 variety of groundnut.

Sl. No.	Fungicide and concentration	Seed germination (%) (*)	% increase over control	Shoot length (cms)(*)	% increase over control	Root length (cms) (*)	% increase over control	Total dry wt / plant (g) (*)	% increase over control
1.	Carbendazim + thiram (2g/kg of seed)	96	20	18.7	21.43	10.6	24.41	0.65	47.72
2.	Carbendazim (2g/kg of seed)	92	15	18.0	16.88	10.0	16.27	υ.60	36.36
3.	Thiram (2g/kg of seed)	92	15	12.9	16.23	10.1	17.44	0.62	40.90
4.	Captan (2g/kg of seed)	92	15	17.2	11.68	10.0	16.27	0.56	27.27
5.	Copper oxychloride (2g/kg of seed)	84	5	16.4	6.49	9.2	6.75	0.50	13.63
6.	Control (Untreated)	80	—	15.4	—	8.6	—	0.44	—
	C.D. at 5% level	4.512	—	0.9007	—	0.539	—	0.059	—

(*) mean of three replications.

fungicides tested in enhancing seed germination and seedling vigour. Phips (1984) also has reported an improved performance of groundnut seed infested with seed-borne pathogens like *Asperqillus niger* and *Sclerotium rolfsii* when treated with a combination of systemic fungicide like carboxin and non-systemic fungicide like thiram.

It is apparent from the results that combination of systemic fungicides with non-systemic fungicides were found to be more effective in controlling seed-borne fungi of groundnut. Even though sole treatments of fungicides like carbendazim could effectively inhibit the growth of fungi, it might be more advantageous to adopt combination of systemic and non-systemic fungicides like carbendazim + thiram to effectively control seed-borne pathogens and improve the seedling stand.

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EFFECT OF MACRO-NUTRIENT DEFICIENCIES ON SEEDLING AND MINERAL UPTAKE OF CASTOR (*RICINUS COMMUNIS L.*) IN SAND CULTURE

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ABSTRACT

Castor (*Ricinus communis* L) cv Aruna was grown in sand culture with or without N, P, K, S, Ca and Mg for 5 wk and the deficiency symptoms were observed. Also the effect of these macro-nutrients on the growth, nutrient uptake and utilization efficiency was studied. To identify the macro nutrient deficiencies a key was devised. Reducton in growth was very severe in N and Ca deficiency treatments. Leaf area development in relation to the total drymatter produced was increased due to N, S and Ca deficiencies. Severe reduction in chlorophyll content was caused by N and Mg deficiencies but Ca deficiency increased the chlorophyll content of leaves. Accumulation of proline in leaf tissue was noticed in N,P,S, and Ca deficient plants whereas proline concentration decreased in K and Mg deficient plants. The decrease in nitrate reductase activity in the leaf was attributed to the accumulation of proline and probably other amino acids. Mineral uptake was in general reduced due to the deficiency of macro-nutrients. However, the macro-nutrient deficiencies had considerably increased the utilization efficiency of that element which was deficienct.

Key words : *Ricinus communis* L., Macro-nutrients, Deficiency symptoms, Mineral uptake, Mineral utilization efficiency.

INTRODUCTION

Castor (*Ricinus communis* L.) is one of the important oilseed crops of India. It is grown in any type of soil ranging from the very poor *chalka* soils of Telangana region of Andhra Pradesh to the heavy loamy soils of Uttar Pradesh. A large number of genotypes has been evolved for increasing the productivity of this crop (Kulakarni and Ramamurthy, 1977). Although the N,P and K requirements for certain cultivars of castor has been worked out, its mineral nutrition is not very much understood. Like the other crops, castor also requires essential elements for its growth and development. Inadequate supply of any essential element exhibits characteristic deficiency symptoms on the foliage. Such symptoms sometimes vary among crop species. Foliar symptoms are the preliminary indication to identify the nutrient deficiencies. Plant growth essentialy depend on the mineral uptake and utilization. Therefore inadeqaute supply or availability of essential elements not only exhibits foliar symptoms but also reduction in plant growth depending on the element in questions. Such informtion is available for many crops like groundnut (Reid and York Jr. 1958; Narayanan and Reddy, 1985), cotton (Marcus-Wyner and Rains, 1982) and sesame (Prasad, 1987). Therefore the present investigation was initiated first to identify the macro-nutrient deficiencies in castor by foliar symptoms and also to study the extent of damage caused by the deficiencies on plant growth and nutrient uptake.

MATERIALS AND METHODS

Castor seeds of cv Aruna were sown directly in polythene bags containing 1 kg of river sand washed with 10% HCl and deionized water repeatedly till the washings

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were free of acid. Seedlings were grown for a fortnight (3-leaf stage) by providing deionized water. Afterwards they were given modified form of Hoagland solution (Johnson *et al*, 1957) at weekly interval based on the treatment. Every week the sand medium was flushed with deionized water to remove the unabsorbed mineral nutrients before adding the fresh treatment solutions. The seven treatments consisted of complete Hoagland solution (control), -N, -P, -K -Ca and -Mg. Each treatment was replicated five times. The bags were arranged in a randomized block design inside a net-house under natural conditions during the monsoon season of 1989. The average and night temperatures during the growth period were 30 and 25°C respectively.

The plants in each treatment were observed carefully for the development of visual nutrient deficiency symptoms. Two days before sampling total chlorophyll content, proline content and nitrate reductase activity (NRA) of the lamina were estimated by following the methods of Yoshida *et al.*, (1976), Bates *et al* (1973) and Hageman and Flaesher (1960) respectively. Destructive growth analysis was carried out on 5-week-old seedlings. Plant height, number of leaves, leaf area, length of tap root, number of first order laterals and root volume (by water displacement method) were recorded. The leaf area was measured in a Δ -T automatic leaf area meter. The plants were separated into lamina, petiole, stem and root. The roots were thoroughly washed with deionized water. These plant parts were oven dried at 80°C for 48 h and weighed. From these basic data, specific leaf weight (SLW), net carbon assimilation (NCA), leaf area ratio (LAR) and root/shoot ratio were computed (Hunt, 1978). The dried plant samples were powdered and analysed for total nitrogen (Bremner and Mulvaney, 1982), phosphorus (Jackson, 1967), potassium (by flame photometry - Jackson, 1967), Ca and Mg by titrimetry (Jackson, 1967) and S (Tabatabai and Bremner, 1970). The micro-nutrients, Fe, Mn, Zn and Cu were determined in the acid aliquot of the plant samples by using Atomic Absorption Spectrophotometer model Hitachi 170-30 (Lindsay and Norvell, 1979).

RESULTS AND DISCUSSION

Deficiency symptoms

As a general rule, symptoms of deficiencies are first noticeable in older and lower leaves for elements such as N, P, K and Mg which are able to move readily from one place to another within the plant. When the supply of one of them to the plant is limited, the element is translocated away from older tissues to younger, mcre metabolic active tissues. But deficiencies of elements such as S and Ca which are not mobile within the plants are noticeable first in younger leaves and growing shoot tips. These tissues are the first to suffer when the supply of one of these elements is limited because these elements tend to remain in older leaves (Noggle and Fritz, 1979).

Using these basic principles the macro-nutrient deficiencies of castor were identified with the help of the key given in Table 1. This key may not be of very much use for a crop showing multiple mineral deficiencies. However, it describes the actual symptoms caused by a particular macro-nutrient in castor. Similar type of key is given

TABLE 1. Key to identify macro-nutrient deficiency symptoms in castor

Code	Symptoms	Deficient element
I	EFFECT GENERAL ON WHOLE PLANT LOCALISED ON OLDER, LOWER LEAVES.	
	A. Effects usually general on whole plant, often manifested by yellowing and drying of older leaves.	
	1. Yellowing of the leaves, stunted plants with reduced internodal length	.. Nitrogen
	2. Dark green young leaves which are very small and yellowing of older leaves, plant growth very much stunted	.. Phosphorus
	B. Effects usually local on older, lower leaves	
	1. Interveinal chlorosis followed by marginal scorching of leaves	.. Potassium
	2. Chlorosis commences at the tips and margins of the leaf and spreads inwards towards the mid-rib. The chlorotic areas become necrotic and whitish or brown patches	.. Magnesium
II	EFFECTS LOCALIZED ON YOUNGER LEAVES	
	A. Terminal leaves light green	
	1. Crinkling of the leaf followed by brittleness of younger leaves which are chlorotic	.. Sulphur
	B. Unexpanded terminal leaves	
	1. Older leaves become slightly thick and dark green, marginal chlorosis in younger leaves, terminal bud dies	.. Calcium

TABLE 2. Effect of macro-nutrient deficiencies on morphological characters of 5-wk-old castor seedlings.

Treatment	Plant height (cm)	Number of leaves $plant^{-1}$	Leaf area ($cm^2 plant^{-1}$)	Tap root length (cm)	Root volume (cm^{-3})	No. of first order laterals $plant^{-1}$)
Control	24.2	6.0	198	33.3	10.0	25
—N	7.6	3.0	18	26.0	1.5	10
—P	14.3	5.0	74	39.9	3.2	13
—S	16.8	5.7	103	29.5	5.8	25
—K	17.2	5.3	94	26.4	7.1	25
—Ca	7.0	3.0	18	7.2	0.7	7
—Mg	17.3	6.0	136	30.5	5.4	23
LSD (0.05)	1.8	0.5	16	3.7	1.7	3

TABLE 3. Effect of macro-nutrient deficiencies on the drymatter accumulation in plant parts and whole plant of 5 wk-old castor seedlings.

Treatment	Plant parts (g $plant^{-1}$)				Whole Plant
	Lamina	Petiole	Stem	Root	(g $plant^{-1}$)
Control	0.66	0.08	0.42	0.69	1.85
—N	0.04	0.01	0.05	0.05	0.15
—P	0.25	0.02	0.16	0.25	0.68
—S	0.35	0.04	0.15	0.24	0.78
—K	0.33	0.04	0.24	0.34	0.95
—Ca	0.05	0.01	0.03	0.02	0.11
—Mg	0.52	0.05	0.30	0.53	1.40
LSD (0.05)	0.08	0.06	0.09	0.07	0.21

TABLE 4. Effect of macro-nutrient deficiencies on the growth characteristics of 5-wk-old castorr seedlings.

Treatment	SLW (mg cm^{-2})	NCA (g g^{-1})	LAR (cm2 g^{-1})	Root / Shoot Ratio
Control	3.33	2.80	107	0.59
—N	2.22	3.75	120	0.50
—P	3.38	2.72	109	0.58
—S	3.40	2.05	132	0.44
—K	3.51	2.88	99	0.56
—Ca	2.78	2.20	164	0.22
—Mg	3.82	2.69	97	0.61
LSD (0.05)	0.50	0.40	10	0.11

by Narayanan and Reddy (1985) for groundnut for easy identification of mineral nutrient deficiencies.

