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INTERCROPPING STUDIES IN *TORIA*
(*Brassica campestris*, var. *toria*)

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ABSTRACT

A field experiment was conducted at Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar (Nainital), U.P. during *rabi* seasons of 1984-85 and 1985-86 to find out the remunerative *toria* based intercropping system. The highest seed yield equivalent of *toria* (25.08 q/ha) and land equivalent ratio (1.26) over two years were obtained when one additional row of lentil was grown between two rows of *toria*. This treatment also gave 96.97 per cent mean yield index of *toria*. Similarly, the mean net returns (Rs. 9689/ha) over two years were proved to be superior in this treatment over the sole crop (Rs. 8005/ha).

Key Words : *Toria*; Intercropping; Land equivalent ratio (LER)

Intercropping has been recognized as a potentially beneficial system of crop production in comparision with sole cropping. Advantages in intercropping may be specially important because they are achieved not by means of costly inputs, but by the simple expedient of growing crops together (Willey, 1979). Kumar and Singh (1982) observed that growing *toria* with lentil had shown profitability over sole *toria*. With this in view, the present investigation was carried out to study the production potential and feasibility of various intercropping systems with *toria*.

MATERIALS AND METHODS

An experiment was conducted at Crop Research Centre, G.B. Pant University of Agriculture and Technology, Pantnagar (Nainital) U.P. in *rabi* seasons of 1983-84 and 1984-85. The soil was silty clay loam in texture, rich in organic matter (1.57%) and high in available phosphorus (232 kg P_2O_5/ha) and available potassium (236 kg K_2O/ha).

The experiment was laid out in a Randomised Block Design with 14 treatments replicated thrice. The varieties of toria, lentil, gram and linseed were T-9, L-9-12, PG-114 and L.C. 54, respectively for both the years. Planting was done on October 15 and October 10 during 1983 and 1984, respectively under irrigated condition. Seeds were drilled manually in the furrows spaced at 30 cm with recommended seed rates. Seeds of *toria* and its associate crop were mixed and broadcasted in case of broadcast sown intercropping treatments. Thinning was performed 15 days after sowing in *toria* to maintain 15 cm plant to plant spacings.

In treatments comprising sole toria, nitrogen was applied at the rate of 90 kg/ha in two splits, 45 kg as basal and 45 kg as top dress after first irrigation. 20 kg N/ha was applied as basal in sole crop of lentil and gram. In linseed, 30 kg N was applied as basal and 30 kg/ha top dressed after first irrigation. An uniform basal application of 40 kg P_2O_5 and 20 kg K_2O/ha was made in each treatment.

Toria seed yield equivalent and land equivalent ratio were calcualted as follows :

Toria seed yield equivalents in intercropping systems =

$$\text{Yield of } toria\text{(q)} + \frac{\text{Yield of intercrop(q)} \times \text{price / q}}{\text{Price of } toria \text{ / q}}$$

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Land Equivalent Ratio =

$$\frac{\text{Yield 'a' crop in intercrop}}{\text{Yield 'a' crop in pure crop}} + \frac{\text{Yield 'b' crop in intercrop}}{\text{Yield 'b' crop in pure crop}}$$

The price per quintal of *toria*, lentil, gram and linseed were Rs. 525/-, 300/-, 400/- and 540/- for 1983-84 and 450/-, 375/-, 400/- and 500/- respectively for 1984-85.

RESULTS AND DISCUSSION

Seed yield of toria and intercrops

Toria, seed yield was affected by different intercropping systems (Table 1). During 1983-84, significantly highest seed yield of *toria* (22.81 q/ha) was recorded in line sown sole *toria* in comparison with all other intercropping combinations except *toria* + lentil (c) combination where one additional row of lentil was grown between two rows of line sown crop of *toria*. In 1984-85 also these two treatments recorded higher yield. The mean yield of *toria* was recorded to be highest in sole *toria* (L) because of more plant population, higher dry matter accumulation per plant and reduced competition.

Lower seed yield of *toria* was recorded when *toria* was grown in alternate rows with lentil during 1983-84 and with linseed during 1984-85. In general all intercropping systems with *toria* in alternate planting (A) gave lower yield of *toria* as compared to one additional row of intercrop between two rows of sole *toria* (L). This was mainly due to reduced plant population of *toria*. Similar results were found in case of broadcasting sowing of *toria* + lentil, *toria* + gram and *toria* + linseed treatments due to uneven plant population.

The seed yield of intercrops i.e. lentil, gram and linseed was adversely affected in different intercropping systems. The highest seed yield of all associated crops was recorded in their sole stands.

Significantly highest seed yield equivalents of *toria* was obtained in the treatment where one additional row of lentil was grown between two rows of line sown sole *toria* in both the years.

Land equivalent ratio (LER)

The LER was significantly affected by intercropping treatments during both the years (Table 1). The treatment where one additional row of lentil was grown between two rows of line sown sole toria gave the highest LER during both the years i.e 1.23 in 1983-84 and 1.28 in 1984-85, respectively. Thus, irrespective of geometry, all intercropping treatments except two treatments where lentil and linseed was taken in alternate rows with *toria*, were superior to respective pure stand. Beets (1977) reported that intercropping system has higher LER than monoculture of maize and soybean.

Net returns

Mean net returns was maximum when one additional row of lentil was grown between two rows of line sown sole *toria* followed by sole *toria* (L) (Table 1). The other intercropping treatments gave lower net returns than line sown sole crop of *toria*.

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Table 1. Effect of sole and intercrop combinations on seed yield, seed yield equivalents of *toria*, land equivalent ratio and net returns.

Treatments	Yield of sole crop (q/ha) 1983-84	Yield of sole crop (q/ha) 1984-85	Mean yield Index	Yield of inter-crop (q/ha) 1983-84	Yield of inter-crop (q/ha) 1984-85	Seed yield equivalents of *toria* (q/ha) 1983-84	Seed yield equivalents of *toria* (q/ha) 1984-85	Mean	Land Equivalent Ratio 1983-84	Land Equivalent Ratio 1984-85	Mean net returns (Rs/ha)
Sole *toria* (L)	22.81	18.00	100.00	-	-	22.81	18.00	20.41	1.00	1.00	8005
Sole *toria* (B)	17.23	14.20	77.02	-	-	17.23	14.20	15.72	1.00	1.00	5845
Sole lentil (L)	-	-	-	28.61	25.64	16.35	21.36	18.86	1.00	1.00	5845
Sole gram (L)	-	-	-	11.21	8.78	8.97	7.80	8.39	1.00	1.00	2197
Sole linseed (L)	-	-	-	12.64	14.68	18.15	16.31	17.23	1.00	1.00	6364
Toria + Lentil (C)	21.26	18.20	96.67	8.65	6.90	26.21	23.95	25.08	1.23	1.28	9689
Toria + Gram (C)	17.48	14.48	78.29	3.63	2.50	20.25	16.70	18.49	1.08	1.08	6062
Toria + Linseed (C)	17.93	15.00	80.69	4.05	3.08	22.10	18.42	20.26	1.01	1.04	7189
Toria + Lentil (A)	14.54	12.56	66.39	4.04	3.20	16.85	15.22	16.04	0.78	0.81	5690
Toria + Gram (A)	15.49	13.86	71.93	5.23	3.95	19.47	17.32	18.42	1.12	1.22	6720
Toria + Linseed (A)	14.60	11.72	64.48	4.88	3.90	19.63	16.27	17.95	0.92	0.92	6605
Toria + Lentil (B)	16.14	12.94	71.24	5.44	4.00	19.25	16.27	17.76	1.13	0.88	6570
Toria + Gram (B)	15.21	12.00	66.68	3.87	3.95	18.16	15.51	16.84	1.21	1.12	5847
Toria + Linseed (B)	15.26	13.15	69.62	4.07	4.00	18.14	17.59	17.87	1.12	1.00	6901
CD at 5%	1.38	3.82	-	-	-	1.55	0.72	-	0.06	0.04	-

L - Line sown, B - Broadcast sown, C- One additional row of associated crop between line sown *toria*.

A - One row *toria* alternated by one row of associated crop.

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PHENOTYPIC STABILITY OF SOYBEAN GENOTYPES IN RELATION TO FLOWERING, MATURITY DURATION AND YIELD

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ABSTRACT

Thirty diverse soybean *(Glycine max* (L) Merrill) genotypes were evaluated for stability of performance for yield, days to 50% flowering and days to maturity over six environments characterized by three dates of planting in each of the two years, 1983 and 1984. Both linear and non-linear components accounted for observed variability for all the characters; the magnitude of the former being greater than the later. Apart from regression coefficient of genotypic values on environmental indices (b_i) and deviation from regression ($S^2 d_i$), another stability parameter phenotypic index (P_i) was estimated for each character. Genotypes with combined high mean yield (high phenotypic-index), unit regression coefficient and non-significent deviation from regression were considered as average stable. The number of average stable genotypes for both yield and days to maturity were three in medium (PK-459, Alankar and JS-760-259), one (DS-75-1-29) in late and none in the early maturing group. However these genotypes did not possess average stability for days to 50% flowering. The genotypes PK 262 and Co-1 possessed below average stability and none in the above average stability group for grain yield.

Keywords: Soybean; Stability; Phenotypic index

Variation in relative performance of genotypes across environments is the observable manifestation of genotype × environment (GE) interaction and its presence has long been recognized to be an impediment in the progress of plant breeding. Attempt to partition this interaction into meaningful purposes for describing the stability of performance is a comparatively recent technique. Various regression approaches have been used to provide a measure of phenotypic stability of genotypes (Finlay and Wilkinson, 1963 Eberhart and Russell, 1966; Rowe and Andrew, 1964; Perkins and Jink, 1968 a,b; Johnson *et al* 1962; Breese, 1969, Baker, 1969, Hardwick and Wood, 1972). Eberhart and Russel (1966) developed a more elaborate method based on the regression technique for measuring stability of genotypes by considering two emperical parameters viz., (1) the slope of the regression line and (2) the deviation from the regression line. A stable genotype was defined as one with (1) high mean yield (2) unit regression (b_i=1) and least (non-significant) deviations from regression (S^2 d_i=o).

Soybean breeders have long emphasized the need for the selection of genotypes that performed consistantly when grown over a wide range of conditions because in the context of production and productivity it is the consistency of performance rather than performance *per se* that determines the general acceptability of a genotype.

In the present investigation, 30 diverse soybean genotypes were grown in six environments characterized by six dates of planting to study the genotype × environment interactions and to interpret the same in terms of stability of different genotypes using the model suggested by Eberhart and Russel (1966).

MATERIALS AND METHODS

The 30 genotypes were evaluated in randomized replicated trials under six planting dates namely 2nd November, 1983 and 15th January, 2nd February, 16th June, 10th July and 18th August, 1984 in the experimental farm of Assam Agricultural University, Jorhat. The planting dates were considered as separate environment each

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laid out in RBD with 3 replications. Individual plot size in each replication was 3m x 1.35m. Observations were recorded on ten randomly sampled plants per plot for grain yield, days to 50% flowering and days to maturity and the data were subjected to analysis of variance at individual environment and pooled analysis of variance over environments for GE interaction following Eberhart and Russel (1966).

RESULTS AND DISCUSSION

The pooled analysis of variance (Table 1) for genotype x environment interaction revealed significant variation of genotypes for all three characters. The environment + (Genotype x environment) component was significant for all the characters indicating that genotypes interacted significantly with the environments. Both linear and non-linear components significantly contributed towards genotype x environment interaction for all the characters as evident from significant genotype x environment (linear) and pooled deviations. However, for all the characters, linearity was more pronounced which indicated that the performance of the genotypes could be predicted to a great extent for these characters when grown over variable environments.

Table 1. Pooled analysis of variance for genotype environment interaction of 30 soybean genotypes grown over six environments.

Source	d.f.	Mean Square		
		Yield	Days to 50% flowering	Days to maturity
Genotype	2q	0.14*	21.35**	127.78**
Env. + (G X E)	150	0.23*	164.72**	317.55**
Env. (Linear)	1	0.98	0.99	1.02
G E (Linear)	29	2.40**	811.57*	1396.53**
Pooled deviation	120	1.89**	9.83**	48.50**
Pooled error	360	0.35	5.30	28.38

*P=0.05 ** P= 0.01

In addition to mean, regression coefficient (bi) and deviation from regression (S^2 di), another stability parameter phenotypic index, 'Pi' (Choudhury *et al.*, 1972) which is the deviation of mean performance of each genotype from grand mean over all the genotypes and all the environments was estimated for each genotype and for each character. The genotypes which exhibited high mean performance (consequently positive phenotypic index), unit regression and low deviation from regression were considered as average stable genotype for yield. However, with respect to days to maturity the genotypes were classified into three groups viz. early maturing, medium maturing and late maturing. Considering all the stability parameters, none of the genotypes were found to be stable for days to 50% flowering obviously because of high and significant deviation mean squares. The average, above average and below average stable genotypes within different maturity groups for grain yield per plot and days to maturity are listed in Table 2 and the stability performances with regard to the three characters of a few important genotypes identified for grain yield per plot are presented in Table 3. None of the genotypes of early maturing group exhibited stability for grain yield per plot. However three genotypes viz., PK 459, Alankar and JS-76-259 of medium maturing group and four genotypes, *viz.*, PK 412, DS-75-1-29, MACS-111 and KHSB-3 of late maturing group exhibited average stability. The genotype PK 262 of medium maturing and Co-1 of *late maturing group* exhibited below average stability for grain yield per plot. One of the significant findings of the study was that almost all the genotypes of the medium maturing group exhibited average stability for days to maturity while three genotypes, PK 327, JS-78-77 and DS-16 of early maturing and DS-75-1-29 of late maturing group exhibited average stability for the character. Considerable linear stability was evident in PK 450 as it exhibited above average stability for days to maturity. The genotypes DS-75-29-1 of medium maturing and SI-96 and Co-1 late maturing group exhibited below average stability for the character.

Table 2. List of average, above average and below average stable genotypes within different maturity groups for grain yield/plot and days to maturity (No stable genotype for days to 50 flowering).

Character	Maturity groups	Stability performance	Name of genotypes
Grain yield (kg/plot)	Early	Average	None
		Above Average	None
		Below Average	None
	Medium	Average	PK459, *Alankar, JS-76-259*
		Above Average	None
		Below Average	PK 262
	Late	Average	PK412, DS-75-1-29, MACS - 111 and KHSB-3
		Above Average	None
		Below Average	Co-1
Days to maturity	Early	Average	PK327, JS-78-77, DS-73-16
		Above Average	None
		Below Average	None
	Medium	Average	*PK 459, Alankar* PK 416, JS-76-259, DS-76-137-1, S-76-190 PK -309, DS-71-18-2, *PK-403, Pk 387 and PK 407*
		Above Average	PK 450
		Below Average	DS-75-29-1
	Late	Average	DS-75-1-29
		Above Average	None
		Below Average	SI-96, Co-1

Table 3. Estimates of stability parameters of a few important genotypes with regards to grain yield/plot exhibiting differential phenotypic stability within different maturity groups.

Maturity Groups	Genotype	Stability class	Stability parameters											
			Grain yield (kg/plot)				Days to 50% flowering				Days to Maturity			
			m_i	p_i	b_i	S^2d_i	m_i	p_i	b_i	S^2d_i	m_i	p_i	b_i	S^2d_i
Early	None	-	-	-	-	-	-	-	-	-	-	-	-	
Medium	PK 459	Average	0.53	0.12	0.72	0.03	64.00	2.17	0.77**	21.62**	133.70	1.23	0.95	1.28
	Alankar	Average	0.51	0.10	1.45	0.09	59.49	2.39	1.01	11.67**	130.44	-2.03	1.12	2.12
	JS-76-254	Average	0.45	0.04	0.33	0.06	61.05	-0.83	0.99	8.48**	131.31	-1.16	1.01	-1.48
	PK 262	Below Average	0.95	0.54	4.80**	0.16	60.83	-1.05	1.16*	4.90**	128.77	-3.70	1.00	13.09*
Late	PK 412	Average	0.46	0.05	0.35	0.03	62.44	0.56	0.76**	12.81**	135.44	2.97	1.17*	11.77*
	DS-75-1-29	Average	0.42	0.01	0.85	0.09	64.60	2.72	1.18*	32.75*	137.21	4.74	1.08	3.51
	MACS-III	Average	0.31	0.10	0.47	0.11	63.83	1.95	0.85	10.20**	138.94	6.47	0.84*	21.69
	KHSB-3	Average	0.49	0.08	1.50	0.11	63.44	1.56	0.98	5.43**	138.71	6.24	0.80*	18.78**
	CO-1	Below Average	0.71	0.30	3.75*	0.26	65.10	3.22	0.98	7.13**	137.88	5.41	1.34*	-19.06

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STUDIES ON GENETIC VARIATIONS IN GROUNDNUT (*Arachis hypogaea* L.) UNDER WATER STRESS AND NATURAL CONDITIONS

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ABSTRACT

Groundnut genotypes were grown under natural field conditions and in "drought tolerant test house" for three consecutive seasons and variability in seven characters were analysed. The results indicated that days to 50% flowering, plant height and days to maturity exhibited moderate to high values of heritability under both the growing conditions. The heritability for number of pods was moderate under drought condition. Moderate to high genetic advance was observed in plant height, 100 kernel weight and days to maturity in both the conditions, which indicated that these characters can be improved through selection for drought tolerance.

Key Words : Coefficients of variability; Heritability; Genetic advance; Drought tolerance.

The availability of genetic variation is advantageous for crop improvement. Such type of variability brought about by a group of genes have a small individual effect which can be studied through quantitative measurements. Groundnut being the most important oilseed crop is largely grown under rainfed condition and frequently suffers due to dry spell in rainy season. Dixit *et al.*, (1970), Patil and Bhapkar (1987) and Kale and Dhoble (1988) have reported genetic variation in groundnut, but the information on variability measurements in drought screening house is very limited. Therefore, the present investigation was planned to study the extent of genetic variation in groundnut under natural field and water stress conditions.

MATERIALS AND METHODS

Twenty nine varieties of groundnut which included 14 of bunch type and 15 of spreading type were tested. The studies were conducted during 1985-86, 1986-87 and 1987-88 in drought tolerance test house and in natural field conditions. An artificial moisture stress was created after 35 days of sowing by covering the test house with polythene cover. The stress period was counted from the date on which available soil moisture was reached to 50 per cent of field capacity and the said stress to the crop was continued for 20 days. After completion of stress period (drought), the crop was allowed to grow as that of field conditions. The recommended package of practices were adopted in both the conditions. The quantitative observations on days to 50 per cent flowering, number of pegs/plant, number of pods/plant, days to maturity, 100 kernel weight and pod yield/plant were recorded on five randomly selected plants in each treatment in both the conditions. The data was subjected to statistical analysis to work out genotypic and phenotypic variances as per Weber and Moorthy (1952); genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability in broad sense as described by Hanson *et al.*, (1956) and genetic advance as suggested by Johnson *et al.*, (1955).

RESULTS AND DISCUSSION

Range and estimates of different genetic parameters for various characters measured on different genotypes grown in drought tolerance test house and in natural conditions (control) are presented in Table 1 and 2, respectively. Pooled estimate for both the conditions are presented in Table 3.

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Table 1. Range and estimates of genetic parameters in Groundnut under water stress condition (drought tolerance test house)

Characters	Years	Range	Phenotypic variance	Genotypic variance	PCV	GCV	Heritability (%)	Genetic advance
Days to 50% flowering	85-86	33-38.5	2.864	1.939	5.00	4.20	67.7	2.360
	86-87	25-33.5	4.088	3.825	5.60	5.40	93.6	3.898
	87-88	31-36.5	2.897	2.470	5.20	4.81	85.0	3.580
Plant height (cm)	85-86	24.1-35.6	18.909	13.943	17.80	15.30	73.7	6.605
	86-87	19.25-29.5	13.185	9.028	12.30	10.20	68.5	5.123
	87-88	21.0-40.4	28.980	27.410	17.92	17.43	94.0	10.420
Number of Pegs/Plant	85-86	6.0-19.4	15.920	13.943	17.80	15.30	73.7	6.605
	86-87	2.5-10.8	6.978	1.547	23.90	11.30	22.2	1.205
	87-88	8.5-21.4	19.340	8.010	33.34	21.45	41.0	3.710
Number of pods/plant	85-86	6.0-12.7	4.781	2.343	42.10	29.50	49.0	2.207
	86-87	2.9-8.5	7.208	6.715	30.10	29.00	93.2	5.154
	87-88	3.9-11.6	2.120	1.240	16.07	12.29	84,0	1.751
100 Kernal Wt. (g)	85-86	24.5-45.17	28.650	26.860	86.00	81.00	94.0	10.360
	86-87	10.20-34.43	22.710	20.710	18.00	17.00	92.0	8.630
	87-88	19.50-33.25	21.524	13.690	17.11	13.69	64.0	6.120
Maturity in days	85-86	115.0-134.0	45.80	42.300	35.00	34.00	92.0	12.750
	86-87	116.5-135.0	41.75	38.330	30.00	33.00	92.0	12.240
	87-88	116.0-138.0	40.50	37.300	29.00	32.00	90.0	12.000
Pod yield / plant (g)	85-86	7.2-15.9	0.994	0.447	31.80	21.30	44.9	0.923
	86-87	2.44-5.00	0.698	0.555	15.50	13.90	79.5	1.368
	87-88	2.77-6.49	0.940	0.294	20.36	11.48	31.2	0.624

A wide range of variation was noticed for almost all the characters under study during all the years in test house as well as in natural conditions (Table 1, 2 and 3). In general, the phenotypic variance and phenotypic coefficient of variation values were higher than that of genotypic variance and genotypic coefficient of variation during all the three years and on pooled basis in both the situations. The genotypic variance and genotypic coefficient of variation were greater in drought (stress condition) tolerance test house than natural condition during all the years for plant height and days to maturity. Where as number of pods/plant, 100 kernel weight, days to maturity and pod yield exhibited greater values for genotypic variance and genotypic coefficient of variation in drought tolerance test house than in natural condition on pooled results.

The plant characters viz., height, number of pegs/plant, number of pods/plant, 100 kernel weight and days to maturity exhibited higher degree of phenotypic and genotypic variances in both the conditions and in all the years. Similar trend in these characters except number of pods/plant was observed in pooled analysis. The magnitude of variance for days to 50 per cent flowering and pod yield/plant were similar and comparatively low during all the three years under both the situations.

The phenotypic coefficient of variation and genotypic coefficient of variation was larger for the characters viz., height, number of pods/plant, 100 kernel weight in drought (stress condition) tolerance test house than in natural condition during individual years as well as in pooled data. The high phenotypic as well as genotypic coefficient of variation observed for number of pegs/plant and number of pods/plant indicated that the variation for these traits were mostly due to genetic factors.

The estimate of heritability (broad sense) was higher (h>65) for the characters viz., 50 per cent flowering, plant height in drought tolerance test house (stress condition), whereas, number of pegs/plant exhibited higher heritability (h>65) in natural condition. The heritability for the characters viz., 100 kernel weight and days to maturity was higher (h>90) in both the situations. Heritability estimate was moderate (h<65) for the number of pegs/plant, pod yield/plant during all the years under both the situations. Whereas pooled data showed that the character i.e. days to 50 per cent flowering exhibited higher heritability (h>65) and 100 kernel weight showed moderate heritability (h<65) in both the conditions. Number of pods/plant had moderate heritability (h<65) in drought condition. High genetic advance was observed during all the years for plant height, number of pegs/plant, 100 kernel weight and days to maturity in natural condition, whereas, it was higher for plant height, 100 kernel weight and days to maturity in stress condition in all the years of study. However, pooled data revealed that there was moderate genetic advance for days to 50 per cent flowering, plant height, number of pegs/plant, 100 kernel weight and days to maturity in natural condition. Whereas 100 kernel weight and days to maturity recorded higher genetic advance in drought condition. Such advantage of higher heritability in conjuction with genetic advance in soybean was reported by Johnson et al., (1955).

In the present study, the characters viz., plant height, 100 kernel weight and days to maturity had moderate to high values of heritability coupled with expected genetic advance indicating the presence of additive gene action under stress condition. Therefore single plant selection under stress condition for these characters will be effective for the development of a variety tolerant/resistant to drought conditions. But the characters viz., plant height, number of pegs/plant, 100 kernel weight and days to maturity exhibited moderate to high values of heritability and expected genetic advance indicating presence of additive gene action under natural condition and as such they can be improved through single plant selection. Dixit *et al.*, (1970), Patil and Bhapkar

(1987) and Kale and Dhoble (1988) also reported existence of additive gene action in groundnut indicating scope for improvement by selection.

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Table 2. Range and estimates of genetic parameters in Groundnut under natural condition

Characters	Years	Range	Phenotypic variance	Genotypic variance	PCV	GCV	Heritability (%)	Genetic advance
Days to 50% flowering	85-86	33-41	5.22	5.08	14.05	14.00	97.0	4.57
	86-87	34-41.5	7.22	6.98	15.08	15.01	97.0	5.37
	87-88	33.5-42.0	8.96	7.10	8.90	7.92	79.0	4.87
Plant height (cm)	85-86	23.6-36.50	12.15	10.19	12.00	11.00	84.0	6.03
	86-87	16.95-27.90	6.57	4.61	12.00	10.00	70.0	3.69
	87-88	24.1-42.5	23.37	21.57	15.33	14.73	92.0	9.16
Number of pegs/plant	85-86	4.5-28.6	29.67	24.35	40.00	36.00	82.0	9.20
	86-87	4.2-19.5	19.85	14.51	51.00	43.00	73.0	6.69
	87-88	8.1-27.7	43.12	25.86	46.37	35.91	59.0	7.98
Number of pods/plant	85-86	7.7-16.7	6.46	4.25	22.00	18.00	66.0	3.45
	86-87	6.4-12.2	3.79	2.86	21.00	19.00	75.0	3.00
	87-88	6.7-13.9	4.80	3.09	51.17	32.94	63.0	2.87
100 kernel Wt. (g)	85-86	23.78-42.06	29.96	28.01	16.00	15.00	94.0	10.82
	86-87	25.10-41.55	19.19	17.71	13.00	12.00	92.0	8.30
	87-88	22.11-35.79	16.85	13.30	13.75	13.10	90.0	7.61
Maturity in days	85-86	107-128.0	37.44	30.39	5.50	5.00	81.0	10.21
	86-87	108-128.5	34.92	34.33	52.00	51.00	98.0	11.93
	87-88	110-130	36.50	32.00	51.00	50.00	98.0	10.00
Pod yield / plant (g)	85-86	5.71-9.44	1.27	0.45	16.00	9.00	35.0	0.81
	86-87	5.4-10.19	2.43	1.69	22.00	18.00	70.0	2.23
	87-88	4.48-10.33	1.63	1.61	21.12	21.01	99.0	2.60

Table 3. Range and estimates of genetic parameters in Groundnut under natural field condition and water stress condition (drought condition) (Pooled over three years).

Characters	Years	Range	Phenotypic variance	Genotypic variance	PCV	GCV	Heritability (%)	Genetic advance
Days to 50% flowering	Natural	31.3-40.0	5.92	5.11	6.92	6.43	a92	4.65
	Drought	33.0-39.6	**3.27**	**2.21**	5.04	4.14	67	2.51
Plant height (cm)	Natural	22.20-34.43	18.00	**8.32**	15.29	**10.60**	46	4.03
	Drought	23.53-34.13	16.81	**4.44**	14.42	**7.14**	26	2.23
Number of pegs / plant	Natural	12.0-27.4	43.30	**8.65**	31.35	**14.06**	19	2.69
	Drought	13.43-27.23	31.35	**7.04**	33.17	**14.15**	22	2.85
Number of pods/plant	Natural	7.73-12.13	**3.71**	0.75	19.81	**7.72**	38	1.54
	Drought	4.8-9.26	**1.68**	0.86	16.34	**11.69**	51	1.36
100 kernal Wt. (g)	Natural	25.37-39.45	18.70	11.20	13.14	**10.17**	59	5.33
	Drought	21.99-36.45	20.75	**12.60**	15.82	**12.33**	61	5.72
Maturity in days	Natural	109.3-126.6	37.41	34.23	5.10	4.88	91	11.51
	Drought	116.67-139.67	91.93	39.89	7.45	4.91	43	8.57
Pod yield / plant (g)	Natural	5.02-7.81	**1.41**	**0.50**	17.60	10.40	35	0.867
	Drought	3.37-6.13	**2.40**	**0.94**	32.54	20.36	39	1.25

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OCCURRENCE OF TERMITES AND EARWIGS ON GROUNDNUT AND THEIR CONTROL

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ABSTRACT

The distribution, nature and extent of damage caused by termites and earwigs in groundnut and their chemical control were studied during *kharif* and summer seasons of 1989-90 under Western Orissa conditions. Both termites and earwigs were found to bore the maturing and matured pods to the tune of 7 to 18 per cent in *kharif* and 15 to 25 per cent in summer seasons. Maximum incidence was noticed in Western parts of the zone. Soil drenching with sprayable formulations such as endosulfan, aldrin and carbaryl applied at 40 DAS proved to be superior to dust formulations of BHC, aldrin and heptachlor applied as basal.

Key Words : Groundnut; Surveillance; Termites; Earwigs; Soil drenching; Dust and sprayable formualtions.

The extensive damage of termites causing plant death and boring of pods has been reported from different parts of the country (Srivastava *et al.*, 1962; Kaushal and Deshpande, 1967; Rawat *et al.*, 1970; Amin and McDonald, 1981; Singh *et al.*, 1984). Earwigs have been reported as pod borers causing damage to the tune of 20 to 50 per cent from the states of South India (Cherian and Basheer, 1940; Puroshothaman *et al.*, 1970; Padmanabhan *et al.*, 1973). Recently, these pests found to cause considerable damage to the groundnut pods under the agroclimatic zone of Western Orissa. Therefore, attempts were made to study the occurrence of termites and earwigs at pod formation stage in different locations, their extent and nature of damage both in *kharif* and summer seasons and their control with insecticides applied as soil drenching and dust formulations.

MATERIALS AND METHODS

For the surveillance studies, different villages in blocks such as Barpalli, Bhatli, Bhedan, Bargarh and Maneswar mainly of Sambalpur district (Orissa) were selected consecutively for two years (1988 and 1989). Observations on the incidence of termites and earwigs were recorded during both *kharif* and summer seasons. In addition to this, data was also obtained from plant samples from Bolangir and Sundergarh districts.

Station trials, field experiments were conducted in R.B.D. with three replications at Regional Research Station, Chiplima, during *kharif* 1989 and summer 1989-90. Groundnut cv OG 85-1 was sown on 24th June, 1989 in *kharif* and on 6th January, 1990 in summer with a spacing of 30 x 10 cm. Crop husbandry and fertilizer doses were followed as per the local recommendations. One general spraying of methyl demeton was given at 25 DAS to control the foliage feeding pests. Treatments of three insecticidal dusts at sowing @ 40 kg/ha and five treatments of insecticidal soil drenching at 40 DAS @ 750 litres spray solution/ha were imposed (Table 1 and 2). Observations on symptoms and extent of pod borer damage at pod development and maturity stages were recorded for which 10 randomly selected plants at 50 DAS and 90 DAS were uprooted and observed critically. Besides, two plots of 100 m^2 size at different locations of Research Station were maintained unsprayed for appropriate observations.

RESULTS AND DISCUSSION

Pest Surveillance

Through repeated field trials and pest surveillance under the agroclimatic zone of Western Orissa, two subterranean pests, i.e., termite (*Odontotermes obesus* Rambur) and earwig

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(*Anisolabis annulipes* Luc) were found to infest the groundnut pods at developing and maturity stages causing considerable damage. Though, there are occasional references regarding termite and earwig damage in groundnut, there was no in depth study on these pests in Orissa.

In general, the pod boring during summer season was comparatively more than that of *kharif* season. Among the various blocks of Sambalpur district surveyed, maximum pod borer incidence to the tune of 15-18 per cent in *kharif* and 22-25 per cent in summer season was noticed in Barpalli block. Substantial incidence (7-12% in *kharif* and 15-18% in summer) was also found in nearby Bhedan, Bhatli and Bargarh blocks. In Maneswar and Attabira blocks, pod borer damage was found to be negligible (below 5%). In addition to this, the data obtained from the subject matter specialists of Bolangir and Sundergarh districts where groundnut is grown only in *kharif*, it was observed that pod borer damage was up to 30 per cent in some pockets of Bolangir district, while no incidence was marked in Sundergarh district. This shows importance of pod borers in Bolangir district and their absence in Sundergarh district.

Nature and symptoms of damage

Termite : Termites were found to scarify both immature and mature pods externally and enter inside the pods to feed on the developing kernels. Inside such bored pods, termites filled the gaps with mud gallaries. Besides pod damage, plant mortality caused by root feeding of termites also noticed. Termite infested plants (root feeding) showed wilting and could be pulled out easily.

Earwig : Both nymphs and adults were observed to make small holes on pods and then such holes were plugged with excreta and sand particles. The pods bored at initial stage were found to develop black colour without any kernels inside, while at harvesting stage kernels were noticed to be partly or fully eaten without much discolouration of pods.

Efficacy of insecticides against pod borers and pod yield : Kharif 1989.

At R.R.S., Chiplima, during *kharif* season, maximum pod borer damage was 9.7 per cent at 50 DAS and 15.4 per cent at 90 DAS in untreated control. All the insecticides both in dust and sprayable formulations were significantly superior to control at both 50 and 90 DAS. Among the insecticides tested, soil drenching with endosulfan 35 EC registered lowest pod borer damage (3.6% at 50 DAS). However, it was statistically at par with plots treated with carbaryl 50 WP (4.2%), aldrin 5D (4.8%) and aldrin 30 EC (4.9%). Damage in other treatment was 6 to 7% as against 9.7 per cent in untreated plots (Table 1). Observations recorded at 90 DAS revealed that the soil drenching of aldrin, endosulfan and carbaryl could control the pod borers effectively indicating minimum incidence of 5.5, 5.9 and 6.7 per cent, respectively. The treatments receiving aldrin, chlorpyriphos and quinalphos were statistically at par with pod borer incidence ranging from 7.7 to 9.8 per cent.

As regards pod yield, no statistical difference were observed between the treatments of aldrin 30 EC (14.25 q/ha), endosulfan (14.15 q/ha), carbaryl (13.96 q/ha) and BHC (12.60 q/ha) with maximum return of Rs. 3656, Rs. 3564, Rs. 3408 and Rs. 2656/ha, respectively. The cost benefit ratio in these treatments were 1:11, 1:10, 1:9 and 1:16, respectively. Higher C:B Ratio in BHC 10 D was due to low cost of insecticide. Other treatments recorded less return with low C:B ratio.

Summer 1989-90

Maximum pod borer damage was found to be 15.2 per cent at 50 DAS and 20.5 per cent at 90 DAS in untreated control during summer season (Table 2). In general, all the insecticides in sprayable formulations applied as soil drenching at 40 DAS were superior to basal application of dust formulations in respect of pod borer control

Table 1. Effect of insecticies on pod borer damage and pod yield of groundnut cv OG 85-1 (*Khairf*, 1989)

Treatment	Dose (kg/ha)	Pod borer incidence(%) 50 DAS	Pod borer incidence(%) 90 DAS	Pod yield (q/ha)	Increased yield over control (q/ha)	Cost of increased yield @ Rs. 700/q (Rs.)	Cost of insecti-cide + labour/ha (Rs.)	Net profit (Rs./ha)	C:B ratio
Basal application									
1. **BHC 10 D**	40	6.0 (13.93)	7.9 (16.32)	12.60	4.03	2821	165	2656	1:16
2. **Aldrin 5D**	40	4.8 (12.70)	7.7 (16.10)	11.53	2.96	2072	585	1487	1:02.5
3. **Heptachlor 6D**	40	6.9 (15.23)	10.4 (18.79)	10.63	2.06	1442	505	937	1:1.8
Soil drenching at 40 DAS									
4. Endosulfan 35 EC	2.25	3.6 (10.93)	5.9 (14.04)	14.15	5.58	3906	342	3564	1:10.4
5. Carbaryl 50WP	3.0	4.2 (11.92)	6.7 (14.99)	13.96	5.39	3773	365	3408	1:9.3
6. Chlorpyriphos 20 EC	2.25	6.4 (14.66)	9.0 (17.43)	11.78	3.21	2247	365	1882	1:5.1
7. Aldrin 30 EC	2.25	4.9 (12.72)	5.5 (13.53)	14.25	5.68	3976	320	3656	1:11.4
8. Quinalphos 25 EC	2.25	6.3 (14.60)	9.8 (18.23)	10.98	2.41	1687	410	1277	1:3.1
9. Control (No application)		9.7 (18.12)	15.4 (23.13)	8.57					
CD at5%		1.78	2.19	1.67					
CV %		7.43	7.47	14.80					

Figures in parentheses are arc sine transformed values.
Cost of insecticides, labour charges and groundnut pods are as per the local rates.

Table 2. Effect of insecticies on pod borer damage and pod yield of groundnut cv OG 85-1 (Summer, 1989-90)

Treatment	Dose (kg/ha)	Pod borer incidence(%) 50 DAS	90 DAS	Pod yield (q/ha)	Increased yield over control (q/ha)	Cost of increased yield @ Rs. 700/q (Rs)	Cost of insecti-cide + labour/ha (Rs.)	Net profit (Rs./ha)	C:B ratio
Basal application									
1. BHC 10 D	40	8.4 (16.90)	13.2 (21.34)	29.65	3.54	2478	165	2313	1:14.0
2. Aldrin 5 D	40	8.3 (16.74)	11.6 (19.40)	30.28	4.17	2919	585	2334	1:3.9
3. Heptachlor 6 D	40	10.5 (18.96)	12.7 (20.86)	28.74	2.63	1841	505	1336	1:2.6
Soil drenching at 40 DAS									
4. Endosulfan 35 EC	2.25	3.5 (10.75)	7.2 (15.62)	33.33	7.22	5054	342	4712	1:13.7
5. Carbaryl 50 WP	3.0	5.4 (13.50)	7.1 (15.45)	32.89	6.78	4746	365	4381	1:12.0
6. Chlorpyriphos 20 EC	2.25	6.3 (14.61)	8.1 (16.56)	33.25	7.14	4998	365	4633	1:12.6
7. Aldrin 30 Ec	2.25	4.7 (12.48)	6.8 (15.15)	34.89	8.78	6146	320	5826	1:18.2
8. Quinalphos 25 EC	2.25	7.5 (15.92)	9.2 (17.64)	30.45	4.34	3038	410	2628	1:6.4
9. Control (No application)		15.2 (22.99)	20.5 (26.84)	26.11					
CD at 5%		2.22	1.94	3.14					
CV %		8.10	5.96	12.90					

Figures in parentheses are arc sine transformed values.
Cost of insecticides, labour charges and groundnut pods are as per the local rates.

and pod yield. Endosulfan 35 EC was proved to be the most promising with least pod borer incidence (3.5% at 50 DAS and 7.2% at 90 DAS) followed by aldrin 30 EC (4.7% at 50 DAS and 6.8% at 90 DAS). Carbaryl 50 WP and chlorpyriphos 20 EC were at par and recorded comparatively lower incidence of pod borer (5.4 and 6.3 at 50 DAS and 7.1 and 8.1 at 90 DAS). Soil drenching with quinalphos 25 EC resulted in higher incidence of 7.5% at 50 DAS and 9.2% at 90 DAS and on par with chlorpyriphos 20 EC. All the three dust formulations applied as basal registered comparatively higher incidence both at 50 and 90 DAS.

Maximum pod yield of 34.89 q/ha was obtained due to aldrin 30 EC with maximum net profit of Rs. 5826/ha with C:B ratio of 1:18. This treatment was statistically at par with all the sprayable formulations except quinalphos. Treatments receiving insecticidal dust as basal and soil drenching with quinalphos 25 EC had statistically at par pod yields ranging from 28.74 to 30.45 q/ha with net profit ranging from Rs. 1336 to Rs. 2628 with low C:B ratio except in BHC 10D.

Palaniswami (1977) and Sathiamoorthy *et al.*, (1979) suggested the control of earwig damage by the application of persistent dust such as DDT, BHC and chlordane @ 50 kg/ha once and even twice as basal and at 40 DAS. However, the results of Singh *et al.*, (1984) on termite control confirm the present findings.

Overall, it may be concluded that soil drenching once at 40 DAS with sprayable formualtions such as endosulfan, aldrin and carbaryl are better than single application of dusts for the control of pod borers.

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SPACING AND NITROGEN REQUIREMENT OF SUNFLOWER HYBRIDS

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ABSTRACT

An experiment was conducted to study the optimum spacing and nitrogen requirement for sunflower hybrids. Results of three years study revealed that hybrid BSH-1 gave the highest seed yield of 1133 kg/ha followed by MSFH-1 (1053 kg/ha). These hybrids were on par and significantly superior to PKV-SUF-37-76 variety (954 kg/ha). Wider row spacing of 60 cm gave signifcantly higher seed yield of 1121 kg than the closer row spacing of 45 cm (975 kg/ha) and application of 60 kg/ha nitrogen gave significantly higher seed yield (1158 kg/ha). Both hybrid and open pollinated sunflower fared better with wider row spacing and 60 kg nitrogen per ha.

Key Words : Spacing; Nitrogen; Sunflower

Sunflower has been accepted as an oil seed crop of the state of Karnataka next only to groundnut. The added advantage with this crop is that it can be grown in all seasons.

