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Genetic analysis of pod yield and other confectionery traits in large seeded groundnut, *Arachis hypogaea* L.

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Abstract

Genetic analysis of pod yield and other important yield traits in large seeded genotypes using six generation means indicated the major role of non-additive (h) gene action in the inheritance of pod yield, shelling per cent, sound mature kernels, number of pods, number of mature and immature pods in both the crosses *viz.*, J 11 x TGLPS 3 and TKG 19A x J 11. The character SMK per cent was the only trait, which was influenced by additive as well as non-additive genetic effects (d) in both the crosses. The traits shelling per cent and 100-kernel weight were found to be governed by both additive as well as non-additive genetic effects in the crosses J 11 x TGLPS 3 and TKG 19A x J 11, respectively. Among the epistatic components of genetic variance, the fixable additive x additive genetic component (I) was significant for almost all the traits except for days to flowering in both the crosses and only in J 11 x TGLPS 3 for 100 kernel weight. However, interaction due to additive x dominance (j) was lacking for all the traits except for 100-kernel weight in the cross J 11 x TGLPS 3. The interactions due to dominance x dominance (1) genetic effects prevailed in both the crosses for shelling per cent and days to flowering, while for number of pods and SMK per cent only in the cross J 11 x TGLPS 3 and for 100 kernel weight in TKG 19A x J 11. Thus, the inheritance of majority of the yield traits appears to be complex, which necessitates intermating in the segregating generations followed by pedigree breeding for the genetic enhancement of large seeded groundnut.

Key words: Large seeded genotypes, additive, non-additive, inheritance

Introduction

Groundnut, *Arachis hypogaea* L. is one of the most important oilseed crops grown for variety of purposes. The large seeded groundnut genotypes serve as better candidates for confectionery traits. Among several traits determining confectionery values of export oriented groundnut, aflatoxin level in the produce is considered to be the most important from the health point of view. Hence, incorporation of certain degree of tolerance to large seed types would play a pivotal role in future breeding programmes.

A sound planning of breeding programme for the improvement of quantitative traits rests upon the knowledge of their inheritance. Eventhough significant amount of work has been done on development of large seeded groundnut genotypes, studies on the genetic architecture conditioning the inheritance of different yield components are meager. For such information, the estimation of various genetic effects from the generation means is quite useful in understanding the inheritance of a character and hence the present study was undertaken to estimate gene actions for different yield components in groundnut.

Material and methods

Experimental material for the present study consisted of six generations of two crosses (TKG-19A x J-11) and (J11 x TGLPS-3) *viz.*, P_1, P_2, F_1, F_2, B_1 and B_2. The parent J-11 a Spanish bunch variety with normal size kernels (30-35 g) and fairly good levels of resistance to aflatoxin build up has been crossed with TKG-19A and TGLPS-3, both virginia bunch types with large sized kernels (70 g on grading) but susceptible to fungus producing aflatoxin during *kharif* 2002. Two F_1s were grown in summer 2003 to effect respective back crosses B_1 and B_2. The F_2 generations of both the crosses were derived by selfing part of the F_1s saved.

All the six generations of two crosses were sown in a Randomized Block Design at the Main Agricultural Research Station, Dharwad during *kharif* 2003 with three replications. The plot size consisted of three rows of 5m length for parents and F_1s, 12 rows of F_2s and six rows for B_1 and B_2 randomised in each replication. A spacing of 30 cm and 10 cm was maintained between and within rows, respectively. Hand dibbling was done to maintain proper spacing and optimum plant stand. All the other agronomic practices were followed to raise a successful experimental crop. Observations on eight quantitative traits have been recorded on 100 plants at random in each replication of segregating population, whereas in non-segregating generation, observations were recorded on 10 randomly selected plants per replication.

The data was subjected to generation mean analysis and the interaction effects were estimated as suggested by Hayman (1958). The scaling tests for each character were analysed as per the method suggested by Mather (1949).

Results and discussion

The results pertaining to scaling test and components of variance for all the eight characters (Table 1). The scaling tests A, B, C and D appeared significant for the characters, days to 50% flowering, number of pods/plant, number of mature and immature pods, pod yield, shelling per cent, SMK per cent and 100-kernel weight in both the crosses indicating that additive-dominance model is inadequate to explain the observed variation. Further, significance of any one of the scaling test for a character indicates the role of gene interactions in its inheritance, which may be due to additive x additive (I), additive x dominance (j) and dominance x dominance (l) effects. Therefore, further analysis was extended to know the different interactions prevailed in the inheritance of these characters in both the crosses.

It has been observed that considerable magnitude of variance due to additive genetic effects (d) prevailed for SMK per cent in both the crosses. The important traits such as pod yield, number of pods, number of immature pods and number of mature pods, total number of pods and days to 50 per cent flowering lacked this exploitable variance. However, the cross J-11 x TGLPS-3 indicated additive variance for shelling per cent, while TKG-19A x J-11 for 100-kernel weight. The role of additive gene actions in the inheritance of above traits has also been reported by Kuchanur *et al.* (1997) and Rudraswamy *et al.* (1999) for shelling per cent, Vindhiya Varman and Paramasivam (1992) for SMK per cent, Sudheer Kumar and Patel (1999) and Anderson *et al.* (1993) for 100-kernel weight.

Among the epistatic components of genetic variance, the fixable additive x additive genetic component (I) was significant for almost all the traits except days to flowering in both the crosses. The trait 100 kernel weight, however, appeared to be influenced by additive interactions only in the cross J 11 x TGLPS 3, which assumes importance for increasing seed size in breeding for large seeded genotypes. Prevalence of additive x additive epistasis for these traits is in conformity with the earlier results reported by Halward and Wynne (1991), isleib and Wynne (1983) for pod yield, Kuchanur *et al.* (1997) for 100 kernel weight and shelling per cent, Sudheer Kumar and Patel (1998) for number of mature and immature pods, Varman (2000) for mature pods. Therefore, the selection in early segregating generation of a cross for the improvement of these traits could be advantageous.

The detailed analysis of gene actions revealed that the characters exhibiting significant and positive additive genetic effects invariably have accompanied by additive x additive (I) interaction effects in respect of shelling per cent in the cross J-11 x TGLPS-3 and SMK per cent in both the crosses. However, the notice of positive and significant additive x additive interactions along with negative additive genetic effects in respect of number of pods, number of mature and immature pods and pod yield/plant in both the crosses indicate the predominance of interaction component rather than their direct influence. Additive as well as additive x additive interaction effects with duplicate epistasis is being observed in the cross TKG-19A x J-11 only for SMK per cent. In this case rapid improvement by simple selection programme can be expected since there is possibility of occurrence of transgressive segregants which get stabilised in the early segregating generation itself.

The variance due to dominance genetic effects (h) has also been found to be of greater importance in view of their magnitude and significance over additive genetic effects for almost all the traits except days to flowering. However, the character 100 kernel weight exhibited significant dominance variance only in the cross J-11 x TGLPS-3. The predominant role of dominant gene action in the inheritance of pod yield has also been reported by Halward and Wynne (1991), Sudheer Kumar and Patel (1999) and Dobaria *et al.* (2004) for shelling per cent; Bhagat *et al.* (1986) for SMK per cent; Mather *et al.* (2000) for number of mature pods and Rudraswamy *et al.* (1999) for number of immature pods. The opposite signs for dominance (h) and dominance x dominance (l) components have been observed for days to 50 per cent flowering, number of pods/plant, number of mature pods, number of immature pods and pod yield in both the crosses, indicating duplicate type of epistasis (Sudheer Kumar and Patel, 1998). While for SMK per cent in TKG-19A x J-11 and for 100-kernel weight in J-11 x TGLPS-3 the opposite signs have been observed (Dobaria *et al.*, 2004). The crop probably might have accumulated dominant mutations and perpetuated as an adaptive complex (linkage blocks) to overcome the adverse environmental factors during the course of its evolution. There are also evidences to support that non-additive genetic inheritance may be on account of residual heterozygosity that is being conserved due to segmental polyploidy of groundnut crop (Dobaria *et al.*, 2004).

As pod yield and many of the yield traits are being influenced mainly by the dominance genetic effects, which is unusual in a highly self-pollinated crop like groundnut, its genetic improvement using pedigree breeding may not be effective in isolating superior genotypes. Under the circumstances, the crop demands adoption of alternative breeding strategies to exploit non-additive genetic variance possibly by heterosis breeding. However, heterosis breeding is a distant possibility in groundnut doe to lack of male sterility systems and mode of pollination. In order to exploit non-additive genes conditioning traits Vindhiya Varman and Patel (1994) suggested to delay selection until the genotypes are stabilized in homozygous dominant state, so that superior dominant allelic combinations can be selected.

It is evident from the present investigation that there is complexity in the nature of inheritance of different *characters, since some of the kernel traits like shelling per* cent, SMK per cent and kernel weight are influenced both *by additive as well as non-additive gene actions. Vindhiya* Varman and Paramasivam (1992) have also reported *prevalence of similar type of gene actions for SMK per* cent. Under these circumstances, it becomes inevitable to adopt intermating among the selected genotypes in the early segregating generation of a cross followed by pedigree breeding. This enables to mop up desirable alleles on account of rare recombination and hence efficiently can exploit both additive and non-additive portion of genetic variance as suggested by Vindhiya Varman and Patel (1992) and Parameshwarappa and Satish Kallappagoudar (2005) *in groundnut.*

***Table 1* Scaling test, components of variance and interaction effects for different traits in two groundnut crosses**

Characters	Cross	Scaling test					Interaction effects				
		A	B	C	D	M	(d)	(h)	(i)	(j)	(l)
Days to 50% flowering	TKG-19A x J-11	-9.38**	-8.57**	0.427	9.38**	34.33**	-0.7	-8.52**	-9.40**	-0.631	12.24**
	J-11 x TGLPS-3	-5.71**	-0.71	1.25	3.27**	33.33**	-1.40	-1.96*	-3.26**	-3.47**	4.28**
No. of pods/plant	TKG-19A x J-11	-1.99*	1.04	-4.13**	-5.28**	23.08**	-7.15**	4.72**	5.29**	-3.17**	-2.89**
	J-11 x TGLPS-3	-2.16*	3.58**	-13.88**	-9.50**	19.27**	-0.33	10.92**	9.51**	-3.83**	5.41**
No. of mature pods	TKG-19A x J-11	-1.48	-0.21	-3.52**	-2.49**	18.59**	-2.93**	2.44*	2.49**	-0.88	-0.90
	J-11 x TGLPS-3	-1.63	-1.94*	-8.49**	-6.46**	15.72**	-0.173	7.42**	6.46**	-2.65**	-3.23**
Number of immature pods	TKG-19A x J-11	-0.001	1.92*	1.41	-2.03*	4.48**	-1.98	1.93*	2.03*	-1.29	-1.82
	J-11 x TGLPS-3	-0.157	1.24	-3.60**	-7.00**	3.43**	-0.31	5.72**	7.00**	-1.04	-3.48**
Pod yield/plant	TKG-19A x J-11	-1.60	1.56	-3.53**	-5.17**	28.01**	-3.42**	4.96**	4.17**	-3.62**	-2.62**
	J-11 x TGLPS-3	-1.85	2.01*	-2.57**	-2.42*	29.15**	-2.07*	2.95**	2.41**	-2.82**	-2.12**
Shelling (%)	TKG-19A x J-11	0.097	1.97*	-1.21	-2.67**	67.80**	-15.91**	2.53**	2.67**	-2.22*	2.64**
	J-11 x TGLPS-3	3.86**	4.73**	2.68**	-5.66**	66.92**	4.45**	5.43**	5.67**	0.153	7.22**
SMK (%)	TKG-19A x J-11	-0.75	-1.19	-3.87**	-3.61**	88.81**	2.04*	4.28**	3.62**	0.35	-1.57
	J-11 x TGLPS-3	1.09	0.002	-3.22**	-3.49**	86.77**	1.99*	3.43**	3.49**	0.70	2.37*
100-kernel weight (g)	TKG-19A x J-11	-3.26**	-0.169	0.07	1.82*	54.39**	7.55**	-0.27	-1.82	-3.63**	2.72**
	J-11 x TGLPS-3	3.84**	-2.43*	-1.95*	-4.33**	52.10**	-6.10**	6.55**	4.34**	6.07**	-2.97**

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

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Effect of environment on clustering pattern in toria (*Brassica campestris* sp. *oleifera* var. *toria*)

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Abstract

Genetic divergence (D^2) analysis was studied in 34 genotypes of *toria* to quantify the nature and extent of diversity over two diverse locations. Analysis of variance revealed significant differences among genotypes for all the 13 characters studied at both the locations. Thirty four genotypes were grouped into eight and seven clusters at L_1 and L_2, respectively. The relative composition of clusters differed at the two locations due to involvement of g x e interactions. The distinctness of clusters was proven by distance matrix as inter-cluster distances were greater than almost all the intra-cluster distances. On the basis of inter-cluster distances, genotypes IC 268326, IC 212034 and IC 230974 at L_1 and genotypes IC 212034, IC 212077, IC 230974, IC 259444 and IC 259462 at L_2 are genetically more divergent. Further, the genotypes IC 212031, IC 259352, IC 259441, IC 268318 and IC 212034 showed stability in their divergence over both the locations and were proposed to be included in hybridization programme.

Key words: Genetic divergence, *toria*, inter-cluster distance, seed yield

Introduction

Crosses between divergent parents usually produce greater heterosis than those between closely related ones (Moll and Stuber, 1971). Use of diverse parents in hybridization programme can serve the purpose of combining desirable genes or to obtain recombination. The multivariate D^2 analysis (Mahalanobis, 1936) is one of the important biometrical tool in quantifying the genetic divergence in the germplasm. Using this method in the present study, an attempt has been made to classify the 34 elite strains of *toria* into different groups at two diverse locations and to quantify the magnitude of genetic divergence for their further use in recombination breeding with expectation of getting potential transgressive segregants.

Material and methods

Thirty four genotypes of *toria* procured from Germplasm Collection Centre, NBPGR, New Delhi, were grown in a Randomized Block Design experiment with three replications during 2003 at two diverse locations i.e., Simbholi (L_1) and R.S. Pura, Jammu (L_2). In each replication, each genotype was sown in a row of 3 m length with inter and intra-row spacing of 30 x 15 cm. Recommended agronomic practices were followed. At both the locations, five competitive plants/genotype/ replication were tagged and observations on various traits were recorded (Table 3).The data were subjected to multivariate analysis (Mahalanobis, 1936). The genotypes were further grouped into different clusters based on Euclidean cluster analysis (Beale, 1969).

Results and discussion

Analysis of variance revealed significant differences among the genotypes for all the 13 characters at both the locations suggesting adequate variability among the genotypes. Samad and Khalequa (2000), Chaudhary and Joshi (2001) and Ghosh and Gulati (2002) also reported the genetic diversity for yield and other agronomic characters in *Brassica* entries using multivariate analysis. Thirty four genotypes were classified into eight and seven clusters at L_1 and L_2, respectively, on the basis of their observed traits (Table 1 and 2) revealing the presence of considerable amount of genetic diversity in the material. Cluster I, II and V at L_1 and cluster II and III at L_2 were the largest as having seven genotypes each while the cluster VI (IC 268326) at L_1 and cluster VII (IC 212034) at L_2 were having only one genotype each.

Maximum genotypes included in cluster I and L_2 were accommodated in cluster I of L_1 also. In addition, genotypes from cluster III of L_2 also accommodated in cluster I of L_1. Interestingly, some of the genotypes such as IC 212032 (cluster II), IC 259352, IC 259441 and IC 268318 (cluster V) and IC 212034 (cluster VII) did not change their clustering behaviour at both the locations. In the present study, though the total number of clusters at two locations were comparable, the relative composition of different clusters varied markedly at two locations. Some of the genotypes, however, changed their clustering at two locations indicating the role of genotype x environment interaction on genetic divergence.

Statistical distances between the clusters (inter-cluster distance) represent the extent of diversity amongst the genotypes which are accommodated into different clusters. A perusal of the distance matrix (Table 3) indicated that inter-cluster distance was maximum between cluster V and VI of L_1 and between cluster IV and VII of L_2. The intra-cluster distance was the lowest for the cluster III (L_1) and for cluster I (L_2) indicating that these clusters were the most compact than others. This indicated that the genotypes of the clusters having more intra-cluster distance are more heterogenous that is, diverse among themselves.

A perusal of the Table 4 revealed that wide range of variations occur for all the characters except days to 50% flowering, days to maturity, number of primary branches, 1000-seed weight and oil content at both the locations. The maximum and minimum cluster mean values for different clusters did not reveal any consistency over the two locations. The maximum contribution to divergence was made by number of secondary branches (11.43% and 11.96% at L_1 and L_2) followed by days to maturity (9.58% at L_1) and seed yield (9.90% at L_2).

After D^2 analysis, divergent genotypes may be selected on the basis of inter-cluster distances, since it is obvious that the genotypes included in clusters with maximum inter-cluster distances are genetically more divergent. Thus, genotypes in the cluster VI and VII (IC 268326, IC 212034 and IC 230974) of L_1 and genotypes in cluster IV and VII (IC 212034, IC 212077, IC 230974, IC 259444 and IC 259462) of L_2 are genetically more divergent. Further, it is of interest to note that the genotypes IC 212031, IC 259352, IC 259441, IC 268318 and IC 212034 showed stability in their divergent over both the locations and thus showed greater divergence. Therefore, the use of these genotypes in hybridization programme for improvement in seed yield of *toria* is recommended, because the behaviour of these genotypes is expected to be relatively consistent over the locations.

Table 1 Distribution of 34 genotypes of *toria* in different clusters at L_1 (Simbhaoli)

Cluster	No. of genotypes	Name of genotype
I	7	IC-259353, IC-259355, IC-259445, IC-259449, IC-259457, IC-259467, IC-259468
II	7	IC-212032, IC-212033, IC-214824, IC-259444, IC-259448, IC-259456, IC-259460
III	3	IC-259443, IC-259462, IC-268313
IV	3	IC-259446, IC-259447, IC-259465
V	7	IC-212129, IC-259230, IC-259340, IC-259351, IC-259352, IC-259441, IC-268318
VI	1	IC-268326
VII	2	IC-212034, IC-230974
VIII	4	IC-212077, IC-259461, IC-268317, IC-268321

Table 2 Distribution of 34 genotypes of *toria* in different clusters at L_2 (R.S. Pura, J&K)

Cluster	No. of genotypes	Name of genotype
I	5	IC-259355, IC-259443, IC-259445, IC-259449, IC-259463
II	7	IC-212032, IC-212129, IC-259340, IC-259446, IC-259461, IC-268313, IC-268326
III	7	IC-259351, IC-259353, IC-259447, IC-259457, IC-259460, IC-259465, IC-259467,
IV	4	IC-212077, IC-230974, IC-259444, IC-259462
V	5	IC-212033, IC-259352, IC-259441, IC-259448, IC-268318
VI	5	IC-214824, IC-259230, IC-259456, IC-268317, IC-268321
VII	1	IC-212034

Table 3 Average inter and intra-cluster (bold values) distance involving 34 genotypes of *toria* at Simbhaoli (L_1) and R.S. Pura (L_2)

Cluster	I	II	III	IV	V	VI	VII	VIII
I	**2.439** **(1.993)**	3.078 (3.513)	3.773 (3.429)	4.717 (5.200)	2.937 (4.263)	5.345 (3.621)	7.882 (5.983)	4.562
II		**2.182** **(2.439)**	4.046 (3.303)	3.132 (3.644)	2.436 (3.560)	5.455 (2.797)	6.509 (5.811)	3.567
III			**2.132** **(2.355)**	4.524 (3.502)	3.104 (4.002)	4.899 (3.943)	6.205 (7.037)	3.078
IV				**2.667** **(2.881)**	3.594 (4.963)	5.577 (5.408)	7.486 (7.332)	3.853
V					**2.306** **(2.659)**	4.552 (3.548)	7.779 (5.125)	2.757
VI						**0.000** **(2.351)**	8.812 (5.751)	5.957
VII							**2.640** **(0.000)**	4.477
VIII								**2.488**

Values in parentheses are for L_2

Table 4 Cluster mean values for 13 characters in *toria* in Simbhaoli (L_1) and R.S. Pura (L_2) locations

Cluster No./Character		I	II	III	IV	V	VI	VII	VIII
Days to 50% flowering	L_1	22.76	24.19	24.78	24.00	23.67	27.67	24.83	24.08
	L_2	23.33	27.19	23.67	25.67	25.53	24.47	25.00	
Days maturity	L_1	89.81	90.86	92.00	91.33	91.86	91.33	95.50	93.50
	L_2	92.47	97.14	92.52	98.58	94.67	94.67	98.67	
Plant height (cm)	L_1	69.06	75.21	82.31	71.29	86.87	77.87	117.79	88.94
	L_2	68.68	86.04	77.85	86.52	84.65	82.58	104.08	
No. of primary branches	L_1	3.20	3.63	3.71	4.90	3.74	4.11	3.28	4.16
	L_2	3.14	3.61	4.40	4.75	3.58	3.18	2.44	
No. of secondary branches	L_1	9.74	11.01	10.11	12.44	10.06	9.00	10.42	11.12
	L_2	10.31	10.43	12.13	12.23	11.27	10.11	9.05	
No. of siliquae/plant	L_1	152.81	160.86	201.44	174.24	182.22	170.33	254.67	242.33
	L_2	146.95	206.47	202.09	240.29	173.73	175.62	105.58	
Siliqua length (cm)	L_1	4.23	3.51	3.58	3.28	4.05	3.55	4.49	4.28
	L_2	4.62	4.23	4.83	4.45	3.95	3.58	5.84	
No. of seeds/siliqua	L_1	15.14	13.98	16.56	11.11	12.65	10.67	17.67	15.83
	L_2	15.73	14.15	13.82	17.08	13.60	12.50	17.89	
Seed yield (g)	L_1	5.42	9.09	6.83	7.85	8.32	3.31	15.66	9.21
	L_2	9.95	10.28	11.90	13.77	10.78	9.05	9.51	
Biological yield (g)	L_1	24.44	32.09	43.71	36.83	36.02	20.64	69.42	43.19
	L_2	42.82	46.27	50.61	53.32	29.19	44.72	28.87	
Harvest index (%)	L_1	22.88	28.68	16.05	21.17	23.27	16.17	24.13	21.78
	L_2	23.21	22.50	23.83	26.20	37.18	20.71	33.69	
1000-seed weight (g)	L_1	2.95	2.44	3.43	2.49	3.10	3.57	2.32	2.70
	L_2	4.16	3.83	3.92	3.48	3.26	2.94	2.41	
Oil content (%)	L_1	38.85	37.44	40.80	37.34	36.72	34.53	36.67	38.28
	L_2	40.15	38.35	37.33	41.06	36.33	36.12	36.13	

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Inheritance of yield contributing characters and oil content in Indian mustard, *Brassica juncea* (L.) Czern and Coss*

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Abstract

The six generation (P_1, P_2, F_1, F_2, BC_1 and BC_2) of three cross combinations of Indian mustard, *B. juncea*, *viz.*, (BEC-144×B-334, GPB-65×B-342 and B-330×BEC-144), were studied for eight traits namely days to 50% flowering, days to maturity, plant height, number of branches, biological yield, 1000-seed weight, seed yield and oil content at S.V.B.P. University of Agriculture and Technology, Meerut. All the generations of each cross combination were evaluated in a Randomized Block Design with three replications. The mean of six generations was subjected to scaling tests to determine epistasis and genetic parameters m, d, h, i, j and l were estimated. An epistatic digenic model including all types of interactions played a major role for all the cross combinations. The study revealed the importance of both additive and non-additive type of gene action for all the characters studied. Duplicate epistasis played a relatively greater role than complementary epistasis. Therefore, reciprocal recurrent selection is suggested for development of a superior variety.

Key words: Mustard, generation mean, gene action, yield components, oil content

Introduction

Indian mustard [*Brassica juncea* (L.) Czern & Coss], is the most important member of the group, accounting for more than 70% of the area under rapeseed and mustard. Yield is one of the most important economic character and is the product of multiplicative interaction of contributing characters. For genetic improvement of the crop, the breeding method to be adopted depends mainly on the nature of gene action involved in the expression of quantitative traits. Line × Tester (L × T) analysis is used to select the parents based on their combining ability but fails to detect the epistasis, which remains the most complex problem and on which it is extremely difficult to obtain reliable results. The epistasis can be detected by the analysis of generation means using the scaling test, which determine the nature of epistasis or accurately whether it is additive × additive (iab), additive × dominance (jab/jba) and dominance × dominance (lab) type of interaction at the digenic level. The objective of this investigation was to obtain information on the gene effects in Indian mustard to provide a basis of selection in a breeding programme for the improvement of the Indian mustard.

Material and methods

Six generations *viz.*, (P_1, P_2, F_1, F_2, BC_1 and BC_2) of three cross combinations of Indian mustard namely BEC-144 × B-334, GPB-65×B-342 and B-330×BEC-144, were raised in a Randomized Block Design with three replications. Ten plants were selected randomly from each of P_1, P_2, and F_1, 30 each of BC_1 and BC_2 and 50 of F_2 generations and utilized for recording of data on eight quantitative characters namely days to 50% flowering, days to maturity, plant height, number of branches, biological yield, 1000-seed weight, seed yield and oil content. The data recorded were subjected to weighted analysis of Cavalli (1952) to know the adequacy of additive dominance model. In the presence of epistasis, the data where any of the 4, 5 or 6 parameters found adequate in the model of Jink and Jones (1968) was subjected accordingly to sequential model in order to obtain more precise estimate for these parameters. The adequacy of these sequential models was tested by χ^2 test, respectively.

Results and discussion

The hybrid performed better than their respective parents for all the traits in all cross combinations except for the crosses GPB-65×B-342 and B-330×BEC-144 with regard to the number of branches per plant, both these crosses showing inferior performance than their respective P_1 generation. In general, however, the trait mean values for the F_1 and F_2 generations were higher than the corresponding values for the BC_1 and BC_2 generations. While the values for the F_2 generation were lower than the corresponding values of F_1 generations in most of the crosses. The mean performance of the BC_2 generation were lower than that of the BC_1 generation for all crosses and traits except for days to flowering in the cross GPB-65 × B-342, seed yield/plant in the crosses BEC-144 × B-334 and B-330 × BEC-144 and oil content in all the crosses.

* Part of Ph.D. thesis of first author.

The expected mean (m) was positive and significant for all the traits in all the three cross combinations.

Simple additive-dominance model was inadequate for days to 50% flowering in cross BEC-144 x B-334 and B-330 x BEC-144 (Table 2). In cross BEC-144 x B-334 and B-330 x BEC-144 dominance, additive and dominance × dominance gene effect were important. In cross GPB-65 x B-342 dominance gene effects was important. Duplicate epistasis was indicated by opposite sign of dominance and dominance × dominance type of gene effects influencing the inheritance of the trait.

Presence of non-allelic interaction was observed for inheritance of days to maturity in cross combinations BEC-144 x B-334 and B-330 x BEC-144. In addition to additive and dominance gene effects additive × dominance in cross BEC-144 x B-334 and additive × additive and dominance × dominance in which cross was also influencing the inheritance of this trait. In cross GPB-65 × B-342 dominance gene effect was important for inheritance of the trait. Anand and Rawat (1984) observed that dominance effect was more important for the inheritance of this trait in Indian mustard.

Presence of epistasis was detected for plant height in all the three crosses. Moreover, in addition to additive dominance, gene effects non-allelic interactions such as additive × additive, additive × dominance and dominance × dominance gene effects were important. The negative value of dominance gene effects suggest the presence of alleles decreasing this trait in the cross B-330 x BEC-144. In the crosses BEC-144 x B-334 and B-330 x BEC-144, dominance and dominance × dominance gene effect indicates duplicate epistasis. Sunil and Singh (2004) also reported similar results in Indian mustard.

In case of number of branches presence of non-allelic interactions were important for this trait. In case of cross BEC-144 x B-334 additive × additive, additive × dominance and dominance × dominance type of gene interactions were important. In cross GPB-65 × B-342 and B-330 x BEC-144 dominance, additive × additive and dominance × dominance gene effects were important for inheritance of this trait. Duplicate epistasis was observed in all three crosses due to opposite sign's of dominance and dominance × dominance influencing the inheritance of this trait. The present findings are similar to earlier reports of Subudhi and Raut (2003), who reported duplicate type of gene action for number of primary branches and secondary branches.

Simple additive-dominance model was inadequate in all the three crosses for biological yield. In cross BEC-144 x B-334, both additive and dominance gene effects were significant along with non-allelic interaction additive × additive and additive × dominance. In cross GPB-65 x B-342 additive, dominance, additive × additive and dominance × dominance type of gene effects were important. Complimentary epistasis was observed in cross GPB-65 x B-342. While in cross B-330 x BEC-144 dominance, additive × additive and dominance × dominance of gene effects were important. Duplicate epistasis was observed in cross B-330 x BEC-144. Singh *et al.* (1996) also observed preponderance of non-additive gene effects influencing this trait in Indian mustard.

In case of 1000-seed weight presence of non-allelic interaction were important. In case of cross GPB-65 x B-342 additive × additive and in B-330 x BEC-144 dominance × dominance gene effects were important in the inheritance of this trait. Complementary type of gene action was observed in cross B-330 x BEC-144. Similar results were observed by Singh *et al.* (1996) in Indian mustard. Simple additive dominance model was inadequate for all the three crosses for seed yield/plant. In cross combinations BEC-144 x B-334 and GPB-65 x B-342, dominance and additive × dominance gene effects were important for the inheritance of this trait. In cross B-330 x BEC-144 dominance, additive × additive, additive × dominance and dominance × dominance gene effects were significant. These results are in agreement with the findings of Sunil and Singh (2004) in Indian mustard.

Presence of epistasis was detected for oil content in all the three crosses. In cross BEC-144 x B-334 both additive and dominance gene effects were significant along with non-allelic interaction, additive x dominance and dominance x dominance. In cross GPB-65 x B-342, additive, dominance, additive x additive and additive x dominance gene effects was important. In cross B-330 x BEC-144 dominance, additive x additive and dominance x dominance gene effects were significant for inheritance of oil content. Duplicate epistasis was observed in BEC-144 x B-334 and B-330 x BEC-144 as indicated by the opposite sign's of dominance and dominance x dominance. Similar result was observed by Rajendra and Singh (2004).

The additive effects and gene interaction additive x additive (I) or other digenic complementary gene interaction can be exploited effectively by selection for the improvement of the characters. Use of reciprocal recurrent selection or bi-parental mating was suggested for improving the characters, when both additive and non-additive gene effects are involved in the expression of these traits. Presence of non- additive gene effects for some characters indicating that conventional selection procedure may not be effective enough for improvement of yield. Therefore postponement of selection in later generations or intermating among the selected segregants followed by one or two generations of selfing could be suggested to break the undesirable linkage and allow the accumulation of favorable alleles for the improvement of this trait.

Thus the study revealed that additive and non-additive gene actions in the expression of these traits. Hence, methods, which exploit additive and non- additive gene action, such as reciprocal recurrent selection could hold promise for genetic improvement of these traits. Furthermore, as the duplicate type of epistasis was observed in most of the traits, so the selection intensity should be mild in the earlier and intense in the later generation to achieve the desirable improvement in these traits in Indian mustard.

Table 1* Mean and their standard error of six generations in three crosses of Indian mustard *for eight traits

Character	Generation and trait	BEC-144 x B-334	GPB 65 x B-342	*B-330 x BEC-144*
Days to flowering	P_1	59.40 ±1.10	56.45 ±2.95	61.50 ±1.50
	P_2	68.90 ±1.51	68.15 ±3.01	59.40 ±1.10
	F_1	72.210 ±2.21	71.48 ±1.98	59.21 ±1.10
	F_2	70.25 ±2.06	69.33 ±2.03	63.12 ±1.00
	B_1	62.75 ±2.56	66.26 ±3.15	56.57 ±1.56
	B_2	62.65 ±2.35	66.75 ±1.25	54.09 ±4.09
Days to maturity	P_1	124.99 ±4.68	129.56 ±1.44	132.51 ±2.60
	P_2	133.00 ±5.00	137.56 ±2.44	127.99 ±4.68
	F_1	137.56 ±2.56	137.56 ±3.44	129.55 ±3.65
	F_2	134.56 ±2.56	136.60 ±2.70	134.16 ±2.04
	B_1	136.50 ±1.50	138.01 ±2.11	129.57 ±1.43
	B_2	131.56 ±6.44	137.59 ±2.59	128.45 ±2.55
Plant height	P_1	148.07 ±9.07	149.00 ±1.00	137.20 ±2.00
	P_2	122.80 ±2.80	136.00 ±5.00	148.07 ±9.07
	F_1	168.65 ±3.65	157.50 ±2.50	142.66 ±2.66
	F_2	157.65 ±2.65	156.01 ±2.12	156.20 ±2.20
	B_1	163.70 ±5.70	152.26 ±2.05	140.70 ±2.50
	B_2	164.30 ±4.00	154.71 ±2.59	147.60 ±2.60
No. of branches	P_1	28.11 ±2.01	30.75 ±0.75	33.65 ±0.65
	P_2	21.71 ±1.71	27.90 ±2.60	28.11 ±2.01
	F_1	31.57 ±1.57	29.058 ±0.95	29.67 ±1.56
	F_2	31.07 ±1.07	30.83 ±0.70	31.16 ±1.97
	B_1	29.06 ±1.07	27.17 ±1.26	28.85 ±1.55
	B_2	27.56 ±2.44	23.26 ±2.36	28.22 ±0.08
Biological yield	P_1	58.78 ±4.64	53.86 ±4.86	56.89 ±3.89
	P_2	64.56 ±1.44	58.03 ±3.70	58.98 ±4.64
	F_1	67.85 ±2.46	66.70 ±1.70	58.16 ±1.16
	F_2	67.01 ±1.11	62.25 ±2.25	61.62 ±1.50
	B_1	67.20 ±1.80	65.12 ±2.00	56.47 ±2.67
	B_2	65.25 ±3.25	65.62 ±0.50	54.69 ±2.69
1000-seed weight	P_1	3.26 ±0.25	4.65 ±0.15	3.53±0.02
	P_2	3.91 ±0.09	3.55 ±0.04	3.26 ±0.25
	F_1	4.22 ±0.41	4.28 ±0.32	3.75 ±0.25
	F_2	4.35 ±0.15	4.50 ±0.00	3.90 ±0.10
	B_1	4.25±0.25	4.28 ±0.16	3.95 ±0.05
	B_2	4.25 ±0.55	4.05 ±0.55	3.53 ±0.42
Seed yield/plant	P_1	19.22±1.08	20.31 ±0.81	18.78 ±0.78
	P_2	20.13±1.43	18.45 ±2.05	19.22 ±1.08
	F_1	21.62±1.50	22.06 ±2.06	19.55 ±1.45
	F_2	21.06±1.06	21.10 ±1.20	20.90 ±0.41
	B_1	20.01 ±1.11	21.70 ±1.40	19.12±0.99
	B_2	21.84 ±0.66	21.67 ±1.43	20.01 ±0.11
Oil content	P_1	37.85 ±2.73	36.04 ±0.56	29.51 ±1.01
	P_2	34.99 ±4.99	36.80 ±1.70	37.85 ±2.73
	F_1	40.25 ±1.75	37.72 ±2.42	36.13 ±2.01
	F_2	39.68 ±1.55	37.95 ±0.95	39.07 ±0.06
	B_1	41.06 ±0.94	36.85 ±1.65	34.01 ±3.11
	B_2	42.00 ±1.00	37.15 ±1.65	35.06 ±2.06

***Table 2** Estimation of genetic parameters in Indian mustard*

Character	Cross	m	(d)	(h)	(i)	(j)	(l)	Epistasis
Days to 50% flowering	C_1	94.35**±2.05	0.10±0.47	-22.15**±5.02	-30.20**±7.75	4.85**±1.59	5.21**±1.83	D
	C_2	83.68**±2.02	-0.48±0.38	-2.10*±.95	-	-	-	-
	C_3	91.61**±0.99	2.47±1.37	-32.41**±8.73	-31.17**±7.62	-	49.17**±8.19	D
Days to maturity	C_1	119.11**±2.55	4.94**±1.61	6.45**±1.26	-	8.94*±4.46	-	-
	C_2	88.76**±2.69	0.41±0.34	8.79**±3.23	-	-	-	-
	C_3	150.84**±2.03	1.11±0.92	-19.80*±10.01	20.61**±7.04	-	21.17**±7.89	D
Pant Height	C_1	154.03**±2.65	-0.60±2.96	58.62**±10.49	25.40*±12.50	1.32**±0.42	-73.22**±10.22	D
	C_2	152.60**±2.11	-2.45±2.30	4.86**±1.31	-10.13**±2.73	-8.95**±3.17	-	-
	C_3	188.65**±2.19	-6.90**±2.60	-48.17**±8.57	-48.19**±7.37	-	42.18**±10.00	D
Number of Branches	C_1	37.94**±1.06	1.50*±0.66	-4.35*±2.11	11.01**±5.01	-	10.71**±1.21	D
	C_2	51.98**±0.70	3.90±2.67	-22.72**±6.27	-22.45**±6.05	-	38.35**±9.55	D
	C_3	41.38**±1.96	0.63±0.55	-11.69*±4.65	-10.49*±4.45	-	17.47*±7.69	D
Biological Yield	C_1	74.17**±1.11	1.94**±0.71	3.04*±1.32	-3.14**±0.65	4.83*±2.44	-	-
	C_2	60.96**±2.25	-0.50**±0.06	23.23**±8.49	12.48**±2.89	-	28.67**±10.06	C
	C_3	82.09**±1.50	1.77±1.78	-23.84**±5.19	-24.16**±8.66	-	33.84**±5.53	D
1000- Seed weight	C_1	3.98**±0.15	0.00±0.60	2.32±1.41	-	-	-	-
	C_2	4.93**±0.00	0.23±0.57	-0.65±1.19	-1.33**±0.14	-	-	-
	C_3	4.03±4.99	0.41±0.40	-0.27**±0.06	-	-	-5.99**±1.80	C
Seed Yield/plant	C_1	22.45**±1.05	-0.18±0.29	1.41**±0.26	-	-1.37*±0.57	-	-
	C_2	17.04**±1.20	3.49±2.00	4.99**±1.69	-	-0.89**±0.28	-	-
	C_3	24.34**±0.40	-0.89±1.00	-4.82**±1.02	-5.36**±2.03	-0.67**±0.20	4.22**±1.36	D
Oil content	C_1	29.01**±1.54	-0.94*±0.37	11.23*±5.55	-	-2.37*±1.15	-20.18*±8.63	D
	C_2	39.22**±0.95	-3.00*±1.33	-25.05**±6.50	-3.80*±5.01	7.99**±2.49	-	-
	C_3	51.82**±5.38	-1.01±3.73	-15.67**±5.86	-18.12**±5.46	-	19.60*±8.72	D

Where, C_1 = BEC-144 x B-334; C_2 = GPB 65 x B-342; C_3 = B-330 x BEC-144; (m) = mean (SEm±); (d)=additive; (h)=dominance; (i)=additive x additive; (j)=additive x dominance; (l)=dominance x dominance. An asterisk (**,*) indicates that the value was significant by the t-test at *the 1% and 5% probability level*

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Maintainer and restorer behaviour of some elite inbred lines on different cytoplasmic male sterile sources and inheritance of fertility restoration in sunflower, *Helianthus annuus* L.

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Abstract

The development of commercial sunflower hybrids based on new CMS sources is of special interest for reducing the potential risk of vulnerability to pathogens and for increasing genetic diversity. Four CMS lines belonging to two different sources of cytoplasmic male sterility, PET-1 (DCMS- 5 and CMS-234) and ARG (DCMS- 41 and DCMS- 42) were crossed with 25 inbred lines to identify the maintainer or restorer behaviour. Few lines restored fertility for *classical petiolaris cytoplasm* PET-1. Out of 25 inbreds tested 9 were found to be restorers for PET-1 while 15 inbreds behaved as maintainers and one inbred acted as partial restorer. For ARG Cytoplasm, 8 inbreds out of 25, could restore fertility, 14 inbreds behaved as maintainers and 3 inbreds were found to be partial restorers. Based on the success of fertility restoration 34 F_1 were studied for the inheritance of fertility restoration. All the crosses showed monogenic control. From the present study, a few effective restorers could be identified for the CMS sources, which can be exploited in developing hybrids with better heterosis possessing alternate cytoplasm.

Key words: Sunflower, cytoplasmic diversity, fertility restoration, male sterility, maintainer

Introduction

Cytoplasmic male sterility (CMS) and genetic fertility restoration have been used in commercial production of hybrid seed of sunflower since 1972. A land mark in sunflower breeding was the discovery of CMS lines by Leclercq (1969) and identification of the genes for fertility restoration by Kinman (1970). It opened a new era in sunflower. breeding, since it has been a shift from population breeding to development of hybrids and leads to the exploitation of hybrid vigour and commercial hybrid seed production. Since 1972, only the PET-1 cytoplasm *has been utilized in* commercial production of hybrid sunflower seed, which creates a high degree of genetic vulnerability in hybrid sunflower.

Sunflower researchers have attempted to identify new, diverse sources of CMS to widen the genetic base of cultivated sunflower. Fortunately, several new sources of cytoplasmic male sterility have been reported by Serieys and Vincourt (1987) and Whelan (1980). The use of new CMS sources would allow broadening of the genetic base of the cytoplasm since molecular studies on the relationships between CMS sources have revealed polymorphisms in the mitochondrial DNA (Crouzillat *et. al.*, 1994). But using this diverse CMS sources, hybrids could not be developed because of the non-availability of effective restorers for these new CMS sources. (Vishnuvardhan Reddy *et al.*, 2002). Present investigation was taken up to explore the possibilities of finding out good restorers and maintainers based on sterility and fertility reactions in different CMS sources. The best inbreds identified have to be converted in to CMS lines before being used in hybrid development, those inbreds *from maintainer* gene pool are used for new CMS lines development and those from restorer gene pool are used as male lines in hybrid programme.

Material and methods

Four cytoplasmic male sterile lines *viz.*, DCMS-5 and CMS-234 belonging to *H. petiolaris* (PET-1) cytoplasm and DCMS-41 and DCMS-42 belongs to *H. argophyllus* (ARG) cytoplasm were crossed to 25 inbreds to determine the fertility restoring ability of the inbred lines. Total 100 crosses were obtained in *kharif* 2003 and F_1s were evaluated in *rabi*, 2003 in Directorate of Oilseeds Research (DOR), Rajendranagar, Hyderabad.

Each F_1 was grown in three rows of 5 m length with a *spacing of 60 cm* between rows and 30 cm between plants with in a row. The hybrids were classified as male fertile/male sterile based on the dehiscence and pollen shedding at anthesis Further, pollen fertility was confirmed in the laboratory by using 1% Acetocarmine staining procedure (Chaudhary *et al.*, 1981).Based upon this data, the lines could be classified as new maintainers *or restorers for the new cytoplasm. Out of 100* F_1 *hybrids*, 34 hybrids which showed complete fertility reaction were selfed and carried forward to F_2 generation to know the

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nature of inheritance of fertility restoration of newly identified restorers for the four CMS lines based on F_2 segregation and the data on fertile and sterile plants was subjected to chi-square test of goodness of fit.

Results and discussion

Results of the present study indicated that out of twenty five inbreds tested in the cytoplasmic background of PET-1 of *CMS- 234 and DCMS-5 nine inbreds viz.*, I_1,I_2, I_{12}, I_{17}, I_{18}, I_{20}, I_{21}, I_{24}, and I_{25}, were proved to be effective restorers, while fifteen inbreds behaved as maintainers and only one inbred I_{10} showed partial restoration. For CMS lines DCMS-41 and DCMS-42 (ARG Cytoplasm) eight inbreds (I_1,I_2, I_5, I_{10}, I_{16}, I_{18}, I_{24}, and I_{25}) restored fertility in both, while 14 inbreds behaved as maintainers and the *remaining 3 inbreds behaved as partial restorers (Table 1* and 2). This indicates that for the male sterile lines with same cytoplasmic background the fertility restoring genes might be same. Similar results of differences in fertility restoring genes for different CMS backgrounds have been reported by Whelan (1980) and Virupakshappa *et al.* (1991). *Five inbreds (I_1, I_2, I_{18}, I_{24} and I_{25}) restored fertility* in all the CMS lines and acted as common restorers, while eleven inbreds acted as common maintainers for both the CMS sources. Kukosh (1981) reported that inbreds were found to carry Rf genes and can restore fertility with CMS lines developed with diverse cytoplasmic background.

Inbreds *viz.*, I_{12}, I_{17}, I_{20} and I_{21} which were found to be good restorers for the traditional PET-1 cytoplasm (CMS-234 and DMCS-5), behaved as partial restorer (I_{12}) and maintainers on ARG cytoplasm (DCMS 41 and 42). For ARG cytoplasm two inbreds (I_5 and I_{16}) could effectively restore fertility but behaved as maintainers on PET-1 cytoplasm. Inbreds I_8, I_{13} acted as maintainers on PET-1 cytoplasm, but behaved as partial restorers on ARG cytoplasm. While, inbred (I_{10}) which was behaved as partial restorer for PET-1 cytoplasm, acted as fertility restorer for ARG cytoplasm.

Table 1 Restorer/maintainer reaction of different inbred lines in the background of four CMS lines (two sources)

Code No.	Inbred Genotype	PET – 1		ARG	
		CMS 234	DCMS 5	DCMS 41	DCMS 42
I_1	RCR 8297	R	R	R	R
I_2	LTRR 5	R	R	R	R
I_3	M 2695	M	M	M	M
I_4	M 1029	M	M	M	M
I_5	M 80 – 1	M	M	R	R
I_6	M 1019	M	M	M	M
I_7	M 1008	M	M	M	M
I_8	M 120	M	M	PR	PR
I_9	M 1017	M	M	M	M
I_{10}	R 344	PR	PR	R	R
I_{11}	PR ARUN 1329	M	M	M	M
I_{12}	HIR 1734 – 1	R	R	PR	PR
I_{13}	M 1024	M	M	PR	PR
I_{14}	SEL 1	M	M	M	M
I_{15}	M 92 – 4	M	M	M	M
I_{16}	LTRR 341	M	M	R	R
I_{17}	RHA 348	R	R	M	M
I_{18}	TUB 346	R	R	R	R
I_{19}	HA 380	M	M	M	M
I_{20}	RHA 341	R	R	M	M
I_{21}	RHA 271	R	R	M	M
I_{22}	NDOL 2	M	M	M	M
I_{23}	BLC P 6	M	M	M	M
I_{24}	RES 834	R	R	R	R
I_{25}	DSI 15	R	R	R	R

M = Maintainer; R = Restorer; PR = Partial restorer

It is evident from the present study, that various inbred lines behaved differently on two CMS background in respect of their maintainer and restorer reaction, there by indicating that these two CMS sources are different from one another and possess distinct mechanism of male sterility. Hence these CMS lines can be safely included in the breeding programme to broaden the genetic base of cytoplasmic male sterility in sunflower to avoid the possible risk of susceptibility. The restorers identified will help in exploitation of new CMS sources for hybrid development with better heterosis and diversity of cytoplasm in sunflower.

A few crosses showed partial restoration on two different cytoplasm (PET-1 and ARG). This was attributed either to contamination of foreign pollen or the heterozygosity of the lines to restorer genes. Hence these crosses need further confirmation. These inbreds can be utilized by selfing and crossing with CMS lines so that the possibility of developing a new restorer is explored. The promising inbreds identified as maintainers after testing for their combining ability and agronomic performance will be utilized in the development of new CMS lines and may be used in sunflower improvement programme for developing diverse hybrids with better heterosis and resistence to diseases and insect pests.

Inheritances of fertility restoration: Segregation analysis of male fertile and male sterile plants in the F_2 population of all the crosses indicate that for both CMS sources a single dominant restorer gene is sufficient to obtain male fertile plants. With PET-1 cytoplasm, eighteen crosses showed complete fertile reaction and with ARG cytoplasm, sixteen crosses showed complete fertile reaction in F_1 generation showing the dominant nature of fertility over sterility. F_1 segregation ratio 3:1 fertile and sterile plants, respectively indicating the presence of single dominant gene for the fertility restoration. The results obtained are in agreement with that of Seiler and Jan (1994), Horn and Ferdiet (1997), Trinadh Kumar (1999) and Rukmini Devi (2002). Single dominant gene in inbreds M 80-1 LTRR 341 restored fertility in ARG cytoplasm but not in PET-1 and single dominant gene in inbreds RHA 341, RHA 271 and RHA 348 restored fertility in PET-1 cytoplasm but not in ARG cytoplasmic source. These results clearly indicate that single dominant gene restoring the fertility in PET -1 cytoplasm in different from the one restoring the fertility in ARG cytoplasm while the single dominant gene in inbreds RCR 8297,LTRR 5, RES 834, DSI 15 and TUB 346 restored fertility in both the CMS sources *viz*., PET -1 (CMS 234 and DCMS 5) and ARG (DCMS 41 and DCMS 42) indicating that single dominant gene restoring the fertility might be same.