Plant growth

Macro-nutrient deficiencies reduced the stem elongation of the castor seedlings by shortening the plant height (Table 2). About 70 per cent reduction was brought about by deficiencies due to N and Ca. However, the reduction was not so much (but almost similar) in -S,-K and -Mg treatments. P deficiency reduced the plant height only by 41 per cent. Similarly the leaf production was drastically affected by N and Ca deficiences as compared to other nutrient deficiency treatments. However, deficiencies due to S and Mg did not affect the number of leaves. Leaf area per plant was severely reduced (91%) by N and Ca deficiencies whereas Mg deficiency showed the least reduction of only 31 per cent. P deficiency inhibited the leaf area devlopment to an extent of 63 per cent. Significant increase in tap root length treatments decreased the length and more severely by Ca deficiency. Deficiency of nutrients decreased the root volume but the decrease was greatest due to N and Ca deficiencies. The number of first order laterals was not changed by S, K and Mg deficiencies whereas N, P and Ca decreased them significantly. Thus the plant growth suffered a great deal due to N and Ca deficiencies as compared to other nutrient deficiencies. Similar results were reported for groundnut (Narayanan and Reddy, 1985), chillies (Prasad *et al.*, 1988) and blackgram (Srinivas, 1988). Therefore it suggests that N and Ca are the elements which contribute much to the growth of shoot and root systems of plants whereas the influence of other mineral nutrients was not so direct and severe.

Drymatter production

The effect of macro-nutrients on the drymatter accumulation in plant parts of castor is shown in Table 3. Here again N and Ca deficiencies diminished the drymatter production of plant parts such as lamina, petiole, stem and roots. Even the whole plant drymatter also suffered similarly. Mg deficiency brought about reduction in drymatter production showing its lesser involvement in this process compared to the other elements especially N and Ca.

Growth characteristics

The SLW indicates the thickness of the leaf. Only N and Ca deficiencies could decrease it and all the other macro-nutrients deficiencies did not affect the SLW (Table 4). NCA represents generally the photosynthetic efficiency of a plant (Huber, 1983). The NCA was increased by N deficiency but decreased by Ca and S deficiencies. There was no significant difference among other defiiciencies. It is evident that there is no relation between SLW and NCA in castor. Also the N deficient plants were able to make more drymatter per unit of leaf drymatter, whereas Ca and S decreased the process significantly. LAR refers to the plants ability to produce leaf area in relation to the total drymatter produced. An increase in LAR was observed in N, S and Ca deficient plants. It suggests that the leaf area development in relation to the total drymatter produced was increased due to N, S and Ca deficiencies. It appears that the plants try to put forth more leaf area by reducing the growth of roots which is evident from the root/shoot ratio given in Table 4. Other deficiencies did not altar this growth characterisctic.

Concentration of Chlorophyll and proline in leaf

Macro-nutrient deficiencies except -Ca reduced the total chlorophyll concentration in the leaves. The reduction was very severe in -N and -Mg treatments which is obvious because both these elements are the constituents of chlorophyll pigment. Ca deficiency could increase the leaf chlorophyll concentration mainly due to reduction in leaf expansion which increases the concentration of chlorophyll per unit weight of leaf.

Proline accumulation has been observed in plants under water stress (Barnett and Naylor, 1966). Nutrient stress also induces the plants to accumulate proline. In Table 5, K and Mg deficiency treatments decreased the proline concentration of leaves whereas all other elemental deficiencies increased the concentration. It might be due to the disrupted protein synthesis which leads to the accumulation of free amino acids. The accumulation of proline may be an adaptive mechanism for the plants to overcome the nutrient stress. However, K and Mg deficiencies infact reduced the proline concentration of the leaf. The reason for it is not quite clear.

Nitrate reductase activity

NR activity was decreased by macro-nutrient deficiencies (Table-5). The decrease was very much drastic in N, Ca and P deficiency treatments. NR is present only in low levels in plants not receiving nitrate (Timpo and Neyra, 1983). NRA was shown to be inhibited by certain amino acids (Oaks *et al.*, 1977) or amides (Breteler and Smit, 1974). In castor leaves accumulation of proline was noticed in N, P, S and Ca deficiency treatments. It is possible that other amino acids and amides might have also accumulated but they were not estimated in the present investigation. Hence the reduction in NR activity in castor leaves may be due to the accumulation of proline and other amino acids. However, mechanism by which these amino acids inhibit the NRA is not still known.

Mineral uptake and utilization efficiency

The uptake of those nutrients which are not supplied in the solution culture was very much decreased (Table 6). Macro-nutrient deficiency treatments except Mg decreased the uptake of N whereas an increase was noticed in Mg deficient plants. Similar observation was also reported for pigeonpea (Raju, 1983). P.S, K and Mg uptake by castor plants were reduced considerably by the macro-nutrient deficiency treatments. The reduction was very severe in N and Ca deficient plant. Mg deficiency increased the uptake of Ca but the reverse was not true.

The effect of macro-nutrient deficiencies on the micro-nutrient uptake showed a decrease in Fe, Zn and Cu but Mn uptake was increased by S deficiency whereas all other deficiency treatments decreased the uptake.

TABLE 5. **Effect of macro-nutrient deficiencies on chlorophyll, proline and nitrate reductase activity (NRA) in leaf tissues of 5-wk-old castor seedlings.**

Treatment	Total chlorophyll (mg g^{-1} fwt)	Proline (μg g^{-1} fwt)	N R A (n mole NO_2 g^{-1} fwt h^{-1})
Control	2.59	79	18732
—N	0.61	224	793
—P	2.46	156	7886
—S	1.52	138	9060
—K	1.46	35	12003
—Ca	2.96	234	7291
—Mg	0.70	19	10085
LSD (0.05)	0.09	31	1271

TABLE 6. **Effect of macro-nutrient deficiencies on the mineral uptake of 5-wk-old castor seedlings.**

	Macro-nutrients (mg $plant^{-1}$)						Micro-nutrient (μg $plant^{-1}$)			
	N	P	S	K	Ca	Mg	Fe	Mn	Zn	Cu
Control	49.7	4.7	4.7	26.3	9.9	16.0	744	65	291	171
– N	1.5	0.8	0.6	2.8	0.7	1.6	83	5	23	111
– P	20.7	0.4	2.2	12.1	4.3	4.9	345	49	235	58
– S	25.7	3.3	0.6	15.4	7.2	8.2	490	75	192	111
—K	36.6	3.2	3.3	0.7	7.7	8.7	282	56	202	72
—Ca	2.8	0.2	0.5	1.9	0.1	0.8	33	3	17	12
—Mg	65.4	3.8	3.0	23.5	13.9	1.8	470	56	273	96

TABLE 7. Effect of macro-nutrient deficiencies on the mineral utilization efficiencies of 5-wk-old castor seedlings.

Treatment	Mineral utilization efficiency (mg DM mg^{-1})					
	N	P	S	K	Ca	Mg
Control	38	399	399	71	188	116
—N	110	210	275	56	232	102
—P	34	2000	321	58	163	142
—S	31	242	1254	51	110	96
—K	26	301	292	1433	124	110
—Ca	43	600	222	65	1714	143
—Mg	22	369	475	60	102	766

Mineral deficiencies had considerably increased the mineral utilization efficiency of that elements which was deficient (Table 7). It means that these plants try to produce more drymatter per unit of the element present in the plant.

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EFFECT OF PHOSPHATE LEVELS AND THEIR METHOD OF APPLICATION ON YIELD AND OIL CONTENT OF SOYBEAN

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A B S T R A C T

An experiment was conducted for two seasons (*Kharif* 1987 and 1988) to study the effect of phosphate levels and their method of application on yield and oil content of soybean. The maximum yield and oil content was observed at 60 kg P_2O5/ha. Amongst the different methods of application, separate drilling of seed and ferilizer in tne form of DAP gave the highest yield and oil content.

Key words: Soybean, phosphorus, oil content

INTRODUCTION

Soybean, being a leguminous crop, requires a small amount of nitrogen for a quick initial growth. It has a high phosphorus requirement and an optimum level of P enhances nitrogen fixation by symbiotic bacteria. The method of phosphorus application is also an important aspect in influencing its optimal availability for plant growth.

Keeping this in view, the present investigation was undertaken to find out the optimum level of phosphate and the best method of its application to obtain the maximum yield and oil content of soybean.

MATERIALS AND METHODS

The study was conducted on medium black soils of R.A.K. College of Agriculture farm, Sehore (M.P.) during *kharif* 1987 and 1988. The soils of the experimental field had pH- 7.9, organic carbon - 0.40%, and available P_2O_5 - 5.05 kg/ha, K_20 - 305. 62 kg/ha, N-62.38 kg/ha.

The experiment was laid out in a randomized block design with four replications and fifteen treatments *viz.*, three phosphate levels i.e. 20, 40 and 60 kg P_20_5/ha in conjunction with 20 kg N/ha and 20 kg K_2 0/ha as general dose. Five methods of phosphate application as follows were adopted.

M_1 — Drilling of soybean seed mixed with phosphorus fertilizer (DAP)
M_2 — Drilling the seed and phosphorus fertilizer (DAP) separately.
M_3 — Drilling the seed and broadcasting the phosphorus fertilizer (SSP).
M_4 — Drilling the seed mixed with half phosphorus dose (through DAP) and broadcasting the remaining half dose (through DAP).
M_5 — Drilling the seed mixed with halt phosphorus dose (thorugh SSP) and broadcasting the remaining half dose (thorugh SSP).

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The oil content in soybean flour was estimated by petroleum ether extracts as per A.O.A.C. (1960).

RESULTS AND DISCUSSION

Growth and yield attributing characters

The data presented in Table 1 showed that P_2O_5-at 60 kg/ha has significantly influenced plant height, number of branches, leaf area index dry matter per plant, number of pods per plant, seeds per pod, test weight, and grain yield per plant as compared to the other levels. It is well known that Phosphorus plays an important role in manufacture and translocation of photo-synthetic material and is considered essential for seed formation and development. This may be a possible explanation for the above findings. Similar results have also been reported by Jones *et al.* (1977) and Sampat (1979).

Among the different methods of application, M_2 i.e. drilling the seed and fertilizer (DAP) separately gave a significant increase in growth and yield attributing characters as in the case of phosphate levels over other methods. Placement of fertilizer had a direct bearing on the availability of nutrients to the plants. The method M_2 induced the highest growth and yield response by slowly releasing the phosphate directly in the root zone and thus increasing its availability to the plants. Groneman (1974) also observed the highest growth response by deep placement of phosphatic fertilizers. Superiority of fertilizer placement has also been demoonstarted by Bullen *et al.* (1983), Machado *et al.* (1983) and Singh and Singh (1986).

Yield and Harvest Index:

The cumulative effect of all the factors resulted in increased grain yield. The highest grain yields (Table 2) were obtained at 60 Kg P_20_5/ha which were significantly superior over other levels during both the years. Dickson (1983) Pinjaria *et al.* (1983) and Desborough and Mears (1980) have also reported similar findings. Harvest Index also increased with the increasing phosphate levels. This clearly showed that grain component of the total biomass increased with increasing phosphate levels. An adequate supply of phosphorus has been associated historically with increased root growth, which in turn resulted in better uptake of nutrients and water in the development of nodules. This could be a possible explanation for increase in yield with increase in phosphate levels.

Separate drilling of soybean seed and P fertilizer in the form of DAP (Method-M_2) produced significantly higher grain yields, followed by methods M_1,M_4 and M_3 Placement of fertilizer below the seed produced significantly higher growth and yield per plant, seeds per pod, test weight, leaf area index etc. which ultimately conributedt towards an increment in yield. Superiority of fertilizer placement on similar lines has also been demonstarted by Bullen *et al.* (1983) and Singh and Singh (1986).

TABLE 1. Yield and growth attributing characters as influenced by different treatments.

