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CYTOPLASM IDENTIFICATION IN SESAME (*Sesamum indicum* L.)

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ABSTRACT

The significant differences observed between direct and reciprocal F_1 and F_2 populations as well as the direct and reciprocal back cross progenies revealed that the cytoplasm of S.00028 differed from the cytoplasms of S.0327 and AC.No. 673.3.130.12 for fourteen and eleven out of sixteen characters respectively. Similarly, the cytoplasm of S.0327 differed from the cytoplasm of AC.No. 673.3.130.12 for thirteen out of sixteen characters studied. It is concluded that S.00028 S.0327 and AC. No.673.3.130.12 may have different cytoplasms.

Key words: Sesame; cytoplasm; segregating population.

INTRODUCTION

The differential contributions of parents to their offsprings have been studied as far back as 1765 by Kolreuter (cited in Roberts, 1929) and Mendel (1865). This has traditionally been done by comparing either the F_1 hybrids from reciprocal crosses (Cockerham and Weirs, 1977) or the F_2 population derived from the reciprocal F_1's. A comparison of reciprocal F_1, F_2 and back cross populations provides unequivocal information on the cytoplasmic differences among genotypes (Bhat and Dhawan, 1969); Mosjidis and Yermanos (1984), Bhat and Dhawan (1969) have shown that reciprocal differences can be determined by the simple 't' test. Michaelis (1954) has very clearly demonstrated that physiologically, genetically or geographically divergent types are more likely to reveal cytoplasmic effects than more closely related ones. Reciprocal differences in sesame has been reported by Pal (1945), Murthy and Hashim (1973), Murthy (1975), Dijigma (1984), Bhagawan Dora and Kamala (1987) and Anitha (1988). However, so far, no report has unequivocally unveiled the existence of cytoplasmic genetic system in sesame, hence the present investigation was formulated to excavate the existence of different cytoplasmic genetic system in sesame, which will be of immense use in the exploitation of hybrid vigour.

MATERIALS AND METHODS

A total of 1168 genotypes of sesame which were raised in uniform environment were evaluated for 1000 seed weight and classified as large (above mean + 1 S.D), medium (in between mean $\pm$ 1 S.D) and small (mean - 1.S.D) seeded genotypes. Out of these 1168 genotypes evaluated, 207 genotypes comprising large, medium and small seeded genotypes were selected and raised in the field. The selfed seeds of the genotypes were harvested separately and evaluated for seed size. The genotypes which were grouped in their respective classes consistently in the two consecutive evaluations were identified and selected. Accordingly, the genotypes namely S.00028, S.0327 and AC.No.673.3.130.12 was

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not traceable. The genotypes from Tamil Nadu may also be from different sources. The genetic diversity has been reported (Thirugnana Kumar, 1991). The present inquiry was formulated to find out the cytoplasmic differences among these three genotypes which differ consistently for seed size.

Six generations namely P_1, P_2, F_1, F_2, B_1, B_2 of three direct crosses and their reciprocals were produced. The crosses are S.00028 x S. 0327; S. 00028 x AC. No. 673.3.130.12 and S.0327 x AC.No. 673.3130.12. Reciprocal crosses were developed by making plant-to-plant reciprocal crosses between two genotypes. The crosses were made during September, 1988. Seed set was good. During January, 1989, three fourths of the F_1 seeds from the six crosses were sown along with their parents and back crossed with their respective parents by keeping F_1's as ovule parents to get direct and reciprocal back cross seeds. F_1's were also selfed to get F_2 seeds. During July 1989, the remaining one fourth of the crossed seeds were sown along with their parents, F_2's B_1's and B_2's in Randomized Block Design with two replications. All the three parents, their first and second generation hybrids, and direct and reciprocal back cross hybrids were selfed. A sample size of 20 plants in parents, and F_1's and 60 plants in F_2's and back crosses were utilized for taking observations.

Data recorded on sixteen characters were utilized to find out the cytoplasmic differences among these three parents. Significant (t'test) differences between direct and reciprocal F_1 and F_2 populations and differences between B_1's of direct crosses and B_1's of reciprocal crosses were also taken into consideration (Dani and Kohel, 1989).

RESULTS AND DISCUSSION

In the cross S.00028 x S.0327, significant differences existed between the direct and reciprocal F_1 populations for days to maturity, plant height, number of branches and flowers, length and breadth of seeds, weight and volume of 1000 seeds, and oil content. The B_1 of the direct cross differed significantly from the B_2 of its reciprocal cross for the aforementioned characters except weight and volume of 1000 seeds. In addition, they also differed for number and volume of capsules, density of seeds, seed yield, total dry matter production and harvest index (Table.1). Similarly, the B_2 of the direct cross differed significantly from the B_1 of its reciprocal cross for days to maturity, plant height, number of branches, breadth of seeds, weight of 1000 seeds, seed yield and total dry matter production. The result indicated that the cytoplasm of S.00028 differed from the cytoplasm of S.0327 for fourteen out of the sixteen characters studied.

In the cross S.00028 x AC.No. 673.3.130.12, significant differences existed between the direct and its reciprocal F_1 populations for days to maturity, plant height, number of branches and flowers, volume of capsules, weight and volume of 1000 seeds, oil content, and total dry matter production (Table 1). The direct and reciprocal F_2 populations differed significantly for days to maturity, plant height, number of seeds per capsule and length and breadth of seeds. The B_1 of the direct cross differed significantly from the B_2 of its reciprocal cross for days to maturity, plant height, number of capsules, seeds per capsule, length and breadth of seeds, density of seeds, oil content, seed yield and total dry matter production. Similarly, the B_2 of the direct cross differed significantly from the B_1 of its reciprocal cross for days to maturity, plant height, volume of capsules, seeds per capsule, length of seeds, oil content, seed yield and total dry matter production. The result implied that the cytoplasm of S.00028 differed from the cytoplasm of AC.No. 673.3.130.12 for eleven out of sixteen traits investigated.

In the cross S.0327 x AC. No. 673.3.130.12, significant differences existed between the direct and reciprocal F_1 populations for plant height, number of branches, flowers and capsules, weight and volume of 1000 seeds, oil content, and total dry matter production. The direct and reciprocal F_2 populations differed significantly for days to maturity, plant height, number of flowers and capsules, volume of capsules, length of seeds, seed yield and total dry matter production. The B_1 of the direct cross differed significantly from the B_2 of its reciprocal cross for plant height, number and volume of capsules, weight of 1000 seeds and oil content. Similarly, the B_2 of the direct cross differed significantly from the B_1 of its reciprocal cross for days to maturity, plant height, volume of capsules, seeds per capsule, volume of 1000 seeds, density of seeds, oil content, seed yield and total dry matter production. The result suggested that the cytoplasm of S.0327 differed from the cytoplasm of AC.No. 673.3.130.12 for thirteen out of sixteen characters analyzed. (Table 1).

The significant difference observed between direct and reciprocal F_1 and F_2 populations; as well as the direct and reciprocal back cross progenies revealed that the cytoplasm of S.00028 differed from the cytoplasms of S.0327 and AC.No. 673.3.130.12 for fourteen and eleven out of sixteen characters respectively. Similarly, the cytoplasm of S.0327 differed from the cytoplasm of AC. No. 673.3.130.12 for thirteen out of sixteen characters studied. It is concluded that S.00028, S.0327 and AC.No. 673.3.130.12 may have different cytoplasms. It is earnestly suggested to hopefully incorporate the identified different cytoplasmic system in the development of cytoplasmic genic male sterile system in hybrid breeding of sesame. Efforts may be made to incorporate the reported genic male sterility (Osman and Yermanos, 1982) in the identified cytoplasmic back ground.

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Table 1. Reciprocal differences in non-segregating and segregating generations of sesame.

Cross combinations	Pairs of non-segregating and segregating generations	Difference ± S.E.			
		Days to maturity	Plant height at maturity (cm)	Number of branches	Number of flowers
S. 00028 x S. 0327	$F_1(D_1)$ Vs $F_1(R_1)$	8.4 ± 0.65**	9.03 ± 2.19**	1.7 ± 0.19**	10.71 ± 2.05**
	$F_2(D_1)$ Vs $F_2(R_1)$	4.2 ± 1.1**	2.35 ± 2.42	0.4 ± 0.4	4.4 ± 3.8
	$B_1(D_1)$ Vs $B_2(R_1)$	6.1 ± 1.2**	25.64 ± 2.69**	1.3 ± 0.5**	31.8 ± 6.6**
	$B_2(D_1)$ Vs $B_1(R_1)$	4.0 ± 1.3**	9.35 ± 2.86**	5.6 ± 0.5**	4.1 ± 5.1**
S. 00028 x AC. No. 673.3.130. 12	$F_1(D_2)$ Vs $F_1(R_2)$	1.1 ± 0.36**	8.34 ± 1.34**	1.3 ± 0.20**	7.1 ± 2.56*
	$F_2(D_2)$ Vs $F_2(R_2)$	5.0 ± 0.9**	9.70 ± 2.70**	0.5 ± 0.4	1.5 ± 5.3
	$B_1(D_2)$ Vs $B_2(R_2)$	4.6 ± 1.3**	7.56 ± 2.54**	0.8 ± 0.6	6.4 ± 4.8
	$B_2(D_2)$ Vs $B_1(R_2)$	3.0 ± 1.4*	11.93 ± 2.89**	0.1 ± 0.5**	0.2 ± 3.5
S. 0327 x AC.No. 673.3.130.12.	$F_1(D_3)$ Vs $F_1(R_3)$	0.6 ± 0.44	10.04 ± 1.84**	1.4 ± 0.24**	8.4 ± 2.45**
	$F_2(D_3)$ Vs $F_2(R_3)$	4.1 ± 1.1**	9.13 ± 2.13**	0.0 ± 0.3	8.9 ± 4.4*
	$B_1(D_3)$ Vs $B_2(R_3)$	0.6 ± 1.2	6.56 ± 2.41**	0.4 ± 0.4	1.4 ± 3.2
	$B_2(D_3)$ Vs $B_1(R_3)$	4.6 ± 1.6**	7.42 ± 2.54**	0.9 ± 0.5	6.1 ± 3.4
S. 00028 x S. 0327	$F_1(D_1)$ Vs $F_1(R_1)$	2.1 ± 1.68	0.01 ± 0.01**	0.40 ± 0.49	0.13 ± 0.02**
	$F_2(D_1)$ Vs $F_2(R_1)$	6.6 ± 4.4	0.00 ± 0.02	0.10 ± 0.41	0.04 ± 0.04
	$B_1(D_1)$ Vs $B_2(R_1)$	39.6 ± 6.1**	0.15 ± 0.02**	0.30 ± 0.44	0.21 ± 0.03**
	$B_2(D_1)$ Vs $B_1(R_1)$	9.3 ± 5.5	0.05 ± 0.03	0.80 ± 0.54	0.04 ± 0.03

D_1, D_2, D_3 Direct crosses

R_1, R_2, R_3 Reciprocal crosses

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

Table 1. (Contd..)

Cross combinations	Pairs of non-segregating and segregating generations	Difference ± S.E.			
		Days to maturity	Plant height at maturity (cm)	Number of branches	Number of flowers
S. 00028 x	$F_1(D_2)$ Vs $F_1(R_2)$	3.2 ± 1.89	0.11 ± 0.01**	0.00 ± 0.58	0.00 ± 0.03
AC. No. 673.3.130. 12	$F_2(D_2)$ Vs $F_2(R_2)$	7.0 ± 5.2	0.02 ± 0.02	1.20 ± 0.43**	0.14 ± 0.03**
	$B_1(D_2)$ Vs $B_2(R_2)$	15.7 ± 5.2**	0.04 ± 0.02	1.80 ± 0.45**	0.11 ± 0.03**
	$B_2(D_2)$ Vs $B_1(R_2)$	2.6 ± 4.1	0.15 ± 0.02**	1.00 ± 0.43*	0.12 ± 0.04**
S. 0327 x	$F_1(D_3)$ Vs $F_1(R_3)$	5.1 ± 1.53**	0.01 ± 0.01**	0.02 ± 0.54	0.03 ± 0.02
AC. No. 673.3.130. 12	$F_2(D_3)$ Vs $F_2(R_3)$	14.9 ± 4.2**	0.06 ± 0.03*	0.00 ± 0.43	0.09 ± 0.03**
	$B_1(D_3)$ Vs $B_2(R_3)$	7.1 ± 3.2**	0.13 ± 0.03**	0.20 ± 0.51	0.03 ± 0.03
	$B_2(D_3)$ Vs $B_1(R_3)$	7.9 ± 4.1*	0.11 ± 0.02**	1.30 ± 0.51*	0.02 ± 0.02
S. 00028 x	$F_1(D_1)$ Vs $F_1(R_1)$	0.16 ± 0.02**	0.24 ± 0.03**	0.93 ± 0.02**	0.05 ± 0.11
S.0327	$F_2(D_1)$ Vs $F_2(R_1)$	0.02 ± 0.02**	0.42 ± 0.20*	1.47 ± 1.87	0.10 ± 0.17
	$B_1(D_1)$ Vs $B_2(R_1)$	0.16 ± 0.02**	0.18 ± 0.22**	0.04 ± 1.71	0.56 ± 0.22*
	$B_2(D_1)$ Vs $B_1(R_1)$	0.06 ± 0.02**	0.79 ± 0.25**	1.15 ± 1.75	0.46 ± 0.31
S. 00028 x	$F_1(D_2)$ Vs $F_1(R_2)$	0.01 ± 0.02	0.61 ± 0.02**	0.59 ± 0.02**	0.11 ± 0.11
AC. No. 673.3.130. 12	$F_2(D_2)$ Vs $F_2(R_2)$	0.15 ± 0.02**	0.04 ± 0.19	0.31 ± 1.88	0.48 ± 0.26
	$B_1(D_2)$ Vs $B_2(R_2)$	0.08 ± 0.02**	0.01 ± 0.16	2.80 ± 1.58	0.84 ± 0.27**
	$B_2(D_2)$ Vs $B_1(R_2)$	0.01 ± 0.02*	0.02 ± 0.22	0.17 ± 1.10	0.06 ± 0.24

D_1, D_2, D_3 Direct crosses
R_1, R_2, R_3 Reciprocal crosses
*, ** Significant at P = 5% and 1% respectively.

Table 1. (Contd..)

Cross combinations	Pairs of non-segregating and segregating generations	Difference ± S.E.			
		Days to maturity	Plant height at maturity (cm)	Number of branches	Number of flowers
S. 0327 x	$F_1(D_3)$ Vs $F_1(R_3)$	0.01 ± 0.02	0.06 ± 0.03*	0.08 ± 0.02**	0.04 ± 0.09
AC. No. 673.3.130. 12	$F_2(D_3)$ Vs $F_2(R_3)$	0.01 ± 0.02	0.21 ± 0.19	2.39 ± 1.56	0.10 ± 0.13
	$B_1(D_3)$ Vs $B_2(R_3)$	0.06 ± 0.03	0.87 ± 0.17**	0.84 ± 1.09	0.28 ± 0.24
	$B_2(D_3)$ Vs $B_1(R_3)$	0.05 ± 0.03	0.19 ± 0.19	4.92 ± 2.15*	0.70 ± 0.21**
S. 00028 x S. 0327	$F_1(D_1)$ Vs $F_1(R_1)$	0.9 ± 0.28**	0.84 ± 0.41	2.51 ± 1.28	1.38 ± 1.75
	$F_2(D_1)$ Vs $F_2(R_1)$	1.0 ± 0.8	0.06 ± 0.53	2.95 ± 2.50	2.07 ± 1.90
	$B_1(D_1)$ Vs $B_2(R_1)$	2.1 ± 1.0*	6.43 ± 0.94**	21.31 ± 2.73**	4.44 ± 2.05*
	$B_2(D_1)$ Vs $B_1(R_1)$	0.7 ± 1.2	1.68 ± 0.66*	8.33± 2.71**	1.24 ± 1.98
S. 00028 x	$F_1(D_2)$ Vs $F_1(R_2)$	2.11 ± 0.26**	0.48 ± 0.33	3.06 ± 0.93**	0.31 ± 2.18
AC. No. 673.3.130.12	$F_2(D_2)$ Vs $F_2(R_2)$	1.0 ± 0.8	0.37 ± 0.51	0.34 ± 2.55	1.97 ± 1.88
	$B_1(D_2)$ Vs $B_2(R_2)$	3.7 ± 0.9**	1.77 ± 0.58**	10.04 ± 2.37**	0.26 ± 2.04
	$B_2(D_2)$ Vs $B_1(R_2)$	2.6 ± 0.9**	1.17 ± 0.47*	8.02 ± 2.34**	0.41 ± 1.97
S. 0327 x	$F_1(D_3)$ Vs $F_1(R_2)$	1.2 ± 0.29**	0.39 ± 0.41	2.44 ± 0.71**	0.26 ± 1.95
AC. No. 673.3.130. 12	$F_2(D_3)$ Vs $F_2(R_2)$	0.2 ± 0.9	0.88 ± 0.40*	5.47 ± 2.19*	0.49 ± 1.89
	$B_1(D_3)$ Vs $B_2(R_2)$	2.3 ± 0.9**	0.16 ± 0.49	1.26 ± 1.94	0.03 ± 2.09
	$B_2(D_3)$ Vs $B_1(R_2)$	4.2 ± 0.9**	1.06 ± 0.49*	7.54 ± 2.29	0.75 ± 2.04

D_1, D_2, D_3 Direct crosses

R_1, R_2, R_3 Reciprocal crosses

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

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GENETIC VARIABILITY IN SUNFLOWER

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ABSTRACT

The analysis of variance revealed significant genotypic differences for all the thirteen characters studied.The range of variation was maximum for *number of seeds per head (SH)followed by weight of head* (HW) and seed yield (SY). By and large, higher mean value was associated with greater range. The magnitude of variation was *maximum* for HM followed by SY, Oil yield per plant (OYP) and SH. The characters plant height (HT) and days to fifty per cent flowering (DFF) were less affected by environment showing a close correspondence between GCV and PCV, *while characters such as* HW, SY, OYP and SH were the most affected. High heritability estimates with low genetic advance was observed for characters DFF, HT, stem diameter at the base (SDI), number of leaves (LN) and oil content (OC) implying less genetic gain if selected upon, while selection for HW,SY, OYP and SH possessing high GCV, moderate h^2 and high GA in the material under study is expected to result in considerable genetic gains. Lowest values of GVC, h^2 and GA were observed for filled seeds (FS), suggesting that this *character cannot be improved effectively by selection.*

Key words: Genetic variability; heritability; genetic advance.

INTRODUCTION

Genetic variability is basic to rational plant breeding (Simmonds, 1983). The variability present in sunflower is reported to vary from considerable (Singh and Yadava, 1986; Chaudhary and Anand, 1987) to marked (Anand and Chandra, 1979) for various quantitative characters. A wide range of variation has been reported for seed yield and seed number (Velkov, 1989) and other important components of yield (Virupakshappa and Sindagi, 1988). Besides, a high expected genetic advance is reported for yield (Srinivasa, 1982). In general, characters which possessed greater variability were reported to show *more expected genetic advance* (Chaudhary and Anand, 1987) studies involving limited number of entries. Therefore the present study was undertaken involving a large number of diverse collections,

MATERIALS AND METHODS

Two hundred and twenty five genotypes of sunflower representing various countries (U.S.A., Turkey) of the world were grown during dry season of 1995 under irrigated conditions. The experiment was conducted in a simple lattice design. The spacing between and within the rows were maintained at 60 and 30 cm respectively. Five competitive plants were selected at random for recording observation on growth , yield and phenological characters. Analysis of variance and estimates of genotypic and phenotypic coefficients of variation, broad sense heritability and expected genetic gain were worked out following usual methods.

RESULTS AND DISCUSSION

The analysis of variance revealed significant genotypic differences for all the thirteen characters studied (Table 1). The range of variation was maximum for seeds/head (141-1632) followed by total weight of head (7-494) and seed yield /plant (3-75), while it was lowest in the case of SD_2 (0.4-2.3) and SD1 (0.9-3.0). Though the comparison between characters is uncalled for, the results would apparently remain same even after standardization with the corresponding

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means. It leads to say that there exists an association between mean values and the range. In other words, higher mean was associated with high range. *It means, there is better scope for* selection for SH, AW and SY compared to others.

However, it would be erroneous to infer on the magnitude of variability based on range as a parameter. Therefore, phenotypic and genotypic *variances and other components of phenotypic* coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were estimated. It is evident from the Table 2 that characters which showed greater range exhibited higher magnitude of variance (phenotypic and genotypic). However, magnitude of variance and variability are not to be misunderstood. For meaningful comparisons among characters for variability, standardization with respective mean values was done to get PCVs and GCVs. It is clear that using coefficient of variation as a measure, the magnitude of variation was maximum for HW followed by SY, OYP and SH. These results are generally in agreement with the reports of Virupakshappa and Sindagi (1988), Velkov (1989), Khan and Islam (1991) and Gangappa (1991).

On the other hand, careful examination of the variances and coefficient of variation indicated that there was no difference between phenotypic and genotypic variance and PCV and GCV for some of the characters. For example, the characters HT and DFF showed little or no difference, which would mean that those characters were less affected by environment, while characters such as HW, SY, OYP AND SH were the most affected.

However, high variance values alone are not the determining factors of the expected progress that could be made in respect of quantitative traits (Falconer, 1981). It was suggested that the GCV together with the high h^2 estimates would give a better picture of the extent of genetic gain to be *expected under selection. In the present study,* high h^2 estimates were obtained for DFF (99%) followed by HT (97%), sd1 (73%), LN (72%) and OC (71%). Similar results have been reported by varshney and singh (1977), Lakshmanaiah (1980) and Venkateshwaralu (1980), However, in general, characters with high h^2 did not possess greater variability (high GCV). In other words, characters with high GCV showed moderate h^2. Incidentally, those characters also showed higher GA. Johnson *et. al.* (1955) suggested that h^2 considered together with GA is more reliable in predicting the effect of selection than h^2 alone. Therefore, selection for HW, SY, OYP and SH which possessed high GCV, moderate h^2 and high GA in the material under study is expected to result in considerable genetic gains. While selection for DFF, HT, SD1 and LN where only *h^2 was high is not expected to result in maximum* genetic gains. Lowest values of GCV, h^2 and GA were observed for FS suggesting that this character cannot be improved effectively by selection.

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Table 1. ANOVA for 13 quantitative traits (QTs) in sunflower

	df	DEF	LN	HT	SD1	SD2	HD	HW	SH	FS	TW	SY	OC	OVP
Genotypes	224	27.71**	18.84**	951.45**	0.19**	0.10**	13.53**	16752.65**	92061.12**	62.00**	2.37**	339.16**	57.19**	27.71**
Error	196	0.10	3.01	16.03	0.03	0.02	5.43	6262.35	37986.40	30.28	0.83	122.01	9.86	10.16

** Significant at 1% level.

DEF : Days to 50 per cent flowering

LN : Number of leaves per plant

HT : Plant height (cm)

SD1 : Stem diameter at the base (cm)

SD2 : Stem diameter just below the capitulum (cm)

HD : Head diameter (cm)

SH : Number of seeds per head

FS : Per cent filled seeds

TW : test weight

SY : Seed yield per plant (g)

OC : Oil content (%)

DYP : Oil yield per plant (g) (Seed yield x Oil content)

Table 2. Components of variability for 13 QTs in sunflower

Characters	Range		Mean	Variance		Coefficient of variation		Heritability	Genetic advance
	Min.	Max.		Phenotypic	Genotypic	Phenotypic	Genotypic	(%)	(% Mean)
DEF	44.00	61.50	48.08	13.90	13.80	7.7556	7.7263	99.27	15.8559
LN	9.50	29.60	17.01	10.92	7.91	19.4268	16.5394	72.18	29.0058
HT	56.00	184.20	110.11	483.74	467.71	19.9745	19.6409	96.68	39.7818
SD1	0.90	3.07	1.67	0.11	0.08	19.8560	16.9366	72.82	29.7425
SD2	0.425	2.27	0.93	0.06	0.04	26.3300	21.5053	66.66	36.1602
HD	5.07	20.50	12.07	9.48	4.05	25.5086	16.6732	42.72	22.4482
HW	6.83	494.00	141.73	11507.50	5245.13	75.6682	51.0994	45.58	91.0673
SH	141.50	1632.00	536.99	65023.76	27037.36	47.4861	30.6200	41.58	40.6741
FS	64.08	98.96	90.25	46.14	15.86	7.5264	4.4100	34.37	5.3288
TW	2.50	7.90	5.79	1.60	0.77	21.8462	15.1553	48.12	21.6545
SY	3.10	75.00	28.59	230.58	108.57	53.1129	36.4452	47.09	51.5222
OC	16.60	43.55	29.40	33.52	23.66	19.6941	16.5464	70.58	28.6336
OYP	0.78	19.22	8.23	18.93	8.77	52.8600	35.9900	46.35	50.4763

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CORRELATION AND PATH ANALYSIS IN SUNFLOWER*

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ABSTRACT

Correlation studies in sunflower revealed that seed yield was positively associated with growth and yield components. Among yield components, correlation of number of seeds per head was maximum followed by weight of head. The plant height (HT) followed by stem diamenter at the base (SD1) showed greater magnitude of correlation. The within and between correlations of growth and yield components were positive. Days to 50 per cent flowering (DFF) showed non-significant association with almost all characters including seed yield and oil content, except number of seeds per head (SH). Oil content (OC) was negatively associated with all growth and yield components. The correlations among yield components were positive, encouraging rapid improvement of yield. Path coefficient analysis showed that the direct effect was maximum for number of seeds per head followed by 100-seed weight (TW) and weight of head (HW) in respect of both seed yield and oil yield (OYP). The maximum indirect effect for any character was through seeds/head (SH) which itself was a major direct contributor. These characters are dependable for the improvement of yield and oil yield of sunflower.

Key words: Correlation; path analysis; sunflower.

INTRODUCTION

The objectives of any plant breeder include selection from a natural population or from the one developed by him for one or several characters (Simmonds, 1983). Yield is a complex character which cannot be improved to a greater extent on its own. Because, it is influenced by a set of other characters known as yield components which are related among themselves and with yield either favourably or unfavourably. In general, in most crops, the associations among yield components are reported to be undesirable thereby hindering the rapid progress that could be made.

Various kinds of associations have been reported in sunflower. The length of developmental phases before and after flowering were independent of morphological characters (Chervet and Vear, 1990) while seed weight was reported to be positively associated with duration of vegetative phase. Hence, it would be necessary to know what kind of relationship exists among and between morphological and yield components and whether a given relationship is a true relationship. Therefore, the present study was taken up to study correlation and path analysis involving 225 diverse genotypes in order to make some general inferences.

MATERIAL AND METHODS

The experiment consisting 225 accessions originating from as many as 24 countries, was laid out in a 15 x 15 simple lattice design, during dry season of 1995 under irrigated conditions. A spacing of 60 cm between the rows and 30 cm between plants in a row was adopted. The observations were recorded on five randomly selected plants. Genotypic correlations were computed as per Weber and Murthy (1952). Path coefficient analysis was carried out as suggested by Wright (1921) and illutrated by Dewey and Lu (1957). The characters which exhibited significant correlation with seed yield were considered for path analysis.

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RESULTS AND DISCUSSION

Genotypic correlations

Based on the nature of relationship, the characters could be grouped into morpho-physiological/ phenological (DFF): growth (LN, HT, SD1, SD2); yield components (HD, HW, SH, FS, TW) and yield characters (SY, OC, OYP). It is evident from the results (Table 1) that seed yield was positively associated with both growth and yield components. However, among yield components, the correlation of seeds/head (SH 0.91) was maximum followed by weight of seed (HW 0.83). While plant height HT (0.80) followed by Stem diameter (SD) showed greater magnitude of correlation among growth characters.

On the other hand, the within and between correlation of growth and yield components were positive. Interestingly, the correlation between certain growth characters (HT, SD1, SD2) and some yield components (HD, HW, SH) were of greater magnitude compared to others. The only phenological/morpho-physiological character, days to 50% flowering (DFF) showed non-significant association with almost all characters including seed yield and oil content, except SH. The oil content (OC) was negatively associated with all growth and yield components. However, the magnitude of correlation was low, while the derived yield character, oil yield on plant (seed yield x oil yield) showed positive association with most of the characters except OC and DFF.

The positive associations among various characters have been reported by several workers (Abdel-Gawad *et al.*, 1987; Alam *et al.*, 1987; Mishra *et al.*, 1985; Omran *et al.*, 1979). The observed positive association between DFF and SH is in explicable, while seed weight is reported to be positively associated with duration of vegetative phase (Cecconi *et al.*, 1989). Lack of association between DFF and seed yield/plant (SY) gives ample scope to select for desired early flowering and high yielding types. Fortunately, SY is reported to be desirably and negatively associated with days to maturity (Rao *et al.*, 1987). Unlike other crops, one of the interesting features in sunflower as reflected by the present study is that the correlations among all yield components were positive which would be encouraging in the rapid improvement of yield. Though, OC is negatively associated with most of the characters including SY, its lower magnitude would not affect much in the simultaneous improvement of yield and oil content.

Path analysis

Path analysis carried out in respect of both seed yield and oil yield (Table 2) showed that the direct effect was maximum for SH followed by test weight (TW) and HW in respect of both seed yield and oil yield. The maximum indirect effect for any character was through SH which itself was major contributor. Similar results have been reported by many authors (Pathak *et al.*, 1983; Dhaduk *et al.*, 1985; Mishra *et al.*, 1985; Diaz *et al.*, 1985). On the contrary, the direct effect of HT and HD was observed to be maximum by some workers (Anand and Chandra, 1979); Giriraj *et al.*, 1979; Alba and Greco, 1980). It was interesting to note that the direct and indirect effects of number of filled seeds (FS) was very less, while the number of seeds per head (SH) was an important character with maximum direct and indirect effects, giving an indication that probably the variability for PS is less. In fact, the variability for FS was the lowest of the 13 traits studied in the present material. It means that FS and SH are associated positively, which was observed to be true (Table 1). Also, the relationship of FS with SY and OYP was not true (Table 2).

From the above results, it would be reasonable to suggest that a breeder engaged in the improvement of sunflower yield and oil content should lay greater emphasis on the number of seeds per head, test weight and total weight of the head.

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Table 1. Genotypic correlations among 13 quantitative traits in Sunflower

	LN	HT	SD1	SD2	HD	HW	SH	FS	TW	SY	OC	OYP
DEF	0.12	0.12	0.08	0.02	0.11	0.13	0.15*	-0.07	-0.07	0.09	0.02	0.07
LN		0.59**	0.50**	0.36**	0.52**	0.62**	0.51**	0.20**	0.22**	0.53**	-0.14*	0.46**
HT			0.70**	0.56**	0.85**	0.76**	0.75**	0.33**	0.53**	0.80**	-0.22**	0.71**
SD1				0.73**	0.88**	0.80**	0.75**	0.23**	0.48**	0.79**	-0.21**	0.69**
SD2					0.81**	0.62**	0.62**	0.27**	0.54**	0.67**	-0.15*	0.64**
HD						0.81**	0.79**	0.49**	0.59**	0.7**	-0.17*	0.74**
HW							0.86**	0.34**	0.45**	0.83**	-0.23**	0.71**
SH								0.44**	0.55**	0.91**	-0.23**	0.52**
FS									0.48**	0.57**	-0.25*	0.52**
TW										0.67**	-0.41**	0.56**
SY											-0.33**	0.88**
OC												0.12**

Note: ** Significant at 1% level * Significant at 5% level

DFF = Days to 50 per cent flowering
LN = Number of leaves per plant
HT = Plant height (cm)
SD1 = Stem diameter at the base (cm)
HD = Head diameter (cm)
HW = Total weight of head (g)
SH = Number of seeds per head
FS = Per cent filled seeds
TW = Test weight
SY = Seed yield per plant
OC = Oil content (%)
OYP = Oil yield per plant

Table 2. Phenotypic path coefficient analysis in sunflower

	LN	HT	SD1	SD2	HD	HW	SH	FS	TW
LN	-0.2240	0.0204	0.0133	-0.0032	0.0017	0.0826	0.2292	0.0054	0.0372
	-0.0249	0.0020	-0.0152	0.0117	0.0279	0.0567	0.2205	0.0090	0.0318
HT	-0.0114	0.0400	0.0197	-0.0050	0.0027	0.1077	0.2981	0.0081	0.1071
	-0.0104	0.0041	-0.0226	0.0185	0.0442	0.0740	0.2867	02867	0.0917
SD1	-0.0094	0.0249	0.0316	-0.0067	0.0030	0.1212	0.3112	0.0085	0.1004
	-0.0104	0.0025	-0.0363	0.0246	0.0484	0.0833	0.2993	0.0143	0.0860
SD2	-0.0069	0.0195	0.0206	-0.0103	0.0026	0.0915	0.2331	0.0067	0.0775
	-0.0077	0.0020	-0.236	0.0379	0.0418	0.0629	0.2242	0.0113	0.0663
HD	-0.0081	0.0231	0.0200	-0.0056	0.0047	0.1476	0.3650	0.0125	0.1060
	-0.0090	0.0023	-0.0229	0.207	0.0706	0.1015	0.3511	0.0209	0.0907
HW	-0.0089	0.0208	0.0186	-0.0045	0.0034	0.2068	0.3861	0.0088	0.0887
	-0.0090	0.0021	-0.0212	0.0168	0.0547	0.1421	0.3714	0.0148	0.0759
SH	-0.0085	0.0197	0.0163	-0.0040	0.0030	0.1320	-0.6047	0.0142	0.0762
	-0.0094	0.0020	-0.0187	0.0146	0.0463	0.0907	0.5815	0.0237	0.0652
FS	-0.0032	0.0085	0.0071	-0.0018	0.0016	0.0484	0.2257	0.0380	0.0656
	-0.0035	0.0009	-0.0082	0.0067	0.0252	0.0332	0.2170	0.0635	0.0561
TW	-0.0031	0.0159	0.0118	-0.0030	0.0019	0.0680	0.1708	0.0093	0.2694
	-0.0034	0.0016	-0.0135	0.0109	0.302	0.0468	0.1643	0.0155	0.2306

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EFFECT OF MOLYBDENUM, ZINC AND CALCIUM ON PRODUCTIVITY OF GROUNDNUT (*Arachis hypogaea* Gaertn.)*

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ABSTRACT

A field experiment was carried out on an Alfisol at the Main Research Station of University of Agricultural Sciences, Hebbal, Bangalore during 1991 to study the effect of seed treatment with molybdenum, zinc+ molybdenum and calcium + zinc + molybdenum on the growth and yield of TMV-2 groundnut (*Arachis hypogaea*). Initially, laboratory studies were conducted to fix the tolerance limits of the micronutrients for seed treatment. The results indicated that root growth improved with root dry weight raising from 0.41g in *Rhizobium* treated control to 0.48, 0.50 and 0.47g per plant and leaf area from 708 cm^2 to 780, 816 and 857 cm^2 with 8g Mo, 8g Zn + Mo and 4g Ca + Zn + Mo per kg seeds respectively. The number of pods increased with most of the treatments, thus, increasing pod yield by 23 to 60 per cent. Compared to 2312 kg/ha with *Rhizobium* treated control, 8g Mo treatment gave 2688 kg while 8g Zn+Mo gave 3548 kg/ha. Use of *Rhizobium* alone increased crop yield by 11.7 per cent compared to control. However, the oil content was not influenced by *Rhizobium* inoculation.

Key words: Seed treatment; groundnut; molybdenum; zinc; calcium; productivity.

INTRODUCTION

In Karnataka state, groundnut is the leading oilseed crop with an area of 1.186 million hectares accounting for 51.43 per cent of total area under oil seed crops (2.306 mha). However, its productivity is low. Micronutrients Zn and Mo singly and combinedly have been found to influence productivity of groundnut (Shivashankar, 1985 and 1987). Since studies on influences of secondary and micronutrients on groundnut crop are limited, the present study on the effect of seed treatment of Mo, Zn + Mo and Ca +Zn + Mo on the growth and yield of groundnut was taken up.