In order to increase the yield potential as well as stabilizing the yields, intensive research was conducted to develop the hybrids, and BSH-1 was a result of such effort. It was found to have higher yield potential (30-50 per cent higher than open pollinated types). Further, yields were stable because of homogenity and self compatability (Seetharam *et al.*, 1977). It was also more resistant to pest and disease than open pollinated types. There is a need to workout the spacing and fertilizer requirement for hybrid sunflower. Therefore, the present study was undertaken to workout spacing and nitrogen requirement of the sunflower hybrids.

MATERIAL AND METHODS

The trial was conducted at University of Agricultural Sciences, GKVK, Bangalore during *kharif* 1982, 1983, 1984 and 1985, under rainfed conditions. However, during *kharif* 1982, the crop couldn't establish due to failure of rains. The released hybrid BSH-1 was compared with pre-release MAHYCO Sunflower Hybrid-1 (MSFH-1) and a PKV variety (PKV-SUF-37-76) with two row spacing of 45 and 60 cm and four nitrogen levels, 0, 20, 40 and 60 kg per ha.

The experiment was laid out in a split plot design with combinations of genotype and spacings as main plots and nitrogen levels as sub plots, with four replications. Each plot was 4.2 m length and 5.4 m width. The soil of the experimental site was red sandy loam and depth varying from 60 to 120 cm. The previous crops raised during 1983, 1984 and 1985 in the experimental area were ragi, horse gram and ragi respectively. The initial fertility status of the soil was, organic carbon (0.49 to 0.58 per cent) available phosphorus (16.2 to 21.5 kg/ha) and available potash (180 to 218 kg/ha) with neutral pH. Entire quantity of phosphorus (90 kg/ha), Potash (60 kg/ha) and 50 per cent of nitrogen was given as basal dose at the time of sowing in the form of single superphosphate, muriate of potash and urea respectively. The remaining 50 per cent nitrogen was given as top dress, when the crop was 30 days old. The data on yield and yield attributes were subjected to statistical analysis and response equation was worked out to findout the optimum dose of nitrogen required for the hybrids. The rainfall

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distribution during different crop growth stages of sunflower at the experimental site is as under:

DAS	Growth stage	Rainfall (mm) 1983	1984	1985
0-28	Seedling stage	168.9	55.4	106.9
28.-35	Primordial initiation	36.6	41.6	1.8
36-49	Grand growth stage	118.5	3.7	29.4
	Pre-flowering Total :	324.0	100.7	138.1
50-63	Flowering	5.1	22.5	102.9
64-98	Seed filling	67.5	355.5	148.3
	Post-flowering Total:	72.6	378.0	251.2
	Grand Total:	396.6	478.7	389.3

RESULTS AND DISCUSSION

The 3 years (1983, 1984 and 1985) data on seed yield and observations on test weight, number of filled seeds per head and oil content are presented in Table 1. The seed yield of sunflower varied with the season. High seed yield of 1435 kg per/ha was obtained during 1983, when the crop received 397 mm rainfall. Lowest mean yield of 610 kg per/ha was obtained during 1984 inspite of 489 mm of rainfall. This was due to very low rainfall received during grand growth period (3.7 mm) and unusually high rainfall of 355.5 mm during seed filling stage. This high rainfall might have washed out the pollen (Anon., 1985). The mean yield during 1985 was 1096 kg per/ha.

Effect of genotypes

Mean seed yield of the hybrids were higher than the open pollinated variety . The hybrid BSH-1 recorded the highest mean seed yield of 1133 kg per/ha followed by MSFH-1 (1053 kg/ha) and these were at par and significantly superior to the variety PKV-SUF-37-76. During 1983, the hybrid BSH-1 was significantly superior (1639 kg/ha) to MSFH-1 (1369 kg / ha) and PKV-SUF-37-76 (1298 kg/ha). Similar trend was observed in 1984 also. During 1985, yield differences were not significant.

Significant differences were observed for yield contributing characters like number of filled seeds per head and test weight. The superiority of hybrids was mainly due to more number of filled seeds per head. In test weight, the open pollinated variety PKV-SUF-37-76 was significantly better than hybrids.

Effect of spacing

Wider row spacing of 60 cm recorded significantly higher mean seed yield of 1121 kg per ha as compared to closer row spacing of 45 cm (975 kg/ha). Similar yield trend was also observed in all the 3 years. The closer row spacing of 45 x 30 cm or 74, 074 plants per ha reduced the number of filled seeds per head as well as 100 seed weight. The highest test weight was evident at wider spacing which reflected in higher seed yield. The results are in agreement with the earlier findings of Shivakumar *et al.*, (1973).

Effect of nitrogen levels

Increasing nitrogen levels from zero to 60 kg per ha increased the yield of sunflower crop up to 60 kg N per ha application. Seed yield differed significantly due to levels of nitrogen. The higher mean seed yield of 1158 kg per ha was obtained with 60 kg nitrogen per ha, which was significantly higher over other levels. The seed yields with 20 and 40 kg N per ha were at par and significantly superior to control (918 kg/ha). During 1983, seed yield differences were not significant for nitrogen levels inspite of higher average seed yield (1435 kg/ha). During 1984, significant seed yield difference was observed for each successive level of nitrogen and the highest seed yield of 766 kg per ha was obtained at the highest level of 60 kg.

During 1985, application of 60 kg nitrogen per ha recorded significantly higher seed yield of 1259 kg per ha as compared to lower levels of nitrogen. Linear increase in seed yield was reported by

Table 1. Effect of levels of nitrogen and spacing on sunflower genotypes

	Seed yield (kg/ha)				Yield contributing characters		
	1983	1984	1985	Mean	No. of filled seeds/head	100 seed weight(g)	Oil content (%)
GENOTYPES							
BSH-1	1639	673	1087	1133	510.0	4.3	47.1
MSFH-1	1369	638	1151	1053	509.0	4.2	46.4
PKV-SUF-37-76	1298	515	1049	954	424.2	5.9	45.1
C.D. at 5%	165	44	NS	92	48.0	0.5	1.1
SPACING							
45x30 cm (74,074 plants/ha)	1325	579	1020	975	480.7	4.4	46.3
60x30 cm (55,555 plants/ha)	1546	643	1174	1121	496.9	5.0	46.1
C.D. at 5%	133	36	72	40	NS	0.3	NS
NITROGEN LEVELS							
0 kg/ha	1389	406	959	918	484.4	4.1	45.1
20 kg/ha	1483	571	1044	1033	442.5	4.6	46.5
40 kg/ha	1422	701	1122	1082	523.3	4.8	46.3
60 kg/ha	1448	766	1259	1158	565.0	5.5	46.8
C.D. at 5%	NS	50.5	102	76	84.4	0.4	NS
CV %	16.2	14.0	17.1	4.4	30.6	16.4	8.9

Massey (1971), Singh *et al.*, (1973) and Ujjinaiah (1985).

The test weight and number of filled seed/head were significant, due to the application of nitrogen. The number of filled seeds per head and test weight increased with the increase in nitrogen levels from 20 to 60 kg per ha. Similar results were reported by Massey (1971); Singh and Kaushal (1975) and Varghese *et al.*, (1976).

Based on the mean yield of seeds as influenced by nitrogen levels, the response equation was worked out (Table 2). Sunflower seed yield was 5.75 kg, per kg nitrogen at 20 kg N per ha and it was 2.45 and 3.80 kg per ha, when 40 and 60 kg/ha doses were tried.

Table 2. Response of sunflower for nitrogen and its economics.

Nitrogen levels (kg/ha)	Seed yield (kg/ha) Mean	Difference	Kg seed/ Kg N used	Rs. earned/ Rs. invested on nitrogen
0	918	-	-	-
20	1033	115	5.74	7-62
40	1082	49	2.45	3-25
60	1158	76	3.80	4-04

Response equation for Nitrogen, $\hat{Y} = 922.65 + 5.31 - 0.02 X^2$

$\hat{X}$ optimum = 59.9 = 60 N kg/ha.

Economics of fertilizer application was also worked out. A return of Rs. 7.62 was obtained per rupee invested on N when 20 kg N per ha was tried and it was Rs. 3.25 and 4.04 with 40 and 60 kg N levels, indicating the benefit up to 60 kg N per ha, which is further confirmed from the response equation.

The interaction effects of genotypes, spacing and nitrogen levels were not significant for seed yield and yield contributing characters studied. However, at both the spacings, BSH-1 responded better to nitrogen levels than open pollinated PKV-SUF -37-76 variety.

Spacing and nitrogen level interactions were found non-significant. The seed yield was higher with 60 x 30 cm than with 45 x 30 cm spacing. However, the degree of response for nitrogen was better with 45 x 30 cm spacing especially at 40 and 60 kg N per ha.

The above findings clearly indicate that the sunflower hybrids performed better. Higher yields were obtained with 60 cm row spacing and with the application of 60 kg nitrogen per ha under rained conditions.

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HETEROSIS STUDIES IN SOYBEAN *(Glycine max* (L.) Merrill)*

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ABSTRACT

Heterosis was studied in a 7 x 7 diallel cross (excluding reciprocals) in soybean *(Glycine max.*(L) Merrill). Maximum beneficial heterosis and heterobeltiosis to the extent of 268.03 and 240.66 per cent respectively, were observed for seed yield followed by number of pods/plant (142.18%). Significant increase in yield was observed in 11 crosses of which 3 were between high, 6 high x low and 2 low x low yielding parents, indicating the presence of interallelic interaction for seed yield. The magnitude of heterosis was relatively low for oil and total protein content. Increase in yield of hybrids was found to be associated with increase in the component characters. High percentage of beneficial heterosis was observed for plant height (65.30), branches/ plant(54.9%), nodes/plant (40.33), seeds/pod (36.78) and 100-seed weight (51.52).

Key Words : Heterosis; Soybean

Study of heterosis besides providing the basic information regarding the breeding methodology also helps in rejecting a large number of crosses in the first generation. This helps in selecting only those cross combinations which show high potential for deriving promising segregants. Soybean is a highly self-pollinated crop and the scope for exploitation of hybrid vigour will depend on the direction and magnitude of heterosis, biological feasibility and nature of gene action. An attempt has been made in the present investigation to estimate the extent of heterosis in a seven-parent non-reciprocal diallel set of soybean *(Glycine max* (L.) Merrill).

MATERIALS AND METHODS

A set of non-reciprocal diallel cross was effected among several parents in soybean viz., Monetta, MACS 13, Kalitur, PLSO 24, EC 201, EC 95837 and JS 72-44. The parents and their 21 F_1s were grown in a Randomised Block Design with three replications. Each parent and F_1 progeny were represented by a single row of 3 m length with 45 cm spacing between rows and 10 cm between plants. Observation on 12 characters, viz., days to 50 per cent flowering, days to maturity, plant height, branches/plant, nodes/plant, mean internodal length, pods/plant, seeds/pod, 100-seed weight, seed yield/plant, oil and protein content were recorded on five random and competitive plants. Magnitude of heterosis (%) was calculated over better and mid-parental values.

RESULTS AND DISCUSSION

The estimates of heterosis over superior parent (SP) and mid-parent (MP) are presented in Table 1. The varieties with early flowering and maturity have special significance in multiple cropping system. With this view, the crosses Kalitur x JS 72-44 and EC 95837 x JS 72-44 in the present investigation would be desirable to obtain early segregates as they were significantly early to flower than the SP. Five other crosses showed

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significant negative heterosis over MP. None of the cross-combination was significantly earlier in maturity than the SP. However, 6 crosses were significantly earlier than MP. Highest negative heterosis for days to maturity (-9.08%) was recorded in the cross Monetta x MACS 13 followed by Monetta x JS 72-44 (-8.19%). Heterosis for earliness was also observed by Kaw and Menon (1981) and Halvankar (1987).

Significant increase in plant height over SP and MP was observed in 4 and 10 crosses, respectively. On the other hand, 9 and 4 crosses were shorter than their respective SP and MP. Shorter hybrids than MP were also observed by Kaw and Menon (1981), while Chen (1982) and Halvankar (1987) observed good amount of heterosis for this character. The highest magnitude of heterosis over SP (55.87%) and MP (68.50%) was observed in the cross EC 201 x EC 95837, whereas least values (-46.18 and -28.15%) were observed in the cross Kalitur x JS 72-44. Heterosis for branches/plant ranged from -36.71 to 20.11 per cent over SP and from -22.96 to 54.97 per cent over MP. The least heterosis both over SP and MP was registered in the cross Monetta x JS 72-44. Significant positive heterorsis over SP was exhibited by the cross MACS 13 x EC 201, whereas 7 crosses showed significant positive heterosis over MP.

In soybean maximum number of nodes on main stem are desirable as the pods are borned on the nodes. According to Nieto *et al.*, (1983), a maximum of 8-9 internodes in poor environments and 13-14 in good environment are satisfactory. In the present investigation internodes ranged between 13-27 and heterosis and heterobeltiosis for this character were 40.33 per cent and 27.36 per cent, respectively. It was exhibited by a cross between parents with high number of internodes i.e. Kalitur x EC 201, indicating the additive x additive type of gene action. Heterosis of 42.20% for mean internodal length was observed in the cross combination EC 201 x EC 95837. Increased internodal lengths over MP and SP were observed in 76 and 52 per cent of hybrids, respectively.

Number of pods/plant is most important yield contributing character, as yield is closely and constantly correlated with it (Sichkor, 1984; Rasaily *et al.*, 1986). Therefore, high heterosis for this trait is of great value. In the present investigation, heterosis to the extent of 142.18 per cent was recorded for this trait in the cross EC 201 x EC 95837. Highly significant increase in pod number over SP was observed in the cross Kalitur x EC 201 (61.92%), a cross between parents with high number of pods, indicating importance of additive x additive type of gene action. For the trait seeds/pod, the highest heterosis over SP and MP was 32.94 (EC 95837 x JS 72-44) and 36.78 (Monetta x JS 72-44) per cent, respectively. However, majority of the crosses showed negative heterosis both over better and midparent. Similar findings were also reported by Chaudhary and Singh (1974) and Paschal and Wilcox (1975).

Heterosis to the extent of 11.91 and 51.52 per cent, respectively, over better and mid parent was observed for 100-seed weight. More than 50 per cent of the crosses showed positive heterosis. The average heterobeltiosis was negative (-14.62%) indicating the inferiority of hybrids to the superior parents. This confirmed the earlier reports by Paschal and Wilcox (1975) and Halvankar (1987). The combinations between small seeded parents (PLSO 24 x EC 201) resulted into small seeded and between bold seeded parents (EC 95837 x JS 72-44, MACS 13 x JS 72-44) resulted into bold seeded hybrids, bringing out the importance of complementary gene action. Strong correlation of test weight with seed yield reveals its importance for expression of yield (Dixit and Patil, 1984); the parents EC 95837 and JS 72-44 were desirable in the present study.

Comparatively low heterosis over MP and SP was observed for both oil (7.69 and 12.85%) and protein content (11.44 and 13.37%). The cross,

Table 1. Heterosis (%) over SP and MP in soybean for 12 characters.

Cross	Days to 50% lowering		Days to maturity		Plant height (cm)	
	SP	MP	SP	MP	SP	MP
Monetta x MACS 13	0.81	-7.48**	2.77	-9.08**	-16.85**	-3.28
Monetta x Kalitur	3.24	-9.94**	9.89 **	-3.47*	-26.50**	7.73
Monetta x PLSO 24	4.28	1.68	9.09**	9.09**	-0.42	29.00**
Monetta x EC 201	5.04	3.30	0.40	-0.19	-34.09**	-25.04**
Monetta x EC 95837	-0.80	-2.00	2.77	-7.30**	24.62 **	34.28**
Monetta x JS 72-44	-3.24	-8.80**	1.98	-8.19**	2.17	18.01*
MACS 13 x Kalitur	4.14	-0.67	-1.25	-1.87	-32.17**	-9.96*
MACS 13 x PLSO 24	26.49*	12.96**	25.31**	10.85**	-26.78**	-16.60**
MACS 13 x EC 201	22.69**	10.61**	25.39**	11.66**	12.72	15.69*
MACS 13 x EC 95837	20.64**	12.18**	-0.65	-2.39	20.74**	31.22**
MACS 13 x JS 72-44	5.80*	3.18	1.29	-0.32	-32.69**	33.79**
Kalitur x PLSO 24	38.46**	17.39**	25.31**	10.07**	-22.75	-7.50
Kalitur x EC 201	38.64**	18.69**	25.39**	10.88**	-21.34**	6.18
Kalitur X EC 95837	30.17**	15.09**	4.22*	1.74	-15.20**	18.95**
Kalitur x JS 72-44	-8.70**	-15.15**	0.00	-2.22	-46.18**	-28.15**
PLSO 24 x EC 201	0.00	-0.86	-0.39	0.98	0.09	16.57**
PLSO 24 x EC 95837	0.00	-3.70	4.35	-5.88**	-10.40	9.58
PLSO 24 x JS 72-44	5.97	-2.71	7.11**	-3.57*	13.17*	29.82**
EC 201 x EC 95837	-0.86	-3.70	3.12	-6.38**	55.82**	65.30**
EC 201 x JS 72-44	6.71*	-1.19	20.70**	9.38**	9.95	11.94
EC 837 x JS 72-44	-6.36*	-10.61**	0.32	0.16	4.50	12.69
Mean	13.01	1.43	7.96	0.57	-3.63	11.92
SE ±	1.06	0.92	1.87	1.62	3.19	2.77
C.D. 5%	2.12	1.84	3.75	3.24	6.40	5.56
CD 1%	2.82	2.44	4.90	4.32	8.53	7.39

Table 1. (C ontd.)

Cross	Branches/plant (No.)		Nodes/plant (No.)		Mean internodal length(No.)	
	SP	MP	SP	MP	SP	MP
Monetta x MACS 13	-19.90*	-11.05	-21.77*	-13.72	5.08	11.85
Monetta x Kalitur	-17.94**	2.94	-19.81**	-3.24	-8.43	17.98
Monetta x PLSO 24	5.13	5.13	-8.63	4.31	8.76	26.38*
Monetta x EC 201	5.69	7.74	-23.97**	-15.83	-13.97	-11.02
Monetta x EC 95837	5.13	30.00*	2.87	4.07	-18.27	29.02*
Monetta x JS 72-44	-36.71*	22.96**	-4.93	0.41	7.52	18.27
MACS 13 x Kalitur	-11.37	1.75	-16.18*	-6.60	-18.99*	-0.50
MACS 13 x PLSO 24	-5.21	5.26	-20.83*	-17.72*	-6.41	2.82
MACS 13 x EC 201	18.48*	29.31**	-1.56	-1.16	13.15	16.57
MACS 13 x EC 95837	15.79	54.97**	3.15	14.96	10.62	13.56
MACS 13 x JS 72-44	-2.91	7.72	1.75	6.48	20.85	25.17*
Kalitur x PLSO 24	-2.34	22.50**	-10.38	-4.38	-11.21	0.56
Kalitur x EC 201	-6.21	15.94*	27.36**	40.33**	-38.46**	-22.67*
Kalitur x EC 95837	-10.08	31.56**	-4.58	16.26*	-11.46	6.50
Kalitur x JS 72-44	-7.74	-4.26	-26.89**	-15.76*	-26.51**	-12.26
PLSO 24 x EC 201	4.93	6.96	-1.78	1.68	5.24	18.75
PLSO 24 x EC 95837	-7.89	13.90	-7.34	6.85	-2.88	4.12
PLSO 24 x JS 72-44	-33.67**	-19.26*	-3.02	5.27	16.56	23.91*
EC 201 x EC 95837	20.11	50.71**	4.23	16.58*	34.57**	42.20**
EC 201 x JS 72-44	-13.54	3.64	2.32	7.48	2.42	9.17
EC 95837 x JS 72-44	-32.53**	-3.44	6.86	14.18	-0.97	-0.06
Mean	-6.31	10.91	-5.86	2.88	0.18	10.49
SE±	0.56	0.48	1.51	1.31	0.34	0.29
C.D. 5%	1.12	0.97	3.03	2.62	0.67	0.58
CD 1%	1.49	1.29	4.03	3.49	0.90	0.78

Table 1. (Contd.)

Cross	Pods/plant (No.)		Seeds/pod (No.)		100-seed weight (g)	
	SP	MP	SP	MP	SP	MP
Monetta x MACS 13	3.37	7.40	1.75	4.21	-7.31	-1.42
Monetta x Kalitur	31.52	49.17**	7.14	12.31	1.16	5.49
Monetta x PLSO 24	21.99	31.65	-9.24	-2.76	-4.46	26.32**
Monetta x EC 201	-14.44	-3.67	-18.98	-10.49	-5.63	35.17**
Monetta x EC 95837	-21.09	13.93	-19.06	-12.72	-24.11**	-8.26
Monetta x JS 72-44	-5.39	4.27	29.37**	-36.78**	-11.59	-4.34
MACS 13 x Kalitur	18.78	30.08	-14.60	-8.43	-4.16	6.09
MACS 13 x PLSO 24	-15.55	-5.60	-7.73	1.08	-0.47	37.27**
MACS 13 x EC 201	4.74	13.87	-36.26**	-28.06*	-2.12	51.52**
MACS 13 x EC 95837	47.22*	117.08*	0.18	5.61	-16.34**	-4.02
MACS 13 x JS 72-44	30.35	38.60*	4.95	8.44	10.38	12.34*
Kalitur x PLSO 24	-24.96	-9.15	-10.45	-8.37	-9.15	16.63
Kalitur x EC 201	61.92**	63.22**	-16.86	-12.13	-2.63	36.05**
Kalitur X EC 95837	-4.13	48.13*	14.44	28.87*	-29.95**	-12.41*
Kalitur x JS 72-44	17.16	20.92	-19.84	-11.40	-24.24**	-14.82*
PLSO 24 x EC 201	25.74	51.27**	-20.40	-17.72	-15.71	-4.92
PLSO 24 x EC 95837	15.83	59.60	-8.18	5.48	-69.82**	-54.77**
PLSO 24 x JS 72-44	6.40	25.54	-20.30	-10.09	-54.54**	-36.64**
EC 201 x EC 95837	57.30**	142.18**	-28.47*	-15.48	-28.20**	14.10*
EC 201 x JS 72-44	36.44*	39.73*	-6.52	8.55	-24.24**	13.38
EC 95837 x JS 72-44	-40.84*	-9.96	32.94*	35.74*	11.91*	27.02*
Mean	12.02	34.69	-6.34	0.45	-14.62	6.56
SE ±	22.19	19.22	0.26	0.23	0.81	0.70
C.D. 5%	44.49	38.53	0.52	0.45	1.63	1.41
CD 1%	59.28	51.33	0.69	0.60	2.17	1.88

Table 1. (contd.)

Cross	Seed yield(g)/ plant		Oil content (%)		Total protein content (%)	
	SP	MP	SP	MP	SP	MP
Monetta x MACS 13	-4.20	6.74	3.11	5.49	-2.93	2.37
Monetta x Kalitur	26.87	39.81*	2.78	2.38	5.62*	7.14**
Monetta x PLSO 24	64.35**	114.84**	-8.17**	1.15	-2.57	1.17
Monetta x EC 201	7.48	37.07	-21.32*	-16.71**	11.45**	13.37**
Monetta x EC 95837	-28.36	-3.40	7.69**	12.85**	7.50**	9.66**
Monetta x JS 72-44	9.59	26.48	-3.98	-2.03	-9.67**	-3.38
MACS 13 x Kalitur	44.82*	46.62**	-0.40	1.91	-0.22	3.70*
MACS 13 x PLSO 24	-9.65	27.18	-2.09	7.64**	-2.10	3.76*
MACS 13 x EC 201	-20.79	9.22	-12.79**	-9.70**	-7.04**	-3.56
MACS 13 x EC 95837	57.19**	127.21**	-4.30	-1.93	-1.83	1.65
MACS 13 x JS 72-44	47.60**	53.54**	-2.99	-2.72	-0.65	0.85
Kalitur x PLSO 24	-33.08	-6.91	-0.77	6.82*	-3.02	-0.70
Kalitur x EC 201	37.04*	87.50**	-10.68*	-5.46*	1.25	1.53
Kalitur X EC 95837	15.72	66.12**	-4.68	-0.11	2.19	2.69
Kalitur x JS 72-44	2.74	8.15	-3.41	1.45	-6.06**	-0.87
PLSO 24 x EC 201	*106.35***	*113.38***	*-20.53***	*-9.85***	2.45	4.61*
PLSO 24 x EC 95837	34.77	40.99	-16.83**	-12.57**	3.86	7.87**
PLSO 24 x JS 72-44	-27.50	4.44	-12.33**	-3.86	-0.59	2.52
EC 201 x EC 95837	240.55**	268.03**	-8.42**	-7.45**	7.89**	8.11**
EC 201 24 x JS 72-44	33.56*	88.68**	-5.68*	-2.08	-0.90	4.30*
EC 95837 x JS 72-44	38.70*	104.86**	-11.45**	-9.01**	-4.70	0.01
Mean	30.69	60.03	-6.53	-2.20	0.20	3.18
SE ±	4.59	3.98	0.50	0.43	0.85	0.74
C.D. 5%	9.21	7.97	1.00	0.86	1.70	1.48
CD 1%	12.27	10.62	1.34	1.16	2.27	1.96

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

Monetta x EC 201, showing highest percentage of total proteins had lowest percentage of oil content with significant negative heterosis. Similar results were also observed in 6 more crosses. Such effect may probably be due to internal cancellation of effects of some genes. Katoch and Tandon (1979) have also suggested, the heterotic expression for one character and its absence for the other at the same time; it may be due to co-adoption between the parental genetic system and cancellation effect of some of genes. Two crosses in the present study viz. Monetta x Kalitur and Monetta x EC 95837, showed positive heterorsis for both these characters.

Appreciable amount of heterosis over MP and SP was observed for seed yield/plant to the extent of 268.03 and 240.66 per cent respectively. Highly significant positive heterosis over SP and MP was observed in 5 and 11 crosses, respectively. Out of all 11 crossed combinations showing significant increase in yield, 3,6 and 2 resulted from combinations of high x high, high x low and low x low yield in parents respectively, indicating the role of dominance factors and complementary gene action for this trait. The average heterosis over SP (30.69%) and MP (60.03%) for this character was higher than all other characters studied. The increase in yield in hybrids was found to be associated with increases in the component characters. The high heterotic hybrid for yield/plant, EC 201 x EC 95837 showed significant heterotic effects for the component characters such as plant height, number of branches, nodes, pods per plant, 100-seed weight and internodal length. Similarly, the crosses, MACS 13 x EC 95837 and Monetta x PLSO 24, which showed high heterotic performance for seed yield also showed high values for the above characters. Obviously, heterosis for seed yield in these crosses seemed to be due to heterotic effects of component characters. These results are in confirmity with the results of Halvankar (1987).

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A SIMPLE METHOD TO DETERMINE FEEDING AND OVIPOSITION BEHAVIOUR OF GROUNDNUT JASSID (*Balcluthe hortensis* Lindb)

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ABSTRACT

The feeding sites, preference of feeding and oviposition behaviour of the Jassid (*Balcluthe Hortensis* Lindb.) in thirteen groundnut varieties were studied. This jassid depended about 62% on phloem followed by xylem (9%) and parenchyma (8%) for its sap. A simple method in locating the eggs of this species was developed, which was successfully employed in the screening of groundnut genotypes with reference to the oviposition. Boiling of leaves at 75°C for 10 minutes in methylsulphoxide (DMSO) followed by washing in running water cleared the chlorophyll. Thereafter, rinsing the leaves in 1% aqueous acid fuchsin solution for 5 minutes and washing in water, leaves the eggs stained. Irrespective of age of the leaves this species laid its eggs, in the lamina (65%) 33% in midrib and 2% in margins of the leaflets.

Key Words : Oviposition; Jassid; Resistant.

The groundnut jassid, (*Balcluthe hortensis* Lindb.) is a serious pest in groundnut in Saurashtra area of Gujarat (Nandagopal and Reddy, 1987) causing severe yield loss to an extent of 584 kg/ha at 125 jassids infestation in 5 m row of groundnut during pod filling stage (Anon, 1988). Many methods were employed to control jassids in groundnut (Amin, 1988), however, selecting a resistant variety is now tried at various research organisations (Dwivedi *et al.*, 1986; Amin, 1988). To identify resistant lines large number of germplasm has to be screened. Measurement of feeding, oviposition sites and desap pattern is essential to measure the resistance in groundnut to insect pests. Generally host plants are dissected under binocular microscope and the eggs are counted (Saxena *et al.*, 1984) but this method was not reliable as it caused damage to eggs. Methods such as bleaching the leaves with hot water and alcohol (Everett and Trahan, 1961and Khan and Saxena, 1986) were also reported. An attempt was made to develop an efficient and easy method to overcome the disadvantage of prolonged processing of the samples in the previous techniques.

MATERIALS AND METHODS

Source of feeding : Three randomly selected twenty day old potted plants of the spanish groundnut variety GG 2 was uprooted and the roots were washed and immersed in 25% red ink + water mixture for 2 hr to stain the entire xylem vessels of the aereal parts of the plant. In each plant only 3 leaves and terminal bud were retained. The roots were then inserted into a glass vial (20 ml capacity) containing tap water to maintain turgidity in the plant. The mouth of the vial was secured with cotton swab. The vial with the plant was placed, inside a feeding chamber on an inverted petridish lined with filter paper (Whatman No 1). Ten laboratory reared adult jassids of both the sexes were released inside the feeding chamber. The filter papers were replaced thrice at 2 hr. interval followed by 12, 24 and 48 hours of exposure. The filter papers were then assessed for coloured honey dew spots. They were then traced, measured and quantified following the procedures developed by Paguia *et al.*, (1980) (Table 1).

Location of jassid eggs : Twenty day old potted plants of the groundnut variety GG 2 were arranged inside an insect proof mylar cage. Ten gravid females were released inside the cage and allowed for seven days for oviposition. Later, leaves were collected and processed in different methods.

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Method 1: Ten leaves were immersed in water, boiled for 5 minutes and transferred in 95% ethyl alcohol for 3 days. Then, the leaves were washed and transferred to 1% aqueous acid fuchsin solution for 2 days. Finally the leaves were washed under running water until the stained jassid eggs were differentiated from the destained plant tissues (Khan and Saxena, 1986).

Method 2: Thirty leaves were collected and put in 100 ml Dimethyl Sulphoxide (DMSO). Five leaves were removed at an hourly interval and rinsed in water followed by staining in 1% aqueous acid fuchsin solution for 5 minutes. Finally the leaves were washed in running water until the stained eggs were clearly differentiated.

Method 3: Among the twenty leaves collected, from ten leaves, each leaflet was cut longitudinally from tip to the collar region, while the other ten leaves were transferred to a beaker containing 50 ml DMSO separately. Both the beakers were kept inside an oven at 65^0 C for two hours. After incubation, two leaves were removed into petridish containing water at hourly interval. Then the leaves were immersed in 1% acid fuchsin solution for 5 minutes. Finally these were washed under running water and the eggs were observed under microscope.

Method 4: Each leaflet of a batch of 10 leavs were cut longitudinally and transferred to 50 ml DMSO and boiled at 75°C. During boiling, two leaves were removed at 10 minutes interval and processed as explained in the method 3.

Oviposition behaviour

Experiment 1: To find out the oviposition preference on different aged leaves, twenty day old potted groundnut genotype PES 33 (27 plants) were arranged in a large feeding chamber. Ten gravid female jassids were released inside the chamber, and were allowed for oviposition for 10 days. Leaves of +1, +2, +3, +4 and +5 from 3 plants were collected separately from "n" branch. Three leaves formed one replication and each leaf was replicated thrice. The sampled leaves were subjected for bleaching in DMSO and stained as explained in method 4, the eggs were finally counted under microscope.

RESULTS AND DISCUSSION

Sources of feeding : In this experiment there were three types of honey dews namely red honey dew representing feeding from xylem vessel, green honey dew indicating the feeding from parenchyma and the third one being phloem. The honey dew excreted out of feeding from phloem was represented by the difference in area before (red + green honey dew) and after bluish colour due to ninhydrin treatment (Paguia *et al.*, 1980). This observation showed that for the first 12 hr, the jassids depended for its sap only from pholem, (69%) followed by xylem (21%) and 10% from parenchyma (Table 1).

Table 1. Feeding preference of *B. hortensis* in groundnut (GG 2)

Hour	Souce of feeding and the honey dew excreated in (mm ^{2}) area			
	Parenchyma	Xylem	Phloem	Total
2	0	0	16	16.0
4	0	0	24(0.96)	24.0
6	0	0	62 (2.5)	62.0
12	0	0	98(3.9)	98.0
24	53(2.1)*	106(4.2)	923(36.9)	1082.0
48	224(8.0)	479(19.2)	1548(61.9)	2251.0
%	9.95**	21.28	68.77	

* Mean/jassaid

** percentage contribution to total sap ingestion

Location of jassid eggs : Among the three methods assessed for their efficacy in locating the eggs of the jassid in the plant tissue of the host plant, the method suggested by Khan and Saxena (1986) appeared to be efficient in locating the eggs. However, this method was time consuming, taking 5 days to complete the processing. Among the 3 methods using Dimethyl sulphoxide as bleaching agent adopted in this study, the 4th

Table 2. Technique to locate eggs of jassid inside the leaf tissue of groundnut

Method	Observation
Khan & Saxena (1986)	Clear leaf, eggs could be seen easily taking 5 days
DMSO method	not bleached completed, eggs are not visible
DMSO method-full leaf	Partial bleaching at 4th hr. eggs are visible at 6th hr.
DMSO method-cut leaf:	complete bleaching at the end of 3rd hr. and eggs are visible
DMSO method-cut leaf	maximum bleaching by the end of 10 minutes, eggs are visible clearly.

method appeared to be the quite effective in locating the eggs of the jassid as was evidenced by clearly visible eggs at a shortest time interval of 10 minutes (Table 2). This method facilitated screening of large number of germplasm for screening against this pest. This obviates the use of costly and harmful chemicals. The results of this method is in confirmation with Hiscox and Isrealstam (1978) wherein, with use of DMSO, maximum amount of chlorophyll was removed on the leaves of Pisum sativum in 15 minutes time.

Oviposition behaviour: The jassid showed no preference between leaves of different age group within a host plant. As regards distribution of eggs, about 65% eggs were inserted into the leaf lamina, whereas 33% were deposited in midrib and 2% in the margins of the leaf.

The method using DMSO as bleaching agent and staining with acid fuchsin may help in large scale screening of germplasm in short time. The method can be used in other crop pests that insert their eggs inside the plant tissues.

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EFFECT OF LEVELS OF NITROGEN AND *Azospirillum* INOCULATION ON OIL, PROTEIN CONTENT AND OIL YIELD OF SAFFLOWER AND ON N, P, K UPTAKE

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ABSTRACT

A field experiment was conducted during *rabi* 1989-90 at College of Agriculture, Rajendranagar, Hyderabad with safflower to study the effect of different levels of nitrogen and *Azospirillum* inoculation on oil, protein, oil yield and on N, P, K uptake. Increased levels of nitrogen application significantly increased N,P,K uptake and oil yield. The highest oil yield, potein content and uptake of N,P, and K were recorded by the treatment which received 20 kg N ha^{-1} as basal + 20 kg N ha^{-1} as foliar spray at 60 and 90 DAS in two equal splits and was on par with the treatment where 60 kg N ha^{-1} as basal was applied. Application of N slightly decreased the oil content. The results obtained by the treatments *Azospirillum* inoculation alone and in combination with 20 kg N ha^{-1} as basal were on par with basal applications of 20 kg N ha^{-1} and 40 kg N ha^{-1} respectively.

Key Words : Oil Content; Oil yield; NPK.

Safflower *(Carthamus tinctorius L.)* is a winter annual edible oilseed crop. The seed contains 28-34% oil. Since chemical fertilizer is the costliest input for crop production its management is very essential. Information with regard to the nitrogen requirement, method of application of the fertilizer for obtaining optimal yields in safflower is meagre. Tiwary and Lehri (1990) have stressed the need for using biofertilizer technology in complement with chemical fertilizers for increasing the productivity of oil yield in India. Information on the effect of inoculation of *Azospirillum* on oilseed crop, is meagre. Especially for safflower the research output is low. In view of this the present study was conducted with the objective to know the effect of different levels of nitrogen and *Azospirillum* inoculation on uptake of N, P and K, oil content, oil yield and protein content of safflower.

MATERIALS AND METHODS

A field experiment was conducted with safflower variety Manjira in Randomised Block Design and replicated thrice. The soil of the experimental field was sandy loam (Sand 63.92%, silt 18.74% and clay 17.34%), low in available nitrogen (241.34 kg ha^{-1}), phosphorus (21.72 kg. ha^{-1}) and high in available potassium (306.50 kg. ha^{-1}). The pH of soil was 7.4.

The treatments included in the experiment are indicated in Table 1. Nitrogen was applied as per the treatment through urea (46% N). Uniform levels of phosphorus and potassium at the rate of 30 kg P_2O_5 and 30 kg K_2O ha^{-1} were applied through SSP (16% P_2O_5) and muriate of potash (60% K_2O) respectively just before sowing the crop.

Azospirillum inoculation

To the mixture of required quantity of safflower seed, the contents of 300 g packet of *Azospirillum* and small quantities of jaggery solution were sprinkled and mixed well. The process was repeated till uniform black coating on the seeds was obtained. Both treated and untreated seeds were sown as per the treatments at a spacing of 45 x 20 cm. A packet of *Azospirillum* containing 300 g was thoroughly mixed with 50 litres of water. A 5 cm depth of small furrow was opened along the

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side of plant rows, *Azospirillum* culture mixed with water was poured in furrow and the soil was covered. This was done at 25 DAS for the treatment plots (T_7, T_8, T_9, T_{10} only).

Irrigation

Five irrigations were given to the crop. The crop was first irrigated immediately after sowing, the 2nd, 3rd, 4th and 5th irrigations were given at 25, 60, 80 and 90 DAS respectively.

RESULTS AND DISCUSSION

Oil content, oil yield and protein content

The results revealed no significant variation in oil content among different treatments. The highest oil content (32.6%) was observed in the control (T_1) and the lowest (32%) was observed in the treatment T_6. As the levels of nitrogen increased there was slight decrease in the oil content. The results on oil content and oil yield are presented in Table 1 and Fig. 1. Sagare *et al.*, (1986), Zaman (1988) also observed reduction in oil content due to increased N fertilization. This might be due to degradation of carbohydrates in tricarboxylic acid cycle (TCA) which by reductive amination and transmination process forms more amino acids and thereby increased protein content in seed with a decrease in oil content as reported by Mahler and Cardes (1971).

The results showed a significant influence of various treatments on oil yield. Even though the highest oil content was recorded by the treatment T_1 (22.6%) it recorded the lowest total oil yield (225.56 kg/ha) due to the low seed yields. The highest oil yield (372.07 kg. ha^{-1}) was obtained by the treatment T_6. As the levels of nitrogen as basal application increased from 0 to 60 kg N ha^{-1}, the oil yield was also increased from 225.56 to 359.81 kg ha^{-1}. Nitrogen received through foliar application (T_5 and T_6) showed increased oil yield

Table 1. Influence of different levels of nitrogen and *Azospirillum* inoculation on seed yield, oil content, oil yield and protein content of safflower.