Treatments	Plant height (cm)		Branches / plant		Leaf area Index		Dry weight / plant (g)		No of pods / plant		No of seeds / pod		Test weight (g)		Grain yield / plant (g)	
	1987	1988	1987	1988	1987	1988	1987	1988	1987	1988	1987	1988	1987	1988	1987	1988
(A) P_2O_5 levels Kg/ha																
1. 20	65.6	65.1	2.9	3.0	4.55	4.57	9.2	9.3	36.4	36.8	2.12	2.17	96.6	99.9	3.37	4.25
2. 40	67.3	66.8	3.2	3.3	4.96	4.98	9.9	10.0	40.9	41.4	2.28	2.33	100.6	103.7	3.83	4.90
3. 60	69.0	68.5	3.5	3.6	5.34	5.36	10.7	10.8	45.3	45.9	2.42	2.47	104.6	107.6	4.21	5.41
SEm ±	0.59	0.58	0.07	0.06	0.07	0.06	0.26	0.25	1.03	1.05	0.01	0.01	0.94	0.93	0.04	0.11
CD at 5%	1.68	1.67	0.19	0.19	0.21	0.17	0.75	0.73	2.94	3.00	0.03	0.03	2.70	2.66	0.11	0.31
(B) Methcds of application (M)																
4. M_3	67.6	67.1	3.3	3.4	5.09	5.11	10.3	10.4	42.6	43.1	2.33	2.38	102.2	105.2	3.99	5.04
5. M_2	70.3	69.8	3.7	3.8	5.55	5.57	11.0	11.1	47.0	47.6	2.50	2.55	106.2	109.3	3.40	5.26
6. M_3	64.4	64.1	2.8	2.9	4.35	4.37	8.7	8.8	33.7	34.2	2.06	2.11	94.1	97.7	3.12	3.90
7. M_4	67.9	67.4	3.5	3.4	5.08	5.11	10.3	10.4	42.7	43.1	2.30	2.35	102.4	105.5	3.97	5.02
8. M_5	66.3	65.8	3.0	3.1	4.68	4.70	9.4	9.5	38.2	38.7	2.19	2.24	98.1	101.2	3.54	4.66
SEm ±	0.76	0.75	0.09	0.08	0.09	0.08	0.34	0.33	1.33	1.35	0.02	0.01	1.22	0.94	0.05	0.14
CD at 5%	2.17	2.19	0.25	0.24	0.27	0.22	0.97	0.95	3.80	3.88	0.04	0.04	3.48	2.68	0.14	0.41
PXM	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	N	NS	NS	NS

TABLE 2. Harvest Index, Oil content and Yield (Kg/ha) as Influenced by different treatments

Treatments	Harvest Index 1987	Harvest Index 1988	Oil content (%) 1987	Oil content (%) 1988	Yield (Kg/ha) 1987	Yield (Kg/ha) 1988
(A) P_2O_5 levels Kg/ha						
1. 20	0.42	0.41	18.74	18.75	674	1432
2. 40	0.43	0.42	18.81	18.84	863	1603
3. 60	0.44	0.43	18.91	18.92	1032	1790
SEM ±	NA*		0.05	0.06	27	50
CD at 5%			0.16	0.17	77	144
(B) Methods of application (M)						
4. M1	0.45	0.43	18.83	18.85	987	1743
5. M2	0.45	0.43	19.34	19.36	1156	1913
6. M3	0.44	0.41	18.53	18.55	625	1383
7. M4	0.40	0.42	18.74	18.77	802	1559
8. M5	0.41	0.41	18.66	18.67	714	1471
SEm ±	NA*		0.23	0.24	35	65
CD at 5%			0.66	0.67	99	186
PXM			NS	NS	NS	NS

* Statistically not analysed

The yield levels of soybean were low in 1987 due to low rainfall. It is to be noted that the total rainfall during the year 1987 was only 644 mm during the growth period. However, during 1988, the total rainfall was almost 928 mm and the seasonal conditions were generally more favourable than during the previous year.

Oil content

The oil content increased significantly with increase in phosphate levels. Maximum oil content was recorded at 60 kg P2O5/ha during both the years. Phosphorus is known to be directly responsible for oil and albumin synthesis. The findings are in conformity with the reported findings of Kesavan and Morachan (*1973*) and Pawar et al. (1982). Among the different methods of P application M_2 gave *significantly* *highest* oil content in both the years. Proper placement *of fertilizer* resulted in optimal availability of nutrients thus giving an increase in yield as well as oil content of soybean.

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CHARACTER ASSOCIATION AND PATH COEFFICIENT ANALYSIS IN PARENTAL LINES AND THEIR F_1 HYBRIDS OF SESAME

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ABSTRACT

Correlation and path coefficient were carried out in a set of parents and their all possible F_1s (excluding reciprocals) separately. In parents as well as hybrids the characters, number of branches per plant, number of capsules per plant, seed yield per plant possessed highly significant and positive relationship with oil yield per plant and in turn inter-related among themselves. On the other hand seed yield/plant could be singled out in its highest direct and indirect positive contributions to oil yield per plant. Therefore, seed yield which is a major component of oil yield per plant can be improved by selecting for more number of branches and capsules per plant.

Key words: Correlation coefficients, path analysis, *Seasamum indicum* L.

INTRODUCTION

In any breeding programme, selection based on the knowledge of and direction of association between different yield attributes and yield will be very useful in identifying key characters which can profitably be exploited in a short time to achieve the desired level of improvement in yield. Data on correlation of seed yield and yield attributes is available in seasamum, while information on character association of oil yield per plant, which is the ultimate economic product, with seed yield and other yield attributes is scanty in hybrids as related to their parents. The associations in the same direction in parents and hybrids are expected to behave similarly in the segregating generations and will be dependable for selection (Reddy *et al.*, 1984). These associations at the genotypic level will be discussed in the present study to develop appropriate selection criteria.

MATERIALS AND METHODS

Nine parental genotypes of diverse origin viz., Madhavi, Rauss 17-4, X-198 RT 54, Gouri, B 9, R 84-4-2, VS 16 and R 84-360-3 were utilized in a diallel cross (excluding reciprocals). These parental lines along with their 36 F_1s were sown in Randomized Block Design with three replications during *rabi*, 1989 with a spacing of 40×15 cm. Each entry represented as a signle row of 4.05m long. All the normal agronomic practices were followed in raising the crop. Observations were recorded on five randomly selected competetive plants in each entry and in each replication. The data were recorded on days to 50% flowering, flowering duration, days to maturity, leaf area index, per cent powdery mildew infection, relative height to first capsule, plant height, number of branches per plant, number of capsules per plant, length/breadth ratio, number of seeds per capsule, 1000-seed weight, harvest index, seed yield per

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plant and oil yield per plant. Leaf Area Index (LAI) was estimated by feeding all the leaves of each plant collected on 60th day after sowing, to the leaf area meter to obtain the leaf area per plant in square centimeters and is devided by ground area of that plant. Oil per cent in the uncrushed seed was recorded with NMR spectrophotometer at the Directorate of Oilseeds Research, Rajendranagar, Hyderabad. Oil yield per plant was computed based on oil content and seed yield per plant. Correlations were worked out separately in the parents and hybriids. Path coefficients were worked out by utilising the correlation coefficients as per Dewey and Lu (1959).

RESULTS AND DISCUSSION

Correlation coefficients for the parents and their hybrids are given in Table 1. The association analysis revealed that seed yield per plant and oil yield per plant possessed positive and highly significant association with number of branches per plant and number of capsules per plant both in parents as well as in hybrids. This indicated the possibility of obtaining segregants possessing more number of branches per plant and more number of capsules per plant. The observations of Ramachandran et al. (1972), Kaushal et al. (1974), Paramasivan and Prasad (1980) and Krishnadoss and Kadambavanasundaram (1986) in parental lines and hybrid populations were also similar. The relationship of seed yield per plant with oil yield per plant was highly significant and positive both in parents and hybrids. Thangavelu and Rajasekaran (1984) and Reddy et al. (1984) also reported similar results.

Days to 50% flowering was significantly and negatively associated with flowering duration but positively with relative height to first capsule in parental populations only, indicating that early flowering increased the flowering duration which was desirable and late flowering (50 per cent) increased the height to first capsule which is not desirable. Therefore, by selecting lines for early flowering, simultaneous improvement of the other two characters i.e., flowering duration and relative height to first capsule could be achieved. Flowering duration and days to maturity were positively and significantly related with one another in hybrids indicating the possibility of obtaining segregants with less flowering duration and early maturity. Days to maturity had positive and significant association with plant height and number of capsules per plant in hybrids, which indicated that prolonged duration of crop increased plant height and allowed more number of capsules to be formed in hybrids, while in parents it had negative association with plant height and positive association with number of capsules per plant, though, non-significant. This sort of relationship which was observed in hybrids alone but not in parental lines might be due to dominance effects of the individual characters in hybrids. However, Desai *et al.* (1982), Thangavelu and Rajasekaran (1983) and Mohamed (1989) observed similar relationship in a set of parental lines as was observed for hybrids in the present study. This deviation from the present study might be due to the utilization of more number of late maturing varieties in their experiments. On the other hand, days to maturity and oil yield per plant were negatively associated with each other both in homozygous and heterozygous populations. Earliness was reported to be advantageous over lateness for obtaining high oil content and in turn high oil yield per plant (Weiss, 1971 and Reddy

TABLE 1. Genotypic correlation coefficients in parents and their F_1s in sesame

		Flowering duration	Days to maturity	Leaf area index	Powdery mildew inection	Relative height to first capsule	Plant height	Number branches per plant	Number capsules per plant	Length/breadth ratio	Number of seed per capsule	1000seed weight	Harvest index	seed yield per plant	Oil yield per plant
Days to 50% flowering (X_1)	(P)	-0.845**	-0.059	0.450	-0.115	0.956**	0.204	0.184	0.023	0.022	0.006	-0.062	-0.0338	-0.211	-0.332
	(H)	0.218	0.189	0.209	-0.154	-0.039	0.288	0.115	0.212	-0.250	0.057	0.131	-0.244	0.384*	0.261
Flowering duration (X_2)	(P)		0.092	-0.396	0.103	-0.664	-0.389	-0.332	-0.314	0.315	-0.269	0.224	0.200	-0.051	0.003
	(H)		0.376*	0.076	0.056	0.007	0.057	-0.139	-0.102	0.000	0.106	0.021	-0.123	-0.227	-0.735
Days to mature (X_3)	(P)			-1.020**	0.202	-0.359	-0.379	0.166	0.084	0.310	-0.068	0.402	0.230	0.292	0.400
	(H)			-0.017	0.041	-0.018	0.413*	0.273	0.450**	-0.129	0.122	-0.092	-0.202	0.010	0.085
Leaf area index (X_4)	(P)				-0.401	0.478	0.253	-0.022	-0.046	-0.322	-0.056	-0.417	-0.275	-0.288	-0.392
	(H)				-0.177	0.027	0.258	-0.262	-0.342*	0.124	0.284	-0.133	-0.305	0.044	0.050
Per cent powdery mildew nfection(X_5)	(P)					0.036	0.112	0.408	0.206	0.268	0.587	0.407	0.402	-0.378	-0.345
	(H)					0.388*	-0.331	0.047	0.162	0.021	-0.127	0.215	0.096	-0.150	-0.121
Relative height to first capsule (X_6)	(P)						0.863	-0.124	-0.287	-0.017	-0.042	-0.122	-0.490	-0.559	-0.629
	(H)						-0.186	0.361*	0.112	0.255	-0.300	0.367*	0.076	0.241	0.245
Plant height (X_7)	(P)							0.126	0.595	-0.445	0.197	0.132	-0.014	0.310	0.222
	(H)							0.220	0.486**	-0.134	0.055	-0.264	-0.400*	0.347*	0.348*
Number of branches per plant (X_8)	(P)								0.762*	-0.019	0.704*	-0.151	0.402	0.827**	0.745*
	(H)								0.706**	-0.051	-0.379*	0.123	0.226	0.607**	0.626**
Number of capsules per plant (X_9)	(P)									-0.527	0.415	0.052	0.517	0.893**	0.858**
	(H)									-0.072	-0.147	-0.101	0.005	0.614**	0.631**