Varanceanu and Stoenescu (1978) reported that in three cases, fertility restoration was conditioned by three complementary genes and in one case by cumulative action of two non-allellic dominant genes. Whelan (1980) reported the cases in which fertility restoration was controlled by four non-allelic genes .However, in this study, no case was found in which three or more genes are responsible for pollen fertility restoration. Thus it can be concluded that the fertility restoration ability was controlled by single or two dominant genes with different interaction effects depending on restorers involved and CMS lines used.

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Effects of organic and inorganic sources of nutrition on growth and yield of soybean in soybean-wheat sequence

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Abstract

The field experiment was initiated during *kharif* 1996 by keeping organic (pure), integrated (partial) and chemical farming systems. On the same field the present investigation (2000-01 and 2001-02) was conducted at the experimental farm of the Department of Agronomy, Punjab Agricultural University, Ludhiana on sandy loam soil. In soybean-wheat sequence, FYM application @10 t/ha to soybean and 20 t/ha to wheat along with incorporation of residues, Recommended levels of chemical fertilizers along with incorporation of residues and green manuring of sunnhemp (*Crotolaria juncea*) gave 18.0 and 13.7% higher soybean seed yield, respectively than the recommended chemical fertilizer treatment (16.57 q/ha). The full and partial organic farming treatments showed discernible edge in the yield attributing characters, periodic photosynthetically active radiation interception, plant height, drymatter accumulation, leaf area index over alone chemical fertilizer treatments. The nodule count and their dry weight and root density was significantly more where as the soil and canopy temperature was less in sole and partial organic farming treatments as compared to alone chemical fertilizer application.

Key words: Chemical farming, crop residues, farmyard manure, green manuring, organic farming, soybean

Introduction

With the continuous practicing of very intensive and exploitive agriculture, the Punjab soil stand degraded. Deficiency of macro and micro nutrients have become common and wide spread. Organic farming even if practiced on a small scale could be a step in the right direction because it is based on the principle that soil is a living system and not an inert bowl for unloading chemical and it uses the nature as the best role model for rejuvenating the soil health. So, keeping the agro-ecosystem maintenance and diversification in Punjab, the studies on organic *vs.* chemical farming in soybean under soybean-wheat cropping systems for sustainable agro-ecosystem were planned to compare production potential of organic *vs.* chemical farming systems.

Material and methods

The field experiment with soybean under soybean-wheat cropping system was conducted at Department of Agronomy, Punjab Agricultural University, Ludhiana during *kharif*, 2001 and 2002 (on already in progress experiment since *kharif* 1996). The soil of experimental field was loamy sand (Samana series, Typic Ustochrept), medium in organic carbon content (0.48 %), low in N (145 kg/ha), high in P (27 kg/ha) and low in K (116 kg/ha) status. The experiment was arranged in a in Randomized Block Design with 4 replications comprised of 8 treatments, consisting of 2 farming systems i.e. organic and chemical farming systems. The full organic treatments were M_{10}-M_{20}-R_I (FYM 10 t/ha to soybean, 20 t/ha to wheat and incorporation of residues of both crops), M_5-M_{15}-GM-R_I (GM-green manuring), M_5-M_{15}-GM-R_I (R_I- incorporation of residues of both crops) and M_5-M_{15}-GM-R_0 (R_0-residue removed); while partial organic treatments were Rec.-GM-R_I (Rec.-recommended chemical fertilizers), Rec.-GM-R_0 and in chemical treatment 32 kg N/ha and 62.5 kg P_2O_5/ha was applied to soybean at sowing through urea and single super phosphate, respectively and in Rec. + 25 % N treatment. 25 % additional nitrogen was applied. In organic farming, well rotten farmyard manure was applied on air-dry weight basis at 10 t/ha to soybean and 20 t/ha to wheat along with crop residues incorporation for first five years. Later on the quantity of FYM was reduced to 5 t/ha to soybean along with green manuring (with and without crop residues incorporation) and 15 t FYM/ha to wheat (with and without crop residues incorporation). Green manuring of sunnhemp (*Crotalaria juncea*) 45 days old but 5-7 days before sowing soybean crop was done. Crop residues were incorporated at harvest as per treatments. Soybean (cv. SL 295) was sown on 22^{nd} and 8^{th} June during 2001 and 2002, respectively. Weeds were controlled mechanically in organic farming, while pre-emergence application of stomp (30% pendimethalin) at 0.45 kg a.i./ha was done in chemical farming system. Leaf area was recorded through leaf area meter (LI-COR 3000, USA) and LAI was calculated by dividing leaf area with land area. The periodic canopy air temperature data were recorded (from one replication only) from dry bulb readings of an Assman Psychrometer between 9.00 a.m.

to 10.00 a.m. and 2.00 p.m. to 3.00 p.m. and average was presented. Soil temperature (°C) was recorded (from one replication only) at 5 cm soil depth with a bimetal soil thermometer between 9.00 a.m. to 10.00 a.m. and 2.00 p.m. to 3.00 p.m. Penetration of PAR (nm) in the range of 400-700 nm was measured between 9.00 a.m. to 10.00 a.m., 12.00 noon to 1.00 p.m. and 3.00 p.m. to 4.00 p.m. at the base within the crop canopy. The mean values for the day were calculated for further use. Line quantum sensor (LI-COR photometer Model LI-191-84) which measures quantum (photon) response through wavelength range of 400-700 nm for PPFD (photosynthetic photon flux density) was used for PAR measurements. The data were used for calculating the photosynthetically active radiation interception (PARI) by crop as under:

$$\text{PARI (\%)} = \frac{\text{PAR above crop canopy} - \text{PAR at soil surface}}{\text{PAR above the crop canopy}} \times 100$$

For root density, one soybean plant from each treatment plot of one replication was detopped for roots weight. Samples were taken with core sampler (7.5 cm diameter) depth wise *viz.*, 0-15, 15-30, 30-60, 60-90, 90-120 cm, roots were properly washed and kept in sun for few days. After drying, they were oven dried at 60±2°C to constant weight and dry weight was recorded. By dividing dry weight with volume of the core sampler, root density was calculated and expressed as g/cm^3.

Results and discussion

Growth and development

Plant height: The data on plant height of soybean presented in Table 1 indicated that the plant height of soybean at harvest stage was not affected by source of nutrition. However, the sole/partial organic farming treatments showed edge over chemical farming treatments.

Drymatter accumulation: The lowest drymatter was recorded in the recommended treatment, which was significantly less than sole organic treatments (M_{10}-M_{20}-R_I, M_5-M_{15}-GM-R_I); partial organic treatments (Rec.-GM-R_I and Rec.-GM-R_0) recorded at 60, 90 and 120 days after sowing.

Leaf area index: The differences were found to be significant statistically at 30 and 120 days after sowing, whereas these differences were non-significant at 60 and 90 days after sowing. Leaf area index of soybean in the M_{10}-M_{20}-R_I (2.1) and Rec.-GM-R_I (2.0) treatments at 30 days crop stage was found to be significantly more as compared to Rec. treatment (1.7). Leaf area index recorded during late growth stage i.e., 120 days after sowing was significantly higher in all the fully and partial organic treatments as compared to recommended inorganic treatment (Rec.).

More plant height, dry matter and leaf area index of soybean crop grown after adding FYM, green manuring or inclusion of respective crop residues may be due to better initial growth rate of the crop (Table 1) and favorable soil conditions. Soil organic matter and soil total nitrogen levels were increased by about 120% over 150 years in the manured plots. Such carbon stores might have appreciated the sink for global carbon (Tillman, 1998).

Micro-climatic observations

Photosynthetically active radiation interception: Periodic data on percent photosynthetically active radiation interception (PARI %) by soybean crop have been presented in Table 2 as mean percent values for the day. The data showed that light interception (%) by the crop increased up to 90 days after sowing and thereafter, it declined marginally. At all the stages the pure organic farming treatments *viz.*, M_{10}-M_{20}-R_I, M_5-M_{15}-GM-R_I, partial organic farming treatments *viz.*, Rec.-GM-R_I and Rec.-GM-R_0 treatments recorded significantly more PARI than alone chemical fertilizer treatments (Rec.). The increase in PARI may be due to increased leaf area index in the pure/partial organic treatments where as, decrease in soil and canopy temperature in these treatments may be due to more plant height, dry matter accumulation, leaf area (Table 1), more light interception (Table 2) and more light was intercepted by crop canopy resulting in lower soil and canopy temperature. Such results have also been reported earlier (Walia and Kler, 2005).

Soil temperature: Soil temperature (°C) beneath the crop canopy presented in Table 2 showed that the fully (M_{10}-M_{20}-R_I, M_5-M_{15}-GM-R_I)/partial(Rec.-GM-R_I and Rec.-GM-R_0) organic farming treatments tended to record lower soil temperature at 60 and 90 days after sowing during both the years of study which may be due to more leaf area index (Table 1) of these treatments as compared to chemical farming treatments (Rec. and Rec. + 25% N). PARI and soil temperature showed inverse relations and direct correlations with yield in various crops (Kler *et al.*, 1987). Thus, when a crop intercepts more solar radiations, soil temperature is lowered.

Canopy temperature: Data for periodic canopy temperature (°C) presented (taken from one replication) in Table 2, showed slightly higher values than that of soil temperature and showed similar trend as that of soil temperature. The fully/partial organic farming treatments registered slightly lower temperature than chemical farming treatments (Rec. and Rec. + 25% N) during both the years at 60 and 90 days after sowing. The less temperature recorded in these fully/partial organic treatments may be due to their more leaf area (Table 1) and more PARI (%) (Table 2) so temperature decreased. Similar results were obtained earlier by Kler *et al.* (2002).

Root density: The data regarding the root density (Table 3) amply demonstrated that more than 90% roots were confined to the top 0-15 cm soil layer. All the fully/partial organic treatments obtained higher rooting density. The M_{10}-M_{20}-R_I, M_5-M_{15}-GM-R_I, Rec.-GM-R_I and Rec.-GM-R_0 reported 21.1, 19.5, 13.1 and 9.3% higher root density than alone chemical fertilizer (Rec.) treatment in 0-15 cm soil layer. The trend of more root density in fully/partial organic treatments was observed up to lower depth. Better root development under pure/partial organic farming might be due to improved aeration, moisture and temperature conditions, and improved drainage as described by Zhao (1991).

Yield and yield attributing characters

Number of nodule/plant: At 90 days after sowing significantly more number of nodules/plant were recorded in M_{10}-M_{20}-R_I, M_5-M_{15}-GM-R_I, M_5-M_{15}-R_I and M_5-M_{15}-R_0 treatments as compared to Rec. treatment while at harvesting all organic and Rec.-GM-R_I treatments showed significantly higher number of nodules/plant than Rec. and Rec.+25 %N both pure chemical farming treatments. More number of nodules/plant in organic/partial organic treatments may be due to synchronous release of nitrogen from organic carbon sources present in the soil under these treatments.

Nodule dry weight: Dry weight of nodules (Table 3) recorded 90 days after sowing and at the time of harvest was found to be significantly more in all the organic or partially organic treatments as compared to Rec. + 25% N and Rec. treatments. More dry weight of nodules in these treatments may be due to their more number/plant (Table 3).

Number of pod bearing branches/plant: The data revealed that significantly more number of pod bearing branches and number of pods/plant were observed in M_{10}-M_{20}-R_I (7.9, 95.8), M_5-M_{15}-GM-R_I (7.7, 92.4), Rec.-GM-R_I (7.8, 92.7) and Rec.-GM-R_0 (7.7, 90.6) treatments as compared to Rec. treatment (6.6, 86.5).

Number of seeds/pod: The number of seeds/pod is one of the most important yield attributing character (Table 3). Number of seeds/pod was significantly less in Rec. treatment as compared to M_{10}-M_{20}-R_I and M_5-M_{15}-GM-R_I. More number of pod bearing branches and seeds/pod in these treatments may be due to more drymatter and leaf area index (Table 1).

Seed yield: The maximum seed yield was recorded in M_{10}-M_{20}-R_I treatment which was followed by M_5-M_{15}-GM-R_I and both these treatments produced significantly higher seed yield than Rec. treatment and both the former treatments were found to be at par with Rec.-GM-R_I and Rec.-GM-R_0 treatments (Table 3). There was 18.0 and 9.8% increase in seed yield with M_{10}-M_{20}-R_I and M_5-M_{15}-GM-R_I treatments as compared to Rec., respectively. Since, organic manure contains almost all the essential plant nutrients, its incorporation in soil improved soil properties thereby making favourable conditions for growth and development of soybean, thereby, increasing the sink size in terms of pod/ear and seed/grain growth. Gill *et al.* (2006) reported the percent increase in terms of rice equivalent yield under organic management practice over chemical farming in basmati rice- wheat-green manure; turmeric-onion; summer groundnut -garlic and rice-garlic + mentha was 9.2, 62.2, 14.5 and 12.4, respectively. The improved growth coupled with transport of photosynthates towards reproductive structures on the other hand might have increased the yield attributes and finally increased yield. In the Broad balk experiment running for more than 150 years at Rothamsted Experimental Station in the United Kingdom, the averaged wheat yields were 3.45 t/ha on manured plots as compared with 3.40 t/ha on plots receiving complete NPK fertilizers (Tillman, 1998).

It may be concluded that the organic farming will definitely improve the quality of agricultural produce without loosing quantity besides maintaining soil fertility especially organic carbon content and also combating against emergence of multi-nutrient deficiencies. Moreover, it is ecologically, socially and economically viable and environmentally unhazardous.

Table 1 Periodic plant height, drymatter and LAI of soybean as influenced by organic vs. chemical farming treatments in soybean-wheat system (pooled 2 years)

Treatment	Plant height at harvest (cm)	Drymatter (g/plant)				LAI			
		30	60	90	120	30	60	90	120
M_{10}-M_{20}-R_I	92.4	5.0	18.3	41.7	61.8	2.1	3.9	6.4	2.5
M_5-M_{15}-GM-R_I	90.7	5.0	17.4	41.6	60.6	1.9	3.7	6.2	2.4
M_5-M_{15}-R_I	87.7	4.8	14.8	37.6	54.8	1.7	3.4	5.9	2.2
M_5-M_{15}-R_0	87.0	4.6	13.9	37.3	54.3	1.7	3.4	5.8	2.2
Rec.-GM-R_I	89.5	4.9	17.1	41.0	61.1	2.0	3.8	6.3	2.2
Rec.-GM-R_0	88.5	4.9	16.7	40.7	60.3	1.9	3.7	6.3	2.1
Rec. + 25% N	86.1	4.8	14.8	36.4	56.8	1.7	3.4	5.9	1.7
Rec.	84.6	4.4	14.4	35.3	55.3	1.7	3.4	5.8	1.6
CD (P=0.05)	NS	NS	1.8	3.9	4.4	0.24	NS	NS	0.48

Table 2 **Micro climate of soybean as influenced by organic vs. chemical farming treatments in soybean-wheat system**

Treatment	PARI (%)			Soil temperature (°C)			Canopy temperature (°C)		
	60	90	120	60	90	120	60	90	120
M_{10}-M_{20}-R_I	80.3	89.4	72.4	30.7	28.7	23.6	32.2	30.3	28.0
M_5-M_{15}-GM-R_I	76.7	86.1	70.1	31.0	29.0	23.9	32.5	30.5	28.6
M_5-M_{15}-R_I	71.5	77.5	60.1	32.7	30.0	24.7	32.8	30.7	28.4
M_5-M_{15}-R_0	69.6	76.2	59.4	32.1	31.1	25.1	33.0	30.9	28.7
Rec.-GM-R_I	77.9	87.2	70.5	31.3	29.1	24.3	32.7	30.7	28.4
Rec.-GM-R_0	76.3	85.3	69.5	32.5	29.6	24.5	32.9	30.9	28.6
Rec. + 25% N	72.6	79.3	64.1	32.7	30.9	25.1	33.1	31.0	29.0
Rec.	69.8	74.3	59.3	32.8	31.4	25.4	33.4	31.6	29.7
CD (P=0.05)	4.1	5.8	5.0	-	-	-	-	-	-

Table 3 **Root density, nodulation, yield attributing characters and yield of soybean as influenced by organic vs. chemical farming treatments in soybean-wheat system (pooled 2 years)**

Treatment	Root density (μg/cm³)					Nodules/plant		Nodules dry weight/plant (mg/plant)		Pod bearing branches/ plant	Pods/ plant	Seeds/ pod	Seed yield (kg/ha)
	0-15 cm	15-30 cm	30-60 cm	60-90 cm	90-120 cm	90 DAS	At harvest	90 DAS	At harvest				
M_{10}-M_{20}-R_I	7010	312	79	31.5	15.5	88	31	318	94	7.9	96	4.0	1955
M_5-M_{15}-GM-R_I	6919	286	80	28.0	16.0	84	30	310	91	7.7	92	3.8	1820
M_5-M_{15}-R_I	6353	262	65	28.0	12.0	79	28	283	84	6.6	86	3.3	1690
M_5-M_{15}-R_0	6078	259	61	23.5	9.5	77	27	270	77	6.5	84	3.1	1636
Rec.-GM-R_I	6548	305	79	29.0	15.0	41	18	238	76	7.8	93	3.7	1884
Rec.-GM-R_0	6329	291	75	28.0	14.0	39	15	219	71	7.7	91	3.5	1848
Rec. + 25% N	5904	248	65	25.5	10.5	32	13	178	54	7.1	89	3.4	1737
Rec.	5788	249	64	25.0	11.0	35	13	178	58	6.6	87	3.3	1657
CD (P=0.05)	-	-	-	-	-	6.8	2.1	17.5	9.2	0.9	4.0	0.4	211

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Use of saline water in groundnut, *Arachis hypogaea* L. - wheat, *Triticum aestivum* rotation in calcareous black clay soils of Saurashtra region in Gujarat

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Abstract

Field experiment was conducted during 2002 and 2003 to evaluate the use of saline water in groundnut - wheat cropping system in calcareous black clay soils using four salinity levels (0.5, 2, 4 and 6 dS/m) of irrigation water and five cultivars of groundnut (Gangapuri, GG 2, ICGS 44, JL 24 and MH 2). After the harvest of kharif groundnut, wheat (Var. GW 496) was taken with same salinity levels of saline water irrigation. Germination, pod yield and other yield contributing characters of groundnut were significantly decreased with increase in salinity of irrigation water from 4 to 6 dS/m whereas saline water of 2 dS/m can safely be used for optimum yield. However, wheat can tolerate irrigation water salinity of 4 dS/m and soil salinity of 7.3 dS/m. Groundnut genotypes ICGS 44 and JL 24 were found more tolerant to salinity as compared to other genotypes. Oil content, Nitrogen and Protein content in groundnut decreased significantly at higher level of soil and water salinity. Among the genotypes, MH 2 showed significantly lower oil content and low oil yield in the saline environment. Decrease in Stability index (Oleic/Linoleic ratio) with an increase in salinity level was non significant. Build up of root zone salinity as a result of saline water irrigations to wheat was much greater in comparison to the salinity build up in kharif groundnut. But the threshold soil salinity for groundnut was 2.1 dS/m and for wheat this limit was 7.3 dS/m. Hence, saline water irrigation of 2 dS/m salinity in groundnut and 4 dS/m in wheat can safely be used for getting optimum yield using groundnut - wheat rotation in calcareous black clay saline soils of Saurashtra area in Gujarat. This threshold salinity limit for groundnut and wheat crop may vary depending upon the extent and its distribution of rainfall, soil texture, leaching efficiency and type of cultivars of a given crop.

Key words: Soil and water salinity, yield, oil content, stability index, rainfall, groundnut and wheat crop

Introduction

In India, groundnut is annually grown in an area of 7.6 million hectare, with a production of 7.8 million tones of pod. The average productivity of groundnut in India is about 1000 kg/ha. About 80% of the groundnut area is covered under *kharif* and mainly rain fed. About 88% of area and production of groundnut are mainly confirmed to Andhra Pradesh, Karnataka and Maharashtra states. Availability of good quality water for irrigation in these states is a limiting factor and farmer has no choice but to use saline water for irrigation. Generally, farmers in Saurashtra region of Gujarat are taking single crop of groundnut in *kharif* and summer and winter season are being kept fallow due to non availability of good quality irrigation water. Lot of work on the tolerance of wheat to soil and water salinity in India and abroad have been done by taking single crop in a year but very little work is available on wheat in rotation with other crops and particularly the information is lacking on groundnut - wheat rotation using saline water in saline soils (Gupta and Pahwa, 1978). In view of this, study was conducted on the management of use of saline water irrigation by taking two crops in a year i.e., Groundnut in *kharif* and wheat in winter season in order to increase the productivity of saline black soils of Gujarat.

Material and methods

Field experiment was conducted during 2002-2003 on use of saline water irrigation in groundnut - wheat rotation in calcareous saline black clay soils at National Research Centre for Groundnut, Research farm, Junagadh with kharif groundnut followed by winter wheat. Soils of this area are clayey, mixed hyperthermic, lithic haplustepts. Four salinity levels of irrigation water (0.5, 2, 4 and 6 dS/m) in the main plot and five cultivars of groundnut (Gangapuri, GG 2, ICGS 44, JL 24 and MH 2) in the subplot were tested in a Split Plot Design and wheat (Var. GW 496) in Randomized Block Design with three replications.

Each salinity treated plots was separated from another plot by putting a 250 micron polycarbonate sheet up to 60 cm soil depth in different channels surrounding the various treated plots (5x4 m^2 plot size). Bunds of each plot were raised to the height of 30 cm and width of 30 cm with the objective to absorb maximum rainwater in the plot. The recommended dose of NPK was applied in both groundnut and wheat crops in both the years. Four sintex drums of 1000 litres capacity each were used for application of different saline water irrigation. These saline waters were prepared using commercial sodium chloride salts. Four number of supplemental saline water irrigation of 5 cm depth each were applied during the stress period and sensitive stages of the groundnut besides the rainfall of 537 mm in *kharif* 2002.After the harvest of groundnut on 5-10-2002, wheat was sown on 15-11-2002. Wheat was irrigated with saline water of different qualities and total number of irrigations applied was ten. The depth of each irrigation was 5 cm. Similarly in the year 2003, only one saline irrigation was applied to kharif groundnut beside high and well-distributed rainfall of 1275 mm followed by wheat irrigated by the application of 10 Nos. of saline water irrigation. Monthly rainfall and evaporation data for the year 2002 and 2003 are illustrated in Fig. 1. Soil samples were taken at 15, 30 and 45 cm soil depth periodically during the crop growth cycle and were analyzed for pH and ECe. Yield and yield contributing characters in groundnut and wheat were recorded at the harvest of the crop besides the germination count at different DAS (Days after sowing). The oil content and its quality in different genotypes of groundnut under varying salinity stress were also determined. The average salinity of the tube well water at NRCG Farm is 0.5 dS/m and this level of salinity has been taken as control for comparing the other salinity levels of the irrigation water.

Results and discussion

Germination: Germination of groundnut decreased with an increase in soil and water salinity. The decrease was non-significant up to the saline water of 2 dS/m and soil salinity of 3 to 3.3 dS/m and after these salinity levels the germination was affected significantly in both the years (Table 1). Further, 83% germination which was recorded in control on 7th DAS (Days After Sowing) was also observed in similar magnitude on 12th and 15th DAS at ECiw of 2 and 6 dS/m and ECe of 3.3 and 4.8 dS/m respectively. These results indicate that the germination is delayed under high salinity stress by 5 to 8 days in the *kharif* 2002 and almost similar trend was observed in *kharif* 2003. The significant decrease in germination as well as delayed germination by the high soil and water salinity further affect the plant growth and other yield and yield attributing characters of groundnut. Different genotypes behaved differently with respect to germination in the saline environment. Results indicate that MH 2 and Gangapuri performed very well at germination stage but were poor yielder in comparison to ICGS 44 and JL 24 in the saline environment. Hence the tolerance of different cultivars of groundnut to salinity hazards is different and also changes with respect to the different growth stages of the groundnut. In case of wheat, the final germination was not affected significantly by soil salinity ranging from 1.2 to 4.2 dS/m and water salinity ranging from 0.5 to 6 dS/m where as germination of groundnut was significantly decreased by the above levels of salinity.

Groundnut and wheat yield vs salinity: Effect of saline water irrigation (ECiw 4 to 6 dS/m) and soil salinity (ECe 2.5 to 4.8 dS/m) on decrease in groundnut pod yield in both *kharif* 2002 and 2003 was significant. But soil and water salinity up to 2 dS/m can safely be used for optimum groundnut pod yield (Table 2) in calcareous black clay soil and almost similar effect of different salinity levels was observed on haulm yield, 100 kernel weight and shelling percentage in both the years (Data not provided).

Among the tested genotypes of groundnut to varying soil and water salinity indicate that ICGS 44 and JL 24 are found to be more tolerant than MH 2 and Gangapuri. In case of MH 2, the germination in a given saline environment was good but this genotype did not perform well at the later stages of crop growth. The results also showed that groundnut is relatively more tolerant at germination stage than at later stages of the crop growth. Further, the ratio of pod yield to haulm yield decreased with an increase in salinity which indicates that the effect of high salinity on pod yield was greater as compared to its effect on haulm yield. Pod yield/haulm yield ratio at a given salinity level was greater in kharif 2002 than in *kharif* 2003 which indicate the vegetative growth was more in the later year because of the more rain at vegetative stage and the leaching efficiency was also more in the year 2003 as result of high rainfall (RF=1275 mm) than the year 2002 (RF=537 mm). Pod yield of groundnut in kharif 2003 was high in all the treatments whereas in the year 2002 the yield was low because of low rainfall, more number of irrigations with saline water and more salinity build up in the root zone in the later year (*kharif*, 2002). Results in both the *kharif* seasons indicate that the soil and water salinity of 2 dS/m can safely be used for getting the groundnut pod yield between1000 to 2000 kg/ha in calcareous saline black soils of Saurashtra region depending upon the amount of rainfall and its distribution in a given season. Patel *et al.* (1993), Padole *et al.* (1993) and Yogesh Sharma *et al.* (2003) also reported more or less similar results. On the other hand in case of wheat, irrigation with high salinity level (ECiw up to 4 dS/m) can be used without any significant decrease in grain yield (Table 2). Wheat can tolerate the soil salinity up to 7.3 dS/m after the application of 10 number of saline water irrigation of 4 dS/m salinity (Table 2) in calcareous black clay soils. Almost similar effect of salinity on other yield contributing characters of wheat was also observed (Data not provided). Early stages of the crop growth were more sensitive to high salinity than at later stages of crop growth in wheat. These results are in confirming with the findings of Africa and Narnolia (1999), Phogat *et al.* (2001), Nadaf *et al.* (2001) and Yogesh *et al.* (2003). This Reduction of groundnut pod yield at ECe (soil salinity) of 4 dS/m over control was 54% where as in case of wheat (2002-03, 2003-04), the reduction in grain yield at the same level of salinity was less than 10% in both years (Fig.2). Hence the tolerance of wheat to soil and water salinity is much greater than in case of groundnut but their permissible limit to salinity may vary with the extent and its distribution of rainfall, soil texture, leaching efficiency and the type of cultivars of the given crop.

Oil yield and its quality: Mean oil content of *kharif* groundnut decreased with an increase in the soil and water salinity in both the years but the decrease was significant in the 2002-03 and was non significant in the 2003-04 (Table 3) may be because of the high rainfall (1275 mm), more leaching efficiency and low salinity build up in the second year (2003-04). Adverse effect of salinity on oil content also varied with the different genotypes. MH 2 showed the significantly lower oil content in comparison to other genotypes in the saline environment. Total oil yield of different genotypes of groundnut also decreased with an increase in soil and water salinity (Table 4). Mean oil yield decreased from 460 to 112 kg/ha with an increase in soil salinity from 0.8 to 4.8 dS/m and irrigation water salinity from 0.5 to 6 dS/m in the year 2002-03 and the decrease from 571 to 242 kg/ha as a result of increase in soil salinity from 1.2 to 2.8 dS/m and water salinity from 0.5 to 6 dS/m in the year 2003-04. These differences in oil yield as a result of salinity stress was significant. Arjunan and Gopal Krishnan (1980), Aljibury and Talabany (1982) and Girdhar (1989) have reported the similar findings. The oil yield in case of all the genotypes was higher in kharif 2003 than in case of *kharif* 2002 may be because of high and well distributed rainfall in the year 2003. Decrease in Stability Index (Oleic/Linoleic ratio) with an increase in salinity was non significant. Proportionate decrease in Nitrogen and Protein content of groundnut kernels with an increase in soil and water salinity was observed both in *kharif* 2002 and 2003 (Table 5). This decrease in N and protein content was non-significant up to the soil and water salinity of 2 to 3 dS/m whereas the decrease was significant at high salinity ranging from 3 to 6 dS/m. Further among the tested genotypes JL 24 contains the highest N and Protein content in the saline environment.

Root zone soil salinity build up: The initial salinity levels of the different saline soils before taking groundnut crop was 1.4, 5.0, 7.4 and 12.6 dS/m (Table 6). This initial status of soil salinity was monitored on 3-6-02 which was reduced significantly from 5.0 to 3.3, 7.4 to 3.6 and 12.6 to 4.8 dS/m as a result of 277 mm rainfall received in June 2002. There after kharif groundnut was taken by giving supplemental irrigations with different levels of salinity depending upon the extent and distribution of rainfall during the period of crop cycle and soil moisture stress in root zone. Total rainfall received during this monsoon season (2002) is 537 mm. At the harvest of the groundnut crop the soil salinity build up was ranging from 0.8 to 4.8 dS/m as a result of saline water irrigations having salinity ranging from 0.5 to 6.0 dS/m. After that winter crop of wheat was taken using saline water of varying salinity of 0.5 to 6 dS/m and again the salinity build up in root zone was increased significantly as a result of 10 numbers of saline water irrigation to wheat crop in year 2002-03. This increased salinity ranging from 2.0 to 13.4 dS/m at wheat harvest was further reduced from 1.7 to 5.7 dS/m as a result of 175 mm rainfall received in June 2003. Again kharif groundnut was repeated in 2003 with an initial salinity at the time of sowing under different treatments was 1.7, 3.0, 3.6 and 5.9 respectively (Table 6). These levels of salinity further reduced at harvest of groundnut. These reduction in salt due to high leaching efficiency as a result of high and well distributed rainfall (Total rainfall=1275 mm). Again second crop of wheat was taken in the winter season in 2003-04 using saline water irrigation as a result which again the salt build up in the root zone increased in all the treatments (Table 6). Hence with an increase in the salinity of the irrigation water, the soil salinity in the root zone increased both in groundnut and wheat crop (Fig. 3) but the build up in soil salinity at a given salinity of the irrigation was greater in wheat crop than in *kharif* groundnut mainly because sufficient rain water was available to leach down the salts below the root zone in case of groundnut crop.

Table 1 Periodic germination (%) of groundnut as affected by soil and water salinity

Water Salinity (dS/m)	Soil Salinity (dS/m)	*Kharif* 2002 Days After Sowing							Soil Salinity (dS/m)	*Kharif* 2003 Days After Sowing				
		6	7	8	10	12	14	15		6	7	8	9	11
0.5	0.9	73	83	87	88	88	87	88	1.7	54	71	78	78	83
2	3.3	64	76	79	82	83	82	82	3.0	31	62	74	75	80
4	3.6	48	64	73	79	81	81	83	3.6	24	48	65	69	77
6	4.8	18	45	51	70	73	78	83	5.9	15	27	43	52	64
SEm±		3.3	3.2	2.9	2.4	2.2	2.2	2.2		3.0	3.1	2.7	2.4	2.0
CD (P=0.05)		9.5	9.1	8.2	7.0	6.3	6.2	NS		9	8	8	7	9
CV (%)		25.3	18.5	15.3	11.9	10.4	10.3	9.9		37.8	22.8	16.0	13.3	10.1

Table 2 Effect of soil and water salinity on yield of groundnut and wheat crop

Water salinity (dS/m)	Soil salinity (dS/m)	2002-03 Cultivars of Groundnut Gangapuri	GG 2	ICGS 44	JL 24	MH 2	*Mean*	Soil salinity (dS/m)	Wheat
0.5	0.8	1011	1744	1632	1876	285	1309	2.0	3664
2	1.7	692	1431	1428	1484	196	1046	4.7	2963
4	3.3	619	840	1345	1041	90	787	9.5	2061
6	4.8	333	313	744	665	46	420	13.4	1388
Mean		664	1082	1287	1266	154			
		Salinity		Cultivar		Interaction			
SEm±		66.4		74.2		148			213
CD (P=0.05)		190		212		424			737
CV (%)		28.9							-
		Rainfall =537mm			4 Nos. of irrigation = 200 mm				
				2003-04					
0.5	1.2	1502	1619	1991	1525	1624	1652	2.6	3923
2	2.1	2217	1957	2091	2319	1611	2039	5.1	3771
4	2.5	1209	955	1161	1438	761	1105	7.3	3549
6	2.8	757	644	1019	701	542	733	7.8	2548
Mean		1421	1294	1565	1496	1134			
		Salinity		Cultivar		*Interaction*			
SEm±		117		130		261			**258**
CD (P=0.05)		333		NS		NS			**892**
CV (%)		32.7							**12.9**
		Rainfall =1275mm			One irrigation = 5 0mm				

Table 3 Effect of soil and water salinity on the oil content of different cultivars of *kharif* groundnut

Water Salinity (dS/m)	Soil Salinity (dS/m)	Oil Content (%) 2002 Gangapuri	GG 2	ICGS 44	JL 24	MH 2	Mean
0.5	0.8	49.8	50.8	49.3	48.7	47.0	49.1
2	1.7	49.5	49.8	48.2	47.8	45.3	48.1
4	3.3	47.2	47.5	47.7	46.3	45.2	46.8
6	4.8	43.3	45.6	44.7	44.7	44.4	44.5
Mean		47.5	48.5	47.5	46.9	45.5	
Water Salinity (dS/m)	Soil Salinity (dS/m)			Oil content (%) 2003			
0.5	1.2	50.4	49.4	50.1	48.6	47.6	49.2
2	2.1	49.4	49.8	49.5	49.7	48.0	49.3
4	2.5	49.6	50.7	50.9	48.7	48.4	49.7
6	2.8	50.6	50.3	50.1	50.1	48.0	49.8
Mean		50.0	50.1	50.2	49.3	48.0	

SEm± =0.3; CD (P=0.05) for salinity = 0.8; for cultivar = 0.9; CV (%) =2.2 (2002);
SEm± =0.3; CD (P=0.05) for salinity = NS; for cultivar = 1.0; CV (%) =2.3 (2003)

Table 4 Effect of saline environment on oil yield and quality of different genotypes of groundnut

Water Salinity (dS/m)	Kharif, 2002					
	Pod Yield (kg/ha)	Shelling %	Kernel Yield (kg/ha)	Oil Content %	Oil Yield (Kg/ha)	Stability Index (O/L Ratio)
0.5	1309	72	936	49.1	460	1.24
2	1046	69	704	48.1	339	1.21
4	787	68	533	46.8	249	1.20
6	420	60	252	44.5	112	1.19
SEm±	66.4	1.0	44.1	0.3	22.9	0.02
CD (P=0.05)	190	3	126	0.8	66	NS
CV (%)	28.9	6.0	29.9	2.2	29.8	6.7
Cultivar	Kharif, 2002					
Gangapuri	664	64.5	428	47.6	204	1.24
GG 2	1082	68.8	744	48.5	361	1.29
ICGS 44	1287	65.3	840	47.5	399	1.21
JL 24	1266	70.6	894	46.9	419	1.19
MH 2	154	64.4	99	45.5	45	1.11
SEm±	74.2	1.1	53.1	0.3	25.6	0.02
CD (P=0.05)	212	3	152	0.9	73	0.07
CV (%)	28.9	6.0	29.9	2.2	29.8	6.7
Cultivar	Kharif, 2003					
0.5	1652	70	1160	49.2	571	1.20
2	2032	70	1431	49.3	706	1.23
4	1105	70	768	49.7	382	1.19
6	733	66	485	49.8	242	1.12
SEm±	117	0.5	83.9	0.3	42.0	0.02
CD (P=0.05)	333	1	240	NS	120	NS
CV (%)	32.7	2.6	33.7	2.3	34.1	5.6
Cultivar	Kharif, 2003					
Gangapuri	1421	67.1	954	49.99	477	1.16
GG 2	1294	70.4	911	50.07	456	1.26
ICGS 44	1566	69.3	1085	50.15	544	1.18
JL 24	1496	71.5	1070	49.27	527	1.12
MH 2	1134	67.1	761	47.98	365	-
SEm±	131	0.5	93.9	0.3	46.9	0.02
CD (P=0.05)	NS	2	NS	1	NS	0.06
CV (%)	32.7	2.6	33.7	2.3	34.1	5.6

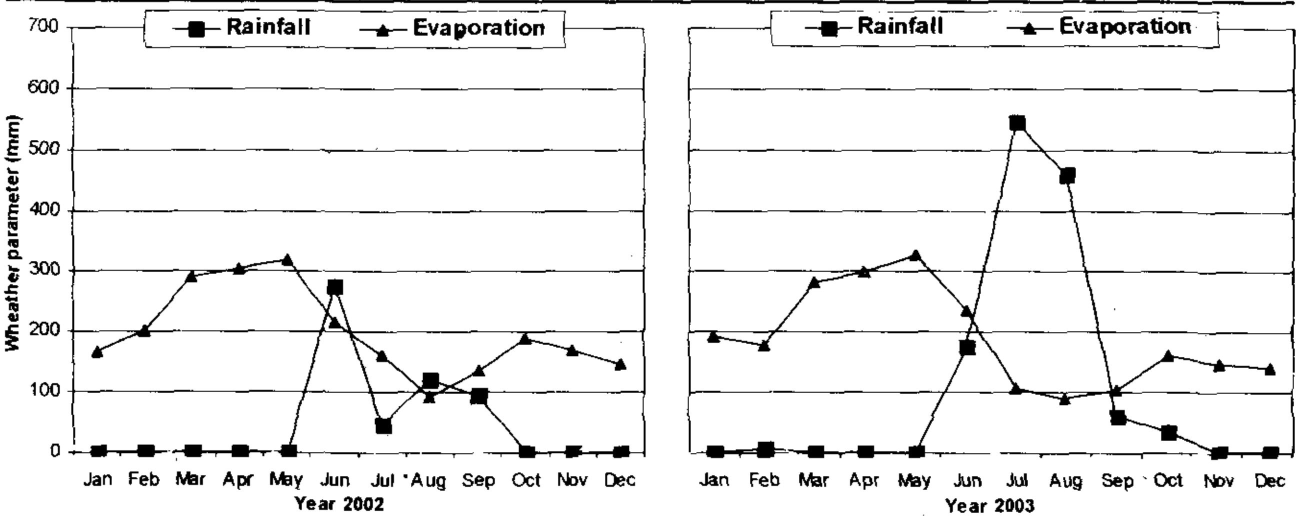

Fig. 1 Rainfall and evaporation for the year 2002 and 2003

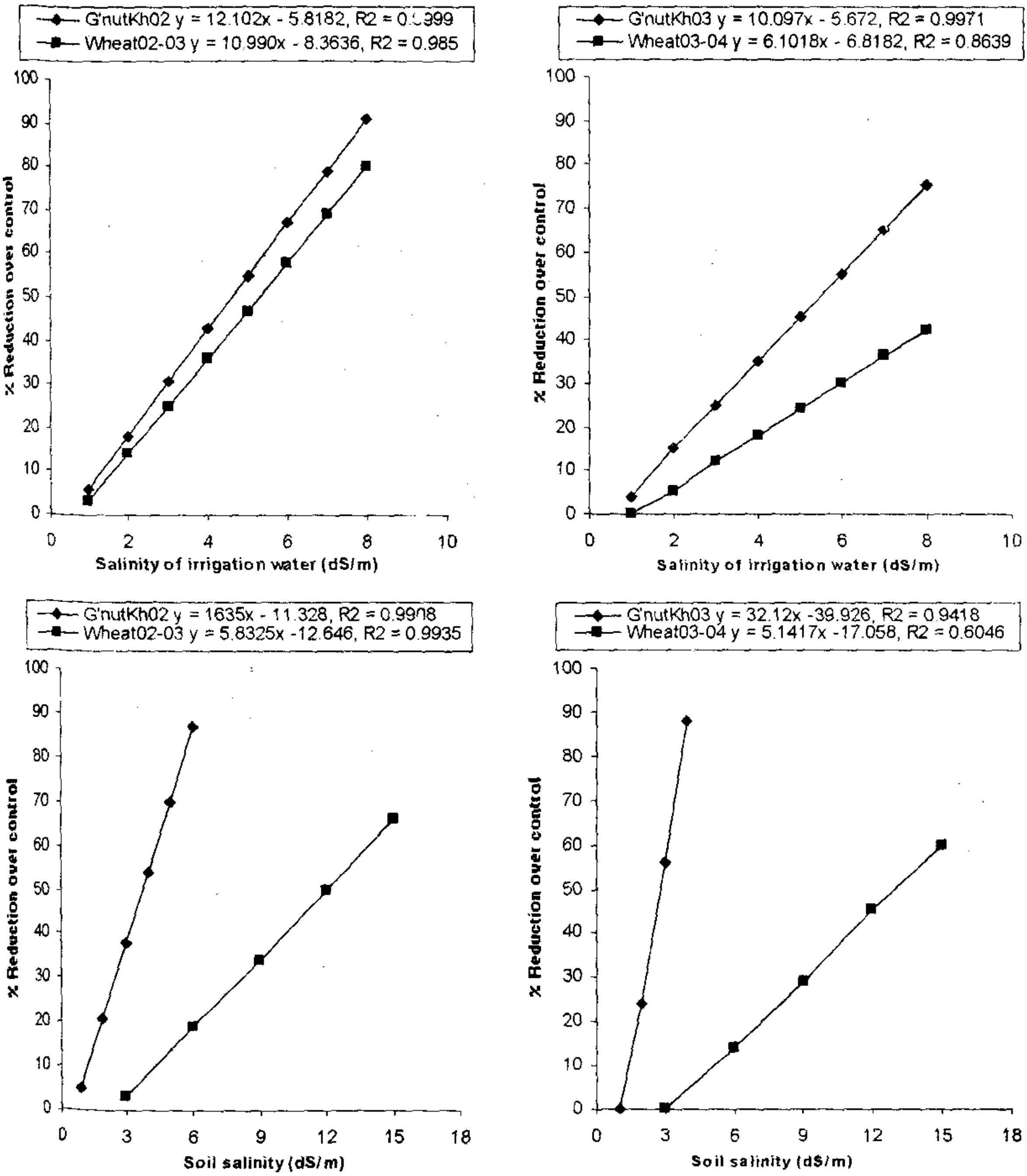

Fig. 2 Effect of soil and water salinity on per cent reduction in yield of groundnut and wheat

Table 5 Effect of soil and water salinity on nitrogen and protein content of groundnut kernals

Water Salinity (dS/m)	*Kharif*, 2002				*Kharif*, 2003			
	Soil salinity (dS/m) at		Nitrogen content (%)	Protein content (%)	Soil salinity (dS/m) at		Nitrogen content (%)	Protein content (%)
	Sowing	Harvest			Sowing	Harvest		
0.5	0.9	0.8	3.5	19.2	1.7	1.2	4.5	24.6
2	3.3	1.7	3.4	18.4	3.0	2.1	4.1	22.5
4	3.6	3.3	3.3	18.1	3.6	2.5	3.9	21.4
6	4.8	4.8	3.0	16.6	5.9	2.8	3.7	20.1
SEm±			0.14	0.45			0.12	0.66
CD(P=0.05)			0.4	2.2			0.4	2.2
CV (%)			13.7	13.7			11.4	11.2

Table 6 Changes in the root zone salinity and soil pH as a result of saline water irrigation and rainfall to groundnut and wheat

Water Salinity (dS/m)	*Kharif* Groundnut 2002			Wheat 2002-03		*Kharif* Groundnut 2003		Wheat 2003-04	
	Root zone salinity (ECe dS/m) at								
	Initial	Sowing	Harvest	Sowing	Harvest	Sowing	Harvest	Sowing	Harvest
0.5	1.4	0.9	0.8	1.2	2.0	1.7	1.2	1.2	2.6
2	5.0	3.3	1.7	2.4	4.7	3.0	2.1	2.1	5.1
4	7.4	3.6	3.3	5.9	9.5	3.6	2.5	3.6	7.3
6	12.6	4.8	4.8	6.4	13.4	5.9	2.8	4.2	7.8
				Soil pH					
0.5	8.0	7.9	8.1	8.0	7.9	8.0	8.0	8.1	8.0
2	7.9	8.1	8.3	7.8	8.0	8.2	8.3	8.2	8.0
4	8.1	8.2	8.3	7.9	7.9	8.3	8.5	8.2	8.0
6	7.9	8.3	8.4	8.0	7.9	8.2	8.4	8.2	8.2

Rainfall in 2002 = 537 mm; Four irrigations = 200 mm; Rainfall in 2003 = 1275 mm; One irrigation = 50 mm

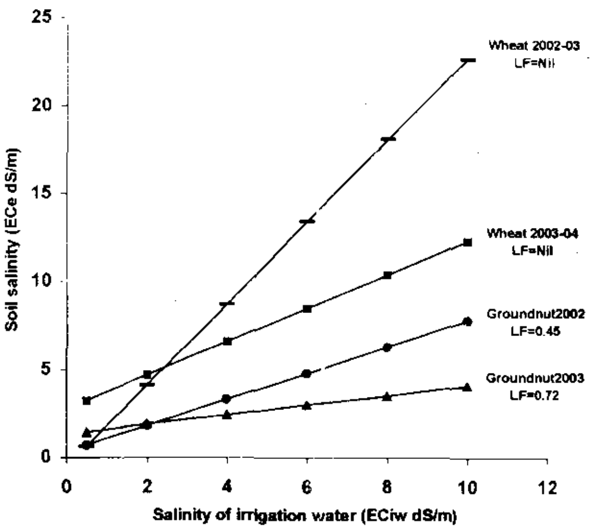

Fig. 3 Soil salinity build up in the root zone as a result of saline water irrigation and leaching fraction (LF) to groundnut and wheat

Further in case of groundnut crop the salt accumulation was greater in the year 2002 than in case of 2003 because of more leaching efficiency as a result of more rainfall in the later year. Greater salt build up in the root zone as a result of high saline water irrigation affects the water absorption even though the soil was well watered. This results in stunted plant growth and reduced nutrient availability which further decreased the yield significantly. Slight increase in soil pH due to increase in soil and water salinity did not affect the yield adversely. An increase in soil pH as a result of NaCl dominated saline water irrigation (ECiw 0.5 to 6 dS/m) is mainly due to the increase in Na and decrease in Ca in the soil exchange complex. (Girdhar and Yadav, 1982).

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Soil test based fertilizer recommendation under IPNS for groundnut, *Arachis hypogaea* L. in Torripsamments of Rajasthan

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Abstract

Soil test crop response correlation studies were conducted with groundnut (Var. Chitra) under integrated plant nutrition system (STCR-IPNS) in Torripsamments of Rajasthan. Fertilizer adjustment equations under IPNS were formulated for groundnut following Ramamoorthy's inductive-cum targeted yield model. The nutrient requirement for producing one quintal of groundnut was found to be 3.6, 1.7 and 3.0 kg of N, P_2O_5 and K_2O, respectively. The per cent nutrient utilization efficiencies from soil and fertilizer nutrients were found to be 100 and 176 for N, 98 and 65 for P_2O_5 and 44 and 210 for K_2O, respectively. Like wise the per cent nutrient utilization efficiency from farmyard manure (FYM) was 148 for N, 60 for P_2O_5 and 61 for K_2O, respectively. In STCR-IPNS technology, the fertilizer doses are tailored to the requirements of specific yield targets of groundnut taking into account the contribution from soil, fertilizers and organics.

Key words: Groundnut, STCR-IPNS, fertilizer adjustment equations, Torripsamments

Introduction

Fertilizers with instant ability to refurbish depleted nutrients in necessary quantities and forms have been recognized as a key component of soil fertility management. The fertilizer prices have gone up and hence their use in required amounts depends much upon the purchasing ability of the farmers. Accordingly, economic rationality dictates a more comprehensive approach for fertilizer use, incorporating soils tests, magnitude of crop response to applied nutrients and economic evaluation of the results (Katyal, 2001). In these efforts, soil test based fertilizer recommendation plays a vital role in increasing the soil productivity. Research work done using soil test crop response approach in different parts of the country have shown that oil seed crops respond to the nutrients added through organics and chemical fertilizers (Suri *et al.*, 2002; Riazuddin, 2003). Therefore, in sandy soils of poor fertility, it becomes pre-requisite to use organic manures along with fertilizers to achieve advancement in productivity of oil seed crops in an economically and ecologically sound manner.