Treatments	Seed yield (kg ha^{-1})	Oil content (per cent)	Oil yield (kg ha^{-1})	Protein content (per cent)
T_1 : '0' nitrogen	692	32.6	225.56	13.8
T_2 : 30 kg Nitrogen ha^{-1} as basal	835	32.4	270.57	14.75
T_3 : 40 kg N ha^{-1} as basal	1080	32.0	346.63	15.56
T_4 : 60 Kg N ha^{-1} as basal	1125	32.0	359.81	15.75
T_5 : 10 kg N ha 1 as basal + 10 kg N ha^{-1} as foliar at 60 DAS	944	32.2	303.95	14.87
T_6 : 20 kg N ha^{-1} as basal + 20 kg N ha^{-1} as foliar at 60 and 90 DAS in two equal splits.	1163	32.0	372.07	15.93
T_7 : Azospirillum	818	32.5	265.83	14.50
T_8 : 20 kg N ha^{-1} + *Azospirillum*	1073	32.2	345.42	15.44
T_9 : 40 kg N ha^{-1} + *Azospirillum*	1065	32.2	342.85	15.31
T_{10} : 60 kg N ha^{-1} + *Azospirillum*	1057	32.3	341.32	15.31
Mean	985.2	32.25	317.50	15.12
F test	*	NS	*	*
S.Ed	29.15	--	6.887	0.28
C.D (0.05)	61.24	--	14.469	0.59

* Significant at 5% level

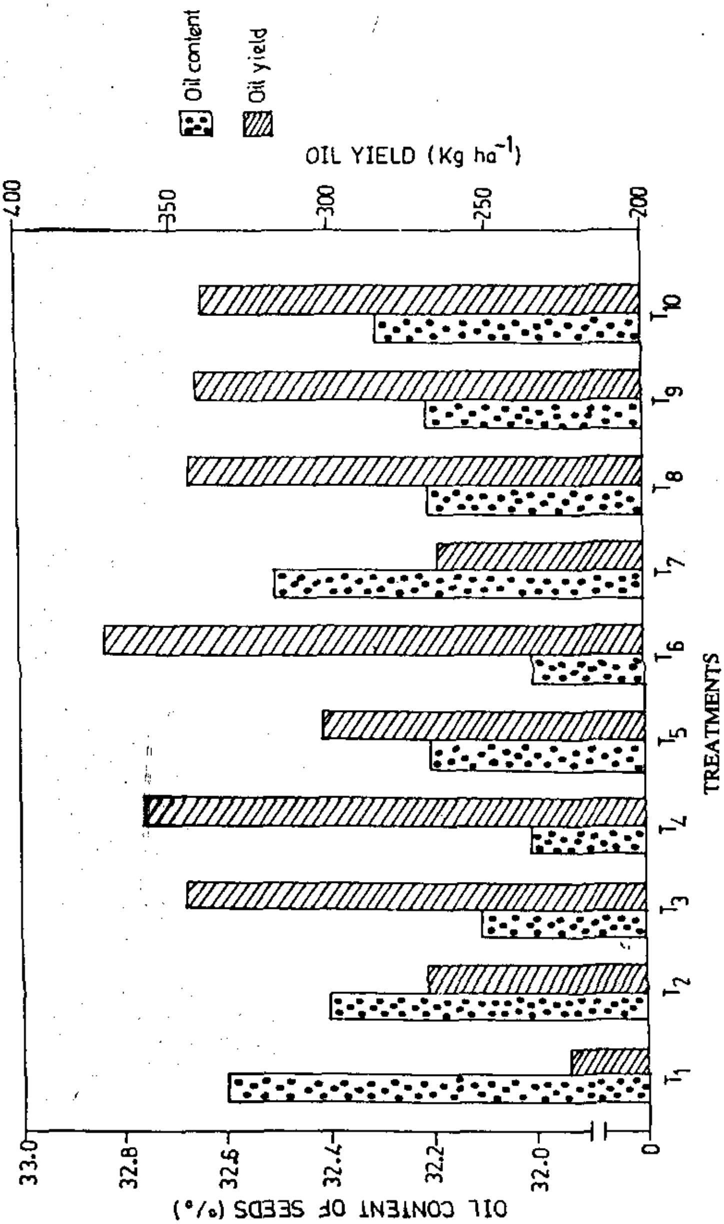

Fig 1. Per cent Oil Content and Oil yield (kg/ha)

over the corresponding levels of nitrogen through basal application (T_2 and T_3) respectively. This increase in oil yield was due to positive effect of nitrogen on yield. Patil and Shah (1983) also ascribed increased oil yields for increased seed yield in sunflower crop. Inoculation with *Azospirillum* showed an increase in oil yield only up to 20 kg N. ha $^{-1}$ (T_7 & T_8) when compared to corresponding N levels of both basal and foliar application. This increase was obtained due to positive response of safflower in terms of seed yield to *Azospirillum* inoculation alone and in combination with 20 kg N ha $^{-1}$. Inoculation of *Azospirillum* along with 40 and 60 kg N ha $^{-1}$ (T_9 & T_{10}) resulted in decreased oil yield when compared to the corresponding levels of N application through basal or foliar. This is due to depressing effect of *Azospirillum* inoculation with higher doses of N on yield of safflower. Subbaiah and Chamy (1984) has similar observation for nitrogen application above 22.5 kg N. ha^{-1} with *Azospirillum* inoculation on sesame crop.

The protein content of the seed increased significantly as the levels of nitrogen increased (Table 1). The highest protein content was observed in the treatment T_6 (20 kg N. ha^{-1}) as basal and 20 kg N ha^{-1} foliar in two equal splits at 60 and 90 DAS. This treatment has succeeded in providing a continuous supply of nitrogen to the crop to sustain a optimum protein metabolism. Zohra Ahmed *et al.*, (1985) and Sagare *et al.*, (1986) also concurred the role of of N in sustaining a better protein metabolism in safflower.

N, P and K uptake

The data on N, P & K uptake (kg ha^{-1}) are furnished in Table 2. Nitrogen uptake increased with increased levels of N application. The highest uptake of N both by the stalk and seed was recorded in the treatment T_6 and was on par with T_4. The higher dose of N was found to be significantly superior to lower dose in respect of N uptake. Similar results were reported by Zohra Ahmed (1983), Hazra and Tripathi (1986) and Sagare *et al.*, (1986).

Positive response to *Azospirillum* inoculation alone (T_7) and in combination with 20 kg N ha^{-1} (T_8) was observed with regard to uptake of nitrogen. This was evident by comparing T_7 and T_8 with T_1 (without nitrogen) and T_2 (20 kg N ha^{-1} as basal) respectively. This might be due to the dual influence of *Azospirillum* on nitrogen fixation and on production of growth producing substances as reported by Subba Rao (1981). Significant increase in N uptake with *Azospirillum* inoculation in safflower was reported by Nawale and Kande (1990). Kapulvik *et al.*, (1987) reported enhanced nutrient accumulation (N, P and K) by *Azospirillum* inoculation which was prominently affected by the level of applied N. No significant effect of inoculation was found by them at higher N level. In the present investigation also, the uptake of N contents and was enhanced by *Azospirillum* inoculation (T_7) along with 20 kg N ha^{-1} (T_8) when compared with T_1 and T_2 respectively. At higher levels of N (40 and 60 kg N ha $^{-1}$) with *Azospirillum* inoculation, nutrient accumulation of N was descreased when compared to their corresponding N levels without inoculation.

The contents and uptake of P and K were also significantly influenced by various treatments. There was an increase in P and K uptake by the crop with increased levels of nitrogen. The highest P and K uptake by both stalk and seed was observed in the treatment (T_6) and was on par with T_4 and the lowest was observed in the treatment T_1. Zohra Ahmed (1983) and Sagare *et al.*, (1986) also reported similar increase in P and K uptake in safflower due to nitrogen application. The P and K uptake were higher in the *Azospirillum* inoculation alone (T_7) and in combination with 20 kg N ha^{-1} as basal (T_8) than control (T_1) and T_2 respectively. Higher levels of N application in combination with *Azospirillum* inoculation (T_9 & T_{10}) resulted in decrease in uptake of K when compared to the corresponding levels of nitrogen (T_3 & T_4) repectively.

Table 2: Influence of different levels of nitrogen and *Azospirillum* inoculation on uptake of N, P and K (kg ha^{-1}) by safflower.

Treatments	Nitrogen (kg ha^{-1})		Phosphorus (kg ha^{-1})		Potassium (kg ha^{-1})	
	Stalk	Seed	Stalk	Seed	Stalk	Seed
T_1 : '0' Nitrogen	15.29	15.28	2.14	**2.21**	35.21	7.54
T_2 : 30 kg Nitrogen as basal ha^{-1}	23.27	19.71	2.86	**2.92**	45.68	9.27
T_3 : 40 kg N ha^{-1} as basal	31.76	26.89	4.11	**4.21**	56.42	12.41
T_4 : 60 kg N ha^{-1} as bsal	33.13	28.11	4.21	**4.50**	58.21	13.05
T_5 : 10 kg N ha^{-1} as basal + 10 kg N ha^{-1}	26.98	22.47	3.04	**3.50**	47.42	10.38
T_6 : 20 kg N.ha^{-1} as basal + 20 kg N. ha^{-1} as foliar at 60 and 90 was in two equal splits	33.63	29.66	4.22	**4.77**	56.90	13.49
T_7 : *Azospirillum*	21.28	18.98	2.71	**2.78**	42.41	9.08
T_8 : 20 k N ha^{-1} + *Azospirillum*	30.75	26.50	4.05	**4.08**	55.13	12.20
T_9 : 40 kg N ha^{-1} *Azospirillum*	30.43	26.09	3.82	**4.04**	54.31	12.03
T_{10} : 60 kg N ha^{-1} + *Azospirillum*	29.59	25.91	3.74	**3.91**	53.66	11.94
Mean	27.62	23.96	3.49	**3.69**	50.54	11.14
F test	*	*	*	*	*	*
S.Ed	1.99	0.99	0.37	**0.21**	3.80	0.36
CD (0.05)	4.18	2.08	0.77	**0.43**	7.98	0.77

* Significant at 5% level

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EFFECT OF DATE OF SOWING ON THE GROWING DEGREE DAYS, PHOTOTHERMAL UNIT AND HELIOTHERMAL UNIT REQUIREMENT FOR DIFFERENT PHENOPHASES IN SESAME

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ABSTRACT

A field experiment on sesame was carried out for five years to investigate the growing degree day, photothermal unit and heliothermal unit requirement for different phenophases when sown on different dates. Results suggest that the duration of different phenophases would be increased when the crop was sown in February or in early March. Growing degree days and photothermal unit requirement for emergence to branching did not follow a definite pattern when the crop was sown in February, however, the requirement increased linearly for flower initiation to 100% flowering and capsule initiation to capsule maturity. The heliothermal unit requirement increased for different phenophases upto 23rd February sowing; it did not follow any definite pattern for the late-sown crop.

Key words: Growing degree days; Heliothermal units; Phenophases; Photothermal units; sesame.

Temperature is one of the major physical variables influencing the rate of growth and development of crop plants in a particular agro-climatic condition. Hence the duration and occurrences of different phenophases depend and vary according to the availability of thermal unit or growing degree days, photothermal unit and heliothermal unit during the growing season of the crop. Singh *et al.*, (1990) discussed the requirement of growing degree days, heliothermal units and photothermal units and phenology of winter maize, however, no such study is reported for sesame. Therefore, the present study was carried out for 5 years to investigate the thermal unit requirement for the growth and development of different phenophases in sesame.

MATERIALS AND METHODS

The field experiment was carried out at the University Teaching Farm at Mohanpur during 1986, '87, '88, '89 and '91. The soil was sandy loam. The treatments comprised 10 sowing dates spanning from 3rd February to 3rd May at 10 days interval. The treatments were replicated 4 times in Randomised Block Design with a plot size of 5 m x 3 m. The variety B-67 was used with a fertilizer dose of 40 kg N, 40 kg P_2O_5 and 40 kg K_2O per hectare at the time of sowing.

Three phenophases viz. emergence to branching (GS_1), flower initiation to 100% flowering (GS_2) and capsule initiation to capsule maturity (GS_3) were identified arbitrarily. The growing degree days, the photothermal and heliothermal units per day were calculated as follows:

$$\text{Growing degree days (GDD)} = \frac{(\text{Maximum temperature} + \text{Minimum temperature})}{2} - T_b$$

Where T_b is the threshold temperature and in thi study, T_b was 10°C. Narawal *et al.* (1986, 1987 used 7° C as T_b for winter maize in north-wes India. Sesame being a dicot and tropical, it require a higher threshold temperature for survival an growth.

Photothermal unit (PTU) =
(Growing degree days) x (average daylength (hr))
as suggested by Nuttonson (1948).

Heliothermal unit (HTU) =
(Growing degree days) x (bright sunshine (hr/day))
as reported by Singh *et al.* (1990).

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The photothermal and heliothermal units were calculated considering the mean values of day length and sunshine hours (1970-1990) during experimental period. The cumulative units for different growth stages were obtained by summing the daily growing degree days, photothermal units and heliothermal units.

RESULTS AND DISCUSSION

Crop duration

The duration of different growth stages differed in different dates of sowing as well as years (Table 1). However, when the crop was sown on 3rd February, it required 36-38 days for emergence to branching; 28-30 days for flower initiation to 100% flowering and 28-32 days for capsule initiation to capsule maturity in different years. On an average, the sesame crop takes 34-37 days, 32-33 days, 29-31 days when sown in February, March, April and May for branching. Early February sown crop requires maximum time period for branching while the duration declines as the sowing dates are delayed. This is also true in case of other growth stages. Low temperature prevailing during February and early March may delay the initiation of different phenophases.

Growing degree days (GDD)

The cumulative GDD requirement for emergence to branching ranges from 1.06×10^3 to 1.12×10^3 units in different years when sown on 3rd February. No definite pattern existed regarding the GDD requirement for GS_1 (Table 1). However, the cumulative GDD requirement for GS_2 and GS_3 increased continuously from 13 February to 24 April sown crop, this might be due to the increasing temperature during the period concerned. The GDD requirement for all the phenophases declined in May-sown crop because of rainfall which brought down the ambient temperature to some extent.

Cumulative photothermal unit requirement (CPU)

Cumulative Photothermal unit requirement for emergence to branching was lowest when the crop was sown on 3rd February, while it was maximum when the crop was sown on 24th April. There exists no definite trend of CPU requirement for different phenophases (viz. GS_1, GS_2 or GS_3) when the crop was sown at different dates, however, the CPU requirement was higher in GS_2 or GS_3 than GS_1 (Table 1). Singh *et al.,* (1990) also observed a linear relationship for CPU requirement in maize crop.

Cumulative Heliothermal unit requirement (HTU)

The sesame crop took 8.78×10^3, 15.16×10^3 and 20.32×10^3 HTU for GS_1, GS_2 and GS_3 respectively when it was sown on 3rd February. The heliothermal unit requirement for different phenophases increased upto 23rd February sowing and afterwards it did not follow any pattern (Table 2). In general, March, April or May - sown crops required less HTU than the February sown crops. The increasing temperature and sunshine hour/day linearly increased the accumulated heliothermal units with the progressive delay in sowing.

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Table 1. Effect of date of sowing on the duration of different growth stages; cumulative growing degree days and cumulative photothermal unit requirement in *sesamum indicum* (Mean of 1986, 1987, 1988, 1989, 1991).

Dates of sowing	Duration of growing stages (days)			Cumulative growing degree days (unit x 1000)			Cumulative photothermal unit (unit x 1000)		
	GS_1	GS_2	GS_3	GS_1	GS_2	GS_3	GS_1	GS_2	GS_3
3 February	36.8	29.2	29.6	1.09	1.82	2.02	12.91	22.14	25.00
13 February	35.6	29.2	29.6	0.96	1.77	2.00	12.69	21.10	23.39
23 February	34.2	28.0	28.4	1.17	1.82	2.18	14.94	22.47	28.22
5 March	33.0	27.2	27.8	1.07	1.83	2.20	14.60	23.35	28.99
15 March	32.6	26.0	27.4	1.14	1.89	2.34	15.03	18.57	30.12
25 March	32.4	25.6	27.2	1.62	2.00	2.62	15.53	15.86	32.19
4 April	31.4	25.2	26.8	1.24	2.26	2.66	17.76	31.16	35.11
15 April	30.8	24.0	26.0	1.25	2.35	2.68	18.12	32.20	36.45
24 April	29.0	23.2	26.0	1.37	2.40	2.76	20.02	33.24	37.95
3 May	28.8	23.0	25.2	1.01	2.33	2.52	15.47	31.59	32.70

GS_1 = Emergence to branching, GS_2 = Flower initiation to 100% flowering, GS_3 = Capsule initiation to capsule maturity.

Table 2 . Effect of dates'of sowing on the cumulative heliothermal unit requirement for different phenophases in sesame.

Dates of sowing	Cumulative Heliothermal Unit (Unit x 1000)																	
	GS_1						GS_2						GS_3					
	1986	1987	1988	1989	1991	Mean	1986	1987	1988	1989	1991	Mean	1986	1987	1988	1989	1991	Mean
3 February	8.60	8.67	8.80	9.00	8.86	8.78	15.00	15.20	15.26	15.30	15.07	15.16	20.20	20.28	20.28	20.40	20.46	20.32
13 February	9.50	9.60	9.68	10.00	19.63	9.68	15.60	15.36	15.60	15.68	15.32	15.53	20.00	20.18	20.28	20.48	20.05	20.20
23 February	11.20	11.40	11.30	11.50	11.34	11.35	15.00	15.28	15.30	15.36	15.25	15.24	21.00	21.10	21.20	21.26	21.15	21.14
5 March	10.50	10.20	11.27	10.06	10.07	10.42	17.80	17.25	17.38	17.56	17.83	17.57	18.86	19.00	19.18	19.30	19.31	19.13
15 March	10.90	11.20	11.50	11.86	10.99	11.29	14.20	14.28	14.40	14.56	14.26	14.34	16.68	17.18	17.28	17.36	17.52	17.20
25 Mach	10.50	10.60	11.80	10.88	10.49	10.85	14.00	14.18	14.16	14.20	14.04	14.11	17.05	17.15	17.26	17.75	17.86	17.41
4 April	10.36	10.50	10.60	10.48	10.40	10.47	14.80	14.88	14.28	14.58	14.86	14.68	18.98	19.10	19.20	19.46	19.95	19.34
15 April	9.85	9.90	10.10	10.18	9.98	10.00	19.06	19.10	19.28	19.36	19.58	19.27	17.00	17.18	17.28	17.38	17.22	17.21
24 April	10.00	10.20	10.36	1w0.50	10.35	10.28	17.08	17.18	17.66	17.80	17.83	17.51	7.98	7.98	8.10	8.25	8.08	8.08
3 May	7.00	7.15	7.20	7.26	7.09	7.14	14.00	14.25	17.26	17.40	14.65	15.51	7.00	7.10	7.20	7.26	7.06	7.12

GS_1 = Emergence to branching, GS_2 = Flower initiation to 100% flowering

GS_3 = Capsule initiation to capsule maturity.

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PHYSIOLOGICAL ALTERATIONS IN *Sesamum indicum* L. LEAVES INFECTED WITH PHYLLODY MLO AND BY ANTI MYCOPLASMA PRINCIPLES AND CHEMICALS

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ABSTRACT

Significant increase in contents of total protein and RNA were observed in phyllody MLO infected *Sesamum indicum* L plants and in plants treated with anti myco plasma principles from *Vitex negundo* var *Purpurasense* and *Sesbania rostrata* and chemicals viz., L-arabinose, polygalacturonic acid and kinetin, when compared to healthy, whereas, DNA contents of treated plants did not differ appreciably, and maximum content of DNA was noted in plants sprayed with *Sesbania rostrata* followed by inoculation. Electrophoratic separation of soluble proteins revealed that four protein bands with a molecular weight of 112 kd, 87 kd, 40 kd and 30 kd were present in the healthy sesame plants and of these, two proteine bands (87 kd and 30 kd) were absent in phyllody infected plants. A protein band with a molecular weight of 27 kd appeared in all uninoculated plants when sprayed with leaf extracts and chemicals. Six new unidentified bands appeared in plants treated with leaf extracts and chemicals followed by inoculation of phyllody MLO, but these bands were completely absent in phyllody infected and healthy plants.

Key words : Phyllody; AMPS; Physiological changes; Protein bands.

Phyllody is one of the most destructive diseases of sesame. It is transmitted by leaf hopper vector, *Orosius albicinctus* Distant. Plant pathogens induce characteristic changes in the physiology of infected plants which have to provide necessary nutrition for their development. Attempt has been made to manipulate the defence genes using leaf extracts and chemicals that can act as elicitors of defence systems (Gupta *et al.*,1987; Dabek and Hunt, 1976; Narayanasamy and Ganapathy, 1986; Abu jawdah, 1982; Van Huijsduijhen *et al.*, 1986; Nasser *et al.*, 1990). Physiological changes in sesame leaves due to phyllody infection and changes in host resistance following application of effective leaf extracts and chemicals are presented in this paper.

MATERIALS AND METHODS

The AMPs from leaf extracts of *Vitex negundo* var *Purpurasense* and *Sesbania rostrate* and chemicals viz., L-arabiness, polygalacturonic acid and kinetin were selected as elicitors to induce changes in host system based on findings on their ability to reduce phyllody infection in sesame (Srinivasulu, 1991). Antimycoplasma principles (AMPs) were extracted from fresh leaf tissues. The leaf material was ground along with distilled water added at the rate of one ml per gram of tissue by using pestle and mortar and the macerate was extracted using cotton wool to get the extract. Then the extract was diluted to give 10 per cent concentration by adding distilled water. The chemicals were sprayed at 1000 ppm concentration obtained with distilled water.

The leaf extracts and chemicals were sprayed on 15 days old TMV 3 *Sesamum indicum* seedlings and inoculated using viruliferous leaf hoppers at the rate of 3 insects per plant, 24 h after application. Suitable uninoculated controls were maintained for comparison. Leaf tissue analyses were carried out at one day and 4 days after inoculation.

The protein content was estimated by the method of Lowry *et al.*, (1951) and the nucleic acids (RNA and DNA) were estimated using 10 per

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cent Trichloro acetic acid (TCA) as described by Jayaraman (1981).

Electrophoratic separation of soluble protein

Sesamum indicum plants were inoculated with phyllody MLO. Changes in soluble protein content of sesame as per treatments and healthy plants were studied by sodium dodecyl sulphate-polyacrylamide gel electrophoresis (SS-PAGE) (Laemmli and Favre, 1973). The standard proteins used were phosphorylase-A (92 kd) bovin serum albumin (68 kd), globulin heavy chain (50 kd), albumin egg (45 kd) trypsinogen (24 kd) and cytochrome-C (12.5 kd).

RESULTS AND DISCUSSION

The total protein content of healthy sesame plants increased progressively with increase in age of plants. Infection with phyllody caused an increase of 26.3 per cent over healthy plants during initial stages of infection and increased to 31.4 per cent at 4 days after inoculation. Treatment with AMPs and chemicals also increased the total protein content over healthy plants. The maximum increase was noted in plants treated with polygalacturonic acid. However, plants treated with leaf extracts or chemicals and inoculated also had significantly higher concentrations of total protein than all other treatments including controls (Fig. 1). This increase might be due to the contribution of phyllody MLO, synthesis of PR and other nitrogenous substances synthesised in response to infection as well as induction of nitrogenous substances by AMPs and chemicals. Increase in protein content and free aminoacid content due to infection of grassy shoot of sugarcane (Gupta *et al.*, 1987) and lethel yellowing in coconut (Dabek and Hunt, 1976) have been reported. Electrophoretic separation of proteins revealed that four protein bands with molecular weights of 112 kd, 87 kd, 40 kd and 30 kd were present in healthy sesame plants and of these, two protein bands were not present in phyllody infected plants, indicating a depletion of two protein bands with a molecular weight of 87 kd and 30 kd, following phyllody infection. Similar depletion of protein bands in cowpea plants due to TSMV infection was reported by Narayanasamy and Ganapathy (1986). The proteins might have been utilised by the casual agent for its development in host system. A new protein band of 27 kd appeared in all uninoculated plants when sprayed with leaf extracts or chemicals, which was not present either in phyllody infected or healthy plants. Additionally, specific new protein bands with a molecular weight of 100 kd and 123 kd appeared respectively in plants treated with L-arabinose or extracts of *Sesbania rostrata* (plate 1). Synthesis of additional proteins was reported in bean (Abu

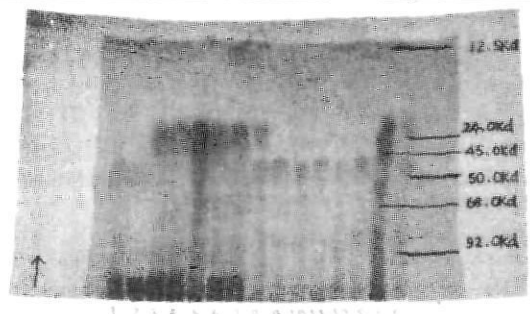
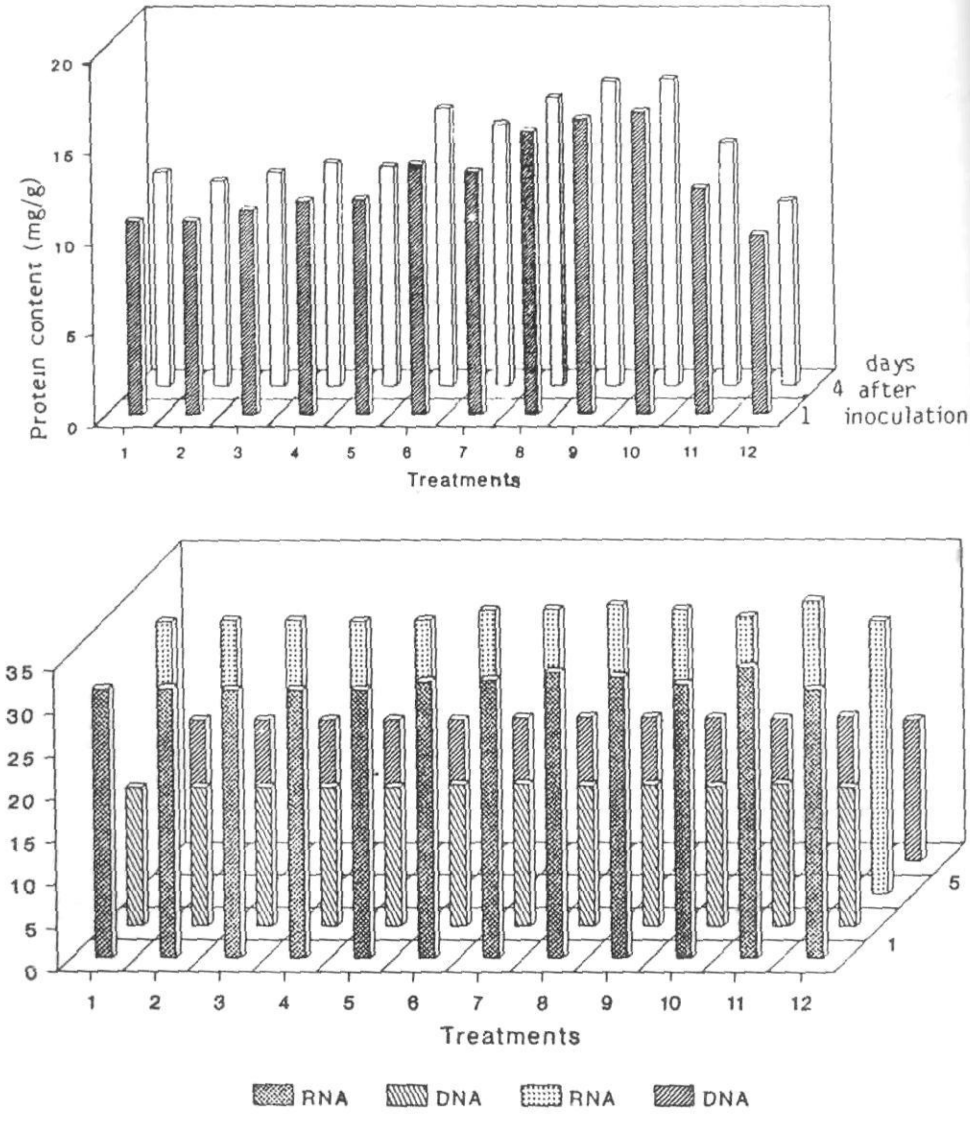


Plate 1 . SDS - PAGE Electrophoretic separation of proteins

1. Healthy
2. Inoculated
3. Kinetin sprayed
4. Vitex negundo var purpurasense sprayed
5. Polygalacturonic acid sprayed
6. L-arabinose sprayed
7. *Sesbania rostrata* sprayed
8. Kinetin sprayed and inoculated
9. Vitex negundo var purpurasense sprayed and inoculated
10. Polygalacturonic acid sprayed and inoculated
11. L-arabinose sprayed and inoculated
12. Sesbania rostrata sprayed and inoculated

S. Standards

Fig. 1: Effect of phyllody infection and treatments with AMPs and chemicals on protein, RNA and DNA contents of sesame leaves.



Treatments

1. *Vitex negundo* var. *Purpurasense*
2. *Sesbania rostrata*
3. L-arabinose
4. Polygalacturnoic acid
5. Kinetin
6. *vitax negundo* var. *Purpurasense inoculated*
7. Sesbania rostrata inoculated
8. L-arabinose inoculated
9. Polygalacturonic acid inoculated
10. Kinetin inoculated
11. Inoculated control
12. Uninoculated control.

Jawdah, 1982), in alfalfa (De Tapia *et al.*, 1987) and in maize (Naaser *et al.*, 1990) due to mercury chloride treatment and in *Semsun* NN tobacco, bean and cowpea (Van Huijsduijhen *et al.*, 1986) due to salicylic acid treatment. Application of AVPs from *Cocos nucifera* and *Nerium odorum* induced the formation of three new protein bands in cowpea plants (Narayanasamy and Ganapathy, 1986). The present study appears to be the first of its kind in studying the changes in protein metabolism after spraying chemicals or plant products in host - MLO combinations. The appearance and depletion of protein bands *pari passu* may indicate the extent of rapid changes induced by AMPs and chemicals to nullify the demands of the pathogen and to increase the level of resistance of the sesame plants.

The plants treated with AMPs and chemicals and then inoculated with phyllody MLO recorded greater RNA contents at both periods of sampling, with a maximum record of RNA content in L-arabinose treated plants (33.4 µg/g). There was no change in the RNA content of healthy plants treated with AMPs and chemicals at one and 4 DAI (Fig.1). In inoculated plants, maximum content of DNA was noted in plants sprayed with extracts of *Sesbania rostrata* and inoculated (16.7 µg/g) as against 16.3 µg/g in uninoculated treatments (Fig.1). Sesame plants inoculated with phyllody MLO recorded a significant increase in RNA and DNA contents over healthy plants. This increase in inoculated plants might be due to the pathogen contribution in addition to the greater synthesis of nucleic acids in infected plants (Fig.1). Similar increase in nucleic acid contents due to spike disease in sandal (Parthasarathi *et al.*, 1973) and RYD in rice (Narasimha Rao, 1988) was reported. The lower levels of nucleic acids in plants sprayed with AMPs and chemicals than inoculated plants indicates a check on the nucleic acid synthesis in plants treated with AMPs and chemicals.

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EFFECT OF SULPHUR APPLICATION ON YIELD AND UPTAKE OF MACRO, SECONDARY AND MICRONUTRIENTS BY SUNFLOWER (*Helianthus annuus* L.) ON A RAINFED ALFISOL

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ABSTRACT

In a study on sunflower (cv.Morden)grown on red sandy loam soil, Sulphur (S) was applied through three sources viz. gypsum, ammonium sulphate and single superphosphate at 0, 20 and 60 kg S ha^{-1}. Response in terms of yield and S uptake by the crop to the applied S was observed upto 60 kg S ha^{-1}. Application of S resulted in increase in uptake of N,K, S, Ca, Zn and B while antagonistic effects were observed on P and Mg at both flowering and maturity stages of the crop growth.

Key words: Sulphur nutrition; Sunflower; Micro nutrients.

Sulphur (S), among secondary nutrients, is vital for maintaining quality of sunflower seed, as it is known to be a constituent of S-containing amino acids such as cystine, cysteine and methionine. Besides, S influences the content and uptake of major and mincronutrients to a large extent which results in quantitative changes in yields of seed and oil. Since application of S is becoming imperative to oilseed crops, particularly when grown on light textured soils such as red sandy loams of Telangana region of Andhra Pradesh, it was felt necessary to investigate the effect of S applied at different levels on uptake of N,P,K,Ca, Mg,S, Zn and B at different stages of crop growth so that appropriate management practice can be developed to avoid nutritional problems with respect to these elements.

MATERIALS AND METHODS

A field trial on sunflower was conducteu during *Kharif* 1988 at college of Agriculture, Rejendranagar, Hyderabad. The soil was sandy loam in texture with neutral pH (6.8). It was low in available nitrogen (142 kg ha^{-1}), medium in available phosphorus (23.0 kg P_2O_5 ha^{-1}) and high in available potassium (289 kg K_2O ha^{-1}). The available sulphur content was 8.6 ppm (Ensminger, 1954).

The experiment was laid out in a split plot design with sources of S as main treatments and levels of S as sub treatments. Sulphur was applied to sunflower through 3 different sources viz. gypsum, *ammonium sulphate and single superphosphate* @ 20, 40 and 60 kg S ha^{-1}. Each treatment was replicated thrice. Nitrogen, phosphorus and potassium were applied at recommended doses of 70 kg N ha^{-1}, 50 kg P_2O_5 and 40 kg K_2O ha^{-1}, respectively. Nitrogen was applied in three splits at sowing (50 kg), bud (10 kg) and flowering (10 kg) stages, while phosphorus, potassium and sulphur were applied basally.

Sunflower (cv. Morden) seeds were sown at the recommended spacing of 45 x 30 cm. Though irrigation was given at flowering (65 days stage) the crop was essentially maintained as rainfed one. Total rainfall received during crop growth period was 390.2 mm starting from first week of August to last week of October. The rainfall received during the months of August and September was 244.6 and 145.6 mm, respectively while in October there was no rainfall. Yields of

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flower heads and stalks at flowering stage and seeds as well as stalks at maturity were recorded. The samples collected were analysed for sulphur (Chesnin and Yein, 1951), phosphorus (Vanado Molybdophosphoric) and potassium (Jackson, 1967) after digesting them with diacid mixture. Nitrogen was estimated by modified micro kjeldahl method. The contents of Ca, Mg and Zn in the extracts were determined using Atomic absorption Spectrophotometer. Boron was estimated by Caramine method (Jackson, 1967).

RESULTS AND DISCUSSION

The data on yields of flower head and stalk seperately at flowering stage and seed as well as stalk yields at maturity are presented in Table 1 alongwith the contents and uptake of S at different growth stages of sunflower crop.

The results indicated response of sunflower to applied S even up to 60 kg ha^{-1} on red sandy loam soil both at flowering and maturity stages. There were increases in the yields of flower heads and stalks at maturity due to application of sulphur. Such beneficial effects of sulphur application on yields of sunflower crop were reported by Gangadhara *et al.*, (1990). Among the sources of sulphur, ammonium sulphate was found superior to others at both the stages of crop growth. This may be due to higher solubility of S present in ammonium sulphate than that is sparingly soluble in gypsum or single superphosphate. Although, the three sources are containing $SO_4^=$, when gypsum is applied to soils, the presence of free Ca^{++} ions in soil solution reduces its solubility as a result of common ion effect. The superiority of ammonium sulphate over gypsum and single superphosphate was observed earlier in sunflower (Khan, 1987) and soybean (Dhillon and Dev, 1980) crops. Similar to yields, content and uptake of S at both the stages were also significantly influenced by sources and levels of applied S (Table 1).

Uptake of macro, secondary and micronutrients.

Results on the uptake of macro, secondary and micronutrients at different stages of crop are presented in Tables 2 and 3. A perusal of the data revealed that the uptake of N,P,K, Ca, Mg, Zn and B was more at maturity than at flowering stage indicating that uptake of nutrients increased with the age of crop growth. Further, the uptake of different nutrients varied significantly with rate of S application.

The uptake of nitrogen differed significantly among the sources at both the stages of crop growth, maximum values being recorded at harvest stage, except at harvest, where ammonium sulphate only differed significantly from gypsum and single superphosphate. Irrespective of sources of S, the uptake of N increased significantly with the increase in level of sulphur, indicating synergism between S and N in nutrition of sunflower crop, thus indicating maintenance of ionic balance in the plant system for favourable increase in yield and oil content (Aulakh *et al.*, 1977).

Application of S had also synergistic effect on other nutrients such as potassium, calcium, zinc and boron showing significant increase in their uptake with increase in level of applied S. However, in seeds at harvest, calcium uptake did not show significant difference due to increase in S levels particularly at higher doses. On the other hand, P and Mg showed antagonistic relationship with sulphur. The antagonism of sulphur with phosphorus might be due to the likely competition between these two nutrients for the same absorption sites on root surface (Aulakh and Pasricha, 1977). Another reason could be precipitation of $PO_4^=$ by the Ca present in gypsum and single superphosphate rendering the phosphate unavailable to plant. While this antagonistic behaviour of sulphur with phosphorus was observed in uptake of P by stalks at flowering stage it was not consistent at maturity stage. Also, the variation recorded in yield and content of P due to S application could have resulted in variations in P uptake by the crop. Since S application increased the uptake of other cationic nutrients such as K, Ca and Zn and

Table 1. Effect of Sulphur application on dry matter/yield of sunflower and Sulphur content and uptake at different stages of growth

Treat-ment	kg/ha	Flowering: Flowerheads Dry matter (q. ha^{-1})	Flowering: Flowerheads S Content (%)	Flowering: Flowerheads S uptake (kg ha^{-1})	Flowering: Stalks Dry matter (q ha^{-1})	Flowering: Stalks S Content (%)	Flowering: Stalks S Uptake (kg ha^{-1})	Maturity: Seed Yield (q ha^{-1})	Maturity: Seed S Content (%)	Maturity: Seed S uptake (kg ha^{-1})	Maturity: Stalks Yield (q. ha^{-1})	Maturity: Stalks S content (%)	Maturity: Stalks S Uptake (kg ha^{-1})
Gypsum	0	8.85	0.16	1.41	20.65	0.17	3.57	9.75	0.14	1.37	31.31	0.12	3.75
	20	9.23	0.21	1.95	21.61	0.21	4.53	10.50	0.19	1.99	34.71	0.16	5.07
	40	10.12	0.28	2.92	22.95	0.27	6.27	11.80	0.23	2.52	36.95	0.21	7.88
	60	11.08	0.29	3.22	24.05	0.29	6.97	12.10	0.25	3.07	37.95	0.22	8.16
Mean		9.89	0.24	2.37	22.31	0.24	5.33	11.03	0.22	2.24	35.23	0.20	6.21
A S	0	8.85	0.16	1.41	20.60	0.17	3.50	9.71	0.14	1.36	31.51	0.12	3.78
	20	9.20	0.23	2.13	22.88	0.23	5.01	10.63	0.20	2.12	34.85	0.16	5.09
	40	11.36	0.29	3.29	24.68	0.28	6.99	12.95	0.24	3.10	37.41	0.22	8,25
	60	12.52	0.31	3.88	25.65	0.33	8.37	13.15	0.27	3.55	38.25	0.24	8.92
Mean		10.48	0.25	2.68	23.44	0.25	5.97	11.61	0.22	2.53	35.50	0.20	6.51
SSP	0	8.85	0.16	1.41	20.60	0.17	3.49	9.75	0.14	1.36	31.51	0.15	3.78
	20	8.91	0.21	1.78	20.90	0.21	4.46	10.27	0.19	1.95	33.95	0.16	5.43
	40	9.51	0.27	2.38	22.63	0.25	5.73	11.17	0.23	2.60	35.90	0.20	7.28
	60	10.56	0.29	2.85	22.83	0.27	6.31	11.44	0.24	2.74	36.85	0.23	8.17
Mean		9.45	0.22	2.10	21.75	0.23	5.00	10.65	0.21	2.16	34.55	0.19	6.17
C.V. (%)		11.9	23.0	-	7.2	22.10	28.0	10.50	16.40	25.60	7.0	-	20.0
C.D (0.05)													
Sources		0.06	0.002	0.02	0.11	0.004	0.20	0.107	0.011	0.172	0.36	0.009	0.387
Levels		0.11	0.003	0.035	0.19	0.007	0.346	0.002	0.01	0.099	0.62	0.008	0.228

AS= Ammonium Sulphate SSP= Single Superphosphate.