Cond. Table-1

		(1)	(2)	(3)	(4)	(5)	(6)	)7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Length/Bredth	(P)										0.197	0.091	-0.229	-0.209	-0.283
ratio (X_{10})	(H)										-0.196	0.152	0.054	-0.033	-0.008
Number of	(P)											-0.431	-0.111	0.439	0.364
sseeds per capsule (X_{11})	(H)											-0.542**	-0.314	-0.063	-0.029
1000-seed	(P)												0.656	0.226	0.245
weight (X_{12})	(H)												0.055	-0.089	-0.108
Harvest index	(P)													0.745*	0.785**
(X_{13})	(H)													0.186	0.211
Yield per	(P)														0.977**
plant (X_{14})	(H)														0.972**

P : Parental genotypes; H : Hybrids

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

TABLE 2. Direct (diagonal) and indirect effects of different characters on oil yield at genotypic level.

		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}	X_{14}	'r' of Oil yield per plant
X_1	(P)	**0.006**	0.089	0.001	-0.092	-0.006	-0.022	-0.003	-0.028	-0.003	-0.003	0.000	0.013	-0.056	-0.228	-0.332
	(H)	**-0.173**	-0.002	0.020	0.012	-0.001	0.001	-0.004	0.000	0.006	0.001	0.003	0.008	-0.007	0.392	0.261
X_2	(P)	-0.006	**-0.106**	-0.002	0.081	0.006	0.015	0.006	0.051	0.047	-0.038	0.016	-0.048	0.033	-0.055	-0.003
	(H)	-0.033	**-0.009**	-0.040	0.004	0.000	0.000	-0.001	0.000	-0.003	0.000	0.006	0.001	-0.003	-0.234	-0.235
X_3	(P)	0.000	-0.010	**-0.018**	0.208	0.011	0.008	0.006	-0.026	-0.013	-0.037	0.003	-0.086	0.038	0.314	0.400
	(H)	-0.033	-0.003	**0.107**	-0.001	0.000	0.001	-0.005	0.000	0.012	0.001	0.007	-0.006	-0.005	0.011	0.085
X_4	(P)	0.003	0.042	0.019	**-0.204**	-0.022	-0.011	0.004	0.003	0.007	0.038	0.003	0.089	-0.046	-0.310	-0.392
	(H)	-0.036	-0.001	-0.002	**0.058**	-0.001	-0.011	-0.003	-0.000	-0.009	-0.001	0.016	-0.008	-0.008	0.046	0.050
X_5	(P)	-0.001	-0.011	-0.004	0.082	**0.054**	-0.001	-0.002	-0.063	-0.031	-0.032	-0.035	-0.087	0.067	0.407	0.345
	(H)	0.027	-0.001	0.004	-0.010	**0.006**	-0.010	0.004	0.000	0.004	0.000	-0.007	0.013	0.003	-0.154	-0.121
X_6	(P)	0.006	0.070	0.007	-0.097	0.002	**-0.023**	-0.001	0.019	0.043	0.002	0.003	0.026	-0.082	-0.603	-0.629
	(H)	0.007	0.000	-0.002	0.002	0.002	**-0.025**	0.002	0.001	0.003	-0.001	-0.017	0.022	0.002	0.249	0.245
X_7	(P)	0.001	0.041	0.007	-0.052	0.006	-0.002	**-0.016**	-0.019	-0.089	0.053	-0.012	-0.028	-0.002	0.334	0.222
	(H)	-0.050	-0.001	0.044	0.015	-0.002	0.005	**-0.012**	0.000	0.013	0.001	0.003	-0.016	-0.011	0.358	-0.348*
X_8	(P)	0.001	0.035	-0.003	0.005	0.022	0.003	-0.002	**-0.154**	-0.114	0.002	-0.042	0.032	0.067	0.892	0.745*
	(H)	-0.020	0.001	0.029	-0.015	0.000	-0.009	-0.003	**0.001**	0.019	0.000	-0.021	0.007	0.006	0.625	0.626**
X_9	(P)	0.000	0.033	-0.002	0.009	0.011	0.007	-0.009	-0.117	**-0.150**	0.063	-0.025	-0.011	0.086	0.963	0.858
	(H)	-0.037	0.001	0.048	-0.020	0.001	-0.003	-0.006	0.001	**0.028**	0.000	-0.008	-0.006	0.000	0.632	0.631**
X_{10}	(P)	0.000	-0.033	-0.006	0.066	0.015	0.000	0.007	0.003	0.079	**-0.119**	-0.012	-0.020	-0.038	-0.226	-0.283
	(H)	0.043	0.000	-0.014	0.007	0.000	-0.006	0.002	0.000	-0.002	**-0.004**	-0.011	0.009	0.001	-0.034	-0.008
X_{11}	(P)	0.000	0.028	0.001	0.011	0.032	0.001	-0.003	-0.104	-0.062	-0.023	**-0.059**	0.092	-0.019	0.473	0.364
	(H)	-0.010	-0.000	0.013	0.017	-0.001	0.008	-0.001	-0.001	-0.004	0.001	**0.055**	-0.033	-0.008	-0.065	-0.029
X_{12}	(P)	0.000	-0.024	-0.007	0.085	0.022	0.003	-0.002	0.023	-0.008	-0.011	0.025	**-0.214**	0.109	0.243	0.245
	(H)	-0.023	0.000	-0.001	-0.008	0.001	-0.009	0.003	0.000	-0.003	-0.001	-0.030	**0.060**	0.002	-0.092	-0.108
X_{13}	(P)	-0.002	-0.021	-0.004	0.056	0.022	0.011	0.000	-0.062	-0.077	0.027	0.007	-0.140	**0.167**	0.803	0.785**
	(H)	0.042	0.001	-0.022	-0.018	0.001	-0.002	0.005	0.000	0.000	0.000	-0.017	0.003	**0.027**	0.191	0.211
X_{14}	(P)	-0.001	0.005	-0.005	0.059	0.021	0.013	-0.005	-0.127	-0.134	0.024	-0.026	-0.048	0.124	**1.078**	0.978**
	(H)	-0.066	0.002	0.001	0.003	-0.001	-0.006	-0.004	0.001	0.017	0.000	-0.004	-0.005	0.005	**1.030**	0.972**

P : Parents; H : Hybrids

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

et al. 1986). The relationship of Leaf area index with seed and oil yield per plant was negative and positive (though non significant) respectively in parents and hybrids which indicated that higher leaf area was not a requirement in parents for higher yields while in hybrids it might be related with the manifestation of hybrid vigour. Per cent powdery mildew infection had negative relationship with seed yield as well as oil yield per plant both in parental lines and hybrid populations. Plant height possessed positive relationship with number of capsules per plant, seed yield and oil yield per plant in the parental lines and their F_1 hybrids. However, it was significant in respect of the latter only. This might be due to the dominance or overdominance effects of these individual characters expressed in F_1 hybrids as was also opined by Reddy *et al.* (1984). The correlation coefficient of number of branches per plant was highly significant and positive with number of capsules per plant, seed yield and oil yield per plant both in parents and their hybrids. Similarly, number of capsules per plant possessed highly significant and positive relationship with seed yield and oil yield per plant. The relationship of seed yield per plant with oil yield per plant was also highly significant and Positive.

Considering the inter-relationships among the various yield attributes, highly significant and positive associations existed among number of branches per plant, number of capsules per plant and seed yield per plant which inturn were associated significantly and positively with oil yield per plant both in homozygous and their heterozygous populations studied. Thus, improvement in any of the former two traits, would automatically improve seed yield per plant and inturn oil yield per plant. The observations of Kaushal et al. (1974), Paramasivan and Prasad (1980), Reddy *et al.* (1984) and Krishnadoss and Kadambavanasundaram (1986) were also similar. Further selection of parents possessing more number of branches and capsules per plant would yield not only superior hybrids but also would likely to throw superior high yielding segregants in advance generations.

Seed yield per plant singled out in its highest direct and indirect contributions to oil yield per plant both in parental and hybrid populations (Table 2). The direct effects of flowering duration, relative height to first capsule, plant height and length/breadth ratio of the capsule were negative both in parents and their F1 hybrids. Further, none of these traits had significant association with seed yield per plant and inturn with oil yield per plant, nor were they significantly interrelated among themselves in parents or in hybrids. Thus, improvement in oil yield per plant is expected through seed yield per plant alone which inturn is a function of more number of branches and capsules per plant as was also emphasized by Reddy *et al.* (1984).

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INTER-RELATIONSHIP AND PATH ANALYSIS OF CERTAIN QUANTITATIVE CHARACTERS IN CASTOR (*RICINUS COMMUNIS* L.)*

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ABSTRACT

Correlation coefficient and path-coefficient were worked out in castor under irrigated and rainfed conditions to determine the relative importance of different yield components. Seed yield was significantly and positively correlated only with number of capsules per plant under both the environments. Capsules per plant also had the highest direct effects followed by effective branches per plant and plant height on seed yield under irrigated and rainfed conditions.

Key words *Ricinus communis*, Path analysis.

INTRODUCTION

Castor seed Yield is a complex quantitative character highly influenced by environmental fluctuations. Hence direct selection for yield as such does not give expected results. Determination of the correlation co-efficient of yield components has been helpful to breeders in selecting suitable plant types. However, the simple association does not provide the exact basis of simulataneous improvement of the different traits (Niles, 1923 and Tukey, 1954). Under such circumstances, path co-efficient analysis is a more sophisticated technique which facilitates the partitioning of the correlation coefficient into components of direct and fndirect effect (Li, 1956). The present study was therefore, under taken to estimate the genotypic correlations among different characters and to determine the direct and indirect effects of component characters of yield in castor.

MATERIALS AND METHODS

Forty castor genotypes (Appendix-I) were grown in RBD with three replications under irrigated (I) and rainfed conditions (R) during Kharif 1984 at the Regional Agricultural Research Station, Sardar Krushinagar. Each plot consisted of a single row of 9 m. length accommodating 15 plants. The distance between rows was 90 cm. Ten competative plants, excluding terminal ones were randomly selected in all the replications and used for recording of data on different traits (Table 1). The correlations were worked out by the method suggested by Al-Jibouri *et al.* (1958) and path coefficients were calculated by the formula suggested by Dewey and Lu (1959).