In Rajasthan groundnut is being cultivated in an area of about 2.75 lakh ha with a production of 2.65 lakh tonnes and average productivity of less than 1 tonne/ha. Hence, in order to step up the productivity of the groundnut in the state, soil test based balanced fertilization is essential. Currently, a general recommendation of 46:64:0 kg N, P_2O_5 and K_2O/ha, respectively is being followed. Fertilization based on blanket recommendation results in either over use or under use of fertilizers, so balanced fertilization is a must for realising higher efficiency and economy of fertilizer use (Velayutham and Reddy, 1990). In fertilizing the crop existing soil fertility and crop requirements should be taken into account (Ramamoorthy *et al.*, 1967). This demands the maintenance of optimum balance between all essential nutrients, as per the crop requirements of the nutrients and their availability in soil and possible recycling of organic sources.

Material and methods

A field experiment based on inductive methodology was conducted in Torripsamments of Bikaner with groundnut (Var. Chitra). The soil of the experimental field is loamy sand in texture with pH 8.3 and non-saline (EC_2 0.3 dS/m). The initial $KMnO_4$-N, Olsen-P and NH_4OAc-K status were 97.0, 19.0 and 178 kg/ha, respectively. The P and K fixing capacity of the soil was observed to be 62 and 80 kg/ha, respectively. Following the inductive methodology of the Ramamoorthy *et al.* (1967), four fertility gradients were created in the preceding season by dividing the experimental field into four equal stripes which were fertilized with $N_0P_0K_0$, $N_1/2P_1/2K_1/2$, $N_1P_1K_1$ and $N_2P_2K_2$ levels. An exhaust crop of fodder (oats var. Kent) was grown so that the fertilizers could undergo transformations in the soil with plant microbial agencies.

By growing the exhaust crop, the operational range of soil fertility was created in the fertility stripes, which was evaluated in terms of variations in yield, uptake and soil test values. After the harvest of the exhaust crop, each strip of the fertility gradient was divided into four equal blocks across the strip for farmyard manure (FYM) levels. Then each strip was divided into 32 plots and distributed fertilizer treatments in such a manner that every treatment was accommodated in each gradient strip as well as in FYM block.

Pre-sowing soil samples were collected from each gradient plot before superimposition of the treatments and were analysed for alkaline $KMnO_4$-N (Subbiah and Asija, 1956), Olsen-P (Olsen, *et al.*, 1954) and neutral N NH_4OAc-K (Hanway and Heidel, 1952). Groundnut (Var. *Chitra*) crop was grown with usual agronomic practices. After the harvest of crop, the kernel and stover yields of groundnut were recorded plot wise. The plant samples from each plot were analysed for total N, P and K content (Piper, 1966) and total uptake was computed using groundnut yield data.

Using the data of groundnut yield, nutrient uptake, pre-sowing soil available nutrients and fertilizer doses applied, the basic parameters *viz.*, nutrient requirement (kg /q), contribution of nutrients from soil (Cs) and fertilizer (Cf) were calculated as described by Ramamoorthy *et al.*, (1967). The per cent utilization efficiency of nutrients from applied FYM was also estimated in the similar manner. These parameters were used for the formulation of fertilizer adjustment equations for deriving fertilizer doses and the soil test based fertilizer recommendations were prescribed in the form of a ready reckoner for desired yield target of groundnut under IPNS.

Results and discussion

Soil available nutriments and groundnut yield: The $KMnO_4$-N ranged from 97.5 to 142.5 kg/ha with a mean of 128 kg/ha, Olsen P ranged from 19 to 37 kg/ha with a mean of 28.8 kg/ha and NH_4OAc-K ranged from 178 to 278 kg/ha with a mean 228.6 (Table 1). The groundnut yield in fertilizer treated plots ranged from 27.6 to 33.3 q/ha without FYM and 32 to 38.5 q/ha with FYM, and in control plots ranged from 8.5 to 15.2 q/ha without FYM and 12 to 24 q/ha with FYM. The above data clearly indicate that a wide variability existed in the soil test values and groundnut yield of treated and control plots, which is a pre-requisite for calculating the basic parameters and fertilizer adjustment equations for calibrating the fertilizer doses for specific yield targets.

Table 1 Range and mean values of available nutrients in the pre-sowing surface soil and yield of groundnut

Parameter		Range	Mean
Soil test values			
KMnO4-N		97.5-142.5	128.0
Olsen-P		19.0-37.0	28.8
NH4OAc-K		178.0-278.0	228.6
Groundnut yield (q/ha)			
Treated plots	Without FYM	27.6-33.3	30.2
	With FYM	32.0-38.5	34.3
Control plots	Without FYM	8.5-15.2	11.3
	With FYM	12.0-24.0	17.1
Nutrient uptake (kg/ha)			
Treated plots			
N uptake	Without FYM	104.2-121.0	112.3
	With FYM	117.1-143.0	128.6
P Uptake	Without FYM	44.4-56.0	49.6
	With FYM	50.6-64.5	56.6
K uptake	Without FYM	86.0-105.0	93.9
	With FYM	96.2-120.0	105.0
Control			
N uptake	Without FYM	34.0-72.2	48.4
	With FYM	46.5-91.1	65.4
P uptake	Without FYM	15.1-24.0	18.7
	With FYM	19.8-38.8	27.4
K uptake	Without FYM	27.0-46.6	34.8
	With FYM	37.5-78.2	55.4

Basic parameters: The basic data, *viz.*, nutrient requirement for producing one quintal of groundnut yield, the per cent nutrient utilization efficiency for soil, fertilizer and FYM have been calculated and presented in Table 2. For calculation of nutrient requirement of groundnut, 32 plots (response based) were selected. and the uptake of nutrients regressed with the yield to obtain the nutrient requirement in kg/q. Similarly, for calculating the soil nutrient utilization efficiency, fertilizer nutrient utilization efficiency and nutrient utilization efficiency from FYM , the uptake of nutrients from all the 32 plots regressed with their respective soil nutrients value, fertilizer dose for particular nutrient and FYM dose for obtaining the respective regression coefficients.

The nutrient requirements of N, P_2O_5 and K_2O were 3.6, 1.7 and 3 kg/q of groundnut, respectively. The per cent nutrient utilization efficiencies from soil and fertilizer nutrients were found to be 100 and 176 for nitrogen, 98 and 65 for phosphorus (P_2O_5) and 44 and 210 for potassium (K_2O). Similarly, the per cent contribution of N, P_2O_5 and K_2O from FYM was 148, 60 and 61, respectively.

The data presented in Table 2 indicated that application of FYM not only contributes for particular nutrient but also improves the utilization efficiency of soil and fertilizer nutrients. The findings are in close agreement with those reported by Sharma *et al.* (1999) for mustard in Inceptisols, Sreedevi *et al.* (2001) for sunflower in Vertisols and Riazuddin (2003) for castor, sunflower and groundnut in Vertisols.

Fertilizer adjustment equations for desired yield targets of groundnut: Soil test based fertilizer models or equations for targeted yield of groundnut were formulated using the basic parameters and are furnished in Table 3.

On the basis of these equations a ready reckoner was prepared for range of soil test values and for a yield target of 35 q/ha (Table 4) under different fertilization programmes. For producing 35 q/ha of groundnut in Torripsamments, the fertilizer doses required for the average soil test values 100, 20 and 180 kg/ha N, P_2O_5 and K_2O, respectively was found to be 18.2, 55.2 and 10.8 kg N, P_2O_5 and K_2O, respectively with 5 ton FYM.

The finding of the above study indicate that in STCR-IPNS technology, the fertilizer doses are tailored to the requirements of specific yield targets of groundnut taking into account the contribution from soil, fertilizers and organics, thus, avoiding either under or over uses of nutrient inputs.

Table 2 Nutrient requirement, per cent contribution from soil, fertilizer and FYM for groundnut

Parameter	N	P_2O_5	K_2O
Nutrient requirement (kg/q)	3.6	1.68	3.0
Soil nutrient utilization efficiency (%)	100	98	44.0
Fertilizer nutrient utilization efficiency (%)	176	65	210
Nutrient contribution from FYM (%)	148	60	61

Table 3 Soil based fertilizer equations for targeted yield of groundnut

$$FN = 2.05\,T - 0.57\,SN - 0.84\,FYM$$

$$FP = 2.58\,T - 1.51\,SP - 0.98\,FYM$$

$$FK = 1.43\,T - 0.21\,SK - 0.29\,FYM$$

Note: FN, FP and FK - Fertilizer N, P_2O_5 and K_2O in kg/ha, respectively; T = Yield target in q/ha; SN, SP and SK - $KMnO_4$-N, Olsen-P and NH_4OAc-K in kg/ha, respectively

Table 4 Estimates of soil test based fertilizer recommendations for 35 q/ha pod yield target of groundnut (kg/ha)

Soil test value N (kg/ha)	Fertilizer N (kg/ha)		Soil test value P_2O_5 (kg/ha)	Fertilizer P_2O_5 (kg/ha)		Soil test value K_2O (kg/ha)	Fertilizer K_2O (kg/ha)	
	Without FYM	With FYM		Without FYM	With FYM		Without FYM	With FYM
80	26.15	21.95	10	75.20	70.30	170	14.35	12.90
90	20.45	16.25	20	60.01	55.20	180	12.24	10.80
100	14.75	10.55	30	45.00	40.10	190	10.15	8.70
110	9.05	4.85	40	29.90	25.00	200	8.05	6.60
120	3.35	-	50	14.80	9.90	210	5.95	4.50

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Biomass accumulation and its mobilisation in Indian mustard, *Brassica juncea* (L.) Czern & Coss under moisture stress

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Abstract

An experiment was conducted in concrete micro plots filled with light textured dunal sand at CCS Haryana Agricultural University, Hisar. The soil retained about 11.3 and 4.3 cm water/meter soil depth at - 0.1 and - 15 bars of soil water potential, respectively. The percent contribution of different plant parts to the total biomass at physiological maturity was 13.3, 33.8, 12.1, 40.7 and 18.1 among leaves, stem, roots, siliquae and seeds, respectively. The moisture stress imposed by withholding irrigation at 65 DAS reduced the contribution of leaves by 4.0%, stem by 1.2% and roots by 2.1% with an increase of 6.7% by siliquae to the total biomass. The rewatering at 90 DAS increased the percent contribution of leaves by 2.3% and stem by 0.3% with no effect on roots and decreased the contribution of siliquae and seeds by 2.6% and 0.3% respectively. The moisture stress increased the translocation by 17.5%, 9.1%, and 13.0% from leaves, stem and roots, respectively. Among the yield attributes, the moisture stress affected the siliquae number and seeds/siliquae, whereas, 1000-seed weight was the least affected. The allocation of biomass to seed in term of absolute dry weight was highest in RH 30 followed by RH 819. The significant association of seed yield was observed with total biomass in stressed environment, seeds/siliquae in recovered and siliquae number/plant under irrigated control.

Key words: *Brassica,* biomass partitioning, assimilates mobilisation, moisture stress

Introduction

The oilseed *brassicae* are the most important oilseed crop of north India grown on conserved soil moisture, where, crop suffers due to moisture stress of different degree and durations causing large reduction in its productivity. The import bill of edible oil and oilseed is consistently increasing during last one decade increasing gap between productivity and demand. Therefore, to narrow down the gap we have to increase the production and productivity of oilseed crops. Partitioning of photosynthetic assimilates has paramount importance in crop improvement programme. Partitioning of photosynthates from source to sink was reported to be affected by relative sink size, source and sink distance, growth stages, inter sink competition and position of sink (Ryle *et al.*, 1981; Ishita *et al.*, 1998). The partitioning of biomass into leaves, stem, roots and reproductive organs provides information that all the plant organs are not equally sensitive to environmental stress. Hence, the present study was undertaken to study the relative performance of different genotypes of *brassica* for biomass partitioning in under-ground and above ground plant parts, mobilization of pre-anthesis assimilates to the sink and seed yield at maturity under irrigated, terminal moisture stress and recovery after stress conditions to find suitability of genotypes for different moisture stress environments.

Material and methods

To study the effect of moisture stress on dry matter accumulation and its partitioning into different plant parts, an experiment on five Indian mustard genotypes (*B. juncea*) namely RH 30, RH 819, DHR 9701, DRH 8 and RH 9304 of same maturity duration (125-130 days after sowing) was conducted during rabi seasons of 2002-03 and 2003-04 in specially constructed concrete micro plots filled with light textured dunal sand with rainout shelter facilities at Agronomy Research Farm, CCS Haryana Agricultural University, Hisar (29°10'N latitude, 75°46' E longitude and 215 M altitude). The plot size was 6 x 1 x 1.5 m *(length, breadth and depth), adopting factorial* randomized block design with three replications. Three moisture stress treatments *viz.*, normal irrigated control, stressed (withholding irrigation at 65 DAS till harvest) and recovery from moisture stress (half the number of stressed plots were re-irrigated at 90 DAS). The soil retained about 11.3 and 4.3 cm water/ meter soil depth at -0.1 and -15 bars of soil water potential, respectively. A sample of five representative plants was taken from each plot for recording the plant height, root length and biomass partitioning among different plant parts *viz.*, stem, leaves, root and siliquae along with seed yield and its attributes at harvest under all the environments. All the plant parts were first dried in sun and then in oven at 70°C till constant weight. Recommended agronomical practices were adopted to raise the crop. Yield attributes recorded at harvest were expressed on per plant basis.

Results and discussion

The highest plant height was recorded in DRH 8 and lowest in RH 9304. The root length was highest in RH 9304 (Table 1). The lower root mass with deeper root system is also good for efficient partitioning due to its thin roots (Pannu *et al.*, 1997). The root: shoot ratio is another important drought tolerant trait. The ratio in term of length increased with increase in moisture stress. This might be due to roots growing deeper in search of water. Similar increase in biomass allocation to plant parts with limiting factors has been reported by Poorter and Nagel (2000). The ratio worked out on the basis of dry weight at maturity indicates that stress decreased the ratio and could not recover even after rewatering over irrigated control. It means roots continuously accumulate more biomass under well watered conditions may be due to supply of more water and nutrients for strong sink, while under stressed environment plant translocated some of the reserved carbohydrates in roots to developing seeds during reproductive phase. Similar variability in roots has been reported by Reynolds and D'Antonio (1996). Among the genotypes RH 30 and DRH 8 had significantly lower root: shoot weight ratio than other genotypes. This indicate that these genotypes had partitioned less biomass to the roots but also translocated more reserved food from vegetative parts to developing sink, which is desirable trait for drought tolerance.

Among the various plant parts of brassica, the maximum biomass was accumulated in siliquae followed by stem, leaves and minimum in roots (Table 2). The moisture stress caused about 38.4 % reductions in total plant biomass. Among the different plant organs maximum reduction was observed in leaves (55.1%) followed by roots (46.7%), stem (40.4%) and it was minimum siliquae (27.2%). This indicates that leaves are most sensitive to moisture stress and siliquae the least, although the moisture stress was most severe at the time of seed filling. This comparative less reduction of biomass accumulation in siliquae at reproductive stage may be due to development of alternate source of photosynthesis in the form of chlorophyllous siliquae (Cooper and Fox, 1996). The rewatering of crop at 90 DAS resulted in recovery of total biomass by 24.5%, with maximum increase in biomass over stress was recorded in leaves (54.5%) followed by stem (25%), roots (20.8%) and siliquae (16.5%). This proved the fact that the leaves are most sensitive and siliquae the least due to drought stress. Almost same trend of biomass accumulation in different plant parts was observed in tested genotypes. Among the genotypes the lowest reduction in biomass due to moisture stress was observed in RH 30 (31.7 %) and percent increase due to recovery was highest in RH 819. Similarly, siliquae biomass (13.7 %) and seed yield (26.8 %) was found in RH 30 but highest recovery in biomass due to rewatering in seed was recorded in DRH 8 and in siliquae biomass in RH 819.

Mobilization of pre-anthesis assimilates to grain particularly under stress environment is important drought tolerant trait. The moisture stress increased the translocation of assimilates to developing sink (Table 3). Among the plant parts maximum translocation was observed from leaves and it was almost similar from stem and roots in terms of percentage but in terms of absolute values it was much higher from the stem. The stress *increased the translocation by 17.5%, 9.1%, and 13.0%* from leaves, stem and roots, respectively. Among the genotypes DRH 8 had maximum mobilization from vegetative plant parts followed by RH 30 and was least in RH 9304. This indicate that DRH 8 had such a mechanism as it create a buffer when the moisture in soil profile is in plenty and utilize this buffer at the time of stress in yield build up.

The moisture stress reduced the seed yield of brassica by 38.3% (Table 4). The reduction was mainly due to reduction in number of siliquae per plant (47.3 %) followed by 21.5 % reduction in number of seeds/siliquae and it was least in the test weight (8.3%). This reduction in siliquae number was mainly due to less amount of photosynthates available at the time of siliquae formation under stress. Beside this, reduced duration of crop due to forced maturity caused by terminal moisture stress was responsible for reduction in siliquae number. (Ishita *et al.*, 1998). Rewatering of stressed plant leads to 24.3 % recovery in the seed yield. The least increase due to rewatering and least reduction due to stress in test weight indicate that it is controlled genetically and influence of environment are little on this character. The significant association of seed yield was observed with total biomass ($r = 0.87$) in stressed, seeds per siliquae ($r = 0.96$) in recovered and siliquae number per plant ($r = 0.85$) under irrigated control. Similar association between yield and its attributes had been reported by Singh *et al.* (1990). Among the genotypes the highest seed yield was recorded in RH 30 closely followed by RH 819 and DRH 8 which were statistically at par. The higher yield in these genotypes was due to significantly higher number of siliquae per plant over RH 9304 and DHR 9701. The genotype DRH 8 had highest recovery after the removal of water stress. The drought tolerance in RH 30 caused the least reduction in yield and its attributes under moisture stress. This genotype had an additional advantage of escape due to its early phenology in comparison to other genotypes (Pannu *et al.*, 1996).

Therefore, based on the results of study it can be concluded that genotype RH 30 is the best genotype along with DRH 8 and RH 819, not only from productivity but also from drought tolerance and partitioning efficiency point of view.

Table 1 Plant height, root length and their ratio at harvest in *B. juncea* under moisture stress

Genotype	Plant height (cm)				Root length (cm)				Root length: Plant height				Root weight: Shoot weight			
	I	S	R	M	I	S	R	M	I	S	R	M	I	S	R	M
DRH 8	5.3	2.5	4.0	3.9	13.8	7.1	9.2	10.0	4.8	2.3	2.9	3.3	0.15	0.11	0.11	0.12
RH 30	5.7	3.0	4.2	4.3	11.9	7.3	8.7	9.3	4.2	2.2	2.8	3.1	0.14	0.10	0.11	0.12
RH 819	4.7	2.1	3.5	3.4	10.7	7.1	8.5	8.8	4.1	2.6	3.2	3.3	0.15	0.15	0.14	0.15
RH 9304	5.7	2.0	2.7	3.5	9.8	6.5	7.8	8.0	3.9	2.5	2.8	3.1	0.15	0.15	0.15.	0.15
DHR9701	3.3	1.5	2.4	2.4	10.8	6.0	8.3	8.4	4.5	2.2	2.9	3.2	0.17	0.15	0.15	0.16
CD (P=0.05)	E	G	ExG		E	G	ExG		E	G	ExG		E	G	ExG	
	0.61	0.79	NS		0.40	0.50	0.80		0.2	0.2	0.45		0.14	0.20	NS	

I = Irrigated; S = Stress; R = Recovered; M = Mean

Table 2 Biomass partitioning (g/plant) of different plant parts at harvest in *B. juncea* genotypes under moisture stress

Genotype	Leaf weight (g)				Stem weight (g)				Root weight (g)				Pod weight (g)				Total dry weight (g)			
	I	S	R	M	I	S	R	M	I	S	R	M	I	S	R	M	I	S	R	M
DRH 8	5.3	2.5	4.0	3.9	13.8	7.1	9.2	10.0	4.8	2.3	2.9	3.3	13.7	10.7	12.5	12.3	37.6	22.6	28.6	29.6
RH 30	5.7	3.0	4.2	4.3	11.9	7.3	8.7	9.3	4.2	2.2	2.8	3.1	13.1	11.3	12.0	12.1	34.9	23.8	27.7	28.8
RH 819	4.7	2.1	3.5	3.4	10.7	7.1	8.5	8.8	4.1	2.5	3.2	3.3	12.2	8.1	11.3	10.5	31.6	19.9	26.5	26
RH 9304	5.7	2.0	2.7	3.5	9.8	6.5	7.8	8.0	3.9	2.4	2.7	3.0	10.8	8.1	8.4	9.1	30.2	19.1	21.7	23.7
DHR9701	3.3	1.5	2.4	2.4	10.8	6.0	8.3	8.4	4.5	2.2	2.9	3.2	12.7	7.1	8.8	9.5	31.3	16.8	22.4	23.5
CD (P=0.05)	E	G	ExG		E	G	ExG		E	G	ExG		E	G	ExG		E	G	ExG	
	0.61	0.79	NS		0.40	0.50	0.80		0.2	0.2	0.45		0.70	0.90	1.50		1.20	1.50	2.60	

Table 3 Per cent biomass mobilisation from different plant parts to seeds in *B. juncea* genotypes under moisture stress

Genotype	Leaf				Stem				Root				Pod			
	I	S	R	M	I	S	R	M	I	S	R	M	I	S	R	M
DRH 8	30.1	50.0	36.8	37.6	12.7	20.2	16.4	15.7	13.5	26.3	21.4	19.1	226.2	117.0	177.8	170.7
RH 30	18.2	35.8	33.6	28.2	15.0	21.5	19.4	18.2	16.0	24.1	20.0	19.3	151.9	91.5	118.2	119.3
RH 819	7.9	23.1	18.0	14.9	15.1	26.4	22.7	20.9	9.6	18.8	15.8	14.2	144.0	13.7	65.4	66.7
RH 9304	14.9	28.6	25.0	20.6	10.7	20.1	18.2	15.9	15.0	21.4	17.2	17.5	140.0	62.2	83.5	94.0
DHR9701	14.6	28.6	25.0	21.4	4.4	13.4	9.8	8.5	15.1	23.6	16.4	17.6	193.3	58.0	104.2	117.7

Table 4 Seed yield and yield attributes of *B. juncea* genotypes under moisture stress

Genotype	Number of siliquae/plant				Number of seeds/siliquae				1000 seed weight (g)				Seed yield (g/plant)			
	I	S	R	M	I	S	R	M	I	S	R	M	I	S	R	M
DRH 8	263.2	114.8	183.2	187.1	12.8	10.3	11.6	11.6	6.0	5.6	5.8	5.8	6.7	3.7	4.8	5.1
RH 30	259.2	122.6	176.4	186.1	14.5	10.8	12.4	12.6	6.3	5.8	6.1	6.1	6.5	4.8	5.3	5.5
RH 819	252.2	120.8	172.0	181.7	13.6	10.0	12.6	12.1	6.2	5.4	5.8	5.8	6.5	4.0	5.1	5.2
RH 9304	169.2	116.0	155.2	146.8	12.2	10.4	11.2	11.3	6.1	5.7	5.8	5.9	5.5	3.2	4.1	4.3
DHR9701	206.0	131.2	173.2	170.1	12.0	9.5	10.5	10.7	5.6	5.0	5.6	5.4	5.0	2.9	3.4	3.8
CD (P=0.05)	E	G	ExG		E	G	ExG		E	G	ExG		E	G	ExG	
	8.9	11.5	20.0		1.20	0.70	1.85		0.45	NS	NS		0.33	0.42	0.73	

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Productivity improvement in soybean, *Glycine max* L. Merrill through technological interventions

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Abstract

Oilseeds contributed to yellow revolution, significant role has been played by introduction of soybean (*Glycine max* L. Merrill) and sunflower (*Helianthus annuus* L.). Frontline demonstrations were conducted through technological interventions on soybean during the period from 2001-02 to 2005-06 during *kharif* crop season under rainfed conditions. The results had shown that per cent increase in yield ranged from 5.3 to 20.1 while additional net returns/ha ranged from Rs. 1817/- to Rs. 2643/-. This study i.e., whole package, seed inoculation with biofertilizers, chemical weed control and improved variety indicated that, cultivation of more than one variety in a geographical area, seed inoculation with biofertilizers @ 5 g/kg of seed, pre-emergence application of herbicide (Alachlor 4 l/ha) followed by one hand weeding at 30 days after sowing helps to get maximum net returns.

Key words: Soybean, frontline demonstrations

Introduction

Soybean is a newly introduced and commercially exploited crop in India. The crop has been playing an important role in national economy by earning an average of Rs. 20,000 million per annum through export of soy meal and contribution about 10% to the edible oil production. At present, soybean covers an area of nearly 7 m.ha in the country (Chauhan and Joshi, 2005). Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Andhra Pradesh are the main soybean producing states in India. In Andhra Pradesh, Adilabad is a leading district in cultivation of soy crop followed by Guntur and Prakasam (Srinivasa Rao *et al.*, 2005). Soybean has brought the revolutionary changes in the rural economy management by way of increasing the social and economic status of the farmers through soybean farming.

Material and methods

Many technologies for soybean cultivation have been evolved for increasing productivity but farmers have not adopted many of them. Keeping in view, Krishi Vigyan Kendra (KVK), Adilabad has made an attempt to identify the production constraints/gaps in cultivation of soybean through various extension methods including the Participatory Rural Appraisal technologies in its adopted villages in particular and district in general.

The speedy adoption of improved agricultural technologies and innovations are the most important tools for enhancing the agricultural production at faster rate and hence it is a crucial aspect under innovation diffusion process (Kareem and Manohari, 2001). The main objective was to demonstrate the productivity potential and profitability of the latest improved production technology as well as single component technologies under real farm situations.

The KVK discriminated the improved technologies of soybean to the farmers in Adilabad district in order to implement the mandatory functions. Scientists adopted the villages *viz.*, Busimetta, Chinchughat, Wadagaon, Vaizhapur, Jamdapur, Guda and Umri. Different extension activities were taken up for technology assessment and refinement, educating the farmers through trainings, method demonstrations and raising the socio-economic status considerably. The beneficiary farmers were identified based on the proportionate random sampling method, the cause for low yields of soybean were identified and then prioritized. Based on the major causes and constraints for low yields, i.e., poor package of practices, non-adoption seed incoulation with biofertilizers, non-availability of labourer during the critical crop growth period and dependence on single variety over long period, the technological intervention were initiated during the year 2001-02 and continued upto 2005-06 crop season. Whole package oriented demonstration from 2001-02 to 2004-05 and single component oriented demonstrations from 2001-02 to 2005-06 (biofertilizers 2001-02 to 2002-03, weed control 2004-05 to 2005-06 and improved variety 2004-05 to 2005-06).

Results and discussion

Strategies followed in transfer of improved technology in soybean: One pre-season orientation training were conducted to the selected farmers and regular field visits were made to explain the production technology of soybean particularly on nutrient management and weed management.

The productivity potentials and profitability of the latest soybean improved technologies were demonstrated under farmers' field condition at 88 locations in adopted villages of KVK, Adilabad during rainfed conditions. Sowings were done in black cotton soils at spacing of 45 cm in 2nd fortnight of June in all the years of demonstrations. Each demonstrations plot both with Improved Technology (IT) and Farmers' Practice (FP) had an area of 0.4 ha. The components of improved technology involved were whole package of practices and single component demonstrations *viz.*, seed inoculation with *Rhizobium japanicum* and phosphorus solubilizing bacteria, weed management through chemical weed control and hand weeding at 30 days after sowing and high yielding variety (PK-1029).

The production potential of improved technologies were worked out taking the mean yields attained through demonstrations. The economics of improved technology in relation to prevailing farmers' practices was studied to know the superiority of the technology. The superiority of IT over FP was assessed mainly in terms of per cent yield increase, additional net returns and benefit cost ratio.

The data generated through the frontline demonstrations conducted during the period from 2001-02 to 2005-06 had shown the potential of various improved technologies in soybean and results are presented in Table 1.

The single component oriented technology was demonstrated during the period from 2001-02 to 2002-03 under rainfed condition. The per cent increase in yield in IT over FP was 16.4 and the additional net returns realised were Rs. 2116/ha with benefit cost ratio of 2.31.

Net returns and benefit cost ratio was more when seed was inoculated with *Rhizobium japonicum* + phosphorus solubilizing bacteria. The cost of fertilizers was very high as compared to bacterial inoculation, hence, bacterial inoculation proved to be more remunerative. Bacterial incoculants help in partial supplementation of nutrients. The results are in agreement with the findings of Dubey *et al.* (1995) and Kulkhare *et al.* (1996). The increase in yield on seed inoculated with biofertilizer over the farmers' practice is ranging from 13.10 to 20.01%.

Table 1 Productivity improvement in soybean through technological interventions at Adilabad, A.P.

Intervention	Demonstrations (No)	Year	Mean yield (kg/ha)		Increase in yield (%)	Cost of cultivation (Rs/ha)		Gross returns (Rs/ha)		Additional returns (Rs/ha)	B:C ratio	
			IT	FP		IT	FP	IT	FP		IT	FP
Whole package	18	2001-02 to 2004-05	1700	1615	5.3	8259	8248	20400	18572	1817	2.47	2.25
Biofertilizer	30	2001-02 to 2002-03	1897	1629	16.4	8427	9275	21816	19548	2116	2.31	2.11
Weed control	30	2004-05 to 2005-06	2075	1929	7.6	9415	9379	23862	21219	2643	2.53	2.26
Improved variety	15	2004-05 to 2005-06	1978	1647	20.1	9639	9289	22747	19764	2633	2.35	2.13

IT = Improved technology; FP = Farmers' practice

Weed management: The technology was demonstrated during the period from 2004-05 to 2005-06 under rainfed condition using the JS-335 as a variety. The major weeds observed were *Echinochoa colanum* (L.) Link, *Cynodon dactylon* (L.) Pers., *Cyprus rotundus* L., *Partinium stolanifer*, *Amranthus spinosus* L., *Digiteria sanguinali*, *Phyllanthus firuri*, *Trianthema pertulocastram* and *Digera arvensis* L., etc. The per cent increase in yield was 7.6 and additional net returns recorded was Rs. 2643/ha.

The superiority of IT in controlling weeds over FP was due to fact that by applying Alachlor (4 l/ha), early growth of weeds checked and one hand weeding at 30 DAS helped in removal of all types of weeds. The increase in yield under IT may be due to reduction in crop weed competition, which provided congenial environment to the crop for better reproductive potential, better availability of resources like moisture, nutrients and light, which in turn improved the yields.

Improved variety: The national soybean productivity achieved is only about one tonne/ha inspite of varietal potential of 3.5-4 t/ha and yield realised to the tune of 2 t/ha under real farm situations. Nearly 82 improved soybean varieties developed for different agro-climatic regions of the country (Singh and Saxena, 1972). The improved variety demonstrated under the present study was PK-1029 and local variety used by the farmers was JS-335. The increase in yield in improved variety over the local variety was 20.1%. The additional net return per hectare obtained was Rs. 2633/- with return/rupee investment was 2.35.

Frontline demonstrations conducted on soybean indicated that the per cent increase in yield ranged from 5.3 to 20.1 over the farmers' practice. These results of present observation are in close conformity with the finding of Billore *et al.* (2004). Cost of cultivation was more in improved technologies is due to purchase of certified foundation seed from the Agricultural Research Station, Adilabad while farmers purchased the seed on subsidy basis from HACA, Adilabad.

From the findings it could be concluded that, instead of using the single variety farmers are advised to cultivate the more than one variety recommended for their region in line with varietal cafeteria approach and to reduce the build up of pest and diseases. Before sowing the seed, it was recommended to treat the seed with fungicide and biofertilizer (2:1 Thiram : Carbendazim followed by *Rhizobium japanicum* and PSB (5 g/kg). It helps in control of seed as well as soil borne diseases and reduces the external application of chemical fertilizers. Pre-emergence application of herbicide (Alachlor 4 l/ha) followed by hand weeding was found to be the most cost effective practices for managing the weeds in *kharif* soybean to get maximum net returns.

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Combining ability analysis for physiological and yield attributes in groundnut, *Arachis hypogaea* L.

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Abstract

Combining ability analysis of physiological and yield traits was conducted involving eight parents of groundnut in all possible combinations excluding reciprocals. The mean squares for both general combining ability and specific combining ability were significant for all the characters studied. This indicated the involvement of both additive and non-additive gene action in the inheritance of characters. In general, high magnitude of general combining ability variance depicted the greater role of additive gene action in the inheritance of traits under study. Parents K-134, TIR-46 and JL-24 have emerged as desirable general combiners. The crosses, JUG-37 x ICR-45, TIR-46 x JUG-43 and JUG-43 x JL-24 etc., were the most desirable specific combinations for pod yield and for other physiological and yield attributes.

Key words: Combining ability, groundnut, physiological traits, yield traits

Introduction

Groundnut is an important oilseed crop of India with an area of 8.2 m.ha and production of 6.2 m.tonnes. As the major area under groundnut (81%) is in the *kharif* (rainy) season, the crop often suffers heavy losses due to drought. The annual estimated losses in groundnut production, equivalent to over US$ 520 million, are caused by drought. Yield losses due to drought are highly variable in nature and depend mainly on the timing, intensity and duration of drought (Stan Sell and Pallas, 1979).

Genetic improvement for drought tolerance is crucial in many regions where agriculture depends on scarce water resources. Plant survival under severe drought, is an important aspect of the tolerance to drought, as it contributes to ensure a minimum yield in subsistence farming. The breeding of high yielding drought tolerant groundnut cultivars has been hampered by the lack of information and the genetics of physiological traits contributing to drought tolerance under limited water conditions (Hammons, 1973). Identification of the traits involved in the drought tolerance and their insertion in the genetic background of agronomic ally preferred varieties could enhance and/or stabilize the yields under drought prone situations (Rucker *et al.*, 1995). In this direction combining ability analysis helps in identification of parents that wood nick well and throw up desirable segregants in the segregating generations for various physiological and yield traits in groundnut.

Material and methods

Eight parents, *viz.*, TIR-46, JUG-37, ICR-45, TIR-10, K-134, JAL-6, JUG-43 and JL-24 were crossed in diallel manner without reciprocals to produce 28 F_1s. The eight parents and their resultant 28 F_1s were raised in a Randomized Block Design with three replications during *kharif* 2003 at the Regional Agricultural Research Station, Tirupati. In each replication, each parent and F_1 was grown in a single row of 4m length spaced 30 cm apart with a plant to plant distance of 10 cm. Recommended cultural practices were adopted to produce good crop. At 75 days after sowing 3rd healthy leaf from the apex of main stem from 10 plants of each plot and replication was selected to record data on SPAD chlorophyll meter reading, specific leaf nitrogen, specific leaf area and per cent reduction of Fv/Fm. Similarly at maturity 10 plants from each plot were selected at random from each replication for recording data on nine characters (Table 1). The mean value of ten plants were analysed for combining ability following Griffings method II model I (Griffing, 1956).

Results and discussion

The analysis of variance indicated that the progenies differed significantly for all the traits under study. A further analysis of data for combining ability (Table 1) showed that variance due to both general and specific combined ability was significant for all the traits. This shows that both additive and non-additive genetic effects operate for almost all characters. Similar findings were reported by Swe and Branch (1986) in groundnut.

The estimates of general combining ability effects are presented in Table 2. The *gca* effects reveal that none of the parents had good general combining ability for all the traits. The genotypes, JUG-37, K-134 and JUG-43 expressed significant positive *gca* for SPAD chlorophyll meter reading and specific leaf nitrogen. JUG-37 and TIR-10 exhibited significant negative *gca* for specific leaf area. Therefore, JUG-37 was the best general combiner for specific leaf nitrogen and specific leaf area and JUG-43 for

SCMR. *For harvest index,* TIR-46 *and* K-134; *for kernel* yield/plant and number of well filled and mature pods/plant, *TIR-46; for sound mature kernel per cent and* pod yield/plant, TIR-46 and JUG-37 exhibited significant positive *general combining ability* effects. Therefore, among parents, TIR-46 was the best general combiner for harvest index, umber of mature pods/plant, sound mature kernel (%), pod yield/plant and kernel yield/plant. Parents, K-134 are the best general combiners for oil per cent and JL-24 for root length and per cent reduction of Fv/Fm.

The estimates of specific combining ability effects are presented in Table 3. Out of 28 crosses, two gave significant positive *sca* effects for pod yield/plant. The best cross combinations for pod yield/plant was JUG-37 x ICR-45 (high x low) followed by TIR-46 x JUG-43 (high x low). The highest *sca* effects for this trait was exhibited by the cross involving parents with high x low general combiners *obviously due to concentration of opposing allels in* parents which in F_1 showed high allelic concentration. *Transgressive sergeants could be obtained in such* crosses, if the additive genetic system present in low *combiner in the cross, acts in a complementary fashion to* maximize desirable attributes (Tyagi and Srivastava, 1999).

The crosses that showed high *sca* effects in desirable direction for drought tolerant traits involving low x low combiners are *viz.*, for SPAD chlorophyll meter reading three (TIR-46 x JAL-6, TIR-46 x JAL-6 and JAL-6 x JL-24) out of four, for specific leaf nitrogen four (TIR-46 x JAL-6, ICR-45 x TIR-10, ICR-45 x JAL-6 and ICR-45 x JL-24) out of 11 and for specific leaf area four (TIR-46 x TIR-10, TIR-46 x K-134, TIR-46 x JAL-6 and TIR-10 x K-134) out of five crosses. These crosses showing high specific combining ability effects with low x low general combiner suggesting significance of non-additive gene effects for these traits. Conversely it was also true i.e., some *crosses, for example* JUG-37 x JUG-43, *for specific leaf* nitrogen involved high x high combiners. Such crosses *could be exploited by simple conventional breeding* programmes like pedigree method, which may give stable *high performance progenies in advanced generations and* therefore, merit special attention as suggested by Labana and Mohinder Singh (1983).

For SPAD chlorophyll meter reading and specific leaf area, four crosses were in the desired direction in their *sca* effects, the best cross being JUG-43 x JL-24 which involved JUG-43 as the best general combiner for this character. Among 28 F_1s, 11 crosses showed *sca* effects in the positive direction for specific leaf nitrogen, the best cross being JUG-37 x JUG-43 in which both the parents were good combiners. Similarly, the top ranking specific crosses for root length, JUG-37 x JAL-6; for SMK per cent, TIR-10 x JAL-6; for number of mature pods/plant, TIR-46 x JAL-6; *for oil per cent,* TIR-10 x JUG-43 and for harvest index, JAL-6 x JUG-43 had *sca* effects in the desirable direction. Similar results were reported earlier by Manivel *et al.* (2003). In all the above crosses that exhibited *significant sca effects involved both poor combiners or one* good and one poor combiner indicating operation of non-*additive gene action in controlling these characters.* Biparental mating followed by selection might be worthwhile for fostering greater recombination in these crosses (Francis and Ramalingam, 1999).

Results of the present study are based on only one season data and may be biased due to G x E interactions. However, they have implications for breeding and selection procedures for drought tolerant traits in groundnut. In general, non-additive gene effects are likely to play more important role in the inheritance of quantitative traits in groundnut if selected parents are more divergent as suggested by Nigam *et al.* (2001).

Table 1 Combining ability analysis for physiological and yield attributes in groundnut

Source	*d.f.*	SPAD chlorophyll meter reading	Specific leaf *nitrogen* (gNm^{-2})	Specific *leaf area* (cm^2/g)	Per cent *reduction* of Fv/Fm	Root *length* (cm)	Shell *thickness* (mm)	Oil (%)	Shelling per cent	Sound *mature* kernel (%)	No. Of well filled and mature pods/plant	Kernel *yield/* plant	Pod *yield/* plant
gca	7	7.78**	0.19*	449.36**	243.54**	2.74*	0.97**	13.63**	13.68*	87.17**	6.80*	2.98*	9.42**
sca	28	2.94**	0.05**	211.83**	80.52**	7.38**	3.19**	4.01*	23.85**	58.80**	4.99*	1.82*	2.86*
Error	70	0.69	0.00	10.85	4.65	1.01	0.00	2.26	6.21	5.01	2.89	1.07	1.76
Var. (*gca*)		0.71	0.02	43.85	23.89	0.17	0.10	1.14	0.75	2.84	0.39	0.19	0.66
Var. (*sca*)		2.25	0.10	200.98	75.86	6.38	3.19	1.76	17.37	53.70	2.10	0.77	1.10
h^2 (narrow sense)		0.33	0.29	0.29	0.37	0.04	0.06	0.36	0.06	0.09	0.14	0.17	0.32

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

Table 1 Combining ability analysis for physiological and yield attributes in groundnut

Source	SPAD chlorophyll meter reading	Specific leaf nitrogen (gNm^{-2})	Specific leaf area (cm^2/g)	Per cent reduction of Fv/Fm	Root length (cm)	Harvest index	Shell thickness (mm)	Oil (%)	Shelling per cent	Sound mature kernel (%)	No. Of well filled and mature pods/plant	Kernel yield/ plant	Pod yield/ plant
TIR-46	-1.19**	-0.19**	-0.70	1.76*	-0.47	0.07**	-0.04**	1.00	1.61	4.55**	1.65**	1.04*	1.80**
JUG-37	0.65*	0.26**	-13.43**	0.61	0.33	-0.01	0.23**	0.15	-0.26	3.55**	0.22	0.41	0.93*
ICR-45	0.52	-0.09**	2.84*	5.07**	-0.20	0.01	-0.04**	-0.74	-1.16	-0.92	-0.30	-0.54	-0.99*
TIR-10	0.34	-0.06**	1.34	2.78**	-0.49	-0.03**	-0.06**	-1.82**	-0.89	-4.25**	-0.30	-0.40	-0.52
K-134	0.59*	0.08**	2.80*	0.28	-0.02	0.03**	-0.05**	1.75**	-0.36	-2.62**	-0.06	0.29	0.47
JAL-6	-0.87**	0.02	2.22	-5.38**	0.30	-0.01	0.02	-0.71	1.51	-0.12	0.21	-0.01	-0.35
JUG-43	1.01**	0.08**	-4.57**	4.20**	-0.14	-0.03**	0.02	-0.53	0.08	0.88	-0.53	-0.35	-0.58
JL-24	-1.05**	-0.10	9.50**	-9.31**	0.71*	-0.02**	-0.08**	0.91	-0.25	-0.108	-0.89	-0.43	-0.76
SE (gi)	0.25	0.01	0.98	0.64	0.30	0.01	0.01	0.44	0.74	0.67	0.50	0.31	0.39

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

Table 3 Crosses showing significant specific combining ability effects in desirable direction for physiological and yield attributes

Characters	Crosses
SPAD chlorophyll meter reading	JUG-43 x JL-24, TIR-46 x JL-24, TIR-46 x JAL-6, JAL-6 x JL-24
Specific leaf nitrogen	JUG-37 x JUG-43, JUG-37 x JL-24, JUG-37 x JAL-6, TIR-46 x JAL-6, ICR-45 x TIR-10, ICR-45 x JAL-6, ICR-45 x JL-24, TIR-10 x K-134, TIR-10 x JAL-6, JAL-6 x JUG-43, JUG-43 x JL-24
Specific leaf area	JUG-43 x JL-24, TIR-46 x TIR-10, TIR-46 x K-134, TIR-46 x JAL-6, TIR-10 x K-134
Per cent reduction of Fv/Fm	JAL-6 x JL-24, JUG-37 x K-134, K-134 x JL-24, TIR-10 x JUG-43, TIR-46 x K-134, TIR-46 x JUG-43, JUG-37 x ICR-45, ICR-45 x JL-24
Root length	JUG-37 x JAL-6, TIR-10 x JUG-43, TIR-46 x ICR-45, JUG-37 x TIR-10
Harvest index	JAL-6 x JUG-43, TIR-46 x ICR-45
Shell thickness	TIR-46 x JL-24, TIR-46 x JUG-37, K-134 x JL-24, TIR-46 x ICR-45, JUG-37 x IR-45, TIR-10 x K-134, K-134 x JAL-6, JAL-6 x JUG-43
Oil (%)	TIR-10 x JUG-43, TIR-10 x JL-24
Sound mature kernel (%)	JUG-37 x JL-24, K-134 x JUG-43, TIR-10 x JAL-6, TIR-46 x ICR-45, TIR-10 x JUG-43
Number of well filled and mature pods/plant	TIR-46 x JAL-6
Pod yield/plant	JUG-37 x ICR-45, TIR-46 x JUG-43
Kernel yield/plant	JUG-37 x ICR-45, TIR-46 x JAL-6, TIR-46 x JUG-43

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Effect of locations, seasons and staggered planting on seed yield and its components in RSFH-1 sunflower hybrid

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Abstract

A field experiment was conducted at Water and Land Use Management Institute, Dharwad and Agricultural Research Station, Bagalkot during *kharif* and *rabi* season of 2003-04, to study the influence of location, season and staggered sowing on seed yield and its components. The results revealed that hybrid seed production at Bagalkot location significantly increased all the yield attributes leading to increased processed yield by 42% over Dharwad location. Higher processed seed yield was noticed in *rabi* season (633 kg/ha) compared to *kharif* (563 kg/ha). Among the staggered sowings, sowing of male parent seven days early recorded significantly higher (776 kg/ha) processed seed yield over four and ten days staggered sowings (614 and 637 kg/ha, respectively).

Key words: Locations, season, staggered sowing, seed yield, sunflower

Introduction

An identification and selection of suitable location and season are the primary criteria for increasing seed yield, since the weather conditions such as temperature, relative humidity, photoperiod, wind velocity vary over the locations and seasons resulting in differential seed yield. The major barrier in producing the hybrid seed of sunflower is non-synchronization of flowering of the parents. The problem of non-synchrony is observed in the recently released hybrid RSFH-1. The male parent (R-64NB) flowers later than seed parent (CMS 103A). Hence, the present study was undertaken during 2003-04 to ascertain the effect of locations, seasons and staggered planting on seed yield and its components.

Material and methods

An experiment was conducted on black clay loam and deep black soil at Water and Land Use Management Institute (WALMI), Dharwad and Agricultural Research Station (ARS), Bagalkot, respectively under irrigated conditions during the year 2003-04. It consisted of eight treatments laid out in Randomized Block Design with three replications. The plot size was 5.4 x 4.2 m. The seed of parental lines (CMS-103A and R-64NB) were treated with captan @ 2 g/kg of seed, female parent (CMS-103A) was sown on 1st August and 5th November, 2003 during *kharif* and *rabi* season, respectively at Dharwad. Similarly, 13th August and 18th November at Bagalkot location. The female and male parents were sown in separate blocks with planting ratio of 3:1 and at a spacing of 60 x 30 cm. All the recommended agronomical and plant protection measures were carried out. The different treatments imposed on the male parent were (S_0 = simultaneous sowing of both male and female parents), S_1 = sowing of male parent four days early, S_2 = sowing of male parent seven days early and S_3 = sowing of male parent ten days early, $S_4 = S_0$ + urea spray 2% to the male parent at button formation stage, $S_5 = S_1$ + urea spray 2% to the male parent at button formation stage, $S_6 = S_2$ + urea spray 2% to the male parent at button formation stage, $S_7 = S_3$ + urea spray 2% to the male parent at button formation stage. Fertilizers were applied at 30:90:40 kg N, P_2O_5, K_2O/ha as basal dose and 30 kg N/ha as top dressing at 30 days after sowing (DAS) to all the treatments. The observations were collected on five randomly selected plants in each treatment and were subjected to statistical analysis.

Results and discussion

Effect of location: The higher processed hybrid seed yield (682 kg/ha) was recorded at Bagalkot compared to Dharwad location (514 kg/ha) (Table 1). The increase in the seed yield can be attributed to the contribution of yield components like increased test weight (6.0 g), number of filled seeds/head (326), seed set percentage (53.9) and seed yield/plant (18.5 g) and seed recovery (89.4%). Further, it can be attributed to the dry weather, absence of clouds and higher light intensity at flowering and maturity stage might have helped the higher pollination and seed set which in turn contributed to the higher seed yield/ha.

Significantly higher seed recovery percentage (53.9) and processed seed yield (682 kg/ha) were recorded at Bagalkot location compared to Dharwad (48.8% and 563 kg/ha, respectively).