Table 2 . Effects of sulphur application on N, P, K, Mg, Zn and B uptake in flower heads and stalks at flowering stage of sunflower

Treat-ment	Uptake (kg/ha)													
	N		P		K		Ca		Mg		Zn (g.ha^{-1})		B(g.ha^{-1})	
kg/ha	Head	Stalk	Head	stalk	Head	stalk	Head	stalk	Head	stalk	Head	stalk	Head	stalk
G 0	23.01	53.69	3.00	7.23	21.53	54.72	5.83	28.93	5.30	13.00	24.33	58.60	22.12	51.30
20	24.45	57.63	3.13	6.98	24.33	61.24	6.46	33.86	5.13	12.89	26.16	61.90	22.16	57.60
40	27.76	76.82	3.14	6.50	29.00	67.70	7.71	38.98	5.24	11.85	30.20	68.60	22.92	52.00
60	30.46	88.18	3.32	5.93	33.00	76.63	8.42	44.09	5.28	10.66	33.96	75.50	23.27	50.30
Mean	26.42	69.08	3.22	6.66	26.96	65.07	7.10	36.46	5.24	12.10	28.66	66.15	22.60	51.30
AS 0	23.01	53.69	3.00	7.21	21.53	54.59	5.96	28.91	5.31	12.98	24.18	58.30	22.12	51.30
20	24.10	60.91	3.03	7.61	24.06	65.50	6.52	35.79	4.99	14.47	27.46	67.11	21.16	54.80
40	31.10	84.72	3.53	7.40	32.00	74.54	8.33	43.19	5.68	14.06	34.36	74.95	23.86	54.30
60	39.23	95.69	3.71	6.15	37.80	81.73	9.58	47.42	5.88	12.21	39.03	82.54	25.03	53.30
Mean	29.33	73.75	3.32	7.09	28.79	69.09	7.59	38.80	5.46	13.43	31.26	70.79	23.00	54.00
SSP 0	23.01	53.69	3.00	7.20	21.52	54.51	5.83	28.86	5.34	13.03	24.36	58.32	22.12	51.30
20	23.16	55.76	2.67	6.31	23.46	56.41	6.18	30.30	5.29	12.19	25.10	60.22	21.40	50.90
40	25.20	74.69	2.72	6.41	25.70	69.90	7.10	35.45	5.00	11.92	27.06	67.41	21.87	50.50
60	30.44	81.82	2.89	5.63	30.06	67.74	8.02	40.72	4.85	10.27	31.56	72.31	22.17	47.96
Mean	25.45	66.49	2.82	6.39	25.19	60.41	6.78	33.84	5.12	11.85	27.02	64.56	21.90	50.40
CV(%)	21.9	23.0	10.2	9.5	19.0	13.8	16.8	17.5	5.5	9.9	16.2	12.0	4.7	4.4
CD(0.05)														
Sources	0.20	0.89	0.096	0.079	0.506	0.553	0.130	0.388	0.184	0.421	0.52	0.347	0.25	1.31
Levels	0.25	0.96	0.05	0.061	0.350	0.612	0.075	NS	0.107	0.382	0.30	0.282	0.17	1.28

G= Gypsum AS = Ammonium Sulphate SSP = Single superphosphate

Table 3 . Effects of sulphur application on uptake of N, P, K, Ca, Zn, and B in seeds and stalks at maturity of sunflower

Treat-ment	Uptake (kg/ha)													
	N		P		K		Ca		Mg		Zn (g.ha^{-1})		B (g.ha^{-1})	
kg/ha	Seed	Stalk	Seed	stalk	Seed	stalk	Seed	stalk	Seed	stalk	Seed	stalk	Seed	stalk
G 0	21.93	62.52	1.52	5.67	7.50	55.41	5.79	37.92	4.52	24.26	21.10	65.06	36.40	91.37
20	24.36	66.59	1.99	5.89	9.13	63.17	9.59	44.20	4.59	25.91	24.70	24.70	32.20	97.18
40	28.91	83.14	2.16	6.28	10.14	68.97	11.21	48.77	4.83	27.46	27.90	87.36	32.90	99.76
60	31.83	87.28	2.22	6.07	12.10	73.34	12.17	51.61	4.23	27.83	31.80	91.33	38.20	94.87
Mean	26.76	74.88	2.08	5.97	9.71	65.22	9.69	45.62	4.54	26.36	26.38	86.13	38.68	95.05
AS 0	21.84	63.02	1.95	5.67	7.74	55.41	8.31	37.81	4.58	24.23	21.00	65.20	36.00	91.37
20	24.44	68.47	2.24	5.91	9.67	65.63	10.44	44.02	5.10	26.36	26.90	78.50	36.70	97.58
40	31.72	86.50	2.33	6.36	12.17	73.31	12.25	47.55	5.39	27.43	32.20	86.73	36.20	101.02
60	34.84	89.88	2.24	6.12	13.16	78.92	12.75	53.55	4.99	27.92	35.10	92.10	37.60	99.45
Mean	28.21	76.84	2.19	6.02	10.61	68.31	10.93	46.40	5.02	26.48	28.80	80.63	35.12	97.36
SSP 0	21.93	63.02	1.95	5.66	7.50	55.11	8.32	37.81	4.51	24.25	21.10	66.56	36.00	91.37
20	24.13	71.29	2.02	5.88	9.75	62.80	9.20	43.23	4.59	25.69	24.90	76.10	35.60	97.32
40	27.36	80.79	2.15	6.22	10.49	71.56	10.53	47.03	4.87	26.08	28.60	85.30	35.70	95.74
60	29.55	86.59	1.83	6.26	11.09	76.16	11.17	50.72	4.49	25.93	31.70	88.20	36.30	95.81
Mean	25.74	75.41	1.98	5.98	9.70	66.48	9.81	44.69	4.62	25.48	26.58	79.04	35.90	95.06
CV (%)	20.4	14.5	7.9	4.5	21.5	12.5	21.6	12.0	6.8	5.2	17.1	12.8	8.3	3.5
CD (0.05)														
Sources	0.882	0.84	0.054	0.157	0.22	0.937	1.5	0.783	0.081	0.504	0.567	2.57	1.92	1.46
levels	0.92	0.81	0.032	0.165	0.25	0.860	1.22	0.695	0.065	0.460	0.651	2.48	1.65	1.39

G= Gypsum AS = Ammonium Sulphate SSP = Single Superphosphate depressed the uptake of Mg, the S x Mg antagonism can be suspected (Aulakh and Pasricha, 1978). Among the sources, application of S as ammonium sulphate resulted in higher magnesium uptake than through gypsum and single superphosphate. Such beneficial effects might be because of increase in dry matter/seed yields due to application of the former than the latter two sources of S. These results suggest that the observed depression in Mg uptake is mainly becuase of the Ca present in gypsum and single superphosphate but not by the S *per se.*

Application of sulphur through different sources irrespective of levels of S tried significantly increased the uptake of zinc and boron. Similar trend was observed with respect to these two nutrients by Dixit and Shukla (1984) and Aulakh and Pasricha (1986) in mustard plants. The increased uptake of zinc due to sulphur application is due to increased efficiency of sunflower crop to utilize more nutrients including zinc and boron because of increased growth and vigour when S was applied to it. The synergistic behaviour between S x B that was observed due to application of sulphur through ammonium sulphate and gypsum was not seen with single superphosphate which evidently indicated that the efficiency of S sources also contributes to a large extent in bringing out variability in boron uptake pattern by the sources via dry matter production. The superiority of ammonium sulphate in increasing the uptake of cationic nutrients such as K and Zn might also be due to replacement of these nutrients from the exchange complex by NH_4^+ ions present in the source thereby increasing their availability to the crop.

In view of the above, it can be concluded that the P and Mg nutrition of sunflower has to be taken care of whenever sulphur is applied particularly at higher doses through sources such as gypsum and single superphosphate. In the absence of such a precaution, crop yields are likely to suffer due to nutrient imbalances.

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GROWTH OF MUSTARD AND GROUNDNUT IN UTTAR PRADESH : A REGION-WISE STUDY

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ABSTRACT

The variability, growth rates and the effect of area, productivity and their interaction have been studied on production of rape seed and mustard and groundnut crop. The study was made for different regions as well as for state based on the secondary information collected for the period of 1965-66 to 1985-86. For groundnut the study revealed that most of the regions and the state as a whole have achieved a considerable improvement in area and production of rape seed & mustard but this is true only for Bundelkhand and Eastern regions. Maximum and minimum coefficients of variation were observed for production and productivity respectively in most of the regions for both the crops. Bundelkhand region had the highest variation in area, production and productivity of both the crops. The compound growth rate in area and production of rape seed and mustard was found to be significantly positive in all the regions (except Hill) and state as well. Bundelkhand and state as a whole recorded a positive and significant growth rate in productivity also. In case of groundnut, all the regions (except Bundelkhand and Eastern) and state as well, have experienced a negative and significant growth rate in area and production. Though, Eastern region has a positive and significant growth rate, Bundelkhand region has achieved a quite remarkable success in area and production of groundnut as the growth rates of these two were estimated as 83.30 per cent and 76.50 per cent respectively. The area effect was found to be mainly responsible to increase and decrease the production of rapeseed and mustard and groundnut respectively in Western Central and Bundelkhand regions while contribution of yield effect was main to increase the production of these crops in Hill region. In Eastern region, whereas area contributed maximum to the production of rape seed and mustard, yield was found to be responsible to increase the groundnut production. On the basis of findings it is suggested that the efforts should be directed to increase the productivity of crops in those regions where increased production was only due to significant growth in area.

Key Words: Growth rate; Coefficient of variation; Variability; Area effect; Yield effect; Interaction effect.

Before the green revolution period and even till 1980, the greatest challenge before the nation was to achieve self sufficiency in foodgrains. Increase in the total output, particularly the cereals, could be attained either by increasing the area under cultivation or increasing the productivity. As most of the cultivable land was already under the plough, the increased output is the result of increased productivity. Efforts of agricultural scientists working to evolve a better technology to attain the higher yield and resource productivity, have brought good results to achieve self sufficiency in food grains production. However, it is not in case of oilseeds and pulses.

At present the availability of oil is only 3.70 million tonnes as against a demand of 4.90 million tonnes of oil in the country. This gap would further widen with increasing population and rising standard of living if we could not achieve a desired pace in case of area, production and productivity of oilseeds. Therefore, a study was undertaken to examine the variability, growth rates and magnitudes of effect of area, productivity and their interaction on production of oilseeds.

MATERIALS AND METHODS

Uttar Pradesh, has 9 per cent of total area in the country. Though the production of any crop mainly depends on area and its productivity, it may be affected by various agro-climatic conditions. Keeping in view of this the study was made for different regions of Uttar Pradesh. The rape seed and mustard and groundnut crops were considered for the study as these two are the main oilseed crops of the state. The district-wise data

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on area and production of these two crops from 1965-66 to 1985-86 were collected and used for the study. The region-wise data were calculated with the district wise date.

The variability in area, production and productivity was estimated by using the following method.

$$C.V.\ \% = \frac{S.D.}{\bar{Y}} \times 100$$

$$\text{Where S.D.} = \sqrt{\frac{(Y - \bar{y})^2}{n - 1}}$$

Where Y = Index number (1,2 .... 21)

$\bar{y}$ = Mean value and

n = number of years

The compound growth rates of area, production and productivity of both the crops were computed for all the regions and state separately by using the following function.

$P_t = P_0 (1 + r/100)^t$ *to the 21 years time series data* for individual region and state as a whole.

In log term, *the function is*

$$\log P_t = \log P_0 + \log (1 + r/100)^t$$

$$r = Antilog\left[\frac{(\log P_t - \log P_0)}{t} - 1\right] \times 100$$

Where r = compound growth rate

P_0 & P_t = Production in base year and **current year** respectively

t = time variable in years (1,2,3 ..... 21)

An attempt was also made to examine the affect *of area, productivity and their interaction on the* total change in the production of both crops. The *total change in production was decomposed in* area effect, yield effect and the interaction effect.

$P_0 = A_0 Y_0$ (i) Production in base year

$P_t = A_t Y_t$ (ii) Production in t year

Where A_0, Y_0 and P_0 are area, yield and production *in base year.*

A_t, Y_t and P_t are area, yield and production in t year.

Further more $A_t = A_0 + \Delta A$

$Y_t = Y_0 + \Delta Y$

$P_t = P_0 + \Delta P$

also $P_t = A_t Y_t = (A_0 + \Delta A)(Y_0 + \Delta Y)$ (iii)

$\Delta P = P_t - P_0$ (iv)

By substituting the values of P_t and P_0 from equation (iii) and (i) respectively in equation (iv)

$$\Delta P = (A_0 + \Delta A)(Y_0 + \Delta Y) - (A_0 Y_0)$$

$$= A_0 \Delta Y + Y_0 \Delta A + \Delta A \Delta Y$$

Where $A_0 \Delta Y$ = yield effect

$Y_0 \Delta A$ = area effect

and $\Delta A \Delta Y$ = interaction of yield **and area**

RESULTS AND DISCUSSION

General Characteristics

The number and area under small and marginal holdings are presented in Table 1. It is evident from the table that small and marginal holdings (below 2 hectares) are predominant in Eastern, Central and Hill regions of the state. The

TABLE 1. Proportion of small and marginal holdings in different regions of Uttar Pradesh.

Region	Small and marginal holdings as percentage of total number of holdings	Area under small and marginal holdings as percentage of the total area.
Hill	86.9	47.9
Western	81.9	42.2
Central	88.2	56.0
Bundelkhand	67.7	26.3
Eastern	92.0	62.1
State	86.9	48.3

Source: Agricultural Census of Uttar Pradesh percentages of total number of holdings is varying from 67.7 per cent in Bundelkhand region to 82.0 per cent in Eastern region. Among all the regions, Bundelkhand and Western are two regions where the percentage of small and marginal holdings is less than the state average (86.9 per cent). The percentage of area occupied by small and marginal farmers is also maximum (62.1 per cent) and minimum (26.3 per cent) in Eastern and Bundelkhand regions respectively. Area occupied by these categories of farmers is 48.3 per cent in the state. All the regions except Central and Eastern have this percentage less than the state average.

Variability, Growth rate and contribution of various effects

The trend in area, production and productivity, coefficients of variation, compound growth rates and the contribution of area, productivity and their interaction to the total change in production of both the crops are presented in Tables 1 to 5.

Hill Region

The area, production and productivity of rape seed & mustard was high during 1970-71. The highest production (0.14 lakh tones) in this year was due to increase in area (0.19 lakh hectares) and productivity (742 kg/ha) of this crop. On the other hand the area and production of groundnut recorded low during this year. The maximum and minimum coefficients of variation were estimated for production and productivity in both the crops. However, the variation is more in groundnut. The growth rates were found negative in both the crops except in productivity of rape seed and mustard. Though, the positive change in production was recorded in both the crops but it was very nominal may be due to yield effect.

Western Region

The area and production of rape seed & mustard were increasing, however, they were decreasing in case of groundnut during the period of analysis. It is interesting to note that when area and production of groundnut were at minimum level in 1985-86, the productivity of this crop was observed as maximum i.e. 909 kg/ha. The coefficients of variation of production and productivity were found as maximum and minimum in both crops. Unlike the Hill region, all the coefficients of variation of area, production and productivity were found as higher in rape seed and mustard as compared to groundnut. The growth rate of area and production of rape seed & mustard was found to be positive and significant. The highest positive change in production was recorded for rape seed & mustard, while it was negative in case of groundnut. The area effect and interaction effect were responsible to increase the production in mustard, the area effect was found as responsible to decrease the production of later in this region.

Central Region

The area and production of rape seed & mustard were continuously increasing till 1980-81. In this year, it touched a level of 1.25 lakh hectares and 0.57 lakh tonnes respectively. In case of groundnut the area and production recorded as 1.77 lakh hectares and 1.53 lakh tones in 1975-76, which dropped to 0.64 lakh hectares and 0.39 lakh tonnes till 1980-81 and further dropped till 1985-86. The productivity varied from 459 kg to 559 kg per hectare and 611 kg to 1019 kg per hectare of rape seed and mustard and groundnut, respectively. The values of coefficient of variation were observed to be maximum and minimum for production and productivity respectively in both the crops.

The compound growth rate of area and production was found to be significantly positive for rape seed and mustard while it was negative and significant for area, production and productivity for groundnut. The area effect was observed as 130 per cent due to which a positive change of 0.24 lakh tonnes in the production of rape seed and mustard was recorded. The same factor was also responsible to reduce the total production of groundnut.

Table 2. Area production and productivity of rape seed and mustard and groundnut in different regions of Uttar Pradesh.

Region		Rapeseed and Mustard					Groundnut				
		65-66	70-71	75-76	80-81	85-86	65-66	70-71	75-76	80-81	85-86
Hill	A	16.91	18.55	16.14	15.82	17.38	0.14	0.35	0.59	0.24	0.15
	P	8.17	13.77	7.77	9.37	9.42	0.09	0.22	0.39	0.16	0.12
	Y	483	742	481	592	542	642	629	661	667	800
Western											
	A	73.05	94.74	153.44	229.10	393.38	217.34	186.09	239.42	113.86	44.79
	P	27.07	69.80	99.02	137.95	278.17	197.15	105.98	152.76	81.84	40.71
	Y	371	722	645	602	707	907	570	630	719	909
Central											
	A	54.68	67.10	97.36	125.15	110.15	153.71	149.71	176.98	63.71	51.97
	P	30.55	31.49	44.99	57.45	54.40	156.67	111.70	153.09	38.90	40.66
	Y	559	469	462	459	494	1019	746	865	611	782
Bundelkhand											
	A	9.69	10.05	17.80	15.87	15.76	0.16	0.11	1.81	1.78	10.74
	P	3.59	2.66	9.64	5.25	6.79	0.15	0.07	1.33	1.21	9.10
	Y	370	265	542	331	431	938	636	735	680	847
Eastern											
	A	22.91	25.42	29.81	42.92	59.22	9.93	11.42	14.21	14.86	11.44
	P	8.96	10.97	11.25	18.05	25.83	5.86	6.98	10.43	10.10	11.69
	Y	391	432	377	420	436	590	611	734	680	1022
	A	175.07	225.70	322.77	428.89	595.89	381.56	347.53	433.03	194.44	124.29
State	P	80.60	132.77	174.83	228.06	374.62	359.95	224.96	318.02	132.21	105.28
	Y	460	588	542	532	629	943	647	734	680	847

A- Area in thousand hectares P - Production in thousand tonnes Y - Yield in kg per hectare

Table 3. Co-efficient of variation of area, production and productivity of rapeseed and mustard and groundnut in Uttar Pradesh (1965-66 to 1985-86)

(Percentages)

Region	Rapeseed and Mustard			Groundnut		
	Area	Production	Productivity	Area	Productivity	Productivity
Hill	19.40	36.25	16.31	36.07	42.92	18.47
Western	56.92	75.68	28.08	31.68	40.84	20.08
Central	27.87	34.55	15.86	27.56	38.44	24.26
Bundelkhand	59.21	83.52	29.20	153.10	150.94	25.13
Eastern	44.10	57.15	17.54	20.58	35.70	21.50
State	40.11	55.17	17.96	26.07	36.13	21.85

Table 4. Compound growth rate of area, production and productivity of rapeseed and mustard and groundnut in different regions of Uttar Pradesh (1965-66 to 1985-86)

(Percentages)

Region	Rapeseed and Mustard			Groundnut		
	Area	Production	Productivity	Area	Production	Productivity
Hill	-4.00 **	-3.80	0.80	-1.90	-1.90	-0.30
	(.0060)	(.0102)	(.0060)	(.0146)	(.0164)	(.0071)
Western	20.30*	27.20*	3.30	-12.60*	-13.80*	-1.00
	(.0084)	(.0114)	(.0099)	(.0098)	(.0117)	(.0083)
Central	9.50*	10.10*	0.60	-8.70*	-12.70*	-5.40**
	(.0052)	(.0087)	(.0061)	(.0093)	(.0119)	(.0090)
Bundelkhand	14.80*	22.90*	7.30*	83.30*	76.50*	-3.90
	(.0113)	(.0180)	(.0096)	(.0195)	(.0200)	(.0090)
Eastern	14.30*	15.50*	1.00	5.00*	5.60**	0.70
	(.0062)	(.0115)	(.0070)	(.0067)	(.0105)	(.0082)
State	14.00*	18.00*	3.50**	-9.10*	-12.10*	-2.80
	(.0056)	(.0095)	(.0058)	(.0076)	(.0107)	(.0080)

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

Note: Figures in the parentheses indicate the Standard error.

Table 5. Effect of area, productivity and their interaction to change the production of rapeseed and mustard and groundnut in different regions of Uttar Pradesh.

Region	Rapeseed and Mustard				Groundnut			
	Total change ('000 tonnes)	Yield effect	Area effect	Interaction effect	Total change ('000 tonnes)	Yield effect	Area effect	Interaction effect
Hill	1.25	0.99	0.23	0.03	0.03	0.02	0.005	0.005
	(100.00)	(79.20)	(18.40)	(2.40)	(100.00)	(66.67)	(16.67)	(16.66)
Western	251.10	24.55	118.88	107.67	-156.44	0.44	-156.53	-0.35
	(100.00)	(9.78)	(47.34)	(42.88)	(-100.00)	(0.28)	-100.06	-0.22
Central	23.85	-3.55	31.01	-3.61	-116.01	-36.44	-103.69	24.12
	(100.00)	(-14.88)	(130.01)	(-15.13)	(-100.00)	(-31.41)	(-89.38)	(20.79)
Bundelkhand	3.20	0.59	2.24	0.37	8.95	-0.02	9.93	-0.96
	(100.00)	(18.44)	(70.00)	(11.56)	(100.00)	(-0.22)	(110.95)	(-10.73)
Eastern	16.87	1.03	14.21	1.63	5.83	4.29	0.89	0.65
	(100.00)	(6.11)	(84.23)	(9.66)	(100.00)	(73.58)	(15.27)	(11.15)
State	294.02	29.56	193.40	71.06	-254.67	-36.65	-242.73	24.71
	(100.00)	(10.05)	(65.78)	(24.17)	(-100.00)	(-14.39)	(-95.31)	(9.70)

Base Year: 1965-66

Note: Figures in the parentheses indicate the corresponding percentages.

Bundelkhand Region

The 1975-76 year was good for area (0.18 lakh hectare) and production (0.10 lakh tonne) of rape seed and mustard in this region. The highest production resulted in highest productivity (542 kg / ha) in this year. In case of groundnut, the area and production were negligible till 1970-71 but sudden increase is observed after 1980-81 till 1985-86. Due to this steep rise, the highest coefficients of variation of area and production of groundnut were found as 153.10 and 150.94 per cent respectively among all the regions. Coefficient of variation, in case of rape seed & mustard were found 83.52 per cent and 29.20 per cent for production and productivity respectively.

The positive and significant growth rates were found for area, production and productivity in case of rape seed and mustard crop. Due to steep rise in area and production of groundnut, growth rates were noticed positive and significant but it was found to be negative and non-significant for productivity. Here the area effect was observed as main to change total production of both the crops. In case of groundnut, the contribution of area to the production was as high as (110.95 per cent) and it neutralised the negative effect of yield and its interaction with area.

Eastern Region

Like in western region, the area and production of rape seed and mustard increased steadily in this region. They reached to a level of 0.59 lakh hectares and 0.26 lakh tonnes respectively in 1985-86. The area and production of groundnut were increasing continuously till 1980-81. Highest production i.e. 0.12 lakh tonnes, was noticed in 1985-86 (even after the reduction in area by about 25 per cent) only due to the high productivity of this crop i.e., 1022 kg per hectare in his year.

The values of coefficient of variation were observed as higher for area and production of rape seed and mustard as compared to groundnut. The positive and significant growth rates were found in area and production of both the crops, however, productivity of these two was not satisfactory in this region. The positive change in production of both the crops was noticed in this region. Whereas, area contributed maximum i.e. 84.23 per cent to the production of rape seed and mustard, yield was mainly responsible to change the groundnut production in positive direction.

Uttar Pradesh

From Table-2 it was observed that the area and production of rape seed and mustard increased in the state, and decreasing trend in case of groundnut except in 1975-76. The productivity of groundnut was high in 1965-66 but it declined in subsequent period. The highest productivity (629 kg/ha.) in rape seed and mustard was recorded in 1985-86.

The coefficients of variation in area and production of rape seed and mustard were observed as 40.11 and 55.17 per cent respectively which were considerably higher as compared to groundnut. The positive and significant growth rates were found in area (14 per cent), production (18 per cent) and productivity (3.50 per cent) in rape seed and mustard while they were observed as negative and significant for area and production of groundnut. A positive change of 2.94 lakh tonnes was recorded in rape seed and mustard, where as negative (-2.55 lakh tonnes) change for groundnut. Area effect was found to be mainly responsible either to increase or decrease the production of crops in the state.

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CASTOR OIL EXPORTS: A PROMISING BUSINESS

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ABSTRACT

This paper highlights the potential of castor oil exports and its capacity to generate foreign exchange for the country. But, it warns that unless certain steps are taken to strengthen India's production-marketing-trade system, we may lose this edge to Brazil or China.

Key words : Exports; Imports; Growth rate; Industry; Oil derivation.

Of the nine major oilseeds, castor is a non-edible oilseed crop and brings a sizeable amount of foreign exchange to the country (Table 1.) Although magnitude of foreign exchange earned from castor oil exports vary with market prices, to a great extent it depends upon what we can produce as well. For example, during drought years from 1985 to 1988, there was a substantial reduction in the foreign exchange earnings mainly because of reduced castor production in the country. Since 1989 good monsoonic conditions have resulted into a good crop and higher *production, which resulted into increased castor* oil exports as well from the country (Figure 1).

It is interesting to note that the demand for Indian castor oil has been increasing over time from both domestic and foreign sources. The domestic and export demands have been increasing with an exponential growth rate of 5-7% per annum during the period 1971-92 (Figure 2). The major reason for this increase has been the multiple uses of castor oil such as in making dyes, detergents, plaster of paris, soaps, ointments, costumes, polishes, greases, rubber, wetting agents etc. (Figure 3). As a result, demand for castor oil in and out-side the country has been growing with the advancement of industrialization all over the world.

International trade has become a major activity in the world castor economy. For example, 40-60% of the world castor oil production is internationally traded, including beans and oil; and, 80% of this trade is in the form of oil alone. In the oil trade, both India and Brazil are major contributors in the international market. They jointly supply 60 to 80% of the world castor oil exports; and, India's oil market has steadily risen since 1970's (Figure4). The credit of this success goes to the performance of castor hybrids in Gujarat. Four major castor growing provinces in India are Gujarat, Andhra Pradesh, Karnataka and Orissa. Gujarat alone produces more than two-thirds of Indian castor seed with only one-third of the castor acreage in the country. Such an achievement has been made *possible through yield improvement in Gujarat.* The introduction of castor hybrids has doubled the national average of castor yield from 282 kg/ ha during 1961-65 period to 583 kg/ha during the 1981-85 period and further increased to 1400 in 1990-92. The speedy adoption of hybrids and ample water and use of other high management in Gujarat paved the way for higher yields. All the more, the average yield (1200 kg/ha) in Gujarat is now twice the national (583 kg/ha) average and has surpassed the Brazilian yield too (Figure 5).

Increased production has thus contributed the boom in Castor oil exports more so due to high international prices of castor oil in the past. Castor oil is the cheapest oil in the domestic market and is used in a greater quantity in soap-making and other industries.

The castor oil exports may not last long because of increasing competition from other exporting countries such as Brazil and China. Although

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Table 1. Value of Foreign Exchange Earned from Castor Oil Exports and from all Agri-exports, 1973-89.

Year	Castor oil exports (million US$)	Agri-products exports (million US$)	Castor as propotion of agri-expots (%)
1973	42.33	1015.43	4.17
1974	23.91	1376.10	1.74
1975	11.74	1710.83	0.69
1976	18.31	1728.00	1.06
1977	21.00	1937.50	1.08
1978	37.89	1734.16	2.18
1979	40.56	2019.67	2.01
1980	42.30	1836.61	2.30
1981	37.00	2698.00	1.37
1982	46.00	2309.50	2.00
1983	51.00	2403.50	2.12
1984	95.00	2259.20	4.21
1985	55.00	2264.60	2.43
1986	31.50	2376.10	1.33
1987	28.80	2373.40	1.21
1988	36.00	2207.40	1.63
1989	88.30	2469.00	3.58

Souce: **FAO Trade Year books.**

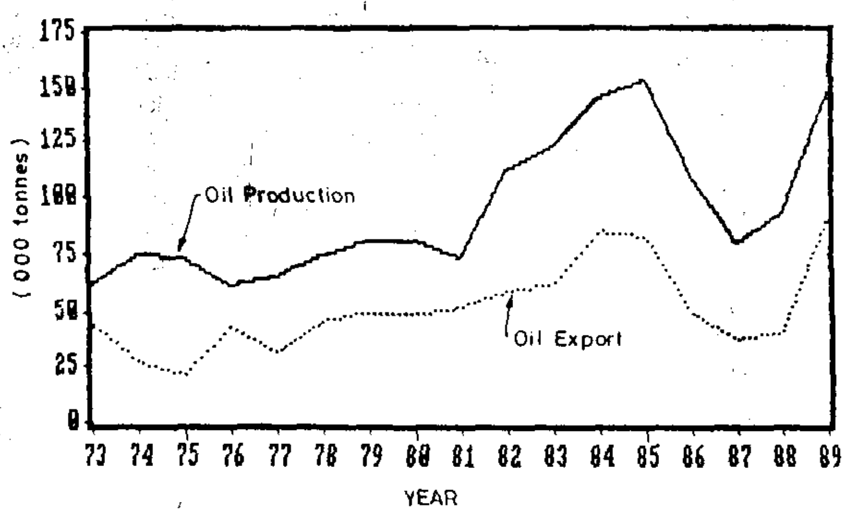

Fig 1. Castor Oil Production and Exports, India

Brazil's production of castor beans has been declining steadily, policy makers in Brazil realized the significance of castor oil trade and they are making efforts to maintain the market leadership by importing castor beans from China and Thailand and then re-exporting the castor oil after crushing it domestically. In recent years, Brazilian policy makers have shifted their focus upon raising castor yields and have visited India too in this regard. At the same time, China is also emerging as a major exporter of castor beans and its castor oil exports are also increasing rapidly. China's exports of castor oil during the 1961-86 period have increased at the rate of 16.4% per annum as against India's exports of 7.1% and the world export of 1.3%. India has therefore to compete with existing competition from Brazil and China. It is estimated that 10% increase in a acreage in China by year 2000 can increase castor production by 40% (Tewari and Rao, 1992). This will certainly create more competition in the international market and may be a threat to our exports.

What India Can Do ?

India has the edge to compete with China and Brazil provided the following suitable steps are taken.

Developing Stable Production System

The castor oil exports in India are very much affected by monsoon conditions and steady rise in production is a key to have a strategic edge over competitors. The instability in production is mainly due to acreage and yield. Acreage-induced instability is originated primarily by fluctuating producer prices and other public policies which create uncertainity in the minds of producers towards making decisions of growing the crop. This is true in Gujarat where castor producers are very much price responsive and hence a protective shield against low prices would be necessary. The most critical is the yield-induced instability in production which needs to be monitored through use of hybrid seed, fertilisers, and water. This technology can be extended to other castor growing areas such as Uttar Pradesh and Madhya Pradesh, if proper marketing framework in these areas are developed.

Developing Adequate Crush Capacity

Having streamlined production the next step would be to develop adequate crush capacity. Currently we do not have the reliable data on the existing crushing capacity. In addition to building up the crushing capacity, we also need to resort to solvent extraction to increase the oil production.

Developing International Market and Promoting Exports

The USSR has been the major importer of castor oil from India in the past under bilateral trade agreements. However, since 1983 there has been a great change in the trade relations and more and more castor oil is now being exported to Western Countries. It is interesting to note that castor oil is the cheapest in the country and the costliest one in the international market. As a result, a very large proportion (40%) of domestic consumption of castor oil goes to soap industry. If other non edible oils are used in the soap industry this portion can augment export purposes.

Since castor oil has many industrial uses, such as, in manufacturing paints, costumes, aircraft lubricants, surface coatings, perfumes, medicines, soaps, nylons, etc., exporting of these value-added products of castor oil have also been found in recent years in the form of urethane foams, dimers etc. These products are found environmentally harmless. The export demand for such products is likely to increase from the West as a result of increased environmental awareness. Some estimates suggest the exports of castor oil derivatives from India have been rapidly rising from Rs.855 million in 1987-88 to Rs.3596 million in 1989-90 an increase of 320% during the three year period (CHEMEXIL 1989/90).

It should be noted that castor oil is a lucrative export item at present and ample scope exists for doubling exports from the current level by improving production. The potential for earning foreign exchange is estimated between US $250 to 350 million in 1995, and US $260 to 360 million in 2000 AD.

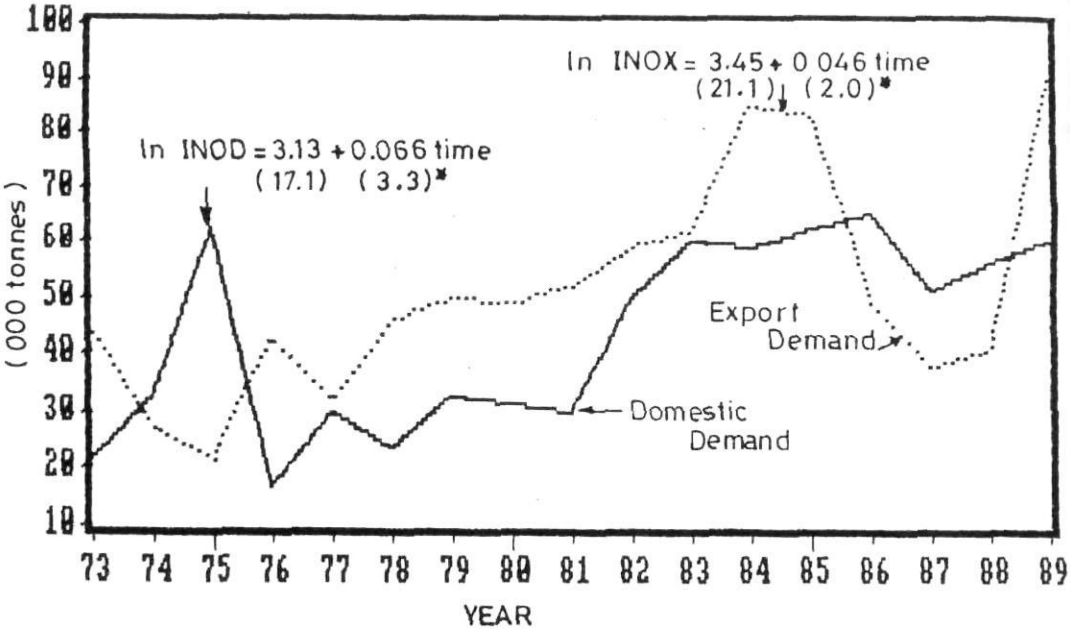

Fig 2. Domestic and Export Demand for Castor Oil, India

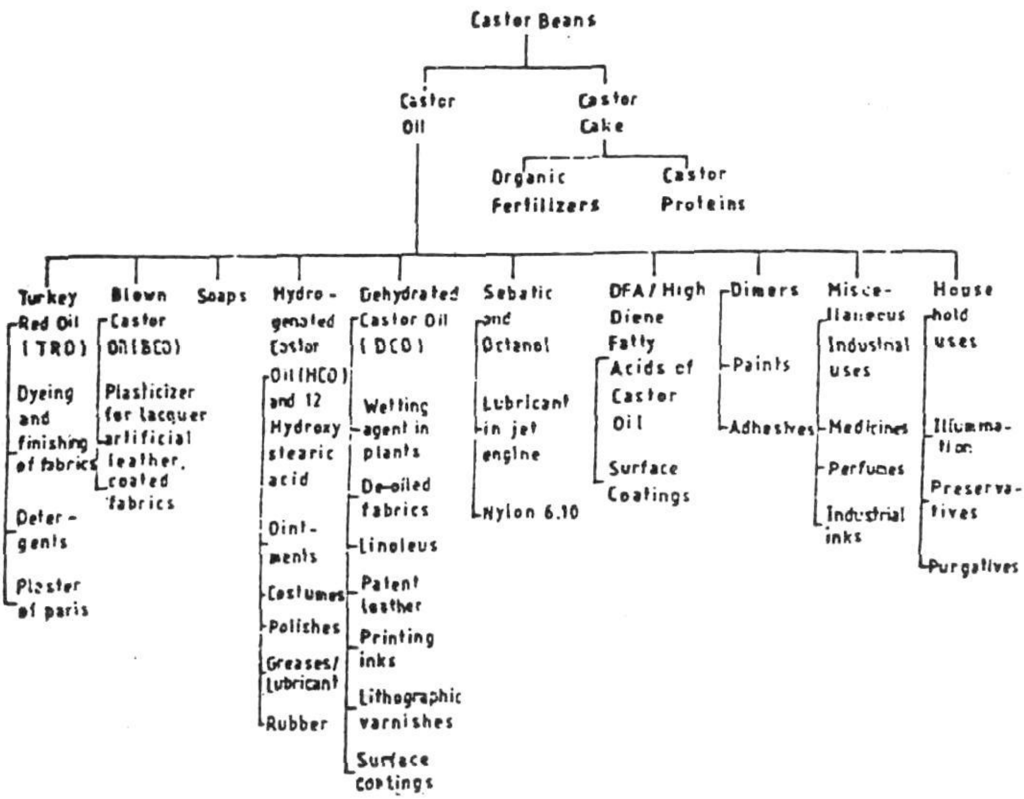

Fig 3. Different uses of Castor Oil

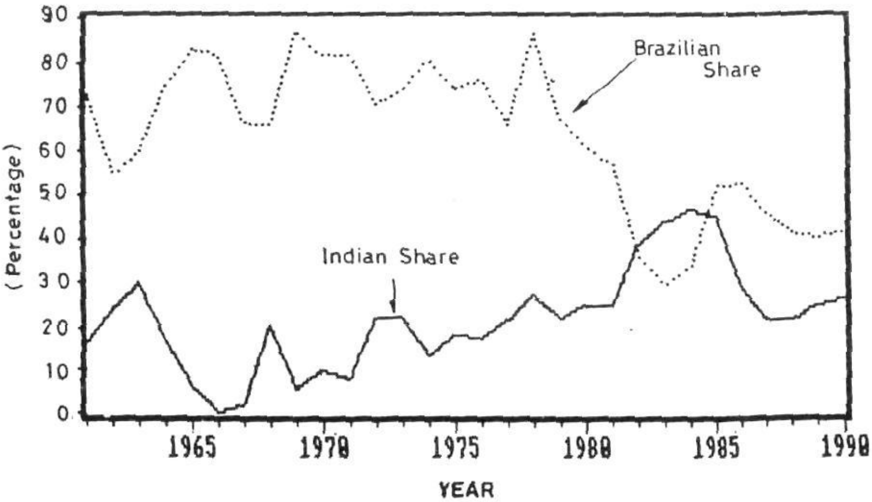

Figure 4 : Relative Shares of India and Brazil in the World Castor Oil Exports

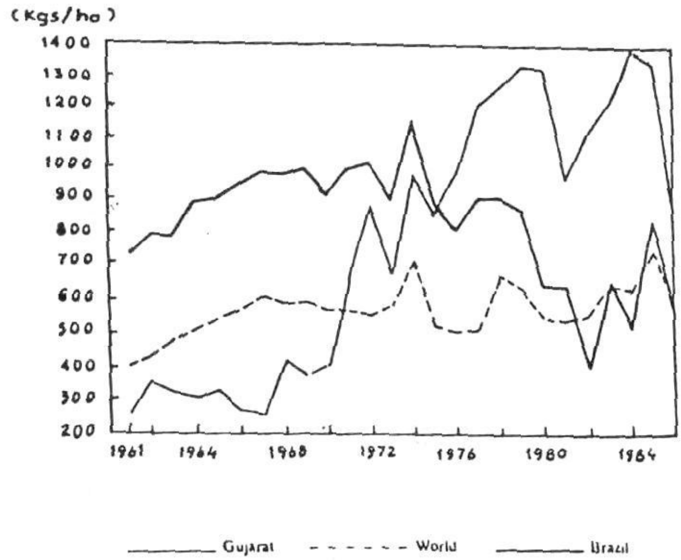

Fig. 5: Average Castor Yield in Gujarat, Brazil, and the World

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RESPONSE OF MUSTARD *(Brassica juncea* (L) Czern & Coss. ex. Coss.) TO WEED MANAGEMENT PRACTICES AND NITROGEN LEVELS, AND THEIR RESIDUAL EFFECT ON SUCCEEDING SUMMER GREEN GRAM WITH AND WITHOUT NITROGEN

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ABSTRACT

Field experiment conducted during *rabi* and summer seasons of 1989-90 and 1990-91 at Navsari (Gujarat) revealed that weed free condition and two hand weedings at 25 and 46 days after sowing were found most effective in reducing dry weight of weeds, increasing the weed control efficiency, seed yield of mustard and net realization. Increased application of nitrogen from 60 to 90 kg/ha linearly increased the total weed biomass, seed yield of mustard and net realization. Weed management practices and nitrogen levels applied to preceding mustard crop did not impose any favourable or adverse effect on succeeding summer green gram. The grain and straw yields of green gram and net realization increased appreciably at 20 kg N/ha applied to green gram.

Key words : Weed control; Herbicides; N management; Residual effect

Mustard grown as sole crop under irrigated condition of South Gujarat is invariably infested by weeds because of initial slow growing nature of the crop. Weeds which emerge with mustard crop offers severe competition and bring about considerable reduction in crop production. Yield losses in mustard has been reported to the tune of 24 to 70 per cent due to adverse effect of weeds on the growth and development of mustard(Ghosh and Mukhopadhyay,1981). A great deal of attention has been directed recently towards the nitrogen fertilization to mustard as well as effective control of weeds, using newer broad spectrum herbicide for controlling weeds for sustaining high production. From the total herbicides applied to soil, only a small amount is actually utilized in controlling weeds. The major portion of the herbicide is diluted by soil material and is subjected to transformation and decomposition. The study on residual effect of herbicide will be an important consideration of its use in arable farming(Bainade, 1988 and Patel *et al.*, 1990). The residual effect of herbicides in conjunction with high doses of nitrogen should be ascertained for successful cropping system. The weed management and nitrogen application to *rabi* mustard has not yet been adequately studied on succeeding summer green gram with and without nitrogen in Vertisol of South Gujarat. Hence, this study was undertaken to find out residual effect on succeeding summer green gram.

MATERIALS AND METHODS

The field experiment was conducted at the Agricultural College Farm, Gujarat Agricultural University, Navsari during *rabi* and summer seasons of the years 1989-90 and 1990-91 on a Vertisol. The soil of experimental field was clayey, low in total N (0.050 and 0.042%), medium in available P (20.50 and 12.88 kg/ha) and high in available K (270.24 and 278.09 kg/ha) with pH 7.7 and 7.9 during 1989-90 and 1990-91, respectively. The study involved ten weed management practices and three levels of nitrogen (as indicated in Table 1). The experiment was conducted in split plot design with weed management practices in main plot and nitrogen levels in sub plot and replicated thrice. Half dose

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Table 1. Dry weight of weeds (kg/ha) and seed yield of mustard (kg/ha) as affected by weed management practices and nitrogen levels.

Treatments	Dose (kg) a.i./ha	Dry weight of weeds (kg/ha)						Seed yield of mustard (kg/ha)		
		1989-90		1990-91		Pooled		1989-90	1990-91	Pooled
Weed management practices										
Pendimethalin	1.0	11.11	(127.00)	11.31	(130.00)	11.21	(128.00)	1055	1445	1250
Pendimethalin + One H.W. (45 DAS)	1.0	10.63	(116.00)	10.72	(127.00)	10.67	(116.00)	1101	1580	1341
Alachlor	1.0	12.57	(161.00)	12.66	(163.00)	12.61	(162.00)	1004	1264	1134
Alachlor + One H.W. (45 DAS)	1.0	11.74	(141.00)	11.81	(142.00)	11.78	(141.00)	1034	1332	1183
Two hand weedings (25, 45 DAS)	-	9.24	(88.00)	9.37	(89.00)	9.31	(89.00)	1134	1665	1400
One interculture (25 DAS)	-	17.45	(311.00)	17.73	(320.00)	17.60	(315.00)	934	1035	985
One hand weeding (45 DAS)	-	16.81	(288.00)	16.90	(290.00)	16.85	(289.00)	967	1174	1071
One interculture + One H.W. (25 and 45 DAS)	-	15.80	(254.00)	15.91	(257.00)	15.85	(256.00)	978	1208	1093
Weed free condition (H.W. at 25, 45 and 65 DAS)	-	8.27	(71.00)	8.42	(72.00)	8.35	(71.00)	1195	1795	1495
Unweeded conrol	-	28.41	(829.00)	28.38	(818.00)	28.39	(823.00)	835	824	830
C.D. at 5%		1.78		0.18		0.87		182	142	308
Nitrogen Kg/ha										
60		13.74	(220.00)	14.19	(236.00)	13.97	(228.00)	936	1201	1069
75		14.19	(235.00)	14.33	(240.00)	14.26	(237.50)	1062	1321	1192
90		14.68	(259.00)	14.44	(243.00)	14.56	(251.00)	1073	1475	1274
CD at 5%		0.40		0.12		NS		85	38	113

Note: Figures in parenthesis refer to actual dryweight of total weeds
- Figures outside the parenthesis refer to square root transformed value

of N and 50 kg P_2O_5 / ha were applied at sowing and the remaining half dose of N was top dressed at 30 days after sowing to mustard crop. Mustard variety Varuna was sown under irrigated condition with a row spacing of 60 cm in November and was harvested in March in both years. After harvest of mustard crop, the treatments of green gram crop was superimposed in summer with two levels of nitrogen i.e. no nitrogen and 20 kg N/ha in split-split plot design. 20 kg N/ha as per treatment and 40 kg P_2O_5 / ha was applied at sowing. Green gram variety K-851 was sown under irrigated condition with a row spacing of 30 cm in March and was harvested in May in both the years. The dominant weeds observed in mustard field were *Echinochola colonum* (L) Link, *Digera arvensis* Forsk, *Convolvulus Arvensis* L, *Trianthema monogyna* L and *Cyperus rotundus* L.