MATERIALS AND METHODS

Four sets of laboratory experiments were conducted to test the tolerance limits of groundnut to varied levels of molybdenum, zinc +molybdenum and calcium + zinc + molybdenum. Groundnut seeds were treated with sodium molybdate (39% Mo) and in the form of zinc +molybdate (60:40) and zinc + calcium +molybdenum(30:30:40). As per the procedure, 4 per cent sucrose solution in case of Mo treatments and with methyl salicylate as a binder in case of Zn +Mo and Ca + Zn +Mo treatments were used. The seeds after treating were sown on germination paper placed in petridishes and were kept under laboratory conditions. The germination percentage was recorded. After examining the tolerance of groundnut crop to sodium molybdate and compounds of zinc + sodium molybdate and calcium + zinc +molybdate at varied levels from 0 to 16g/kg seeds, two levels of 4 and 8g of each compound were selected for further studies.

Based on the results obtained, a field experiment was conducted in the main research station, University of Agricultural Sciences, Hebbal, Bangalore, during the late *kharif* seasons of 1990 and 1991 in an Alfisol with a pH of 5.6 EC of 0.20 dsm^{-1} (Richards 1954) and with contents of 0.39 per cent of OC (Piper 1966), 160 kg N/ha

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(Alkaline permanganate method, Subbaiah and Asija, 1956), 13.5 kg P_2O_5/ha (Jackson, 1973), 200.2 kg K_2O/ha (Jackson, 1973), exchangeable Ca (meq/100g soil) 2.3 (Complexometric titration method). Available Zn 0.38 ppm and Available Mo 0.32 ppm.

In the field experiment response of groundnut to micronutrients was studied with the treatments laid out in a split-plot design having 4.2 m x 3m gross plot size and 4.2 m x 1.5 m net plot with four replications. TMV-2 variety of groundnut was used as test crop.

Treatment combinations

1. Control
2. Control + *Rhizobium*
3. Molybdenum @ 4g kg^{-1} seed
4. Molybdenum @ 4g kg^{-1} seed + *Rhizobium*
5. Molybdenum @ 8g kg^{-1} seed
6. Molybdenum @ 8g kg^{-1} seed + *Rhizobium*
7. Zinc + Molybdenum @ 4g kg^{-1} seed
8. Zinc + Molybdenum @ 4g kg^{-1} seed + *Rhizobium*
9. Zinc +Molybdenum @ 8g kg^{-1} seed
10. Zinc + Molybdenum @ 8g kg^{-1} seed + *Rhizobium*
11. Zinc + Calcium + Molybdenum @ 4g kg^{-1} seed
12. Zinc + Calcium + Molybdenum @ 4g kg^{-1} seed + *Rhizobium*
13. Zinc + Calcium + Molybdenum @ 8g kg^{-1} seed
14. Zinc + Calcium + Molybdenum @ 8g kg^{-1} seed + *Rhizobium*

At the time of sowing, nitrogen as urea, phosphorus as single super phosphate and potassium as muriate of potash were applied at the recommended dosage (10 kg N, 30 kg P_2O_5 and K_2O ha^{-1}). The seeds were dried in shade before sowing. Seeds were sown 15 cm apart in furrows at the rate of 2 seeds per hill. After 20days of sowing, in treatments with *Rhizobium*, IGR-40 suspension was injected near the stem region of each plant and all the normal operations were carriedout.

Plants were watered before uprooting and were uprooted carefully alongwith root system. Roots were washed to remove the adhering soil. Radicle length of the three randomly selected plants from each plot was measured. The mean length of mean root per plant was worked out. After taking the above crop growth observations, the root portion was dried at 70°C in the oven and the weight was recorded. Leaf area was measured using a Leaf Area Meter (LI-COR 3000 model) Oil content of the kernel was recorded using a Nuclear Magnetic Resonance Spectrophotometer.

RESULTS AND DISCUSSIONS

From the laboratory experiments it was ascertained that 4 and 8g of micronutrients were tolerable in respect of germination, root and shoot growth. The combined treatments were equally efficient as Mo alone (Table 1).

It was observed that none of the treatments effected seed germination significantly. Though seed treatment with 8g sodium molybdate brought down the germination to 75 per cent compared to 92.5 per cent in control (Subbaraman and Selvaraj, 1989; Yuan *et al.*, 1990).

The main root length was significantly higher in all the treatments (3.3 to 5.4 cm) compared to the control (2.5 cm). The Zn +Mo at both the levels were on par with each other (3.3 and 3.7 cm). It was observed that the main root length was significantly highest in treatment with 8g Mo per kg seed (5.4 cm) followed by Ca + Zn + Mo at 8g per kg seed (4.7).

Table 1. *Effect of seed treatment of Mo, Zn + Mo and Ca +Zn +Mo on the germination, main root length,* shoot length and number of rootlets per seedling of groundnut (8 DAS, lab studies).

Sl. No.	Treatment	Germination % 8 DAS	Main root length (cm) 8 DAS	Main root length (cm) 20 DAS	No. of rootlets/seedling (8 DAS)	Shoot length (cm) (8 DAS)
1.	Control	92.5	2.5	5.2	23.3	3.8
2.	Mo 4g/kg seed	90.0	3.3	5.7	23.3	3.5
3.	Mo 8g/kg seed	75.0	5.4	5.2	16.5	5.6
4.	Zn +Mo 4g/kg seed	87.0	3.3	6.1	32.0	3.9
5.	Zn +Mo 8g/kg seed	97.5	3.7	5.3	24.4	3.0
6.	Ca +Zn +Mo 4g/kg seed	95.0	3.9	4.9	32.8	3.3
7.	Ca + Zn + Mo 8g/kg seed	92.5	4.7	5.2	20.9	4.3
	F-test	NS	*	*	*	*
	CD @ 0.05		0.53	0.51	2.82	0.85

* Significant @ 5% level (Average of 4 replications) NS - Non-significant

Table 2. Main root length, root dry weight and leaf area in groundnut as influenced by interaction Mo, Zn +Mo and Ca +Zn + Mo x *Rhizobium*

Sl. No.	Treatments	At 60 DAS Main root length (cm/plant) *Rhizobium* Without	With	At 60 DAS Root dry weight (g/plant) *Rhizobium* Without	With	At 50 DAS Leaf area (cm2/plant) *Rhizobium* Without	With
1.	Control	12.8	13.1	0.39	0.41	704.8	708.3
2.	Mo 4g/kg seed	11.4	12.1	0.40	0.45	724.7	896.9
3.	Mo 8g/kg seed	12.6	13.1	0.40	0.48	649.4	779.5
4.	Zn +Mo 4g/kg seed	12.9	13.2	0.36	0.40	604.6	763.3
5.	Zn +Mo 8g/kg seed	12.0	12.8	0.44	0.47	619.3	851.3
6.	Ca +Zn +Mo 4g/kg seed	12.1	13.0	0.41	0.50	711.5	816.1
7.	Ca + Zn + Mo 8g/kg seed	12.7	14.2	0.36	0.47	685.3	857.7
	Mean	12.4	13.1	0.39	0.45	685.3	810.4
		S.Em ±	CD @ 5%	S.Em ±	CD @ 5%	S.Em ±	CD @ 5%
- For comparing subplot treatments at fixed level of main treatment		0.27	0.80	0.02	0.07	31.44	95.38
- For comparing the main treatments at fixed or different levels of sub treatments		0.44	1.34	0.05	0.14	57.324	176.232

The number of rootlets per seedling was 23.3 in control and the treatments with molybdenum at 4g per kg seed, Zn + Mo at 8g per kg were on par with it. The highest number of rootlets were seen in Ca+ Zn + Mo 4g per kg seed (32.8/seedling) and Zn + Mo at 4g per kg seed (32/seedling) which were on par with each other (Shivashankar, 1985). These were followed by the treatment with Zn + Mo at 8g per kg seed (24.4/seedling). It was also observed that with each compound the number of rootlets got reduced significantly with higher level (Shivashankar and Hagstrom, 1991).

The shoot length was significantly highest in treatment with sodium molybdate at 8g per kg seed (5.6 cm) followed by Ca+Zn+Mo 8g per kg seed (4.3). The least shoot length was with Zn + Mo at 8g per kg seed (3.0). The rest of the treatments were on par with each other (Gupta and Potalia, 1987; Lumpungu and Muteba, 1983).

The data from field experiment indicated that the main root length, root dry weight and leaf area in groundnut were significantly influenced by seed treatment with Ca + Zn + Mn (Table 2).

At 60th day, the treatment with Ca +Zn +Mo at both the levels with *Rhizobium* were superior to their respective controls. The treatment with Ca + Zn + Mo (8g/kg seed) with *Rhizobium* gave the highest main root length of 14.2 cm/plant which was on par with its lower level of 4g/kg seed with *Rhizobium* (13.0 cm plant). The treatment with Ca +Zn +Mo (8g/kg seed) with *Rhizobium* was superior to the rest of the treatments. Synergistic effect of *Rhizobium* and the presence and availability of Mo were beneficial (Burton and curely, 1966; Shivashankar, 1976).

Root dry weight was improved in groundnut at all stages with *Rhizobium* treatment. At the 60th day, Mo at 8g/kg seed, Zn +Mo at 8g/kg seed and Ca + Zn + Mo at both the levels all treated with *Rhizobium* were superior to those without *Rhizobium*. Similar results were observed by Shivashankar (1976 and 1987). Leaf area of groundnut in the presence of *Rhizobium* inoculation was significantly superior to the controls. At the 50th day, all the Mo treatments showed significant improvements in the leaf area in the presence of *Rhizobium* inoculation. The three-way interaction at 50th day indicated that with *Rhizobium* +Mo alone at 4g/kg seed (896.9 cm^2/plant) was superior to the control with or without *Rhizobium* and four other treatments without *Rhizobium* viz., Mo (8g/kg seed) and Ca +Zn +Mo (4g/kg seed).

Hundred kernel weight, pod yield and oil content in groundnut were favourably influenced by treatment with Mo, Zn +Mo and Ca +Zn +Mo (Table 3).

Hundred kernel weight in control (33.3g) was on par with Mo (kg seed), Zn +Mo (8g/kg seed) and Ca +Zn +Mo (4g/kg seed). In all, these were superior to Mo at 4g per kg seed (Dhillon *et al.*, 1977); Lumpungu and Muteba, 1983). However, this treatment with lower dose of Mo was on par with the lower dose of Zn + Mo and higher dose of Ca +Zn +Mo.

The *Rhizobium* inoculated treatments were found to be superior to those without *Rhizobium* inoculation.

Two-way interaction indicated that hundred seed weight in Zn + Mo at 4g per kg seed, Ca +Zn +Mo both at 4 and 8g per kg seed with *Rhizobium* inoculation were superior to respective treatments without *Rhizobium* whereas, the rest of the treatments without *Rhizobium* were on par with their respective controls.

Three-way interactions indicated that the treatment with 8g per kg Mo with *Rhizobium* had the highest hundred kernel weight of 35.2g, which was on par with almost all the treatments except with Mo at 4g per kg seed or without *Rhizobium* and Zn + Mo 4g per kg seed without *Rhizobium*. The hundred kernel weight increased with most of the treatments, thus increasing pod yield by 23 to 60 per cent compared to 2312 kg/ha with *Rhizobium* treated control (Paker and Harris,

Table 3. **Hundred kernel weight, pod yield and oil content in groundnut at harvest as influenced by interaction of Mo, Zn +Mo and Ca +Zn + Mo x *Rhizobium*.**

Sl. No.	Treatments	Hundred kernel weight (g) *Rhizobium*		Pod yield (kg/ha) *Rhizobium*		Oil per cent *Rhizobium*	
		Without	With	Without	With	Without	With
1.	Control	32.7	33.9	2016	2312	47.0	46.3
2.	Mo 4g/kg seed	28.6	29.5	2177	2285	47.0	45.6
3.	Mo 8g/kg seed	34.4	35.2	2634	2688	47.6	48.8
4.	Zn +Mo 4g/kg seed	31.3	33.4	2484	3522	46.5	46.3
5.	Zn +Mo 8g/kg seed	33.3	34.1	3172	3709	47.1	47.3
6.	Ca +Zn +Mo 4g/kg seed	32.3	33.7	3387	3548	47.0	47.3
7.	Ca + Zn + Mo 8g/kg seed	31.9	33.5	2473	3413	46.8	49.1
	Mean	32.1	33.3	2621	3068	47.0	47.2
		S.Em ±	CD @ 5%	S.Em ±	CD @ 5%	S.Em ±	CD @ 5%
	- For comparing subplot treatments at fixed level of main treatment	0.39	1.18	168.1	510.0	0.5	1.5
	- For comparing the main treatments at fixed or different levels of sub treatments	1.18	3.65	164.4	502.0	0.5	1.4

1962; Murvin and Shumbin, 1969). The 8g Mo treatment gave 2688 kg, 8g Zn +Mo treatment increased it to 3709 kg and 4g Ca +Zn +Mo gave 3548 kg/ha. Lower response in some treatments at higher levels of micronutrients could be due to toxicity effects. Molybdenum could be highly toxic to the *Rhizobium* leading to complete or partial loss of nodulation (Sims *et al.*, 1974; Shivashankar *et al.*, 1975). However, inoculation of the *Rhizobium* improved the situation marginally. In general, it was found that *Rhizobium* increased the pod yield of groundnut from 2621 kg in control to 3068 kg per hectare registering a 11.7 per cent improvement.

In the treatment with Ca +Zn + Mo at 8g per kg of seed, the higher proportion of Zn + Mo together must have masked the effect of calcium (Martinez, *et al.*, 1977). Yet the toxic effect of Mo in this treatment must have been nullified by Ca which promoted extensive root growth. Zinc is also known to enhance both dry matter and kernel weight of groundnut (Srinivasan and Velu, 1982; Malewar *et al.*, 1982). Thus, the combined effects of Zn + Mo and of Ca + Zn +Mo were superior to mere molybdenum seed treatment when inoculated with *Rhizobium*.

The oil percent was highest with Ca + Zn + Mo 8g per kg seed (49.1%) which was on par with 8g per kg seed molybdenum with *Rhizobium* was beneficial in providing high yields whereas the treatment, Ca +Zn +Mo at 8 per kg seed was helpful in raising the oil per cent up to 49 per cent (Lumpungu and Muteba, 1983).

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INFLUENCE OF IRRIGATION AND FERTILIZATION ON SEED YIELD, NUTRIENT UPTAKE AND FERTILIZER USE EFFICIENCIES IN SUMMER SESAME (*Sesamum indicum* L.)

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ABSTRACT

Field experiments were conducted to study the influence of irrigation, nitrogen and phosphorus on sesame yield, nutrient uptake and fertilizer use efficiencies. Seed yield and NPK uptake by sesame was significantly higher at 1.0 IW/CPE ratio but it was on par with 0.8 IW/CPE ratio and significantly superior to 0.6 IW/CPE ratio. Application of 50 kg N/ha 30 kg P_2O_5/ha significantly enhanced the yield and nutrient uptake over control. Higher N (100 kg/ha) and P(60 kg P_2O_5/ha) levels did not provide any significant benefit. The agronomic efficiency which is the product of apparent recovery and physiological efficiency indicated that the efficiency of the first increment of N and P was more and decreased with increase in fertilizer dose under all the irrigation levels.

Key words: Sesame; fertilization; irrigation; yield; nutrient uptake.

INTRODUCTION

It is well documented that irrigation water increases fertilizer needs and its use efficiency (Van Keulen, 1986). Very little information is available on sesame response to fertilization (N and P) under variable irrigation levels. Likewise studies on nutrient uptake and use efficiency by sesame are limited. Hence, the present investigation was taken up to study the effect of irrigation, N and P on sesame yield, NPK uptake and fertilizer use efficiency.

MATERIALS AND METHODS

Field experiments were conducted at Students' Farm, College of Agriculture, Rajendranagar, Hyderabad, during summer seasons of 1992 and 1993. The soil of the experimental site was sandy loam in texture, slightly alkaline in reaction (pH 7.47) with 245 kg N, 27 kg P_2O_5 and 311 kg K_2O ha^{-1}. The average soil moisture retentivity at field capacity and wilting point was 17.25% and 5.27%, respectively, in 60 cm soil depth, whereas the average bulk density value was 1.52 g cm^{-3}. The depth of ground water table from the soil surface was below 6 m during both the seasons. The weather during both the seasons was fairly dry and rainless except that a total precipitation of 2.3 mm in 1992 and 4.8 mm in 1993 was received.

The treatments comprising three irrigation levels (0.6, 0.8 and 1.0IW/CPE ratio) in combination with 0, 50 and 100 kg N ha^{-1} and 0, 30 and 60 kg P_2O_5 ha^{-1} were tested in 3^3 partially confounded design in 2 replications with block size of 9 plots each. The second order interaction was confounded in the block. The measured quantity of irrigation water was delivered to the crop by installing a Parshall Flume (7.5 cm throat width) in the irrigation channel. The irrigation water depth was 5 cm and the CPE was measured from U.S. Class A pan evaporimeter. The total number of irrigations under 0.6, 0.8 and 1.0 IW/CPE ratio in 1992 were 6, 8 and 10, respectively. The corresponding number of irrigations in 1993 were 5, 6 and 8, whereas the seasonal irrigation water depth under 0.6, 0.8 and 1.0 IW/CPE ratio in 1992 were 30, 40 and 50 cm and in 1993 were 25, 30 and 40 cm, respectively.

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Sesame variety "Rajeshwari" was sown at 30 cm x 10 cm spacing using 1.0 Kg seed/ha to achieve a desired plant population of 3.33 lakh/ha on 30 January in 1992 and on 2 February in 1993. The crop uniformly received 30 kg K_2O/ha along with entire P_2O_5 as basal application, whereas N was applied in 2 equal splits at sowing and 30 days after sowing.

Nitrogen (Piper 1952). phosphorus and potassium contents (Jackson, 1967). In seed and straw were estimated the N, P and K contents were multiplied with seed and straw to compute N, P and K uptake. The uptake values in conjunction with the seed yields were used to calculate the fertilizer use efficiency indices *viz.* Agronomic efficiency, Physiological efficiency, Apparent recovery fraction and nutrient harvest index as suggested by Nova and Loomis (1981).

RESULTS AND DISCUSSION

Seed yield and Nutrient uptake

Scheduling of irrigation at 1.0 IW/CPE ratio recorded significantly higher seed yield but it was on par with 0.8 IW/CPE ratio and significantly superior to 0.6 IW/CPE ratio (Table I). NPK uptake exhibited trends similar to that of seed yield in relation to irrigation except that each higher level of IW/CPE ratio significantly enhanced the N uptake. The low nutrient uptake under 0.6 IW/CPE ratio could be due to reduced mobility of nutrients under water deficient conditions and also possibly due to reduced straw and seed yield. Increase in N-uptake due to frequent irrigation was also observed by Metawally *et al.* (1984) and Vyas *et al.* (1985). Significant reduction in phosphorus uptake with increased degree of moisture stress (0.6 IW/CPE ratio) could be ascribed to slow movement of phosphorus to the roots through reduced thickness of water films, and this might have increased the diffusion path length and reduced the P absorption by roots. The nutrient accumulation was more in seed than straw which may be due to greater remobilization of nutrients to reproductive organs.

Nitrogen effects

Application of 50 and 100 kg N/ha significantly increased the seed yield, NPK uptake by sesame over control (N_O Nitrogen). However, there was not any significant difference between 50 and 100 kg N/ha. Availability of adequate nitrogen has been shown to enhance leaf area development and yield attributes of sesame resulting in good seed yield (Kamel *et al.* 1983; Metawally *et al.* 1984 and Rao and Raikhelkar, 1993). Thus the increased NPK uptake with application of N may be attributed to the increased seed and straw yield and partly due to high mobility of these nutrients (Metawally *et al.* 1984 and Rao *et al.* 1993).

Phosphorus effects

Application of 30 and 60 kg P_2O_5/ha were equally effective and recorded significantly more seed yield and NPK uptake over no phosphorus. This increase may be attributed to beneficial role of phosphorus in promoting root development and proliferation and due to greater mobilization of phosphorus with added P_2O_5 (Rao *et al.* 1993). However non significant response to higher levels of P_2O_5 may be due to inherent medium phosphorus status of experimental soil.

Irrigation x Nitrogen interaction:

The seed yield and uptake of N by seed were significantly influenced by IxN interaction. The seed yield recorded at 50 and 100 kg N/ha both under 0.8 and 1.0 IW/CPE ratio were on par and significantly superior to other combinations.

Fertilizer use efficiencies

The apparent recovery fraction (ARF) of N was highest by the crop irrigated at 1.0 IW/CPE ratio in conjunction with nitrogen @ 100 kg/ha. Similarly irrigations at 1.0 IW/CPE combined

Table 1. Seed Yield, N, P, and K uptake (kg/ha) by Sesame as influenced by irrigation and fertilizer (*Mean of 1992 and 1993*)

Treatment	Seed Yield (Kg/ha)	Nitrogen uptake		Phosphorus uptake		Potassium uptake	
		Straw	Seed	Straw	Seed	Straw	Seed
IW/CPE Ratio							
0.6	624	13.43	27.04	4.13	9.76	6.49	13.97
0.8	779	16.55	32.30	4.77	11.91	8.37	17.98
1.0	861	19.72	31.03	4.77	11.88	8.85	20.01
S.Em±	30.5	0.53	0.69	0.28	0.60	0.50	0.77
CD (0.05)	90.5	1.55	2.01	0.83	1.76	1.47	2.28
Nitrogen (kg/ha)							
0	549	11.74	24.96	4.09	9.69	6.16	14.83
50	820	18.66	34.36	4.62	11.76	8.33	18.13
100	878	19.62	35.05	4.96	12.16	9.21	18.94
S.Em±	32.0	0.53	0.69	0.28	0.60	0.50	0.77
CD (0.05)	90.5	1.55	2.01	0.83	1.76	1.47	2.28
Phosphorus (kg/ha)							
0	606	16.20	30.47	3.47	8.08	7.15	16.43
30	802	16.73	31.57	4.85	12.28	8.05	17.39
60	837	16.60	32.33	5.35	13.24	8.50	18.09
S.Em±	30.5	0.53	0.69	0.28	0.60	0.50	0.77
CD (0.05)	90.5	NS	NS	0.83	1.76	NS	NS

with 60 kg P_2O_5/ha contributed to highest apparent P recovery. However, the apparent recovery of N and P in general exhibited descending trend with ascending levels of water, N and P_2O_5 (Tables 2 and 3).

The physiological efficiency of the crop increased with increase in IW/CPE ratio from 0.6 to 1.0 under a given level (50 or 100 kg/ha) of nitrogen. On the other hand at a given level (30 or 60 kg/ha) of P_2O_5, the PE was inversely related to IW/CPE ratio (Table 2 or 3). Further it was also observed that the PE of the crop was more at 100 kg N/ha and 30 kg P_2O_5/ha in comparison to other levels.

The agronomic efficiency, which is a product of ARF and PE, indicated that efficiency of first increment of N or P_2O_5 was more and it decreased with additional increment, irrespective of irrigation schedule, showing a diminishing response of seed yield to higher levels of N and P_2O_5. The nitrogen harvest index decreased with ascending levels of N under all the IW/CPE ratios. Whereas the phosphorus harvest index showed a quadratic response to P application.

Conclusion

From the present study it may be concluded that scheduling of irrigations at 0.8 IW/CPE ratio in conjunction with 50 kg N/ha and 30 kg P_2O_5/ha is necessary to realize higher sesame yield and efficiency of applied fertilizer nutrients in sandy loam soils during summer season.

Table 2. Apparent N recovery (ARF), Physiological efficiency (PE) and Agronomic efficiency (AE) Under different irrigation and nitrogen levels for summer sesame (Mean of 1992 & '93)

Treatment (IW/CPE, N kg/ha)	Seed Yield (Kg/ha)	ARF for N (%)	PE. (Kg seed/ kg N absorbed)	AE= (kg seed/ kg N applied)	AE of extra N increment	Nitrogen Harvest index
0.6 N_0	461.0	–	–	–	–	0.698
0.8 N_0	573.2	–	–	–	–	0.689
1.0N_0	613.3	–	–	–	–	0.658
0.6 N_{50}	656.7	0.24	16.67	3.91	3.91	0.657
0.8 N_{50}	848.0	0.34	16.93	5.50	5.50	0.653
1.0 N_{50}	948.4	0.39	17.48	6.70	6.70	0.635
0.6 N_{100}	702.0	0.15	17.05	2.41	0.91	0.650
0.8 N_{100}	911.9	0.19	18.51	3.39	1.28	0.644
1.0 N_{100}	1004.9	0.20	19.61	3.92	1.13	0.625

Table 3. Apparent P recovery (ARF), Physiological Efficiency (PE) and Agronomic Efficiency (AE) Under diffeent Irrigation and Phosphorus Levels for Summer Sesame (Mean of 1992 & 1993)

Treatment (IW/CPE, P kg/ha)	Seed Yield (Kg/ha)	ARF for P (%)	P E (Kg. seed/kg P absorbed)	AE of extra P increment	AE (kg seed/kg P applied)	Phosphorus Harvest index
0.6 P_0	475.35	–	–	–	–	0.521
0.8 P_0	629.2	–	–	–	–	0.704
1.0P_0	713.0	–	–	–	–	0.706
0.6 P_{30}	663.2	0.15	43.61	6.26	6.26	0.712
0.8 P_{30}	835.9	0.20	35.36	6.90	6.90	0.717
1.0 P_{30}	917.2	0.22	30.10	6.80	6.80	0.720
0.6 P_{60}	690.2	0.10	36.99	0.90	3.59	0.706
0.8 P_{60}	868.0	0.12	33.36	1.08	3.98	0.715
1.0 P_{60}	953.2	0.14	29.39	1.20	4.0	0.715

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RESPONSE OF SAFFLOWER (*Carthamus tinctorius* L.) TO DIFFERENT METHODS OF IRRIGATION

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ABSTRACT

Field Experiments conducted at water management Research Project, M.A.U. Parbhani and at NARP, Aurangabad during *rabi* 1990-91 through 1992-93 showed significant increase in seed yield of safflower with the application of irrigation water over rainfed control. Seed yield of safflower with irrigation in furrows (60x15 cm) and skip row furrow (45x20 cm) were on par and recorded significantly more yield than irrigation in alternate furrow (45x20 cm) and paired planting (60+30x15 cm). The latter two irrigation methods were at par with treatments of irrigation in furrow (45x20 cm) and flat bed. However, irrigating safflower in skip furrow method resulted in 35% saving of irrigation water besides providing high water use efficiency (WUE).

Key words: Skip - row furrow; paired-row furrow; alternate furrow irrigation

INTRODUCTION

Traditionally safflower is grown on vertisols with residual soil moisture. However, research work done on irrigated safflower since two decades have shown encouraging results. Safflower cannot withstand water logged conditions caused by rain or heavy irrigation which results in wilting. As safflower needs limited moisture, it becomes necessary to know how to apply limited irrigation water. The research on this aspect is very meagre. Therefore the present experiment was conducted at Water Management Research Project, Marathwada Agricultural University, Parbhani and National Agricultural Research Project, Aurangabad during *rabi* seasons of 1990-91 to 1992-93.

MATERIALS AND METHODS

A field experiment with Cv. Bhima was conducted during *rabi* season of 1990-91 to 1992-93. Soils of Parbhani and Aurangabad are similar. The soil of experimental site was medium deep and clayey in texture, low in organic carbon and nitrogen, medium in phosphorus and rich in potassium content, with slightly alkaline reaction. The moisture content of soil at 0.3 and 15 bar were 34 and 16 per cent, respectively with bulk density of 1.3 g/cc. The experiment was conducted in randomised block design with four replications. The treatments consisted of rainfed control (T_1), flat bed (45x20 cm), (T_2), ridges and furrows (45x20 cm) with all furrow irrigation (T_3), ridges and furrow (45x20 cm) with alternate furrow irrigation (T_4) , ridges and furrows (60 x 15 cm) irrigation of each furrow (T_5), paired row (30+60) x 20 cm with each furrow (60 cm) irrigation (T_6) and skipped row (T_7). The irrigation water was measured with the help of water meter at each irrigation and total quantity of three irrigations is summed up as irrigation water (IW) of that treatment. The irrigation water applied differed in different methods because of varied spacing between furrows as well as their wetted perimeter. Soil moisture content before and after each irrigation was monitored by gravimetric method and expressed in volumetric units for estimating the actual evapotranspiration (ETa) of crop. The crop received 60 kg N, 40 kg $P_2O_5$and 40 kg K_2O per hectare at the time of sowing. Aphid incidence

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was kept under check by spraying Endosulphan @ 0.07 percent. During 1992-93, 3.8 cm effective rainfall was received. The crop was harvested during second fortnight of March in all the years at both the locations.

RESULTS AND DISCUSSION

Results from the data of two locations indicated that the maximum seed yields of safflower were observed with ridges and furrow (60 x 15 cm) (T_5) (1689 kg/ha) and skipped row - furrow irrigation (T_7) (1662 kg/ha) and these two treatments recorded statistically similar yields. However, they were significantly superior to the rest of the treatments barring T_2 and T_3 (Table 1). Further it was observed that wilt incidence was more in flat bed and ridges furrow (45x20 cm) as compared to skipped row (T_7) or ridges and furrow (60x15xm) (T_5). In seed yield the treatment of skipped row (T_7) performed equally well as that of ridges and furrows (60x15 cm) where less quantity of irrigation water (35% less as compared to other layouts) was applied. Besides, skip furrow method facilities physical convenience in operations such as spraying of insecticide, irrigation, inter culture and harvesting. Low incidence of wilt in T_7 treatment might be the consequence of less period of water stagnation due to presence of dry soil between two skip-row furrows to absorb excess water and reduced exposure of crop plants to saturated soil. This treatment (T_7) also gave the highest water use efficiency (WUE) of 66 kg/ha -cm at Parbhani (Table 2). These results are in conformity with those obtained by Rajput *et al.* (1981) who got significantly more seed yield of safflower with the application of two or three post-sowing irrigations. Further they also reported saving of 50 and 66 percent irrigation water with the application of irrigations through alternate ridges and furrows and skipped row furrow (2:1) of 50 cm spacing, respectively.

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Table 1. Seed yield (kg/ha) of safflower as influenced by different methods of irrigation

Treatment		Parbhani				Plant wilting percentage during (1990-91)	Aurangabad			Pooled over locations (weighted mean)
		1990-91	1991-92	1992-93	Mean		1990-91	1991-92	Mean	
T1 Rainfed control (45x20 cm)		1270	1003	1063	1111	8.8	1057	1654	1355	1153
T2 Flat bed (45x20 cm)		1553	1498	1424	1491	11.5	1466	2446	1956	1609
T3 Ridges & furrows (45x20 cm) Irri. to each furrow.		1598	1612	1446	1550	95	961	2162	1561	1599
T4 Ridges & furrows (45x20 cm) irri. to alternate furrow.		1476	1483	1385	1447	9.0	1314	1946	1630	1478
T5 Ridges & furrow (60x15 cm) irri. to each furrow.		1897	1612	1578	1694	7.4	1214	2105	1659	1689
T6 Paired planting (30+60 cm)x20 cm), irri. in 60 cm furrow.		1717	1372	1327	1472	3.8	1162	1773	1467	1471
T7 Skipped row furrow after two rows (45x20 cm) irri. in skip row furrow.		1736	1460	1482	1558	7.5	1867	2453	2160	1662
SE ±		44	54	70	60	0.18	103	149	162	65
CD (0.05)		135	167	209	167	0.54	308	457	449	180
Season	SE ±				39				87	36
	CD at 5%				109				240	99
Season x Treat.	SE±				280				104	-
	CD at 5%				N.S.				N.S.	-
Locations	SE±									36
	CD at 5%									99
Season x Treatment x Locations	SE±									95
	CD at 5%									262
Mean		1607	1433	1384	1475		1286	2078	1682	1516

Table 2. Irrigation water (IW), Consumptive use (Cu) in cm and water use efficiency (WUE) in kg/ha-cm in safflower at Parbhani

Treatment	1990-91			1991-92			1992-93			Mean		
	IW	CU	WUE	IW	CU	WUE	IW	CU	WUE	IW	CU	WUE
T1 Rainfed control (45x20 cm)	-	11.5	112.2	6.0*	11.8	85.0	--	12.1	87.8	2.0	11.8	94.1
T2 Flat bed (45x20 cm)	21.6	32.3	48.1	24.0	27.7	53.9	18.0	28.2	50.4	21.2	29.4	50.7
T3 Ridges & furrows (45x20 cm) Irri. to each furrow.	20.1	30.6	51.6	24.0	28.4	56.8	18.0	27.3	53.0	20.7	29.8	52.0
T4 Ridges & furrows (45x20 cm) irri. to alternate furrow.	18.3	30.3	48.7	19.5	25.3	58.6	11.7	21.1	65.3	13.2	25.7	56.3
T5 Ridges & furrow (60x15 cm) irri. to each furrow.	20.1	35.2	53.9	24.0	29.1	55.4	18.0	28.3	55.8	20.7	30.9	54.8
T6 Paired planting (30+60 cm)x20 cm), irri. in 60 cm furrow.	20.6	31.5	54.5	19.5	26.8	51.2	12.4	23.3	56.9	17.8	27.2	54.1
T7 Skipped row furrow after two rows (45x20 cm) irri. in skip row furrow.	16.6	25.6	67.8	15.0	22.2	65.6	12.8	22.8	65.0	14.8	23.5	66.3

Soil moisture was at field capacity at the time of sowing.

* Indicates common presoaking irrigation for 1991-92, CPE for base period is 85, 92, 86 cm for the year 1990-91, 1991-92 & 1992-93, respectively. 3.8 cm was effective rainfall during 1992-93.

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EFFECT OF SULPHUR AND ANTITRANSPIRANTS ON YIELD ATTRIBUTES, YIELD AND NUTRIENT UPTAKE IN RAINFED LINSEED (*Linum usitatissimum* L.)*

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ABSTRACT

Field experiments were carried out during winter seasons of 1989-90 and 1990-91 in clay loam soils of Sagar (M.P.) to find out the effect of sulphur and antitranspirants on rainfed linseed cv. R552 revealed that increasing rates of S application significantly increased seed and oil yields upto 20 kg S ha^{-1} mainly due to improvement in capsule $plant^{-1}$, seed yield $plant^{-1}$ and 1000-seed weight. All doses of S application (10, 20 and 30 kg S ha^{-1}) significantly led to higher uptake of N, P, K and S over control, but differences between closer levels were not much. Foliar application of kaolin 6.1% at 30-DAS produced superior yield attributes than suncap 0.5% and cycocel 0.5% and ultimately gave higher seed and oil yields. Cycocel and control were at par in this regard. Use of antitranspirants resulted in significantly higher uptake of N, P, K and S than control. Kaolin 6% proved to be the best followed by suncap 0.5% among the anitranspirants for yield and nutrient uptake.

Key words: Antitranspirants; yield attributes; oil yield; uptake of N, P, K and S.

INTRODUCTION

Linseed is extensively grown as rainfed crop on marginal lands in Vindhya plateau region of Madhya Pradesh with low productivity (294 kg ha^{-1}). Application of major nutrients like N, P and K through fertilizers certainly helps increase the productivity level to some extent. However, intensive use of S-free fertilizers like diammonium phosphate and urea and intensive cropping systems have posed the problem of S-deficiency in soils mainly for growing the oilseed crops. The efficiency of applied N, P and K fertilizers also reduced in S-deficient soils causing low yields (Jain, 1986 and Singh and Sahu, 1986). This necessitates to study the S-requirement of oilseed crops for improving the yields. The use of anti-transpirants to reduce water losses through transpiration in crops also appears to be a field of extensive study for increasing the production in rainfed areas (Singh *et al.* 1981). The magnitude of different sulphur levels and antitranspirants for improving the yield of rainfed linseed widely grown in Satpura plateau region of Madhya Pradesh.