Table 1 Seed set (%), 100-seed weight (g), processed seed yield (kg/ha) as influenced by provenance, planting season and staggered sowing in seed parent of RSFH-1 sunflower hybrid

Treatments	Location (L)		Season (P)		Mean (S)	*Kharif* (P_1)		*Rabi* (P_2)	
	L_1	L_2	P_1	P_2		L_1	L_2	L_1	L_2
					Seed set (%)				
S_0	28.7	29.1	27.9	29.9	28.9	27.0	28.9	30.4	29.3
S_1	44.9	45.4	46.5	43.9	45.2	46.9	46.1	43.0	44.8
S_2	65.9	76.9	68.6	74.3	71.5	63.2	74.0	68.7	49.8
S_3	51.8	56.0	52.6	55.2	53.9	49.3	56.0	54.3	56.1
S_4	32.7	32.2	31.9	33.0	32.5	32.0	31.7	33.4	32.7
S_5	57.4	69.8	62.1	65.1	63.6	55.9	68.3	58.8	71.3
S_6	56.0	68.4	57.5	66.9	62.2	52.2	62.8	59.7	74.0
S_7	53.0	53.2	53.0	53.2	53.1	52.7	53.3	53.2	53.2
Mean	48.8	53.9	50.0	52.7	51.4	47.4	52.6	50.2	55.2
	L	**L x S**	**P**	**P x S**	**S**	**L x P**		**L x P x S**	
SEm±	0.2	0.7	0.2	0.7	0.5	0.3		1.0	
CD (P=0.05)	0.7	1.9	0.7	1.9	1.4	NS		NS	
					100 seed weight (g)				
S_0	5.5	6.1	5.7	5.9	5.8	5.3	6.0	5.7	6.2
S_1	5.2	6.2	5.6	5.7	5.7	5.0	6.2	5.3	6.2
S_2	4.9	5.9	5.3	5.5	5.4	4.8	5.8	5.1	5.9
S_3	5.1	5.9	5.4	5.5	5.5	5.0	5.8	5.1	5.9
S_4	5.5	6.1	5.6	5.9	5.8	5.3	5.9	5.7	6.2
S_5	4.9	6.1	5.3	5.7	5.5	4.7	5.9	5.2	6.2
S_6	5.1	5.9	5.5	5.5	5.5	5.1	5.9	5.2	5.8
S_7	5.1	6.2	5.6	5.7	5.6	5.0	6.2	5.2	6.2
Mean	5.2	6.0	5.5	5.7	5.6	5.1	6.0	5.3	6.1
	L	**L x S**	**P**	**P x S**	**S**	**L x P**		**L x P x S**	
SEm±	0.1	0.1	0.1	0.1	0.1	0.1		0.2	
CD (P=0.05)	0.1	NS	0.1	NS	0.2	NS		NS	
					Processed seed yield (kg/ha)				
S_0	311.05	357.45	305.90	362.61	334.25	270.48	341.31	351.63	373.59
S_1	556.19	673.75	612.35	617.58	614.97	555.24	669.46	557.14	678.02
S_2	632.61	918.93	713.30	838.24	775.77	569.53	857.06	695.69	980.79
S_3	567.93	706.28	611.38	662.77	637.07	520.09	702.67	615.77	709.76
S_4	347.66	387.05	340.88	393.83	367.36	316.98	364.77	378.34	409.33
S_5	556.77	875.97	667.71	765.02	716.37	504.33	831.09	609.20	920.85
S_6	545.44	815.37	604.96	755.85	680.40	481.17	728.75	609.70	901.99
S_7	591.72	724.88	647.43	669.17	358.30	568.48	726.38	614.96	723.38
Mean	513.67	682.45	562.99	633.13	598.06	473.29	652.69	554.05	712.22
	L	**L x S**	**P**	**P x S**	**S**	**L x P**		**L x P x S**	
SEm±	3.73	10.56	3.73	10.56	7.46	5.28		14.93	
CD (P=0.05)	10.55	29.83	10.55	29.83	21.09	14.91		NS	

NS = Non-significant; L_1 = Dharwad; L_2 = Bagalkot; P_1 = *Kharif*, P_2 = *Rabi*

S_0 = Simultaneous sowing of female and male parent; S_1 = Sowing of male parent four days early to the female parent

S_2 = Sowing of male parent seven days early to the female parent; S_3 = Sowing of male parent ten days early to the female parent

S_4 = S_0 + spraying of urea (2%) at button formation stage to male parent; S_5 = S_1 + spraying of urea (2%) at button formation stage to male parent

S_6 = S_2 + spraying of urea (2%) at button formation stage to male parent; S_7 = S_3 + spraying of urea (2%) at button formation stage to male parent

Effect of seasons: *The crop sown during rabi season* recorded higher number of filled seeds/capitulum (318), per cent seed set (52.7), seed yield/plant (16.9 g) and 100-seed weight (5.7 g) compared to *kharif* season (299, 50, 15.3, 5.5 g, respectively).

The increase in yield components resulted in higher processed seed yield (633 kg/ha) during *rabi* season *compared to kharif* (563 kg/ha). *The lower seed yield* during *kharif* season can be attributed to the intermittent rainfall, higher relative humidity and low sunshine hours and lesser day length were some of the factors that might have affected the seed yield. Similar results were reported by Narwal and Malik (1985) in sunflower cultivars.

The test weight was maximum (5.7 g) in *rabi* season compared to *kharif* (5.5 g). Higher test weight in *rabi* season can be attributed to prolonged vegetative growth of crop, that might have resulted in formation of heavier seeds during *rabi* season. The reduction in the seed weight during *kharif* may be due to increase in number of partially filled seeds. Similar observations were made by Kovacik and Skaloud (1972) and Ghosh and Chatterjee (1975) who were studied the variation in sunflower seed development and seed filling in different environments.

The higher seed recovery percentage (90.0) and processed seed yield (633 kg/ha) were recorded during *rabi* season compared to *kharif* season (86.7 and 563 kg/ha, respectively). The higher recovery of seeds may be due to the proper development of seed during *rabi* season compared to *kharif* season. As the heavier seeds were *formed during rabi that resulted in higher seed recovery* per cent. Similar results were reported by Narwal and Malik (1985) in sunflower.

Effect of staggered sowing of male parent: Effect of staggered sowing of male parent the staggered sowing of male parent seven days early to the female parent recorded the higher number of filled seeds (450), seed set *percentage (71.5), seed yield/plant (21.6 g) on female* parent thus resulted in the higher hybrid processed seed yield (776 kg/ha) *compared to other staggered sowing* treatments. This can be attributed to proper synchronization of flowering of both the parents resulted in better availability of pollens from male parent for pollination and leading to higher seed set percentage. Such staggered sowing of 6 D-1 on proper synchronization with female parents was observed by Somashekhara (1997) in KBSH-1 sunflower hybrid seed production.

Staggered sowing of male parent seven days early resulted in reduced 100-seed weight (5.4 g) compared to simultaneous sowing (5.8 g). The reduction in 100-seed weight can be attributed to the increase in per cent seed set as a result of better seed development due to better synchronization in parental lines. The limited source and increased sink strength might have resulted in equal distribution of photosynthates to the more number of seeds which is inturn decreased the 100-seed weight. On the contrary, in simultaneous sowing of parental lines, the number of sinks developing as seeds were less and all the available photosynthates might have translocated to the less number of seeds present in capitulum, resulting increased 100-seed weight compared to other staggered sowing. On the contrary 100-seed weight was found to be superior with staggered sowing compared to simultaneous sowing. Similar results on seed set and decrease in 100-seed *weight due to increase in number of seeds/capitulum* were recorded by Yadav (1994) in KBSH-1 hybrid sunflower seed production due to staggered planting of male parent.

Hence, it can be concluded that taking up RSFH-1 hybrid seed production at Bagalkot location during *rabi* season with staggering of male parent seven days early to the female parent is found to be better for getting higher processed hybrid seed yield.

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Effect of seeding time on productivity of castor, *Ricinus communis* L. cultivars in southern agro-climatic zone of Andhra Pradesh

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Abstract

A field experiment was conducted at S.V.Agricultural College Farm, Acharya N.G.Ranga Agricultural University, Tirupati during *kharif*, 2001 to find out the suitable time of sowing for different castor varieties. All the four castor varieties tested recorded comparable plant height. The variety Jyothi produced higher drymatter. Among the different sowing dates, July 2nd Fortnight (FN) recorded the taller plants, while July 1st FN recorded the highest dry matter over other dates of sowing. All the four varieties took comparable number of days to attain 50% flowering. August 2nd FN sowing took more number of days for 50% flowering. Number of spikes/plant was higher with variety Haritha, while the highest number of capsules/ spike recorded with variety Kiran. The variety Haritha recorded the lowest 100 seed weight. July 1st FN sowing recorded the highest number of capsules/spike and 100 seed weight. All the four varieties evaluated were comparable with regard to seed yield indicating that, the suitability of all the varieties to Southern Agro-Climatic Zone of Andhra Pradesh.Sowing the crop during the month of July recorded the highest seed yield, and delayed sowings of August reduced the yield significantly.

Key words: Castor, cultivars and date of sowing

Introduction

Castor is an important non- edible oilseed crop of India. Despite phenomenal increase witnessed in the production and productivity of castor over the past decade, there is wide disparity in productivity among various castor-growing regions of India. High yield in castor can be achieved through better management practices such as time of sowing and selection of suitable cultivar, which are considered as the principal non- monetary inputs. Though the production efficiency of any variety depends on its genetic potentiality, its yield can be increased to perceptible magnitude by sowing at optimum time. At S.K.Nagar, Gujarat, the cultivar GCH-5 out yielded GCH-2 and GCH-4 (Anonymous, 2000). In Southern Agro-Climatic Zone of Andhra Pradesh, the length of growing season is more due to characteristic bimodal distribution of rainfall. Traitionally the short duration crops like groundnut are grown in drylands with the onset of monsoon, which will be harvested before the fag end of the season. Hence, to utilize available growing period effectively, non-traditional crop like castor needs to be popularized.

Material and methods

The field experiment was conducted at Acharya N.G. Ranga Agricultural University, S.V. Agricultural College, Tirupati during *kharif*, 2001. The treatments comprised of four varieties (Jyothi, Kranthi, Haritha and Kiran) and four dates of sowing (July 1st Fortnight, July 2nd Fortnight, August 1st Fortnight and August 2nd Fortnight. The experiment was laid out in Randomized Block Design with factorial concept with three replications. The soil of the experimental plot was sandy loam with pH 7.6, available N 187.5 kg/ha and available

P_2O_5 and K_2O of 41 kg/ha and 302.5 kg/ha, respectively. All the treatments were supplied with recommended dose of fertilizers i.e., 60 kg N, 40 kg P_2O_5 and 30 kg K_2O/ha in the form of urea, single super phosphate and muriate of potash respectively. One third of the recommended dose of nitrogen along with the entire dose of phosphorus and potassium was applied as basal dose at sowing by band placement. Remaining two thirds of nitrogen was applied in two equal split doses each at 45 and 75 days after sowing. Seeds were scarified by rubbing against rough surface to enhance germination. Seeds were soaked in water for 24 hours and dried under shade before sowing. Seeds were treated with carbendazim @ 1 g/kg of seed to protect from seed borne diseases. The seeds were dibbled @ 2 seeds/hill at a depth of 5-6 cm. The spacing adopted was 60 x 45 cm. The crop was kept free from insect pests and diseases through suitable plant protection measures. The crop was harvested in three to four pickings manually based on physiological maturity of the capsules. Total rainfall of 895 mm was received during the crop duration i.e., July, 2001 to 1st week of April, 2002.

Results and discussion

Growth and yield attributes: The plant height was not significantly influenced by varieties (Table 1.) This might be due to genetic similarity of cultivars under prevailing environmental conditions. All the four varieties produced almost similar dry matter production at harvest. The variety Haritha took more number of days for 50% flowering, which was however comparable with other varieties. Similar observations were also made by Raghuram Reddy *et al.* (1999). The variety Haritha recorded the higher number of spikes/plant followed by Kranthi. The results are in agreement with the findings of Baby Akula and Bapi Reddy (1998). The variety Kiran recorded higher number of capsules/spike followed by Haritha. Similar disparity was reported from the experiments conducted at Jagadalpur, Madhya Pradesh (*Anonymous, 1998). The variety Jyothi recorded higher* 100 seed weight followed by Kiran. Variation in seed weight among varieties was also reported by Baby Akula and Bapi Reddy (1998).

Sowing the crop on July 30th produced the tallest plants (Table 1), however it is comparable with July 1st fortnight. Dry matter production of the crop sown during July 1st fortnight was the maximum. Crop sown during August 2nd fortnight took more number of days to 50% flowering over other sowing dates. Sowings during 1st or 2nd fortnight of July and August 1st fortnight produced identical number of spikes/plant, but delayed sowing on August 2nd fortnight reduced the number of spikes/plant significantly. Similar differences with regard to number of spikes/plant was also reported by Baby Akula and Bapi Reddy (1998). Capsules/spike were higher due to sowing during July 1st fortnight, followed by remaining successive sowing dates. *Similar conclusions were also drawn at Anonymous* (1997). Crop sown during July 1st fortnight recorded the higher 100 seed weight, followed by July 2nd fortnight. Raghavaiah and Sudhakara Babu (2000) reported significant differences in 100 seed weight with different dates of sowing.

Table 1 Effect of varieties and dates of sowing on growth, yield attributes and yield of castor

Variety	Plant height at harvest (cm)	Drymatter production at harvest (kg/ha)	Days to 50% flowering	No. of spikes/ plant	No. of capsules/ spike	100 seed weight (g)	Seed yield (kg/ha)	Stalk yield (kg/ha)	Harvest index (%)
Jyothi	125	3621	74	4	14	19.7	472	1063	31.0
Kranthi	129	3354	73	5	14	18.1	697	1118	41.8
Haritha	128	3561	75	6	16	16.1	601	1083	55.3
Kiran	125	3015	73	4	20	19.4	521	836	40.3
SEm±	4.0	252	0.886	0.375	1.3	0.503	61.7	179	3.76
CD (P=0.05)	NS	NS	NS	1.1	3.9	1.5	NS	NS	NS
Dates of sowing									
July 1st FN	139	4599	72	5	24	20.7	809	1217	41.4
July 2nd FN	145	2912	72	6	18	20.0	728	1486	34.4
August 1st FN	129	3253	63	6	14	18.0	538	894	40.2
August 2nd FN	93	2787	87	3	8	14.6	216	497	32.6
SEm±	4.0	252	0.886	0.375	1.3	0.503	61.7	179	3.76
CD (P=0.05)	12	730	3	1.1	3.9	1.5	178	518	11

NS = Non-significant

Yield: The variety Kranthi recorded more seed yield, stalk yield and harvest index of 697 kg/ha, 1118 kg/ha and 41.8% respectively. But there was no significant difference with remaining varieties (Table 1). The yield of the crop mainly depends on the yield attributes. All the four castor varieties recorded comparable seed yield, because none of the four varieties produced all yield attributes at superior level over other varieties. Similar results of equal performance, with regard to seed yield with different genotypes were also drawn from the experiments conducted at Trivandrum (Anonymous, 1992). Date of sowing influenced the seed yield significantly. Sowing the crop during July 1st fortnight recorded the highest seed yield (809 kg/ha) followed by July 2nd fortnight (728 kg/ha). Yield of these two dates of sowing was significantly higher over August sowings. Increase in yield with July 1st fortnight was 33.50% over August 2nd fortnight. While the yield increase of August 1st fortnight sowing over August 2nd fortnight sowing was 59.85%. The highest stalk yield was obtained with July 2nd fortnight (1486 kg/ha), followed by July 1st fortnight (1217 kg/ha) and August sowing recorded the lowest stalk yield. The increase in stalk yield with July 2nd fortnight over August 1st fortnight and August 2nd fortnight was 18.10% and 39.84%, respectively. There was no significant disparity among the sowing dates regarding harvest index. The yield reduction in castor with delayed sowings was also observed by Patel *et al.* (1991) and Ankineedu *et al.* (1975).

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Simulated defoliation during different crop growth stages to assess insect damage and yield losses in Spanish groundnut, *Arachis hypogaea* L.

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Abstract

Field trials were conducted during three post-rainy seasons from 1999 to investigate the impact of insect simulated artificial defoliation on Spanish groundnut variety cv- GG 2. Four different defoliation levels were tested i.e., no defoliation (treated it as control), 10, 25, 50 and 75% at different crop growth stages such as *vegetative, pegging, pod-filling and their combinations* such as vegetative + pegging, vegetative + pod filling and pegging + pod filling. Pooled analysis of the data for three years showed that irrespective of the growth stages, leaf area growth rate increased with increase in percentage defoliation, up to 50% and it was minimum at 75% defoliation. The loss in yield increased with increase in percentage defoliations during all the stages and their combinations. At 10 % defoliation during vegetative stage the reduction in pod yield was 19.3% over control and highest pod loss (64.2 %) was observed at 75% defoliation during pegging + pod filling stage. The per cent reduction of pod yield over control increased with higher intensity of defoliation and during advanced stages of the crop. Thus it is concluded that defoliation at any stage of the crop resulted in significant loss in yield.

Key words: *Arachis hypogaea*, defoliation, compensation, yield loss

Introduction

Among the biotic stresses, insect pests and diseases cause direct damage to foliage because of loss of photosynthetic area resulting in low productivity. Insect pests such as groundnut leaf miner, *Aproaerema modicella* Dev. (GLM), tobacco caterpillar, *Spodoptera litura* (Fab.); gram pod borer, *Helicoverpa armigera* (Hubner) and red hairy caterpillars (RHCs), *Amsacta albistriga* Walker; *Amsacta moorei* Butler and *Spilosoma obliqua* Walker mines/devour the leaves and feed. The total leaf area is closely related with photosynthesis and ultimately partitioning of the photosynthates (Nautiyal *et al.*, 1999), and may reduce pod yield considerably (Panchabhavi *et al.*, 1986). The loss in yield because of defoliation depends on the growth stage of the crop, plant recovery and compensation through production of new foliage (Taylor, 1972). In spite of the difficulty of exactly simulating natural defoliation by the insect, the leaf cutting is considered a useful method to understand possible loss because of defoliation (Oyediran and Heinrichs, 2002).

Though, Greene and Gorbet, (1973); Enyi, (1975); Sharma and Shrimali (1981), Santos and Sutton, (1982 and 1983);Bhattacharya and Ghude (1985) and Panchabhavi *et al.* (1986) studied the effect of artificial defoliation on the pod yield of groundnut, limited information is available on the response of groundnut cultivars to various levels of insect-simulated- artificial-defoliation during different growth stages individually and in combination and their effect on the pod yield. Present investigation was aimed to study the response of local groundnut cultivar to various levels of insect simulated defoliation during different stages of crop growth.

Material and methods

Field trials were conducted at the National Research Center for Groundnut, Junagadh (70.36°E longitude and 21.31°N latitude at an altitude of 60 m above mean sea level) during the summer (February to June) seasons of 1999, 2000, and 2004. Experiments were conducted in semi-arid type of climate with temperatures ranging from 20°C to 40°C, average RH of 50% and rainfall ranging from 550 to 850 mm. The experiment was laid out in shallow black soils which are calcareous in nature in a Completely Randomized Block Design (CRBD). A local cultivar GG 2 was selected for the study, and crop was sown in a plot size of 3 m x 2 m with a distance of 45 cm and 10 cm between rows and plants. All the recommended cultural practices were followed to raise a good crop of groundnut.

Insect simulated defoliation was performed manually by plucking the leaflets of the compound leaf and the petiole was left intact. Four levels of defoliations i.e., 10, 25, 50 and 75% were carried out at vegetative, pegging and pod-filling phases. The defoliation was also performed in combination of various growth stages such as vegetative+ pegging, pegging + pod-filling and vegetative + pod-filling. All the treatments were replicated thrice. A control set was maintained in each replicate in which defoliation was not performed. Defoliation was planned keeping in view the solar radiation utilization at the different canopy levels i.e., 60% of the upper canopy level and 40% of the lower canopy and accordingly leaflets were removed manually. Total leaf area i.e., the intact leaf area developed after defoliation was monitored at 10 days interval. The total leaf area was calculated following the standard (25.91cm^2) leaf area of same cultivar (Nautiyal *et al*., 1995), multiplied by the total number of leaves in the canopy. The increase in leaf area growth rate was compared to the control plots at 10 days interval and the excessive leaves were defoliated to maintain the specific levels. The increase in the leaf area growth rate compared to the previous stage was recorded. Crop was harvested at maturity and pod yield from each plot was recorded. The data were analyzed for pooled over 3 years following MSTAT statistical package.

Results and discussion

Foliage compensation during different growth stages: During vegetative stage the increase in leaf area growth rate was 147.4% at 10% defoliation and the highest was at 50% defoliation (279.7%) (Table 1). The highest level of defoliation (75%) at vegetation phase could result in a leaf area growth rate of only 169.3% compared to control (229.9%). During pegging stage the increase in leaf area growth rate was increasing with increase in defoliation up to 50% and at 75% the per cent increase in leaf area growth rate was minimum (61.2%) compared to control (190.1%). Similar trend was also observed during the pod filling stage.

Foliage compensation during different combinations of growth stages: The per cent increase in leaf area growth rate increased from 10% to 50% defoliation, and reached maximum at 50% defoliation during different combinations of growth stages such as vegetative+ pegging, vegetative + pod filling and pegging + pod filling stages. While it was minimum at 75% defoliation compared to control and other treatments during all combinations of growth stages.

It was difficult to simulate the defoliation studies to assess the damage caused by the insect pests because plant behaves differentially in its various phenological phases of the growth to insect pest damage and simulated defoliation either by the removal of leaf manually or scissors cut. However, results of the present study could help in assessing the yield losses because of the defoliators, that damage the foliage during different growth stages of the groundnut.

Pod yield was significantly affected by artificial defoliation during different growth stages and in their combinations. The pod yield was maximum in control where groundnut plants were not defoliated at all. Similarly, Panchabhavi *et al*. (1986) reported that yield was the highest without defoliation and lowest with 100% defoliation of 60-day-old plants. The per cent loss in pod yield ranged from 19.3 to 36.4% during vegetative stage, 25.2 to 41.2% at pegging stage, 18.9 to 52.1% during pod filling, 21.4 to 61.4% during vegetative+pegging, 26.3 to 62.2% during vegetative+ pod filling and during pegging + pod filling the loss ranged from 22.5 to 64.2% at 10 and 75 % defoliation, respectively compared to control (Table 2).

In the present study the pod loss increased with increase in level of defoliation during different growth stages. Similarly, Bhattacharjee and Ghude (1985) reported progressive decrease in soybean yield as percentage defoliation increased at the bloom or post-bloom stages, whether the defoliation was natural or artificial.

Highest pod yield loss was recorded at 75% defoliation during all the stages and their combinations. Similar results have been reported by Greene and Gorbet (1973) and Enyi (1975). In the present study the pod loss increased with increase in level of defoliation during advanced growth stages. Similarly, Venturi *et al*. (1993) showed that yield losses increase when larger leaf areas are removed and when defoliation was made at advanced growth stages of soybean. The present study indicates that pegging and pod filling are the critical periods of groundnut when the crop must be protected from defoliators for increasing the yields. This is obvious because groundnut being indeterminate crop it has a competition for the photosynthates between the growth of vegetative parts and reproductive parts, and it seems that in case of damage to the foliage plant always tries to compensate by producing more leaves and thus compensating the leaf area.

Table 1 Per cent increase in leaf area growth rate during different growth stages*

Defoliation (%)	Vegetative	Pegging	Pod filling	Vegetative + pegging	Vegetative + pod filling	Pegging + pod filling
10	147.4	52.6	465.3	260.7	645.4	201.1
25	247.6	109.3	509.3	361.1	776.8	330.7
50	279.7	144.2	655.4	396.2	877.6	499.4
75	169.3	61.2	164.0	178.4	281.4	202.2
Control	229.9	190.1	320.1	373.1	520.5	575.9
SEm±	49.[illegible]	14.2	122.5	36.7	43.8	53.9
CD (P=0.05)	NS	41.1	354.0	109.2	126.5	155.9

* Mean of three post-rainy seasons

Table 2 Reduction in groundnut pod yield (kg/ha) because of different intensity of artificial defoliation at different growth stages*

Defoliation (%)	Vegetative	Pegging	Pod filling	Vegetative + pegging	Vegetative + pod filling	Pegging + pod filling	Mean
10	527 (19.3)	686 (25.2)	514 (18.9)	582 (21.4)	716 (26.3)	612 (22.5)	606 (22.3)
25	699 (25.6)	619 (22.7)	924 (33.9)	600 (22.0)	674 (24.7)	753 (27.6)	711 (26.1)
50	778 (28.5)	887 (32.6)	1077 (39.5)	931 (34.2)	793 (29.1)	1294 (47.5)	960 (35.2)
75	992 (36.4)	1122 (41.2)	1422 (52.1)	1673 (61.4)	1708 (62.2)	1750 (64.2)	1444 (52.9)
Mean	749 (27.5)	829 (30.4)	984 (36.1)	947 (34.8)	973 (35.6)	1102 (40.5)	

	SEm±	CD (P=0.05)
Defoliation (D)	74.67	218.78
Stage (S)	121.62	NS
Interaction (DxS)	413.37	NS

*Mean of three post rainy seasons; Figures in parenthesis are percentage reduction in yield; (Pod yield in control = 2623 kg/ha)

No detailed study was made so far in groundnut for the compensation mechanism involved because of defoliation, however, the possible reasons for the compensation for defoliation could be that the partial defoliation may trigger increase photosynthesis in the remaining leaves and allow an improved supply of cytokinins to the remaining leaves by removal of sinks and leads to an increased carboxilation.

These results suggest that early control of insect pests could result in yield compensation so that yield losses would be minimal by pod-filling. For development of IPM strategies for the groundnut farmers, the compensation of foliage in groundnut to defoliation because of insects must be given due consideration. These results are useful for determining the economic threshold levels (ETL) during different growth stages and the development of a pest management simulation models. Based on the present results, it is evident that even at 10 % defoliation leads to significant yield loss. In order to harvest maximum yields the management tactics should be initiated even before 10% defoliation.

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Biology of safflower aphid, *Uroleucon compositae* Theobalt on different safflower genotypes under laboratory conditions and their field reaction

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Abstract

Safflower aphid, *Uroleucon compositae* Theobalt passed its nymphal stage through 4 instars in 7 to 10 days on different genotypes of safflower (*Carthamus tinctorius* L.). Nymphal stage 1st and 2nd were completed in 2 to 3 days while 3rd and 4th stage took 1 to 3 days. Pre-reproductive, productive and post-reproductive periods were 2, 3 to 5 and 2 to 5 days, respectively. Total fecundity of aphid was more i.e., 25 nymphs/female on CO-1 as against 7 and 8 nymphs/female on the BIP-2 and A-1, respectively. Fecundity index was lowest i.e., 0.28 and 0.34 on BIP-2 and A-1, respectively as against highest i.e., 1 on the host CO-1 (aphid susceptible). The adult longevity varied from 8 days on CO-1 to 12 days on A-1 and BIP-2. Aphid completed its life cycle in shorter period i.e., 15 days on aphid susceptible host CO-1. However, it took more time i.e., 22 days to complete one life cycle on the hosts A-1 and BIP-2 the aphid tolerant hosts. Spiny nature of the genotypes contributed to make them aphid tolerant, as these did not allow its free movement over them. Non-spiny appearance of plants and succulent stem contributed for aphid susceptibility. All safflower genotypes *viz.*, 97-OPP-4, 97-OPP-10, BIP-2, SSF-413-1, A-1 (national check) and Bhima (local check) were found resistant to aphids, while CO-1 was susceptible under field conditions.

Key words: *Uroleucon compositae*, biology, *Carthamus tinctorius*

Introduction

Safflower aphid, *Uroleucon compositae* Theobalt is the key pest of safflower (*Carthamus tinctorius* L.) crop in India (Kulat *et al.*, 1997; Dhembare *et al.*, 1998). The pest depredates the seed yield up to 37% at all India level as reported by Singh *et al.* (2000). Besides the loss in seed yield, aphid incidence also results in reduction in oil content of damaged seeds up to 32% and seed weight by 50.6% (Rathore and Pathak, 1981; Gautam *et al.*, 1995). The biotic potential of the pest determines its severity of multiplication in a given time on a host as well as the extent of yield loss. Literature scanning revealed that no serious attempt has been made to study the biology of safflower aphid in India. So in the present endeavour efforts have been made to study the biology of *U. compositae* in B.O.D. incubator 12 hr photoperiod at 27± 1°C and 65±2% relative humidity.

Material and methods

Biology of *U. compositae* was studied during 2004-05 at Directorate of Oilseeds Research, Rajendranagar, Hyderabad. Gravid females of *U. compositae* were collected from the field during December, 2004 and brought to the laboratory. These were reared for another one week in the B.O.D. incubator, 12 hr photoperiod at 27±1°C and 65±2% RH on leaves of aphid susceptible host CO-1 in glass jars of 30 cm x 15 cm.

Four elite genotypes of safflower *viz.*, 97-OPP-4, 97-OPP-10, BIP-2 and SSF-413-1 (Table 3) with different morphological characteristics reported as aphid resistant (Anonymous, 2002) were grown in the field (two consecutive years 2002-03 and 2003-04) during November every year in a plot size of 10 rows of 4 m length for each genotype at spacing of 45 cm x 20 cm between rows and plants for their field reaction to safflower aphid. When these host genotypes along with 3 checks i.e., A-1 (National check) spiny, high yielding and aphid tolerant; Bhima (Local check) spiny and high yielding and CO-1 non-spiny, tall and aphid susceptible check were in flowering stage i.e., end of December, 2004, the studies on aphid biology were made.

Biology was conducted in Petri plates size 15 cm diameter, lined with white filter paper over which a leaf disk of 1 cm^2 of a particular host was kept. Leaf disks were cut with scissors from the leaves of host plants grown in the field. Efforts were made to take 3rd or 4th leaf from the apex of central shoot of plant every time. These leaf disks served as food for the neonate nymphs of 6-12 hr old as well as adults in later part of studies. Leaf disks were replaced by fresh ones at every 24 hr interval. Presence of exuvae were taken as moultings. Ten replicates were run for each host for the biological studies starting from one day old nymph till its death. Fecundity was judged by counting of nymphs laid per female. These nymphs were removed with the help of camel hair brush every day. Post-reproductive period was observed starting from the day, particular female stopped numphs laying till its death.

Results and discussion

Perusal of results presented in (Table 1) revealed that *aphids completed the nymphal period in shortest time* (7 days) on the host CO-1 (aphid susceptible) as against the longest 10 days on the hosts BIP-2, A-1 and Bhima at 27± 1°C and 65 ± 2 % RH. This indicated that the latter hosts showed antibiosis resistance to aphids, which slowed the speed of development. These hosts were already reported tolerant to aphids (Anonymous, 2002). Efforts are on the come out with the biochemical factors for the antibiosis in these hosts *vis-a-vis* aphid susceptible hosts.

Nymphal stage passed through 4 instars. Nymphal stage 1st *and 2nd were completed in 2 to 3 days on various hosts* while 3rd and 4th stage took 1 to 3 days (Table 1). The present studies got support from the studies carried out by Dhembare *et al.* (1998) who reported 4 nymphal instars for *U. compositae*.

Fecundity/female varied significantly over the different genotypes (Table 1). Fecundity was low i.e., 8 nymphs/ female on the host A-1 (aphid tolerant) as against the highest 25 nymphs/female on the host CO-1 (aphid susceptible). This supported the view of previous workers that the host CO-1 got covered with aphid colonies over a short period of time (less than a week) as compared to A-1 which took more than 2 weeks to have few small aphid colonies (Rathore, 1983; Singh *et al.*, 2000). This *statement was authenticated by the higher fecundity index* per female of *U. compositae* on the host CO-1 as compared to the aphid tolerant hosts (Table 1). Total adult longevity varied from 8 to 12 days on various hosts including pre-reproductive (2 days) each, reproductive (3 to 5 days) and post-reproductive period (2 to 5 days).

The studies suggested that aphids required less time (2 days) to become productive *and laid more nymphs* (25/female) on the susceptible host CO-1 as against lowest of 7 and 8 nymphs/female on the hosts BIP-2 and A-1, respectively. Fecundity index was lowest i.e., 0.28 and 0.34 on BIP-2 and A-1 also, respectively as against 1 on the host CO-1 (aphid susceptible). So with in short period the plants were ladden with aphids. However, reverse was true on the aphid tolerant hosts.

All safflower genotypes *viz.*, 97-OPP-4, 97-OPP-10, BIP-2, SSF-413-1, A-1 (national check) and Bhima (local check) were found resistant and CO-1 was susceptible to safflower aphid *under field conditions (Table 2). Studies* got full support from the data on aphids biology on these genotypes under laboratory conditions (Table 1). There was no significant defference of morphological characteristics of safflower genotypes on their reaction to aphids. However, spiny nature of the genotypes contributed to make them aphid tolerant, as these did not allow its free movement over them. Non-spiny appearance of plants and succulent stem contributed for susceptibility to aphids (Table 3).

Table 1 Biology of safflower aphid on promising safflower genotypes

Genotype	Period (days)								Fecundity (Nymphs/ female)	Fecundity *index*	Adult longevity (days)	Total life span (days)
	Nymphal instar					Pre-reproductive	Reproductive	Post-reproductive				
	1st	2nd	3rd	4th	Total							
97-OPP-4	2	2	2	3	9	2	4	3	15	0.60	9	18
97-OPP-10	3	2	2	2	9	2	4	3	17	0.68	9	18
BIP-2	2	3	2	3	10	2	5	5	7	0.28	12	22
SSF-413-1	2	2	3	1	8	2	5	3	12	0.48	10	18
A-1 (NC_	2	3	2	3	10	2	5	5	8	0.34	12	22
Bhima (LC)	3	3	2	2	10	2	3	5	10	0.40	10	20
CO-1 (SC)	2	2	1	2	7	2	4	2	25	1.00	8	15
SEm±	0.1	0.2	0.1	0.2	0.2	-	-	-	0.4	-	-	-
CD (P=0.0r)	0.5	0.5	0.6	0.5	0.7	-	-	-	2.0	-	-	-

Table 2 Reaction of promising safflower genotypes to safflower aphid in field conditions

Genotype	Aphid No./5 cm apical twig at peak incidence		% aphid population as compared to national check		Aphid infestation index (A.I.I)*		Mechanism of resistance		Seed yield (g/plant)	
	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04
97-OPP-4	51	31	170	152	1.5	1.6	T	T	2.9	3.0
97-OPP-10	52	34	173	146	1.6	1.5	T	T	2.8	3.2
BIP-2	30	23	100	99	1.1	1.1	T	T	3.9	5.7
SSF-413-1	47	39	157	118	1.4	1.3	T	T	2.6	3.1
A-1 (NC_	30	19	100	100	1.0	1.1	HT	T	4.2	5.8
Bhima (LC)	37	25	123	104	1.2	1.3	T	T	4.0	5.3
CO-1 (SC)	129	102	430	185	4.8	4.6	HS	HS	0.0	0.0
SEm±	1.9	1.7	-	-	0.2	0.3	-	-	0.1	0.2
CD (P=0.0r)	5.0	6.0	-	-	0.5	0.5	-	-	0.2	0.3
CV (%)	13.2	12.6	-	-	15.4	14.7	-	-	4.5	3.9

* HI = Highly tolerant (1); T = Tolerant (1.1-2); MT = Moderately tolerant (2I1-3); S=Susceptible (3.14), HS = Highly susceptible (4.1-5) for All

Table 3 Morphological characteristics of promising safflower genotypes and their reaction to aphids

Genotype	Plant height (cm)	Stem girth (cm)	Pri. branches (No./plant)	Sec. branches (No./plant)	Plant succlency	Plant softness	Spiny/non-spiny	Spines (No./Lm)	Flower colour	Capitulum (No./pl)	Reaction to aphids
97-OPP-4	98	2.0	8	22	NSU	H	SP	34	Y	32	T
97-OPP-10	96	1.8	8	20	NSU	H	SP	30	Y	30	T
BIP-2	108	1.8	8	14	NSU	H	SP	32	PY	26	T
SSF-413-1	100	2.0	9	18	NSU	H	SP	20	Y	23	T
A-1 (NC_	106	2.0	10	20	NSU	H	SP	30	Y	32	T
Bhima (LC)	108	2.0	10	18	NSU	H	SP	32	Y	30	T
CO-1 (SC)	110	2.4	13	22	SU	S	NSP	0	Y	28	S

NC = National check; LC = Local check; SC = Susceptible check; Pri. = Primary; Sec. = Secondary; H = Hard; S = Soft; SU = Succulent; NSU=Non-succulent, Lm = Leaf margin; Y = Yellow; PY = Pale yellow; T = Tolerant; S = Susceptible

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Cross mechanism for effective mechanized intercultural operation in soybean

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Abstract

A simple low cost device "Cross Mechanism" attachable on lower link of three-point linkage system on tractor was designed, fabricated and validated for facilitating straight line planting and subsequent intercultural operations in row crops. In soybean, the loss in plant population during intercultural operation using cross mechanism is minimized (from 15 to 7%) as compared to operation done without it. This also results in yield increment to the extent of 7 to 8%. Cross mechanism can be fabricated locally for better fitment of individual tractor.

Key words: Cross mechanism, row crops and plant population

Introduction

Soybean being an export-oriented crop fetches about Rs 20, 000 million per year by the export of de-oiled cake, which constitutes 65% of the total oil meal, export of India. It also supplements more than 10% of edible oil produced in the country (Joshi, 2003). To achieve global competitiveness, it is very necessary to limit the cost of cultivation. Farm mechanization is one of the important avenues that offer good opportunity in this endeavour, not only in case of soybean but other crops also. In addition to limiting the expenditure on manual labour, it helps in executing farm operations timely in limited time available, particularly in Vertisols and associated soils. At present the extent of mechanization in cultivation of soybean is estimated to be 50 % only (Holt *et al.*, 1999).

In crops like soybean, which are planted in row, straight line sowing is crucial for better performance of the crops as well as for future mechanized operations during crop season. After planting, the success of inter row operations such as spraying, inter culture and weed management depends upon the sowing in straight rows. The inter row mechanized operations in a crop with zig zag planting results in greater plant damages. Tractor sowing with checks chains attached to lower links fail to control total lateral movement leading to zig-zag lines of crop row by seed drill. Inter-culture/weeding and spraying equipments cannot move in line with the tractor even if it is moving in straight line. Hence to overcome this problem a simple but effective "Cross Mechanism" was developed at the National Research Centre for Soybean, Indore to stabilize the lateral movement of seed drills by holding lower links in position. The performance of the tool was evaluated in the field.

Material and methods

The cross mechanism (Fig. 1) can easily fixed and detached to and from the lower links of the tractor. This simple device has been made of box section mild steel (5 mm). This mechanism is capable of nearly eliminating the lateral movement of seed drills and other tractor drawn implements. Local artisans can fabricate this simple device at a cost of Rs 120/- matching to individual tractor model for better fitment as per three-point linkage category.

Cross mechanism was tested for its efficacy for three consecutive cropping seasons in soybean cropping season (*kharif*, 2001-03) at National Research Center for Soybean, Indore. The soybean crop was sown using this cross mechanism at 45 cm row-to-row distance. Subsequent inter-culture/weeding operation was performed using a sweep type implement with cross mechanism. The plant population per square meter from 10 random samples in each plot was recorded. The cross mechanism was compared with no cross mechanism and experiment replicated 10 times. Plot size was 125 m^2. The three year data was statistically analysed.

Results and discussion

The plant damage before and after the interculture operation was visible from the results of 2001 trial which shown a significant reduction in the plant population after interculture without use of cross mechanism for sowing and interculture operation. The damage to plants during interculture with cross mechanism was reduced to 6 % as compared to 15% without cross mechanism. The difference was statistically significant. During 2002, cross mechanism reduced the plant damage after interculture to 5% as compared to 14% without it. During 2003, it was reduced to 9% as compared to 12% without cross mechanism. The mean values reveal that on an average the loss in the plant population without cross mechanism was 15% as against 7% with cross mechanism.

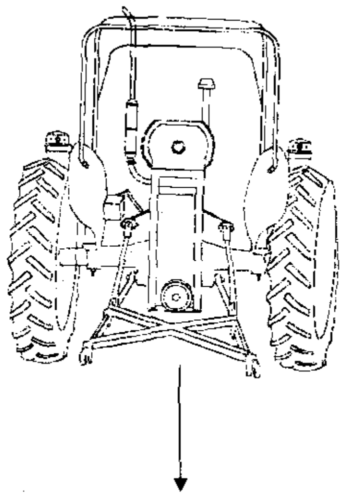

Fig. 1. Cross mechanism attached with the tractor

The data recorded on performance of the soybean crop revealed perceptible increase in seed yield when the cross mechanism was used for sowing and interculture. The extent of increase in yield with cross mechanism was 6.7, 7.0 and 8.8 % during 2001, 2002 and 2003, respectively. About 7-8 % increase in seed yield is realizable without any additional expenditure except initial investment of Rs. 120/- for the fabrication of cross mechanism. Initial cost of the cross mechanism is recovered from its use on one ha of land. During subsequent years it adds to net returns of the farmer. In general all the three years showed an increase in yield primarily due to minimum plant damage during interculture by using cross mechanism.

From the economic point of view, the expenditure on one intercultural operation using farmer's method (Dora) or using a small tool hand hoe amounts to Rs 400/ha and Rs. 700/ha respectively as against Rs. 325/ha by tractor operated sweep type tiller with cross mechanism.

Table 1 The effect of using cross mechanism on plant population in soybean

Intercultural treatment	Average plant population (No./m row length)							
	2001		2002		2003		Mean	
	Before operation	After operation	Before operation	After operation	Before operation	After operation	Before operation	After operation
With cross mechanism	20.65	19.34	20.98	19.89	21.35	19.51	20.99	19.58
Without cross mechanism	20.28	16.95	20.82	17.91	20.90	18.35	20.67	17.74
Mean	20.46	18.14	20.90	18.90	21.13	18.93	20.83	18.63
SEm±	0.53	0.42	0.55	0.45	0.99	0.34	0.42	0.31
CD (P=0.05)								
Treatment	NS	1.34	NS	1.42	NS	1.07	NS	0.91
Year							NS	NS
Treatment x Year							NS	1.10

Table 2 The effect of using cross mechanism on soybean yield (kg/ha)

Treatment	2001	2002	2003	Mean
With cross mechanism	1406.60	1404.10	1403.00	1404.57
Without cross mechanism	1317.90	1312.10	1290.00	1306.67
Mean	1362.25	1358.10	1346.50	
't' value	5.47	10.83	14.16	

Conclusions: The study suggests that the losses in plant population during intercultural operation using cross mechanism could be curtailed to one third to half with added advantage of increment in seed yield of soybean by 7-8%. The operation using the device works out to be cheaper than other traditional operations employed by the farmers.

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Innovative drying technique for seed quality maintenance of summer groundnut, *Arachis hypogaea* L.

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Abstract

Field trials and seed quality assessment studies were conducted to identify a suitable method for drying of summer groundnut, *Arachis hypogaea* L. pods. After bringing the seed moisture content below 7% by using various drying methods, pods were stored in gunny bag under ambient conditions. At monthly intervals stored samples were subjected to different seed quality tests. Drying of pods intact with plant was found better than the pods alone. Further, pods intact with plant or not but dried under shade have maintained significantly more seed quality parameters over the farmer's practice (drying of pods intact with plants directly under sunlight) during both the years. Among the pods drying methods, pods intact with plants dried under shade (D_4) maintained seed germinability of 74.5% followed by drying pods by covering with haulms of other plant method (D_7) and DOR method (D_3) maintained significantly above the minimum seed certification standards (70%) after eight months of storage as compared to farmers practice (57.6%). Hence, the summer season produced groundnut pods can be dried under shade if facility is available. Otherwise, farmer can dry the pods in the field itself from second day of harvest for six days by test method (D_7) covering the pods of one plant with haulms of other plant), which is simple, easy and practicable under field condition.

Key words: Drying methods, seed germination, seed quality

Introduction

In early summer crop, poor plant population is a major constraint for the productivity. Poor plant population owes to use of seed input, which has less seed viability because it is obtained either from last year's monsoon produce or 8-9 months old *rabi* produce.. The rapid loss of seed viability ranges for 60-80 % is due to high temperature prevails during pod drying (summer) or ageing of seeds in case of previous monsoon produce (Nautiyal and Ravindra, 1996; Basave Gowda and Ravi Kumar, 2001; Basave Gowda,2002; Basave Gowda *et al.*, 2002). Uniform and bold seed will be available from the summer produce as it will be grown with irrigation facility whereas, shriveled seed is more in monsoon as it will be produced under intermittent moisture stress conditions in this region. Hence, *rabi*/ summer produce has a vital role to supply as seed input. But, the summer produce has low germinability and poor storability with rapid loss of viability. Hence, in these areas, drying method is more important than storage as ambient conditions can not be altered easily. In this regard, farmers are unaware of ill effects of improper pod drying.

In this direction, several efforts were made to develop the suitable pod drying techniques such as Directorate of Oilseeds Research method or National Research Centre for Groundnut method (Nautiyal, 2003) for improvement of seed storability of *rabi*/summer groundnut. However, these methods are location specific and pose practical problems for adoption under field conditions during large scale handling of the produce. Hence the present study was conducted with an objective to establish a practically feasible and easily adaptable pod drying method for seed quality maintenance in *rabi*/summer groundnut so that the same produce can be used for the next early *rabi*/summer sowing.

Material and methods

The study was conducted at the Seed Science and Technology Research Laboratory, Regional Agricultural Research Station, Raichur during summer (seasons of 2001-02 and 2002-03. The groundnut variety KRG-1 and TMV-2 were raised by adopting recommended cultivation practices and harvested the crop on maturity (in the month of March). Immediately after harvest, the initial seed moisture content was recorded by oven dry method by subjecting coarse ground seed samples to 103±2°C for a period of 17 1 hour (Anonymous, 1999) and on the second day of harvest, the produce was dried by following different drying methods for six days in the field. The drying methods (treatments): D_1 - Sun drying (pods intact with plants-SDPP), D_2 - Sun drying (Only pods-SDP), D_3 - DOR method while pod intact with plants were tied in bundles of about 0.5 m in diameter. The bundles were kept for drying in pairs in such a way that one bundle was placed upside down and the other upright on top of the former so that the pods of the two bundles are meeting together. Thus, the haulms of the upper bundle shaded the exposed pods of the inverted lower bundle from direct sunlight. Each evening the upper bundle was removed and the pods in both the bundles were exposed. The bundles were returned to the inverted position in the next morning. This practice was repeated for six days, i.e., D_4 - Shade drying (pods intact with plants) under tree -Sh DPP), D_5 - Shade drying (Only pods) under tree-ShPT), D_6 - Sun drying (Only pods covered with Jute cloth-SDPJC), D_7 - Sun drying (Pods of one plant covered with haulm of the other plants-SDPPH), D_8 - Sun drying (pods intact with plants covered with hay-SDPPHy), D_9 - Sun drying (Pods intact with plants covered with jute cloth-SDPPJC).

National Research Centre for Groundnut (NRCG) method, in this method a tripod type structure (Pyramid shape) was raised in the field with three bamboo poles, each about 1.5 m long was also followed as one of treatments. A coir rope was wound around the structure starting from the bottom to the top, while maintaining a space of 15-20 cm between two loops. Plants (intact with pods) were placed on the rope of the structure with pods up and haulms hanging down. The structure was filled with plants so that haulm of an upper ring covered the pods of the lower ring thus, forming a slope structure like the roof of a thatched house. The plants were arranged from bottom ring to upward (Nautiyal and Zala, 1991)).

After drying for six days by adopting above methods, the pods were hand picked and wherever necessary the pods were further dried in a single layer in the forenoon (8 to 11 AM) till the seed moisture content reaches below seven per cent. Such pods were hand cleaned and stored in gunny bag (5 kg/replication with three replications/drying treatment) under ambient conditions. At monthly intervals stored samples were subjected to different seed quality tests *viz.*, germination (%), field emergence (%), seed vigour index, seedling dry weight (mg/5 plants) and electrical conductivity (dS/m) by following the standard procedures prescribed by ISTA (Anonymous, 1999). The data was statistically analysed in factorial Complete Randomised Design and the germination data was analysed with arcsine transformed values.

Results and discussion

Weather parameters and pattern of seed moisture loss during drying period: Average maximum temperature was more (39.4°C) during 2002 as against 37.4°C during 2003, but the maximum RH was high (65%) during 2003 as against 52% during 2002 (Table 1). The maximum temperature was more or less remained constant during the drying period. Initial seed moisture content between drying methods ranged from 40.6 to 42.5 with a mean of 41.3°C (data not shown). Mean initial seed moisture (41%) did not vary much between the drying methods as the seed source is being same and decreased with progress in days of drying with constant temperature during all the drying. With progress in drying period, the seed moisture content was decreased gradually i.e., 12.2% on 6th day as against 22.8% on 3rd day and 41% on the 1st day (Table 2). The moisture content at the end of drying period varied drastically with drying methods. The shade drying-D_4 (15.8%) followed by pods intact with plants covered with hay-D_8 (15.2%) and covered with haulms of other plant-D_7 (15.0%) had maintained more moisture content at the end of drying period, indicating the slow drying process in these methods) (Table 1). Further, pods alone or intact with plants dried under shade resulted in slow rate of loss of moisture content. With this principle, the drying techniques used in this study partially provided the shade on the pods by haulms or hay and hence these methods have resulted in slow loss of moisture content. The open drying methods directly under the direct sunlight resulted in faster rate loss of moisture content. Earlier, Patil and Zode (1993) have shown that sun drying requires four days while shade drying requires 12 days to dry and produce to 9% moisture content which depicts the faster rate of drying under sun.