RESULTS AND DISCUSSION

Effect of weed management practices

Dry weight of weeds at harvest in mustard was reduced appreciably in all the weed management practices as compared to unweeded control. Lower dry weight of weeds was recorded under weed free condition and two hand weeding at 25 and 45 DAS, followed by herbicidal treatments as compared to weedy check and H.W. at 45 DAS or I.C. at 25 DAS or both. This might be due to rapid growth of the mustard crop as indicated by taller plants and more number of branches/plant, which did not allow the weeds to grow vigorously due to smothering effect. Patel (1990) and Tomar and Namdeo (1991) also observed the similar trend. These treatments also recorded higher weed control efficiency as compared to treatments of I.C. at 25 DAS, H.W. at 45 DAS and I.C. at 25 DAS and H.W. at 45 DAS indicating their superiority with respect to weed management practices. The results are in confirmation to the findings of Pandey and Kumar (1984) and Patel(1990). The weed competition index values have been presented in Table 2. Crop weed competition resulted in reduction of seed yield by 44.48 per cent. The results showed that weed caused severe competition with crop plants from the very beginning of the crop growth. All weed management practices reduced the weed competition markedly. However, two H.W. at

Table 2. Weed control efficiency (per cent), weed competition index (per cent) and economics as affected by weed management practices and nitrogen levels (mean data basis).

Treatments	Dose (kg a.i./ha)	Weed Control efficiency (%)	Weed competition index (%)	Net realization (Rs./ha)
Weed management practices				
Pendimethalin	1.0	84.39	16.38	3441
Pendimethalin + One H.W. (45 DAS)	1.0	85.84	10.30	3687
Alachlor	1.0	80.32	24.15	3024
Alachlor + One H.W. (45 DAS)	1.0	82.81	20.87	3026
Two hand weedings (25 and 45 DAS)	–	89.24	6.35	4216
One interculture (25 DAS)	–	61.68	34.11	2328
One hand weeding (45 DAS)	–	64.90	28.36	2617
One interculture + One H.W. (25 and 45 DAS)	–	68.97	26.89	2662
Weed free condition (25, 45 and 65 DAS)	–	91.31	–	4485
Unweeded control	–	–	44.48	1546
C.D. at 5%	–	–	–	–
Nitrogen kg/ha				
60		–	–	2568
75		–	–	3181
90		–	–	3560
CD at5%		–	–	–

25 and 45 DAS, pendimethalin along with one H.W. at 45 DAS and pendimathalin alone were found best treatments in respect of weed management practices as reflected on seed yields. The results are in confirmity with the finding of Ghosh and Mukhopadhyay (1981). The highest seed yield of mustard was obtained under weed free condition but it remained statistically at par with two H.W. at 25 and 45 DAS, pendimethalin alongwith one H.W. at 45 DAS and pendimethalin alone in pooled data. On pooled data basis the increase in seed yield was to the tune of 80, 69, 62 and 51 per cent with treatments of weed free condition, two H.W. pendimethalin along with one H.W. at 45 DAS and pendimethalin alone, respectively over unweeded control. The results are in confirmity with the findings of Bhimani (1988) and Tomar and Nandeo (1991). The seed yield is a cumulative effect of different growth and yield attributing characters. Moreover, the yield reflected in these treatments show the effectiveness to control the weeds at important growth stages as well as higher uptake of nutrients by mustard crop. The figures for economics of different weed management practices given in Table 2 revealed that the highest net realization of Rs.4485/ha was obtained with weed free condition, followed by two H.W. at 25 and 45 DAS (Rs.4216/ha.) Whereas, the lowest net realization of Rs.1546/ha was recorded with unweeded control. These results are in confirmity with the findings of Bhimani (1988) and Patel (1990).

Effect of nitrogen

Dry weight of weeds was significantly elevated with increase in the rate of nitrogen up to 90 kg/ha during both the years. This might be due to vigorous growth of the weeds with nitrogen application and higher nutrients uptake by weeds. An increase in weed biomass at harvest due to 90 and 75 kg N/ha was of the order of 10 and 4 per cent over 60 kg N/ha, respectively. The nitrogen played an important role in the growth of weed plants. This revealed that increased level of nitrogen in mustard crop also proved instrumental for enhancing the dry weight of weeds. Application of nitrogen at 90 kg/ha produced the highest seed yield of mustard which was statistically equal with 75 kg N/ha in pooled data. The average per cent increase in seed yield of mustard due to 90 and 75 kg N/ha were to the extent of 19 and 12, respectively over the lowest rate of 60 kg N/ha. This might be due to the low availability of nitrogen in the soil and hence the crop responded well to the application of nitrogen during both the years. The findings are in accordance with those obtained by Vasvelia (1988) and Patel (1989). Application of nitrogen in graded levels up to 90 kg/ha progressively increase the value of net realization per hectare. The highest net realization of Rs.3560/ha was obtained with 90 kg N/ha, closely followed by 75 kg N/ha which realised Rs.3181/ha. The lowest net realization of Rs.2568/ha was accrued with 60 kg N/ha. This result is in accordance with those reported by Patel (1989).

Residual studies on succeeding summer green gram

There was no explicit variation in grain and straw yields of succeeding summer green gram as affected by previous weed management practices during both the years as well as in pooled data, indicating that herbicides applied to mustard were sufficiently degraded in the soil and no residues were left to affect adversely on the germination and emergence of succeeding green gram crop. Almost similar results were reported by Patel *et al.* (1990) for alachlor and Bainade (1988) for pendimethalin.

Application of nitrogen to mustard at varying rates had also not exerted any significant effect on succeeding summer green gram with respect to grain and straw yields. This indicated that applied nitrogen to mustard crop has been fully utilized by the mustard and weeds as evident from higher uptake of nitrogen. Bainade (1988) also reported that the crop did not show any positive effect of nitrogen applied to preceding wheat crop.

Table 3. Grain and straw yields of summer green gram and economics as affected by weed management practices and nitrogen levels

Treatments	*Dose (kg a.i./ha)*	*Grain yield of green gram*			*Straw yield of green gram*			*Net realization Rs/ha*
		1989-90	1990-91	Pooled	1989-90	1990-91	Pooled	
Weed management practices								
Pendimethalin	1.0	1260	962	1111	4451	3459	3954	3441
Pendimethalin + One H.W. (45 DAS)	1.0	1264	967	1115	4429	3437	3933	3687
Alachlor	1.0	1267	969	1117	4444	3453	3948	3024
Alachlor + One H.W. (45 DAS)	1.0	1248	950	1099	4434	3442	3938	3026
Two hand weedings (25 and 45 DAS)	-	1268	970	1119	4438	3446	3942	4216
One interculture (25 DAS)	-	1262	965	1113	4438	3446	3942	2328
One hand weeding (45 DAS)	-	1249	951	1100	4434	3442	3938	2617
One interculture + One H.W. (25 and 45 DAS)	-	1268	970	1119	4445	3452	3948	2662
Weed free condition (H.W. at 25, 45 and 65 DAS)	-	1261	912	1086	4446	3453	3950	4485
Unweeded control	-	1260	962	1111	4403	3411	3907	1546
C.d. at 5%	-	NS	NS	NS	NS	NS	NS	-
Nitrogen kg/ha applied to mustard								
60		1262	964	1113	4440	3448	3944	2568
75		1256	943	1100	4441	3449	3945	3181
90		1264	966	1115	4427	3435	3931	3560
C.D. at 5%		NS	NS	NS	NS	NS	NS	-
Nitrogen kg/ha applied to green gram								
0		1231	923	1077	4323	3331	3826	6623
20		1291	993	1142	4550	3558	4050	7150
C.D. at 5%		42	49	32	162	162	114	-

H.W. = Hand weeding; DAS = Days after sowing; NS = Not significant

Effect of nitrogen applied to succeeding summer green gram

Application of nitrogen @ 20 kg/ha produced significantly higher grain and straw yields of green gram over n^ nitrogen application during both the years as well as in pooled data and the increase was 6.04 and 5.96 per cent, respectively. The results are in accordance with the results reported by Dungrani (1986). Higher net realization of Rs.7150/ha was obtained with 20 kg N/ha applied to summer green gram as compared to nitrogen application (Table 3). This result is in accordance with that report by Dungrani 1986).

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INTERCROPPING OF GROUNDNUT WITH OTHER OILSEED CROPS

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ABSTRACT

A field experiment was conducted at Regional Research Station, Raichur, Karnataka during *kharif* season of 1991 and 1992 on red sandyloam soil under rainfed condition to find out the optimum row proportion of oilseed crops viz., sunflower, sesame and castor with groundnut. In general, the groundnut pod yields were higher in sole cropping (1496 kg/ha). Among the different intercropping systems, groundnut + sunflower (3:1) recorded higher pod yield (1362 kg/ha) as well as higher land equivalent ratio (1.52) followed by the same system in 5:1 row proportion with pod yield of 1316 kg/ha and LER of 1.42.

Key words: Groundnut; Oilseeds; Intercropping; Economics; LER.

Groundnut is one of the important oilseed crops in north eastern dry zone of Karnataka. In this region, groundnut is largely grown during *rabi/* summer season under irrigated condition. During *kharif,* it is grown under rainfed condition. The *kharif* yields are low because of irregular and uncertain monsoon rains. Under these circumstances, an intercropping system gives an insurance against failure of crop due to monsoon vagaries. Besides, in a normal season, it increases the farm income and aim at efficient utilization of solar energy, moisture and nutrients. The present study was undertaken with a view to find out the most compatable and remunerative oilseed crop as intercrop with groundnut.

MATERIALS AND METHODS

A field experiment was conducted during *kharif* season of 1991 and 1992 at Regional research station, Raichur, Karnataka. The soil was red sandy loam having pH 7.7 and organic carbon content of 0.39 per cent. The different oilseed crops used as intercrops in groundnut (JL-24) were sunflower (Morden), sesame (E-8) and castor (SH-41). These intercrops were sown in different row proportions (3:1, 4:1 and 5:1) with groundnut. The details of the treatments are given in Table 2. For sole crops, fertilizers were applied as per the recommended dose. For intercrops, fertilizers were applied proportionate to their plant population.

The experiment was laid out in Randomised Block Design with three replications with plot size 5.4 x 6.0 m. Sowing was done on 27th June during 1991 and 22nd June during 1992. Necessary plant protection measures were taken against pests and diseases. Economics of the various treatments was worked out for the seed yields based on the prevailing market prices during corresponding years. Land Equivalent Ratio (LER) was calculated using the formula suggested by Jha and Chandra (1982).

The rainfall received during crop growth period is presented in Table 1. Rainfall was slightly more during 1992 (598.4 m) as compared to 1991 (561.7 mm). Of the total rainfall, maximum was received during July in 1991 and November during 1992.

Table 1. Monthwise rainfall (mm) during crop growth period .

Months	1991	1992
June	148.8(14)	62.2(3)
July	200.8(13)	110.8(9)
August	82.1(9)	123.2(11)
September	96.3(8)	105.2(4)
October	23.8(4)	42.0(4)
November	9.9(2)	155.0(3)
December	-	-

Figures in parenthesis indicate number of rainy days.

RESULTS AND DISCUSSION

The data on yield of base and intercrops, monetary returns and Land Equivalent Ratio as influenced by different intercropping systems during 1991 and 1992 are presented in Table 2 and 3.

In general, the productivity of groundnut was affected by intercropping during both the seasons. The reduction in pod yield was minimum when it was intercropped with sunflower in all row proportions. Similar results are reported by Sindagi(1982).

During 1991, the yield of groundnut was maximum when grown as sole crop (1267 kg/ha). On an average over all row proportions, intercropping of sunflower, sesame and castor reduced the groundnut pod yield to an extent of 14.4, 12.9 and 12.5 per cent, respectively. In general, yield levels of groundnut both in sole and intercropping systems were higher during 1992. This may be due to even distribution of rainfall during crop growth period (Table 1). But the extent of reduction in pod yield of groundnut when intercropped with castor (24.7%) and sesame (20.3%) was more during 1992. On an average over two years sole groundnut recorded pod yield of 1496 kg/ha followed by groundnut + sunflower (3:1) intercropping system (1362 kg/ha).

Table 2. Yield of base and intercrops as influenced by different intercropping systems.

Treatments		Yield (kg/ha)					
		Groundnut			Intercrops		
		1991	1992	Mean	1991	1992	Mean
1.	Groundnut sole	1267	1726	1496	-	-	-
2.	Castor sole	-	-	-	1394	891	1142
3.	Sesame sole	-	-	-	128	339	234
4.	Sunflower sole	-	-	-	499	558	528
5.	Groundnut + Castor (3:1)	1054	1272	1163	769	494	532
6.	Groundnut + Castor (4:1)	1041	1286	1164	630	373	502
7.	Groundnut + Castor (5:1)	1233	1342	1288	605	358	482
8.	Groundnut + Sesame (3:1)	1173	1315	1244	81	170	126
9.	Groundnut + Sesame(4:1)	1011	1342	1176	62	119	91
10.	Groundnut + Sesame (5:1)	1130	1471	1301	49	87	68
11.	Groundnut + Sunflower (3:1)	1217	1508	1362	292	339	316
12.	Groundnut + Sunflower (4:1)	986	1529	1258	344	227	266
13.	Groundnut + Sunflower (5:1)	1050	1593	1316	370	201	286

All the intercrops produced more yield when sown as sole crop than as an intercrop in groundnut. All intercrops gave higher yield in lower row proportion of 3:1 except sunflower during 1991 which produced higher yield with 5:1 proportion. These results are in agreement with those of Desai and Goyal (1980). On an average over two years, irrespective of row proportions, the reduction in yields due to intercropping was more than compensated by additional yields of intercrops when compared to their respective sole crops was to an extent of 45.3, 55.8 and 75.2 per cent in sunflower, castor and sesame, respectively. This may be due to differential ability of these crops to compete with groundnut when grown in association. The reduction in main crop yield due to intercropping was more than compensated by additional yields of intercrops. It is so in case of castor and sunflower. Similar results were reported by Nikam *et al.*, (1984), Mehta *et al.*, (1985) and Yaragattikar (1986).

Significant differences were observed for monetary returns due to various intercropping systems in both the years (Table 3). Among different sole crops, castor and groundnut gave the highest monetary returns of Rs.10315/ha and Rs.14671/ha during 1991 and 1992, respectively.

Table 3. Gross returns and Land Equivalent Ratio (LER) as influenced by different intercropping systems.

Treatments		Gross Returns (R/ha)			Land Equivalent Ratio		
		1991	1992	Mean	1991	1992	Mean
1.	Groundnut sole	10009	14671	12300	1.00	1.00	1.00
2.	Castor sole	10315	5791	8053	1.00	1.00	1.00
3.	Sesame sole	1564	3563	2615	1.00	1.00	1.00
4.	Sunflower sole	4266	4352	4309	1.00	1.00	1.00
5.	Groundnut + Castor(3:1)	14016	14023	14019	1.38	1.29	1.34
6.	Groundnut + Castor(4:1)	12886	13355	13121	1.27	1.16	1.22
7.	Groundnut + Castor(5:1)	14218	13740	13979	1.41	1.18	1.29
8.	Groundnut + Sesame(3:1)	10319	12963	11641	1.54	1.26	1.41
9.	Groundnut + Sesame(4:1)	8793	12658	10725	1.28	1.13	1.21
10.	Groundnut + Sesame(5:1)	9584	13417	11490	1.27	1.11	1.19
11.	Groundnut + Sunflower(3:1)	12110	15462	13786	1.55	1.48	1.52
12.	Groundnut + Sunflower(4:1)	10730	14757	12748	1.47	1.29	1.38
13.	Groundnut + Sunflower(5:1)	11458	15022	13240	1.57	1.28	1.42
	S.E.m ±	874	519				
	C.D. at 5%	2546	1515				

Crop	Market Prices (Rs/q) 1991	1992
Groundnut	750	850
Sunflower	855	780
Castor	740	650
Sesamum	1300	1051

In case of intercropping, the highest monetary returns of Rs.14218/ha were obtained in groundnut + castor (5:1) system during 1991 and groundnut + sunflower (3:1) (Rs.15462/ha) during 1992. On an average over two years, the groundnut (Rs.12300/ha) recorded the highest monetary returns followed by castor (Rs.8053/ha) among the sole crops. In intercropping systems, the highest monetary returns (Rs.14019/ha) was seen in groundnut + castor in 3:1 row proportion closely followed by groundnut + castor in 5:1 row proportion (Rs.13979/ha), groundnut + sunflower in 3:1 row proportion (Rs.13786 /ha), groundnut + sunflower in 5:1 row proportion (Rs.13240/ha). Studies conducted at Dharwad also showed superiority of groundnut + castor intercropping at 3:1 row proportion (Anon.,1987). Similar results were also reported by Hegde and Reddy (1987).

The LER is an indicator of efficient land utilization for intercropping systems (Jha and Chandra, 1982). The values of LER were higher for groundnut + sunflower in all row proportions than other intercropping systems of castor and sesamum. On an average over two years, the *groundnut + sunflower (3:1) registered highest* LER (1.52) followed by the same intercropping system in 5:1 row proportion (1.42). In general, the LER values were higher at lower row proportion (3:1) in all the intercropping systems.

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PRE-HARVEST ACREAGE ESTIMATION OF SOYBEAN USING IRS DATA FOR PRODUCTION FORECASTING

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ABSTRACT

Contribution of soybean crop to domestic oilseed production and to the national exchequer is increasing significantly year after year. The methodology and results obtained in the experiment on pre-harvest acreage estimation of soybean using remotely sensed data from Indian Remote Sensing Satellite (IRS) - 1A/1B LI sensor during 1991 and 1992 crop seasons have been discussed. The methodology followed is digital analysis of remotely sensed data by adopting stratified random sampling and /or complete enumeration methods. Pre-harvest soybean acreage could be satisfactorily estimated at 90 per cent confidence level.

Key words : Pre-harvest; Fore-casting; IRS data

Contribution of Soybean (*Glycine max* L) to the domestic oilseed production and to the national exchequer is increasing significantly every year. To accelerate the efforts towards self reliance in edible oils, the Government of India is making all efforts through various programmes. In this context, timely and reliable pre-harvest information assumes importance in order to manage domestic market, control large fluctuations in prices, formulate import/export policies and optimally utilise storage, transport and procurement facilities. Crop yield fore casting comprises pre-harvest acreage estimation of crops, condition assessment and yield estimation.

Satellite remote sensing has the advantages like synoptic view, repetitivity, multispectral and multitemporal data acquisition, and computer compatibility. In the recent past, space borne remote sensing techniques have been successfully used to generate pre-harvest crop area statistics, which is cost effective. In India remotely sensed data from space borne sensors like IRS, landsat TM/MSS etc., have been successfully used to estimate acreage of paddy (Sharma *et al.*, 1990), Wheat (Dadhwal *et al.*, 1991), sorghum (Potdar *et al.*, 1991), sugarcane (Vyas and Kalubarme 1990), of major crops in Nizam Sagar command area (Venkataratnam *et al.*, 1991) and others. The paper discusses the methodology and the results of pre-harvest acreage estimation of soybean crop in Madhya Pradesh during 1991 and 1992 crop seasons.

MATERIALS AND METHODS

During 1991 crop season, the study was carried out in Ujjain, Shajhapur, Sehore and Indore districts of Madhya Pradesh; whereas, in 1992 the scope of the study was extended to another ten more districts. In both the years, remote sensing data from IRS - 1A/1B LI sensor, in the form of false colour composites (FCCs) and digital data in computer compatible tapes (CCTs) were used in the study. Survey of India topographical maps at 1:250,000 and 1:50,000 scales were used.

Digital analysis of remote sensing data was carried out by adopting stratified random sampling and/ or complete enumeration methods. FCCs of the study area at 1:250,000 scale were stratified on the basis of crop vigour and density, as manifested in different tones of magenta (Fig-1A). Base maps of each district at 1:250,000 scale were prepared and superimposed on interpreted overlay, and boundaries of different strata were transferred on to the base maps. A grid of 2 cm x 2 cm (corresponding to 5 km x 5 km) was overlaid on

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interpreted map and total number of cropped area segments in each strata were counted. Ten per cent of total number of segments in each strata were selected using random number tables for detailed ground truth collection and digital analysis. Ground truth was collected during crop season for soybean and other land use/land cover classes.

The digital data in CCTs were analysed on image analysis systems at NRSA, Hyderabad in 1991 and at RRSSC, Bangalore in 1992. After loading CCTs on to computer disc, the data was registered with topographical maps and the district boundaries were digitised/top left corner co-ordinates of each selected segment were noted. The data pertaining to each district/segment was extracted. The FCC image of the study areas were displayed on computer monitor and training areas were defined for soybean crop and other land use/ land cover classes. The spectral signature for each class, in terms of mean, standard deviation and variance-covariance were generated. The spectral separability of soybean crop with other land cover classes was studied. Subsequently data was classified district-wise (Fig. 1B) / segment-wise using maximum likelihood algorithm, and corresponding area statistics for soybean crop were generated.

RESULTS AND DISCUSSION

The acreage estimates at 90 per cent confidence level, for soybean crop for 1991 and 1992 crop seasons are given in Table 1 and Table 2, respectively, along with the estimates of Department of Agriculture/Land Record & Settlement, Madhya Pradesh. Raw and classified data of Ujjain district, Madhya Pradesh are given in Fig. 1A and Fig. 1B. Fig. 2 shows the spectral reflectance of soybean, jowar, forest/scrub/other vegetation and pasture land in the study area for 1991 crop season. All the vegetation classes in the study area have shown the expected spectral reflectance pattern. However, Soybean crop either pure or mixed is giving distinct response as compared to other vegetation classes, especially in band 2 (green band) and band 4 (near infrared band). Similar observations are made in 1992 crop season also (Fig. 3), where the reflectance of soybean and other classes are depicted in cluster plots. Pre-harvest acreage of soybean obtained through digital analysis are comparable with those of the Department of Agriculture/Land Records & Settlement, Madhya Pradesh (Tables 1 & 2). Table 1 shows that the results obtained through total enumeration and stratified random sampling are similar because the same training sets were used for classification and the data was cloud free.

TABLE 1. Soyabean acreage estimates in MP, 1991 crop season

(area in ha.)

Sl. No	District	Total enumeration method	Stratified random sample method	DOA/LRS
1.	Ujjain	1,98,925	1,98,348 ± 11,975	2,05,000
2	Shajhapur	1,69,754	1,73,967 ± 8,644	1,57,000
3	Sehore	1,78,963	1,74,464 ± 15,633	1,60,000
4.	Indore	1,14,220	1,13,572 ± 11,354	1,40,000

DOA - Department of Agriculture, MP

LRS - Land Record & Settlement, MP.

FIG. 1A RAW DATA

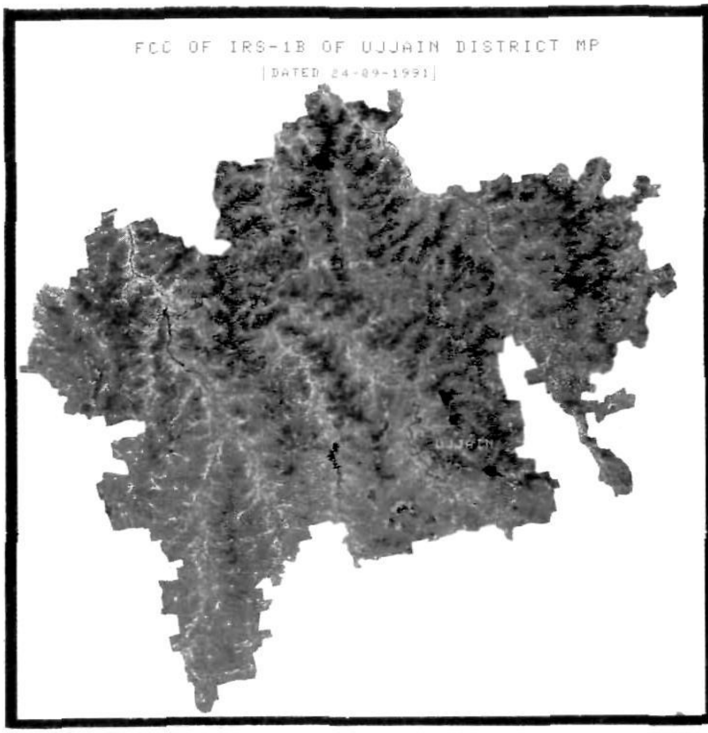

FIG. 1B CLASSIFIED DATA

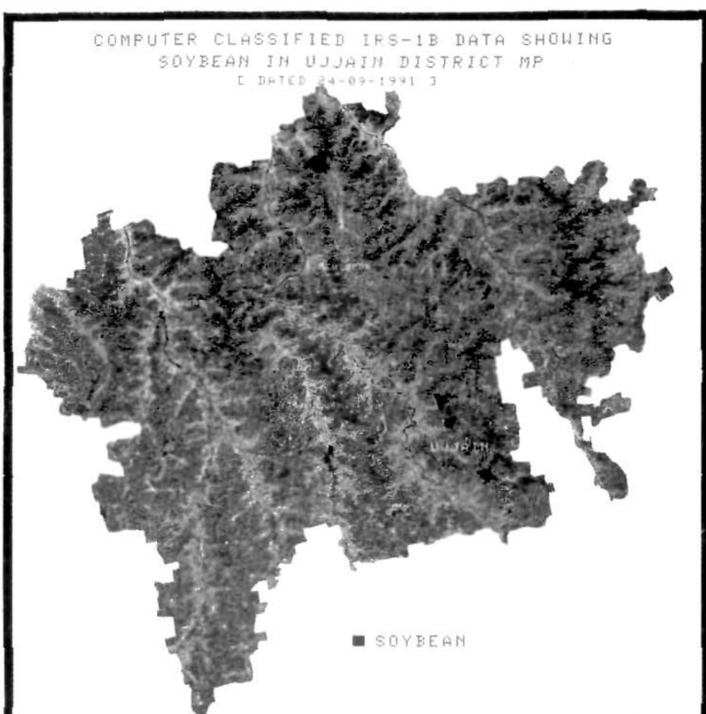

TABLE 2. Soyabean acreage estimates in MP, 1992 crop season

S. No.	Name of the District	Estimated Acreage in Ha	C.V%	Estimated figures of Land Records
1.	Bhopal	50,581 ± 5,354	3.62	48,100
2	Shahapur	2,22,320 ± 22,044	5.41	1,59,900
3	Ujjain	2,21,963 ± 20,790	5.40	3,19,100
4	Dhar	1,51,481 ± 15,900	5.79	1,73,800
5	Indore	1,44,672 ± 15,589	5.54	1,78,200
6	Ratlam	1,02,008 ± 16,834	8.49	1,28,200
7	Mandsuar	91,531 ± 16,834	7.04	1,24,800
8	Dewas	1,66,425 ± 23,698	4.32	1,28,200
9	Sehore	1,84,993 ± 9,230	2.72	1,75,000
10	Hoshangabad	2,46,605 ± 22,889	5.30	2,08,400
11	Betul	1,15,667 ± 14,493	6.61	1,63,900
12	Rajgarh	1,12,572 ± 17,098	8.02	1,50,900
13	Vidhisha	50,302 ± 6,539	5.52	71,100
14	Raisen	98,502 ± 9,370	4.46	1,24,100.

Governmentof Madhya **Pradesh Gwalior**.

CONCLUSION

Digital analysis of remotely sensed IRS-1A/1B LI data enabled satisfactory estimation of pre-harvest acreage of soybean crop during 1991 and 1992 crop seasons. Remote sensing data during the first fortnight of September is more suitable than August for soybean crop identification and acreage estimation. The study is encouraging and further investigations are needed to establish relationships between vegetation indices (derived from remote sensing data) and yield of soybean crop and to develop yield forecasting models.

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FIG. 2 SPECTRAL REFLECTANCE OF CROPS AND OTHER VEGETATION

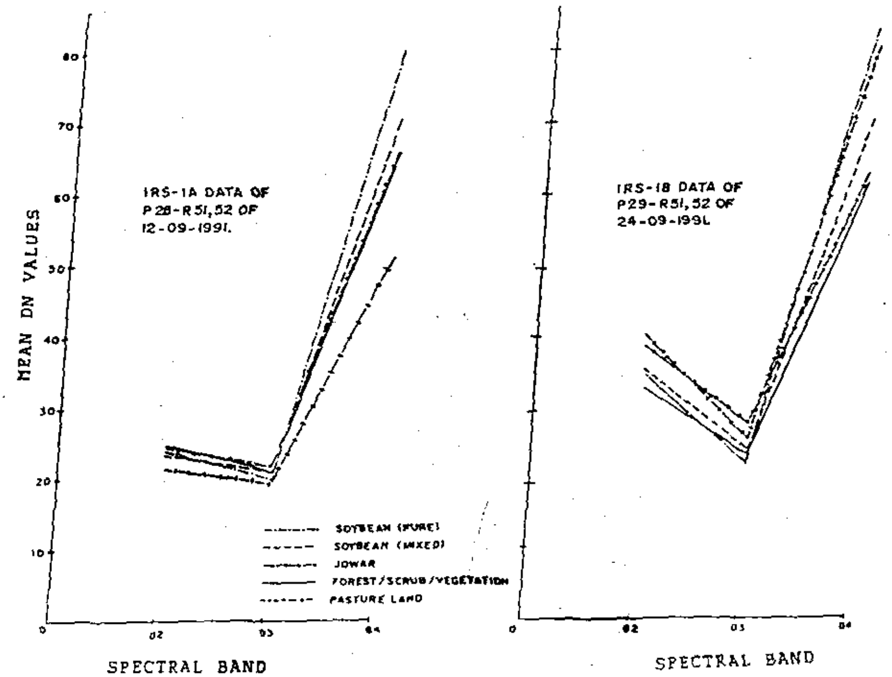
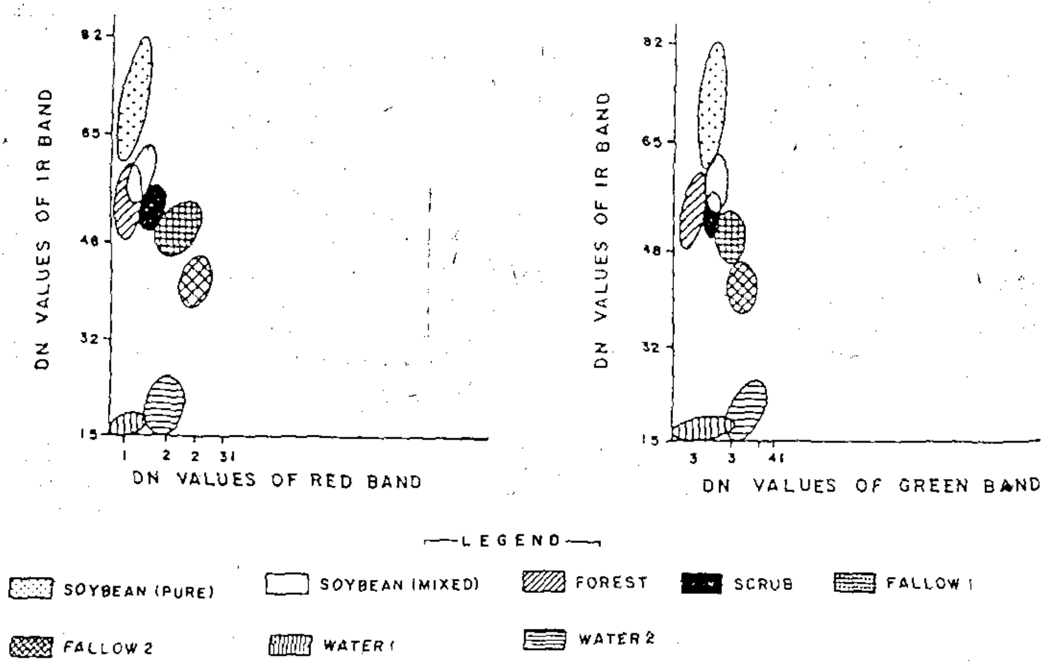


FIG. 3 CLUSTER DIAGRAM OF DIFFERENT CATEGORIES IN STUDY AREA
(AS GIVEN BY VIPS 32 - COMPUTER SYSTEM, RRSSC, BANGALORE)



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INFLUENCE OF IRRIGATION AND FERTILITY LEVELS ON UTILIZATION AND OIL CONTENT IN LINSEED (*Linum usitatissimum* L)

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ABSTRACT

NPK utilization and oil content was studied in three varieties of linseed under three irrigation levels viz., control, irrigation at 30 days after sowing (DAS) and irrigations at 30 + 60 DAS and three fertility levels viz., control (F_0) 30:15:10 NPK kg/ha (F_1) and 60:30:15 NPK kg/ha (F_2). Significant higher NPK utilization in straw was noted under two irrigations. The higher fertility of (F_2) also resulted higher utilization of NPK in seed and straw. JL - 23 utilized more NPK than T-397 and JLS-1. Oil content did not vary significantly due to irrigations, fertility levels and varieties. But the total oil output was significantly increased due to two irrigations, higher fertility (F_2) and JL - 23. Interaction among different factors was significant only during second year.

Key Words: Fertility; Irrigation; Varieties; NPK; Utilization.

Linseed (*Linum usitatissimum* L) is one of the important oil and fibre crop. Oil content of the linseed varies from 35 to 45% depending upon the varieties and environmental conditions. The irrigation and fertilizer may also influence the oil per cent and total oil yield in linseed varieties as the vegetative and reproductive growth are highly influenced by water and nutrients. Water is a key factor for nutrient utilization. Therefore this experiment was conducted to evaluate the effect of irrigation and fertility levels on NPK utilization and oil yield in different varieties of linseed.

MATERIALS AND METHODS

Three varieties viz., JLS-1, T-397 and JL-23 (V_1 V_2 V_3) were grown at three levels I_0 I_1 I_2 of irrigation (control, one irrigation at 30 DAS and two at 30 + 60 DAS) and fertility : control (F_0); 30:15:10 kg NPK/ha (F_1) and 60:30:15 kg NPK/ha (F_2) at JNKVV, Jabalpur during the year 1989-90 and 1990-91. The experiment was laid out in split-split plot design keeping irrigations in main plots, fertility levels in sub-plots and varieties in sub-sub plots in three replications. The soil of the experimental area was sandy clay loam with available N, P_2O_5 and K_2O of 278, 21 and 260 kg/ha, respectively and pH of 7.2. Oil content is determined by Soxhlet Extraction Method (A.O.A.C., 1965). The total oil yield was computed on the basis of seed yield obtained and per cent oil content. The NPK in straw and seed was determined as per methods suggested by Jackson (1967).

RESULTS AND DISCUSSION

The NPK utilization in seed was higher under two irrigations as compared to one irrigation and no irrigation. Similar trend was noticed in second year (Table 1). The higher NPK utilization was noted at higher fertility level (F_2) as compared to F_1 and F_0. NPK utilization also varied significantly among varieties during second year and JL-23 utilized more NPK than T-397 and JLS-1. The maximum utilization in JL-23 was due to the higher seed out-put per hectare, however, NPK content (%) did not vary due to different varieties (Table 1). The interaction of irrigations, fertility and varieties was significant only during second year.

In straw, significantly higher utilization of NPK was in two irrigations than in one irrigation and

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Table 1. NPK utilization in straw and seed and oil out put and oil percent in seed.

Centre	N				P				K				Oil out put (kg/ha)		Oil percentage	
	Seed		Straw		Seed		Straw		Seed		Straw					
	1990	'91	1990	'91	1990	'91	1990	'91	1990	'91	1990	'91	1990	1991	1990	1991
I_0	16.9	12.7	11.2	10.4	2.2	1.7	1.2	1.2	2.0	1.5	23.7	21.9	227.92	171.05	40.81	40.53
I_1	19.3	15.4	12.8	12.2	2.5	1.9	1.4	1.5	2.3	1.9	26.4	25.1	259.82	205.24	41.61	41.23
I_2	22.5	18.5	15.4	15.3	2.9	2.4	1.7	1.8	2.6	2.2	31.7	31.4	302.98	247.73	42.17	41.64
CD	2.51	0.05	1.79	0.09	0.33	0.01	0.18	1.33	0.30	0.08	3.80	0.06	33.49	2.48	NS	NS
F_0	14.0	8.9	9.5	7.5	1.8	1.1	1.01	0.8	1.6	1.0	15.5	15.5	184.96	115.06	39.84	39.46
F_1	19.5	14.9	13.3	12.3	2.5	1.9	1.4	1.4	2.3	1.8	26.9	24.6	271.82	205.63	43.13	42.61
F_2	25.1	22.9	16.6	18.2	3.3	3.0	1.9	2.3	3.0	2.7	35.3	38.2	333.94	303.22	41.61	41.36
CD	2.67	0.45	1.68	0.08	0.35	0.01	0.20	0.16	0.31	0.07	3.50	0.03	34.90	1.25	NS	NS
V_1	18.6	14.3	12.6	11.7	2.4	1.8	1.4	1.3	2.2	1.7	26.1	24.0	251.89	192.87	41.37	41.07
V_2	19.6	15.1	12.9	12.1	2.5	2.0	1.4	1.4	2.3	1.8	27.3	25.5	262.69	202.47	41.64	41.13
V_3	20.5	17.2	13.8	14.0	2.7	2.2	1.5	1.8	2.4	2.0	28.3	28.8	275.14	228.68	41.59	41.24
CD	NS	0.06	NS	0.06	NS	0.01	NS	0.11	NS	0.06	NS	0.03	NS	0.88	NS	NS

no irrigation. The NPK accumulation in straw was also increased due to higher fertility as compared to F_1 and F_0. Among varieties higher NPK accumulation in straw was noted in JL-23 than in T-397 and JLS-1 (Table 1). The higher utilization in seed and straw under higher fertility clearly revealed that if more nutrients are available in soil they are utilized more by the plants which result in greater plant growth and seed production. These results are in conformity with those of Ivanov *et al.*, (1986).

Oil per cent of the seed did not differ due to different irrigations, fertility or varieties. However, total oil out put (Table 1) was significantly higher from those plots which were irrigated twice followed by one irrigation and no irrigation and it had the same trend as noted for seed yield. Yusuf *et al.*, (1978) also reported that oil content of linseed was not affected by irrigation. Significantly higher oil output was noted at F_2 followed by F1 and no fertilization (F_0). A slight increase in oil content was observed by increasing fertility levels from control (F_0) to 60:30:15 kg NPK/ha. (F_2) Pandey and Singh (1970) also noted the similar trend, but Yayock and Quinn(1977) reported that increasing rates of nitrogen from 55 to 88 kg/ha decreased oil content. Among different varieties the higher oil output was noted in JL-23 followed by T-397 and JLS-1. The interaction of different factors was significant during second year.

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PERFORMANCE OF MUSTARD (*Brassica juncea* (L) Czern and Coss.) VARIETIES UNDER DIFFERENT LEVELS OF NITROGEN FERTILIZATION.

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ABSTRACT

The performance of three mustard varieteis (CS-52, Kranti and Rohini) and four nitrogen levels (0,60, 90 and 120 kg/ha) was studied for two consecutive seasons at Oilseed Research Farm, Kalyanpur, Kanpur (U.P.), to assess the effect of nitrogen fertilisation on yield attributes, seed yield, harvest index and oil yield. During the final year an additional level of 150 kg N/ha was also tested. CS-52 gave the highest seed and oil yield during both the years. The crop responded to nitrogen application linearly upto120 kg N/ha and gave significantly higher seed and oil yield i.e 2057 kg/ha & 2978 kg/ha and 849 kg/ha & 1293 kg/ha during 1991-92 and 1992-93, respectively.

Key words: Variety; Nitrogen; Oil yield; Correlation.

Nitrogen is the most limiting nutrient in Indian soils (Ramamoorthy *and Bajaj*, 1969). This is particularly true for rapeseed - mustard which are mostly grown in marginal and sub-marginal soils. On an average, one kg nitrogen produce 7.25 to 7.40 kg mustard. Increase in seed yield by nitrogen is brought by improvement in the number of primary and secondary branches, siliquae/plant, seeds/siliqua and seed weight. Oil content in the seed is either decreased or unaffected, but the total oil yield is always increased by N-application. Balanced fertilisation, specially nitrogen is essential for achieving high seed yields (Saini *et al.*, 1989). With the introduction of new varieties, it becomes imperative to study their performance at varying rates of nitrogen fertilisation.