MATERIALS AND METHODS

Field experiments were conducted on linseed cv. R552 during winter seasons of 1989-90 and 1990-91 in clay loam soils at Regional Agricultural Research Station, Sagar (M.P.). The soil of the experimental field had pH of 7.1 and contained low available N (235 kg ha^{-1}), P_2O_5 (9.6 kg ha^{-1}) and high available K_2O (394 kg ha^{-1}). The rainfall was 746.4 and 1990.5 mm during rainy season from June to September in the two consecutive years of experimentation. A rainfall of 25.1 and 70.4 mm was received during the crop season in the two respective years. The water holding capacity and permanent wilting point of the soil were 36.6 and 21.3%, respectively. The experiment was conducted in a "Haveli" field representing the usual rainfed linseed growing condition of the region. In "Haveli" fields, traditionally rain water is impounded in bunded fields which is drained out a fortnight before sowing of winter crops. Sixteen treatments consisting of four levels of sulphur (0, 10, 20 and 30 kg S ha^{-1}) and four antitranspirants (no spray,

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kaolin 6%, cycocel 0.5% and suncap 0.5%) were tested in a 4-replicated randomized block design. A uniform dose of 30 kg N+10 kg P_2O_5 ha^{-1} was given as basal through diammonium phosphate and urea. Sowing was done by drilling 30 kg seed ha^{-1} in rows 25 cm apart on 6 November, 1989 and 29 October, 1990. Sulphur was given through gypsum (16% S) at sowing alongwith N and P fertilizers. Spraying of kaolin, cycocel and suncap was done on 30th day stage of crop by using 250 liters of water per hectare. Oil content of seeds was estimated by Soxhelet extraction method (AOAC, 1965). N (AOAC, 1965), P (Koeing and Thompson, 1942) and K (Chensin and Yien, 1951) contents of seeds and straw were analysed to work out the total uptake.

RESULTS AND DISCUSSION

Yield attributes and seed yield

Yield attributes viz., capsules plant^{-1}, seed yield plant^{-1} and 1000-seed weight significantly increased with increasing rates of S application upto 20 kg S ha^{-1} (Table 1). Further increase in S levels did not show significant increase in yield attributes and even seeds capsule^{-1} in both years. As a consequence, seed yield ha^{-1} significantly increased upto 20 kgs ha^{-1} and yields tended to decline with further increase in S dose. Efficient utilization of S by the crop probably improved the yield attributes and yields. Similar results were reported by Agarwal *et al.* (1990) and Chourasia *et al.* (1992).

Use of antitranspirants helped to improve above mentioned yield attributes over control. Kaolin 6% significantly produced higher seed yields than control and antitranspirants like suncap 0.5% and cycocel 0.5%. Spraying of suncap also significantly produced more seed yield than control. Improvement in yield attributes with the use of antitranspirants like kaolin and suncap resulted in higher yields. Cycocel being a growth retarder was unable to prove it's efficacy under rainfed condition. Similar results have been obtained by Singh *et al.* (1981) in rainfed wheat.

Oil yield

Oil content significantly varied due to S-application over control, but variations between the doses did not show consistency in both years. Oil yield significantly increased upto 20 kg S ha^{-1} and further increase beyond this dose did not show remarkable increase in oil yield. Seed yield appeared to be directly related with oil yield. There was significant increase in oil yield upto 20 kg S ha^{-1}. Similar results have been reported by Verma and Swarnkar (1987). Application of antitranspirants did not influence oil content of seeds over control. Kaolin produced significantly higher oil output (2.38 q ha^{-1}) than control (1.85 q ha^{-1}) and antitranspirants like sucap (2.16 of ha^{-1}) cycocel (2.09 q ha^{-1}). Seed yield was at par under cycocel and control, but former produced significantly higher oil yield mainly due to more oil content.

Uptake of nutrients

The N content of seeds and straw increased with increasing level of S upto 30 kg ha^{-1} level with non-significant difference between 20 and 30 kg S ha^{-1} (Table 2). The increased seed and straw yields with higher N contents can be attributed to increased N uptake through Sulphur application upto 20 kg S ha^{-1} (Table 3).

Different doses of S application significantly increased P and K contents in seeds and straw, except P content in straw, over control, but variations among the doses were not significant, P content in seeds also declined marginally beyond 20 kg S ha^{-1}. Thus was increase in seed and straw yields and higher concentration of nutrients due to S application upto 30 kg S ha^{-1} in first year and upto 20 kg S ha^{-1} in second year. S-content

Table 1. Effect of sulphur and antitranspirants on growth and yield parameters in rainfed linseed

Treatment	Capsules plant $^{-1}$		Seed yield plant $^{-1}$ (g)		1000-seed weight (g)		Seed yield (q ha^{-1})			Oil content %		Oil yield (q ha^{-1})		
	89-90	90-91	89-90	90-91	89-90	90-91	89-90	90-91	Mean	89-90	90-91	89-90	90-91	Mean
S-level (kg ha^{-1})														
0	20.45	22.71	1.04	0.82	6.09	6.32	5.68	2.74	4.21	39.21	39.85	2.22	1.09	1.65
10	28.23	24.59	1.21	1.23	6.21	6.45	5.96	3.40	4.68	43.40	42.82	2.59	1.45	2.02
20	30.38	27.03	1.70	1.30	6.27	7.14	6.23	4.93	5.58	43.88	43.21	2.74	2.13	2.43
30	30.90	27.73	1.46	1.25	6.21	7.30	6.45	4.37	5.41	44.54	43.19	2.87	1.89	2.38
CD (0.05)	0.68	0.70	0.04	0.04	0.11	0.08	0.35	0.16	0.26	0.81	0.37	0.24	0.14	--
Antitranspirant														
Control	27.57	24.36	1.26	1.05	6.01	6.84	5.48	3.65	4.57	40.55	40.43	2.22	1.48	1.85
Kaolin 6%	31.13	27.68	1.43	1.26	6.18	7.02	6.85	4.06	5.46	43.80	42.82	3.01	1.75	2.38
Cycocel 0.5%	28.51	24.80	1.36	1.12	6.20	6.93	5.91	3.78	4.85	43.37	43.01	2.56	1.63	2.09
Suncap 0.5%	29.01	25.25	1.39	1.17	6.24	6.97	6.07	3.94	5.01	43.31	42.82	2.63	1.70	2.16
CD (0.05)	0.68	0.70	0.04	0.04	0.11	0.08	0.35	0.16	0.26	0.81	0.37	0.24	0.14	--

Table 2. Effect of sulphur and antitranspirants on N, P, K and S contents in seed and straw of rainfed linseed

Treatment	N content (%)				P content (%)				K content (%)				S content (%)			
	Seed		Straw		Seed		Straw		Seed		Straw		Seed		Straw	
	89-90	90-91	89-90	90-91	89-90	90-91	89-90	90-91	89-90	90-91	89-90	90-91	89-90	90-91	89-90	90-91
S-level (kg ha^{-1})																
0	3.60	3.80	1.65	1.75	0.285	0.271	0.055	0.052	0.41	0.45	0.17	0.15	0.165	0.171	0.071	0.058
10	4.71	4.65	1.85	1.85	0.361	0.372	0.059	0.055	0.64	0.60	0.19	0.17	0.189	0.217	0.098	0.073
20	4.90	5.05	1.95	1.90	0.383	0.357	0.060	0.055	0.60	0.50	0.18	0.17	0.218	0.229	0.104	0.094
30	5.05	5.10	2.00	1.88	0.331	0.374	0.058	0.057	0.61	0.55	0.18	0.18	0.223	0.234	0.097	0.096
CD (0.05)	0.16	0.23	0.19	0.19	0.052	0.034	NS	NS	0.06	0.05	0.02	0.02	0.013	0.029	0.011	0.009
Antitranspirant																
Control	3.75	4.15	1.75	1.88	0.296	0.304	0.054	0.053	0.54	0.51	0.17	0.17	0.185	0.203	0.080	0.071
Kaolin 6%	4.90	4.75	1.90	1.87	0.344	0.351	0.059	0.055	0.58	0.53	0.18	0.17	0.198	0.211	0.095	0.083
Cycocel 0.5%	4.85	4.76	1.95	1.85	0.350	0.369	0.058	0.056	0.56	0.50	0.17	0.17	0.209	0.222	0.094	0.083
Suncap 0.5%	4.75	1.95	1.85	1.86	0.370	0.350	0.057	0.054	0.58	0.56	0.18	0.17	0.203	0.215	0.101	0.086
CD (0.05)	0.16	0.23	0.19	NS	0.052	0.034	NS	NS	NS	NS	0.02	NS	0.013	NS	0.011	NS

Table 3. Effect of sulphur and antitranspirants on total uptake of nutrients by rainfed linseed

Treatment	Total uptake of nutrients kg ha^{-1}							
	Nitrogen		Phosphorus		Potassium		Sulphur	
	89-90	90-91	89-90	90-91	89-90	90-91	89-90	90-91
S-level (kg ha^{-1})								
0	52.76	23.32	2.77	1.25	5.75	2.41	2.47	1.04
10	54.75	29.44	2.88	1.58	5.97	3.04	2.57	1.31
20	56.70	42.76	3.00	2.29	6.19	4.41	2.65	1.91
30	58.07	37.80	3.09	2.02	6.36	3.90	2.72	1.69
CD (0.05)	2.22	1.57	0.17	0.18	0.35	0.16	0.15	0.07
Antitranspirant								
Control	51.30	31.08	2.68	1.68	5.58	3.22	2.40	1.39
Kaolin 6%	60.98	35.79	3.25	1.90	6.68	3.68	2.84	1.59
Cycocel 0.5%	54.50	32.08	2.87	1.73	5.94	3.31	2.55	1.43
Suncap 0.5%	55.66	34.36	2.94	1.83	6.07	3.54	2.61	1.53
CD (0.05)	2.22	1.57	0.17	0.18	0.35	0.16	0.15	0.07

increased significantly in S-treated plots upto the highest level over control, but differences among the doses were not much. Total S uptake increased upto 30 and 20 kg S ha^{-1} in first and second years, respectively with non-significant variations among them, because S uptake was directly related to the seed and straw yields. The above results also corroborate the findings of Aulakh *et al.* (1985), Verma and Swarnkar (1986) and Aulakh (1989). Application of antitranspirants resulted in numerically higher N, P, K and S contents in seeds and straw over control, but the variations were significant with respect to nutrient contents of seeds. Kaolin proved to be the best antitranspirant with regard to uptake of these nutrients. Suncap was the next best in this regard. Cycocel was not much useful as it produced low yields.

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PERFORMANCE OF SUNFLOWER AT DIFFERENT IRRIGATION AND NITROGEN LEVELS DURING RABI IN RED CHALKA SOILS

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ABSTRACT

An experiment was conducted at Regional Agricultural Research Station, Jagtial during 1993-94 and 1994-95 in red sandy loam soils to find out the effect of irrigation and nitrogen levels on the performance of sunflower during rabi. The dry matter production and seed number per head significantly increased with increase in irrigation levels from 0.4 to 1.0 IW/CPE ratio and nitrogen application from 0 to 90 kg N/ha. The interaction effect of irrigation and nitrogen levels on pooled data of seed yield was significant. The seed yield increased significantly upto 30 kg N/ha at 0.4 IW/CPE ratio, while there was an increase up to 60 kg N/ha under 0.6 IW/CPE ratio and up to 90 kg N/ha under 0.8 and 1.0 IW/CPE ratio. The total water used (inclusive of effective rainfall) under different irrigation levels was 179 and 214, 229 and 264, 279 and 310, and 329 and 349 mm in 1993-94 and 1994-95 respectively in 0.4, 0.6, 0.8 and 1.0 IW/CPE ratio. The water use efficiency (WUE) was higher under low levels of water supply and it increased with corresponding increase in N levels from 0 to 90 kg N/ha.

Key words: Irrigation; nitrogen levels; water use efficiency

INTRODUCTION

The sunflower crop is being grown intensively in Northern Telangana from 1992 onwards due to remunerative price and water shortage. The area under the crop has increased from negligible in 1990-91 to 78 thousand ha in 1993-94 (Directorate of Economics and Statistics, A.P., 1993-94). The crop is grown from September onwards under irrigation in different soil types. Application of 20-50 kg N/ha (Shiv Kumar *et al.* 1973 and bhosale *et al.* 1994) has been reported to increase the seed yield depending on availability of soil moisture. Sunflower responds to applied N with increased soil moisture status (Pal and Yadav, 1974; Pal, 1981) but, application of N did not enhance moisture use efficiency. The irrigation scheduled at 0.6 or 0.8 IW/CPE ratio during vegetative and 1.0 at later stage was found to give higher yield in sandy loam soils (Venkanna *et al.* 1994). Information on fertilizer and irrigation requirements of the crop during *rabi* is not available for the North Telangana region, hence, an experiment was conducted to find out their needs for this region.

MATERIALS AND METHODS

The field experiment was conducted at the Regional Agricultural Research Station, Jagtial during *rabi* season of 1993-94 and 1994-95 on sandy clay loam (red chalka) soil having pH 7.2, organic carbon 6.1 g/kg soil, 12.4 kg/ha available P_2O_5 and 311 kg/ha of available K_2O. The 12 treatments included four levels each of nitrogen (0, 30, 60 and 90 kg/ha) and irrigation (IW/CPE ratios of 0.4, 0.6, 0.8 and 1.0). The treatments were laid out in split-plot design and replicated three times. A common level of 60 kg P_2O_5 and 40 kg K_2O/ha was applied at sowing. Nitrogen was applied in bands in three equal splits at sowing, 30 and 50 days after sowing (DAS). Hybrid APSH 11 (90 days duration) was sown at 60 cm x 30 cm spacing on October 8, 1993 and October 19, 1994 and harvested on January 11, 1994 and January 25, 1995, respectively.

The single value constants of the soil were: field capacity 12.4%, wilting coefficient 5.3% and bulk density 1.35 g/cc. There was no contribution of ground water and the depth water table was

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6 m below soil surface during the crop growth period. Measured quantity (50 mm) of water with the help of V notch was applied as per treatment. From the total quantity of water applied, water use efficiency was computed. At harvest, the seed and stalk yield, number of seeds per head, 1000 seed weight and seed weight per head were recorded.

RESULTS AND DISCUSSION

Dry matter: In both the years, the total dry matter increased significantly with increase in irrigation levels from 0.4 to 1.0 IW/CPE ratio. There was significant increase in dry matter with increase in N levels from 0 to 30, 60 and 90 kg/ha (Table 1 and 2).

Harvest Index: The harvest index increased from 0.4 to 0.6 IW/CPE ratio and the differences between 0.6, 0.8 and 1.0 were not significant in 1993-94. However, there were no significant differences between irrigation levels in 1994-95. The harvest index increased significantly with increase in nitrogen levels from 0 to 60 kg/ha in 1993-94 and 0 to 30 kg/ha in 1994-95.

Seed yield and yield attributes: The head diameter increased with increase in N level from 0 to 30, 60 and 90 kg/ha (Table 1 and 2). However, there was no significant difference in head diameter between different irrigation levels. There was increase in number of seeds/plant with increase in irrigation level from 0.4 to 0.6, 0.8 and 1.0 IW/CPE and N levels from 0 to 30 and 60 kg/ha in both the years. There was increase in 1000 seed weight with increase in irrigation and N levels.

During both the years, the seed yield increased with the increase in irrigation water supply from 0.4 to 0.6, 0.8 and 1.0 IW/CPE ratio (Table 1). In 1993-94, the seed yield increased significantly with the increase in water supply from IW/CPE ratio of 0.4 to 0.6, 0.8 and 1.0. Where as, in 1994-95, the difference in seed yield between IW/CPE ratio of 0.6 and 0.8 was not significant. During both the years, the irrigations coincided with seedling, button, flowering, seed filling and grain formation stages in IW/CPE ratio of 1.0; seedling, flowering and grain formation stages in IW/CPE ratio of 0.8. On the other hand, irrigations coincided with button, flowering and grain formation stages in 1993-94 and button, seed filling in 1994-95 under IW/CPE ratio of 0.6 and at button and grain formation in 1993-94 and flowering in 1994-95 in IW/CPE ratio of 0.4. In 0.8 and 1.0 IW/CPE ratios, the availability of optimum moist condition at important phenological stages maintained higher water potential, while in 0.4 and 0.6 IW/CPE ratio less number of delayed irrigations induced the water deficit in plant body resulting in lowering of turgidity of plant cells and thereby growth. As enough water was not available for the crop in IW/CPE ratio of 0.6 and 0.4, the seed yield reduction was more in these treatments than that supplied with water at IW/CPE ratio of 0.8 and 1.0.

With the increase in N levels from 0 to 30, 60 and 90 kg N/ha, there was significant increase in seed yield. Almost similar trend was observed in stalk yield.

The pooled seed yield of 1993-94 and 1994-95 showed that there was significant increase in seed yield with increase in irrigation water from 0.4 to 0.6, 0.8 and 1.0 IW/CPE ratio (Table 3). There was significant increase in seed yield with increase in N levels from 0 to 30, 60 and 90 kg N/ha.

The interaction effect of irrigation and nitrogen levels on seed yield was significant. At 0.4 IW/CPE irrigation level, the seed yield was significantly increased upto 30 kg N/ha, while the increase was upto 60 kg N/ha under 0.6 IW/CPE irrigation level and upto 90 kg N/ha in 0.8 and 1.0 IW/CPE irrigation level. These seed yield trends indicate that under higher level of water supply the crop responds to increased supply of

Table 1: Effect of irrigation and N levels on growth and yield attributes of sunflower during *rabi*, 1993-94

Treatments	Total dry matter, (kg/ha)	Harvest index, (%)	Head diameter, (cm)	Seed yield/ plant (g)	Seeds/ plant, (no.)	1000 seed weight (g)
Irrigations (IW/CPE ratio)						
0.4	1484	35	8.0	10.3	177	58.1
0.6	1707	39	8.8	13.4	231	57.8
0.8	1938	40	8.5	15.8	297	52.2
1.0	2174	40	9.1	17.9	277	62.9
S.Em. ±	44	1	0.3	0.6	11	0.8
CD (0.05)	151	4	NS	2.0	37	2.9
N levels (kg/ha)						
0	1191	36	7.5	8.9	176	51.0
30	1883	35	8.5	13.6	235	58.5
60	1977	41	9.2	15.7	259	60.6
90	2251	43	9.3	19.6	312	61.0
S.Em. ±	41	1	0.2	0.6	10	0.8
CD (0.05)	120	3	0.6	1.6	29	2.3

***Table 2: Effect of irrigation and N levels on growth and yield attributes of sunflower during rabi,* 1994-95**

Treatments	Total dry matter, (kg/ha)	Harvest index, (%)	Head diameter, (cm)	Seed yield/ plant (g)	Seeds/ plant, (no.)	1000 seed weight (g)
Irrigations (IW/CPE ratio)						
0.4	2107	38	11.1	13.7	311	44.3
0.6	2325	39	11.6	15.6	378	41.7
0.8	2492	39	11.6	16.5	388	42.5
1.0	2757	38	11.8	17.8	377	47.3
S.Em. ±	39	1	0.7	0.4	13	0.7
CD (0.05)	135	NS	NS	1.3	46	2.5
N levels (kg/ha)						
0	1563	36	10.1	3.2	220	43.8
30	2211	39	11.2	4.8	333	44.1
60	2682	41	12.4	6.0	409	44.2
90	3226	39	12.4	7.2	492	43.5
S.Em. ±	39	1	0.3	0.4	11	0.6
CD (0.05)	114	2	0.8	1.1	33	NS

N. Further, linear relationship between seed yield and irrigation water use ($Y=135.84 + 2.57X$; $R^2 = 0.79^{**}$) and nitrogen level ($Y = 518.85 + 6.18X$; $R^2 = 0.80^{**}$) was observed (Fig. 1).

The increased seed yield with increase in irrigation and nitrogen levels was due to increase in yield attributes (Table 1 and 2). A significant positive correlation between seed yield and total dry matter ($r=0.9^{**}$ and 0.99^{**}), head diameter ($r=0.80^{**}$ and 0.87^{**}) and seed number per head ($r=0.95^{**}$ and 0.97^{**}) was observed. The cumulative effect of all these yield attributes and growth increased the yield of seed in higher irrigation and N levels. Further, the yield attributes had positive correlation with each other. However, the 1000 seed weight has not shown significant correlation with seed yield and other yield attributes.

Water use: The seasonal water use increased with increase in irrigation level from 0.4 to 0.6, 0.8 and 1.0 IW/CPE ratio (Table 4). Under IW/CPE ratio of 0.4 (3 and 2 irrigations in 1993-94 and 1994-95), 0.6 (4 and 3 in 1993-94 and 1994-95), 0.8 (5 and 4 in 1993-94 and 1994-95) and 1.0 (6 and 5 in 1993-94 and 1994-95) each irrigation of 50 mm was given. During 1994-95 , there was 190 mm of rainfall, of which the effective rainfall was 99 mm (1.0 IW/CPE ratio) to 114 mm (0.4 and 0.6 IW/CPE ratio). The higher water supply has increased the yield attributes and seed yield (Fig.1). The water use efficiency decreased with increase in irrigation water supply. The differences were apparent only in 1994-95.

These results indicate that in Northern Telangana, in red chalka soils (sandy clay loam), application of nitrogen at 90 kg/ha and irrigating the crop at IW/CPE ratio of 1.0 with 5 to 6 irrigations (250 to 300 mm of applied water) gave higher sunflower seed yield in *rabi* season.

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Table 3: Interaction effect of irrigation and nitrogen levels on seed yield of sunflower (kg/ha) during rabi (pooled over 1993-94 and 1994-95)

Treatments	Nitrogen (kg/ha)				
	0	30	60	90	*Mean*
Irrigation levels, IW/CPE ratio					
0.4	451	640	724	830	661
0.6	512	726	927	987	788
0.8	501	828	999	1206	833
1.0	497	869	1096	1448	977
Mean	490	766	936	1117	
		SEm. ±	CD (0.05)		
Irrigation		22	68		
Nitrogen		21	60		
Irrigation x Nitrogen		42	120		

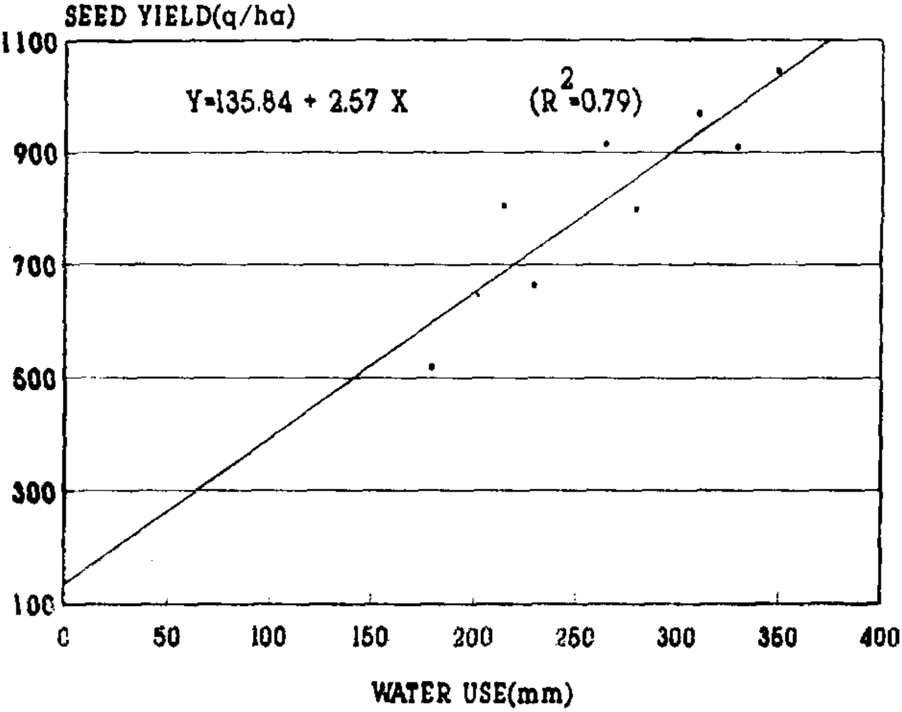
Table 4: Effect of irrigation and nitrogen levels on seed and stalk yield and water use efficiency of sunflower during rabi in red chalka soils

Treatments	Seed yield, (kg/ha)		Stalk yield, (kg/ha)		Total water* used (mm)		Water use efficiency (kg seed/ mm of water)	
	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95	1993-94	1994-95
Irrigations (IW/CPE ratio)								
0.4	518	805	625	759	179	214	2.9	3.8
0.6	662	914	640	789	229	264	2.9	3.5
0.8	799	968	701	887	279	310	2.9	3.1
1.0	909	1045	748	1008	329	349	2.8	3.0
S.Em. ±	43	40	29	46				
CD (0.05)	104	98	72	113				
N Levels (kg/ha)								
0	421	560	451	565	254**	284**	1.7	2.0
30	669	862	717	767	254	284	2.6	3.0
60	795	1061	755	946	254	284	3.1	3.7
90	988	1247	793	1166	254	284	3.9	4.4
S.Em. ±	34	37	29	45				
CD (0.05)	70	76	60	93				

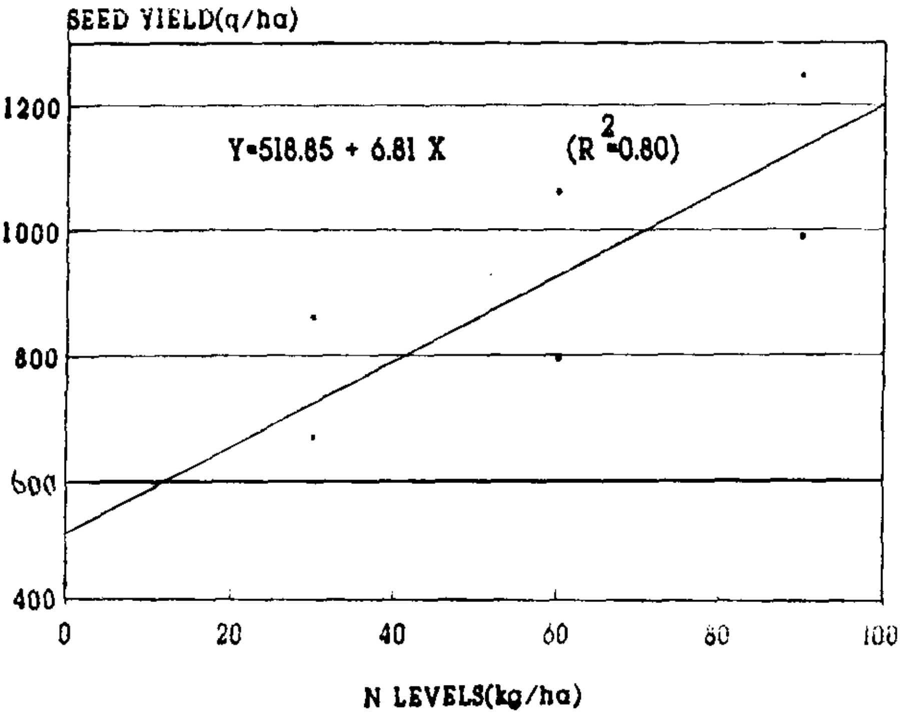
* Includes effective rainfall

** Mean of irrigation levels

RELATIONSHIP BETWEEN SEASONAL WATER USE AND SEED YIELD OF SUNFLOWER



RELATIONSHIP BETWEEN NITROGEN LEVELS AND SEED YIELD OF SUNFLOWER



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STUDIES ON SUNFLOWER AND PIGEONPEA INTERCROPPING IN NORTH-EASTERN DRY ZONE OF KARNATAKA

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ABSTRACT

A three year rainfed experiment conducted in medium deep black soils on sunflower and pigeonpea intercropping system revealed that intercropping in various row proportions increased the net returns over sole cropping. Intercropping of sunflower and pigeonpea in the row proportion of 3:1 was more promising and recorded highest net returns (Rs. 8781/ha), total yield (15.16 q/ha) and LER (1.29) over 1:1, 2:1 and 4:2 row proportions. Intercropping across different row proportions reduced the yield of sunflower and pigeonpea by 22.7 and 55.1 per cent, respectively over their respective sole crop yields. However, the loss of yield of one crop in intercropping system was better compensated by the component crop.

Key words: Pigeonpea; intercropping; net returns.

INTRODUCTION

Pigeonpea (*Cajanus cajan* (L.) Millsp.) being a long duration crop, provides excellent opportunities to grow short duration intercrops because of its wider row-spacing and slow growth at its initital stages. Earlier investigations of intercropping pigeonpea with short duration pulse/oilseed crops viz., groundnut, greengram, blackgram gave encouraging results (Itnal, *et al.*, 1994; Mahapatra *et al.*, 1989). In recent years sunflower (*Helianthus annus* L.) is gaining popularity in the region and there is a lot of scope to exploit the productivity of this crop as an intercrop with pigeonpea. Hence, the present investigation was undertaken to study the feasibility and economics of sunflower intercropping in pigeonpea in different row proportions.

MATERIALS AND METHODS

The experiment was conducted at Agricultural Research Station, Bheemarayanagudi (Karnataka) during *Kharif* 1987-88, 1989-90 and 1990-91 on medium deep black soils of pH 8.2 with 0.37 per cent organic carbon, 19.6 kg P_2O_5 /ha and 380 kg K_2O/ha. Six treatments comprising four intercropping combinatios and two sole crops (Table 1) were tested in a randomised block design replicated four times. Sunflower (Morden) and pigeonpea (GS-1) were sown on 13th, 29th and 18th June in 1987, 1989 and 1990 respectively. The pigeonpea population was maintained at 100 per cent both in sole and intercrops and that of sunflower population at 100 per cent in sole and 50 per cent in intercrops in 45 cm rows. Each treatment received recommended quantity of fertilizers of both crops seperately as basal dose depending on the plant density of component crops. A rainfall of 499.2, 584.2 and 518.6 cm was received during crop growth period (June-Nov) during the year 1987, 1989 and 1990 respectively.

RESULTS AND DISCUSSION

The yield of sole Vs. intercrops

There has been considerable reduction in the yield of sunflower and pigeonpea in intercropping system compared to their respective sole crops

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(Table 1). The seed yield reduction of sunflower in intercropping system varied from 9.5 per cent with 3:1 row proportion to 29.2 per cent with 2:1 row proportion (Average 22.7 per cent) over sole sunflower. The yield reduction of pigeonpea in intercropping system was still higher and it ranged from 49.1 per cent with 1:1 row proportion to 61.4 per cent with 2:1 row proportion (average 55.1 per cent) over sole pigeonpea. Pigeonpea crop performed better during the year 1990 due to late rains (42.8 m) received in the month of October. Lower yields of sunflower and pigeonpea under intercropping system can be attributed to increased plant population pressure resulting in increased competition for growth resources viz., moisture, nutrients and light compared to the sole crops. Similar results of reduced sunflower and pigeonpea yield in intercropping systems was compensated by the component crop. The total yield production in intercropping systems was more compared to sole crop yields. Highest total yield/production was recorded in the intercropping of sunflower + pigeonpea in the row proportion of 3:1 (15.16 q/ha) followed by row proportion of 4:2 (14.33 q/ha).

Land Equivalent Ratio and Monetary Returns

The advantages of sunflower and pigeonpea intercropping was also seen from land equivalent ratio and monetary returns. The LER was highest (1.29) with 3:1 row proportion of sunflower and pigeonpea intercropping followed by 4:2 row proportion (1.24). The low LER observed with 1:1 (1.18) and 2:1 (1.08) row proportion was mainly due to yield reduction of sunflower crop when intercropped with pigeonpea in closer row spacings.

Intercropping of sunflower and pigeonpea irrespective of their row proportion recorded significantly highest net monetary returns over sole cropping. The results confirm the findings of Biradar *et al.*, 1988 and Subba Reddy and Venkateswaralu, (1992). Among different sunflower and pigeonpea row proportions, 3:1 recorded significantly higher net returns (Rs. 8781/ha) over 4:2 (Rs. 8372/ha) and 1:1 (Rs. 8186/ha) row proportion which were on par with each other. Lowest net return (Rs. 6361/ha) was realised from sole crop of pigeonpea which was on par with sole crop of sunflower (Rs. 6404/ha).

Therefore it is evident that growing sunflower and pigeonpea in 3:1 row proportion is advantageous to growing of pigeonpea or sunflower alone.

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Table 1. Seed yield, LER and net returns as influenced by different row proportions of sunflower and pigeonpea intercropping system

Sl. No.	Treatment		Seed yield (q/ha)								LER				Net returns (Rs./ha)			
			Sunflower				Pigeonpea											
			1987	1989	1990	Mean	1987	1989	1990	Mean	1987	1989	1990	Mean	1987	1989	1990	Mean
1	Sole sunflower		8.91	13.67	13.42	12.00	-	-	-	-	-	-	-	-	4645	7071	7496	6404
2	Sole pigeonpea		-	-	-	-	5.83	10.83	14.81	10.49	-	-	-	-	2613	6425	10046	6361
3	Sunflower + Pigeonpea	1:1	7.79	10.55	7.38	6.57	3.26	4.36	8.41	5.34	1.26	1.17	1.12	1.18	5539	6674	10346	8186
4	Sunflower + Pigeonpea	2:1	7.10	9.74	8.64	8.49	3.20	3.30	5.66	4.05	1.19	1.02	1.02	1.06	5096	7298	8974	7123
5	Sunflower + Pigeonpea	3:1	9.09	12.59	10.90	10.86	3.47	3.40	6.04	4.30	1.42	1.23	1.22	1.29	6357	9166	10820	8781
6	Sunflower + Pigeonpea	4:2	8.36	10.40	8.74	9.17	3.76	4.80	6.93	5.16	1.40	1.20	1.12	1.24	6160	8893	10062	8372
	S.Em ±														242	151	210	179
	CD (0.05)														729	455	633	382

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PRODUCTIVITY, ECONOMICS AND LAND EQUIVALENT RATIO OF GROUNDNUT BASED INTERCROPPING SYSTEMS AS INFLUENCED BY MOISTURE REGIMES

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ABSTRACT

Investigation on different groundnut- based intercropping systems carried out at Agricultural College Farm. Rajendranagar, Hyderabad during *rabi* seasons of 1991-92 and 1992-93 showed that intercropping groundnut with mustard or sunflower produced significantly higher groundnut yield equivalents than intercropping with pigenopea and sole crops. Groundnut+ mustard and groundnut + sunflower intercropping systems registered highest net returns and benefit-cost ratio besides higher LER. Scheduling irrigation at IW/CPE ratio of 1.0 resulted in significantly higher groundnut equivalents, net returns and benefit-cost ratio than 0.8 IW/CPE ratio. LER was not influenced by irrigation levels.

Key words: Groundnut; irrigation; intercropping; LER; economics.

INTRODUCTION

Intercropping is generally considered more productive than growing crops separately due to its better utilization of resources. Recent reports have repudiated the general belief that intercropping is advantageous only at lower levels of inputs and technology (Baker and Blamey, 1985). However, reports on advantages of intercropping at different levels of inputs,particularly, irrigation are very few. Groundnut is an important crop of Andhra Pradesh during the *rabi* season and hence it was taken as a base crop for intercropping with other oilseeds (sunflower and mustard) and pulse crop (Pigenopea). Keeping this in view, an attempt has been made to assess the yield advantage and economics of groundnut based intercropping systems under varying irrigation levels.

MATERIALS AND METHODS

Field experiments were conducted during the *rabi* seasons of 1991-92 and 1992-93 at Agricultural College Farm, Rajendranagar, Hyderabad in split-plot design with three irrigation levels (IW/CPE ratio of 0.8, 1.0 and 1.2) as main plots and seven cropping systems (C1= sole groundnut, C2= sole sunflower, C3= sole mustard, C4= sole pigeonpea, C5= groundnut+ sunflower, C6= groundnut+ mustard and C7 = groundnut+ pigeonpea) as sub-plots replicated four times. The experimental soil was loamy having pH 7.46, EC 0.28 dsm^{-1} and organic carbon 0.44 per cent with 215.00, 20.75 and 305.10 kg^{-1} of avilable N, P_2O_5 and K_2O respectively. Field capacity values in 0-20, 20-40 and 40-60 cm soil layers were 19.09, 16.85 and 15.40 per cent, while the respective permanent wilting point values were 7.92, 7.26 and 6.05 per cent. Bulk density values were 1.55, 1.62 and 1.64 g/cc in respective layers.