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RESULTS AND DISCUSSION

The phenotypic and genotypic correlations of various components with seed yield and their direct effect contributing towards yield have been set out in Table-1. In general, the values of genotypic correlation coefficient were higher than those of phenotypic correlation coefficients. Seed yield was positively and significantly correlated only with capsules per plant under both the environments (I=0.6609 and R=0.6755). Days to flowering (-0.4074) and nodes upto primary raceme (-0.3457) showed a negative significant correlation with seed yield under rainfed condition only, indicating the importance of early flowering and lower node number under rainfed conditions. The observations of Patel *et al.* (1984) are in agreement with present finding.

TABLE 1. The estimates of phenotypic (P) and genotypic (G) correlation coefficients and path coefficients showing direct effects of various characters on seed yield in castor under irrigated (I) and rainfed (R) conditions.

Characters		Correlation coefficients with seed yield / plant I	Correlation coefficients with seed yield / plant R	Direct effects of path coefficients I	Direct effects of path coefficients R
Days to flowering	P	-0.1563	-0.3602*	—	—
	G	-0.1737	-0.4074**	-0.22530	-0.88659
Nodes upto primary raceme	P	-0.0305	-0.3026*	—	—
	G	-0.0168	-0.3457*	-0.13484	0.38558
Plant height	P	0.1259	-0.0487	—	—
	G	0.1406	-0.0771	0.59379	0.51169
Length of primary raceme	P	0.1302	0.1188	—	—
	G	0.1201	0.1046	0.14981	0.29519
Effective length of primary raceme	P	-0.0323	0.2265	—	—
	G	-0.0548	0.2608	-0.34313	0.52192
Capsules on primary raceme	P	-0.0622	0.2034	—	—
	G	-0.1020	0.1411	-0.21832	-0.74043
Branches / plant	P	0.2519	0.2636	—	—
	G	0.2004	0.2619	1.42968	-1.11846
Effective branches / plant	P	0.2742	0.3566*	—	—
	G	0.2130	0.2734	1.57505	0.68175
Capsules / plant	P	0.6782**	0.7143**	—	—
	G	0.6609**	0.6755**	0.83711	0.94602
100 seed weight	P	0.2464	0.0810	—	—
	G	0.2672	0.0972	0.27243	0.01034
Oil content	P	0.2077	-0.2329	—	—
	G	0.2563	-0.3311*	0.08747	-0.02254

* Significant at P = 0.05

** Significant at P = 0.01

Among different characters, capsules per plant exhibited significant positive genotypic correlation with length of primary raceme (0.5050); capsules on primary raceme (0.4693); branches per plant (0.4329) and effective branches per plant (0.4192) and significant negative correlation with flowering (-0.4560) and nodes upto primary raceme (-0.4269) under rainfed condition, whereas, capsules per plant also showed positive genotypic correlation only with branches per plant (0.4484) and effective branches per plant (0.4393) under irrigated condition. These results confirm the finding of Memon and Munsi (1969); Stephan Dorairaj *et al.* (1973); Patel *et al.* (1979) and Singh *et al.* (1981). They also reported very high association of capsules per plant with seed yield per plant.

Plant height exhibited significant positive correlation with length of primary raceme (I=0.7153; R=0.4834) and negative correlation with effective branches per plant (I=-0.4959; R=-0.3115) under both the conditions, whereas it also had positive correlation with length of primary raceme (0.7153), effective length of primary raceme (0.6975) and capsules on primary raceme (0.6970). The significant association of plant height with above characters should be taken into consideration for the improvement of yield components under irrigated condition, as reported earlier by Giriraj *et al.* (1973); Stephen Dorairaj *et al.* (1973) and Muthian *et al.* (1982).

Branches per plant effective branches per plant exhibited a significant negative correlation with most of the characters under both the environments. Sindagi (1968) also reported similar results. In the present study oil content has not shown significant association with any character in both the environments. This indicates the total independance of this character, as reported by Patel *et al.* (1979); Jaisani and Patel (1963) and Singh *et al.* (1981).

In the present study, eleven characters were considered as casual variables of seed yield under both the conditions. The critical analysis of the data in Table-1 revealed that effective branches per plant, capsules per plant and plant height had positive direct effect in both the environments. The capsules per plant which also had significant positive correlation with seed yield, manifested a large positive direct effect. A large negative direct effect on seed yield was recorded by days to flowering and capsules on primary raceme under both the conditions. This suggested that the early flowering genotypes would be better for increasing seed yield.

The number of nodes upto primary raceme had less direct contribution to seed yield but it influenced seed yield through effective branches per plant and plant height.

Based on the above findings it may be suggested that capsules per plant is the only character which had significant positive correlation and high positive direct effect on seed yield, irrespective of the management practices. Hence, this component is the most stable under both the environments and be given importance in selection to improve the seed yield further. However, it would be rewarding to lay more stress on earliness for rainfed conditions.

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APPENDIX — I

Sr. No.	Strain	Origin
1.	VI-9	Gujarat
2.	VI-15-2	"
3.	VI-27 B^3	"
4.	VH-25	"
5.	VH-62-2-4	"
6.	JM-3	"
7.	SKI-6	"
8.	SH-1	"
9.	SH-15	"
10.	SH-20	"
11.	SH-2	"
12.	JI-51	"
13.	JI-44	"
14.	SPS-43-3	"
15.	SPS-35-9-B	"
16.	HC-2	Andhra Pradesh
17.	HC-8	"
18.	Aruna	"
19.	Bhaghya	"
20.	6-219-22	"
21.	48-1	"
22.	EB-31	Madhya Pradesh
23.	S2-48-2	"
24.	TMV-2	Tamilnadu
25.	SA-2	"
26.	TMV-5	"
27.	PRT-44	Mysore
28.	T-4	Uttar Pradesh
29.	CH-1	Haryana
30.	Punjab-1	"
31.	RC-7	Karnataka
32.	14805	Nigeria
33.	37503	Israel
34.	Baker-147	U.S.A.
35.	Cimmaron	"
36.	EC-97700	Russia (USSR)
37.	EC-97705	"
38.	1093-1	France
39.	539-1	Egypt
40.	1205	Philippines

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Short Communication

RAPID METHOD OF ESTIMATING LEAF AREA IN SUNFLOWER (*HELIANTHUS ANNUS* L.)

Measurement of leaf area is basic to traditional growth analysis studies; leaf area index (LAI) and leaf area duration (LAD), the growth analysis parameters, have been related to both biological and economic yield. To determine LAD, the leaf area has to be estimated at several stages of plant growth. Measurement of leaf area following the methods such as planimeter, photoelectric cell or gravimetric involves time and prohibitive labour input. However, estimation of leaf area by linear measurement methods is considered as time saving and non destructive. Krishnamurthy, *et. al.*, 1974 in sorghum and Francis, *et al.*, 1969 in maize have found that single leaf measurement could be used to estimate the plant leaf area by multiplying the area of that leaf with the number of leaves present in the plant. Hence, an attempt is made to find out the representative leaf which could be used in estimating the plant leaf area of sunflower.

Three genotypes of sunflower viz., KBSH-1, Morden and EC-68414 were grown in deep black cotton soil under protective irrigation in Kharif 1988 by following all the package of practices at Regional Research Station, Raichur. They were replicated thrice and the average was worked out for each genotype before subjecting to statistical analysis. At peak flowering, leaf length and maximum width for all the leaves of five plants in each genotype were recorded and the area of each leaf was calculated by multiplying the product of leaf length and maximum width with the factor 0.686 (Scheinter, 1978). Plant leaf area was worked out by summing up the area of all the leaves. Similarly, the estimated total leaf area of the plant was obtained by multiplying the area of a leaf at a position with the number of leaves in a plant. This method was followed for all the positions of the leaves. Co-efficients of correlation were worked out for actual leaf area and for the area so worked out. In order to know whether criteria for estimating total leaf area in terms of single leaf area can be evolved common to all the genotypes, Bartlet's test of homogeneity of variance was carried out. When the variances were heterogenous, the weighed analysis of the variance was taken up with completely randomised design to know whether the means of the genotypes are same or not. Analysis of co-variance technique was used to findout the intrinsic relations between the estimated leaf area and actual leaf area. Stability analysis for the regression co-efficients (in terms of co-efficient of determination R^2) was carried out to decide which leaf area is appropriate in estimating the total leaf area common to all the genotypes (Snedecor and Cockron, 1967).

The co-efficients of correlation between actual leaf area and estimated leaf area, taking into account the area of each leaf from the top, is presented in Table-1. It is evident that the total leaf area calculated based on the area of 8th, 9th and 11th position

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TABLE 1. **Actual and estimated leaf area (cm^2) and their correlation co-efficients for different leaf positions in Sunflower.**

Genotype	Actual leaf area	Leaf position from top									
		1	2	3	4	5	6	7	8	9	10
KBSH-1	3545.5	1031.2 0.9468*	1830.5 0.8580	2774.6 0.8176	3632.9 0.9083*	4009.7 0.9913*	4704.8 0.9666*	4886.6 0.9859*	5329.0 0.9830*	5430.6 0.9845*	5043.0 0.9950*
Morden	2083.4	448.8 0.9874*	649.4 0.9349*	978.4 0.9606*	1101.3 0.9216*	1430.2 0.9776*	1779.0 0.9369*	2029.6 0.8256	2266.2 0.9937*	2595.7 0.9641*	3014.0 0.8648
EC-68414	2728.4	752.5 0.0873	1299.5 0.3495	1845.8 0.4009	1939.3 0.8073	3016.7 0.7353	3451.1 0.8045	4163.5 0.9843*	4361.4 0.9744*	4689.5 0.9290*	4247.7 0.9566*

		Leaf position from top									
		11	12	13	14	15	16	17	18	19	20
KBSH-1	3545.5	4821.0 0.9923*	4650.6 0.9954*	4544.4 0.9983*	3916.2 0.9811*	3660.9 0.9935*	3060.8 0.9920*	2800.1 0.9865*	1892.6 0.9965*	1566.5 0.7440	1308.5 0.7522
Morden	2083.4	3323.5 0.8813*	3487.2 0.8299	3294.7 0.7167	3207.9 0.8187	2933.8 0.9032*	2558.3 0.9334*	2027.5 0.7437	1896.6 0.6940	1559.8 0.8973*	1087.9 0.9670*
EC-68414	2788.4	3932.3 0.9866*	3468.4 0.9259*	3074.8 0.8816*	2680.8 0.9052*	2677.0 0.8479*	2162.6 0.3946	2035.6 0.3564	1665.1 0.6008	1283.1 0.1992	771.2 0.9590*

* Significant at ($P = 0.05$)

leaf from the top were closer to the actual leaf area when compared to other leaves and the corresponding correlation co-effifficients were nearer to each other. To know the homogeneity of variances of all the three genotypes with respect to 8th, 9th and 11th leaf, Bartlet's test was carried out. It revealed that the variances are heterogenous. Further, weighed analysis of variance technique showed that the means of variances are not the same. The weighed analysis of co-variance technique revealed that the error correlation co-efficient was low (r=0.463). Hence, it was not considered a proper criterion in estimating the leaf area. This lead to the calulcation of leaf area by formulating regression equation for each genotype. It was found that regression co-efficients pertaining to 8th leaf were stable for all the genotypes. Thus only 8th leaf emerged as a pivotal leaf in deciding the total leaf area of the plant. The regression equation for estimating the actual leaf area (Y) in terms of 8th leaf area ($\times$) is obtained as:

$$Y = 627.9933 + 0.5414 \ (nx)$$

with correlation co-efficient r = 0.9478 and co-efficient of determination $R^2 = 0.8984$, Where n = Number of leaves/plant.