MATERIALS AND METHODS

Field trials were conducted at Oilseed research farm, Kalyanpur, Kanpur, Uttar Pradesh, during *Rabi* seasons of 1991-92 and 1992-93. Three mustard varieties (CS-52, Kranti and Rohini) were tested with four nitrogen levels (0,60, 90 and 120 kg N/ha) in 1991-92 and five nitrogen levels (0,60, 90, 120 and 150 kg N/ha) in 1992-93 in a Factorial Randomized Block Design with three replications. The soil of experimental field was sandy loam in texture with a pH of 7.60, medium in available nitrogen (0.0418), medium in available P_2O_5 (23.5 kg/ha), low in available K_2O (116 kg/ha) and E.C. 0.40 mm hos/cm at 25^0 C. The experimental crop was grown after Jowar (green fodder) during both the years. A common basal dose of 40 kg/ha P_2O_5 and K_2O was applied at the time of sowing. Nitrogen was applied as per treatments, half the dose at the time of sowing and the remaining half after first irrigation through urea. Crop was sown in 45 cm rows with plant spacing maintained at 15-20 cm by thinning at 15 days after sowing. Only one irrigation was given during both the years. The crop received 34.8 mm and 130.6 mm of rainfall during 1991-92 and 1992-93, respectively during the growth period of crop.

RESULTS AND DISCUSSION

Varieties reflected marked differences in growth and yield attributes (Singh *et al.*, 1989). The variety Kranti had the highest plant height which was significantly superior to both the varieties except CS-52 which was at par during 1991-92 (Table 1). CS-52 recorded significantly more branches/plant than the Kranti and Rohini during both the years. Siliquae/plant (1991-92), seed

Table 1. Effect of varieties and nitrogen levels on growth components and yield attributes.

Treatments	Plant height (cm.)		Branches/Plant		Siliquae/Plant		Seeds/Siliqua		1000 Seed weight (g)		Seed Weight/plant (g)	
	'91-92	'92-93	'91-92	'92-93	'91-92	'92-93	'91-92	'92-93	'91-92	'92-93	'91-92	'92-93
Varieties												
CS-52	109.18	188.76	33.20	14.75	458.28	326.05	10.57	12.87	3.36	4.01	15.52	18.30
Kranti	110.50	209.64	23.85	13.51	441.98	326.28	12.07	13.32	2.96	3.95	14.93	17.91
Rohini	97.72	191.28	24.77	14.16	328.70	315.11	10.32	12.44	3.72	4.36	11.55	16.51
SE ±	4.28	4.33	2.41	0.26	19.07	7.70	0.38	0.34	0.11	0.11	0.36	0.28
CD at 5%	8.89	8.87	4.99	0.53	39.56	N.S.	0.78	0.70	0.24	0.23	0.75	0.57
N-Leves (Kg/ha)												
N_0	93.96	183.42	20.24	11.29	329.09	247.36	10.05	12.44	3.10	3.96	9.34	12.80
N_{60}	106.13	194.69	25.78	13.27	393.38	276.87	10.60	12.58	3.37	4.03	12.87	15.33
N_{90}	110.49	199.18	30.62	14.31	443.40	336.96	11.27	12.91	3.46	4.18	15.11	18.15
N_{120}	112.62	202.20	32.44	15.56	472.76	370.45	12.02	13.20	3.45	4.38	18.68	20.38
N_{150}	-	203.31	-	16.27	-	380.78	-	13.44	-	3.98	-	21.21
SE ±	4.95	5.59	2.78	0.33	22.03	9.94	0.44	0.44	0.13	0.15	0.42	0.36
CD at 5%	10.26	11.45	5.76	0.68	45.68	20.36	0.90	N.S.	0.28	0.30	0.86	0.74

weight/plant, seed yield/ha and oil yield/ha recorded significantly higher in CS-52 over Rohini during both the years and was at par with Kranti (Table 1 and 2). However, the differences in siliquae/plant were not significant in 1992-93. Similarly, CS-52 recorded significantly more harvest index during both the years over Rohini which was at par with Kranti during 1991-92 (Table 2). Kranti gave the highest number of seed/siliqua and the lowest 1000-seed weight, however, Rohini recorded the highest 1000-seed weight and the lowest number of seeds/siliqua during both the years (Table 1). It may be due to the size of seed. This is in conformity with the observations made by Shukla and Kumar (1992).

Increasing rate of nitrogen enhanced growth, yield attributes and yield, significantly in both the years (Table 1 & 2). Similar observations were made by Singh and Rathi (1984) and Saini *et al.*, (1989). The per cent increase in yield over control due to application of 60, 90 and 120 kg/ha nitrogen was 28.18, 55.55 and 83.99 per cent, respectively during 1991-92 and due to application of 60, 90, 120 and 150 kg/ha nitrogen was 19.65, 35.59, 50.79 and 54.94 per cent, respectively during 1992-93. Similarly oil yield was also increased significantly due to successive increase in nitrogen application upto 120 kg N/ha during both the years (Table 2). Similar results were reported by Singh and Rathi (1985) and Shukla and Kumar (1992).

Similarly plant height, branches/plant, siliquae/plant and seed weight/plant increased with increasing levels of nitrogen. However, 1000-seed weight and harvest index increased upto 120 kg N/ha and decreased due to further increase in nitrogen levels. Seeds/plant increased significantly in 1991-92, while the differences during 1992-93 were not significant (Table 1). The increasing response of these characters contributed substantially to seed yield/plant.

The combined effect of mustard varieties and nitrogen application had a significant impact on the branches/plant and harvest index in 1992-93, seed yield in 1991-92 and seed weight/plant and oil yield during both the years (Table 3). Branches/plant was found to be increased significantly in all the three varieties upto 120 kg N/ha, except in case of Kranti in which the differences between 60 kg N/ha & 90 kg N/ha and 90 kg N/ha & 120 kg N/ha were non-significant. Although, maximum values were recorded at 150 kg N/ha, but it remained at par with 120 kg N/ha, with all the three varieties during 1992-93. Similar results were obtained in case of harvest index, except in the varieties of CS-52 and Rohini, a slight decrease was recorded at 150 kg N/ha as compared with 120 kg N/ha during 1992-93.

Seed weight/plant was increased significantly in all the varieties upto 120 kg N/ha during both the years except the differences between Kranti with 90 kg N/ha and Kranti with 120 kg N/ha and Rohini with 60 kg N/ha and Rohini with 90 kg N/ha (1991-92) did not differ significantly and also 120 kg N/ha and 150 kg N/ha in each variety was remained at par in 1992-93.

Seed yield of each variety increased significantly during 1991-92 upto 120 kg N/ha, except Kranti of which 120 kg N/ha remained at par with 90 kg N/ha. In 1992-93, a linear increase was observed in each variety upto 150 kg N/ha. Similarly, oil yield was also increased upto 120 N/ha in CS-52 and Rohini and upto 90 kg N/ha in case of Kranti and there after oil yield was decreased, perhaps, due to decrease in oil content.

Therefore, it was concluded that the combinations of CS-52 and Rohini with 120 kg N/ha and Kranti with 90 kg N/ha maintained their superiority over the other combinations. These results confirm the findings of Saini *et al.*, (1989), Bharadwaj (1991) Shukla and Kumar (1992) and AICORPO (1992).

Correlation coefficients were worked out between seed yield and plant height, branches/plant, siliquae/plant, seeds/siliqua and 1000-seed weight (Table 4). The seed yield was positively and significantly correlated with plant height, branches/plant, siliquae/plant and seeds/siliqua.

Table 2: Effect of varieties and nitrogen levels on seed yield (kg/ha), oil yield (kg/ha) and harvest index.

Treatments	Seed yield (kg/ha)		Oil yield (kg/ha)		Harvest index	
	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93
Varieties						
CS-52	1739	2776	712	1185	19.18	24.80
Kranti	1711	2646	700	1102	19.18	22.73
Rohini	1309	2411	557	1014	15.29	22.45
SE ±	38.09	84.77	15.87	36.00	0.90	0.85
CD at 5%	79.01	173.61	32.92	73.73	1.87	1.74
N Levels (kg/ha)						
N_o	1118	1975	469	823	14.72	18.45
N_{60}	1433	2363	600	979	16.96	20.26
N_{90}	1739	2678	707	1149	19.02	23.89
N_{120}	2057	2978	849	1293	20.83	27.36
N_{150}	-	3060	-	1258	-	26.68
SE ±	44.44	109.43	18.25	46.48	1.04	1.10
CD at 5%	92.06	224.11	37.86	95.19	2.16	2.25

Table 3. Combined effect of varieties and nitrogen on mustard.

Treatments	Branches/plant		Seed weight/plant (g)		Seedyield (kg/ha)		Harvest index		Oil yield (kg/ha)	
	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93
CS-52 x N_0	26.13	10.93	8.77	12.29	1045	1940	14.47	16.75	432	820
CS-52 x N_{60}	32.40	13.67	12.56	15.45	1462	2381	17.07	19.05	612	970
CS-52 x N_{90}	35.46	15.07	17.17	19.24	1852	2866	20.28	25.29	759	1226
CS-52 x N_{120}	38.80	16.87	23.59	21.67	2599	3316	24.91	32.63	1044	1473
CS-52 x N_{150}	–	17.20	–	22.87	–	3377	–	30.26	–	1437
Kranti x N_o	18.87	11.60	11.31	14.14	1330	2266	17.02	20.24	542	926
Kranti x N_{60}	22.47	12.87	15.20	16.34	1647	2443	19.09	21.33	669	996
Kranti x N_{90}	27.47	13.93	16.92	19.04	2030	2804	21.28	23.72	820	1226
Kranti x N_{120}	26.60	14.20	16.27	19.86	1838	2840	19.32	23.88	768	1217
Kranti x N_{150}	–	14.93	–	20.17	–	2875	–	24.50	–	1146
Rohini x N_0	15.73	11.33	7.93	11.97	979	1720	12.66	18.35	434	723
Rohini x N_{60}	22.47	13.27	10.86	14.21	1190	2266	14.71	20.40	520	970
Rohini x N_{90}	28.93	13.93	11.24	16.17	1336	2363	15.50	22.67	541	996
Rohini x N_{120}	31.93	15.60	16.19	19.60	733	2778	18.27	25.57	734	1190
Rohini x N_{150}	–	16.67	–	20.60	–	2928	–	2528	–	1190
SE±	5.76	0.68	0.72	0.62	76.43	189.54	1.80	1.90	31.75	80.50
CD at 5%	N.S.	1.19	1.50	1.27	158.51	N.S.	N.S.	3.89	65.84	164.86

Table 4. Correlation Coefficients (r) between seed yield and growth and yield attributing characters

S.No	Characters correlated with seed yield	Correlation Coefficient (r)	
		1991-92	1992-93
1.	Plant height	0.897 **	0.539 **
2.	Branches/plant	0.721 **	0.929 **
3.	Siliquae/plant	0.909 **	0.923 **
4.	Seeds/siliqua	0.812 **	0.799
5.	1000-seeds weight	0.027	0.096

** Significant at t = 0.01.

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EFFECT OF SUPPLEMENTAL IRRIGATION ON YIELD POTENTIAL AND WATER USE EFFICIENCY OF SELECTED OILSEED CROPS AFTER *KHARIF* RICE UNDER TANK IRRIGATION.

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ABSTRACT

Field experiments were conducted during *rabi* 1989 and 1990 to study the growth and yield of some selected upland crops viz., ragi (var. Indaf-7), soybean (var. Hardy) and niger(var. N-65) in relation to irrigation (residual moisture, protective irrigation at critical stages and irrigation at 50% ASM). Supplemental irrigation at 50% ASM showed significantly positive effects on biological yield, seed yield, harvest index and water use efficiency. On the other hand crops grown under residual moisture showed significant adverse effect on biological yield and seed yield when compared to irrigation at 50% ASM. Among the crops tested, soybean performed better in seed yield as compared to ragi and niger.

Key Words: Ragi; Soybean; Niger; Supplemental irrigation; ASM.

Karnataka has 3 lakh hectares under tank irrigation, where single crop of *Kharif* rice is predominant and generally kept fallow after the harvest of the crop (Anon., 1984). In recent years there has been an increase in the area under short and medium duration rice varieties during *Kharif*. Some farmers do grow a catch crop of chickpea, greengram and blackgram after *Kharif* rice by utilising supplemental irrigation and the yield levels are only of the order of 200 to 300 kg/ha. However, in rice fallows, oilseed crops like soybean and niger fits well under rice-based double cropping giving remunerative yields and occupy the land only for short period (Raghu *et al.*, 1982 and Anon., 1988). Therefore, greater emphasis is needed on development of non-traditional oilseed crops by suitably fitting them into cropping pattern. Keeping this in view the present investigation was carried.

MATERIALS AND METHODS

A field experiment was conducted during the *rabi* season of 1989 and 1990 at the wet lands, Main research station, Hebbal, Bangalore on sandy loam soil after *kharif* rice to study the performance of oilseed crops as influenced by supplemental irrigation. The upland crop viz,, ragi, soybean and niger were raised in quick succession with *kharif* rice. The crops were sown on 28.12.1989 and 21.12.1990 respectively in both years. Seeds of ragi and niger were drilled in shallow rows opened at 30 cm apart. Soybean seeds were dibbled at 10 cm apart within the rows. The crops were harvested- ragi on 22-4-1990 and 15-4-1991, soybean 9-4-1990 and 2-4-1991 and niger 10-3-1990 and 2-3-91 respectively in both the years. Three protective irrigation were given during both years (tillering/branching, flowering and pod filling stage) for ragi and soybean, and one irrigation was given to niger at flowering stage. Number of irrigations applied at 50% ASM were five, four and two given to ragi, soybean and niger respectively. The average field capacity, permanent wilting point and bulk density were 21.2%, 10.13% and 1.4 g/cc, respectively. The average depth of water table was 36.4 cm to 75.0 cm from 30 days to harvest, respectively. The effective rainfall received during crop growth period was 1.7 cm and 5.29 cm during 1989-90 and 1990-91 respectively. Measured quantity of irrigation was given using Parshal Flume to satisfy the treatment requirement as and when required. The experiment was laidout in a split-plot design with 3 replications with a

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plot size of 6.0 m x 3.0 . The treatment details are given in Table 1. Recommended culivation practices were followed for all the crops.

RESULTS AND DISCUSSION

It was observed that higher mean grain/seed yield (2330 kg/ha) was obtained with soybean (Table 1) followed by ragi (2295 kg/ha and niger (373 kg/ha). Higher seed yield with soybean may be due to higher water use efficiency (584 kg/ha-cm) (Table 4). Soybean also recorded higher harvest index 0.47 (Table 3) and this indicate that the efficiency of soybean in converting the part of biological yield (5149 kg/ha) towards economic yield (2330 kg/ha) (Table 2).

Assessment of biological yield among upland crops indicate that higher biological yield (5293 kg/ha) was obtained with ragi followed by soybean (5149 kg/ha) and niger (1061 kg/ha). The reason for higher biological yield with ragi might be due to higher rate of assimilation and translocation (Anon, 1987) and can also be attributed to the longer duration (115 days) with ragi.

When the effect of supplemental irrigation is considered, higher grain/seed yield (1929 kg/ha) was obtained with treatment which received irrigation at 50 per cent ASM. This higher grain/seed yield may be due to adequate supply of moisture throughout the growth period. The lower grain/seed yield (1405 kg/ha) was obtained with residual moisture. Lower grain/seed yield of upland crops due to residual moisture was also reported by Raghu *et al.*,(1982) and Khade *et al.*, (1987). The reason for lower grain/seed yield of upland crops with residual moisture may be due to lower biological yield and harvest index. Such effects was also reported for upland crops by Aspinal (1970) and Rao *et al* (1991). Similar trend was seen with biological yield (Residual moisture 3277 kg/ha, Protective irrigation at critical stages; 3933 kg/ha and irrigation at 50 per cent ASM; 4293 kg/ha).

Water use efficiency varied among the crops (Table 4). Water use efficiency was higher with soybean (584 kg/ha-cm) and it was low with niger (108 kg/ha-cm). As regards the levels of irrigation, the water use efficiency was higher (740 kg/ha-cm) with residual moisture and it was low with irrigation at 50 per cent ASM (173 kg/ha-cm).

Different workers working on performance of upland crops under residual moisture after rice also reported higher water use efficiency of soybean (Raghu *et al.*, 1982 and Panigrahi and Patro, 1989).

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Table 1. Effect of levels of irrigation on grain/seed yield (kg/ha) of ragi, soybean and niger.

Treatments	1989-90 Ragi (C_1)	Soybean (C_2)	Niger (C_3)	Mean	1990-91 Ragi (C_1)	Soybean (C_2)	Niger (C_3)	Mean	Pooled	Pooled analysis		
Residual moisture(I_1)	1763	1998	309	1423	1750	1910	308	1386	1405			
Protective irrigation at critical stages(I_2)	2456	2380	405	1780	2390	2360	395	1748	1764			
Irrigation at 50% ASM (I_3)	2778	2578	422	1939	2695	2552	410	1919	1929			
Mean	2312	2352	379		2278	2307	368					
Pooled					**2295**	**2330**	**373**					
F - test	I**	C**	IxC**		I**	C**	IxC**			I*	C**	IxC*
S. Em ±	5.015	7.194	12.460		17.016	17.530	30.363			9.000	9.000	16.005
C.D. at 5%	19.690	22.076	38.237		66.801	53.797	100.529			29.000	28.000	48.015

Table 2. Effect of levels of irrigation on biological yield (kg/ha) of ragi, sybean and niger.

Treatments	1989-90 Ragi (C_1)	Soybean (C_2)	Niger (C_3)	Mean	1990-91 Ragi (C_1)	Soybean (C_2)	Niger (C_3)	Mean	Pooled	Pooled analysis		
Residual moisture(I_1)	4413	4648	881	3314	4330	4500	888	3239	3277			
Protective irrigation at critical stages(I_2)	5517	5330	1085	3977	5385	5210	1070	3888	3933			
Irrigation at 50% ASM (I_3)	6106	5628	1222	4319	**6005**	5577	**1220**	4267	4293			
Mean	5345	5202	1063		**5240**	**5096**	**1059**					
Pooled					**5293**	**5149**	**1061**					
F - test	I**	C**	IxC**		I**	C**	IxC**			**I***	**C****	**IxC***
S. Em ±	6.709	12.709	21.605		63.034	56.066	101.292			10.000	18.008	31.000
C.D. at 5%	26.339	38.280	66.303		247.462	172.058	344.467			31.050	53.000	91.000

Table 3. Effect of levels of irigation on harvest index of ragi, soybean and niger

Treatments	1989-90				1990-91					Pooled analysis		
	Ragi (C_1)	Soybean (C_2)	Niger (C_3)	Mean	Ragi (C_1)	Soybean (C_2)	Niger (C_3)	Mean	Pooled			
Residual moisture(I_1)	0.399	0.462	0.351	0.404	0.404	0.469	0.335	0.402	0.403			
Protective irrigation at critical stages(I_2)	0.445	0.465	0.373	0.428	0.443	0.472	0.369	0.428	0.428			
Irrigation at 50% ASM (I_3)	0.459	0.478	0.375	0.438	0.449	0.476	0.370	0.432	0.435			
Mean	0.434	0.468	0.366		0.432	0.472	0.358					
Pooled					0.433	0.470	0.362					
F - test	I**	C**	IxC**		I**	C**	IxC**			I*	C**	IxC*
S. Em ±	0.003	0.004	0.008		0.001	0.001	0.001			0.020	0.020	0.040
C.D. at 5%	0.012	0.013	0.022		0.003	0.003	0.003			0.050	0.060	0.120

Table 4. Effect of levels of irigation on water use efficiency *(kg/ha-cm)* of *ragi, soybean and niger.*

Treatments	1989-90				1990-91					Pooled analysis		
	Ragi (C_1)	Soybean (C_2)	Niger (C_3)	Mean	Ragi (C_1)	Soybean (C_2)	Niger (C_3)	Mean	Pooled			
Residual moisture(I_1)	1507	1879	264	1217	331	399	58	263	740			
Protective irrigation at critical stages(I_2)	504	440	120	355	199	252	53	168	262			
Irrigation at 50% ASM (I_3)	225	310	97	211	190	221	55	155	173			
Mean	745	876	160		**240**	**291**	**55**					
Pooled					**293**	**584**	**108**					
F - test	I**	C**	IxC**		I**	C**	IxC**			I*	C**	IxC*
S. Em ±	3.006	5.031	8.714		1.698	1.961	3.379			2.000	3.001	4.950
C.D. at 5%	12.664	15.439	26.742		6.665	5.987	10.704			7.000	8.00	12.000

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COMPATIBILITY OF OILSEED CROPS INTERCROPPED WITH *Faidherbia albida* UNDER DIFFERENT ALLEY WIDTHS IN DRYLANDS

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ABSTRACT

In a two year study it was observed that the seed yields of sunflower and castor did not differ significantly in all alley widths when grown with *F. albida*, a nitrogen fixing tree, in comparison with the seed yields of respective sole crops. Though the yields of sole crops of sunflower and castor were slightly more, but the yields were comparable with the respective intercrop yields of sunflower and castor during both the years of study. Similar trend were observed in all yield components of sunflower and castor as well. The values of various physiological parameters like leaf temperature, relative humidity, photosynthetically active radiation, diffusive resistance and transpiration rate of sunflower and castor too did not vary much when grown as associated crops with trees when compared to the values of respective sole crops in both the years. The increment in height and girth of *F. albida* during 1991 and 1992 were also not affected by both the inter crops of sunflower and castor.

Key Words: ***Faidherbia albida***; Alley width; Component crops; Incremental growth; Sunflower; Castor.

Sunflower and castor are regarded as major oilseed crops contributing considerably to the oil seed production in the country. Both the crops have tremendous potential and exhibit wide range of adaptability to extreme climatic and edaphic conditions, as such they can be grown successfully under varying cropping situations. To augment the oilseed production in the country, concentrated efforts are required to extend the cultivation of these crops to non-traditional areas and also to introduce them in varying cropping systems. The studies on the performance of these oilseed crops under intercropping situation with nitrogen fixing trees is meagre. However, Singh (1984) had suggested agri-silvicultural systems of agroforestry having combinations of *Albizia lebbeck* + groundnut and sesame or *Prosopis cineraria* + sesame/groundnut/castor, for rainfall regions of 300 to 500 mm. Certain tree species like *F. albida* were found more compatible with arable crops owing to its main special characteristic of deciduous nature specially during *kharif* season. Being leguminous, it also offers possibility of supplementing the part of nitrogen requirements of associated crops, besides providing fodder, fuelwood and small timber etc. (Felker, 1978). Hence, the present investigation on compatibility of oilseed crops intercropped with *F. albida* in drylands was initiated.

MATERIALS AND METHODS

A field experiment was initiated in Randomized Block Design with three replications at Student's Farm, College of Agriculture, Rajendranagar, Hyderabad on red sandy loam soils having organic carbon content of 0.3% and low to medium in available nitrogen, medium in available phosphorus and high in available potash. The treatments consisted of three alley widths of *F. albida* (A1-3m, A2-4.2m and A3-5.4m), two intercrops (sunflower and castor), respective sole crops and sole trees. *F. albida* was planted during November 1988 with different alley widths as per the treatments and with uniform intra-row spacing of 3 metres. Under each alley width there were three rows of trees and 20 trees in each row, each alley width was suitably divided to form individual plots for sowing of arable crops. Sunflower and castor were sown as intercrops in three year old *F. albida* plantations with their respective recommended spacings during *kharif* seasons (8th July, 1991 and 15th July, 1992).

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The total rainfall received was 817 and 864 mm. during 1991 and 1992 respectively. But the rainfall received during the cropping season accounted for 496.8 mm (33 rainy days) and 483.7 mm (20 rainy days) during 1991 and 1992 respectively. The oilseed crops were fertilized with recommended doses of N,P and K. The physiological parameters like leaf temperature (L.T.), relative humidity (R.H.), photosynthetically active radiation (PAR), diffusive resistance (D.R.) and transpiration rate (T.R.) of sunflower and castor were recorded at different stages of crop growth using "steady state porometer" (LICOR, U.S.A).

RESULTS AND DISCUSSION

1. Yield and yield components

The yield components of sunflower and castor specially the test weight was not influenced significantly by intercropping with *F. albida* as compared to respective sole crops because of less height and poor canopy of the trees in the initial stages. Similarly the seed yields of sunflower and castor (Table 1.) showed that the yields were not affected significantly by intercropping with *F. albida* in both the years of study irrespective of alley widths. The seed yields of sunflower and castor in all alley widths of *F. albida* when grown as companion crops were comparable with the yields of respective sole crops in both the years. These results clearly showed that similar yields of sunflower and castor can be attained in association with *F. albida* due to enrichment of site and less shade effect as reported by Felkar (1978).

2. Physiological Parameters

The values on various physiological parameters (Table 2) of sunflower and castor at different stages (Grand growth and seed maturity periods)

Table 1. Yield of sunflower and castor intercropped with *F. albida* in different alley widths

Treatments	1000 seed wt. (g)		Seed yield (q/ha)	
	1991	1992	1991	1992
SUNFLOWER				
A1 + S	49.5	50.7	4.65	4.45
A2 + S	48.0	49.5	4.59	4.27
A3 + S	49.9	50.1	4.65	4.50
Mean			4.63	4.41
Sole S	53.7	51.2	4.70	4.60
CD at 5%	NS	NS	NS	NS
CASTOR				
A1 + C	163.5	150.6	3.58	4.08
A2 + C	164.9	147.7	3.89	4.08
A3 + C	159.0	149.4	4.31	4.10
Mean			3.93	4.09
Sole C	160.9	153.4	4.22	4.21
CD at 5%	NS	NS	NS	NS

A1 - Alley width - 3 metres   A 2 - Alley width - 4.2 metres
A 3 - Alley width - 5.4 metres   S = Sunflower
C = Castor

Table 2. Physiological parameters of sunflower and castor in association with *F. albida* in different alley widths

	1991					1992				
Treatments	L.T.	R.H.	PAR	D.R.	T.R.	L.T.	R.H.	PAR	D.R.	T.R.
Stage-I (Grand Growth Period)										
A1 + S	29.2	47.1	1290	0.16	69.5	29.0	49.7	1061	0.20	56.1
A2 + S	28.5	46.4	1297	0.15	67.5	29.4	49.3	1064	0.19	59.1
A3 + S	29.2	45.9	1441	0.17	60.2	30.4	48.2	1283	0.19	60.0
Mean	28.9	46.4	1343	0.16	65.7	29.5	49.0	1136	0.19	58.4
Sole S	29.2	46.6	1550	0.21	52.5	30.2	49.8	1385	0.19	70.0
A1 + C	29.4	46.5	1315	0.24	60.7	29.9	52.8	1132	0.22	55.9
A2 + C	29.3	46.4	1164	0.28	59.8	30.6	48.6	1024	0.22	71.1
A3 + C	28.9	46.7	1343	0.25	63.8	30.1	48.5	1046	0.15	66.7
Mean	29.2	46.5	1274	0.25	61.4	30.2	49.9	1067	0.19	64.5
Sole C	29.5	47.0	1587	0.26	58.6	30.8	48.2	1239	0.20	60.8
Stage - II (Seed Maturity Stage)										
A1 + S	31.2	47.6	1440	0.42	33.4	30.7	41.7	1389	0.44	23.3
A2 + S	31.0	47.2	1515	0.52	34.7	29.2	41.9	1178	0.40	24.2
A3 + S	30.8	46.7	1505	0.49	35.8	29.5	42.0	1281	0.34	23.0
Mean	31.0	47.1	1486	0.47	34.6	29.8	41.8	1282	0.39	23.5
Sole S	30.7	44.8	1590	0.49	33.7	29.3	42.0	1558	0.36	27.8
A1 + C	31.0	45.9	1410	0.47	29.6	31.1	35.6	1168	0.48	15.7
A2 + C	31.7	46.2	1253	0.41	38.9	31.5	37.3	1254	0.52	19.1
A3 + C	30.9	45.5	1500	0.49	33.2	31.8	35.4	1262	0.57	23.5
Mean	30.8	45.8	1387	0.46	33.9	31.4	36.1	1228	0.52	19.4
Sole C	32.0	45.4	1568	0.53	32.0	31.3	35.8	1336	0.53	21.7

L.T. = Leaf Temperature (0^0 c); R.H. = Relative Humidity (%); PAR = Photosynthetically Active Radiation (moles/sec/m^2)
D.R. = Diffusive resistance (sec/cm); T.R. = Transpiration Rate (g/cm/sec.); S = Sunflower; C = Castor.

were comparable in both the intercropping and sole cropping systems. Similar pattern was observed in all alley widths in association with *F. albida* in both the years of experimentation though PAR values were slightly lower in closer alley widths. The observations recorded during different periods of the day revealed that the lower values of L.T. and higher values of R.H. of leaf in the morning hours (9 to 11 a.m.) resulted in less diffusive resistance and higher transpiration rates leading to higher intake of CO_2 in the crops, where as during evening hours (1 to 3 p.m.) a reverse phenomenon was noticed. Similarly during seed maturity stage of the companion crops the resistance offered by the leaves was more resulting in decrease of the intake of CO_2 during grand growth period. The reason being the active growth of the crops having high photosynthetic activity resulting in lower values of diffusive resistance of leaves leading to higher intake of CO_2 and more of transpiration. This shows that the diurnal variations and the development stage of crop growth cause variation in leaf turgidity which inturn influence the physiological functions of the plants. But these changes were not noticed in all the cropping systems. The data revealed that *F. albida* tree canopies did not compete for natural resources with the associated oilseed crops, during the period of study, being deciduous, showing that both the tree and oilseed crops like sunflower being of short growing season can be grown in harmony with each other for sustainable crop production in drylands. Peter Poschen (1986) reported increased crop yields under *F. albida* tree canopies due to its deciduous habit and sparse crown.

3. Height and Girth of F. albida

The height and girth of *F. albida* trees (Table 3.) were not affected by the growth of the companion crop in different alley widths in both the years of study. However, mean annual increment in height and girth of *F. albida* was less in association with castor than sunflower because of long duration nature of castor crop. Trees under intercropping systems attained better height and girth as compared to sole trees may be by utilising the fertilizers applied to the intercrops. But the trees in closer alley width had better height and girth than in wider alleys which may be due to exporting deeper soil layers because of high density.

Thus it is clearly evident from the results of experiment that the oilseed crops like sunflower and castor perform well under rainfed conditions in association with tree like *Faidherbia albida* which render in enhancing the area and production of oilseed crops in marginal lands in turn provide stability and sustainability to the substance farming carried out by dry land farmers.

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Table 3 : Height and Girth of *F. Albida* influenced by oil seed intercrops

Treat-ments	Height (m)							Girth (cm)						
	1991			1992				1991			1992			
	B.C.	A.C	Inct.	B.C.	A.C.	Inct.	O.A.I.	B.C.	A.C.	Inct.	B.C.	A.C.	Inct.	OAI
A1+S	2.73	2.94	0.21	3.97	4.27	0.31	0.77	19.4	21.5	2.1	35.4	37.8	2.4	9.2
A2+S	3.06	3.30	0.24	3.60	4.02	0.42	0.48	25.2	28.0	2.8	31.0	33.5	2.5	4.2
A3+S	2.43	2.92	0.49	3.55	3.34	0.30	0.45	17.6	21.4	3.8	30.7	33.7	3.0	8.1
Mean	2.74	3.05	0.31	3.70	4.04	0.34	0.57	20.7	23.6	2.9	32.3	35.0	2.7	7.1
A1+C	3.01	3.30	0.29	3.53	3.81	0.28	0.40	23.8	25.9	2.1	25.3	26.6	1.3	1.4
A2+C	3.17	3.61	0.44	3.63	3.86	0.23	0.34	23.5	26.2	2.7	30.6	33.1	2.5	4.8
A3+C	2.70	3.24	0.55	3.24	3.72	0.48	0.51	23.8	28.2	4.4	26.8	29.9	3.1	3.1
Mean	2.96	3.38	0.42	3.46	3.79	0.33	0.41	23.7	26.7	3.0	27.5	29.8	2.3	3.1
A1 Sole	2.92	2.98	0.06	3.07	3.47	0.40	0.27	24.6	27.5	2.9	31.8	33.6	1.8	4.5
A2 Sole	4.15	4.40	0.25	4.46	4.80	0.34	0.32	27.1	30.1	3.0	35.7	37.5	1.8	5.2
A3 Sole	2.84	3.26	0.42	3.30	3.77	0.48	0.46	23.1	25.4	2.3	28.7	31.0	2.3	3.9
Mean	3.30	3.54	0.24	3.61	4.01	0.40	0.35	24.9	27.6	2.7	32.0	34.0	2.0	4.5

S = Sunflower
C = Castor

B.C. = Before annual cropping
A.C. = After annual Cropping
Inct = Increment
O.A.I. + Overall Annual Increment

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EFFECT OF SULPHUR ON GROWTH, YIELD, PROTEIN AND OIL CONTENT OF SOYBEAN (*Glycine max* (L) Merr.)

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ABSTRACT

In a field experiment conducted on sulphur deficient alluvial soil, four levels of sulphur was applied to soybean cultivar P.K. 327 through ammonium sulphate, single superphosphate and elemental sulphur. The studies revealed that the growth, yield contributing parameters, yield, protein as well as oil content was influenced with increasing levels of sulphur. Application of 40 kg sulphur ha^{-1} through ammonium sulphate was found more economical. Sulphur levels significantly increased the protein content of seeds. Highest oil content in soybean seeds and other yield contributing parameters were recorded when 40 kg ha^{-1} sulphur was applied through ammonium sulphate. Ammonium sulphate was found to be a relatively better sources of sulphur than single superphosphate or elemental sulphur.

Key Words: Soybean; Sulphur fertilization; Oil content; Protein; Growth; Yield contributing parameters.

Soybean is a high yielding pulse crop rich in both protein (40%) and edible oil. The crop requires very high nutrient application. Legumes are usually rich in protein and requires larger quantities of sulpher application. Beneficial effect of sulphur application to soybean and other legumes in sulphur deficient soils were reported by Fox and Hoover (1961), Saggar and Dev(1974), Aulakh *et al.,* (1977). Pasricha and Randhawa (1973) and Dhillon and Dev (1978) indicated that soybean is quite responsive to sulphur application and that it has a high sulphur requirement due to higher quantities of protein - S and S - containing aminoacid. Sulphur is a constituent of three aminoacids (methionine, cysteine and cystine) thus vital for protein synthesis. This paper presents results of an experiment conducted to evaluate the effectiveness of different sources of sulphur on growth, yield contributing parameters, yield, protein as well as oil content in soybean.

MATERIALS AND METHODS

A field experiment was conducted at the Research Farm of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during *kharif* season of 1992. The soil of the experimental field is a typical Ustochrept formed on alluvium deposited by the river Ganga. The average pH of the soil was 7.2 and its organic carbon, available N, P, K, Ca and Mg status were 0.525, 197, 24.9, 159.4, 152.6 and 63.64 kg ha^{-1}, respectively. The soil was deficient in available sulphur (9.3 ppm). The experiment was laid out in a Randomised Block Design with factorial arrangement with four replications. The treatments consisted of 4 levels of sulphur (0, 20, 30, 40 kg ha^{-1}) applied as ammonium sulphate, single superphosphate and elemental sulphur. N,P,K fertilisers @ 40:60:40 kg ha^{-1} were applied through urea, DAP and muriate of potash. Nitrogen and P quantities were balanced with appropriate quantities of urea and DAP. All the treatments and fertilizers were applied as basal application. Elemental sulphur (92% pure) was applied 10 days before sowing. Soybean cultivar P.K. 327 was sown in rows 40 cm apart at a seed rate of 75 kg ha^{-1}. All the recommended cultural practices were followed to raise the crop. Ten plants from each treatment were selected randomly for growth and yield attributing parameters. The seed and straw yield was recorded on net plot (4 x 1.2 m) wise and finally expressed into quintal per hectare. The protein content (per cent) in seed was estimated by

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multiplying the per cent concentration of nitrogen (Walinga *et al.*, (1989) with 6.25. The protein production (kg ha^{-1}) was computed by multiplying the present value of protein with respective seed yield. Oil content in soybean was extracted with a Soxhlet extractor using ether as the extractant.

RESULTS AND DISCUSSION

Growth and yield attributes

The data presented in Table 1 showed that different levels of sulphur had significant influence on plant height, number of branches per plant, number of pods per plant, seed per pod and test weight. Significant increase in plant height was due to the vigorous root growth and establishment of the nitrogen fixation by nodules activated and reached to the requisite level by sulphur. Increase in number of pods per plant may be due to the higher plant height. Significant increase in 100 seed weight at higher levels of sulphur (40 kg ha^{-1}) but not at lower doses, may be due to the fact that at lower dose of sulphur, plant could not attain normal vigour and growth in the absence of optimal dose of sulphur. Similar findings were also obtained by Fazal and Sisodia (1989) and Singh and Singh (1975).

Among the different levels of sulphur higher plant height, number of pods per plant, primary branches and 100 seed weight were obtained with the application of sulphur @ 40 kg ha^{-1} through ammonium sulphate. The increase in number of pods per plant and 100 seed weight with higher sulphur levels may be due to the balanced system of nutrition and consequently producing healthy seeds.

Seed and Straw yield

Significant increase in seed and straw yield was obtained by increasing levels of sulphur. Maximum seed yield of 17.55 q/ha was obtained with the application of 40 kg S/ha through ammonium sulphate (Table 2). The increase in seed and stalk yield with increasing sulphur levels may be due to the conductive effect of sulphur

Table 1. Growth and yield attributing characters of soybean as influenced by sulphur levels.

Treatments	Plant height (cm)	Branches/ plant	No. of pods/ plant	No. of seeds/ pod	Pod length (cm)	100 seed Test weight (g)
Control	82.00	3.90	57.50	2.50	3.6	9.51
Ammonium Sulphate 20 kg/ha	83.90	4.56	76.00	3.13	3.9	10.27
Ammonium Sulphate 30 kg/ha	87.70	5.50	97.80	3.70	4.1	10.86
Ammonium Sulphate 40 kg/ha	89.40	6.33	103.50	3.90	5.2	11.03
Superphosphate 20 kg/ha	82.80	4.16	75.67	3.20	4.1	10.68
Superphosphate 30 kg/ha	87.00	5.00	96.80	3.60	4.9	10.79
Superphosphate 40 kg/ha	88.20	5.86	100.20	3.63	5.0	10.93
Elemental Sulphur 20 kg/ha	83.12	4.00	74.50	3.06	3.8	9.74
Elemental Sulphur 30 kg/ha	86.27	4.36	89.83	3.40	3.9	9.76
Elemental Sulphur 40 kg/ha	87.93	5.26	97.00	3.56	4.7	10.20
CD (5%)						
Treatment	1.26	0.47	4.25	0.24	0.29	2.0
S Sources	0.37	0.23	2.12	0.12	0.12	0.98
S Levels	0.59	0.27	2.45	0.13	0.17	1.13

levels on pods per plant, seeds per pod and 100 seed weight. The increase in straw yield with higher levels of sulphur was due to favourable growth components.

Maximum seed yield was obtained at 40 kg S ha^{-1} which was significantly superior to lower doses. However, on the basis of mean value the seed yield increased significantly with every increase in rate of sulphur application. This may be due to favourable effect of sulphur on plant height, number of pods per plant and 100 seed weight. Similar results were also reported by Kumar and Singh (1980), Pasricha and Randhawa (1973) and Dhillon and Dev (1980).

Protein content

The protein content (Table 2) of seed increased with the increase in sulphur levels. Maximum protein content (40.27%) was recorded at 40 kg S ha^{-1} through ammonium sulphate. The protein content is directly related with nitrogen content of the seed. The plant absorbed sulphur proportionately as a pool of available sulphur increased in soil by addition of higher doses of sulphur. A close association of sulphur with nitrogen is the synthesis of protein and enzymes and biological fixation of nitrogen by legumes has been established. Aulakh *et al.*, (1977) observed that sulphur application accelerated the metabolic activity related with protein synthesis in *alfalfa*. Kumar *et al.*, (1981) reported that increasing levels of sulphur increased the per cent crude protein system, cystein and methionine content in soybean grain. Similar results were also reported by Sharma and Bradford (1973) and Arora and Luthra (1971).

Protein Yield

Almost a similar trend of response as described earlier in seed yield was noticed in case of protein yield. Sulphur application had marked influence on protein yield (Table 2), each increase in levels of sulphur increased the protein yield. Maximum protein yield of 706.74 kg ha^{-1} was harvested with the application of 40 kg sulphur through ammonium sulphate. Increase in sulphur dose produced significantly higher protein per hectare over lower and medium doses.

Table 2. Yields, protein content, protein yield (kg/ha) and oil content in soybean as influenced by sulphur levels.