The variety of groundnut was ICGS-11, while that of sunflower, mustard and pigeonpea were APSH-11, B-85 (Seetha) and MRG-66, respectively. The crops were sown on 26th and 24th October in the first and second years. Groundnut was sown at an inter- row spacing of 30 cm and its optimun population of 3,33,333 plants per hectare was achieved by are adopting intra-row spacing of 7.5 cms. The component

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crops were sown by replacing one row of groundnut after every three rows of groundnut in 3:1 row arrangement. The 50 per cent of sole crop population of component crops was achieved by adopting intra-row spacing of 22.5, 5.0 and 5.0 cm for sunflower, *mustard and pigeonpea* respectively. The recommended dose of fertilizer for groundnut was applied to sole groundnut and groundnut based intercropping system treatments (20: 40: 40 kg NPK ha^{-1}); while the dose of fertilizer was 20: 50: 40, 75:90:30 and 80:60:60 kg NPK ha^{-1} *for pigeonpea, sunflower and* mustard respectively. *Fifty per cent of the* recommended fertilizer dose of component crop was placed by the side of rows of component crop included in intercropping system. The number of irrigations given under 0.8, 1.0 and 1.2 IW/ CPE ratio was 7, 9 and 10 respectively during both the years for treatment C1,C4, C5, C6 and C7 while it was 6, 7 and 8 for C2 and C3 treatments. The depth of irrigation was 50 mm. The soil moisture was estimated gravimetrically by taking the soil sample at 0-20, 20-40 and 40-60 cm soil depth before and after each irrigation.

The intercropping efficiency was evaluated in terms of land equivalent ratio (LER) as computed by Mead and Willey (1980). Net returns and benefit cost ratio was worked out based on prevailing market prices.

For the purpose of comparison of different intercropping systems with sole base crop, the yields of component crops were converted into pod equivalents of base crop to get the total productivity.

RESULTS AND DISCUSSION

Effect of Moisture

Significant increase in groundnut pod equivalence was recorded with increase in the level of irrigation from 0.8 to 1.0 IW/ CPE in both the years (Table 1). IW/CPE ratios of 1.0 and 1.2 were on par. On an average, irrigation at 1.0 IW/CPE ratio recorded 18 per cent more pod equivalence than irrigation at 0.8 IW/CPE ratio. Higher yield equivalence under this irrigation level might be due to higher production of different crops with *optimum level of moisture*. The land equivalent ratio (LER) was not influenced by irrigation levels.

Scheduling irrigation at 1.0 and 1.2 IW/CPE ratio registered significantly higher net returns compared to 0.8 ratio (Table 1). IW/CPE ratio of 1.0 recorded net monetary returns of Rs.15,853.00 and Rs. 14, 738.00 ha^{-1} as against Rs. 12,726.00 and Rs.11,833.00 ha^{-1} obtained with 0.8 IW/CPE ratio during first and second year,respectively. The highest returns per rupee invested was obtained at IW/CPE ratio of 1.0 (2.87 and 2.67) which was significantly superior to 0.8 and 1.2 ratio.

Cropping System

Intercropping groundnut with mustard and sunflower resulted in highest groundnut pod equivalents of 3187 and 3092 kg/ha respectively as against 2533 kg ha^{-1} in sole groundnut which was less by 654 kg ha^{-1} compared to groundnut+ mustard intercropping system. This might be due to better yields obtained from groundnut and higher prices of mustard which compensated the reduction in yields of groundnut crop under intercropping. Among sole crops pigeonpea was significantly inferior in terms of total productivity showing its poor performance compared to other crops. The average yield advantage (LER) due to intercropping with the mustard and sunflower was 35 and 34 per cent, which was mainly due to comparatively less proportion of reduction in yields of groundnut in association with mustard *or sunflower intercrops than pigeonpea, indicating* that pigeonpea offered more competition than *mustard or sunflower, probably because of its* association with groundnut for longer period (124 and 127 days during 1991-92 and 1992-93) than other component crops (93 days in first and 95 days in the second year). Further, the highest LER might possibly be due to better exploitation of above and below ground resources by by groundnut + mustard or sunflower as intercrops. (Table 1).

The average net returns realised were in the order of Rs. 19, 308.00 and Rs.18, 951.00 ha^{-1} in groundnut mustard and groundnut sunflower intercropping systems, respectively with a margin of difference of Rs. 3,871.00 and Rs. 3,514.00 ha^{-1} over sole groundnut. These intercrop combinations still gave significantly much higher net returns of Rs. 4,800.00 and Rs. 4,443.00 ha^{-1} respectively over groundnut+ pigeonpea intercropping. (Table 1). This was mainly due to the effect of pigeonpea which drastically reduced the groundnut yields as the pigeonpea plant during rabi season has short stature with less number of branches and same duration (120 days) as that of groundnut. Minimum net returns were registered in sole pigeonpea (Rs. 6, 287.00 ha^{-1}). Highest net returns with groundnut + mustard has been reported by Parameswaran *et al.* (1988) and with sunflower by Biradar *et al.* (1988). Sole mustard gave significantly higher benefit-cost ratio than sole crops of groundnut and other groundnut based intercropping systems.

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Table 1. Groundnut pod equivalent yield, LER and monetary returns as influenced by irrigation and cropping systems

Treatments	Groundnut pod equivalent yield (kg/ha)		Mean	LER		Net returns (Rs./ha)		Mean	Benefit-cost ratio	
	1991-92	1992-93		1991-92	1992-93	1991-92	1992-93		1991-92	1992-93
Moisture region (IW/CPE ratio)										
0.8	1985	2254	2120	1.37	1.28	12726	11833	12280	2.42	2.27
1.0	2373	2645	2509	1.25	1.27	15853	14738	15296	2.87	2.67
1.2	2303	2578	2441	1.36	1.33	15515	14170	14843	2.69	2.48
S.Em. ±	54	34	70	0.03	0.04	531	255	588	0.03	0.06
C D (0.05)	187	199	217	NS	NS	1835	855	1281	0.09	0.19
Cropping systems:										
Sole groundnut	2459	2646	2553	1.00	1.00	16486	14388	15437	2.62	2.28
Sole sunflower	1798	1989	1894	1.00	1.00	12237	10979	11608	3.03	2.72
Sole mustard	1923	2235	2079	1.00	1.00	13173	12625	12899	3.24	3.11
Sole pigeonpea	*1056*	*1288*	*1172*	*1.00*	*1.00*	*6205*	*6369*	*6287*	*1.86*	*1.91*
G.nut+sunflower	2946	3237	3092	1.36	1.32	20008	17894	18951	2.82	2.52
G.nut+mustard	3013	3360	3187	1.34	1.35	19846	18769	19308	2.83	2.68
G.nut+pigeonpea	2349	2693	2521	1.27	1.22	14928	14087	14508	2.20	2.07
S.Em. ±	90	96	102	0.03	0.04	844	712	551	0.16	0.13
CD (0.05)	255	273	284	0.08	0.108	2395	2018	1079	0.46	0.39

Market Price (Rs./kg)

	1991-92	1992-93
Groundnut	8.82	7.34
Sunflower	9.04	8.00
Mustard	15.00	14.00
Pigeonpea	9.30	8.40

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DROUGHT MANAGEMENT OPTIONS FOR RAINFED CASTOR IN ALFISOLS

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ABSTRACT

Field experiments conducted during 1990 and 1991 in alfisols at the Central Research Institute for Dryland Agriculture, Hyderabad showed that vegetative, formation of primaries and secondaries stages were the most sensitive for moisture stress in reducing the bean yield of castor. Among the management practices, stress-free castor crop gave 42 per cent higher yield than the rainfed crop. Supplemental irrigation of 5 cm either at early (0-45 DAS) or mid (45-90 DAS) stress period gave 26 per cent additional bean yield followed by extra fertilizer N after relief from early stress period. Soil mulch through extra interculture at early stress period gave additional yield advantage to the tune of 8 per cent over the rainfed crop. Management practices imposed during mid stress period resulted in higher production of secondaries. Thus the yields of rainfed castor in Alfisols can be stabilized to a certain extent through extra interculture (low monetary input) or extra nitrogen application (monetary input) after relief of early stress.

Key words: Drought management, castor; Alfisols.

INTRODUCTION

Moisture stress is a recurring phenomenon in rain dependent crops. The productivity of crops in rainfed environments quite often fluctuates due to vagaries of rainfall (Rao and Vijayalakshmi, 1985). During the rainy season in semi-arid tropics, there are periods of decreased or no rainfall. Under such conditions the degree of reduction in yield is dependent on duration and intensity of intermittent drought and stage of the crop that experiences moisture stress (ICRISAT, 1988). Hence there is a need to identify critical growth stages of crops which are sensitive to the moisture stress. The ill effects of moisture stress in dryland crops can be mitigated by selection of suitable crops and varieties (that can match the growing periods) and also evolving suitable agro-techniques. Steward (1985) reported the system of response farming and worked out strong relationships between rainfall and crop growth of crops. Castor is a non-edible oilseed crop grown mainly in rainfed Alfisols. The crop quite often faces moisture stress resulting in fluctuating yields. An experiment was therefore conducted with varied management practices to find out their efficiency in smothering the effects of droughts.

MATERIALS AND METHODS

The experiment was carried out at the Central Research Institute for Dryland Agriculture (CRIDA) farm during 1990 and 1991 *Kharif* seasons. The experimental site was sandy loam in texture, neutral in pH, low in available nitrogen (210 kg ha^{-1}), phosphorous (11 kg P_2O_5 ha^{-1}) and medium to high in available potassium (220 kg ha^{-1}). Castor Cv. Aruna was sown during the second fortnight of June in rows 90 cm apart with 0.75 lakh plant population ha^{-1}. The crop received 10 kg N and 30 kg P_2O_5 ha^{-1} as basal dose and 40 kg N ha^{-1} was top dressed in the form of urea 30 days after sowing (DAS).

The treatments consisted of various management options viz., dust mulch as additional interculture, additional N after relief of stress and 5 cm of supplemental irrigation, imposed at different moisture stress periods (early 0-45 DAS; mid 45-90 DAS; and terminal 90-130 DAS) along with

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control in the years. Whenever the available soil moisture reached 50%, suitable management practices were imposed. The growth components such as dry matter, leaf area index, nitrogen uptake, yield and yield components were estimated. The per day productivity, recovery of growth components (Ravishankar *et al.*, 1991), rainfall and yield use efficiencies (Jorge Elizondo - Barron, 1991) were also calculated.

The crop received a total of 577 and 683 mm of rainfall during its growth period in 1990 and 1991, respectively. The crop experienced drought periods at vegetative (for 13 days), flowering of primaries and formation of secondaries (for 8 and 12 days) and tertiaries (for 30 days) in 1990. In 1991, the crop suffered due to the moisture stress of 15 days at vegetative stage, 12 days at flowering of secondaries and 20 days each during formation of tertiaries and quarternaries.

RESULTS AND DISCUSSION

Growth components

The results showed that the management practices enhanced the growth, drymatter accumulation, leaf area index and N uptake of castor compared to the rainfed crop (Tables 1 and 2). The compensation of growth components after relief of early moisture stress was greater than that of mid moisture stress periods. Among various management practices, supplemental irrigation showed highest drymatter and leaf area followed by extra fertilizer nitrogen and soil mulch through additional interculture. After relief of early moisture stress, higher N uptake was noticed by 73, 18 and 17% with supplemental irrigation, extra fertilizer and soil mulch during 1990. Similar increase in N uptake with management practices was observed in 1991 also. At harvest, supplemental irrigation of 5 cm each at early (0-45 DAS), mid (45-90 DAS) and terminal (90-120 DAS) recorded the highest N uptake of 88 kg ha^{-1} and 98 kg ha^{-1} in 1990 and 1991, respectively. In the year 1991 due to favourable drymatter production higher N uptake was noticed than that in 1990. The increases in growth components with varied management practices were due to increase in better rainfall use efficiencies which resulted in higher yield components (Tables 2 and 3). The soil mulch through extra interculture and also supplemental irrigations resulted in better utilization of moisture in deeper layers by the crop (Fig. 1 and 2).

Yield and economic returns

Castor under stress-free environment i.e. protective irrigation of 5 cm each during early, mid and terminal stress periods recorded 42% additional bean yields and gross returns of Rs. 3,039 ha^{-1} over the rainfed environment. Supplemental irrigation of 5 cm during early or mid stress periods enhanced the bean yields by 14 to 37% and also mean gross return of Rs. 1719 to 1821 ha^{-1} over the crop grown in rainfed situations (Table 3). Soil mulch through additional interculture during early stress period was more beneficial than mid stress period. Extra interculture during early stress period resulted in additional bean yields of 157 kg ha^{-1} and gross returns of Rs. 936 ha^{-1} compared to the rainfed castor. Additional N after relief of early and mid stress periods gave higher bean yields ranging from 11 to 29 and 9 to 24%, respectively (Fig.3). Moisture stress also had influence on productivity of different spike orders. The management practices imposed during early moisture stress had highest influence on primaries and less on subsequent spike orders. The agro-techniques imposed during mid-stress period had an effect on production of secondary spike orders and less on tertiaries and quarternaries.

The increased bean yields of castor with varied management practices at different moisture stress periods were attributed to enhancement of yield components such as spike length, number of capsules, weight of capsules and also test weight of beans (Table 3).

Table 1. The recovery of growth components of castor after different stress periods with various management practices

Treatments	Dry matter recovery (%)						Leaf area recovery (%)			
	1990			1991			1990		1991	
	E.S.	M.S.	T.S.	E.S.	M.S.	T.S.	E.S.	M.S.	E.S.	M.S.
Rainfed Castor	89.3	66.7	7.62	77.7	44.4	54.1	114.2	-32.1	105.3	-10.4
Extra Interculture at E.S.	105.0	58.5	6.69	78.2	49.0	49.9	150.4	-30.9	123.0	-12.2
Extra Fertilizer	95.6	58.0	7.11	79.0	50.3	49.5	156.8	-19.5	122.0	-13.4
Irr. 5 cm at E.S.	104.8	56.4	7.20	77.9	48.3	52.2	186.0	0.9	149.0	-20.7
Extra Interculture at M.S.	--	65.4	7.16	--	47.2	53.7	--	-15.8	--	-18.4
Extra Fertilizer	--	60.4	5.73	--	46.4	53.0	--	-6.0	--	-21.8
Irr. 5 cm at M.S	--	62.3	6.40	--	49.8	56.9	--	0.2	--	-13.2
Irr. 5 cm at T.S.	--	--	9.28	--	--	54.0	--	--	--	--
Irr. 5 cm each at ES+MS+TS	105.6	84.2	5.98	78.5	48.7	51.5	185.0	0.4	176.0	-13.5

E.S. = Early stress, T.S. = Terminal stress, M.S. = Middle stress, Irr. = Irrigation.

Table 2. Nitrogen Uptake (kg/ha and Rainfall Use Efficiency in castor as influenced by management practices

Treatments	Nitrogen uptake (kg/ha) (DAYS AFTER SOWING)						Rainfall use efficiency (kg/ha/mm)			
	1990			1991			1990		1991	
	45	60	150	45	60	150	Seed	Biomass	Seed	Biomass
Rainfed Castor	16.7	32.1	58.0	20.7	38.7	63.6	2.0	4.0	2.3	5.6
Extra Interculture at E.S.	19.7	41.9	63.1	22.6	40.8	71.0	2.2	4.1	2.7	6.1
Extra Interculture at M.S.	16.7	35.4	58.0	18.2	40.7	65.6	2.1	3.8	2.5	5.7
Extra N after E.S.	24.6	41.5	67.0	22.0	44.6	86.4	2.3	4.4	3.0	6.5
Extra N after M.S.	17.8	37.5	69.7	19.7	43.9	87.1	2.2	4.5	2.9	6.4
Irr. of 5 cm at E.S.	29.0	56.9	71.5	29.0	55.0	86.9	2.3	4.7	3.1	6.6
Irr. of 5 cm at M.S.	16.4	52.4	63.8	20.0	53.9	86.2	2.2	4.8	3.2	6.8
Irr. of 5 cm at T.S.	17.0	31.0	68.4	20.6	50.6	84.2	2.3	4.3	3.2	6.7
Irr. of 5 cm each at ES+MS+TS	29.1	68.2	88.4	24.7	58.9	98.4	2.8	5.6	3.3	7.8
C.D. (0.05)	3.3	9.0	8.9	2.8	6.9	8.9	--	--	--	--

E.S. = Early stress, T.S. = Terminal stress, M.S. = Middle stress, Irr. = Irrigation.

Table 3. Influence of management practices on the yield and its components in castor under drought

Treatments	Bean Yield (kg/ha)		Sticks (kg/ha)		Gross Returns (Rs/ha)		Harvest index (%)		Capsule Numbers	Weight per/seed (mg)
	1990	1991	1990	1991	1990	1991	1990	1991	1990	1991
Rainfed Castor	1153	1330	1118	1886	6918	7980	50.77	41.35	427.0	260.7
Extra Interculture at E.S.	1231	1564	1061	1952	7386	9384	53.70	44.48	469.1	276.9
Extra Interculture at M.S.	1181	1451	962	1842	7086	8706	55.10	44.06	425.8	270.3
Extra N after E.S.	1279	1717	1200	2012	7674	10302	51.59	46.04	513.6	278.4
Extra N after M.S.	1257	1654	1312	1980	7542	9924	48.92	45.51	438.7	274.6
Irr. 5 cm at E.S.	1311	1765	1352	2028	7866	10590	49.23	46.53	541.6	276.2
Irr. 5 cm at M.S.	1235	1821	1475	2074	7410	10926	45.57	46.75	484.3	278.3
Irr. 5 cm at T.S.	1282	1808	1165	2032	7692	10848	52.39	47.08	425.8	270.9
Irr. 5 cm each at ES+MS+TS	1588	1908	1561	2587	9528	11488	50.42	42.54	642.8	285.3
C.D. (0.05)	81	89	98.6	105	-	-	-	-	12.6	8.00

Fig. 1. Soil moisture depletion by castor at different depths with extra inter culture

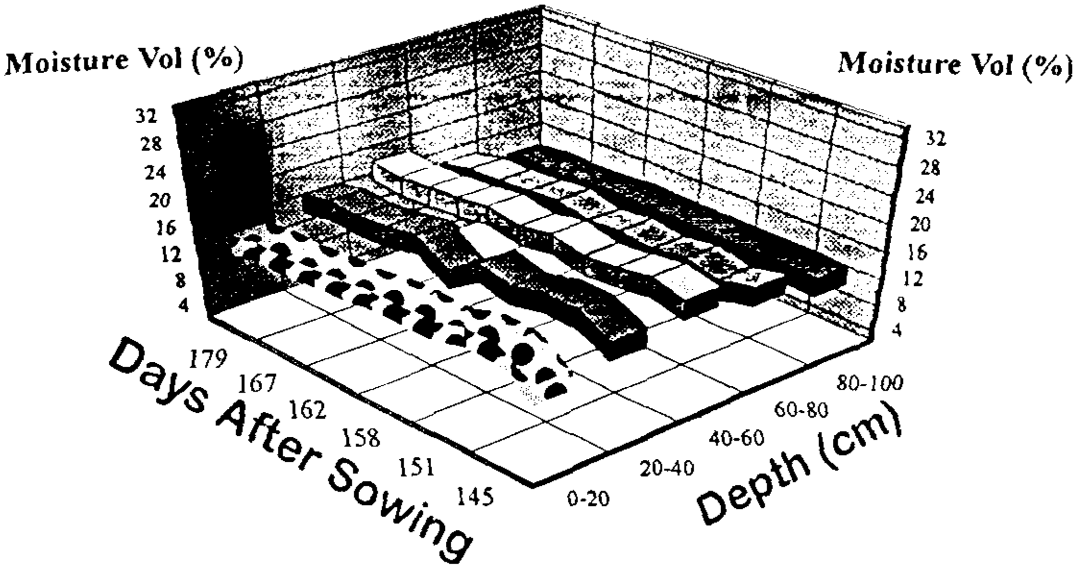


Fig. 2. Soil moisture depletion by castor at different depths with three supplemental irrigations

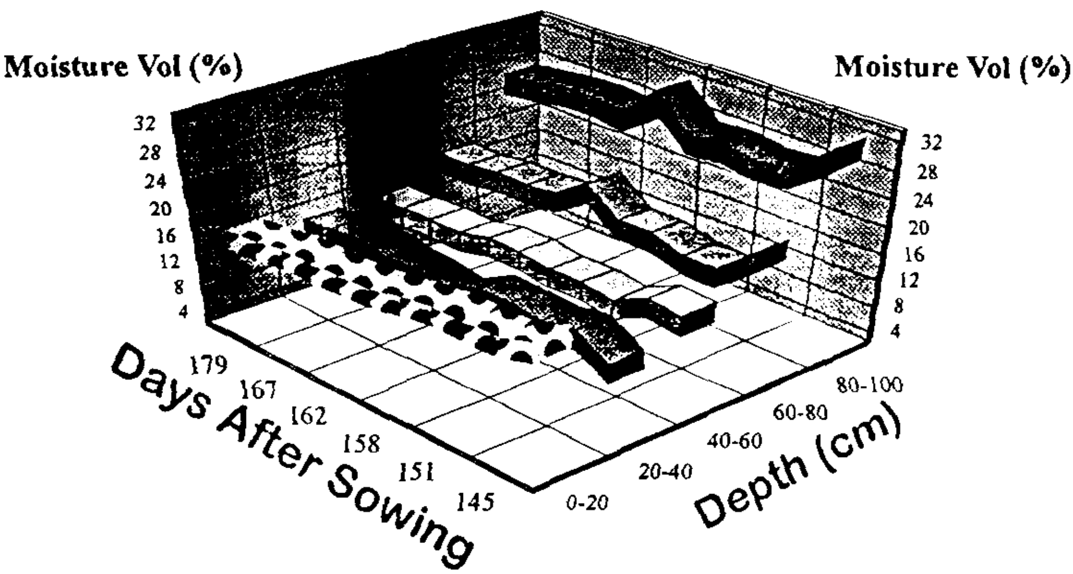
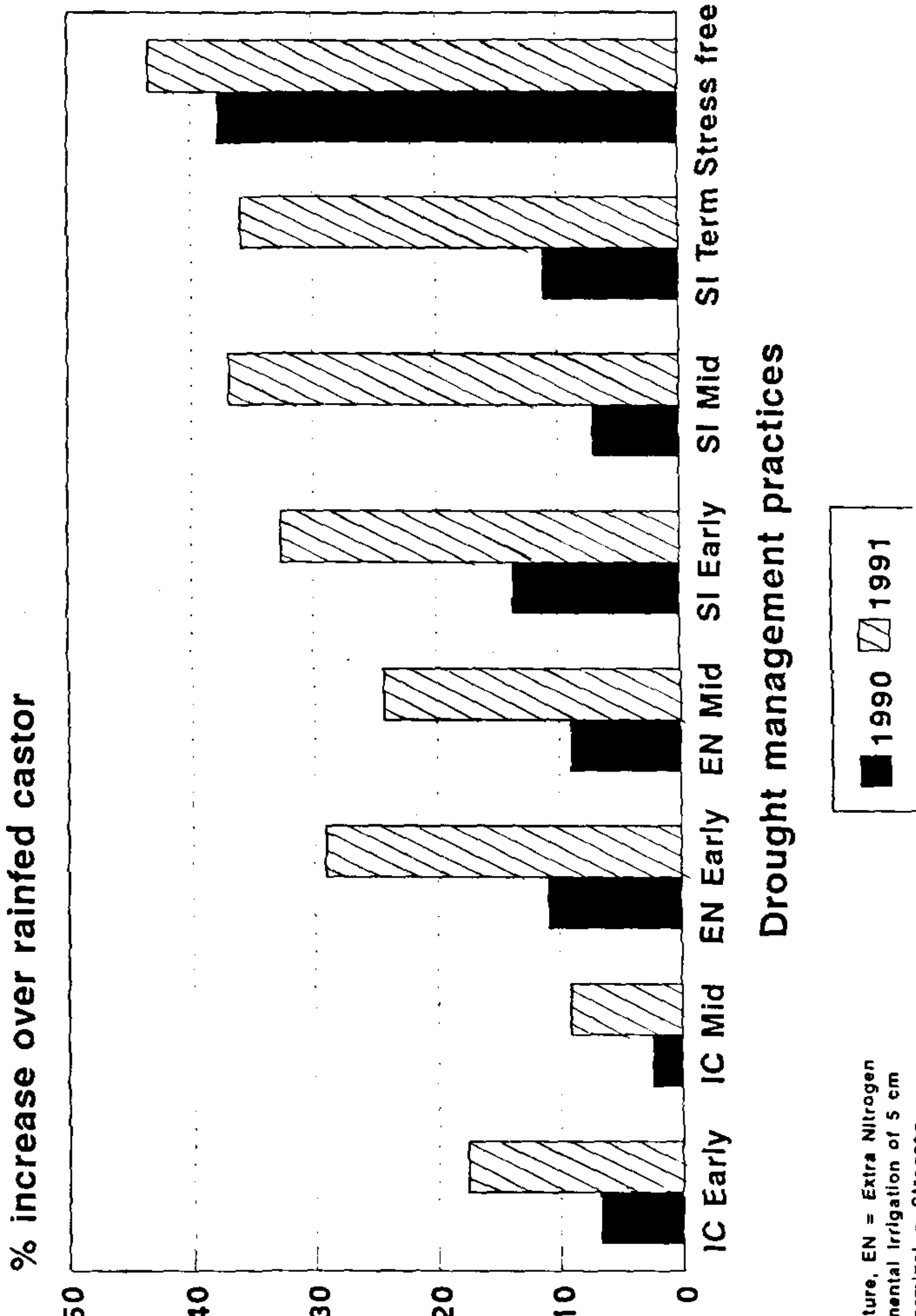


Fig. 3 Influence of drought management practices on yield of castor (1990 and 1991)



IC = InterCulture, EN = Extra Nitrogen
SI = Supplemental Irrigation of 5 cm
Early, Mid, Terminal = Stresses

Thus the study indicated that the moisture stress during vegetative phase and formation of primaries and secondaries was very critical in influencing the growth and yields of rainfed castor. Management practices imposed during early and mid stress periods showed the stabilization of primaries and secondaries respectively. The highest increase in bean yields of castor with supplemental irrigation was due to higher compensation of drymatter production, leaf area recovery, N uptake, higher rainfall use efficiencies and better utilization of moisture after relief of stress periods. The experimental results from dryland research centres showed that pod yields of groundnut in Anantapur, grain yields of fingermillet at Bangalore and maize yields of Rakhdhiansar increased by 25 to 40% due to supplemental irrigations compared to the rainfed environment (AICRPDA, 1990). The higher castor bean yields due to additional fertilizer N after early and mid-stress periods is the result of compensation of growth components offering higher bean yields of primaries and secondaries. The subsequent rainfall after relief of early moisture stress was helpful for better utilization of nutrients (AICRPDA, 1992). Soil mulch through additional interculture registered additional gross income of Rs. 936 ha^{-1} and Rs. 450 ha^{-1} during early and mid stress periods, respectively. Soil mulch during stress periods reduced the evaporative losses of soil moisture. The soil moisture thus conserved during stress period was helped higher yields in castor than without interculture. Similar yield increase in maize at Arjia and soybean at Indore and water use efficiency in wheat at Rewa with soil mulch and additional fertilizer N after relief were recorded (AICRPDA 1992). It can be concluded from this study that the bean yields of rainfed castor can be stabilized by supplemental irrigation, additional fertilizer application and also by soil mulch through extra interculture for early and mid-stress periods.

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YIELD AND ECONOMICS OF CASTOR TO NITROGEN APPLICATION INTERCROPPED IN SUBABUL ALLEYS

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ABSTRACT

In a two-year study, the seed yields of rainfed castor in association with subabul differed significantly due to level of nitrogen. Though 50% more than the recommended dose of nitrogen rsulted in higher yields of castor (6.11 and 4.03 q/ha) it was comparable to the recommended dose of N (5.66 and 3.39 q/ha) and superior to no Nitrogen (N_0) and 50% less than the recommended dose of N during both the years. Sole castor recorded signiicantly higher seed yields (5.35 and 3.32 q/ha) than intercropped castor (3.56 q/ha and 2.11 q/ha). The seed yields of castor were comparatively lower during second year in association with Subabul. Intercropping castor with subabul at 80N/ha gave almost equal yield (4.52 and 2.74 q/ha) to that of 120 N/ha ((5.08 and 3.42 q/ha). The values of leaf temperature, PAR and transpiration of leaves of castor were lower under the tree compared to unshaded area, while the relative humidity and diffusive resistance were higher in shaded area. The growth of subabul trees in terms of height and girth was not affected due castor crop in both the years.

Key words: Castor; Intercropping; Subabul alley; Nitrogen.

Castor is an important oilseed crop of Andhra Pradesh and is mostly grown under rainfed conditions. Research results indicated that the yields of castor can be enhanced with increased application of nitrogen (Sharma, 1985). But currently the yields of castor are low, specially in drylands due to low nitrogen fertilizer use efficiency which may be attributed to undependable rains. The resource-poor farmers in drylands are reluctant to apply the costly input nitrogen, because of the risk involved in that the applied fertilizer may go waste due to unpredictable rains. Under such situations the advantage of nitrogen to the associated crops can be obtained by growing in association with certain nitrogen fixing trees (NFTS) like Subabul, Sissoo, Siris, African Babul etc., It was reported by Kang *et al* (1981) that the effect of nitrogen contributed by subabul mulches on maize grain yield was equivalent to about 100 kg N/ha for every 10 t/ha of fresh prunings and maize yields were equal at 0 and 50 kg N/ha. Singh *et al.*(1987) reported that when castor was grown in alley cropping with subabul the yields were reduced by 62% affecting nutrient and moisture relations. Keeping this in view the present study was initiated to findout the compatabililty of castor and also to assess the nitrogen requirement for enhancement of productivity when intercropped with subabul.

METERIALS AND METHODS

A field experiment was conducted during *Kharif* 1993 and 1994 rainfed castor under different levels of nitrogen when intercropped in Subabul (*Leucaena leucocaephala*) at students Farm, College of Agriculture, Rajendranagar ,Hyderabad. The soil of the experimental plot was low in organic carbon (0.2 -0.3) and available nitrogen (168 kg/ha), medium in available P (10 kg/ha) and high in available K (401 kg/ha). Subabul plantations planted at a spacing of 4 x 3m during 1991 and watered during first year for better establishment were used. There were 8 rows and 12 trees in each row. The entire area was suitably laid out to have four levels of nitrogen and three replications in Factrrial Randomized Block design. Castor Variety Aruna was sown at 60 x 30 cm in first week of July in between the alleys of subabul and also as sole crop separately in the plots of 24 x 4.2 m size during *Kharif* season. Nitrogen at 0,40,80 and 120 kg/ha was

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applied in two split doses through urea at the time of planting and flowering, while P and K were applied as basal at the rate of 60 kg/ha respectively. Castor was harvested in the months of October - November in respective years. The data on physiological parameters like leaf temperaure (LT); Relative Humidity (RH); Photosynthetically Active Radiation (PAR); of Diffusive Resistance (DR) and Transpiration (TR) of leaves of castor under shaded and unshaded area of trees was recorded using steady state porometer.

RESULTS AND DISCUSSIONS

Seed yields

Application of 120 kgN/ha resulted in higher seed yields of castor (6.11 q/ha 1993 and 4.03 q/ha 1994), but was on par with 80 kgN/ha (5.66 q/ha and 3.39 q/ha during 1994). Significantly lower yields of castor were observed with 40 kgN/ha (4.28 and 2.22 q/ha) and N_O (1.77 and 1.23 q/ha) levels. Sole crop of castor recorded substantially higher yield (5.35 q/ha and 3.32 q/ha during 1993 and 1994) as compared to Intercropped castor (3.56 and 2.11 q/ha). The lower yield of castor raised in association with subabul may be attributred to competition from the trees for nutrients, moisture and solar radiation in particular, since trees have wide spreading dense crown and deep root system (Singh *et al.*, 1987 and Singh, 1986). These results further indicated that growing of any arable crop in assiciation with subabul is not advisable from fourth year of the tree, as it had suppressing effect on castor growth and needs pruning of the tree either through coppicing, pollarding or lopping. These lopped material of subabul trees can be used as mulch to enrich the site for enhancing the crop yields and reducing part of nitrogen requirements to the associated crop (Kang*et al.* 1981). The seed yield of intercropped castor at recommended dose of 80 kg N/ha was almost equal to the yields recorded with120 kg N/ha indicating, that subabul being a legume tree might have not competed for nitrogen applied to the castor. The lower seed yields of castor during 1994 may be due to low (47 mm) and erratic rainfall specially during September 1994, as compared to 142 mm during 1993. The shading effect of subabul trees was yet another cause for low yields of castor during 1994.

Physiological Parameters

In both the years of study under the shade of subabul tree, the leaf temperature, photosynthetically active radiation and transpiration of castor leaf was reduced considerably while relative humidity and diffusive resistance of castor leaves was increased (Table 2) Reverse phenomenon was observed in the values of all physiological parameters of castor leaves when there was no shading effect of trees irrespective of the nitrogen levels imposed in both the intercropped and sole Castor. These results clearly showed that the reduction in values of the transpiration and photosynthetically active radiation in castor intercropped with the subabul might be due to low leaf temperature, less moisture availability and high diffusive resistance resulting in poor growth of castor. Higher values of Diffusive Resistance under the tree indicates reduced stomatal conductance for exchange of CO_2 and O_2. On the contrary the castor plants maintained high traanspiration and low values of diffusive resistance when there was no shading effect resulting in better growth of castor. Such favourable physiological parameters of castor raised under *Faidherbia albida*, a deciduous tree specially during rainy season, was also observed by Bheemaiah *et al.*(1994).

Growth of subabul trees

The growth of subabul trees in terms of height and girth (Table 4) showed that the associated castor did not exert any autagonestic effect on the growth of trees during both the years of study, irrespective of nirtogen levels applied to castor.

Table 1. Seed yield of Castor (q/ha) intercropped with subabul under different nitrogen levels

Treatments	1993			1994		
	Sole	Intercropped	Mean	Sole	Intercropped	Mean
Nitrogen (kg/ha)						
0	1.93	1.61	1.77	1.88	0.58	1.23
40	5.55	3.01	4.28	2.72	1.71	2.22
80	6.79	4.52	5.66	4.03	2.74	3.39
120	7.13	5.08	6.11	4.63	3.42	4.03
Mean	5.35	3.56		3.32	2.11	
CD (0.05):						
N levels	–	0.60			0.80	
cropping systems	–	0.43			0.41	
N x C	–	0.86			–	

Table 2. Physiological parameters of castor intercropped with subabul

Treatments		1993					1994				
		LT	RH	PAR	DR	TR	LT	RH	PAR	DR	TR
N0	S	31.1	59.4	1600	0.80	14.0	27.8	45.6	270	0.65	15.22
	US	31.2	58.4	1650	0.54	17.5	27.8	45.2	1570	0.21	28.81
N 40	S	31.6	56.6	1605	0.68	13.5	27.8	46.0	480	0.61	14.09
	US	32.3	53.6	1850	0.54	22.1	28.4	45.8	1460	0.27	20.45
N 80	S	31.7	56.0	1330	0.77	14.5	27.8	44.8	260	0.64	17.30
	US	31.8	57.0	1736	0.60	26.5	28.0	45.0	0690	0.35	20.39
N 120	S	31.3	59.6	1280	0.88	16.75	27.5	45.6	260	0.65	16.60
	US	31.7	56.1	1900	0.57	22.5	27.8	45.6	979	0.31	29.00

L.T. = Leaf temperature (^{O}C); R.H. = Relative Humidity (%), PAR = Photosynthetically Active Radiation (μ mole S^{-1} cm^{-2}
DR = Diffusive resistance (S cm^{-1}); T.R. = Transpiration (μ g cm^{-2}), S = Shaded area; US = Unshaded area.

In general, the growth rate of subabul was quite normal even under adverse edaphic and climatic conditions.

Economics of N application

The net returns due to application of nitrogen to castor differed considerably in both the years (Table 3) where increased dose of nitrogen upto the recommended dose (80kg N/ha) increased the net returns gradually. Application of 50% more than the recommended dose of nitrogen (120 kg/ha) did not benefit the crop in enhancing the returns. But the increase of net returns during 1994 was on negative side, because the castor crop has suffered due to erratic and low rainfall during the season. Among the cropping systems, sole castor gave higher net returns than interropped castor. This can be attributed to the competition for natural resources like light, moisture, nutrients etc., due to competition from Subabul trees which started from 1993 itself.

From the returns, it is amply evident that the recommended dose of nitrogen (80 kg/ha) proved economical in both sole croping as well as intercropping situations.

Thus from the results of our study it can be summarized that growing of arable crops like castor as intercrop with subabul will be advantageous, as part of nitrogen requirements of associate crop can be supplemented, besides enriching the degraded sites in drylands. However, to obtain greater advantage from subabul after fourth year of tree Plantation,it is advisable to prune the tree either through pollarding or coppicing which can be used as off-season green fodder, and enhances the productivity of associated crop.