Since the co-efficient of determination is about 90 per cent, it is concluded that the actual leaf area can be estimated with the help of the area of 8th leaf with 90 per cent confidence using the aforesaid regression equation.

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NUTRIENT UPTAKE BY SOYBEAN (*GLYCINE MAX* L. *MERILL*)

Considerable literature is available regarding the effect of phosphorus and irrigation on the yield of soybean but little is known about the influence of phosphorus, irrigation and row spacing on uptake of N, P and K by soybean particularly in alluvial soils having low rainfall. Study of nutrient uptake by the crop may be a helpful guide to the formulation of sound fertility programme. The present investigation was therefore, carried out to study the nutrient uptake by soybean as influenced by phosphorus, irrigation and row spacing on alluvial soils.

A field experiment was conducted at the Zonal Agricultural Research Station, Morena (M.P) during *kharif* seasons of 1983 and 1984. The soil of the experimental area was sandy loam with pH 7.3 having low organic carbon 0.160 per cent, low in available N (77.2 kg/ha), medium in available phosphorus (120 kg/ha,) medium in available potassium R (385 kg/ha) and EC 0.15 dsm-1. The experiment was laid out in split plot design with three replications. Irrigation and phsophorus were allocated in the main plot and row spacing in sub plots. There were three irrigation treatments (no irrigation, irrigation at 0.3 and 0.6 IW/CPE), three phosphorus levels (0, 40 and 80 kg/ha) and three row spacings (30, 45 and 60cm). The irrigation at 0.3 IW/CPE could not be achieved during both the seasons. Hence the treatment no irrigation and 0.3 IW/CPE ratio both are included in one and statistical analysis was done by dummy method. A uniform dose of 20 kg N/ha^{-1} and 20 kg K ha^{-1} as urea and muriate of potash respectively was applied at sowing. The experiment was sown on the 26th and 12th July during 1983 and 1984 respectively. The crop was harvested on the 7th Nov. (1983) and 25th Oct. (1984). Representative samples of grain and straw at harvest from different plots of various treatments were analysed separately for N, P and K (Jackson 1973). The uptake of N, P and K calculated by multiplying the concentration of these nutrients in grain and straw with soybean yield in different treatments. The total rainfall during the crop growing season (July to September) was 559 mm and 451mm in years 1983 and 1984 respectively with maximum rains in the month of August.

The grain and straw yields were significantly higher in the irrigated plot (IW/CPE 0.6) as compared to the un-irrigated, in both the years (Table 1). The grain and straw yields increased significantly with the increased levels of phosphorus during both the seasons. Significantly higher grain and straw yields were recorded under narrow row spacing as compared to wider spacing during both the years. Similar results were reported by Scoot and Batchelor (1979) and Lomera and Pava (1983).

The N, P and K contents of grain and straw were significantly higher in irrigated plots as compared to the un irrigated ones. Similarly the contents of N, P and K increased with increase in phosphorus levels as well as increase in row spacing except phosphorus content in straw due to row spacing.

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TABLE 1. Grain and straw production q/ha, 100 seed weight (g) of soybean as influenced by irrigation, phosphorus and row spacing.

Treatments	Grain yield (q/ha)		Straw yield (q/ha)		Test weight (100 seed, g)	
	1983	1984	1983	1984	1983	1984
*Irrigation Schedules						
$I_0 + I_1$	7.84	9.28	11.28	10.01	9.30	7.77
I_2	9.00	10.10	15.15	11.24	9.80	8.15
CD at 5%	0.095	0.113	0.456	0.119	0.109	0.166
**Phosphorus levels						
P_0	7.53	9.28	10.45	9.80	9.20	7.72
P_1	8.16	9.60	12.70	10.43	9.46	7.87
P_2	8.99	9.79	14.56	10.84	9.65	8.10
CD at 5%	0.109	0.132	0.526	0.138	0.126	0.192
***Row spacing						
S_1	8.93	10.23	14.92	11.01	6.13	7.52
S_2	8.23	9.47	12.34	10.44	9.29	7.94
S3	7.53	8.96	10.45	9.81	9.98	8.23
CD at 5%	0.503	0.183	0.880	0.789	0.185	0.277

* I_1 = No irrigation, I_1 = 0.3 IW/CPE, I_2 = 0.6 IW/CPE

** P_0 = 0 kg/ha P_1 = 40 kg/ha P_2 = 80 kg/ha

*** S_1 = 30 cm row spacing S_2 = 45 cm row spacing S3 = 60 cm row spacing

The data regarding the uptake of the nutrients by soybean (Table 2) revealed that nutrient uptake was significantly better when irrigation was applied at IW/CPE 0.6 as compared to no irrigation in both grain and straw during both the years. The uptake of N, Pand K in grain and straw significantly increased with the increasing, phosphorus levels during both the years. The highest levels of phosphorus application resulted in the maximum uptake of N, Pand K due to closer inter-relationship between N and P metabolism in plant cell. Similar result was reported by Hoque *et al.* (1984). The data further revealed that the uptake significantly decreased with increasing row width in grain and straw during both the years, since there was a corresponding decrease in the yield also. Similar result was reported by Singh and Singh (1983).

TABLE 2. Uptake of N, P and K (kg/ha) by soybean as influenced by irrigation, phosphorus and row spacing

Treatments	Nitrogen (kg/ha)				Phosphorus (kg/ha)				Potassium (kg/ha)			
	Grain		Straw		Grain		Straw		Grain		Straw	
	1983	1984	1983	1984	1983	1984	1983	1984	1983	1984	1983	1984
*Irrigation Schedules												
$I_0 + I_1$	41.73	51.76	36.51	34.73	4.51	5.94	5.65	5.22	13.63	16.61	35.43	33.03
I_2	48.45	57.01	59.29	45.84	5.50	7.05	8.47	6.43	16.36	18.69	54.16	41.79
CD at 5%	0.394	0.681	1.70	0.45	0.078	0.075	0.229	0.069	00.168	0.213	1.375	0.477
**Phosphorus levels												
P_0	39.67	51.55	35.45	35.52	4.13	5.41	5.07	5.01	12.75	16.11	31.80	31.08
P_1	43.75	53.75	44.19	38.20	4.81	6.12	6.61	5.61	14.38	17.36	41.34	35.83
P_2	48.41	55.23	52.67	41.54	5.67	7.40	8.09	6.26	16.49	18.45	51.87	40.94
CD at 5%	0.455	0.787	1.96	0.52	0.090	0.086	0.264	0.080	0.195	0.246	1.588	0.550
*** Row spacing												
S_1	47.39	57.11	51.73	39.89	5.18	6.65	7.73	5.88	15.70	18.40	48.54	37.83
S_2	44.22	53.01	43.25	38.63	4.87	6.25	6.47	5.63	14.54	17.14	41.05	36.04
S_3	40.30	50.42	37.32	36.78	4.55	6.04	5.56	5.37	13.39	16.38	35.42	34.43
CD at 5%	2.471	0.565	3.04	0.80	0.314	0.123	0.454	0.115	0.864	0.331	2.803	0.781

* I_0 = No irrigation, I_1 = 0.3 IW/CPE, I_2 = 0.6 IW/CPE

** P_0 = 0 kg P/ha, P_1 = 40 kg P/ha P_2 = 80 kg P/ha

*** S_1 = 30 cm row spacing S_2 = 45 cm row spacing S_3 = 60 cm row spacing

Thus the findings of these studies reveal that for increasing yield and nutrient uptake of soybean the crop should be grown under irrigation and high phosphorus level with narrow row spacing.

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GENETIC COMPONENTS AND COMBINING ABILITY ANALYSIS OF OIL CONTENT IN INDIAN MUSTARD

Oil content of seed is an essential component of oil yield per unit area in Indian mustard (*Brassica juncea* L. Czern & Coss.). There is considerable variability for oil content in this crop in Indian and recently introduced germplasm lines of exotic origin. In the present study an effort has been made to find out the genetic components of oil content. Twelve parental lines, seven from India, four from USSR and one from Canada were involved in a diallel mating design excluding reciprocals. These lines were, RH 30, Varuna, Kranti, RH 785, Prakash, RH 7859, RC 781 from India; EC 126741, EC 126743-2, EC 126745, EC 126746 from USSR and Domo-4 from Canada. The twelve parental lines and 66F_1 cross progonies were grown in single row each with 6m length in randomized block design in two replications under normal (22 Oct. 1985) and late (8th Nov. 1985) sown conditions. Under each planting date, there further two environments, viz., natural and artificially created epiphytotic conditions. Thus the four different environments were, normal sown natural condition (E_1), normal sown epiphytotic (E_2); late sown natural (E_3) and late sown epiphytotic conditions (E_4). The distance between rows was kept at 30cm and plants within row were maintained at 15 cm by thinning after 3 weeks of sowing. Loamy soil of the experimental plot was fertilized with 80 kg N/ha and was irrigated twice. Five plants were randomly selected from each entry at harvesting time and the seed lot of these plants was analysed for oil content (percent) by NMR (MK III A New port). The genetic components of variation were worked out as per Hayman (1954) whereas combining ability analysis was done using method 2 Model 1 of Grifting (1956).

There were significant differences among the parental lines as well as among the crosses in respect of oil content and seed yield. The genetic parameter which measures the variance due to additive genetic effects was significant in all the environments (Table 1). Similarly the non-additive components, H_1 and H_2 were also significant in all the environments. However, the magnitude of non additive gene effect H_1 was higher as compared to additive gene effects (D) in all the environments. The ratio $(H_1/D)^{\frac{1}{2}}$ also indicated the presence of over dominance under all the environments. Distribution of negative and positive allels among the different parents was a symmetrical in all the environments. The ratio $(4DH_1)^{\frac{1}{2}} + F/(4DH_1)^{\frac{1}{2}} - F$ attained the value of more than unity which revealed that the dominant genes were more frequently distributed than the recessive genes in the parents in all the environemnts. The ratio, h^2/H_2 indicated involvement of one major gene group in the inheritance of oil content in all the environments. The heritability estimates were moderate. The above observations as a whole indicated prevalent role of non-additive genetic components in the control of oil content which is in agreement with the earlier findings (Yashpal and Singh 1986). However, the significant values of additive components indicated that there was still some scope of oil improvement by pedigree selection also. Based on the pooled analysis of gca in the four environments, RH 7859 was the best general

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TABLE 1. Estimates of genetic components of variance for oil content in Indian mustard in four environments.

Components of variation	Environments			
	E_1	E_2	E_3	E_4
D	11.05**	7.43**	12.26**	9.66**
	± 2.512	± 2.60	± 2.65	± 2.06
H_1	24.21**	19.03**	29.71**	23.24**
	± 5.02	± 5.20	± 5.30	± 4.13
H_2	18.83**	15.47**	24.06**	19.87**
	± 4.18	± 4.33	± 4.41	± 3.44
	4.46	0.70	4.44	2.36
	± 2.79	± 2.89	± 2.95	± 2.30
F	8.07	3.06	2.51	1.36
	± 5.69	± 5.90	± 6.01	± 4.68
E	0.37	0.27	0.24	0.20
	± 0.69	± 0.72	± 0.73	± 0.57
Degree of dominance	1.479	1.600	1.556	1.550
Symmetry of genes	0.194	0.203	0.202	0.213
Proportion of dominance and recessive alleles.	1.655	1.296	1.140	1.095
Groups of genes exhibiting dominance effects	0.237	0.045	0.184	0.119
Heritability (n.s.)	0.451	0.489	0.551	0.530
t^2	6.682	4.920	0.050	0.512

** P = .01

combiner followed by Kranti, RH 30 and Prakash. Interestingly these genotypes are also important from seed yield point of view. A yellow seeded exotic genotype, EC126743-2 was also identified as a good combiner.