Treatments	Seed yield (q/ha)	Straw yield (q/ha)	Protein content (%)	Protein yield (kg/ha)	Oil content (%)
Control	11.96	16.80	27.71	331.41	22.34
Ammonium Sulphate 20 kg/ha	14.55	19.20	31.89	464.00	22.88
Ammonium Sulphate 30 kg/ha	15.65	19.95	38.10	596.27	23.67
Ammonium Sulphate 40 kg/ha	17.55	22.38	40.27	706.74	23.74
Superphosphate 20 kg/ha	14.74	18.65	31.92	470.50	21.86
Superphosphate 30 kg/ha	15.68	19.65	38.31	600.70	22.34
Superphosphate 40 kg/ha	17.39	21.76	40.02	695.95	23.29
Elemental Sulphur 20 kg/ha	14.66	18.67	31.12	456.22	21.95
Elemental Sulphur 30 kg/ha	15.68	20.20	34.54	541.59	22.16
Elemental Sulphur 40 kg/ha	17.40	21.72	38.83	675.64	23.16
C.D. (5%)					
Treatment	0.25	0.23	0.46	42.65	0.48
S Sources	0.14	0.14	0.27	23.12	0.28
S Levels	N.S.	N.S.	0.23	19.06	0.24

Oil content

The oil content (Table 2) increased with the increase in sulphur levels. Ammonium Sulphate 30 and Ammonium Sulphate 40 treatments were at par in oil content and were closely followed by Superphosphate 40. The maximum oil content (23.74%) was recorded at 40 kg S ha^{-1}. Similar results were also reported by Pasricha and Randhawa (1973), Kumar *et al.*, (1981) and Aulakh *et al.*, (1990).

The yield attributes like number of pods per plant, seeds per pod and 100 seed weight increased appreciably with increasing sulphur levels. The seed, straw yield, protein and oil content increased significantly with each increase in sulphur levels. The study indicated that application of 40 kg S/ha through ammonium sulphate, superphosphate or elemental sulphur in order of preference is helpful in achieving higher productivity with better bean quality with respect to oil and protein contents.

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MECHANICAL EXPRESSION OF OIL FROM SAFFLOWER
(Carthamus tinctorius)

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ABSTRACT

Studies were conducted for extraction of oil from safflower (Var. JSF-1) using small and medium capacity screw type oil expellers, Model I and Model II. The paper presents the comparative performance of these two expellers in terms of capacity and oil recovery as affected by different seed pre-treatments, viz: instant water addition, size reduction and mixing calculated amount of seed hull with the decorticated kernels in the feed prior to expelling under cold pressing. While extracting oil from whole seed, it was observed that both the expellers got choked. Similarly, use of fully decorticated kernels resulted in the formation of semi-liquid paste without cake formation and any oil yield. The oil recovery (two pass basis) varied between 80.4 to 88.7% for Model I and from 48.4 to 81.6% for Model II expeller depending on hull percentage in the feed. The maximum crushing capacity was found to be 10.0 and 40.0 kg of seed/hour for Model I and Model II expellers, respectively. Whereas, energy consumption at maximum oil recovery was observed as 0.180 Kwh and 0.104 Kwh per kg of seed crushed in Model I and Model II expellers, respectively.

Keywords: Safflower; Mechanical expression; Pre-treatment; Oil recovery.

Large scale cultivation of safflower, containing 35 to 40 per cent oil, has started about 25 years ago in India. Traditionally known as source of dye in ancient India, the safflower has attained considerable importance as an oilseed crop. Increasing interest is being evinced in safflower (Sawant and Moghe, 1985) oil for edible purposes in India and abroad in view of the high essential fatty acid (linoleic acid) content of the oil. This trend consequently, has given impetus to the development of better strains of seed on the one hand and to adopting more efficient methods of processing the seed for oil recovery on the other (Lakshminarayana and Afzalpurkar, 1988). Being a new crop identified for edible oil, very little attention has been given towards the development of modern technology on various post harvest aspects of safflower. In modern methods, oil from safflower seed is extracted by continuous press, combination of continuous press and solvent extraction or by direct extraction. Hydraulic press and screw press are also used for this purpose (Shukla *et al.,* 1992).

Studies conducted at OTRI, Anantapur (Shukla *et al.,* 1992) reported that there is not much difficulty in expelling of either whole or ground cooked seed containing all the hull but as the percentage of hull decreases, it presents difficulty in formation of normal cake as the whole material becomes a mass in the cooker itself and expeller does not accept the pasty mass. Since safflower seed contains 46% hull (Annual report, 1992) by weight and it is very hard to crush in mechanical expellers under cold pressing. However, various investigators (Singh and Bargale, 1990) conducted studies on various oilseeds and reported that choke settings, pre-treatments and the moisture content influenced the capacity, per cent oil recovery and thickness of the cake. Therefore, it was felt that pre-treatment of seeds may help the expression of oil using mechanical expellers. The present article describes about the effect of different pre-treatments on oil recovery from safflower under cold pressing.

MATERIALS AND METHODS

The two oil expellers used for extraction of oil from safflower seeds (Fig. 1 & 2) consist of feed hopper, three major assemblies namely worm shaft and operating screw, feed barrel and main

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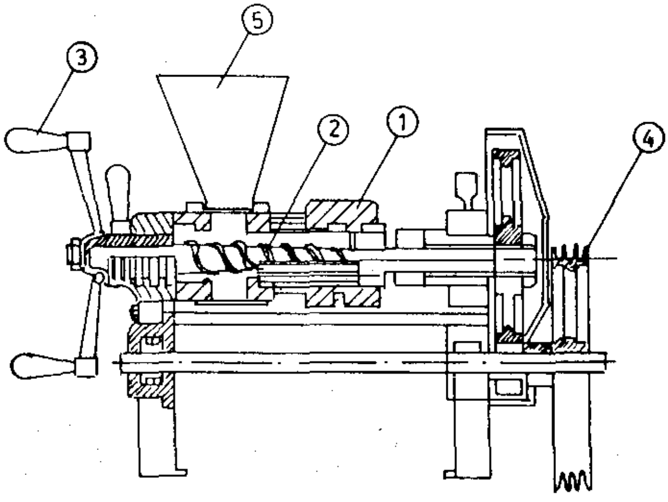
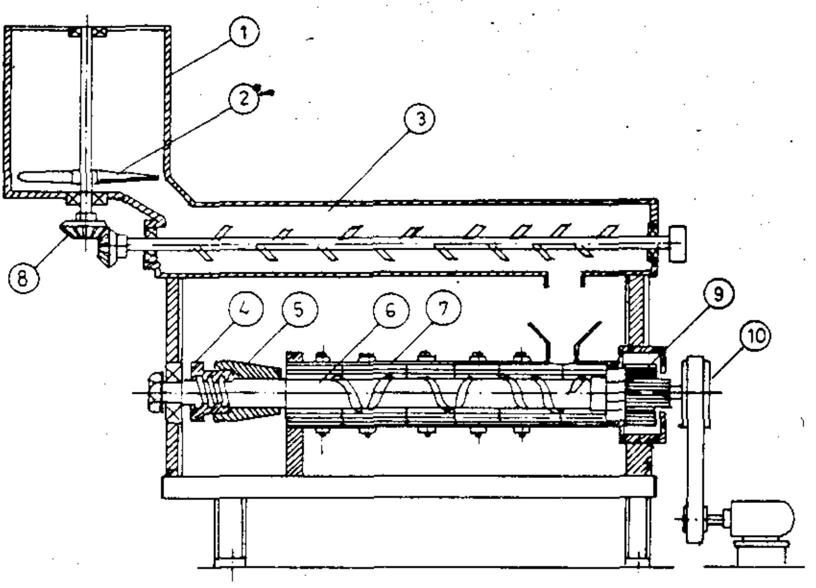


1. DRUM
2. WORM SHAFT
3. HANDLE
4. PULLEY
5. HOPPER

FIG.1. SECTIONAL VIEW OF MODEL-I EXPELLER



1. HOPPER
2. AGITATOR
3. FEEDING KETTLE
4. CHUCK NUT
5. TAPERED BUSH
6. WORM SHAFT
7. BARREL
8 BEVEL GEAR
9 GEAR-PINION
10. PULLEY

FIG. 2. SECTIONAL VIEW OF MODEL-II EXPELLER

frame-drive. The details of worm shaft of both the expellers are shown in Fig. 3 & 4. While Table 1 reports the other relevant details of these expellers. Model I is reported to be suitable for mustard and groundnut whereas, Model II is recommended for crushing of all major oil seeds.

Safflower (Var. JSF-1) taken for the study, was cleaned of its impurities like trasnes, dirt, dust etc. The oil content of safflower seed was determined using soxhlet extraction method. A weighed amount of dry sample was taken into a thimble and plugged with cotton, placed in soxhlet apparatus and extracted with an-hydrous hexane for about 16 hours (Raghuramulu *et al.*, 1983). The oil content of the seed was found as 29.0 per cent.

For expression of oil, the following pre-treatments were given to the seed,

i) Instant addition of water to raise the moisture content and sprinkling of pre-determined quantity of water in the seed 24 hr earlier to expression and putting the sample in air-tight polythelene bags to attain uniform moisture

ii) size reduction of whole seed in a multi-purpose mini-grain mill and instant water addition

iii) mixing calculated amount of seed hull with the decorticated kernels prior to expelling.

The decorticated kernels and hull was separated out with the help of sieving. The size of the kernel was reduced in the range of 6.42 mm from the average size of the kernel, i.e. 8.64 mm. The moisture content of seed was determined by standard hot-air-oven method by placing a sample of 25-30 g in the hot air oven at 100^0 C for 72 hours (Hall, 1970). The sample was then cooled in a desiccator, weighed and the moisture content of seeds was determined. The barrel clearance was adjusted by using handle provided in both the expellers and time taken for crushing the seed in each pass was observed by using a stop watch (least count 0.1 sec.). Model I expeller was operated under maximum pressing, i.e. the clearance between the barrel and screw was maintained at minimum (4 mm) whereas clearance in Model II expeller was kept between 7-8 mm during all the experiments. Energy consumption was recorded with the help of energy meter reading 60 revolutions of rotating disc for 1 Kwh. The following methods were used for the calculation of capacity, extraction efficiency and oil content in the cake.

Capacity of expeller (kg / h) =

$$\frac{\text{quantity of sample crushed}}{\text{time required to crush the sample in minutes}} \times 60$$

Extraction efficiency of expeller (%) =

$$\frac{\text{quantity of oil expelled}}{\text{amount of oil available in sample}} \times 100$$

Table 1. Comparative description of small and medium capacity screw type oil expeller

Parameters	Model I (Table oil expeller)	Model II (Tiny tech oil expeller)
Overall dimensions, mm x mm x mm	1060 x 530 x 890	2700 x 1460 x 1970
Power requirement, hp	2	10
Labour requirement	2	2
Rated capacity, kg seed/h	30	100
Suitability for oilseeds	Mustard & groundnut	Groundnut and other major oilseeds
Developed by	M/s S.P. Engg., Corporation, Kanpur, India.	M/s Tiny Tech Udyog, Rajkot, India.

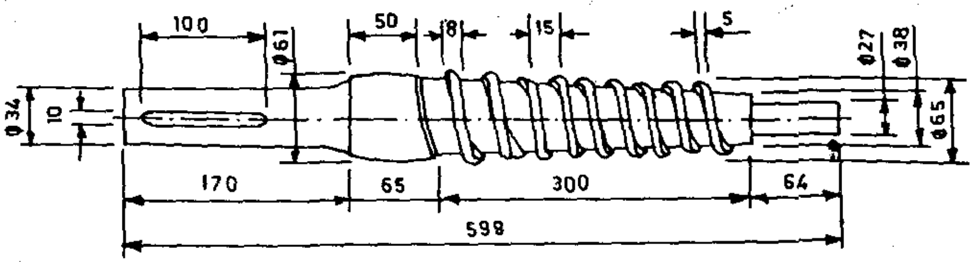


Fig. 3 Detail of worm shaft of model-I oil expeller

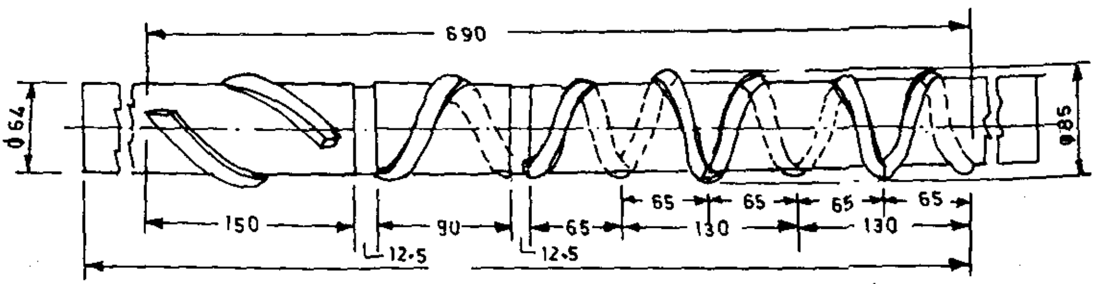


Fig. 4 Detail of worm shaft of model-II oil expeller

Oil content in the cake was determined using Soxhlet extraction method explained earlier.

RESULTS AND DISCUSSION

While extracting oil from whole safflower seeds with expellers, it was observed that both expellers got choked. Similarly, use of fully decorticated seed resulted in the formation of semi-liquid paste without cake formation and any oil recovery. This happened probably because hull of safflower seed is very hard and its percentage in the seed is quite high (46% by weight) whereas, fully decorticated kernels cause the plasticizing effect, which reduces the level of compression resulting from cake matrix. It is in agreement with the studies of Srivastava *et al.,* 1990 on sunflower. Increasing moisture content of whole safflower seeds either by instant water addition or mixing of water 24 hours prior to expelling did not give any oil recovery. Similarly, size reduction of seeds also did not help in expression of oil from safflower.

Results of the oil recovery and energy consumption in respect of feed having different hull content, i.e. 10, 20, 30, 40, 50 and 60 per cent are shown in Table 2 and Figs. 5 & 6. As can be seen from Fig. 5, oil recovery varied from 80.4 to

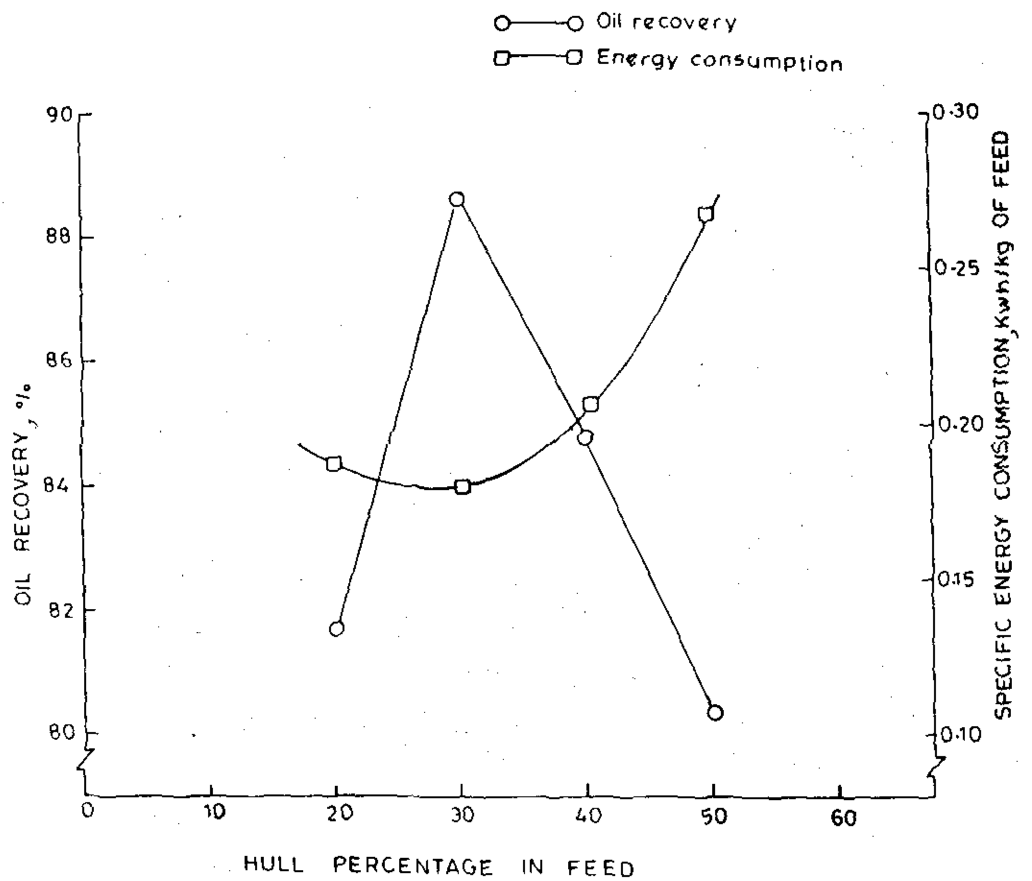


FIG. 5. VARIATION IN OIL RECOVERY AND SPECIFIC ENERGY CONSUMPTION WITH HULL PERCENTAGE IN FEED FOR MODEL-I EXPELLER

Table 2. Comparative performance of oil expellers for safflower (2 pass basis)

Treatment: Mixing calculated amount of hull with decorticated kernels followed by instant water addition.

Composition of feed	M.C. of seed % (wb)	Oil recovery Ist Pass	Oil recovery IInd Pass	Oil recovery Total	Energy Consumption Kwh/kg
Model I expeller					
Whole seeds	7.1	expeller choked			
decorticated kernels	9.4	semi-liquid paste and no oil			
10% hull + 90% decorticated kernels	9.2	*semi-liquid paste and no oil*			
20% hull + 80% decorticated kernels	9.4	65.4	16.3	81.7	0.188
30% hull + 70% decorticated kernels	9.3	78.7	10.0	88.7	0.180
40% hull + 60% decorticated kernels	9.2	71.2	13.6	84.8	0.206
50% hull + 50% decorticated kernels	9.4	67.6	12.8	80.4	0.268
60% hull + 40% decorticated kernels	9.2	expeller choked			
Model II expeller					
Whole seeds	7.1	expeller choked			
Decorticated kernels	9.3	semi-liquid paste and no oil			
10% hull + 90% decorticated kernels	9.2	*			
20% hull + 80% decorticated kernels	9.6	*			
30% hull + 70% decorticated kernels	9.2	35.3	13.1	48.4	0.110
35% hull + 65% decorticated kernels	9.4	64.5	17.1	81.6	0.104
40% hull + 60% decorticated kernels	9.3	50.4	25.9	76.3	0.122
50% hull + 50% decorticated kernels	8.9	49.5	10.9	60.4	0.130
60% hull + 40% decorticated kernels	9.2	39.7	15.3	55.0	0.156
70% hull + 30% decorticated kernels.	9.1	expeller choked			

* semi-liquid paste and no oil

88.7% in Model I expeller depending upon hull content in the feed. It can be clearly seen from Table 2 that semi liquid paste was obtained without any oil yield upto 10% hull content and expeller got choked when hull content in the feed exceeded 59%. In other words, expeller could yield oil within 20 to 50 per cent hull in the feed. The maximum oil recovery i.e. 88.7% was obtained while the mixture of 70% decorticated kernels and 30% hull was expelled. The crushing capacity at maximum oil recovery was found at 10 kg/h whereas, energy consumption varied from 0.180 to 0.268 Kwh/kg of feed depending on hull content, i.e. 20 to 50% in the feed.

Similarly, Model II expeller gave oil recovery from 48.4 to 81.6% depending on the hull content in the feed (Fig. 6). This expeller also gave semi-liquid paste upto 20% hull content and got choked beyond 60% hull percentage in the feed. In other words, Model II expeller could yield oil within 30

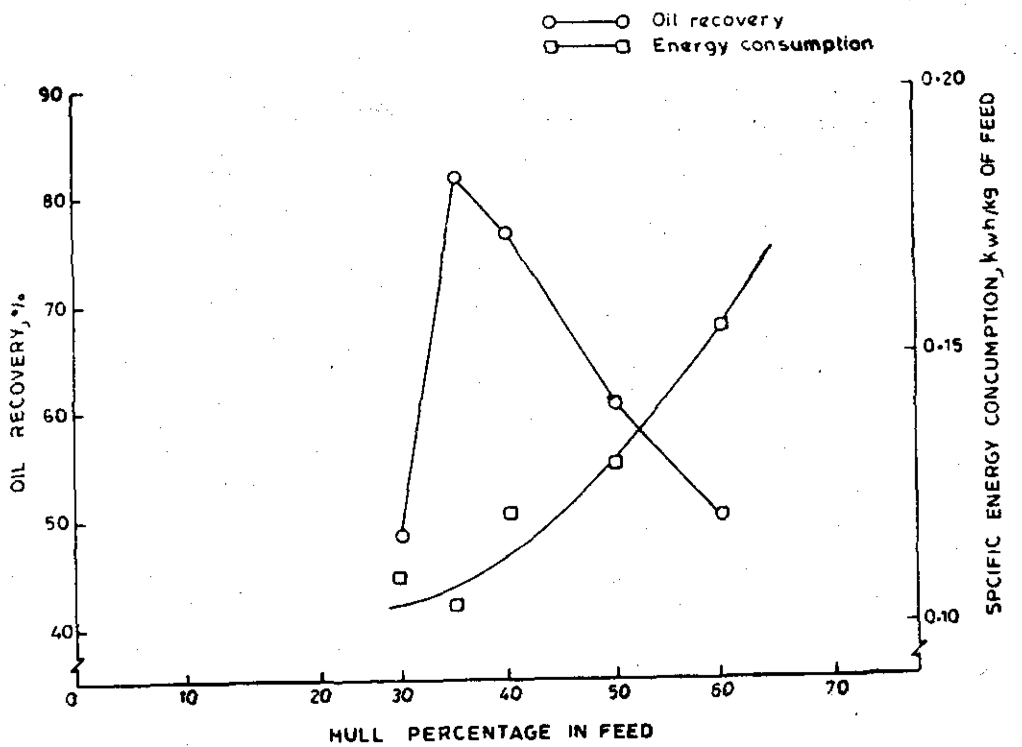


FIG. 6. VARIATION IN OIL RECOVERY AND SPECIFIC ENERGY CONSUMPTION WITH HULL PERCENTAGE IN FEED FOR MODEL-II EXPELLER

to 69 per cent hull content in the feed. The maximum oil recovery i.e. 81.6% was obtained while 65% decorticated kernels and 35% hull was mixed in the feed. The crushing capacity at maximum oil recovery was found as 40 kg/h whereas, energy consumption varied from 0.110 to 1.56 Kwh/kg of feed depending on hull percentage, i.e. 30 to 60% in the feed.

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SHORT COMMUNICATIONS

INTERRELATION AMONG VARIABLES AND THEIR IMPLICATION IN SELECTION FOR YIELD IN SOYBEAN*

Present investigation was undertaken to ascertain interrelationships of different traits in soybean (*Glycine max* merr.), Through correlation, multiple linear regression and path coefficient analysis.

A set of 40 genotypes of soybean collected from different agro-climatic regions of the country were grown in Randomised Block Design in three replications during *kharif* 1986. Detailed observations were recorded for twelve characters. Correlation coefficient, multiple regression and path coefficient were done by standard methods.

Seed yield showed a highly significant positive correlation with number of pods per cluster, number of seeds per plant, number of clusters per plant, number of leaflets per plant, number of pods per plant, number of primary branches per plant, plant height, days to 50 per cent flowering and maturity. Earlier, Veeraswamy and Rathnaswamy (1975), Sharma *et al.*, (1983) and Mahto and Haider (1990) have also reported similar result for different character combinations with yield. Seed yield, however, had weak positive association with 100 seed weight and number of seeds per pod. Weak positive association of 100 seed weight has also been reported by Lal and Haque (1971), Mahto and Haider (1990) and Prabhakar and Tiwari (1993). The present findings show significant negative association between 100 seed weight and number of seeds per pod and number of seeds per plant; while number of seeds per pod had negative association with days to maturity. This has also been reported by Mahto and Haider (1990). Number of pods per plant showed a highly significant and positive interaction with number of pods per cluster, number of seeds per plant, number of clusters per plant, number of leaflets per plant, number of primary branches per plant, plant height, days to 50 per cent flowering and maturity as has also been reported by Lal and Haque, 1971; Sharma *et al.*, 1983 and Mahto and Haider, 1990. Number of pods per cluster had a highly significant and positive correlation with number of seeds per plant and days to 50 per cent flowering.

As is evident from Table 1, the number of seeds per plant had direct positive influence (0.5514) on seed yield and was followed by, 100 seed weight. Earlier, Mahto and Haider (1990) also observed similar results in soybean. Plant height had the least direct negative influence on seed yield. Most of the variables contributed through number of seeds per plant. This is in confirmity to the findings of Patil and Pokle (1974).

The multiple regression equation based on number of leaflets per plant, 100 seed weight, number of seeds per pod, number of pods per plant, number of seeds per plant, number of clusters per plant, days to maturity and number of leaflets per plant accounted for 67.5 per cent variability in seed yield (Table 2). Partial regression coefficient of yield attributing characters, except plant height, were positive. This was expected in view of positive correlation coefficient between yield and yield contributing characters because it is in perfect accordance with the results of path coefficient analysis. Prabhakar and Tiwari (1993) also

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identified a desirable sub set through multiple regression analysis where pods per plant was more important than seed size in contributing towards yield.

From the study it is evident that for effective selection in soybean, all the characters, barring 100 seed weight, number of seeds per pod and plant height, are to be taken into consideration.

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Table 1. Direct (diagonal) and indirect effects (off diagonal) of different characters on seed yield in soybean

Characters	100 seed weight (g)	Number of seeds/ pod	Number of pods/ plant	Number of pods/ clusters	Number of seeds/ plant	Number of clusters/ plant	Plant height (cm)	Days to 50 per cent flowering	Days to maturity	Number of primary branches/ plant	Number of leaf-lets/ plant	Correlation with seed yield
100 seed weight(g)	0.4043	-0.0736	-0.0105	0.0102	-0.1800	-0.0363	0.0004	-0.0253	0.0048	-0.0044	-0.0154	0.0537
Number of seeds/pod	-0.1473	0.2020	-0.0041	-0.0000	0.1617	-0.0114	0.0004	-0.0160	-0.0070	0.0009	-0.0080	0.1712
Number of pods/plant	-0.0689	-0.0134	0.0615	0.0268	0.3509	0.1080	-0.0106	0.0785	0.0111	0.0170	0.0799	0.6407 **
Number of pods/cluster	-0.0531	-0.0001	0.0213	0.0773	0.2676	-0.0156	-0.0018	0.0827	0.0055	0.0063	0.0217	0.4118**
Number of seeds/plant	-0.1319	0.0583	0.0391	0.0375	0.5514	0.1535	-0.0100	0.0955	0.0090	0.0221	0.0842	0.9095**
Number of clusters/plant	-0.0689	-0.0108	0.0312	-0.0097	0.3973	0.2130	-0.0109	0.0631	0.0097	0.0193	0.0826	0.7194**
Plant height(cm)	-0.0093	-0.0045	0.0391	0.0083	-0.3322	0.1393	-0.0166	0.0623	0.0060	0.0134	0.0687	0.6390**
Days to 50% flowering	-0.0765	-0.0242	0.0361	0.0478	0.3936	0.1004	-0.0077	0.1338	0.0118	0.0162	0.0739	0.7091**
Days to maturity	0.0888	-0.0653	0.0314	0.0194	0.2273	0.0897	-0.0046	0.0728	0.0217	0.0152	0.0629	0.5534**
Number of primary branches/plant	-0.0634	0.0067	0.0369	0.0173	0.4299	0.1451	-0.0079	0.0765	0.0117	0.0283	0.0938	0.7752**
Number of leaflets/plan	-0.0532	-0.0138	0.0420	0.0143	0.3960	0.1501	-0.0097	0.0843	0.0117	0.0226	0.1177	0.7614**

Note: (i) Residual efect = 0.1035 and (ii) Directefects are underlined.

Table 2. Individual and multiple linear regression equation alongwith contribution to seed yield in soybean.

Individual and multiple linear regression equation	Contribution to seed yield (%)
$\hat{Y} = 12.7108 + 0.1352\, X_1^{*}$ (100 seed weight)	99.791
$\hat{Y} = 7.6822 + 4.0898\, X_2^{**}$ (Number of seeds per pod)	96.310
$\hat{Y} = 5.3030 + 0.1410\, X_3^{**}$ (Number of pods per plant)	94.299
$\hat{Y} = 4.8268 + 1.7762\, X_4^{**}$ (Number of pods per cluster)	94.212
$\hat{Y} = 2.0998 + 0.1129\, X_5^{**}$ (Number of seeds per plant)	91.686
$\hat{Y} = 3.5983 + 0.8723\, X_6^{**}$ (Number of clusters per plant)	93.022
$\hat{Y} = 4.4853 + 0.2312\, X_7^{**}$ (Plant height)	93.741
$\hat{Y} = -15.0481 + 0.6895\, X_8^{**}$ (Days to 50 per cent flowering)	80.253
$\hat{Y} = -8.2494 + 0.2358\, X_9^{**}$ (Days to maturity)	85.100
$\hat{Y} = -1.6040 + 3.6471\, X_{10}^{**}$ (Number of primary branches per plant)	89.389
$\hat{Y} = 3.8966 + 0.3852\, X_{11}^{**}$ (Number of leaflets per plant)	93.164
$\hat{Y} = -29.0465 + 1.0302\, X_1^{**} + 4.8464\, X_2^{**} + 0.0144\, X_3^{**} + 0.3333\, X_4^{**} + 0.0683\, X_5^{**} + 0.2602\, X_6^{**} - 0.0067\, X_7^{**} + 0.1315\, X_8^{**} + 0.0086\, X_9^{**} + 0.1326\, X_{10}^{**} + 0.0588\, X_{11}^{**}$	58.860
$\hat{Y} = -29.2219 + 1.0078\, X_1^{**} + 4.8946\, X_2^{**} + 0.0125\, X_3^{**} + 0.3527\, X_4^{**} + 0.0670\, X_5^{**} + 0.2548\, X_6^{**} + 0.1288\, X_8^{**} + 0.0109\, X_9^{**} + 0.1571\, X_{10}^{**} + 0.0583\, X_{11}^{**}$	60.735
$\hat{Y} = -28.3438 + 1.0054\, X_1^{**} + 4.6833\, X_2^{**} + 0.0121\, X_3^{**} + 0.3028\, X_4^{**} + 0.0715\, X_5^{**} + 0.2391\, X_6^{**} + 0.1243\, X_8^{**} + 0.0131\, X_9^{**} + 0.0644\, X_{11}^{**}$	62.820
$\hat{Y} = -27.6777 + 1.0289\, X_1^{**} + 4.5257\, X_2^{**} + 0.0135\, X_3^{**} + 0.2922\, X_4^{**} + 0.0723\, _5^{**} + 0.2388\, X_6^{**} + 0.1334\, X_8^{**} + 0.0663\, X_{11}^{**}$	64.569
$\hat{Y} = -25.4819 + 1.0268\, X_1^{**} + 3.8038\, X_2^{**} + 0.0135\, X_3^{**} + 0.0837\, X_5^{**} + 0.1565\, X_6^{**} + 0.1486\, X_8^{**} + 0.0573\, X_{11}^{**}$	67.469

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

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PATH COEFFICIENT ANALYSIS IN LINSEED

Seed yield in linseed (*Linum usitatissimum*), like other crops, is a polygenically controlled character and product of many componental traits of economic value which are greatly influenced by environment. Correlation between various agronomic traits alongwith path coefficient analysis of component characters of seed yield is important for determining the components of seed yield (Gill, 1987). This knowledge is a pre-requisite for undertaking effective breeding programme.

Twenty three genotypes of double purpose linseed were grown in Randomised Block Design with 3 replications at experimental farm of Birsa Agricultural University, Ranchi, during winter season of 1989-90. Six rows of 3 meters length in each genotype were sown 20 cm apart. The data on different characters were recorded on five randomly selected plants of each treatment of every replication. Correlation and path coefficient analysis were done as per Dewey and Lu (1959).

Straw yield, number of primary branches and number of secondary branches had a significant positive correlation with seed yield. This has also been reported by Saxena and Asthana (1962), Gill (1987) and Rao and Singh (1985) in linseed. Seed yield had non-significant association with plant height and technical height as earlier observed by Pathak and Bajpaye (1964) in linseed. Significant positive association was observed for straw yield with number of capsules, number of secondary branches, days to maturity and days to 50 per cent flowering. Number of capsules, number of primary branches and number of seeds/capsule had a significant but negative association with plant height, whereas technical height, days to maturity and days to 50 per cent flowering had a highly significant positive association with plant height as also reported by Saxena and Asthana (1962). Number of capsules had a significant and positive association with number of primary branches and number of seeds/capsule, as also observed by Saxena and Asthana (1962) and Pathak and Bajpaye (1962).

Technical height had a high significant and positive correlation with days to maturity and days to 50 per cent flowering. The number of primary branches with number of secondary branches and number of secondary branches with number of seeds/capsule had significant positive interrelationship.

The correlation were partitioned into direct effect of each component and its indirect contribution through other yield components (Table 1). The results indicated that all characters except days to 50 per cent flowering, number of primary branches, number of seeds/capsule and days to maturity had positive direct effect on seed yield which is in conformity with the results of Chaudhary *et al.*, (1984), Rai (1984) and Rao and Singh (1985) for different direct effects in linseed.

Straw yield possessed the highest positive association with seed yield, whereas path coefficient analysis also revealed its importance as it recorded the highest direct effect, as also reported by Rai (1984). It was observed that those traits which had high direct influence on seed yield also effected indirectly through other component characters. The low residual effect factor (0.0525) indicated that the component characters under study were responsible for 95%

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Table 1. Direct (diagonal) and indirect effect (off diagonal) of different characters on seed yield in linseed.

Characters	Straw yield	Plant height	No of capsules	Technical height	No of pimary branches	No of secondary branches	No of seeds/ capsule	Harvest index	Days to maturity	Days to 50 per cent flowering	Correlation with seed yield
1. Straw yield	1.5365	-0.0003	0.2164	-0.0045	-0.4246	0.1474	0.0575	-0.0031	0.0544	-0.6470	0.9328**
2. Plant height	0.0072	0.0572	-0.2572	0.5929	0.5263	-0.0677	-0.1411	0.0178	0.0680	-0.9159	-0.1124
3. Number of capsules	0.8456	0.0358	0.0886	-0.3248	-0.4275	0.0751	0.1491	0.0124	0.0110	-0.1282	0.3375
4. Technical height	-0.0132	-0.0617	-0.2429	0.6790	0.4786	-0.0676	-0.1279	0.0110	0.0562	-0.7892	-0.0776
5. Number of primary branches	0.8300	0.0366	0.2139	-0.3202	-1.0199	0.1675	0.0901	-0.0043	-0.0240	0.4920	0.4619*
6. Number of secondary branches	0.9636	0.0158	0.1257	-0.1512	-0.5604	0.0978	0.0979	0.0185	0.0289	-0.2150	0.4215*
7. Number of seeds/capsule	0.4873	0.0425	0.3232	-0.3707	-0.3905	0.1268	-0.0533	-0.0009	-0.0023	0.0717	0.2335
8. Harvest index	0.0614	0.0124	-0.0622	-0.0738	-0.0434	-0.0556	0.0021	0.3167	-0.0118	0.2289	0.3747
9. Days to maturity	1.0382	-0.0462	0.0538	0.3670	0.2338	0.0842	-0.0053	0.0115	-0.0709	-1.2836	0.3825
10. Days to 50 per cent flowering	0.9522	-0.0460	0.0483	0.3975	0.3704	0.0484	-0.0125	0.0172	0.0990	-1.5524	0.3200

Residual effect = 0.0525

*, ** = Signiicant at 0.05 P and 0.01P respectively; Underlined values show direct effects.

of variability in the seed yield. Further, in case of *number of secondary branches* and number of capsules, the high correlation values were associated with very low direct effect as was also observed by Rao and Singh (1985) in linseed.

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EFFECT OF MOISTURE STRESS ON SEED SIZE AND OIL CONTENT IN THE INDIAN MUSTARD (*Brassica juncea,* L) GENOTYPES

Twenty five mustard genotypes representing two maturity groups (Eighteen medium duration 150 ±2 days, and seven short duration 140 ±2 days, were selected out of 179 genotypes grown in drought plots for their morphological behaviour during previous years. In the 1981-82 season, sowing was done in pots of 12 kg soil capacity on 5th November taking four replications in Completely Randomised Block Design. Four irrigation treatments i.e. i) irrigated through out the crop season (S_0), ii) irrigated through out the crop season except stressed for two weeks (85 to 100 DAS) at siliquae formation stage(S_1), iii) irrigated upto siliquae formation stage (110 DAS) and dry thereafter (S_2) and iv) irrigated upto siliquae initiation stage (85 DAS) and dry thereafter (S_3). The experiment was conducted as per procedure given by Singh *et al.,* (1988).

Moisture stress significantly reduced test weight (Table 1). The reductions were 32.7, 40.4 and 43.3 per cent in S_1, S_2 and S_3 treatment over So

Table 1. Effect of four irrigation levels on test weight and oil content in seeds of mustard genotypes.

Geno types	Test weight (g/1000 seeds)				Oil content in seeds (%)			
	S_0	S_1	S_2	S_3	S_0	S_1	S_2	S_3
RH 7513	3.43	1.61	1.60	1.58	40.25	39.70	26.35	21.76
RH 785	3.26	1.90	1.90	1.83	39.78	39.81	27.24	26.00
RLM 29/25	2.53	1.30	1.27	1.60	38.82	36.05	23.45	22.80
RLM 603	2.90	2.60	1.68	1.65	38.37	36.72	29.65	23.76
RLM 240	2.64	1.80	1.67	1.50	40.66	37.20	30.60	26.70
Durgamani	2.88	2.45	2.00	1.90	40.96	39.19	24.00	22.60
Prakash	2.48	2.48	1.97	1.75	40.01	39.19	25.63	25.52
Varuna	3.73	2.00	1.80	1.75	40.37	39.90	24.48	23.17
RC3	2.80	2.05	1.83	1.65	38.48	35.53	29.31	24.44
RC 162	2.26	1.70	1.55	1.43	39.19	38.25	26.72	25.22
RC 781	2.18	1.67	1.67	1.50	40.96	36.60	21.37	18.98
RC 431	2.33	1.83	1.75	1.60	37.54	33.19	31.27	30.93
RC 471	2.24	1.83	1.77	1.60	37.66	35.42	31.03	26.26
RC 569	2.50	1.63	1.58	1.53	37.78	36.10	27.24	27.89
RC 692	2.78	2.13	1.99	1.74	39.78	39.38	27.93	23.73
RC 1200	2.70	1.66	1.57	1.50	40.25	33.06	24.91	21.70
RC 1316	3.68	1.53	1.55	1.50	38.13	35.22	27.89	27.17
RLM x 514	3.91	2.63	1.99	1.99	38.84	38.25	27.25	24.58
RK 7	2.98	2.60	1.99	1.85	38.01	34.83	30.30	29.29
PR 2	2.75	2.60	2.05	1.99	39.19	37.59	32.90	31.42
Pusa bold	5.34	3.18	2.97	2.83	39.19	37.24	33.10	29.76
UUR 12	2.83	2.20	2.05	1.93	37.42	37.32	31.60	30.36
RH 786	3.57	2.10	2.00	1.90	37.78	34.95	28.85	27.10
R-75-2	2.73	1.80	1.67	1.63	38.84	38.08	27.36	27.54
RH 30	5.33	3.67	2.83	2.78	37.67	37.48	31.81	31.42

CD at 5%	Test weight	Oil content
	Genotypes (G) = 0.05	Genotypes (G) = 0.18
	Irrigation (I) = 1.56	Irrigation (I) = 0.12
	Interaction (GXI) = 0.09	Interaction (GXI) = 0.39.

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irrigated control, respectively. The genotypes RH-30 and Pusa bold had significantly higher test weight than other genotypes irrespective of irrigation levels. Significantly higher test weight was recorded in cv. Pusa bold in S_0 and S_2 and in RH-30 in S_1 and S_3 treatments. Significantly lowest test weight was recorded in genotypes RC 781 under S_0 and cv. RLM 29/25 under S_1, S_2 and S_3 treatments.

The significant variation in seed size and response to moisture stress has also been reported in oil seed Brassica by Richards and Thurling (1978).

The oil content in seed was affected most by irrigation treatments. The average reduction (mean) across genotypes in oil content was 5.1, 29.6 and 33.2 per cent in S_1, S_2 and S_3 over So treatments, respectively. This might be due to poor development of seeds under moisture stress conditions. The oil content (average) across different irrigation treatments was statistically higher in genotypes like Pusa bold, PR-2, UUR 12, RC 431 and RH 30 than RC 1200, RH 786, RLM 29/25, Durgamani, Varuna and RC 781. The short duration genotypes generally showed more oil content in seed under stress conditions than long duration genotypes. This might be due to the early formation of seed. There was no association between seed size and oil content in So and S_1 treatments . However, under moisture stress conditions, the oil content in seed showed positive significant association with seed size. This indicated that the reduction in oil content was proportional to the seed size under severe moisture stress conditions at reproductive growth phase in mustard.

Moisture stress at reproductive growth phase resulted in significant reduction in both seed size and oil content in different genotypes. The genetic difference, however, become more distinct with the increase in degree and duration of moisture stress. The highest oil content was recorded in RC 781 in So, RH 785 in S_1 and Pusa bold in S_2 and S_3 treatments.

The reduction in oil content in response to moisture stress was related to the seed size. The large genetic variability recorded for both seed size and oil content in seed indicates the need for selection of suitable mustard genotypes for obtaining higher oil yield in the drought prone areas.

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RESPONSE OF SESAME TO APPLICATION OF MACRO AND MICRO NUTRIENTS IN COMBINATION WITH FARM YARD MANURE

Sesame is one of the important oilseed crops of Karnataka grown in an area of 1.98 lakh hectares with a production of 0.78 lakh tonnes. The productivity of sesame is hardly 2.5 to 3.0 q/ha. Poor nutrient management is one of the reasons for low yields in sesame. The results of experiments conducted at various locations indicated that, sesame crop responds to the application of NPK and sulphur fertilizers (Gopal Rao *et al.*, 1985, Singh and Sahu, 1986 and Mujumdar *et al.*, 1987). Hence, an attempt was made to know the response of sesame to application of micro and macro nutrients in combination with farm yard manure (F.Y.M).