Effect of drying methods on seed quality parameters

Seed germination: Initially (before storage), the drying methods D_3, D_4, D_5, D_7 and D_8 were on par to each other and had significantly higher germination (with more than 90 per cent) compared to the other treatments (Table 4). Further, during 2002 or 2003, initially, D8 was on par to D_3 or D_4 or D_5 or D_7 but had significantly lower seed germination at 8 MAS. These results indicate that, though seed germination is affected by the drying methods, initially all the methods possessed germination of 70% or more as per the seed certification standards. Hence, seed germination of aged seeds is of more concern compared to the initial seed quality. Hence, data on initial values for other parameters are not discussed here.

At eight months of storage, significant differences were observed for seed germination (Table 4). Farmer's practice of drying of pods under direct sunlight (D_1) had less germination. The drying methods (D_3, D_4, D_5 and D_7) have maintained more than 70% germination at 8 MAS, this reveals that these drying methods are found to be superior.

Among the varieties, though there are no significant differences before storage, at 8 MAS significant differences existed. However, the performance of a variety was not stable, therefore, it can be inferred that irrespective of the variety, the method of drying is more important.

In the present study, D_4 being the shade drying of pods intact with plants has maintained highest germination (74.5 %). Similarly, the D_7, where in pods were covered by the haulm of other plant to provide shade as well as proper aeration also maintained good seed germination (72.0%) and hence this study emphasizes the practice of D_7 in the field condition by seed growers.

Field emergence (%): Field emergence is very crucial for proper plant population and crop yield. Field emergence at 8 MAS differed significantly between drying methods during both the years (Table 1). The lowest field emergence was recorded in the farmer's practice of pod drying (49.9%). Among the treatments, at 8 MAS only D_4 method maintained germination percent of more than 70%.

Nautiyal and Zala (1991) reported a negative relationship between EC and germination, suggesting that loss of seed germination is due to loss of membrane integrity which depicted by leakage of salts in terms of EC. Faster rate of moisture loss leads to greater damage to seed membrane integrity leads to more efflux of solutes.

Vigour Index: Vigour index differed significantly between treatments (Table 4); the pods intact with plants dried under shade (D_4) recorded higher vigour index at eight months of storage (1675), and lowest was observed in D_6 (1182) where in only pods are dried under the direct sunlight and covered with jute cloth (Table 1).

Seedling dry weight (mg/ 5 plants): The pods dried by D_4 method has recorded highest value of 1170 after eight months of storage followed by D_5 (1148) and D_7 (1114) after eight months of storage (Table 1).

Electrical Conductivity (dS/m): The lowest EC values were recorded in D_4 (0.34) followed by D_3 (0.36) or), D_5 (0.36) or D_7 (0.37) after eight months of storage which were on par to each other. Highest EC was recorded in *pods dried under open field* D_2 *(0.56) and* D_6 *(0.56)* followed by farmer's practice i.e., pods intact with plant (0.50) and dried under direct sunlight (Table 4).

Pooled data over two years shows that, after 8 months of storage, only shade drying method, (D_4), shade drying only pods (D_5), pods intact with plants covered with haulms of other plant (D_7) and DOR method (D_3) has maintained minimum standards of germination and other *quality parameters. These methods have 16.9, 14.5, 14.4* and 12.9% more germination respectively over the Farmers Practice (D_1).

Similar results were reported by Patra *et al.* (2000) and Tripathy *et al.* (1999) showing that, shade drying of stripped pods showed significantly more seed viability (74.2%) than DOR method (67.0%) at 6 months of storage. Therefore, adoption of test method would be easy and more relevant for this dry zone. In contrast, Shade and DOR method were on par to each other with respect to *germination (Jolli et al., 2000 and 2004).*

Consistency of drying methods: Farmer' practice has maintained minimum standards of germination only upto three to five months in different years. The NRCG method maintained up to 4 to 7 months of storage and DOR method between 7 to 8 months. *But the Shade drying* pods intact with plants (D_4), Shade drying (Only pods) under tree (D_5) and Pods intact with plants covered with haulms of other plant (D_7) maintained up to 8 months in both years suggesting the consistency (Table 2).

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Table 1 ***Effect of drying methods on seed quality parameters after eight months of storage period (pooled data of 2002 and 2003 with two varieties)***

Drying method	Moisture at the end of drying period (%)	Initial germination (%)	Germination (%)	Field emergence (%)	Seedling dry weight (mg/plants)	Vigour index	Electrical conductivity (dS/m)
D_1	8.1	84.9 (67.2)	57.6 (49.4)	55.2 (47.7)	1010	1248	0.50
D_2	7.7	83.2 (66.2)	55.0 (47.9)	49.9 (46.1)	992	1195	0.56
D_3	11.7	90.4 (72.0)	70.4 (57.1)	67.5 (56.1)	1102	1522	0.36
D_4	15.8	92.1 (74.1)	74.5 (59.7)	70.3 (57.9)	1170	1675	0.34
D_5	14.8	91.2 (73.2)	72.1 (58.2)	68.5 (56.7)	1148	1608	0.36
D_6	9.6	83.8 (66.3)	53.0 (46.7)	47.4 (45.0)	1010	1182	0.56
D_7	15.0	92.6 (74.4)	72.0 (58.0)	68.2 (56.3)	1114	1607	0.37
D_8	15.2	91.5 (73.2)	67.3 (55.2)	63.0 (53.0)	1073	1482	0.45
D_9	11.6	84.9 (67.1)	59.7 (50.6)	55.2 (50.6)	1024	1350	0.48
D_{10}	13.0	89.5 (71.1)	66.7 (54.7)	62.9 (53.6)	1082	1465	0.43
SEm±		0.83	0.93	0.78	11.72	18.38	0.02
CD (P=0.05)		2.4	2.67	2.25	33.05	52.62	0.04

Figures in parenthesis are arc sine transformed values.
D_1 = *SDPP*; D_2 = *SDP*; D_3 = *DOR method*; D_4 = *Sh. DPP*; D_5 *(Sh. PT)*, D_6 = *SDPJC*; D_7 = *SDPPH*;
D_8 = SDPPJC; D_9 = SDPPJC; D_{10} = NRCG

Table 2 Maintenance of minimum seed certification standards for germination in terms of duration (months after storage) in different methods of drying

Methods of drying	2002 Months after storage Germination (%)			2003 Months after storage Germination (%)			
	5	7	8	3	4	7	8
Farmers practice (D_1)	71.7	-	-	70.6	-	-	-
DOR method (D_3)	-	-	70.8	-	-	70.1	-
Shade drying pods intact with plants (D_4)	-	-	74.2	-	-	-	72.0
Shade drying (only pods) under tree (D_5)	-	-	71.6	-	-	-	70.1
Pods intact with plants covered with haulms of other plant (D_7)	-	-	71.1	-	-	-	70.8
NRCG method (D_{10})	-	70.0	-	-	72.1	-	-

Minimum seed germination for certified seed production is 70%.

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Growth analysis of production technology in castor, *Ricinus communis* L.

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Abstract

The growth and instability analysis of castor (*Ricinus communis* L.) area, production and productivity in the Rajasthan was studied using statistics from 1985-86 to 2003-2004. Compound growth rate analysis showed higher growth rates for production and area as compared to productivity. The castor area and production were instable. Production potentials and impact of improved technology was assessed from 217 Frontline Demonstrations conducted during 1991-2004. The adoption of whole package with hybrid GCH-4 gave 3035 kg/ha seed yield and effective gain of Rs. 8211/ha and with newly developed hybrid RHC-1 recorded 3070 kg seed yield/ha and effective gain was Rs. 9926/ha over farmers practice. Component technology demonstrations *viz.*, variety component, fertilizer component and plant protection components demonstration registered 44.4%, 30% and 16.2% increased seed yield as compared to farmers practice respectively. Cropping system FLD's on Castor + Clusterbean/greengram in 1:1 ratio under irrigated as well as rainfed condition provided higher: seed yield of castor, additional seed yield of inter crop and effective gain. Efforts to increase productivity are required by development of diverse genotypes, ensuring availability of quality seed and input supply in traditional as well as in newly expanded area and reducing yield gaps by dissemination of improved technology.

Key words: Compound growth rate, castor frontline demonstrations

Introduction

Castor (*Ricinus communis* L) is an important non edible oilseeds cash crop of country earning foreign exchange through export of castor seed, oil and oil derivatives. The India is major castor growing country in the world sharing 54% global area and 51% of the production. In India, the states *viz.*, Andhra Pradesh (2.91 lakh ha), Gujarat (2.90 lakh ha) and Rajasthan (0.64 lakh ha) covers 39.8, 39.6 and 8.7% of the total castor area in the country respectively. In terms of the production Gujarat ranks first with 67.5% contribution followed by Andhra Pradesh (16.4%) and Rajasthan (11.2 %). The Rajasthan is an important state because state shares less area and contributes more production of castor (Anonymous, 2006).

The area, production, and productivity have increased largely during last 15 years in the Rajasthan. However, the gain in area production and productivity was highly inconsistent and fluctuating over years. The minimum average castor productivity of 147 kg/ha was recorded in the year 1986-87 while maximum of 1437 kg/ha was recorded during 2001-02. Such wide fluctuations required the study of compound growth rate of the area, production and productivity and extent of instability.

In present study data of 217 Castor Frontline Demonstrations conducted at farmer's field during last 14 years (1991-92 to 2004-05) were used to study production potential and effectiveness of castor production technology under real farm situation in Rajasthan.

Material and methods

The statistics of area, production and productivity as per Department of Agriculture, Government of Rajasthan were used to estimate compound growth rates and extent of instability using time series data of the period 1985-86 to 2003-04 (Anonymous, 2004). The castor area, production and productivity were highly fluctuating from year to year hence to keep consistency in the data smoothening was done by taking three years moving averages. To compute compound growth rates of time series data of the period 1985-86 to 2003-04 three years moving average were used for present study.

Analytical tools

Estimation of growth rates: The compound growth rates of area, production and productivity of castor for the state as a whole for period 1985-86 to 2003-04 by fitting an exponential function of the following form:

$Y = Ab^t$ $\quad\quad$ $\text{Log } Y = \text{Log}A + t.\log b$

Where,

Y= Area/Production/Productivity

A= Constant

b=(1+r)

r = Compound growth rate

t = Time variable in years(1,2,3, ...n)

Estimation of extent of instability: The coefficient of variation (CV) which explains the fluctuation over the period was used to explain instability and calculated as under.

$$CV = \left[1/n - 1 \sum \frac{(X_t - \bar{X})^2}{\bar{X}} \right]^{1/2}$$

Where;

CV= Coefficient of variation

N=Number of years

X_t = Area/production/productivity in the year t

$\bar{X}$ = Mean of area/ production/productivity

To estimate extent of instability various methods like Coppock's instability index (CII) and coefficient of variation (CV) are commonly used. The coefficient of variation has been used to study instability in groundnut by Rama Rao and Raju (2005a). Higher the values of CV greater the instability of area/ production/ productivity in studied period.

Front line demonstrations (FLDs) on various Agro-production/protection technological aspects and cropping system were conducted in agro climatic zone *viz.*, Transitional Plain of Luni Basin II B (Pali, Jalore and Sirohi districts) and Arid Western Plain Zone I A (Jodhpur and Barmer districts) of the Rajasthan state. The FLDs on various components i.e. whole package(whole package demonstration included all the technology required for the castor production), recommended fertilizer dose, adoption of new variety/hybrid, plant protection measures and intercropping system were laid out at farmer's fields and assessment were made. Each demonstration covered 0.8 ha, out of that 50% was used to raise the crop through improved technology (as per component of FLD) and rest of the area was used for raising the crop through farmer's practice. The soils of the demonstration site were sandy loam to clay loam in Pali, Jalore and Sirohi districts and loamy sand in Jodhpur and Barmer districts. The average fertility status of the soil was low in nitrogen content, medium to high phosphorus and potassium content. The net returns were calculated as per then existing cost of cultivation and sale rate of castor in the local Krishi Upaj Mandies (Agricultural Marketing Yards). To asses over all impact of technology and production potentials each year's data on different aspect of demonstration were used and average worked out using weighted means. Extension gaps were calculated as per Vaghasia *et al.* (2005).

Results and discussion

The castor area, production and productivity have registered a many fold increase in last 17 years. The differences in highest and lowest values were ranging sixty times for area and almost ten times for productivity. The year to year variation was high for area, production and productivity hence three years moving average was used to compute compound growth rate. The growth rate analysis indicated that the production registered higher compound growth rate of 1.217 followed by area 1.169 and productivity registered low growth rate of compound growth rate as compared to production and area (Table 1). The coefficient of determination was high for area and production indicating the higher validity of conclusion drawn for the growth of area and production. The CV for area and production was higher than productivity it indicated that instability in the castor area was the highest followed by the castor production. The low value of CV for productivity indicated that productivity was more stable as compared to area and production. Rama Rao and Raju (2005b), also reported high instability in castor area and production in Andhra Pradesh.

The high instability in area, production, was mainly due to seasonal rainfall, high year to year variation in castor area, prices of castor as well as higher economic remunerations from castor crop as compared to other crops are the major reasons of inconsistency in castor area. The high prices and good rainfall are enduring to increase in area. During drought years when sowing of other *kharif* crops is delayed or damaged farmers use available limited irrigation source to take castor crop as it's sowing time starts from second fortnight of July to first week of August.

Besides these increase in area in non traditional districts like Hanumangarh etc., has also influenced compound growth rate of area and production. Productivity of castor in the state was more stable indicating need to develop diverse genotype with higher yield potential and resistance to biotic and abiotic factors. To stabilize production and achieve higher productivity in traditional and non traditional areas ensured supply of quality seed of hybrids, other inputs like fertilizers and plant protection measures and dissemination of improved technology are some impact points needs to be adopted immediately.

The Frontline Demonstrations Conducted during last seventeen years was used to study the production potential of castor through adoption of latest improved technology. The impact of technology assessed through FLD is discussed here under:

Whole package demonstration: In all, 163 on farm demonstration were conducted to exhibit impact of whole package (Table 2) out of these, in 126 demonstration castor hybrid GCH-4 was used whereas in the rest demonstrations newly developed castor hybrid RHC-1 was used. All these FLD's were conducted under irrigated condition. Results on whole package demonstration revealed that, Castor hybrid GCH-4 grown with improved agro-production and need based protection techniques produced mean seed yield of 3035 kg/ha and recorded 35.4% increase in seed yield over farmer's practice of castor cultivation, the mean effective gain of Rs. 8211/ha was recorded with the adoption of full package of practices indicating higher return with adoption of improved technology. The mean seed yield of castor hybrid RHC-1 was 3070 kg/ha in 37 whole package FLDs *and recorded 30.4% increase over farmers techniques*, the maximum mean effective gain of Rs. 9926/ha was recorded when castor hybrid RHC-1 was grown with whole improved package over farmer's grown GAUCH 1/local castor. Higher seed yield (700-800 kg/ha) and more net effective gain obtained with adoption of whole package showed that improved technology has remarkable impact in increasing production of castor (Table 3). The additional potential of seed yield can be easily achieved by covering extension gap.

The extension gap in whole package FLD was worked out on mean basis indicated a wider extension gap in GCH-4 (793 kg/ha) compared to RHC-1 (715 kg/ha). The state Department of Agriculture and other extension agencies have to take lead in promoting recommendation of whole package in order to tap the available additional yield reservoirs in castor production. Vaghasia *et al.* (2005) also reported importance of improved technology in FLD conducted on groundnut.

Component technology demonstration: In 10 FLDs, castor hybrid GCH-4 grown with recommended fertilizer application (80 kg N + 50 kg P_2O_5/ha) produced seed yield of 2762 kg/ha which was 637 kg/ha higher over farmer's practice growing hybrid GCH-4 with improper fertilizer doses. The seed yield recorded in improved technology demonstration plots exhibited 30% increase over farmers practice. The effective gain due to application of recommended dose of fertilizer was Rs. 5246/ha. These results clearly indicated the need of proper dose of fertilizer application in the nutrient hungry light textured soils of the Western Rajasthan. Rao *et al.* (1995) and Singh (2002), also reported importance of fertilizer component in castor.

Similarly in 10 FLDs of improved variety, hybrid GCH-4 gave 1055 kg/ha higher seed yield over hybrid variety GAUCH-1, the increase being 44.4% over wilt susceptible hybrid GAUCH-1 .The FLD on variety component clearly indicated the importance of hybrid GCH-4.

A field survey conducted in the area revealed that irrigated castor sown after mid July was found infested with various sucking pests which cause yield loss up to the tune of 10-15%. The eight FLDs conducted to demonstrate importance of plant protection measures (one/two sprays of monocrotophos @ 0.04%) gave mean seed yield of 2942 kg/ha and registered increment of 411 kg/ha in the seed yield over the plot kept without plant protection measures. The effective gain in net return through adoption of plant protection measures was Rs. 2911/ha, the mean extension gap in plant protection measures was quite substantial (411 kg/ha) to adopt plant protection measures.

Castor is long duration crop (210-240 days under irrigated conditions) being grown at wider spacing of 90-120 cm under irrigated conditions and 60-90 cm under rainfed conditions. Recommendation of taking inter crop as additive series in castor based cropping system provides additional returns and higher production per unit area/time. To demonstrate better cropping system FLDs on inter crop were taken under irrigated as well as rainfed conditions.

Intercropping system demonstrations: Castor + cluster bean demonstration (1:1 ratio) carried out under irrigated condition with hybrid GCH-4 + Suvidha/RGC 936 improved the seed yield of castor by 874 kg/ha with additional bonus yield of 313 kg clusterbean/ha over sole castor hybrid GAUCH-1. The cropping system technology provided mean effective gain of Rs. 8702/ha over sole castor. Similarly, the mean effective gain of castor.+ greengram (1:1) intercropping system under irrigated condition with hybrid GCH-4 + K 851 was Rs. 8647/ha over farmers grown sole castor hybrid GAUCH-1.

Castor + clusterbean intercropping system (1:1) carried out under rainfed condition increased the seed yield of castor by 45.0% with additional yield of 375 kg clusterbean/ha. Intercrop system generated additional net return of Rs. 1887/ha over sole castor. Castor + greengram (1:1) intercropping system carried out under rainfed condition gave additional seed yield of castor and greengram by 405 and 45 kg/ha, respectively over sole castor. Respective gain in net return due to this technology was Rs. 2498/ha over sole castor.

FLD's conducted on cropping system showed that additional yield of pulses can be easily harvested by adopting inter crop system.

Conclusion: Based on present study it was concluded that for state as a whole growth rate in production (1.217) was higher than area (1.168) and productivity (1.060). The instability analysis on the basis of CV suggested that area (71.4%) and production (63.0%) showed higher instability as compared to productivity (33%). Reasons of instability in area, production and productivity need to be analysed thoroughly by the district wise growth analysis and ascertain the yield gaps.

Adoption of improved technology resulted in higher effective gains. Among various components of production technology variety alone contributed 44.4% increase in seed yield, fertilizer component raised the seed yield by 30% and protection component increased 16.2% seed yield.

Cropping system FLDs on Castor + Clusterbean/ greengram in 1:1 ratio under irrigated as well as rainfed condition provided higher: seed yield of castor, additional seed yield of inter crop and higher effective gain.

Castor production and productivity in the Rajasthan can be increase with adoption of improved production technology and cropping system. Considering higher realised yield potentials in improved plots of FLD, the Extension agencies of Agriculture Department of Rajasthan/ KVKs and Public/Private Seed production agencies shall have prime role in increasing castor production and productivity in the Rajasthan.

Policy implication: Area and production were most instable factors in castor the instability in production was mainly influenced by area indicating that there is a need of in depth study about factors influencing the area expansion, remunerative prices to farmers, assured and timely supply of quality seeds and other inputs. To stabilize the productivity, development of superior high yielding genotypes suitable to various farming systems and their quality seed availability is required. To reduce yield gaps dissemination of improved technology has to be taken up at priority by extension agencies in a mission mode approach.

Table 1 Compound growth rate, coefficient of determination and coefficient of variation of area, production and productivity of castor in Rajasthan

Item	Compound growth rate	Coefficient of determination	CV (%)
Area	1.168	0.873	71.4
Production	1.217	0.718	63.0
Productivity	1.060	0.374	33.0

Table 2 Impact of improved technologies on the production potential and net return of castor under real farm situation (Average of various frontline demonstrations conducted during *kharif*, 1991-92 to *kharif*, 2004-05)

Particular	No. of demo.	Variety		Seed yield (kg/ha)		Net return (Rs./ha)		Effective gain (Rs./ha)
		IT	FP	IT	FP	IT	FP	
Whole package	126	GCH 4	GAUCH 1/ local	3035	2242	26466	18255	8211
Whole package	37	RHC 1	GAUCH 1/ local	3070	2355	34830	24904	9926
Component technology								
Fertilizer dose*	10	GCH 4	GCH 4	2762	2125	18844	13598	5246
Variety	10	GCH 4	GAUCH 1	3430	3175	21091	11319	9772
Plant protection	8	GCH 4	GCH 4	2942	2531	19208	16297	2911
Intercropping (Irrigated)								
Castor + Clusterbean (1:1)	3	GCH 4 (Suvidha/ RGC 936)	GAUCH 1	2833 (313)	1959	15975	7273	8702
Castor + Greengram (1:1)	16	GCH 4, (K 851)	GAUCH 1	3154 (124)	2058	17534	8887	8647
Intercropping (rainfed)								
Castor + Clusterbean (1:1)	2	GCH 4 (Suvidha/ RGC 936)	GAUCH 1	1000 (375)	688	6142	4255	1887
Castor + Greengram (1:1)	5	GCH 4, (K 851)	GAUCH 1	925 (45)	520	4505	2007	2498
Total	217							

* 80 kg N + 50 kg P_2O_5/ha; IT = Improved technology; FP = Farmer's practice; Figures in parenthesis denotes intercrop yield

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Production and economics of castor-based sequential relay-intercropping systems in Karnataka

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Abstract

Field experiments were conducted for two years at the *College of Agriculture and Zonal Agricultural* Research Station, Navile, Shimoga, to evolve economically viable castor based sequential-intercropping systems under rainfed conditions during *kharif*, 2003 and 2004. Sowing castor in paired rows (2101 kg/ha) and normal planting (2177 kg/ha) has recorded similar bean yield of castor. However, yield was significantly reduced in all the intercropping systems as compared to normal planting. The castor equivalent yield was significantly higher in paired row of castor intercropped with baby corn followed by *field bean (4849 kg/ha) over different relay* intercropping systems except castor + frenchbean followed by field bean (4660 kg/ha). Among the intercropping systems, paired row of castor + frenchbean followed by field bean recorded significantly higher net returns (Rs. 40,738/ha) and B:C rato (3.68).

Key words: Sequential intercropping systems, castor equivalent yield, economics

Introduction

Castor (Ricinus communis L) is an important non edible oilseed crops of drylands. Castor is cultivated in Alfisols, which occupies nearly 30% area of dry farming region of India. Possibility of multiple cropping under dryland conditions is remote. Nevertheless, the traditional mixed/intercropping system could be viewed as a system, which can meet the various domestic demands of farmers and also a method of increasing production and profits. Past experience of cropping system research in drylands indicated that intercropping has one of the most promising options for improving production of dryland crops through increased cropping intensity, which imparts sustainability to dryland crop production.

Fingermillet or groundnut or pigeonpea based intercropping systems are the predominant cropping systems grown on dryland of southern India. Off late castor is becoming one of the promising crops for profitable farming under rainfed situation. There is a good scope to include castor in dryland crop production in view of the recent development of high yielding varieties/hybrids of different duration. The crop is of long duration, widely spaced with relatively thin plant population as compared to other field crops and takes about 70-80 days for complete inter row canopy cover. Hence, it offers a great scope for using its interspaces by growing short duration crops like greengram, blackgram, cluster bean, frenchbean, onion, etc., and thereby helps in harvesting the potential productivity (Singh and Singh, 1988). Several workers attempted to study the suitable intercrops with castor (Sarada Devi *et al.*, 2002; Vani and Bheemaiah, 2004; Raghavaiah, 2005). However, attempts made to develop and evaluate sequential intercropping systems were lacking. This paper reports the possibility of growing sequential intercropping systems with castor.

Material and methods

A field experiment was conducted during *kharif* 2003 and 2004 at the College of Agriculture and Zonal Agricultural Research Station, Navile, Shimoga to evaluate the *economic viability of castor-based sequential intercropping* systems under rainfed conditions on Alfisols. The soil topography was fairly uniform having 44.8% coarse sand, 32.2% fine sand, 12.4% silt and 10.6% clay. Soil was slightly acidic (6.2) and low in electrical conductivity (0.30 ds/m). The organic carbon content was 0.43% and low in available N (260 kg/ha), high in P (198.58 kg/ha) and medium in K (173.83 kg/ha). The experiment was laid out in Randomized Block Design with 12 treatments replicated thrice. Deep furrows were opened with inter and intra-row spacing of 90 cm and 60 cm, respectively for normal sowing of castor. For paired row system of planting, two rows of castor were spaced at 60 cm with an inter row space of 120 cm between two pairs. Three rows in between two pairs of castor were earmarked 30 cm apart for sowing/planting intercrops of french bean and fingermillet. Similarly, two rows were earmarked 40 cm *apart for sowing baby corn and marked 45 cm apart for* field bean.

Observations on castor growth parameters, 100-seed weight and bean yield were recorded on randomly selected five plants. The land equivalent ratio (LER) and castor equivalent yield were worked out for the sequential intercropping systems.

Results and discussion

Significant reduction in castor yield was observed due to relay intercropping system as compared to normal planting of castor, whereas, paired row planting and *normal planting of castor as sole crop recorded* statistically similar bean yield (Table 1). However, castor sequential intercropped with frenchbean *fb* fieldbean and sole crop of castor under paired row planting have recorded similar yields. Sequential intercropping in paired row castor with babycorn *fb* transplanted fingermillet has given significantly lower yield of castor followed by paired row of castor *sequential intercropped with babycorn fb* fieldbean as compared to sole cropping of castor grown either as normal or paired row planting which can be attributed to competition offered by the intercrops for light, nutrients and moisture. Prasad *et al.* (1989(, Gupta and Rathore (1993), Rajput and Shrivastava (1996), Patel *et al.* (2002) and Srilatha *et al.* (2002) also observed reduction in the castor bean yield due to intercropping systems.

Significant differences in the bean yield of castor in the present study could be attributed to significant variation in the growth as well as yield attributes like plant height, number of leaves, number of branches, number of *spikes/plant, number of capsules/spike, length of primary* spikes and test weight (Table 2).

Table 1 Plant growth and yield parameters of castor as influenced by relay intercropping system (pooled data 2003 and 2004)

Treatment	Plant height (cm) at 120 DAS	No. of leaves/plant at 120 DAS	No. of spikes/plant at harvest	No. of branches/ plant at harvest	No. of capsules/ spike	Castor bean yield (kg/ha)	Test weight (g)	Length of primary spike (cm)
T_1 = Normal planting of castor (90 x 60 cm)	166	42	8	12	81	2177	32	55
T_2 = Paired row planting of castor (60 x 120 cm)	163	41	8	11	80	2101	31	53
T_8 = T_2 + French bean *fb* transplanted finger millet	176	37	6	10	65	1857	30	47
T_9 = T_2 + French bean *fb* field bean	173	35	7	10	67	1927	31	50
T_{10} = T_2 + Baby corn *fb* transplanted finger millet	182	29	5	9	47	1649	27	42
T_{11} = T_2 + Baby corn fb field bean	*178*	*30*	*5*	*9*	52	*1654*	*29*	*44*
T_{12} = T_2 + transplanted finger millet	172	37	7	10	59	1791	29	47
SEm±	1.34	1.03	0.34	0.36	0.76	73.8	0.56	0.62
CD (P=0.05)	3.85	3.01	1.00	1.08	2.18	219.8	1.56	1.82

Table 2 Castor equivalent yield (kg/ha), land equivalent ratio (LER) and economics as influenced by intercropping system

Treatment	Castor equivalent yield (kg/ha)			Land equivalent ratio			Economics			
	2003	*2004*	*Mean*	*2003*	*2004*	*Mean*	Gross returns (Rs/ha)	Cost of production (Rs/ha)	Net returns (Rs/ha)	B:C ratio
T_1 = Normal planting of castor (90 x 60 cm)	2126	2228	2177	1	1	1	26124	11303	14821	2.31
T_2 = Paired row planting of castor (60 x 120 cm)	2022	2180	2101	1	1	1	25212	11303	13909	2.23
T_3 = Sole crop fingermillet	1779	1899	1839	1	1	1	22068	10036	12032	2.20
T_4 = French bean *fb* transplanted fingermillet	4816	5445	5130	1	1	1	61556	18327	43229	3.36
T_5 = French bean *fb* field bean	6007	6612	6307	1	1	1	75680	17099	58581	4.43
T_6 = Baby corn *fb* transplanted fingermillet	5981	6802	6392	1	1	1	76702	20474	56228	3.75
T_7 = Baby corn *fb* field bean	7391	7655	7523	1	1	1	90280	22257	68023	4.06
T_8 = T_2 + Frenchbean *fb* transplanted fingermillet	4072	4450	4260	1.89	1.81	1.85	51123	16872	34251	3.03
T_9 = T_2 + Frenchbean *fb* field bean	4461	4862	4660	1.74	1.77	1.76	55924	15186	40738	3.68
T_{10} = T_2 + Baby corn *fb* transplanted fingermillet	4328	4831	4579	1.71	1.71	1.71	54953	20353	34600	2.70
T_{11} = T_2 + Baby corn *fb* fieldbean	4671	5028	4849	1.55	1.59	1.57	58193	21262	36931	2.74
T_{12} = T_2 + transplanted finger millet	2947	3185	3066	1.54	1.54	1.54	36785	12523	24262	2.94
SEm±	98.2	75.7	83.2	0.05	0.01	0.03	344	NA	398	0.10
CD (P=0.05)	289.3	223.0	250.1	0.14	0.03	0.09	1027	-	1189	0.30

Among the castor-based sequential intercropping systems, the net return was higher in castor sequentially intercropped with frenchbean *fb* fieldbean followed by castor sequentially intercropped with babycorn *fb* field bean as compared to sole crop of castor either under normal planting or paired row planting. The B:C ratio was also higher for castor sequentially intercropped with frenchbean *fb* field bean followed by paired row of castor sequentially intercropped with frenchbean *fb* transplanted fingermillet as compared to sole castor either at normal planting or paired row planting.

All the sequential intercropping systems as well as the intercropping of castor with fingermillet resulted in *significantly increased plant height at 120 DAS as* compared to sole crop irrespective of the methods of planting. Sole cropping either by normal or paired row planting recorded significantly lower plant height as compared to different sequential intercropping systems. Significantly lower number of leaves/plant were recorded in castor relay intercropped with babycorn *fb* transplanted fingermillet as compared to rest of the treatments except castor sequentially intercropped with babycorn *fb* fieldbean.

Significantly higher number of branches/plant was recorded in normal planting of castor as sole crop as compared to rest of the treatments except paired row sole cropping of castor and intercropping of castor with transplanted fingermillet.

The highest number of spikes/plant was recorded in normal planting which was significantly superior over inter/sequentially intercropped treatments but was on par with castor grown under paired row planting. Among the sequential intercropping systems, the spikes number was significantly more when castor was relay intercropped with frenchbean *fb* either field bean or fingermillet as compared to castor+babycorn *fb* transplanted fingermillet (5.0) and castor + babycorn *fb* fieldbean.

In general, all the intercropping systems have recorded significantly higher LER as compared to sole castor. The land equivalent ratio was highest (1.85) with paired row castor sequentially intercropped with french bean *fb* transplanted fingermillet as compared to sole castor either under paired row or normal planting, followed by paired row of castor relay intercropped with either frenchbean *fb* field bean or babycorn *fb* transplanted fingermillet (1.76 and 1.71, respectively). The reasons for large yield advantages in sequential intercropping systems were due to the fact that component crops were efficient in utilization of resources resulting in higher productivity per unit area. Higher LER in sequential intercropping systems could be due to combined yield of both main as well as component crops involved as compared to sole crop. Al-Bakry and Saran (1985), Prasad and Verma (1986), Yadava (1992), Gupta and Rathore (1993), Rajput and Shrivastava (1996) and Patel *et al.* (2002) also reported that castor can be intercropped with pulses or oilseeds for higher yield advantages.

In the present study, all the sequential intercropping systems recorded significantly higher castor crop equivalent yield as compared to sole castor either under normal planting or paired row planting (Table 3). Among castor-based sequential intercropping systems the castor equivalent yield was higher in paired row castor sequentially intercropped with baby corn *fb* field bean followed by sequential intercropping of castor with frenchbean *fb* field bean as compared to that of sole castor planted either at normal planting or in paired rows. This is in accordance with the findings of Al-Bakry and Saran (1985), Rajput and Srivastava (1996), Patel *et al.* (2002) and Srilatha *et al.* (2002). However, double cropping of babycorn *fb* fieldbean recorded significantly higher castor equivalent yield as compared to all other sequential intercropping systems.

Based on this two years study it can be concluded that castor sequentially intercropped with frenchbean were found to be profitable systems for rainfed situation of southern India.

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Genotypic variation for chemical composition in confectionery groundnuts

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Abstract

Bold seeded groundnut varieties are important for confectionary and table purposes. The quality requirement for groundnut as a source of food is determined by chemical and nutritional factors. The present study was aimed at critical evaluation of 49 bold seeded genotypes for different chemical constituent's *viz.*, oil, protein, carbohydrate, and reducing and non-reducing sugars over two seasons. The genotypes exhibited significant variation for all the constituents besides seed mass and yield. Significant seasonal differences and genotype x season interaction were also evident. Seed mass was negatively associated with oil and protein content. Oil content showed negative association with protein, carbohydrate and sugars. The range of variation was narrow for oil content (42.7 to 48.7 %), but substantial for other constituents. It ranged from 18.8 to 34.2 % (protein), 7.3 to 16.5 % (carbohydrate) and 3.0 to 7.8% (total sugars). The genotypes DCG 21, DCG 24 and DCG 26 were high yielding with low oil and high protein and sugars and thus found superior for confectionary purpose. These genotypes could be extensively evaluated for commercial exploitation and utilized in future breeding programmes.

Key words: Carbohydrate, confectionary, groundnut, oil, protein, sugars

Introduction

Among the major oilseed crops, groundnut has some specific advantages as it can be used as food because of its good nutritional composition and palatability (*Bandyopadhyay and Desai, 2000*). Confectionery groundnut is used for manufacturing peanut butter, confections and chocolate-based products. The final *nutritional quality of edible groundnut as a source of food* is principally due to the chemical composition of the oil, protein, carbohydrate fractions of the seed. The large seed size is of considerable importance for direct consumption and is one of the most important trade attributes for export of hand picked selected kernels (Rajgopal *et al.*, 2000). Keeping this in view, the present study was carried out for critical evaluation of 49 bold seeded genotypes for different chemical constituents.

Material and methods

The material consisted of 49 bold seeded genotypes comprising of 36 derivatives obtained from nine crosses *viz.*, TG 49 x B 37c (10), D 39d x TG 49 (3), TG 49 x D39d (5), TG 49 x Mutant 28-2 (5), TG 49 x R 9227 (4), R 9227 x TG 49 (4), TG26 x Mutant 28-2 (2) TAG24 x Mutant 28-2 (1) and Mutant 28-2 x NC Ac 343 (2), other advanced breeding lines (9) and four check varieties *viz*, M 28-2, Somanth, TKG 19-A, and TG 41 that are under cultivation in different states of India (Desmukh, 1997; Gowda *et al.*, 2002; Kale *et al.*, 2004).

The material was evaluated at the University of Agricultural Sciences, Dharwad during rainy (2003) and post rainy (2004) seasons in a Randomized Complete Block Design (RCBD) in two replications. Each genotype was grown in *three rows of 2.25m length with spacing of 30 cm between* rows and 10 cm between plants, respectively. The experimental material was sown on first week of July during the rainy and third week of January during post rainy season. The crop was harvested at 110 days during rainy and at 117 days during the post-rainy seasons. Observations on kernel yield (kg/ha) and hundred seed mass (g) were recorded. The genotypes were analyzed for oil content on dry weight basis (oven dried) with NMR spectrometer (Ramamurthi *et al.*, 1985), protein content by Micro-Kjeldhalmethod (Sadasivam and Manickam, 1992) and carbohydrate by Phenol Sulphuric acid (Dubios *et al.*, 1956) and sugars by Dinitrosalicilyc method (Miller, 1972). The determinations were done on defatted flour prepared from the moisture free seed-meal by solvent extraction using petroleum ether (BP 60°C to 80°C) in a Soxhelt apparatus. Two season's data were statistically analyzed.

Results and discussion

Genotypes differed significantly for kernel yield, seed mass, oil, protein, carbohydrate, total sugars, reducing sugar and non-reducing sugar. All these traits also exhibited significant variation between seasons and genotype x season interactions indicating the impact of environment and differential response of genotypes over seasons (Table 1). Significant genotypic differences for chemical constituents (Gupta *et al.*, 1982; Dwivedi *et al.*, 1990; Harold *et al.*, 2000; Manivel *et al.*, 2000) and G x E interactions for kernel yield and seed mass (Dwivedi *et al.*, 1990) were reported earlier in groundnut

Correlation coefficients measure mutual relationship between various characters, which help in devising experimental strategies for indirect and multiple trait selections. Seed mass, oil and protein contents largely determine the end use of a groundnut genotype and an understanding of the relationship between these traits will help in effective selection for confectionery and or/oil purpose (Dwivedi *et al.*, 1990). Oil content is most important quality attribute, which decides the market value of groundnut. Millers prefer cultivar with high oil content where as cultivars with low oil content but having high protein and sugar contents are exported as confectionery grade ground nuts In the present study, association was negative for oil and protein, but positive for carbohydrate with seed mass (Table 2) indicating low oil and protein but high carbohydrate in the larger seeded genotypes. A Large seeded genotype with less oil is desirable for confectionery purpose and but with less protein, it is undesirable on health considerations. Gadgil and Mitra (1983) and Kale *et al.* (2000) have also reported negative association of oil with seed mass in groundnut. However, Dwivedi *et al.* (1990) and Kale *et al.* (1998) observed positive association of seed mass with oil content. Kale *et al.* (1998) and Dwivedi *et al.* (1990) observed negative correlation between protein content and seed mass possibly due to different material used in these studies.

Oil content showed negative association with protein, carbohydrate and sugars. This negative correlation encourages direct selection for high protein and sugars with low oil content. Similar associations were also observed in earlier studies (Gupta *et al.*, 1982; Gadgil and Mitra 1983; Kale *et al.*, 2000). The 'non-oil' components like proteins and carbohydrates were considered responsible for the drop in oil content in large seeded types (Kale *et al.*, 1998). Positive association among carbohydrates and sugars indicate their obvious relations and it could be useful in indirect selection of any of the traits.

Because of health considerations, consumers prefer low-calorie foods and beverages (Dwivedi and Nigam, 2002). In the present study, oil content showed a limited variation, ranging from 42.7 to 48.7%. Eight genotypes (DCG 2, DCG 10, DCG 21 DCG 24, DCG 25, DCG 27, DCG 30 and DCG 31) recorded low oil content (42.7 to 43.7%) in relation to the best check, TKG 19-A (44.1%) Among these five genotypes (DCG 2, DCG 10, DCG 27, DCG 30 and DCG 31) were also good for kernel yield compared to TKG 19-A (Table 3). Earlier studies (Gupta *et al*, 1982; Rajgopal *et al.*, 2000) have also reported limited variation in oil content ranging from 44.5 to 48.6 and 48.0 to 514%, respectively.

Table 1 Analysis of variance for nutritional traits in confectionery groundnut genotypes

Source of variance	Mean sum of squares								
	DF	Kernel yield/ha	100-seed mass	Oil	Protein	Carbohydrate	Total sugars	Reducing sugars	Non-reducing sugar
Genotype (G)	48	332619**	142**	10.6**	55**	18.8**	5.2**	0.1 **	4.2**
Season (5)	1	67370368**	2434**	996**	32.1**	2.3**	0.9**	0.8**	1.3**
G x S	48	281064*	76*'	4.7**	154**	60**	1.6**	0.1**	1.3**
Error	96	172693	23	04	1.0	0.2	01	0.1	0.1

*, ** indicate significance at 5% and 1% level of probability, respectively

Table 2 Correlation coefficient among nutritional traits in confectionery groundnut genotypes

Character	100-seed mass	Oil	Protein	Carbohydrate	Total sugars	Reducing sugars	Non-reducing sugar
Kernal yield/ha	-0.263	-0051	0.024	-0038	-0006	-0.117	0.010
100-seed mass		-0.552**	-0.280*	0296*	0.190	0.261	0.162
Oil			-0.296*	-0.531 **	-0434**	-0402**	-0.399**
Protein				-0001	-0059	-0.123	-0.123
Carbohydrate					0.358*	0.112	0359*
Total sugars						0402**	0992**
Reducing sugars							0.282*

Table 3 Performance of selected confectionery groundnut genotypes for nutritional traits

Genotype	Kernel yield/ha	100-seed mass (g)	Oil (%)	Protein (%)	Carbohydrate (%)	Total sugars (%)	Reducing sugars (%)	Non-reducing sugars (%)
DCG 21	2353	6315	42.7	31.3	16.5	3.9	082	29
DCG 24	2362	7463	43.3	32.1	123	73	0.80	6.1
DCG 26	2785	6489	42.7	30.2	16.3	6.6	087	54
M 28-2*	2687	58.65	484	293	11 1	45	0.72	3.6
Somnath*	3073	54.71	481	24.2	14.1	6.0	078	50
*TKG-19A**	*2406*	*60.10*	*44.1*	*24.1*	*14.2*	*7.2*	*081*	*61*
TG 41*	3163	6328	466	294	14.2	6.3	0.85	5.2
CD (P=0.05)	591	684	0.9	14	06	04	0.06	04

* Indicates check varieties

Oil quality in groundnut is important since it influences the shelf life and nutritional quality of manufactured products due to development of rancidity. The important quality requirements of groundnut as source of oil are high oil content and high oleic acid content resulting in high oleic acid/linoleic acid ratio for longer storability. A low oil ratio may result in rancidity because of release of free radicals and peroxides (Bandyopadhyay and Desai, 2000). So, further studies on oil quality like fatty acid composition is required in these selected genotypes.

Groundnuts contain high quality protein and are considered good source of protein. On weight-to-weight basis, groundnut contains more protein than meat and about two and half times more protein than egg. This is especially important for children, vegetarians and people eating more meatless meals. In the present study, wide variation ranging from 18.8 to 34.2% was observed for protein content. The entries, DCG 9, DCG 14, DCG 24 and DCG 25 had higher protein content compared to the best check, TG 41. In 8000 germplasm accessions analyzed at ICRISAT, a range of 16 to 34% for protein was observed (Dwivedi *et al.*, 1993). However, these ranges of variation were not maintained when selected genotypes were tested over seasons and locations.

The flavour of the roasted peanuts seed is an important characteristic influencing consumer acceptance Carbohydrates are known to contribute precursors to the compounds imparting roasted peanut characteristics (Mason *et al.*, 1969). A better understanding of the role of carbohydrates in roasted peanut quality requires first an understanding of the genotypic variation in the soluble carbohydrate components. In the present study, it ranged from 7.3 to 165 %. Four genotypes *viz.*, DCG 21, DCG 26, DCG 27 and TG 19 (15.9 to 16.5%) had higher carbohydrate content (7.3 to 16.5%) than the best check TG 41 (14.2%). Harold *et al.* (2000) also reported significant variation among genotypes and test environments.

In groundnut non-reducing sugar (sucrose) content is the major constituent as compared to reducing sugar. The reducing sugar should be as low as possible as they cause browning while roasting. Taste is an important attribute when groundnut is used as food. Free sucrose content of 5 % is desirable since it improves the taste of the kernels (Bandyopadhyay and Desai, 2001). Gadgil and Mitra (1983) through analysis of ethanol soluble sugars by paper chromatography showed that sucrose was the major component of the soluble sugars. In the present study, considerable variation existed for total sugar (3.0 to 7.8 %) and non-reducing sugar (2.4 to 6.6%). Three genotypes, DCG 11, DCG 24 and DCG 34 (7.3 to 7.8%) were superior for total sugars. These genotypes were also good (6.1 to 6.6%) for non-reducing sugar. Gupta *et al.* (1982) reported much wider variability (14.24 to 7.44%) for total sugars. Gadgil and Mitra (1983) reported sucrose concentrations ranging from 1.88 to 8.03 % in 'Trombay Groundnut' cultures. Manivel *et al.* (2000) reported sucrose content ranging from 2.86 to 6.35 and 4.40 to 9.74 %, respectively. There were appreciable differences for reducing sugar, which ranged from 0.40 to 1.08 %. The genotypes DCG 29, DCG 32 and DCG 33 (0.4 to 0.42%) were low in reducing sugar. Previous studies (Gupta *et al.*, 1982) reported non-reducing sugar content ranging from 1.18 to 1.78%. However, from the nutritional point of view, quantitative estimation of stachyose and raffinose sugars is important as they are responsible for flatulence (Hellendoorn, 1969) and lower level of these sugars is considered good for health.

For confectionary purpose, besides high yield and large kernels, seeds with lower oil and higher protein and sucrose contents are preferred. The genotype DCG 24 (TG 49 x R 9227, 8) is excellent for chemical traits with low oil and high protein, total sugar and non-reducing sugar besides high yield and seed mass. The genotype, DCG 26 (TG 49 x R 9227, 19) has low oil, high protein and carbohydrate with moderate level of sugars. It has good yield potential with moderate seed mass. The genotype, DCG 21 (TG 49 x Mutant 18-1) is excellent for low oil, high protein and carbohydrate combined with high yield and seed mass. These genotypes can be used for table and confectionery purposes. The check varieties M 28-2 and TG 41 have high oil and protein content, which can be used for oil and protein extraction The identified genotypes can be further evaluated for commercial exploitation and utilized in future breeding programs.

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Short communication

Heterosis and combining ability in Indian mustard, *Brassica juncea* (L.) Czern & Coss

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Indian mustard is one of the most important oilseed crops, which plays a very important role in oilseeds economy of our country. To enhance the present yield level and overcome yield stagnation, it is essential to reshuffle the genes through hybridization of suitable parents. For this, it is necessary to identify the nature and magnitude of gene action involved in the expression of various yield contributing characters as well as the combining ability of *the parents and the resulting crosses. The present* investigation was undertaken with a view to estimate combining ability and the magnitude and direction of heterosis in Indian mustard.

The experimental material comprised of 12 lines (Table 2). Each parent was individually crossed with each pollen parent in line x tester mating design to produce 48 single cross hybrids. Thus, 16 parental lines and 48 hybrids were evaluated in a Randomised Block Design with three replications at the Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh during *rabi* 2002-03. Each genotype was sown in a single row of 5 m length, spaced 45 cm apart with plant-to-plant distance of 10-15 cm. All the recommended agronomic practices and plant protection measures were followed to raise the good crop. Randomly selected five plants from each entry were used for the purpose of recording the observations on 11 characters (Table 1). The analysis for combining ability was carried out as per Kempthorne (1957) and heterosis was assessed as per standard procedure.

The analysis of variance for combining ability revealed significant differences among lines for all the traits barring number of primary branches/plant, number of secondary branches/plant, number of siliquae/plant and seed yield/plant (Table 1). On the other hand, testers were found significant for all the characters except length of siliqua and number of seeds/siliqua. The differences among lines x testers interaction were significant for length of siliqua, number of seeds/siliqua, 1000-seed weight and oil content. This indicated the manifestation of parental genetic diversity and presence of uniformity among the hybrids. Similar findings have been reported by Ghosh *et al.* (2002) in Indian mustard. The estimates of variances due to GCA and SCA suggested that days to 50% *flowering, days to maturity, plant height, number of primary* branches/plant and number of siliquae/plant were predominantly governed by additive gene action, while number of secondary branches/plant, length of siliqua, number of seeds/siliqua, 1000-seed weight, oil content and seed yield/plant were under the control of non-additive gene action. Additive gene action for days to 50% flowering, days to maturity, plant height, number of primary *branches/plant and number of siliquae/plant has been* reported by Yadav *et al.* (1992) and Singh and Sachan (2003) whereas, non-additive gene action for number secondary branches/plant, length of siliqua, number of seeds/siliqua, 1000-seed weight, oil content and seed yield/plant has been reported by Ghosh *et al.* (2002) and Singh *et al.* (2003) in Indian mustard. The results suggested that for exploitation of the both additive and *non-additive type of gene actions it would be worthwhile to* resort breeding methodologies such as biparental mating, recurrent selection or reciprocal recurrent selection which would accumulate favourable genes in homozygous state or help in breaking linkage blocks thereby generating maximum variability for further selection.