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Table 3. Net returns (Rs/ha) from nitrogen application to castor intercropped with subabul

Treatments	1993			1994		
	Sole	Intercropped	Mean	Sole	Intercropped	Mean
Nitrogen (kg/ha)						
N 0	-342	-534	-438	-372	-1152	-762
N1	1525	1	763	-173	-474	-323.5
N2	1964	602	1283	308	-466	-79
N3	1863	633	1248	363	-363	0
Mean	1252.50	175.50		31.50	-613.75	

Table 4. Growth of Subabul as influenced by intercropping with castor

	Tree height (cm)		Increment	Tree Girth (cm)		Increment
	1993	1994		1993	1994	
Nitrogen (kg/ha)						
0	283.5	317.5	34.0	14.50	16.25	1.75
40	363.5	419.0	55.5	19.00	22.00	3.00
80	199.0	227.5	28.5	10.00	12.00	2.00
120	285.5	385.0	99.5	15.75	20.00	4.25

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SUPER SOIL-A POSSIBLE INGREDIENT FOR *In-Situ* MOISTURE CONSERVATION IN GROUNDNUT (*Arachis hypogaea* L.)

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ABSTRACT

An experiment was conducted in calcareous soil at the National Research Centre for Groundnut, Junagadh during *kharif*, 1994 to study the feasibility of a new material,"Perlite based super soil" as a component of in-situ moisture conservation. "Super soil;" retained high amount of moisture and had very low bulk density value (0.12g/cc). When super soil was mixed with soil was in the proportion of 1:1 or 3:1, moisture retention increased and the bulk density was lower as compared to sole soil. Significantly higher pod yield was also obtained in this proportion (1:1 or 3:1). Increase in pod yield was also obtained in the field on application of super soil because of better moisture availability, air holding capacity and low bulk density.

Key words: Super soil; in-situ moisture conservation; capillary; non- capillary porosity.

INTRODUCTION

In India *kharif* groundnut very often, faces water stress at various stages of growth. On the other hand groundnut grown during *rabi*/summer season requires frequent (10-14) irrigation which constitutes about 1/4th of the total cost of cultivation. Thus, there is a need to develop proper method of *in-situ*moisture conservation so that adverse effect of drought on the crop and total irrigation requirement may be minimized. In the present study a new synthetic material, "super soil" manufactured by Amole Dicalite Ltd. Ahmedabad, India, was tested to find out its feasibility as a component of *in-situ* moisture conservation.

"Super soil" is a Perlite based volcanic inorganic mineral having 6.7 pH which expands to about twenty times its original volume when it is heated to 930°C (Anonymous, 1994) in specially designed furnaces. During the heating process the mineral pops like popcorn and form a granular white material so light that it weighs only 40-128 Kg m^3. The surface of each particle is covered with tiny cavities which provide an extremely large surface area. These surface cavities trap moisture and improve its capillary action. In addition, because of the very low bulk density of the material, air passages are formed providing optimum aeration. Improvement in soil condition is, therefore, anticipated due to improvement of air-water relationship that is developed when it is applied to any soil. Hence, the experiment was undertaken.

MATERIALS AND METHODS

A pot experiment was conducted during *kharif*, 1994 at the National Research Centre for Groundnut, Junagadh with 8 treatments (Table 1) in a randomized block design replicated thrice. Pots of 10 kg capacity were used. Each pot contained 8 kg of the material as per treatment. Five seeds of cv. GG 2 cultivar were sown in each pot on 19th August 1994. Hoagland's nutrient solution (Hewitt, 1966) was applied to each pot at 15 day interval and was continued upto peak flowering stage. Samples for number of nodule, its dry weight and dry weight per plant were taken at peak flowering stage (60 DAS). Plants were harvested at 105 days after sowing and number of pods and pod yield per plant were recorded. Soil samples from each pot were taken at 30 days

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after sowing and moisture per cent at field capacity, bulk density, porosity and capillary porosity were determined. Capillary porosity (%volume of pore pace occupied by capillary water in a soil) was calculated by multiplying bulk density with moisture percent at field capacity. Non-capillary porosity (%volume of pore pace occupied by air in a soil) was calculated by substraction from porosity.

The material was also tested in the field during post-rainy season, 1995 allocating four treatments viz: 0,25, 50 and 75 kg super soil/ha. The plot size of 15m x 5m was maintained. Since super soil is bulky in nature and very light in weight it was mixed with urea and dry soil for uniform distribution in the field. Seeds of GG 2 cultivar was sown on 3rd February and harvested on 23rd May. A basal application of 25 kg N and 60 kg P_2O_5/ha was applied uniformly to groundnut. A total number of irrigations given to control and super soil plot were 12 and 8, respectively. In each irrigation a volume of 500 cubic metre water/ ha was applied through flood irrigation.

RESULTS AND DISCUSSION

Soil Properties

Table I shows that "Super soil" (T1) retained very high amount of moisture as compared to soil (T2) and sand (T3). Moisture content was also high when "Super soil" was mixed with soil in any combination. Significantly lower bulk density value in "Super Soil" (T1) was recorded as compared to soil alone (T2) and bulk density of soil decreased when it was mixed with "Super soil" was mixed with it (T4,T6 and T7) as compared to soil (T2). Similar trend was also observed in field condition. Improvement in soil properties namely moisture percent, porosity etc. and reduction in bulk density were noticed in the plot where "Super soil" was added (Table 1).

Pod yield/plant, number of pods/plant, number of nodules/plant and dry weight/plant were lowest in the plot where only "Super Soil" was added (Table 2). This may be attributed to retention of high amount of moisture throughout the growth period of crop (Table 1) since excess of insufficient soil moisture reduced biological nitrogen fixation and affected pod formation and development (Nambiar, 1990). Visual observation also indicated that due to excess moisture in the "Super soil" only, plant was etiloted and remained completely yellowish even at harvest. The soil where "Super soil" was added in 1:1 ratio (T4) gave significantly higher pod yield as compared to rest of the treatments except T7 and T8, possibly by providing better moisture status around the root (Table1). Improvement in pod yield was also noticed when "Super soil" was added in the field. Significantly higher pod yield was recorded with the application of 75 kg "Super soil" over control and 25 kg "super soil" (Table 2). B:C ratio was maximum when 50 kg "super Soil/ha" was applied followed by 25 kg and 75kg per ha (Table 2). Increase in pod yield due to addition of "Super Soil" may be attributed to increase in air holding capacity of soil (Table 1) which helped in better N fixation.

The present study therefore, indicates that for groundnut cultivation a material like "Super Soil" can be useful as a soil conditioner in enhancing the yield since soil structure best suitable for pegging and pod formation/development could be obtained.

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Table 1. Effect of super soil on soil properties

S.N.	Treatments	Moisture at field capacity (%)	Bulk density (g/cc)	Porosity (%)	Capillary porosity (%)	Non-capillary porosity (%)	Saturation point (%)
T1	super soil	36.6	0.12	78.1	43.3	34.8	453.0
T2	soil only	18.4	1.29	49.8	23.7	26.0	47.2
T3	sand only	9.0	1.06	54.9	9.5	45.4	29.8
T4	super soil + soil (1:1)	39.3	0.89	57.1	35.0	22.1	61.0
T5	super soil + sand (1:1)	23.1	1.05	57.1	24.2	32.9	39.6
T6	super soil + soil (1: 3)	22.6	1.14	46.2	25.7	20.4	49.6
T7	super soil + soil (3:1)	34.3	0.88	61.1	30.2	30.9	53.6
T8	super soil + soil + sand (1:1:1)	25.8	0.82	64.6	21.1	43.3	48.8
	LSD (P=0.05)	17.4	0.12	5.6	9.36	–	–
	Super soil applied to field (kg/ha)						
	25	27.1	1.11	49.7	30.1	19.6	–
	50	28.7	1.06	50.6	30.4	20.1	–
	75	30.3	0.98	43.3	29.7	23.4	
	0	23.0	1.26	43.3	27.8	15.5	
LSD (p=0.05)		4.9	0.17	8.2	–	6.3	–

The ratios shown are all by weight basis

Table 2. Pod yield, yield attributes and economics as influenced by different treatments

Treatments	Pod yield per plant	Pods No. per plant	Nodule No. per plant	Nodule dry wt. (mg)	Plant dry wt. (g)		Pod yield due to super soil (kg)	Net return due to super soil (Rs.)	B: C ratio
					60 DAS	harvest			
T1	0.99	2.6	7.6	18.6	1.06	2.82	–	–	–
T2	2.50	3.6	14.6	39.0	1.85	5.31	–	–	–
T3	3.41	4.6	7.6	31.6	2.10	6.07	–	–	–
T4	6.39	8.0	24.3	49.3	387	8.97	–	–	–
T5	4.82	5.3	8.6	31.0	2.29	6.77	–	–	–
T6	3.52	4.3	22.3	40.6	2.35	5.80	–	–	–
T7	4.97	5.2	26.6	64.3	2.37	7.5	–	–	–
T8	5.07	5.5	23.3	59.6	2.36	6.79	–	–	–
LSD (P=0.05)	1.90	2.2	6.1	13.1	1.28	NS			
Super soil applied to field									
(kg/ha)	(kg/ha)								
25	1330.2	–	–	–	–	–	190	2280	4.56
50	1571.0	–	–	–	–	–	431	5172	5.17
75	1599.9	–	–	–	–	–	459	5508	3.67
0	1140.0	–	–	–	–	–	–	–	–
LSD (p=0.05)	143								

DAS = days after sowing, NS = Non-significant, Costof kg super soil = Rs. 20, Value of q pod = Rs. 1200

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DETECTION OF NITRATE REDUCTASE ACTIVITY IN GYNOPHORES AND PODS OF GROUNDNUT (*Arachis hypogaea L.*)

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ABSTRACT

Nitrate reductase activity (NRA) was detected in the gynophores and pods of groundnut. Selective application of nitrogen in the pod zone significantly enhanced this activity. Coupled with the recent evidence that groundnut pods directly absorb soil N, these results point to the possibility of direct N uptake and assimilation by the gynophores and developing pods of groundnut with significant implications on the N metabolism of this crop.

Key words : Nitrate reductase activity; gynophores; groundnut

INTRODUCTION

Groundnut gynophores and pod walls have been reported to absorb plant nutrients from the soil and translocate to the shoot. Chahal and Virmani (1973) and Chahal *et al.* (1979) have reported that sulphur, calcium and zinc are absorbed through the developing pods from the soil. Recent experiments by Inanaga *et al.* (1988) showed that groundnut pods absorb N directly from the soil. By using ^{15}N labelled fertilizer in the fruiting and rooting zones separately, the authors demonstrated direct N uptake by the fruits and its translocation to the shoots. In the present communication, we report the detection of nitrate reductase activity in the gynophores and the pods of groundnut and discuss its implications in the N metabolism of groundnut.

MATERIALS AND METHODS

In a field experiment on groundnut during *kharif* 1992, we accidentally detected significant levels of NRA in the gynophores and young pods of groundnut when these parts were assayed along with other parts like leaves, roots and nodules. These observations were followed by further experiments to confirm the results. During summer 1993, a pot culture experiment was set up with a total of 60 glazed pots of 15 kg capacity in three replications. The soil used was an Alfisol (pH 6.3; Organic Carbon, 0.41%; total nitrogen, 0.052%). Initially three seeds of groundnut (Cv.JL-24) were planted in each pot which were later thinned to two after emergence. Seeds were inoculated with NC-92 an efficient *Rhizobium*strain received form ICRISAT, Hyderabad, India, to ensure good nodulation. To estimate the NRA in different plant parts, destructive sampling was done by emptying sufficient number of pots each time in order to get adequate plant material for sample preparation. Starting from 20 DAS,6 pots were emptied each time @2 pots in each replication up to 92 DAS. The plant material from two pots (four plants; consisting one replication) was used for preparing the leaf, stem,root, gynophore samples, etc. after thorough mixing. Thus, a total of 48 pots (8 x 6) were utilized for destructive sampling. The remaining 12 pots were used for recording the final dry matter and pod yield just for record. The NRA was assayed in different plant parts according the methods described by Nair and Abrol (1977).

A second pot experiment was conducted during *kharif* 1993 where groundnut plants were raised on an Alfisol in large pots (30 kg) in order to study the effect of N application in root zone and pod zone. A total of 36 pots were included in this

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experiment with each pot containing three plants. The experiment had three replications. The total number of pots were divided into four sets of 9 each. At 45 DAP (at peg initiation) the root zone and the pod zone were separated in all these pots by placing a polythene sheet in such a way that the water and nutrients added in the pod zone do not seep into the root zone. A circular polythene sheet having a total diameter exceeding 5 cm below the soil surface and joined together with glue. The sheets were fastened at the stem with an elastic rubber string. The system was allowed to stabilize for two days. Fertilizer N @30 kg/ha was applied in the form of KNO_3 dissolved in water both in the pod zone and root zone separately. Care was taken to add only that much water to maintain the soil at 75% field capacity and not to allow any downward percolation. Plants not supplied any nitrogen either in the pod zone or in the root zone but added with distilled water served as control. Plants were harvested after 48 hours, 1 week and 2 weeks after application of N and separated into roots, leaves, gynophores and pods. The NRA was estimated by the same methods described earlier. Thus, a total of 27 pots were utilized for destructive sampling in three replications while the plants in the remaining 9 pots were harvested at physiological maturity for recording the drymatter and yield.

RESULTS AND DISCUSSION

Marked nitrate reductase activity was detected in the gynophores, young pods, pod walls and seeds of groundnut. The activity in the gynophores was detected first at 45 DAS which remained steady upto 65 DAS and started declining thereafter (Table 1). Undifferentiated whole pods showed higher activity than gynophores. Considerable NRA was also detected in the pod wall and seeds after 65 DAS. The activity in the pod walls declined while it increased in the seeds.

Nitrate Reductase Activity in plant parts like leaf, root and stem was also assayed simultaneously. Activity in the root remained insignificant throughout the growth cycle while stem of young plants showed moderate levels of activity which declined gradually with age of the plant Leaf NRA increased only upto 32 DAS and remained steady upto 56 DAS. It showed significant decrease at 65 DAP. The activity in case of leaf was much higher than root and stem but lower than leaves. From the data it appears that NRA in the reproductive parts like gynophores and young pods increases steadily upto 65 DAS, while it tends to decline in vegetative parts like stem and leaves indicating that marked levels of nitrate reduction can occur in reproductive parts particularly in later stages of plant growth when the NRA tends to decrease in the vegetative parts.

To confirm whether the NRA in gynophore is affected by the changes in soil nitrogen (due to external application), estimates of NRA were made following selective N application in the root zone and pod zone. The activity levels in the second experiment were relatively higher due to seasonal effects and better plant growth. When nitrogen was selectively applied in the pod zone, there was a significant increase in the NRA of gynophores (Table 2). The NRA nearly doubled one week after N application. The leaf NRA was not affected much. However, when KNO_3 was applied in the root zone, the leaf NRA almost doubled which indicates that N taken up by roots in principally reduced in the leaves, while N taken up by the pods can be used by pods themselves or could go into the vegetative leaves.

Earlier experiments conducted by Inanaga *et al.*(1988) on groundnut support our hypothesis. These authors have found a decline in pod wall N content when the N content of pod zone was decreased. A more direct evidence was provided by Inanaga *et al.*,(1990) who found that about 35-40% of labelled N fertilizer applied in the pod zone was taken by the fruit wall and assimilated in the seeds. Coupled with these findings, our observation on detection of NRA in gynophores and young pods point to the possibility

Table 1. Nitrate reductase activity (μ moles NO_2/g. dry wt./h) in different plant parts of groundnut during the growth cycle (Data represent Mean ± Sd of 3 observations)

Days after sowing	Leaves	Stem	Roots	Gynophores	*Undifferentiated* whole pods	Shell	Seeds
20	10.25±0.65	6.55±0.51	0.61±0.08	-	-	-	-
32	18.34±1.26	4.26±0.61	1.12±0.09	-	-	-	-
45	17.67±2.11	3.16±0.32	0.98±0.08	6.28±0.71	-	-	-
56	16.62±1.06	2.89±0.21	0.86±0.06	8.78±0.06	9.65±1.20	-	-
65	9.87±0.86	2.18±0.19	1.07±0.06	7.65±0.89	11.28±1.16	6.96±0.54	4.65±0.61
74	9.92±1.11	2.01±0.12	0.92±0.07	3.98±0.65	10.62±0.98	3.19±0.28	5.28±0.48
84	6.55±0.56	2.15±0.31	1.02±0.09	3.15±0.21	-	2.75±0.19	4.98±0.39
92	6.16±0.81	1.65±0.18	0.62±0.07	-	-	-	5.12±0.26

Table 2. Nitrate reductase activity in leaves and gynophores of groundnut as influenced by N application in the root zone and pod zone (Data represent mean ± Sd of 3 observations)

Days after *N application*	Treatment	NRA (μ moles NO_2/g. dry wt./h)	
		Leaves	Gynophores
2	Control	13.18±1.65	15.11±1.21
	N applied in pod zone	18.23±1.87	18.73±2.17
	N applied in root zone	36.55±3.15	15.56±1.82
7	Control	12.83±1.89	17.31±2.62
	N applied in pod zone	18.64±3.12	32.80±3.62
	N applied in root zone	38.55±4.19	16.33±2.12
14	Control	15.24±1.69	15.20±2.16
	N applied in pod zone	19.37±2.16	34.76±3.21
	N applied in root zone	28.46±3.12	20.12±3.33

of involvement of these organs in the direct N uptake from the soil. Detection of NRA in wheat ears was reported by Nair and Abrol (1977) but to the knowledge of the authors, this is the first report on the detection of NRA in gynophores and pods of groundnut. In the present study, external application of nitrogen in the pod zone has led to a sharp increase in the NRA of gynophores. Unlike the wheat ears, the gynophores are buried in the soil, hence, it can be speculated that these structures could be involved in the uptake of nitrogen from the soil and directly utilize for the growth of the pods. However, further experiments are required to test these possibilities.

The uptake of other elements like calcium, zinc and sulphur by groundnut gynophores has already been reported (Chahal and Virmani, 1973; Chahal *et.al.*, 1979) and nitrogen could also be another important element that can be taken up by pegs and pods. However, detailed studies are required on the extent to which nitrate uptake and assimilation takes place in the fruiting structures and the factors controlling it.

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ANAEROBIC FERMENTATION OF SUNFLOWER STALK IN PILOT SCALE BIOGAS PLANTS

Huge quantities of sunflower stalk produced are being ineffeciently used as direct fuel. An attempt was made to utilise this abundantly available organic waste efficiently by subjecting it into anaerobic fermentation for generating biogas as well as the reside as manure value.

Sunflower stalk was chopped (2" size) and steeped overnight in lime water (1.0% W/W) (Jagadesh *et al.*, 1990). The lime treated material was washed with water to get rid of traces of alkali. It was mixed with cowdung at 1:20 and 1:10 ratio (dry weight basis) to represent 5% and 10% of the digestion mixture respectively. These ratios were based on preliminary laboratory scale studies. The mixture was mixed with water to achieve a total solid content of around 10 per cent and charged into 1.0 m^3 pilot scale biogas plants. A conventional control of cowdung slurry was also maintained.

The biogas produced was monitored everyday, and measured using a gas flow meter ('Insref'). At regular intervals, the samples of digestion mixture were withdrawn to enumerate anaerobic cellulolytic (Hobson and Mann, 1971) and methanogenic (Touzel and Albagnec, 1983) bacterial population by the MPN technique. The nitrogen content in the fermentation mixture before and after fermentation was estimated by the microkjeldabhl method (Jackson, 1967). The methane content in biogas was analysed using the Orsatt apparatus. The experiment was conducted for two years during 1990 and 1991.

Higher biogas yields were obtained when sunflower was supplemented at 5% level during both the years of investigation (Table 1). In terms of methane yields, the increase in yields averaged at about 23%. However, when the sunflower content in the digestion mixture was increased to 10% level (i.e., 1:10), the gas yields were on par with the conventional control. Qualitatively also, the biogas produced by sunflower supplementation at 5% level was superior (70.5% methane content) over conventional control (67.5%) as well as 10% sunflower supplementation (66.5%).

Anaerobic bacteriological population estimation (Table 2) revealed that sunflower at 5% level exhibited the highest cellulolytic and methanogenic activities. The lower population during early period of charging indicate the time lag for adaptation of the consortium to the sunflower waste. Similarly, Jagadeesh and Geeta (1990) observed higher anaerobic cellulolytic and methanogenic bacterial population when soybean waste was supplemented at 4% level, which resulted in enhanced biogas yields. Suhirman and Melliawaty (1987) also found that 20% (Wet weight basis) supplementation of *Clitoreo ternatea* leaves to rice straw resulted in maximum biogass production.

The N content in the fermented sludge was found to be the highest in sunflower supplementation at 5% (Table 1). The highest methanogenic population might have contributed for the increased N content, as methanogens have been

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known to fix atmospheric nitrogen under free living conditions.

Thus, the two year studies showed that sunflower supplementation at 5% level enhanced biogas yields and N content in the fermented sludge, attributable to increase in anaerobic methanogenic activity in the digesters.

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Table 1. Biogas production from sunflower stalk at different concentrations

Treatments Attributes	Conventional Control			Sunflower supplemented (5% level)			Sunflower supplemented (10% level)		
	I Year	II Year	Average	I Year	II Year	Average	I Year	II Year	Average
Total Biogas Production (litres)	10,678	12,212	**11,445**	12,615	13,729	**13,172**	10,361	12,577	11,469
Gas yields per kg dry matter (litres)	64.32	77.24	**70.78**	74.14	93.19	**83.66**	62.29	78.61	70.45
Methane content (%)	67.0	68.0	**67.5**	71.0	**70.0**	**70.5**	67.0	66.0	66.5
Methane yields per kg dry matter (litres)	43.09	52.52	**47.80**	52.64	65.23	**58.93**	41.74	51.88	46.81
N content in the digestion mixture									
i) Before fermentation	1.81	**1.70**	**1.76**	1.85	**1.91**	1.88	2.21	2.17	2.19
ii) After fermentation	2.11	2.05	**2.08**	2.41	2.53	2.47	2.30	2.39	2.35

Rentention period : 55 days

Temperature : Ambient (I Year: max. 29.6°C; min. 18.5° C)
(II Year: max. 36.0°C; min. 20.3° C)

Table 2. Anaerobic bacteriological changes during fermentation of sunflower-cowdung mixture in pilot scale biogas plants (1.0M³)

Treatments		Cellulolytic bacteria (x10⁶) (cells/ml) Days after charging			Methanogenic bacteria (x10⁴) (cells/ml) Days after charging		
		20	45	55	20	45	55
Conventional	I Year	0.640	0.180	0.700	50.00	72.00	14.00
Control	II Year	0.376	1.835	0.297	63.52	94.38	29.69
	Average	0.508	1.007	0.498	56.76	83.18	21.84
Sunflower	I Year	0.140	3.900	0.110	0.03	280.00	120.00
Supplemented	II Year	0.242	2.373	0.316	46.79	242.76	108.93
5 (%)	Average	0.191	3.136	0.213	23.40	261.38	114.46
Sunflower	I Year	0.039	0.170	0.060	0.120	43.00	20.00
Supplemented	II Year	0.316	1.63	0.199	38.73	89.86	26.35
(10%)	Average	0.273	0.904	0.129	19.42	66.43	23.17

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GENETIC DIVERGENCE IN LINSEED (*Linum usitatissimum* L.)

The D^2 statistic was found as a potent tool for estimating genetic divergence. The present study was taken up to analyse the genetic divergence of 60 strains of linseed collected from six different breeding centres of India, using D^2 and canonical analysis.

Sixty strains of linseed from different geographic regions were grown in a randomized block design with 3 replications in a uniform block. Each entry had 3 rows of 4m long with 30cm and 10cm spacing between rows and plants, respectively. Ten competitive plants per replication from middle rows were taken in each genotype and observations were recorded on individual plants for yield and yield contributing traits viz.. days to flowering, days to maturity, plant height, technical height, primary branches, secondary branches, capsules/plants, sterile capsules/plant, biological yield, straw yield and 1000-seed weight. The analysis of variance was carried out for all characters individually. The clustering of genotypes was done by the Tocher's method (Rao, 1952) and canonical analysis was done following the usual procedure.

Analysis of variance for yield and the contributing characters indicated that mean squares for all the characters were significant. The simultaneous test of significance based on wilk's criterion (Wilks. 1932) for the pooled effect of all the characters also showed significant differences among the genotypes (X^2 for 708 d. f. = 2833.29).

By the application of clustering technique, the 60 genotypes were grouped into 6 clusters (Table 1). Among the 6 clusters, cluster I was the largest having 35 genotypes from different geographic regions. Fourteen strains were accomodated in cluster two genotypes. SPS 77/23-10 and SPS 77/48-5, represented cluster V and VI, respectively.

The clustering pattern revealed that the tendency of genotypes from diverse geographic regions to group together in one cluster may be due to similarity in requirements and selection approaches followed under domestic cultivation (Arunachalam and Ram, 1967). It was also observed that the genotypes belonging to the same state were distributed in different clusters indicating wide genetic diversity among genotypes originating from the same geographic region. The clustering pattern, thus, revealed lack of a strict correspondence between genetic divergence and geographic distribution. This could be due to genetic drift and selection in different environments which caused greater diversity than geographic distance. Murty and Arunachalam, (1966), Jeswani *et al.*, (1970) and Asthana and Pandey (1980) also found no parallelism between genetic diversity and geographic distribution of the genotypes in linseed.

The genetic distance between cluster V and VI (3050.56) followed by cluster I and VI (3009. 17). cluster III and VI (2706.58), cluster II and VI (2664.13) and cluster I and IV (2282.04) was of high order (Table 2). The intra-cluster divergence ranged from 0.00 to 410.66. Among multigenotypes clusters, the maximum intra-cluster divergence was in cluster III and minimum in cluster I. The relative contribution of different quantitative characters towards the expression of genetic divergence was maximum for capsules/plant (38.72%) followed by test weight (34.03%) and days to flowering (15.73%). Rest of the characters contributed less than 5% towards genetic divergence. Thus, diverse parents could readily be obtained in the existing population on the basis of capsules/plant, test weight and days to flowering.

The canonical variate analysis showed that of total variance, 67.56% was accounted for by λ_1 and

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26.29% by λ_2 canonical vectors, representing more than 90% of the total while, λ_3 and λ_4 accounted for only 3.10% and 2.21% variability, respectively. Thus a two dimensional representation of the relative position of the varieties in the Z_1 - Z_2 graph was found adequate. It was observed that clusters were distinctly delineated to their respective positions (Fig.1) similar to their positions in D2 analysis with some discrepancy in respect of cluster I, II and III. The genotypes SPS 77/23-10 and SPS 77/48-5 were situated opposite to each other indicating considerable divergence between them as seen previously. The distribution of genotypes reflected a general parallelism between the grouping pattern obtained by the two methods (D^2 and canonical) of analysis.

The study revealed that geographic distribution was not the sole criterion of genetic diversity. Murty and Arunachalam (1966) stated that genetic drift and selection in different environments could cause greater diversity than geographic distance. Further, there was a free exchange of seed material among the different regions. Consequently, character constellations that might be associated with a particular region in nature lose their individuality under human interference. This suggests that it is not necessary to choose diverse parents from diverse geographic regions for hybridization.

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Table 1. Cluster composition and origin of 60 genotypes of linseed

Cluster	No. of varieties	Varieties included with their geographic origin (in parenthesis)
I	35	LHCK 1 (U.P.), LHCK 3 (U.P.), LHCK 5 (U.P.), LHCK 6 (U.P.), LHCK 7 (U.P.),LHCK 9 (U.P.), LHCK 69 (U.P.), LHCK 82 (U.P.), LHCK 131 (U.P.), LHCK 144(U.P.), LHCK 166 (U.P.), LHCK 172 (U.P.), LMH 27 (U.P.), LMH 88-1 (U.P.), LMH 110 (U.P.), LMH 118-1 (U.P.), LMH 300 (U.P.), LMH 321 (U.P.), LMH 328(U.P.), LMH 350 (U.P.), LMH 354 (U.P.), LMH 360 (U.P.), LMH 438 (U.P.), CS 9 (U.P.), LIK 781 (U.P.), LIK 782 (U.P.), C 219-1-1 (U.P.), SPS 77/30-7 (M.P.), SPS 77/30-5 (M.P.), J 19-13 (M.P.), DPL 20 (H.P.), RAULP 4 (*Bihar*), RAULP 5 (*Bihar*), BAULK 1 (*Bihar*), LC 1007 (Punjab)
II	14	LHCK 2 (U.P.), LHCK 8 (U.P.), LHCK 10 (U.P.), LHCK 11 (U.P.), LHCK 107 (U.P.), LHCK 88 (U.P.), LMH 81-8 (U.P.), LMH 174 (U.P.), LS 2 (U.P.), Neelam (U.P.), B 52 (New Delhi), LC 1013 (Punjab), DPL 4 (H.P.), DPL 17 (H.P.).
III	7	LHCK 4 (U.P.), LHCK 14 (U.P.), LMH 408 (U.P.), LS 3 (U.P.), MUKTA (U.P.), LC 54 (Punjab), LC 1010 (Punjab),
IV	2	Himalini (H.P., T 397 (U.P.).
V	1	SPS 77/23-10 (M.P.)
VI	1	SPS 77/48-5 (M.P.)

Table 2. Intra and inter-cluster D^2 values in linseed

Clusters	I	II	III	IV	V	VI
I	*133.40*	315.44	553.67	2282.04	1045.46	3009.17
II		*213.86*	483.96	1811.99	1118.57	2664.13
III			*410.66*	1571.60	629.70	2706.58
IV				*125.07*	925.91	1759.64
V					*00.00*	3050.56
VI						*00.00*

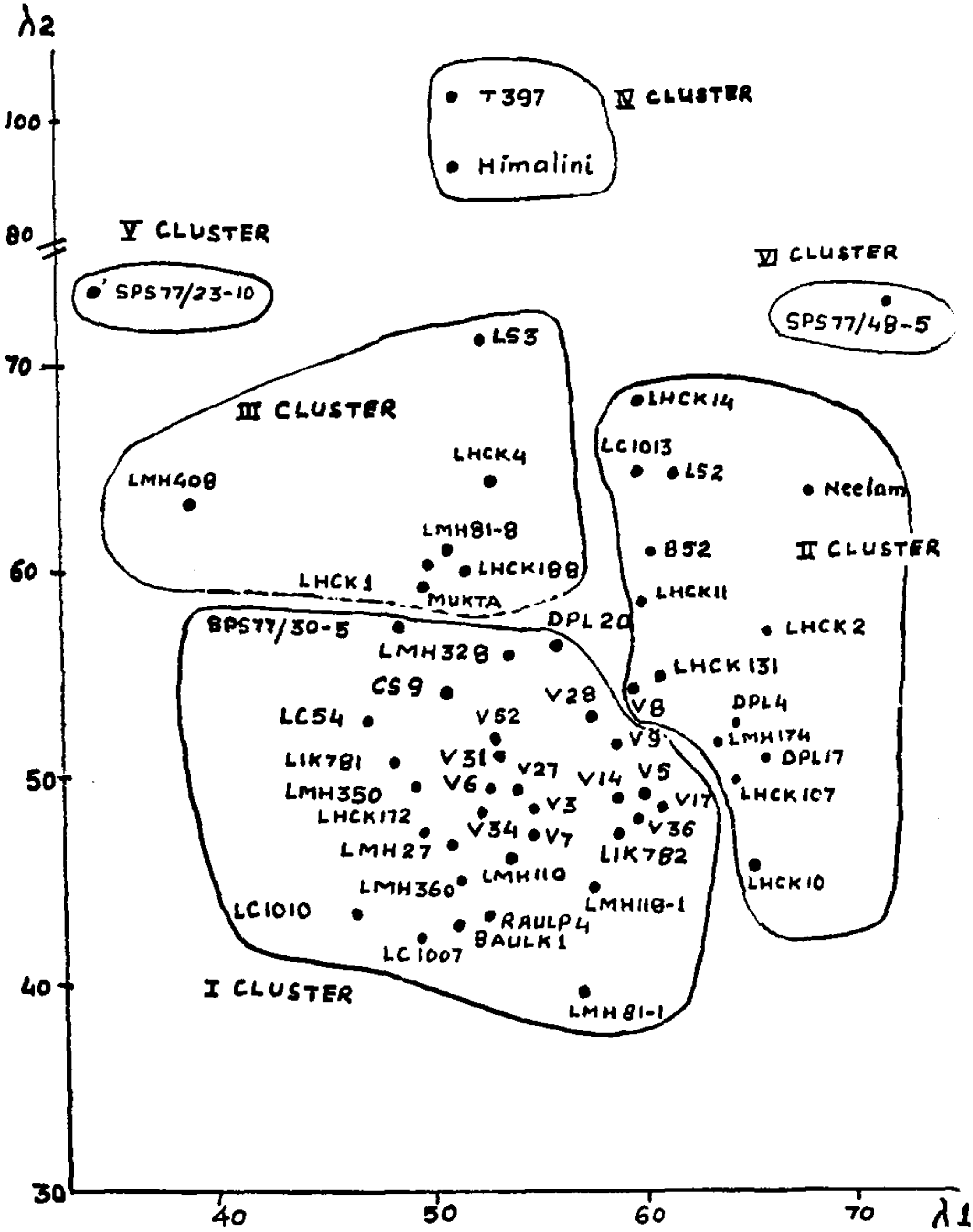

Fig. 1. Relative Distribution of Strains

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MAINTENANCE OF SEED VIGOUR AND VIABILITY IN SOYBEAN (*Glycine max* (L.) Merrill)

Generally soybean seeds are short lived and lose viability rapidly under ambient storage from fourth month onwards. The vigour and viability of seeds stored under ambient conditions could be maintained by hydration-dehydration treatments (Basu *et al.* 1975). The present paper deals with the important biochemical changes that occur in soybean seeds after hydration-dehydration treatments during 12 months of storage.

A laboratory experiment was conducted during *Kharif* 1992 in factorial randomised block design with seven hydration-dehydration treatments and three types of seeds in three replications. The fresh seeds of soybean *cv.* Hardee showing germination of 85-90% (high vigour) were acceleratedly aged to obtain germination per cent of 70 (medium vigour) and 50 (low vigour). Seed tretment consisted of soaking and drying in water, sodium chloride (1×10^{-3} M), p-hydroxy benzoic acid (1×10^{-5} M), tannic acid (2×10^{-5} M), moist-sand conditioning-drying (seed and sand ratio 1:3 for 24 h) and moist-sand conditioning-soaking-drying (First 24h sand treatment followed by fulll immersion in water for 1 hour) and control. The soybean seeds were soaked in double the quantity of water and chemical solutions and were dried back to their original weight. The unsoaked seeds were also dried along with the soaked ones. The treated seed was stored in cloth bags under ambient conditions for 12 months. Later the seed was used to measure electrical conductivity and estimate water soluble sugars (Dadlani and Agarwal, 1983), water soluble amino acids (Plummer, 1988), dehydrogenase activity (Kittock and Law, 1968) and lipid peroxidation activity (Dadlani and Agrawal, 1987) before storage and at 7th and 12th month of storage.

It is evident from the results that high, medium and low vigour seeds treated with or without chemicals and stored subsequently under ambient conditions showed less leakage of electrolytes compared to untreated seed (Fig. 1) due to loss in the membrane integrity. Irrespective of the type of seed, the treatment with p-hydroxybenzoic acid and tannic acid were more effective in recording less leakage of electrolytes compared to control. Such chemicals may act as scavengers and antioxidants to minimise the formation of free radicals and super oxides leading to maintenance of seed vigour and viability for a longer period (Pathak and Basu, 1980).

Leakage of water soluble sugars and amino acids was less in treated ones and high vigour seeds compared to untreated and low vigour seeds (Fig. 1). For any given seed, p-hydroxy benzoic acid, tannic acid and MSC-S-D- seed treatments were more beneficial in checking the leakage of water soluble sugars and amino acids. There was decrease in dehydrogenase enzyme activity with the decrease in viability of the seed. The decline in the activity of this enzyme was checked by p-hydroxy benzoic acid, tannic acid and MSC-S-D treatments. The effect was striking in high vigour treated seed, midway in storage compared to the immediate effects of treatments in medium and low vigour seeds. Repair of biochemical lesions through activation of enzymes during hydration phase may be useful in extending the longevity of seed (Villiers, 1974).