Of the 66 crosses only varuna × EC126746, Varuna × EC126741, Kranti × EC126746, Kranti × RC781, Prakash × EC 126743-2, RH7859 × EC126745, RH 7859 × EC126746, RH7859 × EC126741 and RH7859 × Domo-4 exhibited significant and positive sca effects (Table 2) in all the four environments. It is further evident that out of these crosses only Prakash × EC126743-2 and Kranti × RC781 had the parental lines with significant positive gca effect. These crosses are, therefore,

TABLE 2. General and specific combining ability effects for oil content in Indian mustard in four environments.

Parents	1	2	3	4	5	Parents 6	7	8	9	10	11	12
1. RH-30	0.956*	-0.367	-2.039*	-0.236	-0.728*	-3.574*	0.558*	2.452*	2.219*	3.309*	1.133*	1.268*
2. Varuna		0.081	-1.227*	-0.511*	0.159	-3.675*	1.421*	1.402*	2.107*	1.159*	0.983*	1.293*
3. Kranti			1.104*	-0.784*	-2.13	-2.860*	1.372*	3.141*	1.946*	-0.001	2.297*	0.657*
4. RH785				0.563*	0.339	-0.994*	0.288	2.082*	1.137	-2.648*	0.525*	0.748*
5. Prakash					0.880*	– 786*	0.747*	-0.984*	0.420	-0.014	0.670*	1.807*
6. RH7859						2.152*	2.213*	4.269*	4.561*	3.376*	1.575*	0.372
7. EC126745							-0.586*	-2.098*	-2.206*	-0.716*	-2.193*	0.881*
8. EC-126746								-1.624*	-0.617*	-0.472*	-2.936*	-1.051*
9. EC126741									-0.579*	0.020	-3.794*	-3.021*
10. Domo-4										-3.706*	-3.717*	-2.06*
11. RC-781											0.157*	1.179
12. EC126743-2												0.609*

* P = .05

promising and are expected to be the desirable base material for oil content improvement by selection.

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POD SHATTERING IN SOYBEAN (*GLYCINE MAX* (L.) MERILL)

Pod shattering in soybean is one of the major lacunae that takes a heavy toll of produce. The present investigation with 15 promising varieties including three controls was undertaken with major emphasis on their pod shattering behaviour.

The experiment was conducted in Kharif, 1987 with quadruple replicated randomized complete block design. Each plot was divided into two segements one of it was-harvested at harvest-maturity for collecting data on pod-seed yield, the other was left for collecting data on pod-shattering.

It was observed that at harvest-maturity (R-11 stage, after, Anonymous, 1971) the three varieties viz., JS-1515, JS-1608 and JS-1625 showed no shattering losses, whereas all the three controls expressed losses from 26.2% to 67.5% (Table-1). Similar results were obtained by Tiwari and Bhatnagar (1988) regarding JS-2, Pb-1 and Shyamar After 10 days of harvest/maturity these very three promising varieties still did not shatter. Eight varieties viz., JS-75-5, JS-200 B, JS-1564, JS- 989, JS-1562, JS-1006, JS-1504 and JS-865 exhibited pod shattering under 25% at harvest-maturity. Hence these were grouped into the catagory of varieties which do not shatter, (Anonymous, 1985). However, twenty days after harvest-maturity the differences for this character among all the varieties were seemed to be fast vanishing and crossing the economic threshold limit.

The yield data, by and large, showed a similar trend. Therefore, these non-shattering cultivars may show promise for breeding.

It is suggested that the time is ripe when farmers should become aware and harvest their precious soybean crop at harvest-maturity or at on earliest possible date

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TABLE I. Performance of 15 promising varieties of Soybean for shattering and other important agronomic traits.

Varieties	Seed yield (kg/ha)	Pod Shattering percentage			No. of pods per plant	No. of branches per plant	Plant height) (cm
		at harvest-maturity	10 days after harvest-maturity	2C days after harvest-maturity			
JS – 969	1221.4	26.2	47.5	92.5	46.5	5.7	47.6
JS – 1515	1428.5	0.0	12.5	88.7	53.4	6.9	32.4
JS – 865	1507.1	21.2	61.2	90.0	55.1	8.5	63.5
JS – 1608	1207.1	0.0	11.2	82.5	43.6	6.8	43.2
JS – 1562	1300.0	12.5	45.0	81.2	45.3	7.2	46.8
JS – 1006	1376.1	13.7	45.0	86.2	49.0	7.0	45.5
JS – 1625	1130.9	0.0	11.2	68.7	40.0	5.9	46.6
JS – 200 B	1095.2	6.2	22.5	58.7	40.7	6.2	41.9
JS – 1504	1157.1	18.7	38.7	83.7	41.1	6.6	45.5
JS – 1564	1111.9	10.0	42.5	76.2	40.8	5.8	49.9
JS – 989	1333.3	11.2	47.5	91.2	46.6	7.7	46.4
JS – 71–5	1535.7	5.0	20.0	62.5	55.1	7.6	31.9
JS – 2 (Control)	709.5	67.5	82.5	95.0	38.7	5.5	34.9
Pb–1 "	666.6	26.2	63.7	78.7	28.8	5.8	36.2
Shyama "	1014.2	63.7	76.2	93.7	33.6	6.7	76.3
SEm ±	100.89	—	—	—	3.90	0.46	3.09
C.D. (5%)	285.33	—	—	—	11.37	1.34	9.01

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EFFECT OF SOME CULTURAL FACTORS ON GROWTH AND SPORE GERMINATION OF *ALTERNARIA CARTHAMI* (CHOWDHURY)

Safflower is affected by many diseases amongst which alternaria leaf spot is very important. Environmental conditions affect the development of the disease to a great extent. Spore germination is a pre-requisite for infection of host by fungal pathogen. The effect of temperature, hydrogen ion concentration (pH) and different media were studied to find out the optimum conditions required for optimum growth and sporulation of *Alternaria carthami.*

Seven media, i.e., Asthana and Hawker's Cornmeal agar, Czapek's agar, Potato dextrose agar, Plain agar, Rice meal agar and Richards agar were tested for their effect ion growth of *Alternaria carthami.* Twenty milli-litres of molten sterilized medium was poured in pre-sterilized petridishes of 9 cm. diameter. Seven milli meter discs were cut with the help of sterilized cork borer from the margin of seven day old culture of the fungus grown in petridish on Potato dextrose Agar and one disc of culture was placed aseptically in the centre of each petridish containing solidified medium. The plates were incubated at 25 + 2°C. The data were recorded for radial growth after eight days of incubation.

Three temperatures 20 °C, 25°C and 30°c were tested. The spore suspension was made in tap water. A drop of spore suspension was placed on cavity slide and incubated at different temperatures. The observations were recorded after 24 hours of incubation. The per cent germination was calculated based on spore germination per microscopic field.

Five pH levels, viz, 4,5,6,7, and 8 were used. The tap water was adjusted with 0.1 N HCl, 0.1 N NaoH using digital pH meter. The spore suspension was prepared for each pH level separately in test tubes. One drop of spore suspension of each pH level was placed in cavity slides. Three replications were maintained for each pH level. The cavity slides with spore suspension of *Alternaria carthami* were incubated at 25 °C and the germination was recorded after 24 hours.

Out of seven media tested (Table 1) Potato dextrose agar medium was the best (83mm) followed by cornmeal agar in eight days. No growth on plain agar was recorded. Growth pattern was fluffy on PDA corn meal agar while submerged on Rice agar, appressed on Czapek's agar, Richards agar and Asthana and Hawker's agar. Pigmentation of fungal colony also differed to some extent in different media. According to Fohim (1966) Potato dextrose agar medium was the best for hyphal growth and sporulation of *Alternaria* spp.

The data (Table 2) reveal that the temperature influenced the germination of *Alternaria carthami*. Among three temperatures tested maximum percentage (58.33%)

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TABLE 1. Growth of *Alternaria carthami* on different synthetic and non synthetic media.

Media	Colony (dia. mm)	Growth Pattern	Colony pigmentation	
			Front	Reserve
Asthana and Hawker's	56	Appressed	Brown	Brown
Corn meal agar	62	Fluffy	Black	Black
Czapek's agar	23	Appressed	Brown	Black
Potato Dextrose agar	83	Fluffy	Brown	Black
Plain agar	No growth	—	—	—
Rice meal agar	43	Submerged	Black	Black
Richard's	38	Appressed	Black	Black

TABLE 2. Effect of different temperature level on spore germination of *A. carthami*.

Temperature (°C)	Spore Germination
20	36.36
25	58.33
30	47.80

TABLE 3. Influence of pH on spore germination of *Alternaria carthami*.

pH	Spore Germination (%)
4	26
5	39
6	68
7	56
8	30

of germination was at 25°C. Chowdhury (1944) also reported that 25-30°C to be optimum for the growth of *A. carthami*. The spores of *Alternaria carthami* germinate well under wide range of temperatures ranging from 21 to 30°C (Bock, 1964, Boelema and Ehlers, 19767). Fohim (1966) reported 25°C to be the best for the spore germination of *Alternaria* spp.

The data (Table 3) show that the spore germination varied at different pH levels. However, the highest germination (68%) occured at pH 6 followed by pH 7 (56%). Arya and Prasad (1952) also reported pH range of 5 to 6.5. suitable for mycelial growth and conidial formation of *Alternaria carthami*.

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A CASE OF DOWNY MILDEW OF SUNFLOWER IN MADHYA PRADESH

Downy mildew of sunflower (*Helianthus annus* L.) caused by *Plasmopara* spp. is an important disease that contributes to substantial crop losses in temperate regions (Kolte, 1985). In India, this disease is reported from the state of Maharashtra only (Mayee and Patil, 1986). In Kharif 1990, the disease was observed in the experimental crop of sunflower at R.A.K. College of Agriculture, Sehore. This is the first report of its occurrence in the state of Madhya Pradesh where the sunflower is being introduced for commercial cultivation.

Only a few plants of sunflower variety 'Morden' were infected in the area where sunflower crop was not previously grown. The affected plants were stunted showing epiphyllous mottling on upper leaves. The mottling was observed mainly near the base of the leaf. The affected leaves were thickened and tips were curled downward. On the corresponding areas of the mottling, the hypophyllous downy growth of the fungus consisted of sporangiophores and sporangia. The sporangiophores emerged through the stomata and were hyaline to pale coloured and non septate. They were straight and branched monopodially at right angles 3-6 times. The sporangiophores measured 130 - 500 μ (average 316 μ) in size bearing sporangia singly at tips of branches. The zoosporangia were elliptic to lemon shaped, mostly papillate, light coloured and $11.2\text{-}25.3 \times 11.2\text{-}16.8\mu$ (average $16.0 \times 12.7u$) in size. The disease was observed on plants approximately one month old. Further studies could not be conducted because the crop was subsequently damaged badly by *Alternaria helianthi*. The causal fungus is identified as *Plasmopara helianthi* which forms a species of *Plasmopara halstedii* (Farl.) Beri and de T. complex. Mayee and Patil (1986, 1987) reported that *Plasmopara halstedii* was the causal agent of downy mildew of sunflower in Maharashtra state. The occurrence of the disease in a new sunflower production area of Madhya Pradesh may be attributable to seed borne transmission of inoculum. Systemic symptoms were observed on only a few young plants.