A total of 32 crosses exhibited conspicuous heterosis for seed yield and its attributes. The maximum estimate of significant heterosis over best parent (RAURD 9640) for seed yield/plant was recorded in the crosses RH 9304 x Kranti (23.98 %) and BIO 902 x Rohini (23.72 %). BIO 902 x Rohini also expressed significant heterosis for number of primary and secondary branches/plant; SKM 9812 x GM 1, RSM 9807 x GM 1 and RAURPT 3 x GM 1 for days to 50% flowering, PBR 157 x GM 1 for length of siliqua, BIO 902 x Varuna for 1000-seed weight. Further more these crosses also showed high estimates of *sca* effects for yield and yield attributes. Out of 48 crosses, only two crosses *viz.*, RH 9304 x Kranti and BIO 902 x Rohini were superior combinations for seed yield/plant and involved average x good general combiners. Since only good general combiners had rarely given high *sca* effects in their combination, hence the choice of parents for hybridization should be based on combining ability. High estimates of heterosis for seed yield and its components have been also reported earlier by Singh *et al.* (2003), and Joshi and Patil (2003) in Indian mustard. Therefore, heterosis breeding could be suggested for yield advancement in Indian mustard as male sterility source is available in this crop (Prakash *et al.*, 1998), which can be transferred into the good general combining lines by back cross method and can also be directly used in hybrid development.

Estimates of general combining ability effects (Table 2) revealed that the genotypes Rohini, PBR 157 and GM 1 were found good general combiners for yield and its attributes. Thus, on the basis of their *gca* effects these genotypes could be exploited either involving them in hybridization programme or in recurrent crossing for obtaining desirable segregants.

Table 1 Analysis of variance for combining ability for 11 characters in Indian mustard

Source	d.f.	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches /plant	Number of secondary branches/ plant	Number of Siliquae/ plant	Length of siliqua (cm)	Number of Seeds/ siliqua	1000-seed weight (g)	Oil content (%)	Seed yield/plant (g)
Hybrids	47	23.386**	9.049**	129.211**	1.569	41.515**	17988.2**	0.369**	2.162**	1.039**	3.374**	41.969*
Lines	11	46.688**	14.633**	291.235**	1.110	30.042	10243.6	0.909**++	5.435**++	2.889**++	4.761**+	27.592
Testers	3	131.876**	46.542**	526.491**	6.954**	114.431**	115227.6**	0.142	0.246	1.852**++	11.150**++	155.722**
Lines x Testers	33	5.756	3.779	39.087	1.232	35.984	11729.9	0.210**	1.246**	0.348**	2.204**	36.420
Error	94	6.405	5.009	53.548	1.144	24.814	9988.0	0.056	0.644	0.025	0.560	24.773
		Estimates of genetic component of variance										
σ^2_l		3.410	0.900	21.010	@	@	@	0.060	0.350	0.210	0.210	@
σ^2_t		3.500	1.190	13.540	0.160	3.010	2874.9	0.000	@	0.040	0.250	3.310
σ^2_{lt} or σ^2_{SCA}		@	@	@	0.030	3.720	580.6	0.050	0.200	0.110	0.550	3.880
σ^2_{GCA}		3.480	1.120	15.407	0.116	2.136	2125.2	0.013	0.066	0.084	0.239	2.302
$\sigma^2_{GCA}:\sigma^2_{SCA}$		@	@	@	3.860	0.574	3.6	0.260	0.330	0.763	0.434	0.593

*,** Significant at P=0.05 and P=0.01, respectively against error mean squares

+,++ *Significant* at P=0.05 and P=0.01, respectively against 1x t interactions; @ Estimates negative

Table 2 Estimates of general combining ability effects for 11 characters in *Indian mustard*

Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches/ plant	Number of secondary branches/ plant	Number of siliquae/ plant	Length of siliqua (cm)	Number of seeds/ siliqua	1000-seed weight (g)	Oil content (%)	Seed yield/ plant (g)
Lines											
SKM 9705	0.58	-0.05	-0.34	0.05	1.47	6.68	-0.35**	-1.12**	0.18**	0.26	1.50
SKM 9812	-0.34	-0.88	1.36	-0.27	-1.21	-24.44	-0.15*	-0.40	0.05	-0.62**	-0.60
SKM 9914	2.99**	1.28	6.08**	0.28	2.29	54.75*	-0.15*	-0.96**	-0.30**	0.61**	0.76
PBR 157	2.16**	0.78	6.06**	-0.08	-0.81	-21.39	0.54**	1.20**	0.36**	-0.75**	-0.52
RSM 9807	-1.34	-1.22	-8.94**	0.13	1.54	13.68	0.12	0.41	-0.94**	1.40**	-1.74
RK 9901	2.74**	1.28	6.63**	0.43	1.42	16.93	0.39**	0.77**	-0.67**	-0.28	-1.94
PSR 44	-0.01	0.45	-0.35	-0.05	-1.56	-12.57	0.10	0.20	0.60**	0.42	0.86
RH 9304	0.24	1.53**	1.01	0.01	0.76	-17.04	-0.17*	-0.36	0.42**	-0.05	1.80
RAURD 9640	0.08	-1.13	2.00	0.08	-0.78	24.83	0.02	-0.01	-0.26**	-0.25	-0.05
BIO 902	-0.26	0.45	-4.65*	0.38	0.56	7.00	-0.14*	-0.28	0.64**	0.33	2.37
RAURPT 3	-3.42**	-1.13	-5.22*	-0.57	-0.64	11.38	-0.36**	0.16	0.08	-0.60**	-0.09
Jawahar Mustard 1	-2.42**	-1.38*	-3.65	-0.42	-3.04*	-59.80*	0.15*	0.38	-0.16**	-0.47*	-2.34
SE (gi) ±	0.73	0.65	2.11	0.31	1.44	28.85	0.07	0.23	0.05	0.22	1.44
Testers											
Varuna	0.24	1.23**	-0.40	-0.04	-0.13	-37.01*	0.06	0.02	0.23**	0.18	-1.16
GM 1	-2.76**	-1.52**	-5.26**	-0.32	-2.61**	-56.71**	0.01	-0.06	0.13**	0.34**	-2.34**
Rohini	1.55**	0.23	2.94*	0.63**	2.22**	64.53**	-0.09*	-0.07	-0.28**	0.31**	1.85*
Kranti	*0.97**	*0.06*	2.73*	-0.27	0.51	29.18	0.02	0.11	-0.08**	-0.83**	1.65*
SE (gj) ±	0.42	0.37	1.22	0.18	0.83	16.66	0.04	0.13	0.03	0.12	0.83

*, ** Significant at P=0.05 and 0.01, respectively.

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Short communication

Heterosis for seed yield and its components in Indian rapeseed, *Brassica campestris* var. Yellow Sarson

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The development of hybrids in many crops has brought about the spectacular improvement in the production and productivity. Under experimental condition, high heterosis for seed yield has been reported in rapeseed-mustard, which clearly demonstrated the presence of commercially exploitable magnitude of heterosis. In yellow sarson, some available genetic male sterile lines provided the pollination control. This will help in the development of sarson hybrids, which can bring in quantum jump in productivity of sarson. Hence, the present investigation was undertaken to study the magnitude of heterobeltiosis and standard heterosis for seed yield and its attributes in rapeseed, *Brassica campestris* var. Yellow Sarson. The crosses were attempted by adopting line (9) x tester (5) mating design during *rabi* 2003-04. The resultant 45 hybrids along with their 14 parents were evaluated in a Randomised Complete Block Design with three replications during *rabi* season of 2004-05 at Main Castor and Mustard Research Station, S.D. Agricultural University, Sardarkrushinagar. Observations on agronomic traits were recorded as given in Table 1. A perusal of mean value revealed that the hybrid YSC 99 x RAUDYS 9708 was superior for seed yield followed by MYSL 221 x PS 66 and SSK 9215 x RAUDYS 9708. The analysis of variance for parents, hybrids and parents vs. hybrid revealed considerable amount of genetic variability among the genotypes for the characters studied. Further, partitioning of the genotypic variance into parents, hybrids and parents vs. hybrids indicated that the parents as well as hybrids were significantly different for all the characters. Comparison of parents vs. hybrids suggested that the performance of hybrids was significantly different than that of the parents except for oil content.

The magnitude of heterosis expressed as per cent change in the mean of F_1 over that of better parent (heterobeltiosis) and the standard check variety, Gujarat Sarson 1 (standard heterosis). The heterobeltiosis for seed yield/plant ranged from -62.84% (PSY 9804 x RAUDYS 9708) to 97.2% (MYSL 20/YP x PS 66). The three top ranking heterotic crosses for various characters are presented in Table 1. In the present study, out of 45 hybrids, 19 hybrids significantly out yielded the standard check, GS 1. Their superiority seemed to have resulted from higher values of yield contributing characters, of which "YSC 99 x RAUDYS 9708" recorded the highest economic heterosis (60.2%), whereas, high heterobeltiosis (97.2%) was recorded by the hybrid "MYSL 20 x YP x PS 66". These hybrids were heterotic over GS 1 for most of the yield components also. These findings are in agreement with the reports of Verma *et al.* (1989), Rai and Singh (1994) and Katiyar *et al.* (2004). In case of number of branches/plant, high values of heterobeltiosis (81.7%) and standard heterosis (110.7%) were recorded. For siliquae/plant, 24 crosses manifested significant heterobeltiosis and 40 crosses exhibited significant economic heterosis in desired direction. It may be mentioned that for this important yield contributing trait all the 43 heterotic crosses, except two (YSC 99 x GS 1 and MYSL 221 x GS 1) exhibited positive significant standard heterosis indicating that for this trait the genes with positive effect was dominant. The heterobeltiosis and standard heterosis with respect to seeds/siliqua were moderate (21.1% and 26.3%, respectively). These results are in agreement with Rai and Singh (1994) and Singh and Mishra (2001). The heterosis over better parent and standard check for 1000-seed weight and harvest index were also moderate. Similar results were reported by Verma *et al.* (1989). In case of oil content, the values of heterobeltiosis (3.6%) and standard heterosis (2.6%) were very low. The cross YSC 99 x RAUDYS 9708 had highest *per se* performance (29.5 g/plant), highest standard heterosis (60.2%) and high heterobeltiosis (51.4%) for seed yield/plant. Therefore, this hybrid has potential for commercial exploitation of heterosis if stable restorer is available.

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Table 1 Three top ranking parent and hybrids with respect to *per se* performance and heterosis over better parent and standard check (GS 1)

Character	Best performing parent	Best performing hybrids	*per se*	Range of hetero-beltiosis (%)	Heterosis over better parent		Heterosis over standard check (GS 1)	
					Heterotic crosses	Hetero-beltiosis (%)	Heterotic crosses	Standard heterosis (%)
Days to 50% flowering	MYSL 20/YP	MYSL 20/YP x RS 1	43.3	-2.04 to 25.53	-	-	MYSL 20/YP x RS 1	-9.44**
	MYSL 221	MYSL 20/YP x RAUDYS 9708	43.3		-	-	MYSL 20.YP x RAUDYS 9708	-7.81**
	RS1	MYSL 221 x GS 1	44.7		-	-	PYS 9804 x RS 1	-4.96*
Days to maturity	MYSL 20/YP	MYSL 20/YP x RAUDYS 9708	100.3	-6.48 to 6.23	SSK 9215 x RAUDYS 9708	-6.48**	MYSL 20/YP x RAUDYS 9708	-7.38**
	MYSL 221	SSK 9215 x RAUDYS 9708	101.0		SSK 9215 x PS 66	-5.76**	SSK 9215 x RAUDYS 9708	-6.77**
	RS 1	MYSL 221 x GS 1	102.3		SSK 9215 x YST 151	-5.45**	MYSL 221 x RS 1	-6.15**
Plant height (cm)	MYSL 20/YP	MYSL 20/YP x PS 66	113.8	0.43 to 41.05	-	-	MYSL 20/YP x PS 66	-9.49**
	MYSL 221	MYSL 20/YP x GS 1	115.9		-	-	MYSL 20/YP x GS 1	-7.84**
	PS 66	MYSL 20/YP x YST 151	120.8		-	-	-	-
Branches/plant	RS 1	MYSL 20/YP x RS 1	27.7	-49.80 to 81.61	SSK 9215 x YST 151	81.61**	MYSL 20/YP x RS 1	110.74**
	RAUDYS 9708	SSK 9215 x YST 151	27.2		MYSL 221 x YST 151	71.13**	SSK 9215 x YST 151	106.78**
	PYS 9804	SSK 9215 x RS 1	25.7		MYSL 20/YP x YST 151	69.68**	MYSL 221 x YST 151	88.35**
Siliquae on main branch	RAUDYS 9708	PROYS 9805 x RS 1	57.4	-45.39 to 68.50	MYSL 221 x YST 151	68.50**	PROYS 9805 x RS 1	74.75**
	RS-1	MYSL 221 x YST 151	57.1		PROYS 9805 x RS 1	41.49**	MYSL 221 x YST 151	73.62**
	SSK 9215	YSB 2001 x RS 1	52.7		PYS 9804 x PS 66	38.42**	YSB 2001 x RS 1	60.18**
Siliquae/plant	RAUDYS 9708	SSK 9215 x YST 151	605.0	-42.50 to 215 95	SSK 9215 x YST 151	215.95**	SSK 9215 x YST 151	322.10**
	RS 1	MYSL 221 x RAUDYS 9708	416.7		MYSL 20/YP x PS 66	161.40**	MYSL 221 x RAUDYS 9708	190.63**
	SSK 9215	MYSL 20/YP x YST 151	401.6		MYSL 221 x PS 66	143.65**	MYSL 20/YP x YST 151	180.19**
Length of siliqua (cm)	YSC 35	YSC 99 x YST 151	7.5	-45.04 to 18.03	MYSL 221 x RAUDYS 9708	18.03**	YSC 99 x YST 151	35.80**
	YSPB 24	YSC 35 x YST 151	7.4		MYSL 20/YPxRAUDYS 9708	10.70**	YSC 35 x YST 151	32.91**
	PS 66	YSB 2001 x YST 151	7.3		YSC 35 x YST 151	7.09**	YSB 2001 x YST 151	32.73**
Seeds/siliqua	MYSL 20/YP	YSC 35 x YST 151	27.5	-60.85 to 21.11	YSC 35 x YST 151	21.11**	YSC 35 x YST 151	26.28**
	YSPB 24	YSC 99 x GS 1	26.8		YSC 99 x GS 1	13.88**	YSC 99 x GS 1	22.94**
	PS 66	YSB 2001 x GS 1	25.7		YSB 2001 x GS 11	12.79**	YSB 2001 x GS 1	17.98**
1000-seed weight (g)	GS 1	PROYS 9805 x GS 1	5.8	-12.78 to 23.13	MYSL 221 x PS 66	23.13**	PROYS 9805 x GS 1	13.87**
	YSB 2001	PYS 9804 x GS 1	5.8		PYS 9804 x PS 66	21.90**	PYS 9804 x GS 1	13.09**
	YSPB 24	MYSL 221 x PS 66	5.8		MYSL 20/YP x PS 66	16.74**	MYSL 221 x PS 66	12.30**
Oil content (%)	MYSL 20/YP	YSC 35 x GS 1	43.6	-8.77 to 3.63	YSC 35 x YST 151	3.63**	YSC 35 x GS 1	2.59*
	PROYS 9805	MYSL 20/YP x YST 151	43.2		YSPB 24 x YST 151	3.54**	-	-
	GS 1	MYSL 20/YP x PS 66	43.2		YSC 35 x PS 66	2.97*	-	-
Harvest index (%)	GS 1	MYSL 221 x GS 1	30.7	-46.96 to 34.46	YSB 2001 x PS 66	34.46**	-	-
	PROYS 9805	YSB 2001 x PS 66	30.7		SSK 9215 x PS 66	31.83**	-	-
	RS 1	YSPB 24 x GS 1	30.4		YSC 35 x YST 151	21.41**	-	-
Seed yield/ plant (g)	GS 1	YSC 99 x RAUDYS 9708	29.5	-62.84 to 97.18	MYSL 20/YP x PS 66	97.18**	YSC 99 x RAUDYS 9708	60.22**
	PROYS 9805	MYSL 221 x PS 66	23.5		YSC 99 x RAUDYS 9708	51.35**	MYSL 221 x PS 66	27.88*
	RS 1	SSK 9215 x RAUDYS 9708	23.4		YSB 2001 x PS 66	42.12**	SSK 9215 x RAUDYS 9708	27.12*

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Short communication

Genetic diversity analysis of advance breeding lines of Indian mustard, *Brassica juncea* (L.) Czern & Coss

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Indian mustard (*Brassica juncea* L.) is the pre-dominant crop occupying nearly 80% of the rapeseed-mustard cropped area in the country. Hence, increasing yield potential of the crop is imperative to enhance oilseed production. Knowledge of genetic diversity is essential for choosing parents for utilization in the breeding programmes. Mahalanobis D^2 statistics (1936), made it possible to quantify the degree of genetic divergence amongst biological population and assessing relative contribution of various component characters to the total divergence. Utilization of divergent genotypes in breeding programme is the key to success in evolving pure line varieties or developing heterotic gene pool. In the present study, attempts have been made to assess genetic divergence developing among advanced breeding lines and varieties of Indian mustard.

The experimental material included 21 advanced breeding lines and four varieties, Varuna, Bio 902, Kranti and Rajat of Indian mustard. The 21 breeding lines were derived from nine crosses *viz.*, TERI (OE) M-08 x Bio-902 (BPR-2), TERI (OE) M-21 x Varuna (BPR-6), Shiva x Varuna (BPR-62), Pusa Basant x RLM-514 (BPR-83), (Pusa Bold x RLM-514) x Shiva (BPR-87), (RH-30 x PCR-3) x Shiva (BPR-95), RH-819 x PCR-3 (BPR-96), RL-1359 x PCR-3 (BPR-104) and YSRL-9 x PCR-3 (BPR-106). The experimental materials were sown in Randomized Complete Block Design with three replications during 2001-02 and 2002-03 in *rabi* season. Each genotype was sown in five rows/plot and each row was 5 m long, spaced 30 cm apart, 10-15 cm plant-to-plant distance was maintained within a row by thinning. 40 kg N and 40 kg P_2O_5/ha applied at the time of sowing and the rest of 40 kg N applied after first irrigation. Two irrigations were given at 40 and 78 days after the slowing. Observations were recorded on five competitive randomly taken plants from each genotype in each replication on various traits. The genetic divergence was estimated using Mahalanobis D^2 statistics followed by Rao's (1952) clustering pattern.

The analysis of variance indicated significant differences among genotypes for all the characters except primary branches/plant, siliquae on main shoot, siliqua length and biological yield/plant. Therefore, these four characters were excluded from further analysis. Highly significant differences among the genotypes for eight characters (χ^2 = 706.52 at 192 df) were observed by the analysis using 'V' statistics of dispersion for the test of significance of differences in mean values based on Wilk's criterion. On the basis of D^2 values, the 25 genotypes were grouped into five clusters. Cluster I contained maximum number of genotypes (20) followed by cluster III (BPR 6-1-24-4, BPR-6-166-24-12). Only single genotype each appeared in cluster II (BPR-87), IV (BPR-6-91-53-4) and V (BPR-6-91-46), indicating their uniqueness from breeding point of view.

Minimum inter cluster distance was observed between cluster II and IV whereas, cluster II and III had the maximum genetic divergence (Table 1). The genetic distance indicated diversity between the clusters (Ghosh and Gulati, 2002). Intra-cluster divergence was higher in cluster I than cluster III. It was interesting to note that the breeding lines derived from the same cross grouped in different clusters, whereas those from different crosses (BPR-2, BPR-6, BPR-62, BPR-83, BPR-95, BPR-96, BPR-104 and BPR-106) were grouped together. This could be due to different selection pressure exerted in the segregating generation for specific trait(s). The genotypes belonging to the clusters separated by high estimated distances could be utilized in hybridization programme for obtaining wide variation among the segregating generation.

The major contributor to genetic divergence was 1000-seed weight (25%) followed by oil content (23.7%). Harvest index and secondary branches/plant had the least contribution to total divergence (Table 2). In earlier studies, maximum contributor to divergence was days to maturity (47.1%) followed by plant height (10%), while oil content showed least contribution (3.3%) (Ghosh, 2002). IN the advance breeding lines in the present study, the oil content was one of the major selection criteria, hence, the lines were distinctly different for this character. Cluster means had wide range of variation for plant height, main shoot length and harvest index. Cluster V (BPR-6-91-46) recorded maximum mean values for secondary branches/plant, main shoot length, seeds/siliqua and seed yield/plant.

Table 1 Intra and inter-cluster distance (D^2 values) of the five clusters

Cluster	Cluster distance				
	I	II	III	IV	V
I	3.0	3.6	3.9	3.8	4.2
II		0.0	5.5	3.4	5.0
III			2.2	4.4	4.5
IV				0.0	4.3
V					0.0

I = BPR-96-3, BPR-2-1, Varuna, BPR-96-1, Rajat, Bio-902, Kranti, PCR-18, BPR-6-91-36, BPR-95, BPR-96-2, BPR-6-91-52-3, BPR-104, BPR-6-65-3, BPR-6-91-6-6, BPR-6-91-21-1, BPR-61-91-34-2, BPR-106-1, BPR-83, BPR-62-1
II = BPR-87
III = BPR-6-1-6-24-4, BPR-6-166-24-1
IV = BPR-6-91-53-4
V = BPR-6-91-46

Table 2 Cluster means and contribution of different characters towards total divergence

Character	Cluster means					Contribution to diversity (%)
	I	II	III	IV	V	
Plant height (cm)	178.9	179.8	183.6	143.7	168.9	10.0
Secondary branches/plant	5.1	4.5	8.6	5.8	9.8	4.0
Main shoot length (cm)	69.6	67.1	63.3	50.3	74.8	18.3
Seeds/siliqua	13.7	13.1	14.8	13.9	15.1	6.3
1000-seed weight (g)	5.9	4.8	5.2	5.2	5.3	25.0
Oil content (%)	41.1	43.7	37.9	41.3	40.7	23.7
Seed yield/plant (g)	10.6	8.4	12.0	9.6	20.1	10.0
Harvest index (%)	27.3	24.7	26.2	30.3	27.7	2.7

The mean values of 1000-seed weight and oil content were high in cluster I and II, respectively, while, cluster IV had high mean value for harvest index and also showed low mean values for plant height (Table 2). This indicated that all the desirable characters were not found in a single cluster, which could be directly selected and utilized. Thus, recombination breeding among genotypes of different clusters has been suggested by Ghosh (2002) and Patel and Patel (2006). Cluster II and III showed maximum inter-cluster distance and cluster V had high mean values for secondary branches/plant, main shoot length, seeds/siliqua and seed yield/plant. Therefore, on the basis of D^2 value and high mean values it is suggested that hybridization between the genotypes of cluster II, III and V would produce wide array of variability in the segregating generation and useful in making the new gene pool for selection.

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Short communication

Heterosis for seed yield and its components in sunflower, *Helianthus annuus* L.

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Sunflower (*Helianthus annuus* L.) is one of the important oilseed crops of major economic importance. Due to its cross pollinated nature, it offers considerable scope for commercial exploitation of heterosis utilizing cyto-restorer system (Madrap and Makane,1993; Sugoor *et al.*, 1996; Gangappa *et al.*, 1997). The present attempt has been taken to study heterosis for seed yield, oil content and the yield components in sunflower.

Four cytoplasmic genetic male sterile (CMS) lines *viz.*, CMS-17A, CMS-107A, CMS-234A, CMS-336A were crossed with 10 males *viz.*, RRI, MRI, HAR-3, PISF-110-8, IB-19, HAM-183, ND(NB)-7, R-1381-7 RHA-272 and RHA-856. Crosses were made in a line x tester fashion (Kempthorne, 1957) to synthesize 40 hybrids. The parents and hybrids along with check (MSFH-17) were grown in a Randomized Block Design with three replications. The experiment was conducted at Mahatma Phule Agricultural University, Rahuri. Crossing was carried out during *rabi*, 2002 and the evaluation of the crosses and their parents was done during *rabi*, 2003. Each entry was grown in two rows of 6 m length with a spacing of 60 cm and 30 cm between rows and plants. Recommended agronomic practices were followed to raise the crop. Data for morphological characters was recorded on five randomly selected competitive plants. Oil content was estimated by wide line NMR. Heterosis was calculated over better parent (BP) and standard check (MSFH-17) for seed yield, yield components and oil content.

The analysis of variance revealed highly significant in parents as well as hybrids for all the traits. In contrast the parameters and hybrids showed the presence of dominance for all the traits except harvest index.

The experimental results (of the parent study) indicated the presence of significant amount of heterosis for the traits under the consideration. For seed yield/plant, 29 hybrids showed significantly positive heterosis varying from -45.60 % to 156.24 % over better parent and the four hybrids showed superiority over standard check for seed yield. Thirty seven hybrids exhibited significant positive heterosis over the better parents thereby expressing over dominance for the character, the extreme of heterosis over better parent and standard check for oil content was ranged from -47.16 to 32.72 % (Table1). Large number of crosses showed significant amount of heterosis for other characters also (Table1) which can be further exploited in sunflower breeding. The hybrid 17A x HAM-183 gave maximum heterosis over better parent (156.24%) and standard check (38.82 %) for seed yield. Hybrid 234 A x R-1381-7 displayed significant positive heterosis over standard check MSFH-17 (120.89 %) for harvest index (Table 2). The hybrid 336 A x HAM -183 exhibited maximum heterosis for oil content (32.72%). The hybrid 17 A x RRI-I also exhibited maximum heterosis for oil content 22.5%.

Table 1 Heterosis for different characters in sunflower

Character	Range of heterosis in percentage		No. of hybrids superior on the basis	
	BP	SC (MSFH-17)	BP	SC (MSFH-17)
Days to 50 % flowering	-8.20 to 39.62	-58.91 to 38.82	2	6
Days to maturity	-2.30 to 10.84	-4.55 to 4.59	1	1
Plant height (cm)	8.45 to 175.19	-40.82 to 7.64	33	1
Stem girth at base (cm)	-2.49 to 54.72	-16.31 to 21.18	12	1
Circumference of head (cm)	-7.75 to 67.89	-22.72 to 10.98	6	1
Total number of seed/head	-18.60 to 157.67	-61.23 to 49.28	23	5
Number of filled seed/head	-58.06 to 186.46	-89.67 to 42.79	22	2
Hundred seed weight (g)	-40.06 to 27.08	-44.29 to 29.26	4	2
Harvest index	-82.97 to 141.26	-80.33 to 120.79	4	3
Per cent oil content	-47.16 to 32.72	-41.72 to 33.00	9	10
Seed yield/plant (g)	-45.60 to 156.24	-71.38 to 28.73	21	1

Table 2 Heterosis (%) over standard check (MSFH-17) of best seven crosses selected for seed yield along with their data values

Name of cross	Seed yield (g)	Days to 50% flowering	Days to maturity	Plant Height (cm)	Stem girth at base (cm)	Circum-ference of head (cm)	Total number of seed/ head	Number of filled seed/ head	100 seed weight (g)	Harvest index	Per cent oil content
107A x RRI	36.77**	5.17**	-1.14	-2.04	0.61	6.49	-30.54**	54.27**	-4.54	12.89	-10.39
17 A x HAM-183	28.73**	4.02*	0.76	-8.43	-3.44	-5.19	49.28**	42.79**	0.94	3.11	-17.92**
107A x IB-19	7.15	3.45	-2.27	-0.09	9.73	-2.40	13.21**	-10.38*	14.40	-9.33	-3.92
234A x R-1381-7	4.67	-2.31	-3.41	-0.07	-0.17	-7.14	5.67	60.49**	-26.13**	120.89*	6.42**
234A x IB-19	2.64	5.74**	-2.27	-6.52	-2.63	7.14	-7.65	22.76	5.01	-21.78*	.3**
17A x RRI-1	105.69	5.17	3.14	29.52**	3.20	27.27**	87.77**	97.54**	-20.80	62.60**	22.50**
336A x HAM 183	51.53	8.62*	2.33	30.33*	19.79	-2.87	1.01	-19.05**	-25.27	-3.79**	32.72

*, ** indicate significance at P = 0.05 and P = 0.01 levels, respectively.

The results in general are in agreement with those of earlier workers (Chidambaram and Sundaram, 1990; Giriraj and Virupakshappa, 1992; Dedio, 1993). The best crosses involving 234A female parent performed better for days to 50% flowering, days to maturity, circumference of head, total number of seed/head, number of filled seed/head, 100 seed weight, harvest index and per cent oil content. The CMS 17A was good combiner for days to 50% flowering, number of filled seed/head, and seed yield/plant. The crosses involving male parents HAM-183 showed good performance. Among the top yielding hybrid (Table 2), the hybrid 17A x HAM-183 showed highest heterosis over the check MSFH-17, total number of seeds/head, number of filled seeds/head and seed yield/plant.

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Short communication

Combining ability studies of few male sterile lines and restorers in sunflower, *Helianthus annuus* L.

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The proper choice of parents on the basis of genetic information and methodology that will exploit and make use of nature of gene action is prerequisite in heterosis breeding. Present study was therefore, undertaken to understand nature and magnitude of gene action and combining ability of male sterile lines and restorers of sunflower. Four male sterile lines *viz.*, CMS-17A, CMS-107A, CMS-234A, CMS-336A and ten restorers *viz.*, RRI, MRI, HAR-3, PISF-110-8, IB-19, HAM-183, ND(NB)-7, R-1381-7 RHA-272 and RHA-856 were evaluated in three replications during *rabi*, 2002. Each plot consisted two rows of 6 m length with 60 cm x 30 cm spacing. Observations were recorded on five randomly selected competitive plant in each plot. Data was analysed according to method suggested by Kempthorne (1957).

Table 1 Estimates of general combining ability effects for different character in sunflower

Parent	Seed yield /plant (g)	Days to 50% flowering	Days to maturity	Plant height (cm)	Stem girth (cm)	Circum-ference of head (cm)	Total seed /head	No. of filled seed/head	100 seed weight (g)	Harvest index	Per cent oil content
Female											
17A	4.2**	2.53**	0.025	3.00	-0.19	0.27	176.69**	156.03**	0.10	-0.15**	-4.07**
107A	-6.66**	-3.67**	-0.14	2.28	0.11	0.39	-192.08**	-114.74**	0.34**	-0.10	0.40*
234A	10.01**	-5.47**	-1.28**	-2.09	0.03	0.83**	108.33**	61.56**	0.47**	0.44**	5.94**
336A	-7.59**	6.60**	1.392**	-3.19	0.06	-1.48**	-90.94	-102.85**	-0.90**	-0.19**	-2.22**
SE (gi)	0.847	0.238	0.500	2.616	0.183	0.345	16.148	11.878	0.122	0.056	0.199
SE (gi-gj)	1.198	0.336	0.707	3.699	0.259	0.487	22.837	16.79	0.173	0.079	0.282
Male											
RRI	-1.21	0.77*	0.54	4.62	-0.33	0.25	-19.51*	-109.35**	-0.31	0.19*	4.59**
MRI	0.51	0.60	0.54	6.85	-0.32	-0.76	36.24	47.81**	-0.24	-0.13	-3.40**
HAR-5	-12.91**	0.27	-0.88	-10.53*	-0.11	0.85	-66.01*	-210.52**	-0.39*	-0.45**	0.14
PISF-110-8	-8.03**	0.93*	0.88	-9.46*	-0.55	-0.69	20.24	111.48**	-0.45*	-0.05	2.27**
IB-19	4.79**	3.18**	0.88	-0.36	0.44	0.96	-85.0**	83.60**	0.99**	0.23*	3.01**
HAM-183	15.84**	-1.66**	-0.63	-1.94	-0.12	0.23	60.74**	275.73**	-0.63**	0.49**	-1.51**
ND (NB)-7	-7.36**	0.82*	0.54	-2.22	-0.36	0.05	-370.26**	275.35**	0.97**	-0.17	-0.325
R-1381-7	3.12*	-1.23**	-1.63*	-2.44	-0.07	-0.69	147.16**	-5.77	-0.21	0.64**	2.22**
RHA-272	3.08*	-1.23**	-0.30	10.60*	1.07**	0.30	72.83**	-25.35	0.16	-0.06	-2.19
RHA-856	2.16	-0.82*	0.04	4.93	0.35	-0.49	3.58	107.73**	0.10	-0.24**	1.37**
SE (gi)	1.339	0.376	0.791	4.136	0.289	0.545	25.532	18.780	0.193	0.088	0.315
SE (gi-gj)	1.893	0.531	1.118	5.849	0.409	0.770	36.108	26.559	0.273	0.125	0.446

The analysis of variance indicated significant variation for all the characters studied. In analysis of combining ability, the variance were significant for days to 50% flowering, plant height at maturity, circumference of head, number of filled seed/head, 100 seed weight, harvest index and per cent oil content in female parent and for all the characters in male indicated presence of enough diversity in male parent. The variances due to SCA were higher than GCA for all the characters under study. This indicated that predominance of non-additive genetic action for all the characters. Similar results have been reported by Rudranaik *et al.* (1990) and Kshirsagar *et al.* (1993) for seed yield and its components. The *gca* effect of parents revealed that the female line 234A showed significant effect for seed yield, days to 50% flowering, days to maturity, circumference of head, total number of seeds/head, number of filled seeds/head, 100 seed weight, harvest index and percent oil content thus found best general combiner for these characters.

Amongst the males none showed consistent *gca* effects for seed yield and its important component. The estimates of *sca* effects showed that combinations 107A x IB-19 336A x N.D (NB)-7, 17A x HAM-183 and 17A x RR-I exhibited significant *sca* effects for seed yield and its components. These combinations involved at least one parent as good general combiner and other average to low general combiner as also observed by Vanishree *et al.* (1988).

The overall study indicated that the genetic improvement in sunflower could be achieved through development of hybrids, biparental mating followed by recurrent selection and development of synthetic varieties.

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Short communication

Component analysis in niger, *Guizotia abyssinica* (L.f.) Cass

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Niger, *Guizotia abyssinica* (L.f) Cass is a minor oilseed crop grown mostly in India and Ethiopia. India is a major country producing the niger in the world. Niger is a crop having 100% cross pollination with presence of protrandrous sporophytic self incompatibility mechanism, which results in poor seed yield of niger. Thus, the present investigation on character relationship for utilization in future breeding programme of niger.

Sixty seven elite genotypes of niger were grown in Randomized Block Design with three replications during *kharif* 2003-04. Each genotype has four rows of 5m length. Inter and intra row spacing of 30 x 10 cm were followed apart. Recommended practices were adopted. The observations were recorded on ten randomly selected plants for six yield attributes and seed yield. Heritability and other parameters were estimated following Burton and De vane (1953). Correlations were worked at genotypic and phenotypic levels following Robinson *et al.* (1951). Path coefficient analysis was computed as per Dewey and Lu (1959).

Significant differences among the genotypes indicated that presence of substantial variability for all characters. A wide range of variability was observed for all characters. Genotypic coefficient of variation was more or less equal to phenotypic coefficient of variation. High to moderate heritability estimates were observed mostly for all characters. No linear relationship among genotypic coefficient of variation, heritability and genetic advance was noticed. But, high heritability coupled with high genetic advance as percentage of mean (GA) was observed for seed yield (88.7% and 97.68%), branches/plant (74.6% and 48.85%), seeds/capsule (96.8% and 83.69%) and capsules/plant (84.9% and 55.29%), respectively, indicating important role of additive gene action in the inheritance of these characters. High heritability coupled with low GA was observed for days to flower (93.5% and 18.45%), days to maturity (94.2% and 11.78%), respectively, suggesting prominent role of non-additive gene action for these traits in the inheritance. A low heritability with low GA was observed for plant height (47.8% and 54.84%), suggesting that environment had a major role in its expression.

Genotypic correlations were higher in magnitude than their respective phenotypic correlations (Table 1) indicating that selection for correlated characters could give a better response that would be expected on the basis of phenotypic correlations. Thus, the present results are in general agreement with Sahu and Patnaik (1981), Goyal and Kumar (1985), Chennarayappa (1987), Mathur and Gupta (1993), Borole and Patil (1977), Patil (2003), Patil and Duhoon (2005) and Sreedhar *et al.* (2005). Seed yield was found to be significantly and positively correlated with seeds/capsule, capsules/plant, branches/plant and plant height. Whereas, it was negatively correlated with days to flower and days to maturity. Eleven out of 21 genotypes and phenotypic correlations among seven characters, respectively were significant in positive direction. A genotypic as well as phenotypic correlation among branches/plant, capsules/plant, seeds/capsule and their positive association with seed yield was observed indicating that these are the major yield contributing characters in niger. A selection for these characters would possibly be helpful in getting a quantum jump in yield increase of this crop.

Path coefficient analysis based on genotypic and phenotypic correlations revealed almost same pattern of direct and indirect influence of different characters on seed yield. Thus, the results based on genotypic correlations only are discussed (Table 2). Plant height had large and positive direct effect on seed yield followed by branches/plant, capsules/plant, seeds/capsule and days to maturity. Whereas days to flower had high and negative direct effect on seed yield. The large direct effect of days to flower which has no direct bearing on seed yield and thus, it is very difficult to explain. However, it was also reported by Sahu and Patnaik (1981). The branches/plant had high direct effect in positive direction and it had positive indirect effects via days to maturity and seeds/capsule. The capsules/plant had also positive high direct effect on seed yield and positive indirect effects via days to maturity, branches/plant and seeds/capsule. Seeds/capsule had also high direct and indirect effect on seed yield and positive indirect effects via plant height, days to maturity, branches/plant and capsules/plant.

Thus, for improving the seed yield and developing the high

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yielding genotypes of niger due emphasis should be placed on branches/plant, capsules/plant and seeds/capsule. As all these traits had high heritability coupled with high to moderate genetic advance, it may be possible to have a rapid gain by mass selection. Since late flowering and maturity beyond certain limit*is not desirable, greater emphasis should be laid on earl flowering and** early maturing genotypes as both the characters show significant and negative correlation with seed yield.

Table 1. Estimates of genotypic (above diagonal) and phenotypic (below diagonal) associations in niger

Character	Plant height (cm)	Days to flower	Days to maturity	Branches/ plant	Capsules/ plant	Seeds/ capsule	Seed yield
Plant height (cm)	-	-0.122	0.058	0.673	0.892**	0.341	0.712**
Days to flower	0.118	-	0.921**	0.108	0.042	0.363	-0.245
Days to maturity	0.054	0.925**	-	0.221	0.214	0.405*	-0.366
Branches/plant	0.590*	0.092	0.189	-	0.837**	0.418*	0.490*
Capsules/plant	0.821**	0.022	0.178	0.707**	-	0.438*	0.719**
Seeds/capsule	0.331	0.345	0.385*	0.339	0.400*	-	0.816**
Seed yield	0.672*	-0.219	-0.331	0.427*	0.655*	0.757**	-

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

Table 2. Estimates of direct (diagonal) and indirect effects of component traits towards yield in niger

Character	*Direct and indirect effects*						Genotypic correlation with yield
	Plant height (cm)	Days to flower	Days to maturity	Branches/ plant	Capsules/ plant	Seeds/ capsule	
Plant height (cm)	0.427	-0.281	-0.247	0.287	0.381	0.146	0.712**
Days to flower	-0.1140	-0.383	0.176	0.039	0.003	0.030	-0.245
Days to maturity	0.001	-0.213	0.114	-0.136	-0.138	0.006	-0.366
Branches/plant	-0.084	-0.043	0.087	0.397	-0.033	0.166	0.490*
Capsules/plant	-0.146	-0.101	0.083	0.325	0.388	0.170	0.719**
Seeds/capsule	0.115	-0.229	0.226	0.234	0.240	0.230	0.816**

Residual effect : 0.269; *, ** Significant at 5% and 1%, respectively.

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Short communication

Partitioning of drymatter and yield of rainfed groundnut, *Arachis hypogaea* L. under different dates of sowing

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Groundnut (*Arachis hypogaea* L.) is the major crop of Gujarat mostly grown in Kharif season in about 20 lakh hectares and most of the area is confined to Saurashtra region. The spreading and semi-spreading varieties of the crop are comparatively high yielders but take 130-150 days to mature, unlike the bunch varieties (100-120 days). Rainfed groundnut is sown on varied dates in *kharif* season depending on the onset of monsoon. Under normal arrival of monsoon, the crop is sown in the 3rd week of June, but with subsequent delay farmers prefer cultivation of bunch groundnut instead of spreading and semi-spreading types. The studies on physiological variations under varied sowing dates are meager. Partitioning of photo assimilates to pods during pod filling stage is the major physiological determinant of yield in groundnut. Hence, this study was planned to observe the performance of bunch groundnut varieties under early, timely and late sown conditions and to assess the physiological basis of differential yield response in terms of drymatter partitioning to pods.

A field experiment was conducted during rainy season of the years 2002, 2003 and 2004 at Main Oilseeds Research Station, Junagadh, Junagadh Agricultural University. The soil was medium black, calcareous, clay loam in texture and medium in fertility. The experiment was laid out in Split Plot Design with four replications. The treatments comprised of three dates of sowing *viz*, D_1-early (June 1-5), D_2-Normal (June 10-15) and D_3-late (July 10-15) in main plots and five varieties of bunch groundnut *viz.*, GG-2, GG-4, GG-5, GG-6 and GG-7, in sub-plots. Each plot consisted of 6 rows of 5 m length and the rows were spaced 45 cm apart with a plant to plant spacing of 10 cm. Uniform basal doses of 12.5 and 50 kg of N and P_2O_5 respectively were applied at sowing in the form of urea and single super phosphate. Other recommended packages of practices were followed. Plant samples were taken at pod formation and harvest corresponding to 70th and 98th day after sowing (pod development phase). 10 plants from each replication were taken as samples, dried at 70°C and for 48 hrs. to obtain uniform dry weight and partitioning of drymatter to pods during pod development phase was computed as shown below:

$$P\,(2\text{-}1) = \frac{\text{Drymatter pods }(2\text{-}1)}{\text{Drymatter entire plant }(2\text{-}1)} \times 100$$

Where, P= Partitioning factor

1 and 2 = sampling at 70 and 98 DAS (pod initiation and at harvest respectively)

At harvest, data on pod yield, haulm yield and biological yield as well as plant height were recorded.

The analysis of variance showed non-significant differences among different dates of sowing for pod yield in the results pooled across the three years of investigation. However, significant treatment differences were observed in individual years with respect to pod yield (Table 1). During the year 2002, maximum pod yield was recorded in early-sown crop (2639 kg/ha) which was significantly higher than the late-sown crop (1107 kg/ha), but it recorded on par yield with normal sown crop (D_2-2487 kg/ha). In 2003, normal-sown crop (D_2) recorded maximum pod yield; D_1 and D_3 were at par, whereas in 2004, again early-sown crop recorded maximum pod yield followed by normal and late-sown crop. Mean pod yield of *kharif* groundnut crop sown in the 3rd week of June was reported to be higher than the crop sown in 1st and 3rd weeks of July by Sandhu and Hundal (1993) and Mishra (1996). In the present study, the magnitude of pod yield in the year 2002 was the highest. This could be ascribed to the even distribution of the rainfall during that particular year in comparison to the years 2003 and 2004, when, despite greater amount of the rainfall, the distribution was uneven. For instance, the crop received 1025 mm of rainfall during the year 2004, however, the late rain in the month of September resulted in *in situ* germination of the crop, which was translated in the poor pod yield.

The highest haulm yield was observed in early-sown crop followed by normal and late-sown crop during individual years and in pooled analysis (Table 1). The same was the trend for total biomass production. There was drastic reduction in biological yield of late-sown crop which may be due to the fact that haulm yield registered severe reduction. Also there was successive and significant reduction in plant height from early to late-sown crop as observed in individual years and in pooled data (Table 2).

All the treatments- D_1, D_2 and D_3 were at par with each other with respect to dry matter partitioning to pods during pod development phase (Table 2) as seen in the pooled data across the years. The early sowing enabled the crop to have optimum growing period and to express its inherent potential to the maximum. That could be the reason that despite lesser allocation of drymatter to pods in early-sown crop, increased pod yield was observed. Maximum dry matter partitioning was observed in the late-sown crop. This is contradictory to the results obtained by Ntare *et al.* (1998) who observed decrease in translocation of assimilates in late-sown groundnut. An inverse relationship between haulm yield and partitioning percent could be discerned here. The highest haulm yield and the lowest partitioning percent to pods were observed under early-sown crop. (Tables 1 and 2).

Table 1 Effect of date of sowing on pod, haulm and biological yield of groundnut cultivars

Date of sowing	Pod yield (kg/ha)				Haulm yield (kg/ha)				Biological yield (kg/ha)
	2002	2003	2004	Pooled	2002	2003	2004	Pooled	Pooled
D_1- June(1-5)	2639	1679	1671	1996	3547	4618	3507	3891	5887
D_2- June(10-15)	2487	2217	1168	1957	3339	3958	2199	3166	5123
D_3- July(10-15)	1107	1952	690	1250	1823	3032	1823	2226	3476
SEm.±	51.9	90.0	44.1	287.4	81.9	72.2	67.5	187.9	409.9
CD (P=0.05)	179.8	311.4	152.8	NS	283.2	249.7	233.7	737.8	1609.2
CV (%)	11.2	20.7	16.8	16.8	12.6	8.3	12.0	10.7	11.3
Varieties									
GG 2	2021	1880	1027	1642	2889	3954	2411	3085	4727
GG 4	1947	1843	1050	1613	2816	3733	2440	2996	4610
GG 5	2184	1982	1278	1815	2990	3868	2623	3160	4975
GG 6	2099	1955	1169	1741	2783	3858	2344	2995	4736
GG 7	2138	2086	1358	1861	3038	3935	2730	3234	5095
SEm.±	53.0	72.4	38.5	32.6	84.1	68.2	84.8	46.0	60.9
CD (P=0.05)	152.1	NS	110.5	91.3	NS	NS	243.4	128.7	171.0
CV (%)	8.8	12.9	11.3	11.3	10.0	6.1	11.7	8.9	7.6
Interaction									
D x V : SEm. ±	91.8	125.5	66.7	76.9	145.7	118.1	146.9	138.4	105.6
CD (P=0.05)	NS	360.0	NS	NS	418.2	339.0	NS	NS	296.2
Y x D : SEm. ±				65.2				74.1	122.1
CD (P=0.05)				193.7				220.1	362.9
Y x V : SEm. ±				56.4				79.4	105.6
CD (P=0.05)				NS				NS	NS
Y x D x V : .Em. +				97.7				138.0	183.0
CD (P=0.05)				274.0				386.0	NS

Presumably D_1 favored greater partitioning of dry matter to vegetative parts instead of to pods. While in case of late-sown crop, there was remarkable suppression of vegetative growth, but increased translocation of photosynthates in response to the greater sink demand. Murthy *et al.* (2002) had also observed higher partitioning of dry matter in late-sown crop than in early-sown crop. Besides, the decreased plant height (Table 2) registered under the delayed sowing conditions might have facilitated the increased translocation of assimilates, because, *preferential sinks (pods) are not distant from source* (functional leaves), thus making translocation path shorter. It appears that, due to greater allocation of dry matter to pods during pod development phase, the late-sown crop could exhibit parity in pod yield with early and timely sown crop. Several studies (Vithlapura and Mandavia; 1991 and Kataria and Pandya, 1995) have indicated that in groundnut, yield difference depended on the relative partitioning of recent assimilates between vegetative parts and pods during pod development phase.

Table 2 Effect of date of sowing on partitioning of drymatter and plant height of groundnut cultivars

Date of sowing	Partitioning (%)	Plant Height (cm)
D_1-June(1-5)	56.7	47.9
D_2-June(10-15)	59.7	42.2
D_3-July(10-15)	67.1	30.1
SEm±	3.7	2.6
CD (P=0.05)	NS	10.1
CV (%)	17.6	6.9
Varieties		
GG 2	57.5	37.6
GG 4	61.1	40.4
GG 5	66.1	40.9
GG 6	58.1	39.7
GG 7	63.1	41.7
SEm±	1.8	0.7
CD (P=0.05)	5.0	2.3
CV (%)	17.6	6.2
Interaction		
D x V : SEm±	4.7	0.7
CD (P=0.05)	NS	NS
Y x D : SEm±	2.4	0.6
CD (P=0.05)	7.2	1.8
Y x V : SEm±	3.1	0.7
CD (P=0.05)	NS	2.0
Y x D x V : SEm±	5.4	1.2
CD (P=0.05)	15.1	NS

The varietal differences were significant with respect to pod yield during 2002, 2004 and in the pooled analysis (Table 1). However, they were statistically non-significant during the year 2003. Cultivar GG 7 was the best and GG-5 was at par with it. The same trend was observed with respect to haulm and biological yield, that is, cultivar GG 7 and GG 5 fared better than the other cultivars, for they recorded significant increase in these characters. There was no substantial difference in the performance of the remaining three varieties, *viz.* GG-2, GG-4 and GG-6 when these characters were considered. It seems that GG 7 and GG 5 got the advantage of their status of improved varieties, over and above the fact that there was better partitioning of photosynthates to both varieties, which might have increased their yields. The maximum increase in plant height was also exhibited by GG-7; however, GG-4, GG-5 and GG-6 were statistically at par with GG-7. Cultivar GG-2 was the one with the lowest height.