Deterioration in soybean seeds was further related to the activity of lipid peroxidation (Fig. 1). Low vigour seed recorded higher lipid peroxidation compared to medium and high vigour seed at all observations. It was evident that seed treatments

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especially p-hydroxy benzoic acid, tannic acid and MSC-S-D decreased the activity of lipid peroxidation. Basu *et al.* (1985) explained that the scavenging agents like water and other antioxidants could lower the lipid peroxidation reactions by quenching the naturally produced free redicals in embryo as well as in the whole seed and extend the shelf life of seed. Hence, soybean seeds can be stored safely for seven months from the time of harvest by presowing seed treatment with p-hydroxy benzoic acid ($1x10^{-5}$M) and tannic acid ($2x10^{-5}$M).

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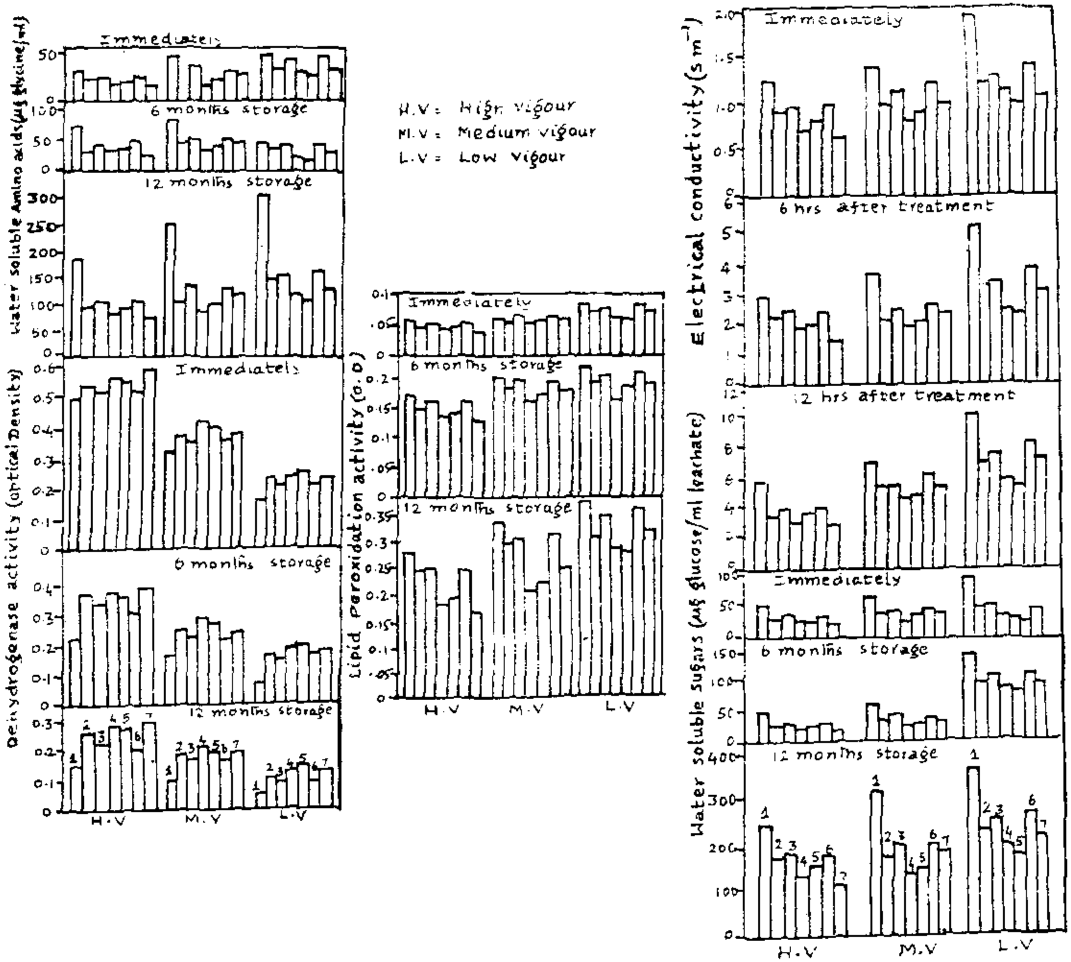

Fig. 1. Effect of hydration-Dehydration on Biochemical changes in different vigour seeds of soybean during storage

1-Control; 2- Water; 3-Nacl; 4- p-hydroxy benzoic acid; 5-Tannic acid; 6-Moist sand conditioning-drying; 7-Moist sand conditioning-soaking-drying

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PLANT DENSITY REQUIREMENT OF LATE SOWN MUSTARD (*Brassica juncea*, L.) IN *Tarai* REGION OF UTTAR PRADESH

Productivity of mustard (*Brassica juncea*. L). is largely dependent upon the prevailing weather conditions throughout its life cycle. Planting time is the foremost non-monetary input. Late planting generally tends to give lower seed as well as oil yield. In addition, sub-optimal plant density often leads to poor productivity of mustard. Patel *et al* (1980) concluded that delay in sowing beyond 15 October reduced the seed yield of mustard. The present experiment, thus, was initiated to study the feasibility of late sowing and plant density requirement for obtaining maximum mustard seed yield.

The experiment was conducted at the crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar during *rabi* seasons of 1991-92 and 1992-93 on a silty clay loam soil hiving pH 6.85. The soil was rich in organic matter (1.43%). medium in available phosphorus (10.5 kg P/ha) and high in available potash (178.6 kg K/ha). During 1991-92, the rainfall was well distributed but in 1992-93, December and January were drier months. The temperature was favourable for crop growth in both the seasons. The experiment was laid out in a spilt-plot design having four sowing dates (25 October, 9 November, 24 November and 9 December) as main- plot treatments and three plant density levels (3.33, 2.22 and 1.66 lakh plants/ha) as sub-plot treatments replicated thrice. Vardan variety of mustard was grown during both the years. Plant density was maintained by keeping row spacings of 20, 30 and 40 cm with uniform plant spacings of 15 cm and thinning was done at 15 days after sowing. A uniform basal applications of 60 kg N alongwith 40 kg P_2O_5/ha was made as basal and another 60 kg N/ha was topdressed after first irrigation. The post planting operations including plant protection measures were carried out as per recommendations. The crop was irrigated twice, first at rosette stage and second at siliquae development stage. The seed yield and yield attributes were recorded on randomly selected five plants. The oil content was determined using Soxhlet's extraction method.

Effect of sowing dates

The yield attributes of mustard were affected significantly due to sowing dates during both the years except 1000-seed weight which was not significant during 1992-93 (Table 1). A decreasing trend in mustard seed yield was recorded with successive delay in sowing after 25 October which gave the highest average seed yield during both the years, on account of higher number of branches, siliquae per plant, 1000 seed weight and seed weight per plant (Table 1). The lowest seed yield was recorded during both the years when mustard was planted on 9 December and the yields reduced by 75. 7% in 1991-92 and by 79% in the 1992-93 compared with 25 October planting. The reduction in number of branches, siliquae and seed weight per plant was 47, 43 and 51 per cent, respectively in 9 December planted crop which collectively were responsible for lower seed yield. Singh and Singh (1984) also reported similar results. The per cent seed oil content and total production were affected significantly by sowing dates during 1992-92 but oil per cent was not significant during 1992-93 (Table 1). Higher oil content and oil yield were recorded when the crop was planted on 25 October and declined in subsequent dates during both the years. Highest oil yield was recorded

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in 25 October planting which was drastically reduced (72.8% when averaged) in 9 December sowing during both the years. Ghosh and Chatterjee (1988) found that delay in sowing of mustard from third week of October to first week of November reduced the oil content by 2-9 per cent

Effect of plant density

The seed yield and yield attributes of mustard were affected by different plant density levels during both the years (Table 1). Significantly highest seed yield was recorded at 3.33 lakhs/ha plant density level but was at par with 2.22 lakhs/ha plant density during 1991-92. However, plant density levels did not influence the yield significantly during 1992-93 but lowest seed yield was recorded at 1.66 lakhs/ha plant density level during both the years. Although, the yield attributes had higher value on per plant basis at lower density but an average reduction on per sq. metre basis in number of branches was 33.6% and siliquae 42.8% at 1.66 lakhs/ha compared with 3.33 lakhs/ha due to lower number of plants per unit area. The seed weight per m^2 also increased and resulted in higher seed yield per hectare at higher plant density under late sown conditions, Singh and Singh (1984) reported that the lower plant density of 1.66 lakhs/ha recorded higher values of yield attributes and but 3.33lakhs/ha density increased the seed and stover yield/ha of mustard. Plant density also affected the seed oil content and oil yield during both the years (Table 1). Higher plant density gave the higher oil content in seeds and the total oil production and vice versa.. The highest oil per cent was recorded at 1.66 lakhs/ha level and declined significantly at higher density level only in 1991-92. Kumar (1992) also reported similar findings. The plant density of 3.33 lakhs/ha gave the highest oil yield (374 kg in 1991-92 and 315 kg/ha in 1992-93). However, the oil yield was not significantly affected due to plant density levels in 1992-93. The average reduction in oil yield at 1.66 lakhs was 16% compared to 3.33 lakhs/ha plant density.

The experimental data revealed that 25 October is the optimum planting date for mustard. Under late sown condition plant density could be increased to 3.33 lakhs/ha for obtaining higher seed yield of mustard in *tarai* region of U. P.

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Table 1. ***Effect of sowing dates and plant density on yield attributes, seed yield, oil content and oil yield of mustard***

	No. of branches/ plant		No. of siliquae/ plant		1000-seed weight (g)		Seed weight/ plant (g)		Seed yield (kg/ha)		Oil content (%)		Oil yield (kg/ha)	
	a	b	a	b	a	b	a	b	a	b	a	b	a	b
Sowing dates														
25 October	18.6	21.5	127.4	179.5	5.0	4.8	5.7	5.2	1302	1377	40.7	41.6	527	432
9 November	15.5	15.3	118.9	175.6	4.6	4.5	5.4	4.9	979	996	40.6	41.6	407	428
24 November	11.0	12.1	115.3	174.7	4.3	4.1	4.8	4.3	706	469	40.5	41.5	288	182
9 December	10.4	10.6	87.3	82.3	3.7	3.5	2.9	2.4	316	288	39.8	41.4	129	129
CD (0.05)	5.6	6.6	42.2	32.7	1.1	NS	0.6	0.8	154	305	0.8	0.8	64	126
Plant density (lakh plants/ha)														
3.33	12.0	12.4	107.3	145.7	3.8	3.7	4.3	3.8	898	805	41.7	41.8	374	315
2.22	14.1	15.2	130.1	154.5	4.4	4.3	4.7	4.2	829	815	40.8	40.6	338	288
1.66	15.5	17.0	129.2	158.8	4.9	4.8	5.1	4.6	751	724	39.9	41.1	301	275
CD (0..05)	2.2	3.5	14.8	NS	1.3	NS	0.5	0.7	69	NS	0.8	NS	27	54

a = 1991-92 and b = 1992-93.

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CORRELATION BETWEEN GROWTH, QUALITY CHARACTERS AND SEED YIELD OF MUSTARD

Yield is a polygenically controlled complex character and is determined by a number of character components which are also quantitatively inherited. Correlations between different agronomic traits, yield components, and yield gives an idea of growth and yield attributes, promotion of which helps in realisation of higher productivity. Although, mustard has been the subject of such a study, no particular investigation has been made in the context of Central Narmada Valley which prompted the present investigation.

A field experiment was conducted during *rabi* seasons of 1988-89 and 1989-90 at JNKVV, Zonal Agricultural Research Station, Powarkheda, Hoshangabad (MP) on clayey loam soils having pH 7.2. The status of available N, P, S and K content was 183.7, 13.6 and 8.03 and 301.4 kg/ha, in 1988-89 and 202.6, 13.6, 7.95 and 333.8 kg/ha in 1989-90. The experiment was laidout in factorial randomised block design with three replications. The treatments consisted of the combination of 4 nitrogen levels (0, 30, 60 and 90 kg/ha) and 6 sulphur levels (0, 10, 10, 30, 40 and 50 kg/ha). Mustard variety Varuna was sown in rows 30 cm apart using 5 kg seed/ha on 28 October, 1988 and November 3, 1989 and harvested 118 days after sowing. A basal dose of 60 kg P_2O_5/ha through triple superphosphate, 40 kg K_2O/ha through muriate of potash, full dose of sulphur through gypsum and half dose of N was top-dressed at 35 days after sowing (DAS) just after first irrigation. The crop received two irrigations at 35 and 60 DAS.

With every increase in the dose of N, there was a significant enhancement in the yield of mustard. The crop responded upto 30 kg S/ha beyond which the increase in seed yield was not discernible (Table 1). Correlation analysis of various morphophysiological components with seed yield of mustard revealed that all these characters among themselves as well as with seed yield exhibited highly significant positive correlation. Amongst eight growth and yield characteristics and seed yield, the number of siliquae/plant exhibited the highest r value of 0.9923 (Table 2).

The standard partial regression coefficients revealed the relative performance of the independent variables. Number of secondary branches/plant (x4) was the most important character followed by number of siliquae/plant (x5). The increased number of branches could have resulted in bearing of greater number of reproductive organs (Table 3).

A positive correlation was observed within the different chemical constituents of mustard seed and seed yield, bearing the oil content, which was negatively correlated (Table-4). Protein content, was significantly correlated with the seed yield (mean value of r=0.981). The mean correlation value of nitrogen and sulphur content was r = 0.981 and 0.997 respectively. Subsequently, the oil and

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protein yield were also influenced by the aforesaid chemical composition and performed well with the seed yield with regard to correlation studies. Pathak and Tripathi (1979) also observed significant positive correlation between seed yield and oil yield, protein content and protein yield, but there was a *negative correlation* between oil content and protein content. Swami and Bajaj (1988) also made similar observations.

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Table 1. *Effect of nitrogen and sulphur on seed yield of mustard*

Treatment	Seed yield (Kg/ha)		
	1988-89	1989-90	Mean
Nitrogen (Kg/ha)			
0	468	622	545
30	820	920	870
60	1238	1280	1259
90	1512	1524	1518
S.Em. ±	50	16	–
C D (0.05)	143	46	–
Sulphur (Kg/ha)			
0	838	814	826
10	906	986	946
20	998	1067	1032
30	1093	1173	1133
40	1112	1208	1160
50	1111	1202	1156
S.Em. ±	61	19	–
C D (0.05)	172	56	–

Table 2. Correlation co-efficient between growth and yield attributes with seed yield of Indian mustard (Mean of 1988-89 and 1989-90)

S.No.	Characters	No. of leaves/ plant at 75 DAS	LAI at 75 DAS	No. of sec. branches/ plant at harvest	No. of siliquae/ plant	No. of seeds/ siliquae	Length of siliquae (cm)	1000 seed weight (g)	Seed yield/ plant (g)
1.	Plant height at harvest (cm)	9048	0.9232	0.9350	0.8650	0.8645	0.7383	0.9066	0.9191
2.	No. of leaves/ plant at 75 DAS		0.8886	0.9314	0.8852	0.8628	0.8100	0.9072	0.9217
3.	LAI at 75 DAS			0.9445	0.8978	0.9310	0.7819	0.9097	0.0175
4.	No. of sec. branches/plant at harvest				0.9177	0.9339	0.8192	0.9638	0.9795
5.	No. of siliquae/plant					0.9255	0.8570	0.9521	0.9902
6.	No. of seeds/siliquae						0.7132	0.8768	0.8234
7.	Length of siliquae							0.6842	0.7013
8.	1000-seed weight								0.8389

All values are significant at P = 0.01

Table 3. Partial regression analysis (Mean of 2 years)

Characters			Standard partial regression	Partial regression
X_1	-	Plant height at harvest	0.4366	0.1437
X_2	-	No. of leaves/plant at 75 DAS	0.2807	0.1714
X_3	-	Leaf area index (LAI)	0.2741	0.1372
X_4	-	No. of secondary branches/plant at harvest	0.5393	0.1948
X_5	-	No. of siliquae/plant	0.5170	0.4167
X_6	-	No. of seeds/siliquae	--	--
X_7	-	Length of siliquae	0.0798	(-) 0.5648
X_8	-	1000 - seed weight	0.1682	(-) 0.2582

Table 4. Correlation co-efficient between qualitative characters and seed yield of mustard (Mean of 2 years)

Characters	Protein content (%)	N-content in seed (%)	S-content in seed (%)	Oil yield (kg/ha)	Protein yield (kg/ha)	Seed yield (kg/ha)
Oil content (%)	<u>(-) 0.123</u>	<u>(-) 0.252</u>	<u>(-) 0.091</u>	<u>(-) 0.227</u>	<u>(-) 0.122</u>	<u>(-) 0.242</u>
Protein content (%)	--	(+) 0.999	(+) 0.985	(+) 0.983	(+) 0.983	(+) 0.981
N-Content in seed (%)	--	--	(+) 0.985	(+) 0.983	(+) 0.983	(+) 0.981
S-Content in seed (%)	--	--	--	(+) 0.996	(+) 0.996	(+) 0.997
Oil yield (kg/ha)	--	--	--	--	<u>(-) 1.00</u>	<u>(-) 0.996</u>
Protein yield	--	--	--	--	--	<u>(-) 0.996</u>

The underlined values are non-significant

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INFLUENCE OF SEED RATE COMPENSATION OF DIFFERENT SEED VIGOUR LEVELS ON GROWTH AND YIELD OF SUNFLOWER HYBRIDS.

Seed vigour is one of the major seed quality characters. It can be manifested in differences in speed of germination, uniformity of emergence and growth, plant growth rate and yield. (Rajendra prasad *et al.* 1990 and Aswathaiah *et.al.* 1987). However, such studies are limited in sunflower.

Four flower hybrids viz., BSH-1, KBSH-1, IAHS-1, MSFH-17 were selected to study the effect of different vigour levels and seed compensation on growth and yield. Four vigour levels viz., high (V_O), medium (V_1), low (V_2), and very low (V_3) vigour were established by accelerated ageing treatment for 0, 2, 4, 6 at 41± 1°C temperature and 100% RH to provide materials for the study. Based on the germination percentage of accelerated aged seeds, the seed rate was compensated to a common desired (70.70%) germination percentage for all the vigour levels by using the following formula.

$$\text{compensated seed rate} = \frac{RG}{AG} \times RS$$

Where, RG = Required germination percentage
AG = Actual germination percentage of different vigour seeds
RS = Required seed rate per plot.

The field experiment was laid out in a factorial randomised complete block design with three replications having 3x3m plot size during *kharif* season, 1992 at the Seed Technology Research Unit , National Seed Project, University of Agricultural Sciences, Bangalore.

Hybrids, vigour levels and seed rates differed significantly for all the parameters studied in the experiment (Table 1). MSFH-17 hybrid recorded maximum plant stand, plant height and dry matter production, days to flowering, head diameter, stem girth, percent seed set and seed yield; while BSH-1 recorded least in all these attributes.

The effect of vigour levels on growth and yield attributes revealed that all the parameters excepting the days to flowering measured were found highest in high vigour seeds(V_O). The least in all these attributes were observed in low vigour seeds (V_3). Days to flowering increased with a decrease in vigour levels. Decreased seed vigour decreased the plant stand. This may be attributed to poor germination and seedling vigour (Chen *et al.* 1972; Carmago and Vaughan, 1973); which results in decreased crop growth rates, yield attributes and seed yields (Jones and Gamble, 1984; Teckrony *et al.* 1989 and Ravinder, 1990).

Compensated seed rate (C_2) yielded 180g more seed yield (g per nine m^2), just due to its higher plant stand; because all other attributes showed no or marginal differences between actual and compensated seed rates (Table 1).

Simple correlation studies between growth and yield attributes showed that the seed yield was mainly dependent on plant stand (Table 2). Plant stand and seed yield showed a positive significant relationship with yield attributes such as head diameter, number of filled seeds and test weight.

It can be concluded that, the seed yield decreased with a decrease in seed vigour for any given sunflower hybrid. Compensated seed rate resulted in better plant stand and thus higher seed yields.

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Table 1. Effect of seed vigour level and seed rate compensation on growth, yield and yield attributes in sunflower hybrids.

Treatment	Plant stand		Plant ht. (cm)		DM Production (g/plant)		Days to 50% flowering	Head Dia (cm)	Stem growth (cm)	Seed set (%)	Test wt. (g/100 seeds)	Seed Yield ($kg/9m^2$)
	D_1*	D_2*	D_1	D_2	D_1	D_2						
Hybrids:												
IAHS-1	37.1	35.2	23.9	151	14.1	74.2	60.1	22.6	2.61	73.9	5.15	1.53
KBSH-1	36.1	35.3	29.9	160	14.9	87.4	51.2	26.2	3.12	75.6	5.30	1.73
BSH-1	35.1	34.4	23.0	140	14.6	81.8	50.2	21.8	2.63	64.1	5.32	1.58
MSFH-17	38.2	35.4	32.3	174	20.9	103.0	60.7	30.5	3.87	78.0	5.21	2.03
S.E.m ±	0.3	0.3	0.2	0.3	0.2	1.4	0.3	0.2	0.04	0.9	0.03	0.01
C.D. at 5%	0.8	0.8	0.6	0.9	0.5	3.8	0.8	0.7	0.11	2.5	0.08	0.05
Vigour Levels:												
Control V_0	41.9	41.9	29.9	161	20.6	97.5	54.1	28.7	3.37	76.9	5.37	2.11
High V_1	38.4	37.4	28.4	158	15.7	90.7	54.7	26.0	3.21	74.1	5.28	1.84
Medium V_2	34.7	33.4	26.3	155	12.1	82.8	56.5	23.8	2.94	72.6	5.17	1.61
Low V_3	29.7	28.3	23.6	150	9.1	75.3	61.5	22.0	2.71	68.3	5.16	1.32
S.Em.±	0.3	0.3	0.2	0.3	0.2	1.4	0.3	0.2	0.04	0.9	0.03	0.01
C.D. at 5%	0.8	0.8	0.6	0.9	0.5	3.8	0.8	0.7	0.11	2.4	0.08	0.05
Seed Rate:												
Actual C_1	33.6	32.7	27.4	157	14.8	88.9	56.8	25.9	3.17	73.4	5.27	1.63
Compensated C_2	38.8	37.8	26.7	155	13.9	84.2	56.6	24.7	2.95	72.4	5.22	1.81
S.Em. ±	0.2	0.2	0.1	0.2	0.1	0.9	0.2	0.2	0.02	0.6	0.02	0.01
C.D. at 5%	0.6	0.5	0.4	0.6	0.3	2.7	NS	0.5	0.07	NS	NS	0.03

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Table 2. Correlation Co-efficients of sunflower hybrids with other ancillary characters

	X_1	X_2	X_3	X_4	X_5	X_6	X_7
X_1	-	0.88	-0.34	0.87**	0.28	0.96**	0.62**
X_2		-	-0.45	*0.57***	*0.52***	*0.86***	*0.56***
X_3			-	0.01	0.06	-0.22	-0.67**
X_4				-	0.17	0.83**	0.42*
X_5					-	0.35	-0.03
X_6						-	0.48*
X_7							-

Note: * Significant at 5% level of probability

r (0.05, 22 df) = 0.404

** Significant at 1% level of probability

r (0.01, 22df) = 0.515

X_1 = Yield per ha.

X_2 = Plant population

X_3 = Days to 50% flowering

X_4 = Head diameter

X_5 = Stem girth

X_6 = No. of filled seeds

X_7 = Test weight

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EFFECT OF SEED VIGOUR LEVELS ON SEED QUALITY PARAMETERS IN SOME SUNFLOWER HYBRIDS

Quality seed is the basic and crucial input in agricultural production. Seed quality can be considered as the summation of all attributes which contribute to seed performance, among which seed vigour is the main attribute. The differences in seed vigour can be manifested in differences in speed of germination, uniformity of emergence, plant growth rate and yield (Rajendra Prasad *et al.* 1990 in corn and Aswathaiah *et al.* 1987 in Sorghum). However such studies are limited especially in sunflower hybrids and hence the study on the effect of seed vigour levels on germination and other quality parameters.

Vigour levels were established by accelerated ageing treatment for 0, 2, 4 and 6 days at 42 ± 1°C temperature and 100% relative humidity to provide materials for the study in laboratory. These four vigour levels using four hybrids were studied by various laboratory tests, such as, standard germination, root and shoot length, vigour index, seedling dry weight, speed of germination, seedling growth rate, electrical conductivity and field emergence test in a RBD design with 4 replications.

Among hybrids, MSFH-17 recorded highest germination percentage, shoot length, root length, seedling dry weight and vigour index, while BSH-1 recorded least in these parameters. Further, electrical conductivity was highest in IAHS-1 and lowest in KBSH-1. But speed of germination was highest in KBSH-1 and lowest in BSH-1 (Table 1).

High vigour level (V_O) seeds recorded highest germination percentage, shoot length, seedling dry weight, vigour index, seedling growth rate, speed of germination and field emergence. All these attributes recorded least in low vigour seeds. However, electrical conductivity was lowest in high vigour seeds and highest in low vigour seeds.

Interaction effect was significant for electrocal conductivity only. Very low vigour seeds of KBSH-1 recorded highest (1405 μ mhos/cm) whereas high vigour seeds of BSH-1, KBSH-1, MSFH-17 and IAHS-1 (571, 603, 628 and 637 μ mhos/cm) recorded lowest electrical conductivity.

Correlation studies between various quality characters showed that all the characters are positively significantly related to each other excepting the EC with other parameters (Table 2). This is in confirmity with the findings of Ram *et al.* (1988) in cotton.

Study revealed that sunflower hybrid MSFH-17 was superior in the quality performance compared to IAHS-1, BSH-1 and KBSH-1. Further, severe deterioration resulted in loss of the capacity to germinate as reflected in the reduced performance of the seeds in low vigour seeds. Correlation study revealed that SGR, speed of germination, EC of seed leachate, AA response may be used as vigour tools to evaluate seed lots.

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Table 1. Laboratory performance of different vigour level seeds of four sunflower hybrids

	Lab. Germ. % (AA response)	Shoot length (cm)	Root length (cm)	Seedling dry wt. (mg)	Vigour index (G&SL)	Electrical conductivity (μmhos/cm)	Seedling growth rate	Speed of germination	Field emergence
Hybrids									
IAHS-1	79.41	11.42	12.85	22.45	1973	992.4	72.90	25.32	67.41
KBSH-1	77.75	11.82	12.82	22.15	1999	836.1	69.00	25.67	66.83
BSH-1	77.66	10.32	12.36	21.22	1877	935.2	64.10	24.04	65.58
MSFH-17	81.25	12.29	13.65	22.92	2186	874.2	63.90	25.31	67.25
S.Em. ±	0.611	0.23	0.25	0.29	28.25	21.21	2.92	0.28	0.82
C D at 5%	1.690	0.63	0.69	0.79	78.31	58.79	NS	0.79	NS
Vigour levels									
High (V0)	92.83	12.55	13.05	23.57	2342	610.00	78.10	28.26	80.33
Medium (V1)	86.83	11.80	12.86	22.91	2212	850.90	70.30	26.64	71.25
Low (V2)	74.50	11.69	12.65	21.90	1882	1016.30	64.90	24.19	63.00
Very low (V3)	61.90	10.44	12.26	20.57	1592	1154.60	56.60	21.27	51.91
S.Em. ±	0.61	0.23	0.25	0.28	28.25	21.21	2.92	0.28	0.82
C D at 5%	1.69	0.63	NS	0.79	78.31	58.79	8.09	0.79	1.72

Table 2. Simple correlation coefficients in all possible combinations among various laboratory tests of different sunflower hybrids

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
X_1	-	0.965**	0.628**	0.590**	0.618**	-0.929**	0.852**	0.953**
X_2		-	0.670**	0.659**	0.651**	-0.904**	0.807**	0.960**
X_3			-	0.856**	0.442*	-0.623**	0.501*	0.752**
X_4				-	0.580**	-0.577**	0.452*	0.640**
X_5					-	-0.486*	0.459*	0.564**
X_6						-	-0.772**	-0.881**
X_7							-	0.859**
X_8								0.883**

Note: * Significant at 5% level of probability r (0.05, 22 df) = 0.404.

** Significant at 1% level of probability r (0.01, 22 df) = 0.515.

X_1 = Field emergence
X_2 = Standard germination
X_3 = Shoot length
X_4 = Root length
X_5 = Vigour index
X_6 = Electrical conductivity
X_7 = Seedling growth rate
X_8 = Speed of germination

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NITROGEN UPTAKE BY CROP AND WEEDS AS INFLUENCED BY INTEGRATED WEED CONTROL IN SUNFLOWER CULTIVARS

Weeds are potential competitors with crops for nutrients. moisture, light and space. Weeds remove large quantity of nutrients from the soil. nitrogen being, the most important. Jayakumar *et al.*, (1988) reported lowest nitrogen content in the plants which were raised in weedy plots. While fluchloralin treatments recorded more nitrogen. Malipatil (1989) reported that, uptake of nitrogen by weeds was maximum in unweeded control (79.1 kg/ha) as against 18.23 kg/ha in alachlor (1.0 kg a.i/ha) treated plots.

An experiment was conducted on sandy loam soil at the Agronomy field unit, Main Research Station, University of Agricultural Sciences, Bangalore during summer 1992. The organic carbon and available nitrogen content of the soil was low (0.35 per cent and 243.5 kg/ha) and high in phosphorus (31.6 kg/ha) and potassium (149.45 kg/ha). The experiment was laid out in split plot design with three replications. There were 24 treatment combinations comprising of two cultivars (main Plots) and 12 weed control treatments (sub plots). Hoeing was done manually by using junior hoe in view of small plots (Table 1). Net plot size was 2.40m x 2.20m. Fertilizers were applied at the rate of 62.5:50: 62.5 kg N, P_2O_5 and K_2O per hectare, 75% of nitrogen was applied as basal dose and remaining 25% was given as top dressing to 40 days old crop. Both the hybrid and the variety were sown by dibbling in 60 cm rows 20 cm apart as per the recommended spacing. The variety Morden was harvested after 87 days while, the hybrid KBSH-1 matured in 90 days. Sunflower (stalk and seeds) samples were finely ground and powdered samples were used for nitrogen estimation by micro-kjeldhal method. Total uptake of nitrogen by crop and weeds were calculated.

Among the weeds in the experimental site during summer,the monocots were more predominant followed by dicot weeds. Among the monocots the most predominant weeds were *Cynodon dactylon,Digitaria marginata, Dactyloctenium aegyptium, Chloris barbata* and among dicots *Acanthospermum hispidum. Euphorbia hirta, Mollugo ceriana, Amaranthus retrofluxes* and *Portulaca oleracea* were predominant and *Cyperus rotundus* was the predominant sedge.

KBSH-1 hybrid removed significantly larger quantity of nitrogen (64.66 kg/ha) than Morden variety (52.93 kg/ha). Seed yield did not differ significantly between KBSH-1 (1152 kg/ha) and Morden (1101 kg/ha), but stalk yield was higher in KBSH-1 (2022 kg/ha) than Morden variety (1254 kg/ha). This was due to increased dry matter production in KBSH-1 hybrid as compared to Morden variety. Among weed control treatments, alachlor at 0.50kg a.i/ha plus one hoeing removed large quantity of nitrogen from the soil (Table 1). This may be attributed to the better control of weeds by alachlor chemical at 0.50 kg/ha followed by one hoeing, which facilitated the crop to grow well and absorb more nitrogen from the soil. Similar findings were reported by Malipatil (1989).

Maximum amount of nitrogen was taken up by weeds in Morden variety (13.84 kg/ha) as compared to KBSH-1 hybrid (8.98 kg/ha). This was mainly due to more dry matter production by weeds in Morden variety, which experienced

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severe competition by weeds for nitrogen. Among weed control treatments, unweeded control recorded maximum uptake of nitrogen (44.73 kg/ha) by weeds, and lowest uptake was recorded in hand weeded twice (2.49kg/ha) treatment. Among herbicidal treatments, alachlor 0.50 kg a.i./ha plus one hoeing recorded lowest nitrogen uptake by weeds (Table 1). Further, correlation studies revealed that grain yield had positive significant correlation with nitrogen uptake by crop (r = + 0.81), while had significant negative correction with weed dry weight (r = -0.37) and nitrogen uptake by weeds (r = -0.39).

Total crop nitrogen uptake was inversely proportional to nitrogen uptake by weeds (r = -0.62*). Thus, application of alachlor or pendimethalin at 0.50 kg a.i./ha plus one hoeing to KBSH-1 hybrid reduces the nitrogen uptake by weeds and improve crop nitrogen uptake.

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Table 1. Total N uptake up by crop and weeds in sunflower cultivars as influenced by different weed control treatments.

Treatments	Kg a.i./ha	Crop nitrogen uptake (kg/ha)			Weed nitrogen uptake (kg/ha)		
		Morden	KBSH-1	Mean	Morden	KBSH-1	Mean
Fluchloralin	1.0 kg/ha	44.49	62.10	53.30	2.57 (6.13)*	3.28 (10.32)	2.93 (8.22)
Fluchloralin	0.50 kg/ha + one hoeing 3 WAS	55.30	73.37	64.32	3.70 (13.18)	2.67 (6.63)	3.18 (9.90)
Butachlor	1.0 kg/ha	52.06	58.06	55.45	3.73 (13.47)	2.94 (8.23)	3.32 (10.85)
Butachlor	0.50 kg/ha + one hoeing 3 WAS	52.06	72.87	62.47	2.92 (8.13)	2.25 (4.56)	2.58 (6.36)
Alachlor	1.0 kg/ha	65.46	65.38	65.42	2.86 (7.75)	2.02 (3.67)	2.44 (5.70)
Alachlor	0.50 kg/ha + one hoeing 3 WAS	70.99	80.94	75.97	2.18 (4.30)	2.01 (3.55)	2.09 (3.93)
Pendimethalin	1.0 kg/ha	50.94	64.72	57.83	3.33 (10.67)	2.98 (8.60)	3.15 (9.63)
Pendimethalin	0.50 kg/ha + one hoeing 3 WAS	60.82	75.83	68.33	3.03 (8.74)	2.32 (4.92)	2.68 (6.83)
One hoeing	3 WAS	42.18	53.85	48.01	5.73 (32.47)	4.05 (15.95)	4.89 (24.21)
One hoeing	3 WAS + One HW 5 WAS	49.67	56.51	53.09	2.38 (5.26)	1.83 (2.88)	2.10 (4.07)
Two HW	3 & 5 WAS	60.89	72.02	66.45	1.69 (2.47)	1.72 (2.51)	1.71 (2.49)
Unweeded control		30.35	39.43	34.89	7.31 (53.49)	6.02 (35.97)	6.66 (44.73)
Mean		52.93	64.66	–	3.45 (13.84)	2.84 (8.98)	–
		F-test	S.Em. ±	CD at 5%	F-test	S.Em ±	CD at 5%
For cultivars		*	0.54	3.27	*	0.10	0.61
For weed control treatments		*	2.73	7.79	*	0.14	0.39
For WC treatments at same cultivar		NS	3.87	–	*	0.19	0.55
For cultivrs at same or different weed control treatments		NS	3.74	–	*	0.21	0.75

* Values in the parentheses indicates original values.

WAS = Weeks after sowing.

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GROWTH, NODULATION AND YIELD RESPONSE OF GROUNDNUT TO MOISTURE STRESS UNDER VARYING SOIL DEPTHS

Repeated droughts during the rainy season often limit the growth and yield of groundnut crop. The soil depth with its associated properties like water holding capacity and nutrient supply, has a marked influence on the productivity of the crop. The effect of water stress experienced at different physiological stages of the crop grown in three soil depths was examined.

An experiment was conducted in green house during *kharif* 1991 at Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad. Groundnut plants (var. Girnar-1) were grown in glazed pots of 30 kg capacity (@ 2 plants/pot) under natural illumination and temperature conditions. Pots were filled with loamy sand soil from Hayatnagar Research Farm (pH 6.6, O.C. 0.5 %, available N 165kg/ha and available P 10 kg/ha). Three different soil depths (Dl, D2 and D3) were artificially created in the pots by first filling the *murram* from the bottom of the pot upto 20, 15 and 10 cm and filling the remaining portion with normal loamy sand soil after passing through a 2 mm sieve. Thus, in all pots total profile was uniform, i.e. 30 cm but the soil depth remained as 10, 15 and 20 cm in D1, D2 and D3 treatments, respectively. All the pots received a uniform dose of NPK @ 20 : 30 : 50 kg/ha. The potted plants were maintained with normal tap water.