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LEAF SPOT OF GROUNDNUT CAUSED BY *SCLEROTIUM ROLFSII* SACC.

Sclerotium rolfsii Sacc. is an important pathogen causing mainly collar and stem rot symptoms in a large number of host plants including groundnut (Aycock, 1966). During a disease survey in Narsinghgarh district, leaf spot symptoms were observed on plants of groundnut cultivar AK 12-24. Collar rot and stem rot symptoms were observed on the same plants. This paper deals with the study made on leaf spot symptoms.

In the field, the leaf spots were observed mostly on lower leaves of several groundnut plants. The spots were 2-7 mm in diameter, mostly circular with greyish centres and reddish brown margins surrounded by chlorotic zones. When coalesced with each other, they produced blighting symptoms. White to brown and round sclerotia were attached in the centre of the spot on lower leaf sutface on isolation, the infected tissues yield a fungus with white feathery mycelium, later producing brown, small and round sclerotia. The fungus was identified as *Sclerotium rolfsii.*

Pathogenicity of the fungus was tested on groundnut plants (AK 12-24) maintained on flasks containing sterilized water. The test plants were kept in moist chambers made of bell jars. Inoculations were done with and without injuries on petioles, upper surface of leaves and lower surface of leaves. A single sclerotium from the 7 day old culture, was used as inoculum for each inoculation site. Suitable uninoculated controls were maintained. Small brown spots developed on leaves within 24 hours after inoculation.

The spots enlarged on leaves quickly gaining moslty circular shape with dark brown border. Rotting of petiole tissues with brown discolouration was induced, but no well defined margin of the spot was observed. All inoculations were successful. Later, white to cream coloured sclerotia developed on the lower surface of the inoculated leaf. *Sclerotium rolfsii* was isolated from infected tissues. The fungus produced larger and darker sclerotia on Potato dextrose Agar medium as compared with sclerotia produced on the host plant surface.

S. rolfsii is considered mainly a soil-borne pathogen attacking mostly the collar or the stem portion of the host plant. However, in few cases like black gram, it infected the foliage and caused leaf spot symptoms (Mishra *et al.* 1971). The small sclerotia are probably dispersed from the soil to the leaf surface through the rain splashes (Aycock, 1966).

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CYTOGENETICS OF FIRST BACKCROSS DERIVATIVES OF *BRASSICA JUNCEA* X *BRASSICA HIRTA* HYBRIDS

While interspecific hybridization in the tribe *Brassicaceae* has been widely used to transfer gene(s) across the interspecific boundaries (Ayotte *et al.*, 1988; Chang and Crete, 1982; Yamagishi *et al.*, 1980; Johnston, 1974), gene transfers between *B. juncea* and *B. hirta* Moench (Syn. *Sinapis alba* 2n=24, SS) have been usnsuccessful because several pre and post - zygotic incompatibility barriers limit the production of sexual hybrids between the two species (Downey *et al.*, 1980). The production, morphology and cytology of the first successful sexual hybrids of *B. juncea* X *B. hirta* will be reported elsewhere. Herein we report the results of the first backcross derivatives of the interspecific F_1 hybrids and *B. juncea*. The present investigation was undertaken to transfer leaf blight resistance from *B. hirta* to *B. juncea*.

Following bud pollination technique, the original interspecific hybrids between *B. juncea* X *B. hirta* and their subsequent backcrosses to *B. juncea* cv Varuna were easily obtained. For meiotic studies, pollen mother cells (PMCs) of the first backcross plants were fixed in 1:3 (acetic acid:alcohol) overnight, stored in 70% alcohol and squashed in 1% acetocarmine.

Backcrosses of the *B. juncea* X *B. hirta* F_1 hybrids to *B. juncea* were easily accomplished. Since our attention was primarily focussed on transfer of leaf blight resistance from *B. hirta* to *B. juncea*, backcrosses of the F_1 hybrids to *B. hirta* were not attempted. Pollen stainability of the BC_1 plants ranged from 85.0 to 95.0%.

Meiosis was studied in 5 BC_1 plants. Based on meiotic data collected on the allotriploid (ABS) hybrids (2n=30), most backcrosses to *B. juncea* were expected to have between 30 to 35 chromosomes. The observed chromosomes of BC_1 plants ranged from 31 to 34 and none of counts lay outside the expected range of chromosome numbers. This suggests that only hypo-and hyperploid female gametes made their contribution to BC_1 zygote formation and chromosomes of *B. hirta* were transmitted at a high rate.

TABLE 1. The mean chromosome associations and range values (in parentheses) in PMCs of *B. juncea* × *B hirta* BC1

No. of plants studied.	No. of PMCs analyed·	2n	Chromosome associations at MI I*	II	III	IV
5	70	31-34	6.11	11.90	0.94	0.014
			(3-14)	*(10-14)*	*(0-2)*	*(0-1)*

*I,II,III and IV indicate univalent, bivalent, trivalent and tetravalent, respectively.

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The data on chromosome associations at Metaphase-I are presented in Table 1. The average chromosome pairing was 6.11 univalents, 11.90 bivalents, 0.94 trivalents, and 0.014 quadrivalents per meiocyte. The most common configurations included 12 II+1 III+5 I (22.8%), 13 II+1 III+5 I (14.2%), and 11 II+1 III+8 I (5.7%). Of the 70 PMCs studied, trivalents were observed in 64 cells (91.4%). Quadrivalents which suggest translocations in the F_1 hybrids were recorded in 1.43% of PMCs.

Tne relative ease of obtaining backcrosses of interspecific F_1 hybrids to *B.. juncea* in conjunction with a high frequency of trivalent associations at metaphase I and high seed fertility of BC_1 plants suggests that possibility of genetic crossing over to reconstruct the *B. juncea* genome does exist and leaf blight resistance can be stabilised in *B. juncea* background by repeated selection and backcrossing.

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EVALUATION OF DIFFERENT SPRAYERS FOR THE CONTROL OF GROUNDNUT LEAFMINER, *APROAEREMA MODICELLA* DEVENTER.

Groundnut crop is subjected to the attack of several insect pests of which, leafminer (*Aproaerema modicella* Deventer) is a major one in many South Asian and South-East Asian countries (Reddy, 1978). The groundnut is mainly grown during *Kharif* season under rainfed conditions in Karnataka and suffers the maximum damage due to the pest during July-August. Application of recommended insecticide with the available high and low volume sprayers is a tedious job under dryland situations. Therefore, there is much scope for the evaluation of plant protection appliances which can minimise the quantity of scarce water used in spraying thereby encourage dryland cultivators to take to chemical pest control. So with a view to finding out the efficacy of different sprayers against leafminer, the present investigation was under taken.

This experiment was conducted during the *Kharif* seasons 1987 and 1988 with JL-24 variety of groundnut. The different treatments included in the study are presented in Table 1. Totally two sprays with monocrotophos 36 SL (625 ml/ha/spray) were given at peak infestation of the pest. The quantity of water used was 625,250 and 12.5 litres/ha in High volume, Low volume and Ultra Low Volume (ULV) sprayers, respectively. The observations on the number of leafminer larvae/20 leaflets were made on five randomly selected plants 24 hours before and 72 hours after the treatment.

The results (Table-1) obtained in *Kharif* 1987 indicated that 72 hours after the first spray, all the treatments were found to be on par with each other but differed significantly from untreated check. The least number of larvae 0.2/20 leaflets were recorded with ULV sprayer with 10 per cent sugar solution after second spray during 1987. Similar trend was also noticed during 1988 with the minimum of 0.70 and 0.20 larvae/20 leaflets after first and second sprays, respectively, with ULV sprayer (10% sugar solution). However, statistically all the treatments were found to be on par with each other in reducing the larval population and proved superior over untreated control. These findings are in confirmity with the reports of the earlier workers (Chandrasekharan and Mahadevan, 1987).

The economics of different sprayers revealed that ULV sprayer with 10 per cent sugar solution had given the highest cost-benefit ratio during both the years and the next best was ULV sprayer. Therefore, ULV sprayers can be used for spraying monocrotophos 36 SL @ 625 ml/ha for mitigating groundnut leafminer population. Since the canopy of groundnut is at lower level to the applicator, it may not cause any health hazard to him. Therefore, ULV sprayers can more efficiently be used under deryland conditions, wherever water is scarce. In addition, a single person can cover an area of our hectares a day as against two persons covering two hectares with low volume

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TABLE 1. Evaluation and economics of different sprayers ofr the control of groundnut leafminer.

Treatments	I-Spray: Av. No· of leaf miner larvae/ 20 leaflets				II-Spray: Av· No. of leaf miner larvae/ 20 leaflets				Yield Kg/ha	Addl. income received by follow ing plant protection Rs	Cost of the treatment Rs	C.B. ratio
	1987		1988		1987		1988					
	B	A	B	A	B	A	B	A				
1 High volume sprayer (Hydraulic)	15.73	1.2 (1.47)	4.27 (2.29)	0.87 (1.36)	3.4	0.26 (1.12)	2.13 (1.76)	0.43 (1.79)	1077	1911	301	1:6.34
2 High volume sprayer (Pneumatic)	13.93	0.73 (1.30)	4.50 (2.34)	0.87 (1.36)	2.2	0.4 (1.18)	2.47 (1.85)	0.33 (1.15)	1039	1674	301	1:5.56
3 Low volume sprayer	16.93	1.67 (1.62)	4.67 (2.38)	1.07 (1.44)	3.5	0.33 (1.15)	2.30 (1.81)	0.47 (1.21)	1036	1660	271	1:6.13
4 Low volume sprayer with 0.1% Sugar solution	14.4	0.53 (1.23)	5.00 (2.44)	0.87 (1.36)	3.2	0.33 (1.15)	2.13 (1.77)	0.43 (1.19)	1022	1551	292	1:5.31
5 ULV sprayer	16.6	1.4 (1.55)	5.27 (2.49)	0.9 (1.37)	2.93	0.6 (1.26)	2.9 (1.79)	0.33 (1.15)	1048	1721	230.5	1:7.47
6 ULV sprayer with 10% Sugar soln.	17.0	1.36 (1.54)	4.13 (2.24)	0.70 (1.30)	2.67	0.2 (1.09)	2.73 (1.93)	0.20 (1.12)	1074	1888	245.5	1:7.69
7 Untreated check.	15.13	15.8 (14.03)	4.40 (2.32)	4.57 (2.36)	4.1	4.33 (2.28)	2.57 (1.88)	3.2 (2.04)	883	—	—	—
S Em±	2.75	0.34	0.23	0.08	0.86	0.16	0.19	0.04				
CD at 5%	NS	0.73	NS	0.18	1.87	0.34	NS	0.11				

Figures in the parentheses indicate X + 1 transformed values.

B: 24 hours before spraying; A: 72 hours after spraying.

sprayer and less than a hectare with high volume sprayer. The only care that has to be exercised is to have a better protective clothing to the applicator.

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