The interaction between dates of sowing and varieties was non-significant with respect to pod yield, haulm yield, partitioning percent and plant height. Nevertheless, biological yield displayed significant interaction between date of sowing and varieties implying that cultivar GG-7 recorded maximum biological yield when sown during the first date of sowing, i.e., between June 1-5. The interaction effects between dates of sowing and years of investigation; as well as between varieties and years of investigation were non-significant in case of all the parameters/traits studied pointing at the reliability of the investigation.

Summarizing the results, it can be inferred that the present investigation substantiates and provide scientific explanation to the farmers' practice of sowing bunch groundnut varieties instead of spreading varieties when monsoon is delayed in Saurashtra. The results demonstrated that under delayed sowing conditions, the rate of partitioning of drymatter to pods during pod filling phase was superior to pods; and this was at the expense of vegetative growth. Such practice, in fact, increases the sustainability of rainfed bunch groundnut crop production.

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Short communication

Production potential of *rabi* groundnut, *Arachis hypogaea* L. in relation to plant density and genotypes

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Groundnut is the principal oilseed crop in India and is grown over an area of 6.86 m.ha witn a production of 5.31 mt. Groundnut variety, TMV-2 bunch is raised at a plant density of 4.44 lakh plants/ha during *rabi* season under irrigated conditions. Besides TMV-2, TPT-2, K-134 and TAG-24 are also under cultivation.

Plant population per unit area was found to be directly correlated with pod yield upto certain point in groundnut crop. Sub optimal plant stand in groundnut fields has been identified as one of the major bottleneck to realize full production potential. Information is lacking about the effect of plant density on bunch groundnut varieties for southern Telangana region of Andhra Pradesh. Hence, an experiment was conducted during 2001-02 at the College Farm of Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad to find out a suitable groundnut variety and optimum plant density for *rabi* groundnut under irrigated conditions for southern Telangana region of Andhra Pradesh.

The soil was sandy loam in texture slightly alkaline in reaction (pH 6.5), low in available N (272 kg/ha) and medium in phosphorus (18.4 kg/ha) and potassium (170 kg/ha). The experiment was laid out in a Factorial Randomized Block Design. The crop was shown on 6th November with a fertilizer dose of 30-40-40 N, P and K/ha. The crop was raised under irrigated conditions. The crop was sown at 30 x 10, 22.5 x 10 and 15 x 10 cm spacings to obtain plant density of 3.3, 4.4 and 6.6 lakhs plants/ha, respectively.

The results indicated that maximum flower to peg percentage was obtained with TPT-2 followed by K-134, TMV-2 and TAG-24 (Table 1). The peg to pod percentage of TMV-2 and TPT was comparable and both were superior to TAG-24 and K-134. Maximum and minimum pod set percentage was obtained with K-134 and TAG-24, respectively. The pod set percentage between TMV-2 and TPT-2 did not vary significantly. Flower to peg and peg to pod percentages obtained with plant density of 3.33 and 4.44 lakh plants/ha was on par and both were significantly superior to 6.67 lakh plants/ha, whereas maximum pod set percentage of 39.9 was obtained with a plant density of 3.33 lakh plants/ha. The pod set percentage between 4.44 and 6.67 lakh plants/ha was not significant.

Maximum number of pegs per plant was obtained in K-134 followed by TMV-2, TAG-24 and TPT-2, whereas total pods/plant and filled pods/plant were significantly higher with K-134 compared to rest of the varieties. TMV-2 and TPT-2 were on par with regard to total and filled pods/plant but were superior to TAG-24. Higher number of total and filled pods in K-134 was due to production of more pegs/plant. Though the pegs/plant in TPT-2 were lower compared to TAG-24, it produced more total and filled pods/plant due to more peg to pod percentage and pod set percentage. Pegs/plant, total pods/plant and filled pods/plant decreased significantly with increase in plant density from 3.33 to 6.67 lakh plants/ha. More number of total and filled pods/plant with low plant density of 3.33 lakh plants/ha was due to higher production of pegs/plant and also higher peg to pod percentage and pod set percentage. High plant density of 6.67 lakh plants/ha gave lower number of total and filled pods/plant, due to more competition between plants for growth factors. These results are in accordance with the findings of Singh and Ahuja (1985) and Patel and Patel (1995).

Results on 100-pod weight, 100-kernel weight, shelling percentage and pod yield (Table 1) indicated that maximum 100-pod weight of 76.4g was obtained with K-134. The weight of 100 kernels of TAG-24 was significantly higher compared to rest of the varieties, while that of the 100-kernel weight of TPT-2 was significantly higher than to K-134 but was comparable with TMV-2. Shelling percentage recorded in K-134 was significantly higher than the to rest of the varieties. Shelling percentage of TMV-2 and TPT-2 was on par and significantly superior to TAG-24. This increase in shelling percentage could be due to channelisation of more photosynthates from pod wall to kernel. Maximum and minimum 100-pod weight and shelling percentage was obtained with a plant density of 3.3 and 6.67 lakh plants/ha, respectively. But, the difference in 100-kernel weight among the plant densities was not significant. Similar results of increase in 100-pod weight and shelling percentage with low plant density was reported by Patel and Parmar (1989) and Kaushik and Chaubey (2000). Significantly higher pod yields was obtained with K-134 than TMV-2, TPT-2 and TAG-24. The higher pod yield of K-134 was due to higher filled pods/plant and higher 100-pod weight compared to TMV-2 and TAG-24. Pod yield obtained with a plant density of 4.44 lakh plants/ha was significantly higher than 3.33 and 6.67 lakh plants/ha. Increase in plant density from 4.44 to 6.67 lakh plants/ha drastically decrease the pod yield/plant because of competition for growth factor that even increased plant population could not compensate the loss in pod yield/plant. At low plant density of 3.33 lakh plants/ha, though the pod yield/plant was high but the increased pod yield/plant could not compensate the loss of plant population. Hence, a medium plant density of 4.44 lakh plants/ha was found optimum. These results are in agreement with findings of Dwivedi and Gautam (1992), Patel and Patel (1995) and Meyyazhagan *et al.* (1999). Haulm yields obtained with K-134 and TPT-2 were on par and superior to TMV-2 and TAG-24. Haulm yield produced in TMV-2 was significantly higher than to TAG-24. Maximum harvest index was obtained in K-134 followed by TMV-2, TPT-2 and TAG-24. Maximum oil content of 48.99% was recorded in K-134 closely followed by TAG-24, TMV-2 and TPT-2.

Haulm yield produced with a plant density of 4.44 lakh plants/ha was significantly higher than to 3.33 and 6.67 lakh plants/ha. Haulm yield with 6.67 lakh plants/ha was significantly higher than to 3.33 lakh plants/ha. This was due to more number of plants/unit area at high density. Similar results were reported by Krishna *et al.* (1995) and Jadhav *et al.* (2000). Maximum harvest index of 39.71% recorded with a plant density of 3.33 lakh plants/ha. The oil content increased significantly with successive increase plant density from 3.33 through 6.67 lakh plants/ha.

Table 1 Agronomic taits of groundnut varieties as influenced by plant density

Treatment	Flower to peg (%)	Peg to pod (%)	Pod set (%)	Pegs/ plant	Total pods/ plant	Filled pods/ plant	100 pod weight (g)	100 kernel weight (g)	Shelling per cent	Pod yield (kg/ha)	Haulm yield (kg/ha)	Harvest index (%)
Variety												
TMV 2	49.8	78.7	39.6	30	23	20	74.9	33.6	75.5	2496	3992	38.9
TPT 2	56.5	80.1	38.2	27	23	20	74.7	34.4	75.6	2316	4250	34.8
TAG 24	47.7	60.4	34.0	28	16	14	74.1	38.0	74.2	2105	3626	36.2
K 134	54.1	75.2	41.7	34	25	21	76.4	32.9	76.7	2998	4370	40.9
SEm±	0.5	1.1	0.7	0.2	0.3	0.3	0.4	0.4	0.2	29	50	0.41
CD (P=0.05)	1.6	3.3	1.9	0.7	0.8	0.8	1.0	1.3	0.5	85	147	1.13
Plant density (lakh/ha)												
3.33	52.9	75.7	39.9	32.9	24	20	76.7	35.2	76.8	2525	3744	39.7
4.44	52.6	73.7	38.0	30.3	22	18	75.0	34.7	75.7	2653	4533	36.6
6.67	50.6	71.5	37.2	27.7	20	17	73.4	34.2	73.9	2257	3901	36.8
SEm±	0.5	1.1	0.7	0.2	0.1	0.2	0.3	0.3	0.1	25	43	0.33
CD (P=0.05)	0.4	0.9	0.6	0.6	0.6	0.7	0.9	NS	0.4	74	127	0.98

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Short communication

Influence of integrated nutrient management on yield and quality of soybean, *Glycine max* (L.) Merrill and pigeonpea, *Cajanus cajan* intercropping system under rainfed condition

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In Maharashtra, the area under cultivation of soybean intercropping with pigeonpea has rapidly increased during last five years. The area under soybean and pigeonpea in Maharashtra during the year 2000-01 was 11.42 and 10.96 lakh ha, respectively with an annual production of 12.70 and 6.60 lakh tonnes, respectively (Anonymous, 2002). The results generated from series of long-term fertilizer experiment revealed that continuous use of high analysis fertilizers increased the crop yield in the initial stage and adversely affected the sustainability at later stage (Virmani, 1994). Sustainable agriculture and integrated approach is the burning need of today to mitigate the gap of nutrients in Indian agriculture.

An intercropping experiment with integrated nutrient management on soybean and pigeonpea was conducted at Agronomy Farm, College of Agriculture, Latur, Maharashtra during *kharif*, 2004-05. The soil of the experimental site belonged to clayey and slightly alkaline. The soil analysis revealed that pH 7.80, EC 0.33 dS/m, organic carbon 4.40 g/kg, available phosphorus 12.8 kg/ha and available potassium 353.3 kg/ha. The area falls under semi-arid agro-climate with annual mean precipitation of 786 mm.

During *kharif*, 2004, the experiment was undertaken with soybean and pigeonpea cultivars JS 335 (Maturity 9-110 days) and BSMR-736 (Maturity 160-165 days), respectively. The spacing for soybean and pigeonpea was 45 x 5 cm and 45 x 20 cm, respectively.

The nine treatments consisting of different combination of recommended dose of fertilizers and organic products were laid out in a Randomized Block Design with three replications (Table 1). The pigeonpea crop was sprayed with 2% urea immediately after harvest of soybean crop in treatment (T_7). The net plot size was 6.0 x 3.6 m. The crop was fertilized @ 30 kg N, 60 kg P_2O_5 and 30 kg K_2O/ha for soybean and 25 kg N, 50 kg P_2O_5/ha for pigeonpea through urea, SSP and muriate of potash, respectively at sowing. The FYM and vermicompost were applied as manures in plots as per the treatments at the time of seed bed preparation.

It was observed from the Table 1 that amongst the different treatment intercropping gave the highest grain yield and productivity than pure crops. The data further revealed that the incorporation of 100% total RDF of system + 2% urea spray on pigeonpea immediately after harvest of soybean (T_7) recorded maximum grain yield of soybean (1042 kg/ha) and the application of 100% RDF through FYM (T_5) produced the higher grain yield of pigeonpea (2156 kg/ha). Similar results were reported by Badanur *et al.* (1990).

The data presented in Table 1 revealed that the highest soybean and pigeonpea grain equivalent yield was observed due to application of 100% RDF through FYM (3484 and 3020 kg/ha, respectively) than other treatments. Similar results were reported by Bisht and Chandel (1996). The total productivity and LER values varying between 1389 to 3153 kg/ha and 1.10 to 1.38, respectively. The highest total productivity and land equivalent ratio (LER) was observed with the application of 100% RDF through FYM (3153 kg/ha and 1.38, respectively). Similar results were also reported by Ramamurthy and Shivashankar (1995). The protein and oil content in soybean was varied from 39.43 to 40.75% and 17.76 to 19.05%, respectively. In general, protein and oil content of soybean were higher with application of 100% total RDF of system + 2% urea spray on pigeonpea immediately after harvest of soybean (40.75 and 19.05%, respectively). The protein per cent in pigeonpea was varied from 17.12 to 19.18%. The higher protein in pigeonpea was observed with application of 100% RDF through FYM (19.18%). However, the results revealed that the protein and oil content in soybean and pigeonpea indicated non-significant variation due to different treatments. Sayed *et al.* (1998) reported that the application of FYM significantly increase oil content and protein per cent of groundnut. Shankar *et al.* (2002) observed same results in Indian mustard.

The results from the experiment revealed that the pigeonpea can successfully be intercropped with soybean under rainfed condition and gave highest grain yield, total productivity, LER and quality parameters due to application of 100% RDF through FYM followed by application of 100% RDF of system + 2% urea spray on pigeonpea immediately after harvest of soybean. The small and marginal farmers can positively respond to this system, which is found better than the traditional monocrop soybean and pigeonpea.

Table 1 Grain yield, grain equivalent, total productivity, LER and quality parameters of soybean and pigeonpea as influenced by different treatments

Treatment	Grain yield (kg/ha)		Soybean grain equivalent (kg/ha)	Pigeonpea grain equivalent (kg/ha)	Total productivity (kg/ha)	Land equivalent ratio (LER)	Soybean		Pigeonpea
	Soybean	Pigeonpea					Protein content (%)	Oil content (%)	Protein content (%)
T_1 100% RDF of main crop to entire system i.e., for all row of both crops	884	1583	2710	2349	2467	1.12	39.62	17.95	17.18
T_2 100% RDF of main crop on area basis + 100% RDF of intercrop on area basis of system	917	2011	3237	2805	2928	1.29	40.18	18.22	18.75
T_3 50% RDF through chemical fertilizer + 50% RDF through FYM	957	2021	3288	2850	2978	1.31	40.37	18.75	19.00
T_4 75% RDF through chemical fertilizer + 25% RDF through FYM	922	1779	2974	2578	2701	1.31	40.00	18.05	18.56
T_5 100% RDF of system through FYM	997	2156	3484	3020	3153	1.38	40.50	18.85	19.18
T_6 100% RDF of system through vermicompost	861	1568	2670	2314	2429	1.10	39.43	17.76	17.75
T_7 100% RDF of both crop + 2% urea spray on pigeonpea immediately after harvest of soybean	1042	1990	3338	2893	3032	1.37	40.75	19.05	18.62
T_8 Sole pigeonpea with RDF	-	2812			2812		-	-	17.12
T_9 Sole soybean with RDF	1389	-			1389		39.75	18.01	-
SEm±	34	110			83.74		1.55	1.00	1.30
CD (P=0.05)	103	340			250.60		NS	NS	NS

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Short communication

Effect of long-term application of manure and fertilizers on yield and yield attributes of rainfed groundnut, *Arachis hypogaea* L.*

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Groundnut is the major oilseed crop in A.P. as also in India. In this state it is being grown in an area of 19.25 lakh ha with a production of 17.19 lakh tonnes and with a productivity of 924 kg/ha. Nearly 80 % of the groundnut area is under rainfed situation, mainly in Rayalaseema districts *viz.*, Anantapur, Chittoor, Kadapa and Kurnool. The average productivity of rainfed groundnut in different districts varied from 559 to 806 kg/ha. Use of fertilizers is a key factor for increasing production and its consumption is increasing rapidly. Monocropping of groundnut under rainfed conditions in red sandy loam soils (Alfisols and Inceptisols) is a common practice in this region and *farmers do not apply the recommended doses of fertilizers* because of their belief that the chemical fertilizers may not be utilized properly under moisture stress condition. Therefore, it was felt necessary to study the effect of manure and fertilizers on pod yield and its attributes under rainfed situation.

Long-term field experiment was started in 1981 at RARS, Tirupati on sandy clay loam soil with 11 treatments in Randomized Block Design and replicated four times. The groundnut variety Tirupati-1 was raised as per recommended package. Well decomposed FYM @ 5 t/ha was applied as per treatment before sowing only during *kharif*, 2002. Nitrogen, P and K in the form of urea, SSP and MoP respectively were applied as per treatments just before sowing. Gypsum or lime was applied at flowering stage as per the treatments. Zinc Sulphate was applied basally once in 3 years.

Hundred-pod weight was significantly influenced by long-term application of manure and fertilizers (Table 1). The highest value was recorded with NPK + gypsum + $ZnSO_4$. The next best treatments were T_4 (P alone), T_7 (NP), and T_{10} (NPK + gypsum) during *kharif*, 2002, and T_2 (FYM alone), T_3 (N alone) and T_4 (P alone) during 2003. It was noticed that irrespective of seasonal conditions (with the low (420 mm in 2002) or normal rainfall (630 mm in 2003, respectively) application of gypsum and zinc sulphate along with NPK performed well.

Shelling percent was significantly influenced by the treatments. The highest shelling per cent of 78.1 was observed in T_{10} (NPK+Lime) during *kharif*, 2002. However, the same parameter was not influenced by the treatments during *kharif*, 2003, with the mean of 64.9%. Test weight was non-significantly influenced by the treatments in both the years. The mean value of 28.9 g was recorded; similar observations were reported by Malewar *et al.* (1993).The data revealed significant differences among the treatments. Pod yield significantly differed in both years of study (Table 2). The treatment NPK+gypsum+$ZnSO_4$ recorded the highest yield and as also reflected in pooled analysis. This might be due to application of critical *nutrients like calcium, sulphur and zinc along with NPK to* groundnut. The treatments which received FYM and N or P or K or gypsum alone were on par with each other but significantly differed from the control (no manure or fertilizers). The observations revealed that combined application of nutrients to the crop was necessary to get maximum yield. These results were confirmed with the findings of Bhaskar Reddy et al. (1992) and Samui *et al.* (2004). Data also clearly indicated that percent increase in yield over control was more during stress period in 2002 than the normal rainfall year of 2003.

Haulm yield also significantly differed in both the years. The treatment NPK + gypsum + $ZnSO_4$ recorded highest haulm yield followed by NP, NPK, NPK+ gypsum and NPK + lime and the same was reflected in pooled analysis also. This might be due to the application of essential nutrients like calcium, sulphur and zinc along with NPK. These findings were in accordance with the findings of Bhaskar Reddy *et al. (1992) and Sagare et al. (1992) in groundnut.* From the present investigation it was concluded that the crop could not perform well with the single nutrient, hence combined application of nutrients is needed to realize higher pod yields. This also showed that the crop response to fertilizers was very high under low rainfall condition of 2002 than normal rainfall in 2003. The impression of the farmers in this region is nullified who believe that the groundnut crop does not favorably yield under moisture stress conditions even after application of fertilizers.

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Table 1 Effect of long-term application of manure and fertilizers on yield attributes of groundnut (*kharif*, 2002 and 2003)

Treatment	*100-pod weight (g)*			*Test weight (g)*			*Shelling percentage*			*Pod yield (kg/ha)*		
	2002	2003	Mean	2002	2003	Mean	2002	2003	Mean	2002	2003	Mean
T_1	63	68	65	25.8	26.8	26.3	70.9	62.4	66.7	830	1399	1115
T_2	64	79	71	26.3	30.7	28.5	72.2	65.5	68.9	970	1763	1367
T_3	64	74	69	26.1	29.1	27.6	72.6	64.2	68.4	956	1677	1317
T_4	72	77	74	26.8	31.7	29.3	73.2	65.4	69.3	1020	1833	1427
T_5	63	68	66	27.3	27.2	27.3	72.7	65.1	68.9	946	1602	1273
T_6	66	70	68	26.6	27.1	26.9	73.2	65.1	69.2	985	1827	1406
T_7	70	73	72	26.9	29.2	28.1	73.7	65.7	69.7	1072	1855	1463
T_8	68	73	71	27.0	28.9	28.0	73.7	64.3	69.0	1236	1860	1548
T_9	69	73	71	27.4	28.0	27.7	74.3	64.9	69.6	1272	1896	1584
T_{10}	74	73	73	27.6	30.1	28.9	78.1	65.7	71.9	1249	1886	1568
T_{11}	74	79	77	27.4	29.1	28.3	74.2	64.3	69.3	1286	2138	1712
Mean	68	73	71	26.8	28.9	27.9	73.5	64.9	69.2	1075	1794	1434
SEm±	1.6	2.1	-	1.0	0.6	-	1.0	1.5	-	20.3	51.0	28.2
CD (P=0.05)	4.5	6.0	-	NS	NS	-	2.9	NS	-	58.7	147.4	79.6

T_1 = Control (no fertilizer/manure)
T_2 = Farm yard manure @ 5 t/ha
T_3 = 20 kg nitrogen (N)/ha
T_4 = 10 kg phosphorus (P)/ha
T_5 = 25 kg potassium (K)/ha
T_6 = 250 kg gypsum/ha
T_7 = 20 kg N + 10 kg P/ha
T_8 = 20 kg N + 10 kg P + 25 kg K/ha
T_9 = 20 kg N + 10 kg P + 25 kg K + 250 kg gypsum/ha
T_{10} - 20 kg N + 10 kg P + 25 kg K + 100 kg lime/ha
T_{11} = 20 kg N + 10 kg P + 25 kg K + 25 kg zinc sulphate/ha + 250 kg gypsum/ha

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Short communication

Soil test crop response correlation studies in Indian mustard, *Brassica juncea* L.

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Mustard is one of the most important edible oilseed crop in India. Fertilizer recommendations in crops are based on the agronomic experiments conducted in different ecological regions or through a semi quantitative approach based on the rating of soil available NPK (Sharma *et al.*, 1999). This methods does not take into account the large scale variation in soil fertility from field to field (Suri and Verma, 1999). But, fertilizer recommendation based on soil test crop response correlation are considered unique. They consider the quantity of nutrients required by the crop, efficiency of nutrient supply by the soil and fertilizers to predict the fertilizer dose to maximize the production and profitability as well as targeted yield. Since mustard is emerging as a promising oilseed crop in the hitherto non-traditional ecosystem of Andhra Pradesh, it was considered to explore it through the STCR approach.

A field experiment was conducted at the Students' Farm, College of Agriculture, Rajendranagar, Hyderabad during *rabi*, 2005. The soil was sandy loam in texture with pH 7.5. The nutrient status was rated as low in nitrogen 213 kg N/ha, rich in phosphorus (75 kg P_2O_5/ha] and medium in potassium (299 kg K_2O/ha). A fertility gradient experiment was conducted in the *kharif* season preceding the cultivation of the test crop of mustard for its soil test crop response evaluation. The field was divided into three strips of 120 m long and 10 m wide separated with 1.5 m wide alley ways along the length. They were designated as 0X, 1X and 2X. Fertilizers were applied in these strips as shown in Table 1.

Table 1 Fertilizer dose (kg/ha) applied to different strips of mustard

Gradient	Nutrient applied (kg/ha)		
	N	P_2O_5	K_2O
0x	0	0	0
1x	150	75	100
2x	300	150	200

An exhaust crop of fodder sorghum var. SSG 59-3 was sown on 30th June, 2005 and harvested on 15th November, 2005. The field was then ploughed, harrowed and leveled without disturbing the layout demarcation of the three strips. Each strip was divided into 24 plots measuring 10 x 4.5 m and separated by bunds of 45 cm. A total of 24 treatments combination from a factorial combine schedule of 4 levels each of N at 0, 40, 80 and 120 kg/ha; P_2O_5 and K_2O at 0, 20, 40 and 60 kg/ha were executed in each treatment in accordance with recommendation by the AICRP on soil test crop response correlation studies (www.iasri.res.in).

Indian mustard variety Pusa Jai Kisan was sown on 25.11.2005 at a spacing of 30 x 10 cm. The soil available N was determined by the alkaline permanganate method (Subbaiah and Asija, 1956). Phosphorus by Olsen's method and potassium through neutral normal ammonium acetate method. The nitrogen content in the plant was *estimated through modified micro kjeldhal method* (Piper, 1966), phosphorus by molybdo phosphoric yellow colour (Jackson, 1958) and potassium through flame photometer (Piper, 1966). The basic parameters for targeted yield equations were worked out as:

kg of nutrient absorbed/q grain = Total uptake of nutrients (kg grain + straw)/Grain yield (q) x 100

% contribution of nutrients from soil = Total uptake in control plots (kg/ha) / Soil test value of nutrients in control plots (kg/ha) x 100

Per cent contribution of nutrients from fertilizers:

$$\frac{\text{Nutrient uptake} - \text{Av. Soil test value (kg/ha)} \times \text{\% contribution of nutrients from soil}/100}{\text{Fertilizer nutrient applied (kg/ha)}} \times 100$$

Targeted yield equation

$$T = \left[\frac{\text{Nutrient requirement}}{\text{\% Contribution from fertilizer}} \times T\right] - \left[\frac{\text{\% Contribution from soil}}{\text{\% Contribution from fertilizer}}\right] \times \text{Soil test value for availed nutrients}$$

The fertilizer adjustment equations of N, P and K are as follows:

$FN = \beta SN/2\beta\ SN^2 - \beta FN\ SN/2\beta SN^2 \times SN$ Maximum yield

$FN = \beta SN/2\beta\ SN^2 - \beta FN\ SN/2\beta SN^2 \times SN - 1/2\beta SN^2 \times R$ Maximum yield

FN=βSN/2β SN² - βFN SN/2βSN² x SN-1/2βSN² x 2 Desired rate of return

Where,

β=Regression coefficient of SN = = soil nutrient; SN^2 = Soil nutrient²; FN = Fertilizer nutrient and R is the rate of return which is the quotient of cost of produce and cost of nutrient fertilizer R = CP/CN where, CP is cost of mustard seed at Rs. 20/kg and CN is the cost of fertilizer nutrients i.e., N @ Rs. 10.90/kg; P_2O_5 is Rs. 23.12/kg and K_2O is Rs. 7.72/kg.

A wide fertility gradient was attained by growing sorghum as the exhaust crop. The soil available nitrogen was 181 kg/ha in the 0X, 328 kg in 1X and 401 kg/ha in the 2X fertility gradient. The available P_2O_5 was 47, 52 and 57 kg/ha while, the available K_2O was 250, 370 and 391 kg/ha in the respective fertility gradient strips. These trends were best reflected in the production of sorghum grain yield which weighted 151, 619 and 914 kg/ha in the corresponding gradients.

The data (Table 2) indicated the positive and significant relationship of mustard grain yield on NPK content supplied through the fertilizers. The quantity of nitrogen removed by the crop also recorded a significant correlation with the seed yield in the three fertility gradients. Consistent and a positive significant correlation for the production of seed yield was exhibited by the soil available P_2O_5. The association of potassium with seed yield of mustard was not significant. The multiple regression *equation was:*

$Y = 703.00 + 10.8180\ FN - 0.0343\ FN^2 - 0.6990\ SN + 0.0004\ SN^2 - 0.0070\ FNSN - 11.5750\ FP = 0.0267\ FP^2 + 2.7210\ SP + 0.0610\ SP^2 + 0.1760\ FPSP + 10.0180\ FK = 0.0907\ FK^2 - 4.7030\ SK - 0.0047\ SK^2 - 0.0071\ FKSK$ ......$R^2 = 0.49$

This equation showed that there was a positive response for the linear, quadratic and interaction term for N and K. This implies that it is possible to estimate the requirement of N and K fertilizers optimum to a site specific soil fertility status. The crop required 5.2 kg N, 1.74 kg P_2O_5 and 3.42 kg K_2O/ha to produce 1 quintal of mustard seed yield/ha. The nutrient supplying efficiency of the soil was 2.2% N, 3.3% P_2O_5 and 1.2% K_2O. The efficiency of fertilizers to supply the nutrients was 19% N, 17% P_2O_5 and 38% K_2O. The targeted yield equation developed from these basic parameters were:

FN = 27.50 - 0.12 SN; F P_2O_5 = 10.25 T - 0.19 SP and F K_2O = 9.02 T - 0.03 SK

The fertilizer requirement of mustard can be worked out from this equations to attain different targeted yields in soils of different levels of available NPK. A ready reckoner of fertilizer doses to obtain targeted yield of 6 and 10 q/ha for a range of soil available NPK is presented in Table 3.

Table 2 Correlation coefficient of nutrients applied through fertilizers and removed by the crop with grain yield of mustard

Fertilizer	*Fertility gradient*		
	0x	1x	2x
N	0.92**	0.78**	0.74**
P	0.54**	0.68**	0.74**
K	0.45**	0.52**	0.59**
Removal			
N	0.81**	0.76**	0.65**
P	0.23	0.15	-0.08
K	*0.43***	*0.36*	*0.45**
Initial soil			
N	0.50**	-0.40	-0.18
P	0.63*	0.40*	0.40*
K	0.23	-0.15	0.02

Fertilizer dose required to attain a maximum yield of mustard, maximum profit and desired rate of return with the existing cost of fertilizers and mustard seed is presented in Table 4. This ready reckoner serve as a prescription of NPK to be applied through fertilizers in soils of different levels of N and K.

Table 3 Ready reckoner of fertilizer doses (kg/ha) for attaining yield targets of mustard

SN	SP	SK	T = 6 q/ha			T = 10 q/ha		
			FN	F P_2O_5	F K_2O	FN	F P_2O_5	F K_2O
100	10	100	153	60	51	263	101	87
150	15	150	147	59	50	257	100	86
200	20	200	141	58	48	251	99	84
250	25	250	135	57	47	245	98	83
300	30	300	129	56	45	239	97	81
350	35	350	123	55	44	233	96	80
400	40	400	117	54	42	227	95	78
450	45	450	111	53	41	221	94	77
500	50	500	105	52	39	215	93	75
550	55	550	99	51	38	209	92	74
600	60	600	93	50	36	203	91	72
700	70	700	81	48	33	191	89	69

Table 4 Ready reckoner of fertilizer doses (kg/ha) for attaining maximum yield, maximum profit and desired rate of return of mustard

SN	SK	Maximum yield		Maximum profit		Desired rate of return	
		FN	F K_2O	FN	F K_2O	FN	F K_2O
100	100	147	51	140	49	132	47
150	150	142	49	134	47	126	45
200	200	137	47	129	45	121	43
250	250	132	45	124	43	116	41
300	300	127	43	119	41	111	39
350	350	122	42	114	39	106	37
400	400	117	40	109	37	101	35
450	450	112	38	104	35	96	33
500	500	106	36	99	33	91	31
550	550	101	34	93	32	85	29
600	600	96	32	88	30	80	27
650	650	91	30	83	28	75	25
700	700	86	28	78	26	70	24

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Short communication

Productivity and nutrient uptake of sunflower, *Helianthus annuus* L. as influenced by site specific integrated nutrient management on Alfisols

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Sunflower (*Helianthus annuus* L.) is an important oilseed crop cultivated profitably in traditional growing areas of Karnataka, Andhra Pradesh, Maharashtra and Tamil Nadu. As a spring crop it is cultivated in the states of Punjab, Haryana, parts of Uttar Pradesh and Bihar. Sunflower occupied an area of 2.162 m.ha with a production of 1.224 m.t and productivity of 566 kg/ha during 2004-05 (Damodaram and Hegde, 2005) in the country. The productivity of the crop is the lowest among the major sunflower producing nations in the world. Due to the high capacity to produce seed and oil, sunflower demands higher nutrition (Hegde, 1998). Inadequate and imbalanced nutrient supply is one of the reasons for low productivity of sunflower. Current blanket application based on state or regional recommendation will be a gross approximation, many times leading to low use efficiency, wastage and losses. Nutrient management based on soil test and target yield method helps in addressing these problems to realize higher efficiency and profitability. Considering the high nutrient demand of sunflower, integrated nutrient management using locally available organic, crop residue, biofertilisers and green manures would reduce the cost besides improving the soil health. Site specific integrated nutrient management for sunflower through organic sources (Farm yard manure, poultry and goat manure) was conducted to achieve higher productivity, improving soil health. The present investigation was carried out during kharif 2005 to standardize the site specific integrated nutrient management practices for sunflower in Alfisols.

A field experiment was conducted at Narkhoda Research Farm of Directorate of Oilseeds Research, Hyderabad during *kharif* season of 2005. The experimental site is located at an altitude of 542 meters M.S.L and at 78° 18' E longitude and 17° 5' N latitude. The soil of the experimental site was shallow Alfisols typically chalka red sandy loam in texture with low in available nitrogen (124.6 kg/ha), phosphorus (6.6 kg/ha) and medium in potassium (217.5 kg/ha) with a pH of 6.6. The experiment was laid out in Randomised Block Design with three replications. The treatments included integration of various organic manure sources (Farm yard manure, Poultry manure and Goat manure) along with inorganic fertilizers. There were nine treatments *viz.*, Control, 50% RDF, 100% RDF, 100% rec. N through Farm yard manure (FYM), 150% RDF, 50% RDF + 50% N through FYM, 50% RDF + 50% N through Goat manure (GM), 50% RDF + 50% N through Poultry manure (PM), 50% RDF + 50% N (25% N through Goat manure + 25% N through Poultry manure).

The nutrient requirement in terms of N, P and K were calculated as per the equations fitted based on soil test values and target yield (14 q/ha). Organic manures were substituted based on the nitrogen content.

Soil test fertilizer equations:

$FN = 11.44 \times 14 - 0.41 \times 124.56 = 109.1$ kg N/ha

$FP_2O_5 = 7.49 \times 14 - 2.10 \times 6.56 = 91.08$ kg P_2O_5 /ha

$FK_2O = 3.80 \times 14 - 0.10 \times 217.46 = 31.45$ kg K_2O /ha

The nutrient contents of different organic manures are as under:

Table 1 Nutrient content of various organic manures

Organic manure	N (%)	P (%)	K (%)
FYM	0.85	0.129	0.41
Goat manure	1.65	0.628	1.78
Poultry manure	2.92	1.350	0.37

Half of the nitrogen and entire P_2O_5 and K_2O were applied, as basal and remaining half of the nitrogen was top dressed along with earthing up at 30 days after sowing (DAS). The crop was sown on 07.07.2005 and grown entirely under rainfed conditions. An amount of 796.5 mm rainfall was received during the crop period (July-October). The plot size was 6.6 x 5.4m. Need based plant protection measures were taken to protect from pests and diseases. During the end of September, there was outbreak of Alternaria disease due to continuous and heavy downpour, which affected the process of seed filling. The N, P and K content of the manures and plant was estimated with standard procedure and the uptake by the plant was calculated. The oil content was estimated by using NMR (model Oxford MQA 7005).

Growth and yield attributes: Significant differences were observed in growth parameters *viz.*, plant height, number of leaves per plant and drymatter production due to various integrated nutrient management practices as compared to control (Table 2). The tallest plants at harvest were observed with combined application of 50%NPK + 50% N (25% N-GM + 25% N-PM) and were at par with 50%NPK+ 50% N-PM and 150% NPK. Maximum number of leaves/plant was associated with 100% NPK, 100% N-FYM, 150% NPK and 50%NPK + 50%N (25% N - GM + 25% N - PM). Dry matter production varied significantly among various treatments. Application of 150% NPK had recorded significantly higher dry matter production (2455 kg/ha) over rest of the treatments but remained on par with 100% NPK (2401 kg/ha) and 50% NPK +50 % N-FYM (2255 kg/ha). Similar findings were also reported by Edera and Patel (2000). Higher SPAD chlorophyll meter reading (SCMR) were observed at 100% NPK, 150% NPK and 50% NPK + 50% N-FYM.

Marked variations in the 1000 seed weight and head diameter were observed with different nutrient management practices over control (Table 2). Application of 150% NPK, 100% NPK and 50% NPK + 50% N-FYM had recorded almost similar test weight and head diameter. These results are in line with those of Mahavishnan *et al.*, (2006).

Seed yield: Seed yield differed significantly among various integrated nutrient management treatments. Maximum seed yield (1297 kg/ha) was recorded with application of 50% NPK + 50% N- FYM and was comparable with 100% NPK (Table 2). The increase in seed yield with 50% NPK + 50 % N-FYM over 150% NPK and control was to the extent of 27 and 57%, respectively. The seed yield recorded with 50 % NPK supplemented either with goat or poultry manure @ 50% alone or 25% in combination was comparable with each other. The significantly higher number of leaves might have increased the photosynthetic area and activity of the crop leading to better growth and yield. attributes observed with the treatments 100% NPK and 50% NPK + 50% N- FYM which ultimately a reflected in seed yield. These results are in agreement with the findings of Singh *et al.*, (2000) and (Mahavishnan *et al.*, 2006).

Oil content and oil yield: Marked variations were observed in oil yield among various treatments (Table 2). Maximum oil yield of 424 kg/ha was observed with 50% NPK + 50% N-FYM, which was comparable with the application of 100% NPK (423 kg/ha). Lowest oil yield was observed with control. The results are in accordance with the findings of Singh and Bansal (1999).

Table 2 Effect of site specific integrated nutrient management practices (Organic manures) on growth of sunflower

Treatments	Dry matter production (kg/ha)	SPAD Chlorophyll Meter Reading	1000 seed weight (g)	Head diameter (cm)	Seed yield (kg/ha)	Stalk yield (kg/ha)	Oil yield (kg/ha)	Nutrient uptake (kg/ha) N	P	K
Control	1339	29.4	39.1	12.4	563	938	186	24.4	7.0	25.8
50%NPK (STB)	1927	32.4	40.1	13.9	1054	1422	353	42.1	12.0	41.6
100% NPK	2401	37.0	40.5	16.4	1291	1801	423	52.9	15.1	52.0
100% N-FYM	1494	29.0	39.8	12.0	706	1142	239	30.4	8.9	31.2
150% NPK	2455	36.4	40.7	17.3	952	1228	317	37.9	11.1	36.6
50% NPK + 50% N-FYM	2255	36.2	40.6	16.2	1297	1758	424	52.9	15.0	51.0
50% NPK + 50% N-G M	1911	30.8	40.1	13.4	926	1330	303	39.0	11.6	38.0
50% NPK + 50% N – PM	1894	30.2	39.4	12.7	855	1246	287	35.6	10.9	35.5
50% NPK + 25% N –GM + 25% N- PM	2025	33.8	40.2	15.1	903	1342	304	37.5	11.2	37.9
CD (P=0.05)	327	NS	0.7	1.5	252	332	89	9.8	2.9	9.5
CV (%)	9	10	9	8	15	14	14	14	14	14

STB = Soil Test Based; FYM = Farm Yard Manure; GM = Goat Manure; PM = Poultry manure

Nutrient uptake: Significant differences in nutrient uptake (N, P and K) were observed among different site-specific integrated nutrient management practices (Table 2). Highest nutrient uptake (52.9, 15.0 and 51.0 kg/ha N, P and K respectively) were observed with the application of 100% NPK, which was comparable with the application of 50% NPK + 50% N-FYM. Higher dry matter production and seed yield recorded with these treatments had resulted in higher N, P and K uptake. These findings are in line with those of Taha *et al.*, (1999) Legha and Giri (1999).

Conclusions: Application of 50% NPK + 50 % N through FYM resulted in higher seed yield, oil yield and nutrient uptake which was comparable with recommended NPK.

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Short communication

Effect of doses and sources of sulphur on the productivity of spring sunflower, *Helianthus annuus* L.

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Sulphur plays a vital role in the primary metabolism of higher plants and is also involved in the synthesis of secondary metabolic products in certain group of plants (Lakkineni and Abrol, 1994). It is involved in the biosynthesis of proteins and many other important compounds that are vital for proper functioning of plant processes. Oilseed crops in general require higher amounts of sulphur than cereals due to their involvement in formation of sulphur containing amino acids. It influences growth, development, yield and quality of crops. Sulphur deficiency in sunflower (*Helianthus annuus* L.) is detrimental to seed yield and quality (Hocking *et al.*, 1987). Sunflower is cultivated in Punjab during spring season (December-January to May-June) under irrigated conditions in the intensive cropping systems. Removal of sulphur by heavy biomass producing crops in the multiple cropping systems, widespread use of sulphur free fertilizers and scarce use of organic amendments have resulted in sulphur deficiency in the crops (Tandon, 1991). Since the evidence is lacking regarding response of sulphur to short duration spring planted sunflower for the agroclimatic conditions of Punjab, a study was conducted to find out the effect of doses and sources of sulphur on the seed yield and oil content of sunflower.

The field experiment was conducted in spring 2003 and 2004 at the Punjab Agricultural University, Ludhiana. The loamy sand soil of the experimental field was neutral in reaction, low in organic carbon (0.23%), medium in available phosphorus (17.5 kg/ha), rich in available potassium (210 kg K_2O/ha) and medium in available sulphur content (12 ppm). The nine treatments comprising combinations of four sources (ammonium sulphate, single superphosphate, gypsum and elemental sulphur) and two doses (20 and 40 kg/ha) of sulphur along with control were randomised in Complete Block Design in three replications. The hybrid PSFH 118 was sown on 19 January in 2003 and 4 February in 2004. The crop was planted in a plant to plant spacing of 30 cm on the southern side of east-west formed ridges at a spacing of 60 cm between ridges. Fertilizers were applied @ 60 kg N and 30 kg P_2O_5/ha in the form of urea except in treatment comprising ammonium sulphate and dia-ammonium phosphate except in treatment comprising single superphosphate as source of sulphur, respectively. The crop was harvested on 6 May in 2003 and 12 May in 2004. All the nutrients were drilled at the time of sowing.

The effect of sulphur application on the plant height, yield attributes and seed yield was non-significant in both years (Table 1). Application of 20 and 40 kg S/ha increased the mean seed yield of sunflower by 6.1 and 10.1%, respectively over no sulphur application. Likewise, different sources of sulphur resulted in statistically similar seed yield (Table 1).

Table 1 Effect of doses and sources of sulphur on the productivity of spring sunflower hybrid

Treatment		Plant height (cm) at maturity		Head diameter (cm) at maturity		100-seed weight (g) at maturity		Seed yield (kg/ha)			Oil content (%)		
Dose of sulphur (kg/ha)	*Source of sulphur*	*2003*	*2004*	*2003*	*2004*	*2003*	*2004*	*2003*	*2004*	*Mean*	*2003*	*2004*	*Mean*
20	Ammonium sulphate	169	124	16.4	14.7	5.6	5.3	2235	1700	1967	32.1	36.2	34.1
	Single super phosphate	167	128	15.2	16.3	5.1	5.4	2217	1620	1918	31.9	32.7	32.3
	Gypsum	168	132	14.8	16.1	5.4	5.4	2146	1754	1950	32.1	34.9	33.5
	Elemental sulphur	167	125	15.9	14.8	5.4	5.2	2162	1517	1840	31.9	34.6	33.3
40	Ammonium sulphate	172	130	16.1	14.8	5.6	5.6	2296	1638	1967	33.5	36.2	34.9
	Single super phosphate	173	130	15.5	15.6	5.7	5.8	2271	1736	2004	32.5	34.1	33.3
	Gypsum	172	131	16.3	14.9	5.5	5.9	2256	1879	2067	31.5	33.8	32.6
	Elemental sulphur	171	134	15.7	16.3	5.4	5.5	2228	1629	1928	31.7	34.5	33.1
	Control	166	134	14.6	15.1	5.2	4.9	2124	1503	1813	31.4	33.5	32.4
	CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	-	1.2	1.1	-

The highest seed yield was, however, registered with the application of ammonium sulphate in 2003 and with gypsum application in 2004. Gypsum proved better source of sulphur for sunflower than elemental sulphur and pyrite in both vertisols and alfisols (Asha Jyothi and Sankara Rao, 2003). Patra *et al.* (1995) reported that gypsum releases available sulphur faster than other sources and also supplies calcium. In both the years, the seed yield was the lowest with application of elemental sulphur as source of sulphur. There are reports in different crops where elemental sulphur proved inferior to gypsum (Arora *et al.*, 1987; Naphade and Wankhede, 1988). Elemental sulphur contains sulphur in non-sulphate insoluble form and has to undergo microbial transformations in soil and get oxidized to SO_4^- form before it is taken up by growing plants. These workers have reported that relatively less effectiveness of elemental sulphur was due to less time available for its oxidation (Arora *et al.*, 1987) or it was drilled at time of sowing. Duhoon *et al.* (2005) reported similar findings of experiments conducted at different locations with sesamum on different doses and sources of sulphur. However, treatment differences for oil content were significant in both years (Table 1). Increasingly doses of sulphur marginally increased the oil content over control. Hocking *et al.* (1987) also reported that sulphur application had no influence on oil content of sunflower. Among different sources of sulphur, application of ammonium sulphate resulted in the highest oil content in both years (mean oil content 34.5%).

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Short communication

Effect of sowing time, moisture conservation practices and fertilizer levels on the yield of sunflower under aberrant weather conditions

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Scarcity zone of Maharashtra is characterized with inadequate, erratic and ill-distributed rainfall with unassured onset of monsoon. The weather data of Solapur station revealed that there was delayed onset of monsoon during three years out of ten years. Vagaries of weather reflected in dwindling of crop productivity as against the growing demand of oilseeds by the increasing population. Sunflower is an important oilseed crop grown in India for edible oil (Damodaram and Hegde, 2000). Though it is an important oilseed crop of rainfed areas, its productivity increment and sustainability are the major concerns in drought prone areas. In view of this, the present investigation was undertaken to assess the response of sunflower to sowing time, moisture conservation practices and fertilizer levels under aberrant weather.

The field experiments were conducted during *kharif* seasons of 1999 to 2004 at the research farm of All India Co-ordinated Research Project for Dryland Agriculture, Solapur. During the year 2003 the total rainfall received was 351 mm which was 51% deficit than the normal. The crop was sown during the year 2003, but no economic yield was obtained. The experimental soil was medium deep (40-45 cm depth), low in available nitrogen (120 kg/ha), medium in available phosphorus (13 kg/ha) and high in available potash contents (460 kg/ha). The experiment was laid out in Split-Split Plot Design with two replications with a net plot size of 19.44 m^2. The main plot treatments comprised of four sowing dates *viz.*, 28 SMW, 30 SMW, 32 SMW and 34 SMW. Three moisture conservation practices *viz.*, ridges and furrow, skip row with furrow and flat beds were placed as sub-plot treatments and three fertilizer levels *viz.*, 40:20, 50:25 and 60:30, $N:P_2O_5$ kg/ha were tried as sub-sub plot treatments. The treatments were given to the same plots every year. The sunflower variety SS-56 was used for sowing. In the ridges and furrow treatment the sunflower was sown on ridges. The total rainfall received during the crop season for different dates of sowing is given below. During the years 1999, 2000 and 2002 there was timely onset of the monsoon during SMW 23 (4-10 June), while the onset of monsoon was delayed by 5 to 7 weeks during the year 2001 (29 July), 2003 (10 July) and 2004 (6 July). Economics was worked out on the basis of existing market price. The sustainable yield index (SYI) and sustainable value index (SVI) were worked out as suggested by Singh, *et al.* (1990).

Total rainfall (mm) during crop season for different sowing dates of sunflower at Solapur

Year	Sowing dates			
	S_1 (SMW 28) (09-15 July)	S_2 (SMW 30) (23-29 July)	S_3 (SMW 32) (06-12 August)	S_4 (SMW 34) (20-26August)
1999	372.7	226.4	173.1	168.4
2000	369.5	391.5	293.7	194.6
2001	423.0	515.2	429.4	501.7
2002	470.3	432.5	229.9	217.4
2003	248.8	236.8	205.3	85.1
2004	392.1	348.4	243.9	228.6

Main effects on yield: The pooled performance of sunflower clearly indicated that early sown crop i.e., during 28th SMW produced significantly higher seed yield (569 kg/ha) than other sowing dates tried. The same trend was noticed over all the years except during the year 2001 which was characterized by delayed onset of monsoon, hence SMW 34 showed better yield (465 kg/ha) while there was dry seeding of 28 and 30th SMW. Bharud and Patil (1996) reported normal sowing at the onset of monsoon (8th June) as the best for obtaining maximum yields of *kharif* sunflower under rainfed situations.

Amongst the six years of experimentation, during only two years, sunflower yield was influenced significantly due to moisture conservation practices. Sunflower sown on ridges and furrows at 45x30 cm spacing produced significantly higher seed yields during the years 2000, 2002 and also in pooled means (449, 405 and 446 kg/ha, respectively) (Table 1).

Pooled results revealed that 20% increase in the recommended fertilizer dose i.e., 60:30 $N:P_2O_5$ kg/ha to sunflower did not produce significantly highest seed yield over recommended fertilizer level i.e. 50:25 N: P_2O_5 kg/ha. However, 20% decrease in fertilizer dose decreased the sunflower yield significantly. Hiray *et al.* (1992) reported significant increase in all yield contributing characters with increase in dose of nitrogen to sunflower upto 80 kg N /ha level. Jagtap and Sabale (1994) also reported 78 kg/ha as an optimum dose of nitrogen for better sunflower yields. Adiseshaiah *et al.* (1978) and Sable and Jadhav (1983) also reported similar results. Vijay *et al.* (1975) recorded higher seed yield of sunflower with the application of 100:100:50 NPK kg/ha under rainfed condition.

Reddy *et al.* (2003) observed higher seed yield of sunflower with the application of 35:50:35 N:P:K kg/ha under Raichur conditions during rabi season which was 53.5% higher over farmer's practice (17.5:25:17.5 N:P:K kg/ha).

Reddy *et al.* (2003) reported magnitude of seed yield increase under recommended method of moisture conservation (key line cultivation and opening furrow between two rows of sunflower after 30-35 days of sowing) was 24% over the farmer's practice of repeated harrowing and inter-cultivation twice.