A field experiment was conducted at Regional Research Station, Raichur during *Kharif* 1992 under rainfed conditions. The soil was red sandy loam with a pH of 7.7 which was low in available nitrogen, zinc and sulphur and high in phosphorus and potassium. There were eight treatments as detailed in Table.

The experiment was laid out in Randomized Block Design with three replications. The variety E-8 was sown at a spacing of 30 x 10 cm on 5th August, 1992. The fertilizers were applied as basal at the time of sowing as per the treatments in the form of urea, single super phosphate and muriate of potash. The rainfall received during the study period was 804 mm in 49 rainy days after sowing. The yield in kg per hectare was computed from net plot area (4.5 x 2.1 m)

Table Seed yield and ancillary observations of sesame as influenced by the application of NPK fertilisers in combination with F.Y.M., $MgSO_4$ and $ZnSO_4$.

Treatments	Seed yield (kg/ha)	Seed yield per plant(g)	Plant height (cm)	Number of branches per plant	Number of capsules per plant
1. Absolute control	157	1.70	87.6	2.07	18.07
2. N, P_2O_5, K_2O @ 37.5:25:25 kg/ha	178	2.17	90.3	2.33	20.53
3. Tr.2 + F.Y.M. @ 1.0 t/ha as row placement at sowing	312	2.33	90.1	2.47	20.67
4. Tr. 2 + $MgSO_4$ @ 30 kg/ha	290	2.23	92.9	2.33	20.93
5. Tr. 2 + $ZnSO_4$ @ 15 kg/ha	353	2.53	93.9	2.30	20.53
6. Tr.3 + $MgSO_4$ @ 30 kg/ha	442	2.47	95.7	2.67	21.67
7. Tr.3 + $ZnSO_4$ @ 15 kg/ha	411	2.40	93.1	2.40	21.00
8. Tr. 4 + $ZnSO_4$ @ 15 kg/ha	444	2.77	93.2	2.53	22.33
S.Em ±	23.9	0.049	3.36	0.25	1.89
C.D. at 5%	71.91	0.148	N.S.	N.S.	N.S.
C.V%	12.3	3.7	6.4	17.9	16.1

The results of the experiment (Table) indicated that application of NPK fertilizers either with F.Y.M., Magnesium sulphate ($MgSO_4$) or Zinc Sulphate ($ZnSO_4$) increased the yields of sesame significantly when compard to absolute control (157 kg/ha) andNPK fertilizers alone (178 kg/ ha). The yield was higher when NPK fertilizers + $ZnSO_4$ were applied (353 kg/ha) followed by NPK fertilizers + F.Y.M. (312 kg/ha) and NPK + $MgSO_4$ (290 kg/ha). Seed yield was further increased significantly when NPK fertilizers were applied in combination with F.Y.M + $ZnSO_4$ or F.Y.M + $MgSO_4$. Application of NPK + $MgSO_4$ + $ZnSO_4$ recorded the highest yield (444 kg/ha) followed by NPK + F. Y. M + $MgSO_4$ (442 kg/ha) and NPK + F. Y. M + $ZnSO_4$ (411 kg/ha) showing an increase in yield of 149, 148 and 130 per cent over NPK fertilizers and 182, 181 and 160 per cent over absolute control. Similarly, Singh and Sahu (1986) noticed higher yield of sesame with NPK + Sulphur fertilizer.

The increase in seed yield per plant (g) to macro and micro nutrient fertilizer in combination with organic manure contributed greatly towards increase in seed yield per ha. Though growth and yield observations viz., plant height, number of branches and capsules per plant did not differ significantly due to various treatments but showed similar trends.

Thus, the results revealed that application of NPK fertilizers in combination with farm yard manure and $MgSO_4$ or farm yard manure and $ZnSO_4$ is beneficial in getting higher seed yield of sesame.

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THE BEETLE *(Zygogramma conjuncta* Rogers), AN AGENT FOR THE BIOLOGICAL CONTROL OF WEED, *Parthnium hysterophorus* L. IN INDIA FEEDS ON SUNFLOWER *(Hellianthus annuus* L*)*

Parthenium (Asterceae) an annual herb and a native of West Indies, Tropical South and North America was first described in India from Pune (Rao, 1956) and now occurs in almost all the states of India (Krishnamuthy *et al.*, 1977) as a naturalised weed (Joshi, 1990). In a span of two decades, Parthenium covered 5 million ha (Gidwani, 1975) and attained the status of a noxious, problematic weed(Joshi, 1990). To combat its menace, an integrated approach involving manually removing the plants (Joshi, 1990); use of herbicides like Paraquat, Atrazine, 2,4-D, Sodium salt, etc. (Krishnamurty *et al.*, 1977; Muniyappa, 1980); cultural practices like interculture, cultural operations and growing competitive crops like fodder sorghum or maize (Joshi, 1990) and biological methods using insects (Jayanth, 1987) and by growing self perpetuating species like *Cassia serice*(Joshi and Mahadevappa, 1986) that displaces *Parthenium* in course of time has now been recommended. The use of beetle, *Zygogramma conjuncta* Rogers (Chrysomelidae; Coleoptera) for checking the weed formed an important component in the integrated pest management of *Parthenium.*

During 1991, when the beetles were observed feeding on sunflower, *Helianthus annuus* L. the identity of the insects was suspected. In 1992, beetles collected from three different districts of Karnataka viz. Kolar, Hassan and Bangalore were sent for identification to the International Institute of Entomology (IIE), U.K. and to three entomologists in the USA. The beetle was identified as *Zygogramma conjuncta*(Rogers) by IIE (Pers. Comm. M.L. Cox, IIE, Sep. 23rd, 1992) and by one entomologist from USA Dr M.L. Cox after examining and dissecting the paratypes of male *Z. concjunta* confirmed the identity of beetle as *Z. conjuncta* (Pers. comm. M L Cox, 23 August, 1993). The beetle was imorted apparently as *Zygogramma bicolorata* Pallister, a host specific insect from Mexico in 1983, has therefore now been identified as *Z. conjuncta* (Pers. comm. M.L. Cox, IIE, 23rd Sep, 1992 & 23rd Aug, 1993). Because of this reason, the beetle will be referred to as *Z. concjunta* in this paper.

The beetle population, established on *P. hysterophorus* at Bangalore, Karnataka, South India during 1987 (Jayanth, 1987). Releases of the beetle were subsequently made in Bangalore to check the weed effectively. The beetle population took four years to establish on Parthenium at th site of release (Jayanth, 1987). However, in 1991, Srikanth and Pushpalatha (1991) doubted the effectiveness of *Z. conjuncta* population in checking the weed.

Now, after about four years of its establishment on *Parthenium* in Bangalore, adults of *Z. conjuncta* were observed feeding on leaves of sunflower *Helianthus annuus.* L. at GKVK, University of Agricultural Sciences, Bangalore during *kharif* season, 1991. Although damage of the beetle on sunflower leaves was evident on several plants, the feeding/chewing operation in the field was observed and recorded 6 times during *kharif* 1991. Later it was confirmed in laboratory in perforated polybags that adult is a nocturnal feeder. The insect defoliated upto 6% of EC-68415 leaves of 35-40 cm 2 size (N = 6). In the field, the damage of *Z. conjuncta* was also recorded on Morden (cultivar), KBSH-1 (hybrid) and CMS-234A (parental line). The beetles were observed from June to October with peak during August-September when 2.0 adults per plant were observed (n = 40). Generally, the beetles preferred to feed on sunflower leaves from margins but their feeding also caused holes usually adjacent to midrib.

During 1992, beetles emerged during Mid-May at the onset of rains in G.K.V.K Farm, Bangalore. Their numbers built-up following rains during June-July and were sighted on different species of plants. The adults were frequently sighted in flight. Although, beetles landed on several plants, feeding occurred only on *Xanthium strumarium* L. a weed, sunflower and *Parthenium* (all asteraceae) in G.K.V.K Farm. Feeding of *Z. conjuncta* on KBSH-1 (0.5% of total plants) and cultivar Morden (2.6% of total plants) sown on 19.5.92 and 23.6.92 under rainfed and irrigated conditions, respectively was recorded. For the season as a whole, sunflower plants surveyed at G K V K Farm showed less than 1% plants fed by *Z. conjuncta*. The feeding was confirmed under wire-mesh cage (0.6 m x 1 m) conditions when ten days starved, 40 beetles were released on 30-days old Morden. The beetles fed from margins and confined their feeding mostly to apical leaves. Under field conditions wherever continuous feeding occurred, the leaves were stained black with excreta. Along with *Zygogramma*, 3 species of *Myllocerus* and a species of *Ptochus* were recorded. Feeding by *Ptochus* species resulted in dark black spot on leaves and *Myllocerus* spp. fed on older leaves leaving serrated margins usually. The *Myllocerus* weevils generally utilised the apical portion of sunflower plants for shelter. This field observation was confirmed by releasing beetles of different species on potted seedlings under wire meshed cages.

In feeding trials in perforated polyethene bags (30 x 20 cm), where a parallel control was run to record survival of beetles with no food, it was established that an adult *Z. conjuncta* consumed 2.3 ± 1.4% leaf area of EC-68415 sunflower leaf and 3.4 ± 1.9% leaf area of *P. hysterophorus* in 72 hr observation periods (n = 20). This suggests that the sunflower leaves are acceptable to the beetles as food and the insects are able to metabolise sunflower leaves as the insects normally defaecated and survived after ingestion of sunfloewr leaves for 28 days during December1991. These observations are in contrast to the observations recorded in 1984 when the beetles were imported to India. The larvae and adult *Z. conjuncta* preferred to starve and die than feed on sunflower then (Jayanth, 1987). The adults without food survived for even up to 30 days.

Jayanth (1987) studied the biology of the beetle on *Parthenium* at Bangalore, and found that eggs hatched in 4 to 5 days, larvae passed through four instars and larval and pupal periods under 28 ± 2°C lasted for 10-15 and 8-10 days, respectively. Observations on biology under a wire meshed field cage (1.2 m^3) on the beetle at GKVK Farm on sunflower (Morden) in August 1991 revealed that eggs were laid singly at apical portion of the plant on leaves, stalk and bracts. On sunflower, eggs hatched in 5 days at av. 22.7 ± 2.9°C and 85% R.H. But the first instar larvae failed to feed and establish on the plant. Thus, the beetle was unable to compete its life cycle on the plant.

In about 700 ha of G.K.V.K Farm with about 4 ha under sunflower, *Z. conjuncta* adults were observed on *Parthenium* (found adjacent to the University boudnary) and sunflower plants continuously from July to October, during 1991 and 1992. Although, in the areas where sunflower was cultivated, *Parthenium* plants were found around 10-15 M distance, the *Z. conjuncta* fed on sunflower leaves. These observations suggest that *Z. conjuncta* beetles can feed on sunflower in presence of *Parthenium*. Thus, sunflower served as a potential food plant under natural conditions for audlt *Z. conjuncta* at G.K.V.K. Bangalore with the possibility of the crop becoming the host-plant for the beetle in future. In fact *Zygogramma exclamationis* (F) is a serious pest *on sunflower in USA and Canada* (Rogers and Thomspon, 1980) and *Z. conjuncta* is similar in many respects to *Z. exclamationis* (pers, comm. CAB institute IIE, 1992).

A survey of different parts of Karnataka during 1991-92 was conducted and farmers were interviewed. Observations and interview with farmers revealed that sunflower grown for seed in three acres at Patapalli, Kolar district were evidently defoliated by adults of *Z. conjuncta*. Maximum number of adults (4-5) of *Z. conjuncta* per plant was observed during July. The plants were defoliated by the beetles and so farmers sprayed Ekalux (Quinalphos) 25% EC (@ 0.5 litre/100 litres of water) in addition to the destruction of *Parthenium* surrounding their plot to protect sunflower from *Z. conjuncta* damage.

Observations recorded during 1992 and 1993 on *the feeding activities of the beetle* on sunflower in Kolar and Bangalore is given in Table. The beetle damage was negligible on sunflower under rainfed conditions compared to that under irrigated conditions. Similarly the beetle appeared to prefer parental lines over cultivar and hybrid for feeding (Table). The farmers adopted crop protection measures (as above) against the beetle damage. In seed production plots in Kolar it was observed that feeding by 3 to 4 adults on 20 to 30 days old parental line seedling caused defoliation of more than 10% and could incur economic damage under

Table Sunflower Infestation by *Z. conjuncta* sown on different dates during 1992 and 1993 in Bangalore and Kolar districts.

Location	Sunflower	Rainfed/ irigated	Sample Plotsize (m^2) area/ (ac)	Max. No. of beetles /plant	Sowing date	Plant age at infestation	Range in infestation (% plants) (n = 10 plots)
GKVK Bangalore	KBSH-1 (hybrid)	Rainfed	7.2 x 4.8	4	19.5.1992	55-58	1.2-3
Hebbal Bangalore	KBSH-1 (hybrid)	Rainfed	4.8 x 3.0	3	30.6.1992	40-70	0.7-7.0
GKVK Bangalore	Morden (cultivar)	Irrigated	6.0 x 4.5	5	23.6.1992	40-65	2.5-7.9
Tagalwara (Kolar)	Parental lines (1:5)	Irrigated	3.0 x 6.0	5	22.6.1992	35-60	30-40*
Gunnehalli (Kolar)	Parental lines(1:5)	Irrigated	3.0 x 6.0	3	15.6.1992	30-57	18-22*
Kengehalli (Kolar)	Parental lines (1:5)	Irrigated	3.0 x 6.0	3	11.6.1992	30-60	18-22*
GKVK, Bangalore	Morden	Rainfed	6.0 x 4.5	1	27.6.1993	30-45	0.0-0.2
Tagalwara, Kolar	Parental lines (1:5)	Irrigated	3.0 x 6.0	5	15.4.1993	70-85	0.3-4.8

* ($P < 0.05$) at i.d.f. by x^2

favourable conditions. During 1993 beetles emergd when the sunflower plats were 70 to 80 days old. At this plant age, the beetles may not feed much. However, studies under confined conditions in this regad are in pogress.

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POD FORMATION AT VARIOUS GROWTH STAGES IN SUMMER GROUNDNUT

Seed yield in groundnut is a function of number of pods, number of seeds per pod and test weight of seeds (Enyi '1977). Seed yield also depends on the number of pegs and peg to pod ratio at harvest. A significant positive correlation between number of mature pods and pod yield were observed (Labana *et al.*, 1980; Nageswara Rao *et al.*, 1985, 1988). The present investigation was undertaken to study the effect of different package of practices on pod formation process in various groundnut genotypes during the summer season. (January - May).

The field experiment was conducted at Parbhani, Maharashtra (19°16'N, 76°47'E, 409 m above sea level) in a medium deep clayey soil having low, medium and high nitrogen, phophorus and potassium, respectively, with a slightly alkaline reaction (pH 7.6 to 7.9). The experiment was laid out in a factorial Randomised Block Design with three replications. A combination of two packages of practices (P_1 = ICRISAT, India; P_2 = Department of Agriculture, Maharashtra State) and four genotypes of groundnut (V_1=ICGS 11; V_2=ICGS 21, V_3=ICGS 44 and V_4 = SB XI) comprising eight treatment combinations. Sowing was done on 15 January, 1989 and the crop was harvested during 13-15 May, 1989 depending on the duration of genotypes. The gross plot size was 7.2 x 6 m and the net plot sizes were 5.6 x 5.4 m for P_1 and 6.0 x 5.4 m for P_2. In P_1, two rows of groundnut were grown on raised beds of 50 cm width. A furrow of 30 cm width and 15 cm depth was formed inbetween beds, through which plots were irrigated. In P_2, the crop was grown on a flat seed bed and irrigated by check-basin method. The details of field operations and inputs used in the two packages are given in Table 1.

Total number of pods per plant were counted and recorded at periodical intervals in two randomly selected plants from each plot up to pre-harvest stage while at the final harvest, observations on total, mature and unfilled pods per plant were recorded on five randomly selected plants. On complete sun drying, the weights of pods per net plot were recorded.

Data presented in Table 2 showed that plants in P_1, had significantly more number of pods per plant at all the stages of crop growth than in P_2. Number of unfilled pods per plant were more in P_2 compared to P_1. In general, total pods per plant, matured and unfilled were higher in V_1, V_2 and V_3 over V_4. The beneficial seed bed effect and optimum crop nutrition under P_1 resulted in higher production of total and mature pods per plant when compared to P_2. Similar results were reported earlier by Patil (1989), Walker and Keisling (1978), Mizuno (1960) and Nijhawan and Maini (1966).

Higher pod yield/ha was recorded in P_1 than in P_2, three genotypes, V_1, V_2 and V_3 produced similar but significantly higher dry pod yields/ha over V_4 (Table 2). Yields of groundnut grow on raised beds or ridges and furrows were significantly higher compared with the flat beds (Rasve *et al.*, 1983; Patil, 1989). It is necessary to apply gypsum to groundnut (Kanwar *et al.*, 1983). Soil application of zinc sulphate increased pod yields (Patil *et al.*, 1979). Spraying of ferrous sulphate + ammonium citrate corrected the iron deficiency to some extent (Chandrasekhara Reddy, 1976). Groundnut cultivars ICGS 11, ICGS 21 and ICGS 44 produced higher pod yields over cultivar SB XI (Oilseeds Research Station, Latur 1990; Raut, 1990). Number of pods per plant (Chandola et al., 1973) and mature pods (Deshmukh *et al.*, 1986) had a high direct effect on pod yield.

The results of this experiment showed that the package of practices recommended by ICRISAT,

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Table 1. Field operations done and inputs used in the different packages of practices.

Sr. No	Field operations/ inputs	ICRISAT package of practices (P_2)	State Department's packageof practices (P_1)
1.	Preparatory tillage	2 ploughings, 2 harowings, clod crushing and stubble collection.	As in P_1
2.	Seed bed	2 row narrow bed and furrow	Flat bed (check basin)
3	Basal dose of manures and fertilizers/ha.		
	i) Farm yard manure	10 t	10 t
	ii) Single super phosphate	500 kg	Nil
	iii) Ammonium sulphate	25 kg	Nil
	iv) Zinc sulphate	10 kg	Nil
	v) Di-ammonium phosphate	Nil	100 kg.
4.	Top dressing/foliar application	i) Ferrous sulphate 2.5 kg + urea 5 kg in 500 l. water/ha/spray, total two sprays, 30 and 50 days after emergence.	Nil
		ii) Gypsum @ 400 kg/ha at flowering.	Nil
5.	Method of sowing and spacings	Hand dibbling at 30 x 10 cm^2	As in P_1.
6.	Seed rate (Kernels, kg/ha)	100-105	125-130
7	Seed treatment with thiram	@ 3g/kg of kernels	@ 5g/kg of kernels.
8.	Seed inoculation	Nil	Rhizobium (MAIDC, Bombay) @ 250 g/10 kg of kernels.
9.	After care		
	i) Weedicide 'stomp' pre-emergence	@ 3.5 l/ha	Nil
	ii) Gap filling	Once	Once
	iii) Weedings	Once	Twice
	iv) Light earthing up	Nil	Once
	v) Uprooting big weeds	Once	Once
	vi) Other	Deepening of furrows thrice	Hoeing twice
10.	Plant protection		
	i) Dimethoate, One spray	@ 660 ml/ha	@ 500 ml/ha.
	ii) Monocrotophos, One spray	@ 1.0/4/ha	@ 700 ml/ha
11.	Irrigations (No)	13	13
12.	Harvesting	By pulling the plants	As in P_1.
13.	Stripping, drying, cleaning the pods and storing	By manual labour	As in P_1.

Table 2. No. of pods/plant and dry pod yield (q/ha) of groundnut during summer season.

Treatments	Days after sowing No of total pods/plant 70	90	110	At harvest No of pods/plant at harvest	Mature	Unfilled	Dry pod yield (q/ha)
Package of practices							
P_1	11.17	20.79	25.46	26.02	21.67	4.35	45.95
P_2	8.17	16.29	20.21	21.07	15.77	5.30	34.93
SE ±	0.37	0.56	1.18	0.88	0.67	0.24	1.44
CD at 5%	1.11	1.70	3.58	2.68	2.05	0.72	4.36
Varieties							
V_1	11.00	21.17	25.83	26.07	20.97	5.10	46.41
V_2	8.92	17.08	22.25	22.50	17.50	5.00	41.49
V_3	10.33	20.08	26.08	27.43	22.03	5.40	45.15
V_4	8.42	15.83	17.17	18.17	14.37	3.80	28.70
SE ±	0.52	0.79	1.67	1.25	0.95	0.33	2.03
CD at 5%	1.57	2.40	5.07	3.80	2.89	1.02	6.16
Interaction P X V							
SE ±	0.73	1.12	2.36	1.77	1.35	0.47	2.87
CD at 5%	NS	NS	NS	NS	NS	NS	NS
G.Mean	9.67	18.54	22.83	23.54	18.72	4.82	40.44

Patancheru, India (P_1) for summer groundnut cultivation and the groundnut genotypes viz., ICGS 11, ICGS 21 and ICGS 44 have better yielding ability compared to the packages of practices recommended by the Department of Agriculture, Maharashtra State(P_2) and the groundnut cultivar SBXI.

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CAN ACHENE CHARACTERS OF SUNFLOWER HYBRIDS BE PREDICTED BASED ON F_0 VALUES ?

The *manifestation of heterosis is normally* exploited in the F_1 generation eventhough the genetic complementation induced by the pollen during fertilization of the seed can bring about *heteroris in the hybrid sporophyte* in the F_0 generation itself. If such pollen effect in F_0 could be explained on the basis of hybridity it would be interesting to know how far it is associated with the hybrid vigour of F_1. Our objective was to find out the possible relationship between the seed characters of sunflower in F_0 and F_1 generations so that early prediction of seed characters might be possible.

The experiment was carried out at the Research farm of University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bangalore in *Kharif* 1990. The F_0 (hybrid) seeds of twenty crosses were obtained by controlled hand pollination of four restorer lines (RHA 274, RHA 299, RHA 297 and MR 1) with five CMS lines (CMS 234, CMS 850, CMS 851, CMS 852 and CMS 821). For pollination control all the heads of CMS lines were covered with cloth bags before anthesis. Pollination by each of the four pollen sources was carried out meticulously in order to get uniform seed set. The crossed seeds thus obtained were analysed for four achene characters viz., 100 seed weight, oil content, seed density and volume weight. The same twenty hybrids were grown in replicated trial to study hybrid performance for the same four characters under strict but effective sib pollination. The achene characters of F_0 and F_1 were subjected to inter generation correlation to establish any possible relationship existing between them.

The mean values of four achene characters of F_0 and the F_1 are presented in Table 1. Comparison *of values* between F_0 and F_1 generation indicated a certain degree of relationship. This was further confirmed by intergeneration correlation (Table 2). From the data it was clear that 100 seed weight of F_0 showed a fairly high and significant positive correlation with that of F_1 values. Further, the oil content and volume weight of F_0 seeds showed highly *significant* positive correlations with F_1 values. For seed density though correlation was positive it was not significant.

The specific influence of male and female gametes on the resulting seed characteristics is reported frequently as a result of gene interaction and dosage effect which *occur as a result of hybrid genetic* composition of the embryo (Kieselbach, 1960; Burton, 1980). In exalbuminous seeds such as sunflower where mature whole seed is made of more than 75 per cent hybrid tissue, the pollen induced changes in seed characters could be expected and has been attributed to the heterotic behaviour of the hybrid sporophyte (Seetharam *et al.*, 1977). In the present investigation, a significant to highly significant correlation was seen for important achene characters - 100 seed weight, oil *content and volume weight* - between F_0 and F_1 generations. Such an association between F_0 and F_1 can provide useful hints on the future performance of the hybrid under evaluation. Poneleit and Egli (1983) have shown that the seed weight and oil content of the F_0 seed developing on the mother plant was determined partly by the newly formed genomic constitution of the seed depending on the pollen source it received.

The results of the present study support the contention that the seed characters - oil content

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Table 1. Mean values for four achene characters in F_0 and F_1 generations

	100 seed weight(g)		Oil content %		Density		Volume weight(g)	
	F_0	F_1	F_0	F_1	F_0	F_1	F_0	F_1
CMS 234 x RHA 274	5.37	4.33	39.00	36.60	0.606	0.626	32.67	35.46
CMS 234 x RHA 299	4.23	4.58	36.23	32.87	0.577	0.585	33.13	32.14
CMS 234 x RHA 297	5.13	4.58	38.53	37.27	0.639	0.614	34.07	35.86
CMS 234 x MR 1	5.07	4.15	38.27	36.70	0.576	0.606	33.40	34.46
CMS 850 x RHA 274	4.73	4.50	36.07	34.70	0.615	0.583	29.40	32.20
CMS 850 x RHA 299	5.20	4.55	34.93	33.13	0.626	0.599	30.20	31.46
CMS 850 x RHA 297	5.87	4.22	36.63	35.23	0.643	0.575	28.60	32.26
CMS 850 x MR 1	5.17	4.50	35.63	34.67	0.611	0.608	28.20	30.60
CMS 851x RHA 274	5.10	4.30	34.73	36.83	0.562	0.588	32.40	31.74
CMS 851 x RHA 299	4.27	4.33	34.13	31.90	0.584	0.566	32.27	30.54
CMS 851 x RHA 297	*5.60*	*4.55*	*35.80*	*36.63*	*0.592*	*0.632*	*33.73*	*31.60*
CMS 851 xMR 1	4.93	4.67	37.27	35.90	0.576	0.619	32.53	31.40
CMS 852 x RHA 274	4.43	4.25	39.03	36.57	0.618	0.632	32.87	35.66
CMS 852 x RHA 299	4.73	4.12	3 .50	34.90	0.614	0.572	32.20	34.40
CMS 852 x RHA 297	4.73	4.30	37.83	33.87	0.647	0.619	32.53	35.80
CMS 852 x MR 1	4.50	3.95	38.17	35.56	0.613	0.588	32.20	34.80
CMS 821 x RHA 274	5.27	4.60	37.47	34.60	0.575	0.614	29.67	32.94
CMS 821 x RHA 299	*4.93*	*3.87*	*37.83*	*36.77*	*0..570*	*0.599*	*30.47*	*31.26*
CMS 821 x RHA 297	4.77	4.58	36.10	37.13	0.572	0.600	30.40	32.34
CMS 821 x MR 1	5.50	4.43	35.70	34.63	0.541	0.604	30.13	31.80

Table 2. Intergeneration correlation for our achene characters

Generations	100 seed weight	Oil content	Density	Volume weight
F_0 vs F_1	0.277*	0.336**	0.039	0.486 **

*** - Significant at 1%* ** - Significant at 5%*

and volume weight and to some extent 100 seed weight - of F_0 are strongly associated with F_1 performance indicating that prior prediction of achene characters in F_1 is possible based upon F_0 values.

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RESPONSE OF GROUNDNUT (*Archis hypogaea L*) VARIETIES TO TIME OF SOWING UNDER RAINFED CONDITION

Groundnut is grown extensively during rainy season in North Eastern Ghat Zone of Orissa. But the productivity is very low (500 to 600 kg/ha) owing to delayed sowings and lack of suitable varieties. Sowing of suitable varieties in proper time not only enhance pod yield but also shelling percentage and oil yield (Padma *et al.,* 1991 and Patel *et al.,* 1991). Hence, the present study was undertaken to find out a suitable date of sowing for groundnut and to identify a suitable variety for rainy season.

Field experiments were conducted during rainy seasons of 1988-90 with three sowing dates (1,15 and 30 June) and five groundnut varieties (AK-12-24, JL-24, Kadiri - 3, Kissan and ICGS -44). The treatments were tested in a split-plot design with five replications. The soil of the experimental site was sandy loam with pH 5.8, low in total nitrogen (0.046%), medium in available P (18.4 kg/ha) and low in available K (122.5 kg/ha). A common dose of 20 kg N, 40 kg P_2O_5 and 40 kg K_2O/ha was applied at the time of sowing. The day degree corresponding to time of sowing was computed by the formula given by Lindsey and Newman (1956).

$$\text{Day Degree} = \sum_{\text{Stage a}}^{\text{Stage b}} \frac{(\text{Min.} - \text{Max.})}{2} - \text{Base temperature}$$

Where, Stage b and a are the developmental phases between phenological stages. The base temperature of 2°C was taken for calculation considering development of plant below 2°C was not possible.

The perusal of data (Table 1) reveal that 1 June sowing recorded significantly the highest pods/plants, filled pods/plant, which consequently resulted in highest pod yield and shelling percentage followed by 15 June sowing. But 30

Table 1. Effect of dates of sowing on yield attributes and pod yield of groundnut varieties

Treatment	Yield attributes (pooled data of three years)						Pod yield (q/a)			
	Plant height (cm)	Pods/ plant	Filled pods/plant	Seeds/ pod	Harvest index	Shelling percent	1988	1989	1990	Pooled
Date of sowing										
1 June	40.13	18.74	11.40	1.80	0.34	63.0	12.78	11.32	12.49	12.20
15 June	45.14	15.03	10.10	1.86	0.33	53.2	11.83	12.51	9.87	11.40
20 June	48.47	14.17	8.60	1.90	0.23	52.2	8.65	6.40	8.66	7.90
SE ±	1.17	0.56	0.26	-	0.02	-	0.35	0.37	0.26	0.27
C.D. 5%	4.05	1.93	0.90	N.S.	0.05	-	1.30	1.21	0.84	1.05
Varieties										
AK-12-24	46.90	17.22	10.90	1.84	0.27	54.6	10.71	9.48	11.01	10.40
JL-24	44.84	17.45	11.36	2.18	0.31	53.0	10.77	11.51	11.90	11.39
Kadri-3	39.79	15.80	9.98	1.75	0.35	56.3	14.76	10.26	9.65	11.56
Kissan	51.89	14.75	9.23	1.74	0.27	61.6	9.63	10.00	9.13	9.59
ICS-44	39.47	14.68	8.65	1.74	0.28	55.0	9.56	9.13	10.00	9.56
S.E. ±	1.02	0.76	0.56	0.04	0.02	-	0.55	0.48	0.38	0.50
C.D. 5%	2.92	2.17	1.59	0.11	0.07	-	1.55	1.35	1.06	1.46

June sowing resulted in significantly the lowest pods/plant, filled pods/plant, 100-seed weight, shelling percentage and pod yield .

The groundnut variety Kadiri - 3 followed by JL-24 and AK-12-24 obtained the highest pod yield whereas ICGS-44 followed by Kissan recorded the lowest. Higher number of pods/plant, filled pods/plant and seeds/pod in case of Kadiri-3 and AK-12-24; higher number of seeds/pod and 1000-seed weight in case of JL-24 contributed mainly to their higher pod yield. But minimum number of filled pods/plant in case of ICGS-44 and Kissan proved them inferior to other varieties. Several workers reported reduction in filled pods/plant (Padma *et al.,* 1991 and Patel *et al.,* 1991), shelling percentage (Reddy *et al.,* 1984) and 1000-Kernal weight (Patel *et al.,* 1991) in delayed sowings and extended them as the major causes for lower pod yield.

The reasons for reduction in pod yield on 30 June sowing were higher rainfall at early stages of the crop that increased vertical growth of the plant which could be the possible cause for inferior development of yield attributes and lower pod yield (Patel et al., 1991). Moisture stress during pod development stage hampered growth of pods and finally lowered pod yield in 30 June sowing. Among the five physiological stages (Table 2), flowering stage showed greater variation for accumulated thermal requirement (degree days). The 1 and 15 June sown crop accumulated more degree days than 30 June sown crop owing to reduction in diurnal temperature during vegetative to flowering stage (max. 30° C and min. 12° C). This not only reduced the number of effective flowers but also lowered the harvest index by interfering into the photosynthetic process and consequently lowered the pod yield.

Table 2. Thermal time and rainfall for physioloical growth of groundnut

	Thermal time for growth phases			Degree days (° C)		
Sowing date	E	E-V	V-F	F-PD	PD-M	Total
1 June	244.41	491.11	6'2.80	325.05	512.26	2183.63
15 June	241.00	450.28	639.74	308.57	523.66	2163.25
30 June	212.55	425.28	567.82	305.27	539.77	2050.67
Average total rainfall (mm)						
1 June	70.5	224.8	199.0	127.7	225.7	847.7
15 June	83.7	148.2	261.7	142.9	247.4	883.9
30 June	55.3	190.1	231.3	109.2	259.8	845.7

E = Establishment, V = Vegetative, F = Flowering, PD = Pod development, M = Maturity

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PERFORMANCE OF SAFFLOWER WITH LEUCAENA (*Leucaena leucocephala* (Lam) Dewit.) LIVE BUND UNDER RAINFED CONDITIONS.

Laying of contour bunds in black soils is not found feasible due to the cracking nature of soils and its presence would lead to wastage of cultivable land (6-8%). Thus it was thought to go in for vegetative barriers across the slope to conserve soil and moisture as well as its fodder yield for cattle during the off season. Leucaena is one such perennial legume which has drought tolerance and hence act as vegetative barrier for better soil and moisture conservation purpose.

A field experiment was conducted at Regional Research Station Bijapur during *rabi* season of 1988-90 and 1989-90 to find out whether safflower, a field crop would be more compatible with lencaena since it may compete for growth resources. The experiment was laid out in Randomised Block Dsesign with three replications. There were 15 treatment combinations which included three stubble heights of leucaena (cut close to ground level, 30 cm and 60 cm) and five distances from the leucaena live bund (1.2, 2.4, 3.6, 4.8 and 6 m). The experimental site was clayey (52.0% clay) with a pH of 7.90. The available nitrogen, phosphorous and potassium were 105, 15.24 and 396.0 kg/ha respectively. Two rows of leucaena were planted in 1984-85 along the contour lines at a distance of 13m. The distances of 1.2, 2.4, 3.6, 4.8 and 6m away from the leucaena on either side were considered as width of the plot with a length of 5m along the leucaena. The area covered by leucaena has been taken into consideration while calculating the yield of safflower. The cultivar Annigeri-1 was planted at a spacing of 60 cm x 30 cm in between the leucaena rows on 21st September during 1988 and '89. The rainfall during September, October, November, December, January and February 1988-89 was 267,88,0, 73,0 and 0 mm respectively (with rainy days of 14,1,0,2,0 and 0). During 1989-90 it was 393, 7.5, 15, 32,5 and 0 mm (with rainy days of 15,1,1,1,1 and 0) respectively. Leucaena was cut at various heights as per the treatments at sowing and 50 days after sowing. The final cut at ground level was taken up at the time of harvest of safflower to record the biomass production.

Leucaena live bund did not have any significant adverse effect on growth and yield of companion safflower when cut at different stubble heights and also at different distances. No doubt the yield of safflower was slightly higher when cut close to ground. This indicated that safflower did not suffer from competition for growth resources mainly the moisture. Probably complimentarity between the component crop must have existed since safflower having a tap root system has extracted moisture from the deeper layers at the later stage and during the early phase of growth there was sufficient moisture due to good amount of precipitation (Table 1). Another reason may be that safflower has a better capacity to withstand drought due to its low water requirement and its leaf structure (thick and short leaves) which demands less water. Similar results have been obtained by Srivastava (1986). The dry matter production and yield components such as

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Table 1. Performance of safflower as influenced by leucaena stubble height and distance from the leucaena live bund.

Treatment	Total dry matter production (g/plant) at at harvest		No of heads per plant		Seed wt. per plant (g)		No of seeds per head		100 seed wt.(g)		Seed yield (q/ha)		Soil moisture (cm of water at 0-60 cm depth) at harvest.	
	88-89	89-90	88-89	89-90	88-89	89-90	88-89	89-90	88-89	89-90	88-89	89-90	88-89	89-90
Leucaena stubble height (cm)														
0	60.05	58.32	25.91	25.21	29.91	29.87	20.68	60.93	60.90	15.65	14.00	16.73	15.63	
30	58.30	56.54	24.89	23.65	29.23	28.46	20.01	19.91	60.00	59.97	15.15	13.30	16.53	15.43
60	54.80	53.29	23.01	22.10	27.52	26.24	19.27	18.97	58.32	58.29	14.41	12.53	16.23	15.10
S.E m ±	1.94	2.01	0.87	0.80	0.90	1.17	0.73	0.67	2.24	2.06	0.47	0.43	-	-
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-	-
Distance from the leucaena (m)														
1.2	53.60	50.32	22.07	21.29	26.31	24.63	18.67	18.31	57.23	56.49	14.43	13.10	15.57	14.93
2.4	54.90	54.03	24.13	23.03	28.34	27.30	19.30	19.21	56.22	55.49	14.81	13.44	16.67	15.57
3.6	58.32	55.12	24.51	23.41	29.30	28.71	20.14	19.78	61.19	60.85	15.31	13.09	17.27	16.67
4.8	61.17	58.50	25.71	24.81	30.08	29.51	20.72	20.61	61.71	61.40	15.72	14.26	17.50	17.00
6.0	63.60	62.26	26.60	25.74	30.79	30.45	21.09	20.69	62.39	61.50	15.91	1443	17.77	17.17
S.m ±	2.51	2.59	1.12	1.03	1.16	1.51	0.94	0.86	2.89	2.65	0.60	0.56	-	-
CD at5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	-	-

Interaction:Not signiicant.

NS:Not significant.

number of heads per plant, seed weight per plant, number of seeds per head and 100 seed weight which determine the yield also showed the same trend as that of the yield.

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STUDIES ON CULTURAL AND CHEMICAL WEED CONTROL IN MUSTARD (*Brassica juncea* (L) Czern & Coss.)

Weeds cause enormous damage, particularly to irrigated mustard crop. Hand weeding in such fields is a costly affair owing to hike in labour wages and acute shortage of labour, at the time of peak period. Therefore, the present investigation was planned to get a comparable information about chemical as well as cultural measures for weed control in mustard crop. An experiment was conducted during 1990 and 1991 at the Research Farm, College of Agriculture, Gwalior (M.P.). The experiment comprised six treatments viz. weed free, hand weeding at 30 DAS, two hand weedings at 30 and 45 DAS, fluchloralin @ 0.75 kg a.i./ha as pre-planting, pendimethalin @ 0.75 kg a.i./ha as pre-emergence and weedy check and were replicated four times in a Randomised Block Design. The soil of the experimental field was sandy loam containing 103 kg/ha available N, 25.8 kg/ha available P and 263.5 kg/ha available K, pH 7.6 and organic carbon 0.42 per cent (two years pooled average). The variety Pusa bold was sown at 4 kg/ha on 15 October, 1990 and 20 October, 1994, at 30 cm apart. The crop was given a basal dose of 40 kg N, 40 kg P_2O_5 and 20 kgK_2O/ha. Nitrogen 40 kg/ha was applied as top dress after first irrigation (30 DAS).

Important weed species that were observed in the experiment were *Asphodelus tenuifolius* (31.15%), *Cyperus rotundus* (23.30%), *Cynodon dactylon* (22.10%), *Chenopodium album* (14.22%) and *Melilotus indica* (7.03%). The first four weed species in weedy check constituted about 90.8 per cent of weed density in both the years. Total weed dry weight was more in 1990 than that in 1991. Maximum weed dry weights (640 and 512 gm/m^2) were recorded at harvest in weedy check in both the years. This was obvious since weeds were allowed to grow unchecked in these plots. Two herbicides and two cultural operations gave lower dry matter production of weeds than weedy check (Table 1). There were significant differences in respect of number of siliquae/plant, length of siliqua (cm), number of seeds/siliqua and 1000 seed weight (g) due to various weed control treatments in both the years. Maximum yield attributing characters were recorded in weed free treatment, closely followed by two hand weedings at 25 and 45 DAS and fluchloralin @ 0.75 kg a.i./ha as pre-planting application and the minimum was attained in the weedy check (control). All the weed control treatments caused significant improvement in grain yield over control (weedy check) except in case of one hand weeding at 30 DAS, only in 1990. The higher yields in these treatments were due to satisfactory control of most of the weed species occurring in the experimental plots. Similar results were also obtained by Gill *et al.*, (1984), De and Reddy (1987) and Mishra *et al.*, (1990).

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Table 1. Yield, yield attributes and quality characters of mustard as influenced by weed control treatments.

Treatment	Weed dry weight (g)		No of siliquae per plant		Length of siliqua (cm)		No of seeds /siliqua		1000 seed weight(g)		Yield (q/ha)		Oil content (%)	
	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991
Weed free	0	0	257.41	337.30	4.85	5.10	14.83	15.25	5.32	5.44	18.84	22.49	44.03	44.12
One hand weeding at 30 DAS	315	240	136.00	216.25	4.43	4.68	12.33	12.75	4.96	5.08	15.30	15.05	43.07	43.16
Two hand weedings at 30 & 45 DAS	185	120	227.50	307.50	4.81	5.06	12.95	13.37	5.27	5.39	16.79	18.35	43.64	43.13
Fluchloralin @ 0.75 kg a.i./ha pre-planting	220	145	207.35	287.50	4.72	4.97	12.13	12.55	5.17	5.29	16.75	18.17	53.60	43.69
Pendimethalin @ 0.75 kg a.i./ha as pre-emergence	232	157	168.18	248.32	4.50	4.75	12.28	12.70	4.98	5.10	16.70	15.40	43.06	43.15
Weedy check (Control)	640	512	85.32	142.50	4.33	4.58	10.88	11.30	4.01	4.13	14.00	12.12	42.82	42.91
CD at 5%	120	117	24.10	28.52	0.12	0.90	1.04	0.98	0.09	0.11	2.04	2.55	0.18	0.28

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