Moisture stress treatments were imposed at three different stages i.e. 25, 50 and 75 days after sowing (DAS) designated as early stress, mid stress and terminal stress, respectively. All the treatments were imposed in plants in each of the soil depth. For imposing moisture stress, watering was withheld for about 6-8 days so that drop in leaf water potential from control was comparable (1.5 Mpa). Control pots received normal watering. The observation on nodulation, drymatter, leaf area, partitioning, root growth and pod yields were recorded at harvest.

Plants grown in 20 cm effective soil depth produced significantly higher number and weight of nodules, total dry matter, leaf area, root dry weight than those in plants of 10 and 15 cm depth. Shallow depth caused a marked elongation of hypocotyl. Which increased from 3.12 cm in 20 cm to 5.61 in 10 cm depth, indicating that 10 cm effective depth is less than the optimum. The leaf area and total dry matter were also markedly lower in plants raised on shallow soil depth. Pod number and pod weight in groundnut significantly increased with increased soil depth. The effect of soil depth was more significant on kernel and pod dry weight.

Generally the groundnut crop suffers more due to water stress during flowering phase than early vegetative or maturity period (Rao *et al.* 1985). In fact, stress at early stage often promotes better partitioning and yield of groundnut. In the present study, no significant interaction was found between soil depth and water stress experienced at different physiological stages. Early stress caused only marginal decline in leaf area, nodule weight, total dry matter, but it increased the pod

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dry weight and kernel weight. This was mainly due to better partitioning of dry matter into reproductive parts (Venkateswarlu *et al.* 1991). A combination of early, mid and terminal stress led to marked decrease in pod and kernel weight and total dry matter.

The results revealed that effective soil depth played a significant role in growth and dry matter yield of groundnut and moisture stress at 75 DAS was found to be more detrimental than early (25 DAS) and mid (50 DAS) stresses.

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Table 1. Effect of soil depth (cm) and moisture stress on growth and productivity of groundnut

Treatments	No. of nodule per plant	Nodule dry weight (g/pl)	TDM (g/pl)	Leaf area (cm^2/pl)	Root dry wt. (g/pl)	Root volume (cc/pl)	Tap root (g/pl)	Hypocotyl length (cm/pl)	Pod dry wt. (g/pl)	No. of pods/ plant	Kernel weight (g/pl)	No. of shrivelled kernels/pl	Oil content (%)
A. Soil depth (cm)													
10	109	52.0	14.78	1168	0.42	1.23	20.30	5.61	3.34	6.06	1.75	1.89	47.66
15	128	56.0	18.67	1228	0.49	1.84	21.10	4.40	4.37	7.04	2.40	1.21	48.75
20	156	67.8	20.50	1323	0.51	1.84	24.15	3.12	5.68	8.13	3.00	1.40	48.80
CD (0.05)	6.3	3.1	1.16	30	0.05	0.15	2.15	0.51	0.38	0.61	0.27	0.37	0.58
B. Stres treatment													
Stress free (SF)	162.3	66.13	21.02	1369	0.50	1.69	20.70	3.57	5.12	6.91	2.56	0.96	48.09
Early stress (ES)	121.0	45.17	19.87	1029	0.56	2.11	25.08	8.39	6.81	7.30	2.70	0.87	48.58
Mid stress (MS)	123.0	50.83	20.71	1319	0.50	1.64	19.19	3.52	6.75	5.90	2.40	0.81	47.52
Terminal stress (TS)	132.7	51.12	16.55	1066	0.52	1.71	19.60	4.54	4.60	8.60	2.06	1.70	48.23
ES+MS+TS	153.3	63.57	13.03	939	0.38	1.60	22.31	4.07	3.04	5.91	1.82	2.16	49.70
CD (0.05)	8.1	5.9	0.71	23	0.04	0.09	1.06	0.51	0.23	0.39	0.17	0.24	1.00

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OCCURRENCE OF BROOMRAPE ON *Taramira* (*Eruca sativa*) IN SOUTH WESTERN REGION OF PUNJAB

Rapeseed and mustard holds an important place in the cropping pattern of Punjab, particularly in semi-arid south-western regions. In recent years, the crop was found severely infected with a phanerogamic parasite known as broomrape (*Orobanche* spp.) which is a root parasite capable of causing serious losses in several broad-leaved crops. Broomrape is an achlorophyllous holoparasitic plant capable of infecting a diverse range of hosts such as flax, lentil, tomato, wheat, (Irmaileh, 1994). clover (Suzuki *et al.* 1994). sunflower and cabbage (labrada and perez, 1988) etc. Four species of orobanche viz. *Orobanche crenate* Forsk (Crenate boomrape), *O. aegyptiaca* Pers. (Egyptian broomrape), *Oramosa* .L. (Branched broomrape) are potential agricultural weeds in Australia (Carter and Cooke, 1994). The incidence of broomrape is reported to be serious in semi-humid and semi-arid conditions of Africa and Asia (Sauberborn, 1993).

The present study reports the occurrence of *O.aegyptiaca* on raya and taramira crops in the experimental fields of the Punjab Agricultural University, Regional Research Station, Bathinda. During 1994-95, broomrape incidence was recorded on rapeseed and mustard crops, the damage being more severe in *taramira* crop. In *taramira* fields its incidence varied from 56.10 to 88.00 per cent (average 73.80%) at different sites. The affected plants lacked profuse tillering habit and foliage looked bronzed or blighted from a distance due to their withering. Early infection resulted in pre-mature death of the plants. The parasite impairs the physiological functioning of the host and requires only a living host for its survival and obtains reduced carbon form its photosynthetic host (Thalowarn *et al.* 1994). The infection of broomrape is also known to enhance the cellulolytic activity; of host cells in *Brassica campestris* var. *rapa* Singh and Singh, 1993).

The effect of broomrape infection on yield and agronomic components of the taramira crop was studied. At least 20 plants each from apparently healthy and diseased fields were selected at random and assessed for various yield parameters (Table 1). The broomrape infection caused a reduction of 40.86% in plant height, 30.63% in branches/plant, 72.99% in number of pods/plant, 16.41% per cent in pod length, 54.9% seeds pod,56.52% in 100-pod weight, 10.96% in root length, 25.93% in 1000-grain weight and 91.68% in grain yield/plant. There was, however, no perceptible reduction in the rooting intensity as measured in terms of root number and root length. The germination of *taramira* seeds from broomrape infected plants did not show a marked reduction over that of healthy ones.

Another interesting observation was that prior broomrape infection pre-disposed the host plants towards increased susceptibility to *Alternaria* blight. The intensity of blight on twigs of healthy and infected plants was 18.3 and 33.09 per cent, respectively, (Table 1), The *Alternaria* being a low sugar pathogen, prefers a depleted host for attack. This indicated that in broomrape infected fields more vigilance is required to be exercised to protect the crop from the *Alternaria* blight.

Various methods studied for the management of broomrape incidence include: mechanical, cultural, biological, genetic, and chemical means (Saghir, 1994). Scientists and farmers must be familiar with broomrape infection before it becomes widespread and acquired serious proportions.

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Different workers have attempted biological control as possible approach to manage broomrape. The antagonists reported to colonize broomrape are *F. oxysporum*(Mazaheri *et al.* 1991), and *F. nygami* Soberborn, 1993). The new technique for broomrape control has been the use of synthetic germination stimulants like several strigol analogues (Saghir, 1994). According to Irmaileh (1994). the nitrogen applied as ammonium nitrate at various concentrations either in distilled water or Hoagland solution markedly decreased germination and radicle length of broomrape in association with its host. Labrada and Perez(1988) recommended the cultivation of trap crops like *Phaseolus vulgaris* cv. ICA-Pijao, *Zea mays* cv. T-66, *Sorghum vulgare* and *Cucumis sativus cv.* Poinsett which stimulated the seed germination of broomrape (*O. ramosa*) entailing their failure to parasitize the host.

The preliminary observations indicated that keeping the fields fallow for a minimum of 2 years can bring about a substantial reduction in the incidence of broomrape in *taramira* fields.

The reported occurrence of *O.aegyptiaca* on taramira is the first report from India.

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Table 1. Effect of broomrape infection on various yield components in taramira

Character	Healthy plant	Diseased plant	Per cent increase (+)/ decrease (-)
Plant height (cm)	118.10	69.84	-40.86
No. of branches/plant	11.10	7.70	-30.63
No. of pods/branch	21.40	5.78	-72.99
Pod length (cm)	2.56	2.14	-16.41
No. of seeds/pod	17.16	7.74	-54.90
Root length (cm)	16.70	14.87	-10.96
No. of roots/plant	2.00	1.90	-5.00
Intensity of *Alternaria* blight on twigs	18.30	33.09	+80.82
100 - pod weight (g)	13.80	6.00	-56.52
1000-grain weight (g)	4.05	3.00	-25.93
Seed germination (%)	78.84	74.38	-4.46
Yield/plant (g)	9.13	0.76	-91.68

Data are based on an average of 20 plants.

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RESPONSE OF SESAME VARIETIES TO PLANT POPULATION AND NITROGEN LEVELS.

Sesame is traditionally a semi-*Rabi* crop of Central Narmada Valley (M. P.) under rainfed conditions. Although sesame is an important oilseed , it is substantially replaced by soybean. Longer duration and poor yield potential of the local/old sesame varieties as well as lack of proper management practices for this crop are major reasons for this crop diversification. Improved short duration and high yielding varieties of sesame are available which can be used as an alternate for soybean, particularly when the soybean crop cannot be sown in time or fails due to continuous heavy rains. Therefore, the present investigation was undertaken to findout a suitable variety and optimum plant population for deep black soils of Central Narmada Valley and the response to nitrogen levels.

The experiment was conducted at Zonal Agricultural Research Station. Powarkheda, Hoshangabad (M. P.) during semi-*Rabi* seasons of 1991-92 and 1992-93. The experimental soil was deep black, alkaline in reaction (pH-7.6) having 230, 40 and 430 kg/ ha available N, P_2O_5 and K_2O, respectively. The treatments comprised of six combinations of two sesame varieties (TC-25 and TKG-9) with three plant populations (3.0, 4.5 and 6.0 lakh plants/ha), in main plots and four levels of nitrogen (0, 30, 60 and 90 kg/ha) in subplots of 18.0 m^2; laidout in a split plot design with four replications. Sowing was done on 18th and 10th September in 1991 and 1992, respectively, in rows 30 cm apart. Thinning was done 15 days after sowing and plant to plant spacing of 11.0, 8.25 and 5.5 cm was maintained to get 3.0, 4.5 and 6.0 lakh plants/ha respectively. Nitrogen was applied as per treatments in two splits i.e. 50% as basal and 505 as top dressing at 30 days after sowing. Phosphorus and potash were given as basal @ 40 and 20 kg/ ha respectively. *Antigastra catalaunalis* Dup. was observed as the most dominant pest during both the years. It was controlled by two sprays of 0.15% nuvacron at 20 and 45 days after sowing. Crop matured on 25th and 4th December during 1991 and 1992, respectively.

The data presented in Table 1 showed significant differences in the yield of sesame varieties and the yield under nitrogen levels, while the effects of varying plant population were non significant during both the years. Variety TKG-9 with the pooled yield of 329.16 kg/ha proved to be superior over TC-25 (259.22 kg/ha). Variation in the plant population between 3.0 to 6.0 lakh/ha had no significant effect on sesame yield which could be due to plastic nature of this crop. However, the trend of increasing yield with higher population was found. Gnanamurthy *et al.*, (1992), and Ghosh and Patra (1994) reported best yields with the population of 3.33 lakh/ha. Therefore, the population of 3.0 to 4.5 lakh plants/ha may be considered optimum.

The seed yield of control (without nitrogen) was minimum (202.72 kg/ha) which was significantly lower than that under 30, 60 and 90 kg/ha i.e. 284. 95, 343.50 and 344.74 kg/ha, respectively. Difference in the seed yield with 30 and 60 kg N/ ha was also significant but that between 60 and 90 kg N/ha was non significant. However the response equation ($Y = 201.40 + 3.6401 X - 0.0225 X^2$) indicated 80 kg N/ha as optimum. Significant response to the nitrogen application upto 60 kg/ ha by Prakasha & Thimmegowda (1992); 90 kg/ ha by Shrivastava and Tripathi (1992) and Kumar and Prasad (1993) was found in terms of improved yield attributes and yield of sesame, Thus, the application of 60 kg N/ha may be considered optimum to obtain higher yield of sesame in deep black soils of Central Narmada Valley of Madhya Pradesh.

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Table 1. Seed yield of sesame under different treatments

Treatment	Seed yield kg/ha		
	1991-92	1992-93	Pooled
Varieties			
T.C. 25	297.20	221.23	259.22
TKG-9	394.60	263.72	329.16
S Em. ±	12.92	10.05	8.74
C D at 5%	38.90	30.91	26.33
Plant population lakh/ha			
3.0	331.10	230.27	281.60
4.5	340.90	240.53	290.72
6.0	363.70	255.18	309.44
S.Em. ±	14.11	12.55	10.71
C D at 5%	NS	NS	NS
Nitrogen levels kg/ha			
0	254.20	151.23	202.72
30	334.20	235.70	284.95
60	396.20	290.79	343.50
90	399.20	290.27	344.74
S.Em. ±	12.02	7.55	9.61
C D at 5%	34.10	21.41	27.17

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EFFECT OF IRRIGATION SCHEDULING AND METHODS OF NITROGEN APPLICATION ON MUSTARD

In Konkan region, mustard is a newly introduced short duration *Rabi* oilseed crop. Crop yield is directly influenced by water stress and fertilizers. On lateritic soils of Konkan, mustard cv. Varuna should be irrigated at 0.5 IW/CPE ratio involving 4 irrigations at 25 days interval, as reported by Murhekar, (1990). Besides, irrigation scheduling to mustard crop, it is also desirable to apply nitrogenous fertilizer by proper method. Therefore, investigations were carried out to study the effect of irrigation and methods of nitrogen application on yield and quality of mustard at Central Experiment Station; Konkan Krishi Vidyapeeth, Dapoli during 1991-92 on a clay loam soil with 5.9 pH; organic carbon 2.01%, available nitrogen 325.17 kg ha^{-1}, available phosphorus 9.17 kg ha^{-1} and available potash 243.8 kg ha^{-1}.

Five irrigation levels were taken as main plot treatments (60 mm CPE; 80 mm CPE; 100 mm CPE; 100 mm CPE with grass mulch @ 6.25 t ha^{-1} and irrigation at various physiological growth stages of the crop) and subplot treatments consisted of methods of nitrogen application (broad casting method 50% at the time of sowing +50% one month after sowing; full dose at the time of sowing by placement method; placement of 25% at sowing +75% one month after sowing and placement of 50% at the sowing +50% one month after sowing). The total dose of fertilizer applied was 90 kg N; 45 kg P_2O_5 and no K_2O. The variety Varuna was sown at a row spacing of 45 cm using 5 kg ha^{-1} seed rate. Plant to plant spacing of 15 cm was maintained. The treatment was replicated thrice in split plot design. The depth of irrigation water given was 60 mm. Quantity of water was measured by water meter.

From the data presented in Table 1, it is revealed that the highest seed yield was obtained from the treatment when irrigation was applied at various crop growth stages. There were no significant differences in treatments comprising irrigation at 60 mm CPE and irrigation applied at various physiological crop growth stages, in respect of seed, stover, oil and protein contents. Adequate availability of irrigation water to mustard crop is well known to improve yield. (Mandal *et al.*, 1987)

Similarly response to methods of nitrogen application was also observed. Highest yield (seed and stover) and protein content were obtained when nitrogen was applied by placement mehtod i.e. 25% of nitrogen applied at sowing +75% of nitrogen applied one month after sowing. These results are supported by Bhan (1976).

Maximum net profit of Rs. 4215/- and cost benefit ratio (1:1.67) was obtained when mustard was irrigated at various physiological crop growth stages. The 60 mm CPE treatment of irrigation was a second best with net profit of Rs. 3629.5 and cost benefit ratio of 1:1.58.

Higher net profit and cost benefit ratio was observed under placement treatments than broadcasting. Band placement of 25% of nitrogen at sowing and 75% nitrogen one month after sowing was found more profitable.

Thus it is concluded that irrigation scheduled at various physiological growth stages of crop i.e. at vegetative stage, branching stage, 50% flowering and grain filling stage and application

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of nitrogen by band placement of 25% at sowing and 75% one month after sowing was found superior in respect of yield (seed and stover) and oil as well as protein containt of mustard.

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Table 1. Effect of irrigation scheduling and methods of nitrogen application on seed, stover yield, oil, protein, net returns ha-1 and cost-benefit ratio of mustard.

Treatments	Seed yield kg ha^{-1}	Stover yield kg ha^{-1}	Oil content (%)	Protein content (%)	Net returns ha^{-1} (Rs.)	Cost Benefit ratio
Irrigation applied at						
60 mm CPE	960	2589	33.27	16.33	3630.0	1:1.58
80 mm CPE	947	2510	32.67	15.97	3613.0	1:1.58
100 mm CPE	690	2167	31.74	14.42	1131.0	1:1.18
100 mm CPE + grass mulch @ 6.25 MT/ha.	820	2503	32.50	14.49	732.0	1:1.09
Physiological crop growth stages.	1010	2687	32.82	16.78	4215.0	1:1.67
C D (5%)	74	273	0.80	0.63	--	--
Methods of Nitrogen applications						
Broad casting (50% at sowing + 50% 30 DAS	619	2146	31.53	12.85 (-)	60.0 (-)	1:0.41
Band placement (full dose at sowing)	832	2353	32.08	14.60	2687.0	1:1.68
Band placement (25% at sowing + 75% 30 DAS)	1078	2746	33.63	17.40	5712.0	1:2.15
Band placement (50% at sowing + 50% 30 DAS)	1013	2720	33.16	17.54	4979.0	1:2.04
C D (5%)	70	124	0.39	0.63	-	-

CPE - Cumulative Pan evaporation; DAS - Days after sowing.

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PERFORMANCE OF SUNFLOWER (*Helianthus annuus* L.) GENOTYPES AT VARYING LEVELS OF NITROGEN FERTILIZATION DURING SPRING SEASON

Recently, sunflower has emerged as a most potential oilseed crop in Indian agriculture. Due to its photoinsensitive nature, it can be grown throughout the year and is gaining popularity as a spring cash crop due to the its short duration (90-100 days) and versatility to fit into different cropping systems after the harvest of late rice, potato, rapeseed-mustard, vegetable pea and sugarcane-ratoons in Northern India. Hence there is a need to work out spacing and fertilizer requirement for maximum production. The present study is an attempt in that direction under Nainital *Tarai* conditions.

The experiment was conducted during spring season of 1994 at crop Research Centre, Pantnagar on a silty clay loam soil, having organic carbon 1.06%, available 56 kg/ ha and available K 232 kg/ ha with pH 7.2. Toria (*Brassica Compestris* var *toria*) was the previous crop. Three cultivars i. e. Morden (Variety), Mega-363 and GHS-777 (hybrids) with four nitrogen rates i. e. 40, 60, 80 and 100 kg/ ha were tested in factorial R. B. D with three replications. The crop was planted on 22 March 1994. Both Morden and GHS- 777 were harvested on 30th June, 1994 while Mega-363 was harvested on 6th July, 1996. Half dose of nitrogen along with 60kg P_2O_5 and 40 kg K_2O/ha was applied as basal dose. The remaining half N was given 30 days of sowing. Interculture and plant protection measures were adopted according to the crop need.

Mega-363 gave significantly higher seed yield than Morden but was at par with GHS- 777. Modern gave the lowest seed yield. Among the genotypes, GHS-777 produced the highest seed yield/day (21.61 kg) followed by Mega-363 (20.67kg) and Modern (18.83kg). Higher head diameter, seed weight/ plant and 1000- seed weight were responsible for yield of Mega-363. The highest harvest index (HI) was observed in GHS-777 which was at par with Mega-363. GHS-777 gave lower stover weight and biological yield/ plant than Mega-363 and resulted in higher HI (Table 1).

Nitrogen fertilization increased seed yields significantly and the highest yield was recorded at 100 kg N/ ha though it was at par with 80 kg N/ha. Linear increase in seed yield with nitrogen rates was reported by Ujjinaiah (1985). The head diameter, seed weight/plant and 1000-seed weight as well as biological yield increased significantly with nitrogen rates. Similar observations were made by Narwal and Malik (1985) and Khargakharate and Nirwal (1991). Nitrogen fertilization did not affect stem girth and harvest index significantly.

On the basis of the above experimental results, it can be concluded that the hybrids GHS-777 and Mega-363 could be grown at 80 kg N/ha for realising maximum production potential.

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Table 1. Performance of sunflower cultivars at varying levels of nitrogen fertilization during spring season

Treatments	Stem girth (cm)	Head diameter (cm)	Seed weight/ plant (g)	Straw weight/ plant (g)	1000 Seed weight (g)	Seed yield (q/ha)	Biological yield/ plant (g)	Harvest index (%)
Genotypes:								
GHS-77	12.06	20.33	24.64	67.22	37.61	21.61	96.22	25.22
Mega-363	12.46	21.74	26.17	77.17	40.23	21.91	104.75	25.02
Morden	11.93	16.03	20.48	76.23	39.51	18.43	94.55	21.97
C D (0.05)	NS	1.71	1.64	NS	NS	0.98	5.01	1.23
Nitrogen (kg/ha)								
40	11.55	14.22	20.96	63.82	36.36	15.98	84.67	24.48
60	11.96	16.84	22.33	69.22	37.67	210.18	93.05	23.48
80	12.23	21.13	24.42	74.69	39.64	22.77	103.71	24.08
100	12.85	25.36	27.34	83.01	42.87	23.67	112.57	24.23
C D (0.05)	NS	1.98	1.90	NS	2.97	1.13	5.79	NS

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PERFORMANCE OF SUNFLOWER AT DIFFERENT TIMES OF SOWING DURING POST RAINY SEASON IN NORTHERN TELANGANA ZONE OF ANDHRA PRADESH

In Northern Telangana, sunflower crop is being grown on a large scale from 1992 due to subnormal rainfall and remunerative prices. The crop is cultivated in 385 thousand ha in Andhra Pradesh. In six districts of Northern Telangana, the area has increased from negligible in 1991-92 to 78 thousands ha in 1993-94. The crop is sown from September till February depending on the land released by previous crop. It is grown in both red chalk (sandy clay loam) and black cotton soils under irrigated conditions. The sunflower crop responds to seeding in all the seasons and its performance is pronounced when sown at right time (Habeebullah *et al.*, 1993.). The information available in neighbouring Maharashtra state under rainfed conditions in Vertic inceptisols (Gaikwad *et al.*, 1994.) indicated that the advancement of sowing time to 24 or 25 meteorological week compared to 28 and 29 meteorological week was better. On vertisols sowing upto 25 Oct gave significantly higher yields (Bhale Rao *et al.* 1991). Information on the performance of the crop during rainfree period sown at different times is not available for Northern Telangana region. Hence, an experiment was conducted for three years in red chalka soils under limited irrigations (5-6) to asses the performance of sunflower sown at different times.

The field experiment was conducted at the Regional Agricultural Research Station, Jagtial during *rabi* and summer of 1992-93, 1993-94 and 1994-95 on sandy clay loam soil which is having a pH of 7.7, 265 kg/ha available nitrogen, 8.33 kg/ha of available P_2O_5 and 373 kg/ha available K_2O. The treatments comprising 12 dates of sowing (Table 1) starting from Sep 10 to Mar 11 at 15 days interval were tested in a randomized block design with 3 replications. A hybrid variety APSH 11 (95 days) was sown as per the dates of sowing at 60 cm x 30 cm spacing. The crop was fertilized with 90 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha. The entire quantity of P_2O_5 and K_2O and 30 kg N/ha was applied at sowing.

The remaining N was applied in two equal splits at 30 and 50 days after sowing (DAS). The crop was irrigated at critical stages-sowing, seedling, button, flowering and seed formation in all the dates of sowing.

At harvest, the seed and stalk yields were recorded at 12% moisture content. The data on number of seeds per head, 1000 seed weight and seed weight per head were recorded and the pooled analyses for three years was presented in the paper (Table 1).

The pooled analysis of dry matter at harvest for three years was significantly higher in the crop sown on Oct 10 than that sown on Sep 25 and the crop sown on these dates were significantly superior to all other dates sowing (Table 1). The reduction in dry matter production was drastic in the crops sown after Nov 24.

The harvest index ranged between 27 to 38% and the highest harvest index was recorded in Sep 25 sown crop. The harvest index was very low in the crops sown on Feb 22 (27) and Mar11 (26%).

The pooled analysis of the seed yield data show that there was no significant different in seed yield

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between the crop sown on Sep 25 or oct 10 and between the crop sown on Oct 25 and Nov 9 (Table 1). The crop in former two dates of sowing resulted in significantly higher seed yield over later dates of sowing, However, the seed yields drastically decreased when the crop was sown on Jan 8. The decrease in seed yield was 55% when compared to that sown on Oct 10.

The higher yield in the crop sown in Sep, Oct and Nov was due to higher head diameter and lower unfilled portion of the head (Table 1). The filling percentage was higher in the above dates of sowing while it was lower in the crop sown later on Jan 8. The crop sown in Sep, Oct flowered and seed filling completed when minimum temperature was around 11°C and maximum temperature of 29 °C. while that in Nov and Dec sowings it was 13 and 34.5 °C respectively, on the other hand, the minimum temperature ranged between 12.7 to 27.2° and maximum 31 to 44° C in the crop sown after Jan 8. As the sunflower prefers cool weather and the crop sown in Sep and oct received lower minimum and maximum temperature resulted in higher seed yield over that of the crop sown after Oct. Further, the crop sown in Nov and Dec received lower temperatures compared to those sown after Jan 8 which flowered in Mar and Apr when minimum and maximum temperatures were high (12.7 to 27 °C and 31 to 44°C.) This resulted in lower seed yield with the date of sowing delayed from Jan to Mar.

The improvement in yield was due to better contribution of yield attributes like seed weight/ head. Seed number/head (r=0. 9531**), filled seed percentage and 1000 seed weight (r=0.66**) (Chaudhary *et al.*, 1978 and Bhale rao *et al.*, 1994). Further, the higher head diameter and dry matter production in the earlier sowings had contributed to higher yields. The dry matter (r=o.97**) and head diameter (r=0.80**) had positive correlation with yield. The stalk yield showed almost similar trend to that of seed yield.

These results indicate that for realizing higher yields during post rainy season in Northern Telengana region of Andhra Pradesh, the sunflower crop has to be sown by Oct 10. However, marginally lower seed yield could be realized by sowing the crop upto Nov 24.

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Table 1. Effect of dates of sowing on performance of sunflower during rainfree period (pooled data of three years 1992-93 to 1994-95)

Dates of sowing	Diameter of head, cm	No. of seeds/ head	1000 seed weight, g	Stalk yield, kg/ha	Total dry matter, kg/ha	Harvest index, %	Seed yield kg/ha
Sep 25	15.1	515	60.2	2534	4073	38	1539
Oct 10	15.9	564	57.9	3122	4730	34	1608
Oct 25	15.2	487	54.7	2606	3912	33	1306
Nov 9	14.1	460	53.2	2504	3710	32	1206
Nov 24	15.0	422	52.7	2309	3394	32	1085
Dec 9	13.8	368	51.9	1719	2629	34	910
Dec 24	13.8	345	50.9	1606	2552	33	858
Jan 8	13.0	297	50.3	1357	2080	34	723
Jan 23	12.2	300	44.2	1266	1898	33	631
Feb 7	9.1	245	39.8	964	1440	34	476
Feb 22	8.6	187	38.8	920	1271	27	351
Mar 11	8.4	162	37.4	829	1122	26	294
S.Em. ±	0.5	22	1.3	169	205	2	65
C D (P=0.05)	1.5	64	3.9	495	602	6	192

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EFFECTS OF IRRIGATION FREQUENCIES AND METHODS ON YIELD OF SUMMER GROUNDNUT

Groundnut *(Arachis hypogaea L.)* is an important oilseed crop of India. Its cultivation is increasing due to its higher productivity during summer season. The information pertaining to response of summer groundnut to irrigation frequencies and methods is meagre. In the present study an attempt has been made to assess the effect of irrigation frequencies in relation to methods of layout on the yield of summer groundnut under Southern Maharashtra conditions. A field experiment was laid out in a randomised block design with five replications. The treatments comprised check basin method (5 x 3.6 m x 4 plots) (T_1). borderstrip method (20 x 3.6 m) (T_2), furrow method (5x3.6 m x 4 plots) (T_3) and farmers method on check basin (T_4). The crop in treatments T_1, T_2 and T_3 was irrigated at 0.6 IW/CPE ratio up to 40 days and afterwards at 0.75 IW/CPE ratio. It was irrigated at an interval of 10 days in treatment T_4. The crop was sown at optimum moisture condition with presowing irrigation at a spacing of 30x10 cm on 6 February, 1993 at Agricultural Research station, Digraj, Sangli. The soil was low in available nitrogen (174.06 kg/ha) and phosphorus (11.99 kg/ha) and high in potassium content (428.7 kg/ha). Field capacity and permanent wilting point of soil were 35.5 and 16.1%, respectively. The soil was slightly alkaline in reaction (pH 8.16). The depth of irrigation water was 60 mm at plot head measured by "V" notch at each irrigation. The relevant data on irrigation parameters are presented in Table 3. The growth attributing characters viz., plant height, spread, number of branches/plant and dry matter/plant were not influenced by the irrigation frequencies and methods (Table 1). The crop had an edge in bearing more number of pods/plant with higher test weight and shelling percentage through furrow irrigation than the check basin method adopted by the farmers (Table 2). The pod and haulm yield was also maximum. But, the difference was statistically significant only for the yield of haulms. Similar results for dry pod and haulm yields were reported by Chavan *et al.*, (1988) and Jadhav *et al. (1989)*. Maximim net returns and benefit: cost ratio were also obtained by the furrow method of irrigation.

The imporved irrigarion methods were superior to the farmers method. The crop needed ten irrigations in the former compared to twelve in the latter method (Table 3). The furrow method of irrigation was most effective with maximum water use efficiency of 3.71 kg/ha-mm. Therefore, the furrow method of irrigation is worth practical consideration as it saved two irrigations with no reduction in pod yield.

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Table 1. Growth attributes of groundnut as influenced by irrigation frequencies and methods

Treatments	Plant height (cm)	Spread (cm)	No. of primary branches/ plant	Dry matter (g/plant)
Check basin	22.82	26.5	5.04	30.54
Border strip	21.72	25.9	5.40	30.52
Furrow method	22.68	28.1	4.88	32.08
Farmers method	22.28	25.1	5.18	29.71
SE ±	0.88	0.85	0.39	–
CD (0.05)	NS	NS	NS	–

Table 2. Yield, yield components and economics of summer groundnut as influenced by irrigation frequencies and methods

	No. of pods plant	*Shelling* (%)	*100* Kernel weight (g)	SMK %	*Yield (q/ha)*		*Net* returns Rs/ha	*B:C* ratio
					pods	haulm		
Check basin	18.42	73	42.8	92	24.44	48.88	16311	2.62
Border strip	18.64	72	41.5	89	24.71	48.00	16763	2.69
Furrow method	20.64	74	43.7	90	25.71	50.77	17655	2.75
Farmers method	18.56	72	39.3	91	23.44	46.96	15868	2.59
SE ±	3.9				0.62	0.84		
CD (0.05)	NS	NS			NS	2.58		

Table 3. Water use efficiency of groundnut as influenced by irrigation frequencies and layouts

Treatments	No. of irriga-tions *	Effective rainfall (mm)	Irrig. water applied (mm)	Total water use (mm)	Field water use efficiency (kg/ha mm)
Check basin	10	73.2	620	693.2	3.53
Border strip	10	73.2	620	693.2	3.56
Furrow method	10	73.2	620	693.2	3.71
Farmers method	12	73.2	740	893.2	2.62

* Inclusive of one presowing and two common irrigations

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INSECTICIDE RESIDUES IN EDIBLE OILS

Though HCH is banned on oilseed crops, lindane is promoted, which helped to avoid the contamination of non-insecticidal isomers which are hazardous. Endosulfan, Synthetic pyrethroids (fenvalerate, cypermethrin and deltamethrin) and organophosphorus compounds (monocrotophos, dimethoate, phosphomidon etc.) are widely recommended. However some of them are lipophilic in nature and can be a source of contamination in oils. Similarly, contamination also results due to pre-storage seed/product treatment with insecticides to avoid storage pests. Keeping this in view, the oil samples from various places in Maharashtra were collected and studied for residues of lipophilic insecticides.

Ten oil samples each of cotton seed, groundnut and vegetable ghee and four of soybean were collected from Ahmednagar, Pune, Solapur, Nasik and Jalgaon districts. Oil sample (3 ml) was extracted in hexane by shaking in separatory funnel and then subjected to clean-up using concentrated sulphuric acid (Anonymous, 1994). Residues of HCH (Retention times- alpha 2.01, beta 2.30, gamma 2.45 and delta 2.63 minutes) and DDT (op-DDE 7.16, PP-DDE 8.67, op-DDD 9.35, pp- DDD 11.71, op-DDT 11.91 and pp-DDT 14.37 minutes) were estimated on gas- liquid chromatograph equipped with electron capture detector (Ni-63) and the working temperatures for injector port, column and detector were 220, 200 and 350°C. The residues of endosulfan (RT-endo-I 1.93 and endo-II 2.37 minutes), cypermethrin (RT 6.96 minutes), fenvalerate (RT 8.52 min.) and deltamethrin (RT 11.83 min.) were estimated on the same GLC and the temperatures were 260, 250 and 350°C for injector port, column and detector, respectively. The sensitivity of the method for each analyte was 0.01 ppm.

HCH and DDT residues were noticed in 8 and 5 samples of cotton seed oil with the levels of 0.06 to 0.49 and 0.09 to 0.35 ppm, respectively. Residues of endosulfan were found in 7 samples (0.07 to 0.14 ppm. Of the three samples with detectable levels of pyrethroids, each one was different viz., 0.26 ppm fenvalerate, 0.07 ppm cypermethrin and 0.03 ppm deltamethrin.

In groundnut oil, detectable levels of residues of HCH (0.04 to 0.29 ppm), DDT (0.02 to 0.54 ppm) endosulfan (0.02 to 0.13 ppm) and fenvalerate (0.02 to 0.15 ppm) were noticed in 10, 6, 5 and 5 out of 10 samples. Only four samples of soybean could be obtained from solvent extraction plants. Residues of HCH and DDT were noticed in 3 (0.05 to 0.18 ppm) and 2 (0.01 to 0.02 ppm) samples. Residues of endosulfan and synthetic pyrethroid were below detectable limit of 0.01 ppm. Eight samples of vegetable ghee showed HCH level in the range of 0.03 to 0.28 ppm. However, DDT residues were noticed in two samples (0.05 to 0.07 ppm). Residues of endosulfan were 0.02 to 0.10 ppm in four samples. Maximum residue limits for various pesticides covered in the present studies are not prescribed for the vegetable oils except for fenvalerate in cotton seed oil (0.1 ppm). However, the noticed levels of HCH and DDT are less than those reported in samples from Delhi, Punjab and Andhra Pradesh (Parmar and Dureja, 1990).

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Table 1. Residues of lipophilic insecticides in edible oils

Oil sample and Sr. No.	Residue (ppm)			
	HCH	DDT	Endosulfan	Pyrethroids
Cotton				
1.	0.12	0.09	0.14	BDL
2.	0.28	0.11	0.10	0.26 (F)
3.	0.49	0.14	0.10	0.07 (C)
4.	0.15	0.35	0.13	BDL
5.	0.10	0.25	0.07	BDL
6.	0.08	BDL	0.11	BDL
7.	0.18	BDL	BDL	BDL
8.	BDL	BDL	BDL	BDL
9.	0.06	BDL	BDL	0.03 (D)
10.	BDL	BDL	0.08	BDL
Groundnut				
1.	0.06	0.02	0.03	0.06 (F)
2.	0.07	BDL	BDL	BDL
3.	0.22	BDL	0.02	0.07 (F)
4.	0.22	0.05	0.02	0.15 (F)
5.	0.04	BDL	BDL	BDL
6.	0.20	0.54	BDL	BDL
7.	0.19	0.41	0.13	BDL
8.	0.12	0.04	BDL	0.0" (F)
9.	0.29	0.48	BDL	BDL
10.	0.28	BDL	0.02	0.02 (F)
Soybean				
1.	0.14	0.02	BDL	BDL
2.	0.05	0.01	BDL	BDL
3.	0.08	BDL	BDL	BDL
4.	BDL	BDL	BDL	BDL
Vegetable ghee				
1.	0.13	0.05	BDL	BDL
2.	0.19	0.07	0.05	BDL
3.	0.03	BDL	BDL	BDL
4.	0.05	BDL	0.02	BDL
5.	BDL	BDL	BDL	BDL
6.	0.15	BDL	BDL	BDL
7.	0.28	BDL	0.10	BDL
8.	0.14	BDL	0.06	BDL
9.	0.08	BDL	BDL	BDL
10.	BDL	BDL	BDL	BDL

BDL = Below detectable limit of 0.01 ppm

(F) = Fenvalerate, (C) = Cypermethrin and (D) = Deltamethrin

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RESIDUES OF SOME LIPOPHILIC INSECTICIDES IN COTTON SEEDS

Several lipophilic pesticides viz. HCH, endosulfan, fenvalerate, cypermethrin and deltamethrin are in use against pests of cotton crop in Maharashtra *(Anonymous, 1992)*, Although DDT is banned for agriculture, its use for public health programme is in vogue. Cotton crop alone consumes around 50% of the pesticides used in agriculture. Possibilities of contamination of cotton seed cannot be ignored due to residual spray of DDT in stores, misuse of HCH in field and stores and excessive use of recommended pesticides in pest control programme. Hence it was planned to study the levels of some lipophilic pesticide residues in cotton seed samples collected from Vidarbha region of Maharashtra.

Twenty samples of cotton seeds were collected randomly from shops, godowns and ginning mills. Ground sample was extracted with hexane in a soxhlet extractor and then subjected to cleanup procedure (Anonymous, 1994). Each sample was screened for residues of DDT (pp-DDT, pp-DDE and pp-DDD). HCH (alpha, beta, gamma and delta isomers), endosulfan (alpha and beta isomers), fenvalerate, cypermethrin and deltamethrin on GC equipped with EC detector with a sensitivity of 0.01 ppm for each analyte. Separation was performed on stainless steel column loaded with 1.5% OV-17 + 1.95% OV-21 on Chromosorb WHP (80/100 mesh) with a nitrogen flow of 60 ml/min. The operating temperatures of injector port, column oven and detector were 200, 190 and 300° C, respectively. The corresponding temperatures for the determination of endosulfan fenvalerate cypermethrin and deltamethrin were 280, 270 and 300 C, respectively.

The residues of HCH (0.066 to 0.194 ppm) and DDT (0.020 to 0.095 ppm) were noticed in 11 and 5 samples (out of 20), respectively. Although, maximum residue limits (MRL) are not prescribed for both the pesticides in cotton seed, the present levels are certainly less than those reported for oil and oilseeds in other states (Parmar and Dureja, 1990). Residues of endosulfan were noticed in all the samples of cotton seeds (0.021 to 0.085 ppm) but the levels were less than the MRL of 0.5 ppm. Detectable levels of synthetic pyrethroids were found in four samples of which two were with fenvalerate (0.016 and 0.021 ppm) and one each with cypermethrin (0.013 ppm) and deltamethrin (0.011 ppm). However, the residues were below the prescribed MRL of 0.1 (deltamethrin) to 0.2 ppm (fenvalerate and cypermethrin).

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Table 1. Residues of lipophilic insecticides in cotton seeds

Cotton seed sample Sr. No.	Insecticide residues (ppm)			
	HCH (Total)	DDT (Total)	Endosulfan (Total)	Pyrethroids
1.	0.125	BDL	0.042	BDL
2.	0.134	BDL	0.024	BDL
3.	0.194	BDL	0.037	0.013 (C)
4.	0.118	BDL	0.025	BDL
5.	0.166	0.041	0.051	BDL
6.	0.063	0.022	0.023	0.011 (D)
7.	BDL	BDL	0.033	BDL
8.	BDL	0.095	0.049	BDL
9.	0.081	BDL	0.083	BDL
10.	0.078	BDL	0.029	BDL
11.	0.056	BDL	0.050	BDL
12.	BDL	BDL	0.024	BDL
13.	BDL	0.043	0.046	0.021 (F)
14.	BDL	BDL	0.028	BDL
15.	0.066	BDL	0.022	BDL
16.	BDL	BDL	0.051	BDL
17.	BDL	BDL	0.085	BDL
18.	0.077	BDL	0.028	BDL
19.	BDL	0.040	0.040	0.016 (F)
20.	BDL	BDL	0.037	BDL

BDL = *Below detectable limit of 0.01 ppm*

(F) = Fenvalerate (C) = Cypermethrin (D) = Deltamethrin

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COMPARATIVE PERFORMANCE OF DIFFERENT SEASONAL WATER PRODUCTION FUNCTIONS FOR SUNFLOWER

In Andhra Pradesh sunflower is extensively grown in *rabi* season under major and minor irrigation schemes. Hence a study was carriedout to develop and evaluate various seasonal water production functions for sunflower.

A field experiment was conducted at the College Farm Rajendranagar, Hyderabad (17.19° N, 78.23°E and 543 altitude) in *rabi* season of 1992-93 on a sandy loam soil. There were eight irrigation treatments designed to allow evapotranspiration deficits to develop in one or more of three specific growth subperiods viz, vegetative (10-32 DAS), flowering-seed set (32-65 DAS), and seed filling-ripening (65-93 DAS). In any given growth subperiod, the crop in a given treatment was either irrigated (W)based on soil (water holding properties), crop (crop coefficient) and climatic (potential evapotranspiration)data to ensure evapotranspiration of the crop at maximum rate or it was not irrigated at all (D) The crop in W-W-W treatment was irrigated eight times. The irrigation interval was 11 days in vegetative and flowering -seed set periods and 16 days in seed filling -ripening period. For instance the crop in D-W-W was not irrigated during vegetative growth sub-period and irrigated during flowering-seed set and seed filling-ripening growth sub-periods. Thus crop in treatment D-W-W, W-D-W,W-W-D, D-D-W, W-D-D and D-W-D if irrigated, the schedule duplicated that of the crop in W-W-W treatment.

The eight treatments were laid out in randomized block design with four replications. The soil pH, EC and bulk density values were 7.5, 0.13 dsm^{-1} and 1.66 g cm^{-3}, respectively. The average soil moisture retentivity at -0.03 MPa,-1.5 MPa and available water storage in 60 cm soil profile were 17.16 cm, 8.68 cm and 8.48 cm, respectively. The ground water table was below 10m from the soil surface. Hybrid MSFH 8 was sown on 20 October, 1992 and was harvested on 30 January, 1993. The total precipitation received was 9.7 cm spread over three rainy days during 32-34 DAS. Since the rainfal occurred during transition period or vegetative to flowering - seed set, the effective precipitation was deducted from the net irrigation requirement while scheduling irrigations in different treatments. The evapotranspiration was estimated by monitoring the soil moisture under different treatments starting from sowing to maturity before and after each irrigation by following gravimetric method (praveen Rao, 1993).

The seasonal water production functions of the following type were dveloped and evaluated:

$$Ya = a+b\,(Eta) \quad (1)$$

$$Ya = a+b\,(Eta)+(Eta)^2 \quad (2)$$

$$Ya = a+b\,(Eta)+(Eta)+(Eta)^3 \quad (3)$$

$$Ya = a+b\,(Eta)+(Eta)^{0.5} \quad (4)$$

$$Ya = a\,(Eta)^b \quad (5)$$

Where, 'Y_a' is seed yield or dry matter production in Mg ha^{-1} 'Eta' is seasonal evapotranspiration in cm, 'a' is intercept on the y-axis, and 'b' 'c' and 'd' are regression coefficients indicating the magnitud of yield variation (Mg ha^{-1}) perunit increase in Eta. Stewart (1972) replaced Eta in equation (1) by seasonal relative Eta deficit (Stress factor) and proposed the following S_1 relationship:

$$Ya = a+b\,(Etd/Etm) \quad (6)$$

Where, Etd is seasonal evapotranspiration deficit i.e., Etm-Eta, and 'Etm' is maximum evapotranspiration in cm associated with maximum yield (Ym).

The equation (6) was later further modified into a dimensionless form to increase the scope of transferability. The dimensionless function (S_2) as reported by stewart *et al.*, (1977) was of the following form:

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$$(1\text{-}Ya/Ym) = b(1\text{-}Eta/Etm) \quad (7)$$

where, 'b' is the yield sensitivity coefficient to Etd, whereas 'ya', Ym', 'Eta' and Etm' are as defined earlier.

However, Singh *et al.*, (1987) assumed that the marginal physical product of Eta in the relationship between ya and Eta decreased after certain value, consistent with most agronomic studies. Hence he proposed a non linear function of the following form:

$$Ya = a+b\,(1\text{-}(1\text{-}X)^2 \quad (8)$$

in which, ya, a and b as defined earlier, and 'x' is relative Eta i.e., Eta/Etm.

The water production functions explained through equation (1) to (8) were varified by regression analysis both for seed yield and dry matter yield of sunflower.

The seasonal crop water production functions as expressed by linear, quadratic, third degree polynomial or cubic, squareroot, power, stewart (s_1), Stewart *et al.*, (S_2) and after Singh *et al.*, performed relatively well for seed yield than dry matter (Table 1 and 2). The coefficient of determination (R^2) varied from 0.76 to 0.86 and 0.72 to 0.81 for seed yield and dry matter yield, respectively. The variance ratio (F-value) for testing R^2 was significant in all the cases except cubic function for dry matter. Though R^2 for the production function as expressed by quadratic, cubic and square root functions varied from0.82 to 0.86 for seed yield and 0.78 to 0.80 for dry matter yield, regression coefficients b, c and d were statistically non-signigicant (P=0.05) Therefore it can be infered that the non-linear functions expressed by quadratic, cubic and square root did not represent the data well. However the regression coefficients were highly signigicant for power function both in seed and dry matter yield, when compared to eq. 2,3 and 4 and the R^2 varied from 0.72 to 0.76.

The Stewarts S1 and S2 functions may be expressed and written in the form of linear function. probably this could be the reason that the reason that the R^2 and F-values, both for Stewart's and linear functions are equal. The regression coefficients for these linear functions eq. 1, 6 and 7 under both seed yield and dry matter yield were highly signigicant (p=0.01) and the R^2 varied from 0.78 (dry matter) to (Seed yield).

The function proposed by Singh *et al.*, (eq.8) modifying the stress factor in Stewart's function assuming a non-linear relationship between crop yield and seasonal evapotranspiration though represented the data well, it had lower R^2, F and t-values when compared to linear and Stewart's functions both for seed and dry matter yield. Hence, linear functions eq.1, 6 and 7 may be considered more useful from practical point of view.

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Table 1. Empirical estimates for testing seasonal water production functions for sunflower seed yield

Water production function	Regression constants, coefficients and test statistics					F-value for testing R^2
	a	b	c	d	R^2	
Linear	0.1371	0.05913** (0.01117)+			0.82	28.0**
Quadratic	0.2894	0.04776 NS (0.13975)	0.00020 NS (0.00246)		0.82	11.6**
Cubic	-15.0008	1.74400 NS (1.63153)	-0.06059 NS (0.05831)	0.00070 NS (0.00067)	0.86	8.2*
Square root	0.2228	0.06227 NS (0.27936)	-0.03305 NS (1.93377)		0.82	11.6*
Power	-1.1448	0.96445** (0.22039)			0.76	19.1**
Stewart S_1	2.3410	-2.20397** (0.41644)			0.82	28.0**
Stewart S_2	0.0126	0.92885** (0.17558)			0.82	28.0**
Singh *et al.*,	-0.8540	1.77416** (0.40772)			0.75	18.9**

NS = Non significant at P = 0.05; ** = Significant at P = 0.01; * Significant at P = 0.05; + Standard error of `b'

Table 2. Empirical estimates for testing seasonal water production functions for sunflower dry matter yield

Water production function	Regression constants, coefficients and test statistics					F-value
	a	b	c	d	R^2	for testing R^2
Linear	1.5012	0.12676** (0.02723)			0.78	21.67**
Quadratic	1.5487	0.12321 NS (0.34130)	0.00062 NS (0.00602)		0.78	9.02*
Cubic	-26.0752	3.18792 NS (4.21683)	-0.10978 NS (0.15073)	0.00127 NS	0.80	5.6 NS
Square root	*0.5676*	*0.09254 NS* (0.64601)	*0.36009 NS* (6.78137)		*0.78*	*9.0**
Power	-0.3501	0.72798** (0.18368)			0.72	15.7**
Stewart S_1	6.2259	-4.72464 (0.01494)			0.78	21.6
Stewart S_2	0.0017	0.75711** (0.16264)			0.78	21.6
Singh *et al.*,	-0.5060	1.44867** (0.36172)			0.72	16.0

NS = Non significant at P = 0.05; ** = Significant at P = 0.01; * Significant at P = 0.05; + Standard error of 'b'

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INFLUENCE OF PLANTING DENSITY ON THE PERFORMANCE OF SOYBEAN GENOTYPES

Soybean ranks first among world oilseeds in production. It has also acquired third place after groundnut and mustard in india in oilseeds. The traditional varieties are of longer duration, indeterminate to semideterminate type and often experience severe moisture stress due to early withdrawal of rains resulting in lower productivity. A number of short duration genotypes have been developed to encounter, such situations. Mostly these varieties are determinate and compact in growth habit, thereby increasing the probability of positive response to higher plant density. Therefore, the present study was carried out to investigate the effect of plant density on different early maturing genotypes of soybean grown on Vertisols of Malwa Plateau.

The trial was conducted in split plot design with 3 replications during *Kharif*, 1995 at Research Farm, National Research Centre for soybean, Indore. Nine genotypes of soybean viz. NRC 7, NRC 14, JS 89-27, MAUS 1, MACS 390, SL 231, PK 1093, JS 71-05 and Pb 1 were allocated to main plots and 3 plant densities i.e. 0.2, 0.4 and 0.6 million/ha to sub plots. The seeds were treated with Thiram+ Carbendazim (1:1) @ 3g/kg seed followed by inoculation with *Bradyrhizobium* and phosphate solubilizing bacteria each @ 5g/kg seed. The recommended fertilizers N:P_2O_5: K_2O were applied @ 20:60:20 kg/ha as basal at the time of sowing through urea, single superphosphate and muriate of potash. The plant population at 45 cm row spacing was maintained in each plot as per treatments (plant to plant distance of approximately 10 cm, 5 cm and 2.5 cm for 0.2, 0.4 and 0.6 m/ha, respectively). The crop was sown on 1st July, 1995 and harvested in the month of October depending on the genotypical maturity. All the biometrical parameters were recorded at the time of harvesting. The oil and protein content in whole seeds were determined employing the Tecator Model INFRATEC 1225.

The genotypes differed significantly in yield, yield attributes, protein and oil contents (Table 1). The Pb 1 acquired maximum plant height and had maximum number of seeds/pod. On the contrary, the variety JS 71-05 was dwarf with superior branching habit, and better seed and harvest indices. JS 89-27 produced maximum pods per plant. Two genotypes PK 1093 and MACS 390 produced significantly more grain yield (2388 and 2003 kg/ha) than all others. The varieties SI 231 (2097 kg/ha). NRC 14 (2003 kg/ha) and NRC 7 (1995 kg/ha) were intermediate in yield. The lowest yield was maximum in NRC 14. Genotype JS 89-27 possessed maximum protein content (42.67%) and remained at par with SL 231 (41.78%) . Pb 1 (41.39%), PK 1093 (40.92%). NRC 7 showed lowest protein content (37.45%) and highest oil content (19.81%).

Soybean grew significantly tall, produced less number of branches and pods per plant but yielded more grain and stover at high densities of 0.4 and 0.6 than 0.2m/ha. This positive yield response was probably due to the relatively high yield from more number of plants per unit area than the per plant yield reduction. The protein % was not influenced by the plant population while the oil% decreased significantly at high densities. Singh *et al.*, (1993) also reported similar results. Genotypes x plant density interaction was not significant.

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Table 1. Biometrical parameters of soybean genotypes as influenced by planting density

Treatments	Plant height (cm)	Branches/ plant (no.)	Pods/ plant (no.)	Seeds/ pod (no.)	Seed index (g/100)	Seed yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)	Protein (%)	Oil (%)
Genotype										
NRC 7	34.46	3.67	32.33	2.12	14.77	1995	2125	48.84	37.41	19.81
NRC 14	37.34	3.97	20.73	2.02	11.91	2003	3755	38.79	38.50	18.43
JS 89-27	40.71	4.77	55.33	1.83	11.84	1614	2292	40.89	42.67	18.55
MAUS 1	48.86	4.13	44.00	1.71	12.38	18.51	3123	39.90	38.72	17.70
MACS 390	47.20	4.53	45.47	2.16	10.32	23.06	3132	42.96	40.42	15.04
SL 231	37.60	5.26	38.47	1.91	10.95	2097	2932	43.62	41.78	16.02
PK 1093	38.80	3.74	23.73	2.36	12.71	2388	3201	44.62	40.92	17.12
JS 71-05	24.04	5.55	31.07	2.37	15.34	1825	1961	49.93	39.76	18.51
Pb 1	66.35	3.73	41.07	2.46	8.14	1718	2909	36.51	41.39	13.61
CD (P=0.05)	8.32	0.55	9.76	0.20	1.40	250	303	2.90	2.14	0.61
Plant population (m/ha)										
0.2	38.10	5.19	56.78	1.83	11.98	1804	2323	43.71	39.83	17.48
0.4	42.63	4.09	39.66	1.70	12.19	2027	2763	42.48	40.23	17.05
0.6	44.38	3.85	37.93	1.53	11.95	2099	2825	42.46	40.45	17.05
CD (P=0.05)	2.55	0.46	5.05	NS	NS	126	137	NS	NS	0.24

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NITROGEN PARTITIONING PATTERN AND ITS NATURE OF ASSOCIATION WITH BIOMASS, HARVEST INDEX AND NITROGEN HARVEST INDEX IN SPANISH GROUNDNUT (*Arachis hypogaea L.*)

Genotypic differences were observed in groundnut with regard to total dry matter, pod yield and nutrient uptake. However, most of the yield variation among groundnut cultivars was due to the differences in the partitioning of assimilates between vegetative and reproductive parts (Duncan *et al.*, 1978). Groundnut has been found to be more efficient both in trapping solar energy and in energy partitioning (Dwivedi *et al.*,1985) and its productivity can be enhanced by increasing biomass or harvest index (HI) or nitrogen harvest index (NHI) or all. A knowledge of the interrelationship among the key growth variables is, therefore, necessary for increasing the yield potentiality.

A field experiment was conducted during *Kharif* season of 1994 on calcareous soil having low in available N (250 kg/ha), medium in available P_2O_5(23.5 kg/ha) and K_2O (180 kg/ha) to study the relationship among N uptake, biomass, harvest index and nitrogen harvest index to groundnut. Twenty two spanish groundnut genotypes were tested in randomized block design with three replications. Seeds were sown during first week of July at 30 cm x 10 cm spacing with a uniform basal application of 12.5., 60 and 30 kg of N, P_2O_5 and K_2O respectively. Five plants were selected from each variety and each replication. Leaves, stem, root, pegs, immature pods, kernels and shells were separated from harvested plant samples. The biomass and nitrogen per cent (using micro-Kjeldahl method as outlined by Jackson, 1967) from each plant part were determined and the results were pooled together to obtain N uptake or N content. The total biomass, harvest index (Donald, 1962) and nitrogen harvest index (NHI) were also recorded at harvest. NHI was computed by dividing pod N content by total N content.

There was substantial variation among genotypes for all the characters (Table 1). The genotype (JL 24) registered significantly higher dry matter over other genotypes except SB XI, Kisan, Pol 2 and TG 3 which were on par with JL 24. The differences in dry matter accumulation among the genotypes could be related to difference in assimilate partitioning between vegetative and reproductive components (Bell *et al.*, 1991). Significantly higher N uptake was recorded by SB XI which were on par with JL 24 and TG 3. The genotype Chico accumulated lowest dry matter and nitrogen. Since N uptake is a function of dry matter and N%, the different genotypes showed almost similar pattern of N uptake as in case of dry matter. Although the genotypes SB XI, Kisan, Pol 2, TG 3, Dh 8, GG 2 and X 11-7-6 had comparatively high N content in kernel, there was no consistency in genotypic differences for N uptake from part to part. Similarly, no genotype was consistently superior for N uptake. Irrespective of genotypes, maximum N uptake was recorded in kernel followed by leaves, stems, shell, pegs, immature pods and root (Table 1). This work was in accordance with the work of Halevy and Hartzook (1988).

Chico recorded significantly higher HI and NHI over all the genotypes while JL 24 recorded the lowest. Thus, the result indicated that the genotypes (Chico and GG 2) which recorded lower

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Table 1. Biomass, harvest index, nitrogen harvest index and nitrogen uptake by different plant parts of spanish groundnut genotypes at harvest

Genotype	TDM	HI	NHI	N uptake (mg)							
				leaves	stem	root	pegs	immature pods	kernel	shell	Total
Chico	15.9	0.60	0.70	75.0	29.8	5.8	5.7	19.6	252.9	62.4	451.2
Co 1	48.8	0.38	0.55	320.9	230.6	12.9	31.8	22.7	651.0	98.2	1368.0
SB XI	56.7	0.35	0.50	545.1	263.4	15.8	35.0	30.7	766.5	109.6	1766.3
Dh 3-30	52.8	0.33	0.48	469.4	216.2	13.1	36.9	25.6	626.6	80.8	1469.0
Kisan	54.2	0.34	0.53	438.7	196.1	13.7	37.2	32.3	711.5	95.6	1525.1
RSHY 1	35.1	0.40	0.54	302.7	129.1	8.7	9.8	18.4	477.3	64.2	1010.2
Jyoti	47.7	0.37	0.53	348.6	212.2	12.5	36.4	25.3	621.6	84.4	1341.2
Pol 2	58.1	0.32	0.49	503.2	268.0	13.9	37.5	21.1	732.4	67.7	1643.8
MH 1	49.5	0.35	0.49	436.7	172.7	12.2	20.4	19.5	670.1	82.9	1414.5
JL 24	59.0	0.31	0.44	624.9	278.0	18.6	35.0	29.3	636.9	123.1	1745.7
KRG 1	50.2	0.35	0.52	387.8	227.7	12.2	34.6	25.0	639.2	105.2	1431.4
S 206	51.9	0.35	0.48	478.1	179.1	13.5	42.1	31.1	606.7	101.5	1475.7
TG 3	54.8	0.33	0.47	619.3	230.2	14.6	21.7	26.0	732.7	71.6	1716.0
TMV 7	52.7	0.34	0.50	471.1	198.1	13.5	36.5	28.1	628.5	112.5	1488.4
GAUG 1	49.9	0.32	0.49	397.8	228.5	23.4	34.9	40.3	645.7	60.1	1430.7
J 11	49.3	0.35	0.49	478.9	205.7	16.0	22.0	19.6	644.7	73.6	1460.5
Dh 8	51.9	0.35	0.51	433.0	248.8	12.1	36.7	30.7	713.4	83.0	1552.7
AK 12-24	48.9	0.35	0.52	378.2	205.6	12.6	19.9	25.5	576.1	111.7	1329.6
ICG 45	43.2	0.39	0.52	437.4	136.8	11.6	17.4	27.6	619.5	74.5	1324.7
GG 2	41.5	0.51	0.65	279.0	93.5	10.4	35.6	32.4	769.1	90.7	1328.7
TMV 2	49.2	0.37	0.48	523.3	208.5	10.0	23.2	25.8	625.9	92.7	1509.7
X 11-7-6	52.3	0.35	0.48	542.9	226.7	12.5	19.3	27.3	702.6	64.7	1596.0
Mean	48.6	0.37	0.52	429.1	196.6	13.0	28.0	26.4	636.4	86.4	1426.2
CD at 5%	5.2	0.03	0.03	68.6	33.8	1.9	5.9	3.0	61.4	10.5	52.5

TDM = Total dry matter (g/plant), HI = harvest index, NHI = nitrogen harvest index dry matter accumulation and N uptake had higher NHI simply because of higher N content in kernel and Vis-a-Vis as in case of JL 24 and SB XI. In this study HI and NHI also showed negative correlation dry matter and N uptake by different plant parts. Negative correlation between dry matter and harvest index was also reported by Dhopte and Zade (1981). Since the NHI takes into account both N % and dry matter and its correlation with HI was positive (Table 2), the genotypes which recorded high NHI also had high HI. Hence higher N content in kernel is expected to give high yield potential. The higher value of NHI obtained in Chico and GG 2 implies that these genotypes are nitrate-tolerant, besides superior in N mobilization, utilization and accumulation. Therefore, NHI and N % in kernel can be used as the criteria for selection in groundnut improvement programme.

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Table 2. Correlation among total dry matter, HI, NHI and N uptake by different plant parts

Characters	TDM	*HI*	NHI
Leaves	0.87**	-0.82**	-0.90**
Stem	0.90**	-0.86**	-0.81**
Root	0.66**	-0.67**	-0.62**
Pegs	0.68**	-0.48*	-0.35
Immature pods	0.38	-0.24	-0.17
Kernels	0.83**	-0.60**	-0.51**
Shell	0.43*	-0.25	-0.22
HI	-0.90**	--	--
NHI	-0.84**	0.95**	--

**, * implis significance at 1% & 5% levels, respectively.

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INFLUENCE OF PHOSPHATE SOURCES ON NUTRIENT UPTAKE AND YIELDS OF GROUNDNUT IN RICE BASED CROPPING SYSTEMS.

Groundnut (*Arachis hypogaea* L.) is commonly cultivated as *rabi* crop in *kharif* rice fallows and the yields of groundnut grown in these soils are observed to be lower than the *rabi* groundnut grown in non-rice soils. The reasons may be partly due to adverse soil structure that exists because of puddling impeding peg penetration and also uptake of critical nutrients like P and Ca. As the crop yields pods rich in oil and protein, it has relatively high requirements for P, Ca and S. Among several sources of P, single super phosphate (SSP) and diammonium phosphate (DAP) which are water soluble P sources are extensively used by farmers for fertilising groundnut crop. Hence this study was undertaken to evaluate the effects of SSP and DAP in influencing the yields and nutrient uptake of groundnut in rice based cropping systems.

A field experiment was conducted at the Directorate of Rice Research (DRR) Rajendranagar during *rabi* 1994-95 in a vertisol. The soil is clayey, low in organic carbon (0.45%), medium in available P (19 kg/ha) and K (275 kg/ha), with alkaline reaction (pH 8.0). Free Ca CO_3 content is 6.1% Cation exchange capacity of the soil is 39.2 me/100 g soil with exchangeable Ca accounting for 27.3 me/100 g soil. The treatments consisting of control (no P), single super phosphate (SSP) and DAP both @ 40 kg P_2O_5/ha were laid out in a randomised block design with ten replications. N and K were applied @ 30 and 40 kg/ha respecstively. Cultivar TMV-2 was used as test crop. Pod and haulm yields were recorded at harvest and the plant and soil samples after harvest were analysed for N,P,K, and Ca adopting standard procedures.

Pod yield increased significantly when SSP was P source (22.69 q/ha) over DAP (18.65 q/ha) and control (16.43 q/ha). The better performance of SSP over DAP may be attributable to presence of nearly 50% Ca SO_4 $2H_2O$ that supplies Ca and S which are essential for better yield and quality of groundnut (Brady, 1947 and Bledsoe *et al.* 1949). Presence of Ca in adequate quantities in the fruiting (pod formation) zone is a key factor for proper filling and development of pods, because root supply of Ca does not reach through xylem by normal transpirational stream as pods are

Table 1. Effect of P sources on yield of Groundnut

Treatments	Pod yield (Q/ha)	Haulm yield (Q/ha)
Control (PO)	16.43	56.00
Diammonium Phosphate (DAP)	18.65	56.38
Single super phosphate (SSP)	22.69	56.88
Mean	19.25	56.42
CD (0.05 %)	3.534	NS

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Table 2. Effect of P sources on nutrient uptake by Groundnut

Treatments	Nutrient uptake (kg/ha)											
	N			P			K			Ca		
	Pd	Ha	TDM	Pd	Ha	TDM	Pd	Ha	TDM	Pd	Ha	TDM
Control (P O)	60.1	98.7	158.9	7.52	6.77	14.14	5.13	40.4	45.6	5.08	91.6	96.7
Diammonium phosphate (DAP)	71.0	112.9	183.9	8.69	7.08	15.77	5.98	39.7	45.7	6.16	95.4	101.5
Single super phosphate (SSP)	88.5	110.3	198.9	10.16	7.54	17.69	7.93	39.9	47.8	7.81	102.2	110.1
Mean	73.2	107.3	180.5	8.79	7.13	15.87	6.34	40.0	46.4	6.35	96.4	102.8
CD (0.05)	15.3	10.37	18.05	NS	NS	2.45	1.62	NS	NS	1.30	NS	NS

Pd - Pods, Ha - Haulms, TDM - Total dry matter

Table 3. Effect of P sources on soil available nutrients at harvest

Treatments	Organic carbon (%)	Phosphorus (ppm)	Potassium (ppm)	Calcium (me/100g)
Control (P O)	0.347	7.50	153	31.55
Diammonium phosphate (DAP)	0.428	8.95	156	32.35
Single super phosphate (SSP)	0.455	8.23	175	37.86
Mean	0.410	8.23	161	33.92
CD (0.05)	0.070	NS	NS	1.742

subterranean and lack stomata and thus do not transpire. Consequently pods have no direct access to xylem transported Ca. Further, Ca is known to be immobile in phloem. Hence in absence of both xylem and phloem supplies of Ca, penetrating gynophores have modified themselves into absorbing organs of Ca from the immediate fruiting zone (Brady, 1947; Bledsoe *et al.* 1949 and Van der straten *et al.* 1995). This result is corroborated by the observation of significant increase of Ca uptake by pods (7.81 kg/ha) in SSP treatment as compared to DAP (6.16 kg/ha) and control (5.08 kg/ha). In addition, Ca being divalent cation, alleviates the adverse effects of puddling on soil structure/crusting by bringing about soil aggregation and consequent reduction in soil strength. This in turn favours successful penetration of gynophores to develop into effective pods (Reddy, 1973).

Sulphur is required for the biosynthesis of the essential S-containing aminoacids, and thus biologically important proteins, chlorolphyll and oil. Thus, these nutrients in combination present in SSP might have contributed for observed increase in biomass production and kernel development leading to increased yields. Similar results were also reported by Aulakh *et al.* (1980), Naphade *et al.* (1991) and Singh *et al.* (1993). Nutrient uptake data given in Table 2 showed that N uptake was significantly more in P supplied plots irrespective of P source indicating synergistic effects of balanced supply of N and P. Ca uptake data indicated that Ca uptake by pods was significantly superior in SSP treated plots as compared to DAP with little calcium in its composition. This is further evidenced by the non-significant differences between control and DAP with respect to Ca uptake.

Soil organic carbon content was observed to be slightly more in fertilised plots (0.455% and 0.428% with SSP and DAP respectively) over control (0.347%). As expected, Ca status of soil also has gone up in SSP treated soils due to the presence of considerable amounts of gypsum in SSP.

Thus application of SSP to groundnut is observed to be useful not only from the standpoint of increasing pod yields but also in increasing organic carbon and available Ca for future crops that go a long way in contributing to soil sustainability.

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COMPARATIVE EFFICACY OF FUNGICIDES IN CONTROLLING LEAF SPOTS ('*Tikka*') OF GROUNDNUT

Early and late leaf spot diseases of groundnut caused by *Cercospora arachidicola* Hori and *phaeoisariopsis personata* (Berk and Curt) V.Arx. commonly known as *Tikka* are the most important foliar fungal diseases of groundnut in India. Leaf spots are endemically present in groundnut growing areas of Sriganganagar district of Rajasthan and cause considerable yield losses particularly when they appear early in the season. The two leaf spots singly or together can cause more than 50% losses in yield (Mc Donald *et al.* 1985). The present paper reports relative efficacy of certain selected fungicides against leaf spots of groundnut.

Field trials were conducted at Sriganganagar during *kharif* 1989 and 1990 crop season on groundnut cultivar M-13 in randomized block design having three replications of 4x3 m^2 plot size with a row spacing of 40 cm. The crop was sown during 2nd fortnight of June in both the years. Six fungicides viz; three carbendazim formulations (Bavistin, 50 W.P., Jkstein 50 W.P. and Derosal 50 W.P.), thiophanate-M (Topsin-M, 70 W.P.), mancozeb (Dithane M-45, 75 W.P.) and captafol (Foltaf, 80 W.P.) were used as seed treatment @ 0.2% (w/w) of the propietory formulation basis. Three sprays of each fungicide were given where the first spray was given after appearance of the disease and two more sprays of respective fungicides were continued at an interval of 15 days. The disease incidence was recorded on five plants randomly selected from each plot, 15 days after last spray following 0-5 rating scale (Gupta, 1985) and finally disease intensity was calculated. Observation on germination percentage and pod yield was recorded.

The pooled data of two years (Table 1) indicated that seed germination was higher when fungicide treated seeds were sown in comparison to control. Maximum germination was observed in captafol treatment closely followed by Bavistin and thiophanate-M. The intensity of leaf spots was significantly less in all the fungicide treatments compared to control. Although both early and late leaf spots occurred together but the latter one was more predominant. The disease appeared during 2nd fortnight of August. the three carbendazim formulations (Bavistin, Jkstein, Derosal) and thiophanate-M most efectively controlled the disease. The average leaf spot intensity in these four fungicides varied from 7.5 to 11% and were statistically at par. the mancozeb and captafol treatments were less effective in controlling these diseases. Several fungicides have been evaluated against leaf spots of groundnut (Ghewande, 1990; Kolte, *et al.* 1978. Shekhawat, *et al.* 1987). The efficacy of carbendezim in controlling leaf spots has been reported earlier (Natarajan and Subramanian, 1983; Rattan and Kang, 1982). The pod yield recorded in carbendazim and thiophanate-M treatments varied from 25 to 28 q/ha in comparison to 19 q/ha in control. Based on the present findings it can be concluded that carbendazim or thiophanate-M may be used for effective control of leaf spots of groundnut.

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Table 1. Effect of fungicides on germination, leaf spot intensity and pod yield of groundnut (two year data)

	Fungicide	Dose (%)		Germination (%)	Leaf spots intensity (%)	Pod yield (q/ha)
		Seed treatment	Foliar spray			
1.	Bavistin (Carbendazim 50 W.P.)	0.2	0.1	84.22 (67.73)	9.33 (17.36)	27.9
2.	Jkstein (Carbendazim 50 W.P.)	0.2	0.1	80.3 (63.89)	8.00 (16.2)	26.95
3.	Derosal (Carbendazim 50 W.P.)	0.2	0.1	76.53 (61.18)	7.55 (15.51)	25.90
4.	Thiophanate-methyl	0.2	0.1	84.18 (67.36)	11.11 (18.58)	27.88
5.	Mancozeb	0.2	0.2	76.44 (61.17)	46.67 (43.10)	23.52
6.	Captafol	0.2	0.2	85.41 (68.69)	48.45 (44.1)	22.55
7.	Control	--	--	71.09 (57.58)	72.0 (59.91)	19.22
	S.Em ±	--	--	(2.38)	(3.28)	2.42
	C D (0.05)	--	--	(6.83)	(9.29)	6.95

Figures in parenthesis are angular transformed values.

CORRIGENDUM

As the authors had not furnished the Table 1 in the article entitled "Genetic potential of artificially synthesized *Brassica juncea* for yield improvement" p.p. 80-83, vol 13(1), 1996 a mistake has occured. The correct Table is reproduced below. The error is regretted.

Table 1. ANOVA (mean squares) of seven traits in F3

Source	*df*	*HT*	*PB1*	*SB1*	*SY1*	*SY*	*HI1*	*HI*
Families	63	1600*	3.9*	39.7*	13.1*	171.8*	4.9*	56.3*
Error	256	185.9	1.2	13.2	5.3	56.7	1.6	11.2

* = Significant at 5% level

INFORMATION FOR CONTRIBUTORS

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