Interactions between sowing dates and moisture conservation practices were significant only during 2000-01, 2001-02 and 2004-05. During 2000-01 significantly higher sunflower seed yield of 849 kg/ha was observed when sown in 28th SMW on ridges and furrows, followed by sowing in the same week with skip row furrow method (716 kg/ha), while during the year 2001, the crop sown in 34th SMW on ridges and furrows produced significantly higher seed yield (652 kg/ha) but it was at par with the sowings during 32nd SMW on flat beds (588 kg/ha) and skip row with furrow (529 kg/ha).

Interaction effects were present during 2000-01, 2001-02 and 2002-03. During the years 2000 and 2002, sunflower sown in 28th SMW fertilized with 60:30 N: P_2O_5 kg/ha produced significantly higher seed yield of 772 and 713 kg/ha, while it was at par with same sowing date and recommended fertilizer level during the year 2002 (693 kg/ha). During the year 2001, sunflower sown in 32nd SMW with 60:30 N: P_2O_5 kg/ha produced significantly higher seed yield (587 kg/ha) and it was at par with same sowing date fertilized with 50:25 N:P_2O_5 kg/ha (543 kg/ha) and also with the crop sown in 34th SMW with 60:30 N:P_2O_5 kg/ha (575 kg/ha).

Economics, SYI, SVI and MUE: The pooled performance of sunflower clearly indicated that early sown crop i.e., during 28th SMW recorded higher SYI of 0.62. Economic analysis revealed that sunflower sown during 28 SMW recorded highest net returns (Rs.5107/ha), B:C ratio (1.62) and SVI (0.67) (Table 4). Moisture use efficiency was also at higher magnitude (2.12 kg ha/mm) when sunflower was sown during 28th SMW (Table 5). Gaikwad *et al.* (1995) reported sustainable production and income through dry seeding (24th SMW) or seeding in 25th SMW (first probability of rains). Sunflower sown on ridges and furrows (45x30 cm) produced highest net returns (Rs.2583/ha), B:C ratio (1.31), SYI (0.69) and SVI (0.74).

Higher fertilizer level (60:30 N:P_2O_5 kg/ha) to sunflower registered higher net returns (Rs.1487/ha), B:C ratio (1.18), SYI (0.55) and SVI (0.65) (Table 5).

Thus for higher and sustainable yield of sunflower under aberrant weather conditions of scarcity zone of Maharashtra State, it should be sown during SMW 28th on ridges and furrows with recommended dose of fertilizers i.e., 50:25 N:P_2O_5 kg/ha.

Table 1 Seed yield of sunflower (SS-56) as influenced by sowing dates, moisture conservation techniques and fertilizer levels (Pooled)

Sl. No.	Treatment	1999-00	2000-01	2001-02	2002-03	2004-05	Mean
				A) Main plots : sowing dates			
S_1	SMW 28	495	699	346	632	696	569
S_2	SMW 30	191	209	296	489	410	317
S_3	SMW 32	219	228	213	100	571	322
S_4	SMW 34	402	271	465	239	479	369
	SEm±	44.0	23.0	16.0	9.2	35.5	64.5
	CD(P=0.05)	198.0	74.0	53.0	28.0	160.0	196.5
				B) Sub-plots : moisture conservation practices			
M_1	R&F (45 x 30 cm)	378	449	454	405	555	446
M_2	SRF(45-90x20 cm)	268	350	379	355	553	373
M_3	FB (45 x30 cm)	334	256	381	334	528	363
	SEm±	34.0	9.9	22.0	10.0	16.6	16.5
	CD(P=0.05)	NS	32.0	NS	33.0	NS	47.4
				C) Sub-sub plots : fertilizer levels			
F_1	40:20 N:P_2O_5 kg /ha	296	318	329	317	506	342
F_2	50:25 N:P_2O_5 kg /ha	334	351	411	366	539	372
F_3	60:30 N:P_2O_5 kg /ha	351	387	414	412	572	393
	SEm±	18.0	5.0	11.0	6.7	20.3	9.3
	CD(P=0.05)	NS	19.0	32.0	19.4	NS	26.1

R & F = Ridges and furrows; SRF = Skip row with furrow; FB = Flat bed

Table 2 Seed yield of sunflower as influenced by interaction effect due to sowing dates x moisture conservation practices

Sowing Dates	Moisture conservation practices								
	2000-01			2001-02			2004-05		
	R&F	SRF	FB	R&F	SRF	FB	R&F	SRF	FB
SMW 28	849	716	532	420	280	337	764	764	560
SMW 30	267	199	162	320	287	280	403	407	418
SMW 32	308	235	142	423	528	588	616	525	572
SMW 34	372	252	189	652	422	321	437	437	563
SEm ±		28.11			39.03			33.17	
CD(P=0.05)		95.03			136.6			108.16	
CV (%)		8.95			26.0			18.5	

R&F = Ridges and furrow; SRF = Skip row with furrow; FB = Flat bed; SMW = Standard meteorological week

Table 3 Seed yield of sunflower as influenced by interaction effect due to sowing dates x fertilizer levels

Sowing Dates	Fertilizer levels N:P_2O_5 kg /ha								
	2000-01			2001-02			2002-03		
	F_1: 40:20	F_2: 50:25	F_3: 60:30	F_1: 40:20	F_2: 50:25	F_3: 60:30	F_1: 40:20	F_2: 50:25	F_3: 60:30
SMW 28	634	690	772	314	338	386	540	693	713
SMW 30	189	205	233	212	326	349	436	484	547
SMW 32	204	232	249	408	543	587	091	093	116
SMW 34	243	276	293	381	438	575	200	246	272
SEm ±		9.98			21.64			13.29	
CD(P=0.05)		29.13			63.16			38.79	
CV (%)		8.95			13.10			16.80	

Table 4 Economics of sunflower (SS-56) cultivation as influenced by sowing dates, moisture conservation practices and *fertilizer levels (Pooled means)*

S No.	Treatment	Yield (kg /ha) Seed	Yield (kg /ha) Stalk	Gross returns (Rs /ha)	Net returns (Rs /ha)	B:C ratio
	A) Main plots : sowing dates					
S_1	SMW 28	569	1931	13311	5107	1.62
S_2	SMW 30	317	1721	8061	-143	0.98
S_3	SMW 32	322	1849	8289	85	1.01
S_4	SMW 34	369	2489	9869	1665	1.20
	SEm ±	65.5	287.4	1081.4	-	-
	CD(P=0.05)	200.0	N.S.	N.S.	-	-
	B) Sub-plots : moisture conservation practice.					
M_1	R&F(45 x 30 cm)	446	2065	10985	2583	1.31
M_2	SRF(45-90x20cm)	373	2177	9637	1535	1.19
M_3	FB (45cmx30 cm)	363	1750	9010	933	1.12
	SEm ±	16.5	200.9	273.9	-	-
	CD(P=0.05)	47.4	N.S.	789.1	-	-
	C) Sub-sub plots : Fertilizer levels N:P_2O_5 kg/ha					
F_1	40:20	342	2172	9012	897	1.11
F_2	50:25	372	1887	9327	1134	1.14
F_3	60:30	393	1932	9792	1487	1.18
	SEm ±	9.3	190.4	151.7	-	-
	CD(P=0.05)	26.1	N.S.	425.8	-	-
	D) Interactions: N. S.					

Table 5 **Consumptive use, moisture use efficiency and sustainability of sunflower as influenced by sowing dates, moisture conservation practices and fertilizer levels (Pooled mean)**

S. No.	Treatment	Seed yield (kg/ha)	Consumptive use (mm)	MUE (kg/ha mm)	Sustainable yield index (SYI)	Sustainable value index (SVI)
		A) Main plots : sowing dates				
S_1	SMW 28	569	269	2.12	0.62	0.67
S_2	SMW 30	317	248	1.28	0.41	0.33
S_3	SMW 32	322	207	1.56	0.27	0.32
S_4	SMW 34	369	203	1.82	0.57	0.65
		B) Sub-plots : moisture conservation practices.				
M_1	R&F(45 x 30 cm)	446	263	1.70	0.69	0.74
M_2	SRF(45-90x20cm)	373	229	1.63	0.51	0.56
M_3	FB (45cmx30 cm)	363	231	1.57	0.52	0.56
		C) Sub-sub plots : Fertilizer levels $N:P_2O_5$ kg /ha				
F_1	40:20	342	238	1.44	0.52	0.59
F_2	50:25	372	246	1.51	0.55	0.65
F_3	60:30	393	241	1.63	0.55	0.65

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Short communication

Economics of inter/mixed cropping of lucerne (*Madicago sativa*) in mustard, *Brassica juncea* (L.) Czern & Coss in northern agroclimatic zone of Gujarat

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Mustard is an important edible oilseed crop of arid and semi-arid region of north Gujarat during *rabi* season. Generally, mustard during *rabi* season followed by bajra crop in summer is taken in this zone. Summer bajra has higher water requirement (10 to 12 irrigations). Due to erratic and irregular rainfall, day-by-day the water table is going down. Therefore, there is a need to find an alternative crop of bajra during summer season which has less water requirement. There appears good scope of inter mixed cropping of lucerne (for seed production) in mustard in this region which require less number of irrigations (4 to 5 irrigation). This practice has an added advantage over sole crop of mustard due to the maximum utilization of natural resources like sun light, moisture, soil and saving of irrigation water and high economic return per unit area. Sardana and Sidhu (1997) reported higher Indian mustard equivalent yield without significant reduction in the yield of main crop of Indian mustard, thus leading to higher income from Indian mustard based intercropping system. At present there is lack of information on inter mixed crop of lucerne (for seed production) with mustard. The present investigation was therefore, conducted to find out suitable technology for inter/mixed cropping and there economic potential in this region.

An experiment was conducted from 2000-01 to 2003-04 at Main Castor-Mustard Research Station, S.D. Agricultural University, Sardarkrushinagar. Out of four years, the experiments were successful for three years. The soil at the experimental site was loamy sand with low available nitrogen (153 to 185 kg/ha), high in available phosphorus (67 to 72 kg/ha), high in available potassium (345 to 370 kg/ha) with pH range of 7.56 to 7.80. The experiment was laid out in randomized block design with four replications. The gross and net plot size were 6.00 m x 3.60 m and 5.10 m x 2.70 m, respectively. The experiment comprises of six treatments as given in Table 1. The mustard (GM 2) was sown in the second fortnight of October and lucerne (Anand 2) was sown (except mustard + lucerne mixed inn line sowing) in the first fortnight of November during each year. The summer bajra (GHB 316) was sown in the first fortnight of March. Seed rate of mustard and lucerne were 3.50 and 5.00 kg/ha, respectively. The mustard and bajra were fertilized with 75:50:30 NPS and 120:40:00 NPK kg/ha in the form of DAP, urea and gypsum, respectively. The mustard crop was harvested first in last week of February, then after cutting of lucerne was done in the first week of March. The lucerne crop was fertilized with 20 kg N/ha in the form of urea. There was no rainfall for the entire cropping programme during all the years, however, during 2002-03, total 106.4 mm rainfall was received in the months of December (36 mm), January (20 mm) and February (50.4 mm). Mustard crop was irrigated 6 times (two common irrigation for germination, 290 mm water), lucerne was irrigated 5 times (250 mm water) and summer bajra was irrigated 10 times (500 mm water) each at 50 mm depth of water except in mustard the second irrigation was given at 40 mm depth for better emergence of seed. The lucerne (seed) and bajra were harvested in the first week of June. Seed yields of mustard, lucerne and bajra and fodder yield of bajra were recorded. Equivalent yield of mustard was calculated on the basis of market rate.

Mustard seed yield: The differences in seed yields of mustard were found to be non-significant among the treatments, which suggested that the seed yield of mustard was not significantly reduced due to inter mixed cropping of lucerne which may be due to lesser competition for light, space and nutrients by inter mixed crop (Table 1). The increase in mustard yield compared with sole crop recorded was 8.70% in the treatment with mustard line sowing-lucerne broadcasting at the time of first irrigation to mustard crop and 4.63% in the treatment with mustard-lucerne mixed in line sowing. This may be attributed to N fixing behaviour of the legume crop lucerne. Singh and Rajput (1996) have also reported similar results.

Mustard equivalent yield: The mustard equivalent yield recorded in individual year and also in pooled analysis showed significant differences among the treatments (Table 1). The mustard equivalent yields were significantly higher under mustard-lucerne mixed in line sowing, but it was at par with mustard-lucerne mixed in line sowing-lucerne broadcasting at first irrigation to mustard crop, mustard-summer bajra and mustard line sowing-lucerne broadcasting during 2000-01 and 2003-04. During 2003-

04, mustard-lucerne mixed in line sowing were found at par with mustard line sowing-lucerne broadcasting. In 2003-04, mustard-lucerne mixed in line sowing along with lucerne broadcasting at first irrigation to mustard, mustard line sowing-lucerne broadcasting and mustard-lucerne mixed in line sowing were found at par among themselves and recorded significantly higher mustard equivalent yield *than rest of the treatments.*

The pooled analysis showed significant differences among the treatments. Mustard equivalent yield recorded under mustard-lucerne mixed in line sowing (37.38 q/ha), mustard-lucerne mixed in line sowing along with lucerne broadcasting at first irrigation to mustard, mustard-summer bajra and mustard line sowing-lucerne broadcasting were found at par among themselves and significantly superior over rest of the treatments. The lowest mustard equivalent yield was recorded under mustard sole crop. These findings are similar to the results of Sarma and Kakati (1991).

Economics: Mustard+lucerne mixed in line sowing recorded the highest net returns of Rs. 43826/ha with a benefit cost ratio of 3l11 followed by mustard line sowing+lucerne broadcasting at first irrigation to mustard crop with net returns of Rs. 41125/ha and benefit cost ratio of 2.87. The higher net returns were due to more total produce and higher support price of lucerne and lower cost of production of lucerne seeds as compared to summer bajra, respectively (Table 2). The lowest net returns were recorded under sole mustard. The mixed cropping of lucerne with mustard indicated an extra income of Rs. 22719 and Rs. 8796/ha over the sole crop of mustard and mustard-summer bajra sequence, respectively. These confirm the findings of Upasani (1994).

Water use efficiency (WUE): On the basis of three years data, mustard-summer bajra require higher number of irrigations needing more irrigation water than mustard+lucerne sown either mixed in line sowing or broadcasting of lucerne in mustard crop intercrop of lucerne with mustard. Mustard+lucerne mixed in line sowing required 490 mm irrigation water resulted to higher WUE (7.63 kg/ha mm) than sole mustard, mustard-summer bajra and other practices of mustard+lucerne. Higher equivalent yield recorded under mustard+lucerne mixed in line sowing than other treatments and required less amount of water as compared to mustard-summer bajra resulted to higher WUE than rest of the treatments. These results confirm those of Singh and Rana (2006).

Conclusion: It was concluded that mixed cropping of mustard+lucerne in line sowing or mustard line sowing+lucerne broadcasting at first irrigation to mustard are superior to other treatments and may be preferred against pure crop of mustard and mustard+summer bajra sequence in arid and semi-arid regions of north Gujarat.

Table 1 Effect of different treatments on seed yield and equivalent yield of mustard (kg/ha)

Treatment	Year				Pooled
	2000-01	2001-02*	2002-03	2003-04	
Mustard sole crop	1534	1665	1834	1944	1771
Mustard-summer bajra	1539 (3708)	1884	2130 (2973)	1958 (3683)	1876 (3455)
Mustard+lucerne mixed in line sowing	1507 (3994)	1669	2001 (3136)	2051 (4084)	1853 (3738)
Mustard+lucerne (1:1), Lucerne sown at the time of first irrigation to mustard crop	1493 (3318)	1642	1975 (2618)	1998 (3164)	1822 (3033)
Mustard (line sowing) + lucerne broadcasting at the time of first irrigation to mustard crop	1525 (3416)	1903	2020 (3145)	2231 (3949)	1925 (3498)
Tr.3 + lucerne broadcasting at the time of first irrigation to mustard crop	1561 (3631)	1540	1922 (3339)	1968 (3597)	1817 (3523)
CD (P=0.05)	NS (587)	1.89	NS (280)	NS (300)	NS (322)

* Data not included in pooled analysis due to severe damage of lucerne by birds resulted in poor seed setting.
Data in parenthesis indicated mustard equivalent yield

Table 2 Economics of different treatments (Average of three years)

Treatment	Mustard seed yield (kg/ha)	Bajra/lucerne yield (kg/ha)		Mustard equivalent yield (kg/ha)	Net returns (Rs/ha)	B:C ratio	Quantity of water applied (mm)	WUE (kg/ha mm)
		Seed	Fodder					
Mustard sole crop	1771	-	-	1771	21107	2.35	290	6.11
Mustard-summer bajra	1876	3072	9153	3455	35030	1.82	790	4.37
Mustard+lucerne mixed in line sowing	1853	528	-	3738	43826	3.11	490	7.63
Mustard+lucerne (1:1), Lucerne sown at the time of first irrigation to mustard crop	1822	331	-	3033	33299	2.34	490	6.19
Mustard (line sowing) + lucerne broadcasting at the time of first irrigation to mustard crop	1925	455	-	3498	41125	2.87	490	7.14
Tr.3 + lucerne broadcasting at the time of first irrigation to mustard crop	1817	483	-	3523	40464	2.78	490	7.19
CD (P=0.05)	NS	-	-	322	-	-	-	-

Sale price (Rs/kg)
Mustard seed : 17.0
Lucerne seeds : 50.0
Bajra seeds : 5.5
Bajra fodder : 0.6

Irrigation charge : Rs. 300/irrigation/ha

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Short communication

Evaluation of groundnut germplasm for physiological, morphological and pod yield with resistance to biotic stresses

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Groundnut is the premier oilseed crop in India. It is grown in about 8.0 m ha with a production of 7.5 m tones. In Andhra Pradesh it is mainly cultivated as rainfed crop during kharif season in dry lands. Besides drought several biotic stresses *viz.*, leaf miner and late leaf spot disease cause significant yield loss and affect the stability of groundnut production. Early maturing Spanish bunch cultures are most popular but they are susceptible to biotic stresses. In order to improve the plateaned productivity of groundnut clear understanding of several of morpho-physiological attributes that contribute to various biotic and abiotic stresses and their relationship with yield is an urgent pre-requisite. Therefore a balanced combination of appropriate physiological, morphological parameters along with resistance to abiotic stresses is necessary to achieve higher productivity in a specific environment. Groundnut has great genetic diversity and is distributed along length and breadth of the country. Further resistance to drought, multiple stresses is warranted because the occurrence and intensity of different biotic stresses is highly variable across space and time. Subramanyam *et al.* (1995) have reported that LLS and rust have caused considerable yield loss (20-25%) and 15-17% by late leaf spot. The present investigation was envisaged to identify potential germplasm accessions resistant to drought, multiple biotic stresses along with desirable morphological attributes.

A set of 604 diverse groundnut germplasm from under different sub species i.e., *hypogea* and *fastigiata* were evaluated. The germplasm accessions were grown in a single row of 5 m length with Kalahasti variety as check sown after every 10 lines of germplasm by adopting a spacing of 30 x 10 cm for Spanish bunch, 45 x 15 cm for Virginia bunch and Virginia runner types at Regional Agricultural Research Station, Tirupati during *kharif*, 2006. Fertilizers were applied as per the recommended schedule. The data for the character germination percentage were recorded for all the lines sown from the material harvested during *kharif*, 2005, days to initial flowering, SPAD chlorophyll meter reading. Disease severity of late leaf spot was recorded by adopting a modified 1-9 scale and leaf miner incidence on 1-7 scale under field conditions (Subramanyam *et al.*, 1995) and jassid incidence (1-8 scale), leaf miner incidence on 1-7 scale under field conditions and pod yield/plant. Morphological characters *viz.*, growth habit, leaflet shape, leaflet size and leaf colour following IBPGR/ICRISAT groundnut descriptors (IBPGR/ICRISAT, 1993). The data on quantitative descriptors were analyzed for frequency of appearance.

The quantitative characters 604 accessions of groundnut subjected to statistical analysis showed that all the characters *viz.*, germination percentage, days to initial flowering, SPAD chlorophyll meter reading, leaf miner incidence and severity of late leaf spot with greater variability. The parameters of variation have indicated sufficient variability in the germplasm for physiological, morphological, yield and biotic stresses and also the germplasm showed considerable variability to majority of the traits as indicated by coefficients of variability, which is required to for the step up breeding strategy in crop enhancement programme of the traits as indicated by coefficients of variation. Pod yield/plant had the highest variability. The lowest was observed for SCMR. On the basis of coefficient of variation the highest CV (>35%) was recorded for pod yield/plant which moderate CV was observed for germination per cent, leaflet length/width ratio and jassid incidence. However lowest coefficient of variation was recorded (<20%) for days to flowering, SCMR, leaflet length, leaflet width, leaf miner incidence and LLS. Germination percentage ranged from 20.0% (ICGV-99085) to 100.0% (23 accessions), days to initial flowering from 22.0 (ISK-06-8) to 31.0 (IVK-1-05-7), SCMR from 25.6 (ICG-9592) to 53.4 (LSVT-1-05-7), leaflet length from 3.24 cm (IVK-04-12) to 7.06 cm (TCGS-64), leaflet width from 1.44 cm (ICGV-87145) to 4.20 cm (TCGS-209), leaflet length/width ratio from 1.22 (TCGS-209) to 4.88 (ICGV-87430), leaf miner incidence from 2.0 (4 accessions) to 7.0 (11 accessions) based on 1-7 scale, jassid incidence from 2.0 (12 accessions) to 8.0 (12 accessions) and pod yield/plant from 0.44g (ICG-7380) to 23.67g (TCGS-381). Earlier Upadhyaya *et al.*, (2005), Holbrok and Dong (2005) and John *et al.*, (2006) reported similar results in groundnut and the severity of late leaf spot from 1.0 (LSVT-1-05-2) to 9.0 (134 accessions) on 1-9 scale.

Based on mean values, some of the promising accessions were identified in the germplasm collection as 117 accessions have good germination, 67 accessions came to flowering early, high SCMR (63 accessions), 43 had shown least damage due to leaf miner on 1-7 scale and 107 recorded a least score for late leaf spot on 1-9 scale (Table 1). The data on frequency distribution of qualitative characters of 604 accessions (Table 2) revealed that the maximum obovate shape of leaflets was observed. The maximum frequency of leaf colour is light green and dark green and leaflet size is large followed by medium size leaves. The maximum frequency of erect growth habit is observed in the population. From this study, it is clear that it is possible to develop high yielding lines with drought resistance and resistant to foliar disease that is late leaf spot with superior agronomic features. Wynne *et al.* (1991) stated that the lines developed through hybridization had moderate levels of resistance with high yield. The parameters have indicated sufficient variability for different characters, so that it would enable the breeder to utilize appropriate genetic resources in the crossing programme to improve the particular character.

Table 1 Promising accessions of groundnut germplasm identified from evaluation for different characters

Character	Promising accessions
Germination percentage (Above 89%)	TCGS-720, LSVT-1-05-3, ICG-9641, TCGS-752, IVK-orange, ICG-4102, TCGS-765, LSVT-1-05-4, ICGV-94361, TG-35, TCGS-209, VR-16, ICGV-93218, VG-8, TCGS-267, CV-6, ICGV-76, CV-24, TCGS-381, ISK-5, ICGV-89280, IBK-9104, TCGS-398, ISK-1-05-1, ICGV-15236, R-8808, TCGS-728, ISK-1-05-20, ICGV-15234, CV-3, ICGV-9940, ISK-03-15, ICGV-99211, ICGV-88635, TCGS-750E, ICGV- 87855, CV-45, INS-9100, ISK-1-05-16, TG-42, ISK-1-05-05, ICG-1533, IBK-9103, ISK-04-26, ISK-04-11, IVK-05-8, ICG-9940, K-134, IVK-05-9, IVK-04-5, TCGS-738, TCGS-578, TCGS-110, TCGS-647, TCGS-325, TCGS-756, TCGS-724, TCGS-645, TCGS-750 C, TCGS-640, TCGS-728, ATG-17, ISK- 1-05-1, ISK-1-06-8, ISK-1-04-16, ISK-19, LSVT-1-05-2, LSVT-05-5, ISK-03-14, IVK-1-06-7, Local red, ISK-1-05-15, ISK-1-05-4, LSVT-05-10, IVK-04-13, AVK-06-3, AVK-06-9, ISK-06-1, ICGV-89280, ICGV-15236, ICGV-15234, ICGV-13919, ICG-9008, ICG-7380, ICGV-87835, ICG-9688, ICG-5597, ICG- 4701, ICG-9110, ICG-8826, ICG-13917, ICG-11108, ICG-10302, ICG-5656, ICG - 5449, ICG - 5494, ICG-156, ICG-13057, ICG-5896, ICG-7825, ICGV-00380, ICGV-03318, ICGV-03331, ICGV-97243, ICGV-94361, ICGV-00310, ICGV-02207, ICGV-020070, ICGV-020072, ICGV-020075, ICGV-00440, ICGV-00401.
Days to initial flowering (Below 25 days)	CV-17, ICG-4597, TPT-4, CV-16, ICG-9887, ICGV-44, K-1209, ICGV-86355, ICG-7848, TG-35, ICG-4588, ISK-1-05-1, ISK-1-04-18, TCGS-645, TCGS-96, ICGV-94361, TCGS-639, ICGV-00314, ICG-9204, -00438, ICGV-95465, ICGV-01005, ICGV-98294, ICGV-03353, ICGV-03352, MLTG-58, TCGS-584, VG-8, ICG-8900, ICGV-92029, ICGV-00304, Local red, ICG-4558, GPB-2, TCGS-451, TCGS-748, TCGS-728, ISK-06-7, ISK-06-8, ISK-06-15, ISK-06-2, ISK-06-3, ISK-06-6, ICGS-91186, ICGV-89280, TPT-1, ICGV-00315, K-1128, ICGV-89104, TG-27, GV-13, ICGS-107, JL-24, ICGS-10, ISK-1-05-3, ICG-481, ICG-4597, ICG2738, ICG-5867, ICGV-7847, ICG-7580, ICG-4654, ICG-7133, ICG-5779, ICG-7882, ICG-11108
SCMR (SPAD chlorophyll meter reading) (Above 45.0)	ISK-1-04-2, MLTG-58, TCGS-634, ICGV-86388, TCGS-752, TCGS-574, 1BK 9105, LSVT 1-05-3, TCGS-764, TCGS-765, ICGV-99210, CV-16, ISK- 9108, TCGS-111, CV-3, TCGS-728, FDRS-10, 1-SVT-1-05-7, ISK-13, TCGS-596, ICGV-91114, FSVT-1-05-4, CV-22, ISK-1-05-2, TCGS-730, TCGS-732, ISK 9109, TCGS-64, TCGS-84, VR-16, TCGS-712, TCGS-617, ICGV-87145, ICG-3056, ATG-17, ISK-1-05-8, TCDS-110, FSVT-1-05-2, JYOTHI MLTG-57, TCGS-14, ICGV-8025, IVK-1-06-7, AVK-2006-8, TCGS-303, LSVT-1-05-8, VG-8, *TG-26, ICGV-00304, TCGS-639, ISK-1-04-04, TCGS-758, TCGS-37, ISK-2-03-15, TCGS736, TCGS-305,* TCGS-10, AIS-9200, ICG-5597, ISK-06-6, ICG-156, ICG-7 825, IVK-06-12, TCGS-574, CV-16
High yield	ANS-9200, LSVT-1-05-3, CV-17, ICGV-86355, ICGV-86145, ISK-1-05-7, TCGS-753, FSVT-1-05-7, ISK-03-1-5, ICGV-94361, ICG-4635, TCGS-305, ISK-25, TCGS-10, CV-16, ISK-1-04-04, TCGS-728, ISK-91013, TCGS-37, TCG-44, CV-23, TCGS-722, IVK -04-12, TCGS-748, GPBD-4, ICG-11691, ISK-06-2, IVK-06-8, ISK-06-25, ICG-11108, ICGV-00440, ICGV-02126, ICGV-97079, ICGV-020075, ICGV-020070.
Late leaf spot (**1-5** score)	LSVT-1-05-2, ISK-5, PBG-6, ISK-03-15, ICGV-87495 ISK-1-05-31, ICG-1533, ICGV-13916, TCGS-240, TG-40, ISK-20, IVK-04-12, GPB-4, ISK06-8, ISK-06-3, ICG-15236, ICG-4995, ICG-13917, ICG-11325, ICGV-02198, ICGV-020069, ICG-12918, ISK-06-15, ICGV-020075, IVK-1-04-14, ICGV-86145, ISK-1-05-05, ICGV-88635, TCGS-715, ICGV-89280, ISK-3, ICGV-15236, IVK-1-06-2, ISK-1-05-20.
Leaf miner incidence **(2-**3 score)	*TCGS-634,* ANS 9200, *ISK 9108, TCGS-111, TCGS-746, NcAc - 343 ICG-5794, LSVT-1-05-7, FSVT-1-05-4, CV-22,* ISK-1-05-21, ICGV-87430, ISK-1-04-16, ISK-19, ISK-3, ICGV-8025, ICGV-11679, ICGV-13942, IVK-1-06-2, AVK-06-05, AVK-06-05, AVK-06-08, ICGV-15234, AIS-9200, ICGV-00292, ICGV-89280, IVK-05-11, ISN-9201, ICGV-87145, IVK-05-5, IVK-05-9, IVK-04-9, ICGV-02133, ICGV-00391, ICGV-00440, ICG-7825, ISK-06-6, ICG-7872, ICG-9688
Jassid incidence **(2-3** score)	IVK-04-13, IVK-03-18, IVK-04-5, IVK-06-14, ISK-06-5, ISK-06-15, ISK-06-21, ISK-06-13, IVK-06-8, IVK-06-9, ISK-06-25, ISK-05-7, LSVT-1-05-5, ISK-04-7, ISK-03-1-5, ISK-1-04-4, ISK-1-05-31, ISK-2-03-15, ISK-04-11, ISK-20, IVK-05-8, IVK-04-7, IVK-04-9, IVK-05-13, IVK-04-6, TCGS- 762, TCGS-647, TCGS-735, TCGS-334, TCGS-756, *TCGS-68, TCGS-331, TCGS-750E, TCGS-740, TCGS-96, TCGS-758, TCGS-750D, TCGS-640,* ICGV-88017, ICGV-86355, ICGV-15234, ICGV-00315, ICGV-89280, ICGV-99210, ICGV-00304, ICGV-94251, ICGV-00290, ICGV-00440, ICGV-97079, ICGV-00457, ICGV-99083, ICGV-00429, ICGV-99085, ICGV-03310, ICGV-03353, ICGV-02063, ICGV-97243, ICGV-94357, ICGV-04042, ICGV-04043, ICGV-02133, ICGV-01005, ICGV-01020, ICGV- 02198, ICGV-020070-1, ICG-5794, ICGV-8115, ICGV-7380, ICGV-4255, ICGV-9204, ICGV-5597, ICGV-8826, ICGV-15236, ICGV-7506, **ICGV-11108**, ICGV-5788, ICGV-5659, ICGV-5656, ICGV-5495, ICGV-5669, ICGV-13070, ICGV-7825, ICGV-**9902**, **ICGV**-2738, VG-7, K-267, K-3, GV-13, GPB-2, PB-06, ICGS-44, TG-42, **IBK**-9103, **TG-26, ICGS-44, GPB-2, ICGV**-020069-1, ICGV-020069-2, ICGV-020070-2, ICGV-970[illegible]9, ICGV-00446, **ICGV-00451, ICGV-99083, ICGV-00440**, NcAc-343.

Table 2 Frequency distribution of qualitative characters of 604 groundnut germplasm accessions evaluated at Regional Agricultural Research Station, Tirupati

Descriptor state	Number of observations	Frequency %
Growth habit		
a) Decumbent-1	8	1.3
b) Decumbent-2	17	2.8
c) Procumbent-3	26	4.3
d) Erect	553	91.6
Leaflet shape		
a) Elliptic	9	1.5
b) Oblong elliptic	89	14.7
c) Narrow elliptic	67	11.1
d) wide elliptic	86	14.2
e) Cuneate	1	0.2
f) Suborbicular	20	3.3
g) Lanceolate	21	3.5
h) Oblong	88	14.6
I) Oblong lanceolate	45	7.4
j) Ovate	35	5.8
k) Obovate	129	21.4
l) Orbicular	14	2.3
Leaf colour		
a) Green	148	24.5
b) Light green	258	42.7
c) Dark green	177	29.3
d) Bottle green	21	3.5
Leaflet size		
a) Small size	105	17.4
b) Medium size	177	29.3
c) Large size	322	53.3

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Short communication

Thrips fauna in sunflower, *Helianthus annuus* L.

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Sunflower (*Helianthus annuus* L.) is a promising oil seed crop in the country next to groundnut and soybean. Sunflower oil contains more unsaturated fatty acids like linoleic acid which makes the oil suitable for heart patient. Recently Sunflower cultivation has been seriously hampered by an unusual necrosis disease (SND). The disease was observed for the first time during 1997 at Bagepally near Bangalore (Karnataka) (Singh *et al.*, 1997). The causal virus of the disease has been identified as tobacco streak ilar virus and shown to be transmitted by thrips in the presence of infected pollen grains (Rao *et al.*, 2000 and Ravi *et al.*, 2001). Present studies were carried out to find the colonization of thrips species on Sunflower and *Parthenium hysterophorus*, a potential reservoir host of tobacco streak ilar virus.

Monthly sowings of Sunflower cultivar Morden were taken from August 2003 to March 2004 in a plot size of 500 sq.m (25 m x 20 m) at College Farm, College of Agriculture, Rajendranagar. The plot was divided into three replications (25 m x 6.7 m of each replication) with 60 x 30cm spacing. Recommended agronomic practices except plant protection measures were taken up. The thrips population was regularly observed on five sq.m selected area in each replication. (one sq.m from four corner of the field and one sq.m from the center) at weekly interval. One plant at random was selected in each one sq.m. area and the head was bent aside and three strokes were given. Dislodged thrips were counted and transferred to 70 % alcohol for identification (Bullock, 1963). Thrips were also collected from Parthenium hysterophorus. The different thrips species were identified using the keys of Amin and Palmer (1985).

Five different thrips species identified both on Sunflower and *P. hystreophorus* were *viz.*, *Thrips palmi* (Karny), *Frankliniella schultzei* (Trybom), *Scirtothrips dorsalis* (Hood), *Megalurothrips usitatus* (Bagnall) and *Haplothrips gowdeyi* (Frnklin). Among five species *H. gowdeyi* belongs to Tubulifera suborder and other four to Terebrantia suborder, respectively. The details of thrips are given in Table 1.

The prevalence of the thrips on sunflower was documented by Basappa and Sriharan (1999) (*S. dorsalis* and *M. usitatus*), Men and Kandalkar (2002), (*S. dorsalis, M. usitatus* and *Haplothrips* sp) Chander Rao *et al.* (2002) (*T. palmi, F. schultzei, S. dorsalis* and *M. usitatus*) and the present findings are in accordance with these workers. The identification of all the five species on P. hysterophorus is probably because the samples were collected on *P. hysterophorus* available within sunflower field or nearer to sunflower fields.

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Table 1 Morphological characters of different thrips species

Thrips palmi (Karny)	*Frankliniella schultzei* (Trybom)	*Scirtothrips dorsalis* (Hood)	*Megalurothrips usitatus* (Bagnall)	*Haplothrips gowdeyi* (Franklin)
Adult females were straw yellow to pale brown in colour, 0.9 mm long	Adult females pale in colour and 1 mm long	Adult female, yellow in colour and 0.7 mm long, and were relatively small	Adult female large and dark brown	Female was dark brown or black in colour and 2.0 mm long
Antennae 7 segmented. Segments III-V equally bicoloured	Antennal segments III and IV paler basally	Antennae 8 segmented. Segment I paler, II concolorous with the body, III-VIII grey brown	Pronotum with two pairs of long posteroangular setae	The head is slightly longer than wide
Pronotum having two pairs of setae on the posteriolateral margin, whereas, no setae on the anteriolateral margin	Pronotum with two pairs of setae on the anteriolateral margin and two pairs on the posteriolateral margin	No setae on the pronotum	Wings banded and forewings with a gap in the row of first vein setae	Mid anternal segments yellow in colour
Metanotum with a pair of campaniform sensillae	Metanotum without campaniform sensillae	Sides of the thorax slightly darker. Pronotum postangulars short stout dark	Sternite VII median posteromarginal setae situated anterior to margin	The internal pigmentation is especially concentrated in the thoracic region is dark red
Forewings with broken rows of wing vein setae	Abdominal IX b1 setae slightly shorter than b_2	Forewings with few small setae on the veins, hind wings with two setae. Forewings nearly uniform grey. Fore wing costa bear 20-23 setae	Male tergite IX median setae finer, posterior margin without projections	Yellowish tip of forelegs
Abdominal tergite II with 4 lateral marginal setae. Abdomen slender and long	Forewings with two complete rows of wing vein setae	Abdominal tergites with dark patch medially. III-VIII segments each with a basal transverse dark line with a light brown blotch below it		
	Ocellar setae III about twice as long as major posto oculars			

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Short communication

Biology of mustard aphid, *Lipaphis erysimi* (Kalt.) on *Brassica* genotypes under laboratory conditions

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Biology of mustard aphid, *Lipaphis erysimi* (Kall.)was studied at 24.1°C and 76% RH on excised leaves of 13 *Brassica* lines to ascertain the basis of resistance against aphid infestation. Nymphal duration (7.7 to 8.0 days) and pre-reproductive durations (1 days each) did not show variations on different rapeseed-mustard genotypes. However, reproductive period, fecundity/female, average fecundity/day/female, average longevity and total life span differed significantly on various *Brassica* lines. The reproductive period ranged from minimum of 10.33 days on TMH-52 (*Eruca sativa*) to maximum of 18.00 days on BSH-1 (*Brassica campestris*) var. brown sarson. Fecundity per female was significantly low and on par with *E. sativa (32), B. tournifortii (32), B. nigra (33), PCR-10 (41) and* RWH-1 (42). The average fecundity/day/female also differed significantly on various genotypes being (2.30) on *B. nigra*. On the basis of lower fecundity i.e., 2.30 to 3.73 nymphs/female/day on the hosts PCR-10, RWH-1, RH 7846, T-6342 and purple mutant (*B. juncea*), TMH-52 (*E. sativa*), *B. nigra* and *B. tournfortii* were considered *promising against mustard aphid. The promising genotype* exhibited antibiosis type of resistance.

The average productivity of rapeseed-mustard crops in India is very low than other countries like Sweden, Canada, Germany and United Kingdom. Out of several constraints responsible for low productivity, the insect pests are important, of which, mustard aphid, *L. erysimi* is a major one causing 35 to 73% reduction in yield (Rohilla *et al.*, 1987; Bakhetia and Sekhon, 1989 and Kumar, 1991) and 6% reduction in oil content (Singh *et al.*, 1987). During the years of out break of this pest, it has to be *managed through use of insecticides only. But, the* extensive use of these chemicals lead to the development of insecticidal resistant insect strains which contributes to *the problems of ecological imbalance and various direct* and indirect health hazards. Looking into the present concept of integrated pest management programmes, the present studies on the biology of mustard aphid, *L. erysimi* was carried out on 13 elite genotypes of *Brassica* to ascertain the basis of resistance against aphid infestation.

The biology of mustard aphid, *L. erysimi* on 13 rapeseed-mustard genotypes (Table 1) was carried out under laboratory conditions at 24.1°C and 76% RH. The second or third leaf along with petiole from the top of the plant were plucked from each genotype and brought to the laboratory in separate polythene bags. The petiole of each leaf was wrapped in water soaked absorbent cotton wool swab separately, to keep the leaf turgid. The leaf along with the swab was placed in a separate water filled, specimen tube (7 x 2.5 cm). The gravid mustard aphid were collected from respective genotypes separately from the field kept under unprotected conditions.

One gravid female from the respective genotype was released on leaf maintained in a separate specimen tube. These specimen tubes were replicated five times. Next day, all newly borne nymphs except one and female were removed. The leaves were changed daily. Aphids were transferred from one leaf to other with the help of camel-hair brush. Observations on the various biological parameters were recorded after every 24 hrs.

The data presented in Table 1 indicates that the first, second and third nymphal instars were completed in two days each on all the genotypes at average temperature of 28.1°C and RH of 76% under laboratory condition. Duration of fourth instar nymph varied from a minimum of 1.7 days on the PCR-10 to the maximum of 2 days on most of the remaining genotypes. The total nymphal duration varied from 7.7 to 8.0 days with no differences on all the genotypes. The pre-reproductive period lasted for one day on each genotype. The reproductive period the real indicative of host plant resistance, differed significantly in *Brassica* genotypes confirming the findings of Singh *et al.* (1965) and Rohilla *et al.* (1987). The reproductive period ranged from 10.33 days on *E. sativa* (TMH-52) to 18.00 days on *B. campestris* (BSH-1). The reproductive period on TMH-52 at par with *B. tournifortii* (10.67 days). It varied from 13.33 to 14.67 days, but statistically at par on the hosts *viz.*, PCR-10, RWH-1, RW-32-2, RH-7846, T-6342 purple mutant and *B. nigra*. The post-reproductive period also varied significantly among the different genotypes, being minimum (0.53 days) on TMH-52 and maximum (1.80 days) on GSH-1. The average longevity of adults of *L. erysimi* varied significantly from a minimum of 11.87 days on TMH-52 to the maximum of 19.80 days each on RC-1425 and BSH-1. The average life span of the reproductive female also differed significantly on different rapeseed-mustard genotypes. It was minimum i.e., 19.87 days on host TMH-52 closely followed by *B. tournifortii* (20.60 days). The total life span was significantly more (27.83 days) on *B. juncea* cv. RH-7846 closely followed by Varuna (albino), RC-1425, BSH-1 and GSH-1 where it ranged from 26.0 to 27.8 days. The present findings are in accordance with the findings of Singh *et al.* (1965), Kundu and Pant (1968), Kalra *et al.* (1987), Dilawari and Dhaliwal (1988), Singh *et al.* (1996) and Agarwal *et al.* (1996) who reported that (*E. sativa*), (*B. tournifortii*), *B. nigra*, purple mutant were resistant to aphid infestation at various locations in India.

Fecundity per female was low on resistant cultivars i.e., 31.67 nymphs on *E. sativa* (TMH-52) which was at par with other hosts like PCR-10, RWH-1, purple mutant of *B. juncea, B. nigra* and *B. tournifortii*. Similarly, average fecundity/female/days was significantly less i.e., 2.30 on *B. nigra* and maximum of 7.03 and 5.80 on Varuna (albino) and BSH-1, respectively. These findings further supported the view that resistant cultivars had antibiotic effect on the development of mustard aphid in the form of reduced reproductive period, adult longevity, total fecundity and average fecundity per day.

Table 1 Biology of mustard aphid, *Lipaphis erysimi* (Kalt.) on excised leaves of rapeseed-mustard genotypes under laboratory conditions

Species/Genotypes	Nymphal instar				Duration (days)						Average fecundity	
	1st	2nd	3rd	4th	Total nymphal period	Pre-reproductive	Reproductive	Post-reproductive	Average adult longevity	Average life span	per female	per female/day
***B. juncea* (L.) Czern & Coss.**												
PCR-10	2.0	2.0	2.0	1.7	7.7	1	14.0	0.9 (1.4)*	15.9	23.6	41.3	3.2
Varuna (albino)	2.0	2.0	2.0	1.9	7.9	1	16.7	0.8 (1.4)	18.5	26.4	116.3	7.0
RWH-1	2.0	2.0	2.0	2.0	8.0	1	14.3	0.8 (1.3)	16.1	24.1	42.0	3.1
RW-32-2	2.0	2.0	2.0	2.0	8.0	1	14.0	1.0 (1.4)	16.0	24.0	65.0	4.6
RC-1425	2.0	2.0	2.0	1.8	7.8	1	17.3	1.4 (1.6)	19.8	27.6	91.0	5.3
RH-7846	2.0	2.0	2.0	2.0	8.0	1	13.3	1.5 (1.6)	15.8	23.8	48.7	3.7
T-6342	2.0	2.0	2.0	2.0	8.0	1	14.7	1.0 (1.4)	16.6	24.6	53.7	3.7
Purple mutant	2.0	2.0	2.0	2.0	8.0	1	13.3	0.9 (1.4)	15.3	23.3	47.7	3.6
***B. campestris* (L.)**												
BSH-1	2.0	2.0	2.0	1.9	7.9	1	18.0	0.8 (1.3)	19.8	27.7	102.3	5.8
***B. napus* (L.)**												
GSH-1	2.0	2.0	2.0	2.0	8.0	1	17.0	1.8 (1.7)	19.8	27.8	92.3	5.5
***Eruca sativa* Mill.**												
TMH-52	2.0	2.0	2.0	2.0	8.0	1	10.3	0.5 (1.2)	11.9	19.9	31.7	3.1
***B. nigra* (L.)**												
Local	2.0	2.0	2.0	2.0	8.0	1	14.7	0.9 (1.4)	16.5	24.5	33.3	2.3
***B. tournifortii* Gouan**												
Local	2.0	2.0	2.0	2.0	8.0	1	10.7	0.9 (1.4)	12.6	20.6	32.0	3.0
SEm±	-	-	-	-	-	-	0.87	0.03	0.9	0.93	5.29	0.52
CD (P=0.05)	NS	NS	NS	NS	NS	1	2.53	0.09	2.6	2.68	15.31	1.49

* Figures in parenthesis are √ n + 1 value

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Short communication

Influence of crop phenology on population dynamics of aphid, *Uroleucon compositae* Theobalt and its predator in safflower, *Carthamus tinctorius* Linn.

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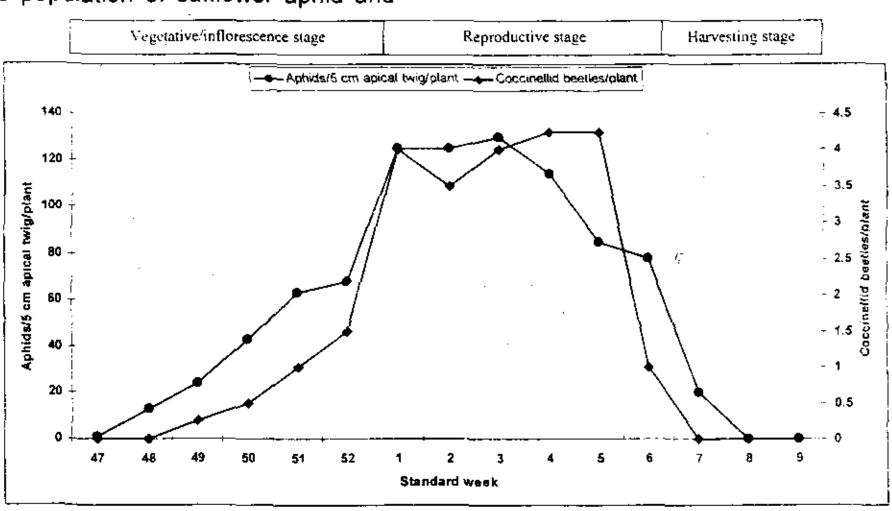
Safflower (*Carthamus tinctorius* L.) is an important traditional *rabi* oilseed crop and India is the highest producer in the world. The crop is invaded by a host of insect pests (Singh *et al.*, 1999). The aphid [*Uroleucon compositae* Theobalt (Aphidae:Homoptera)] is the key pest causing 30-50% loss in seed yield of safflower and if no control measures are undertaken, whole crop is lost (Awasthi and Agrawal 1995, Arya *et al.*, 1996, Singh *et al.*, 2000). A coccinellid beetle [*Menochilus sexmaculatus* Fab. (Coccinellidae:Coleoptera)] has been reported as an important predator of safflower aphid (Upadhyay *et al.*, 1980, Devkumar *et al.*, 1986, Singh *et al.*, 1999). The studies were conducted to find out the influence of safflower crop phenology on population dynamics of safflower aphid and its coccinellid predator.

Safflower cultivar A-I was raised on 22[nd] October, 2001 in a plot size of 10 m x 5 m providing all agronomic practices including 40 and 25 kg N and P/ha, respectively in pesticide free zone of the research farm of Directorate of Oilseeds Research, Rajendranagar, Hyderabad. Observations on the population of safflower aphid and coccinellid beetle/5 cm apical twig/plant were recorded from 20 randomly selected plants at weekly interval starting from 28 days old crop [47[th] standard week (SW) of 2001] up to 127 days old crop (9[th] SW of 2002) as per the procedures of All India Research Workers' Group Meeting of All India Coordinated Research Project on Safflower (Anonymous, 2003). The data on meteorological parameters were collected from the Meteorology Laboratory situated in the vicinity of Research Farm.

Perusal of results indicated severe infestation of safflower aphid during crop season, as its population reached above economic threshold level in the 50[th] SW when crop was in pre-flowering stage and 50 days old (Fig. 1). Preceding two months i.e., 50[th] SW of 2001 to 6[th] SW of 2002 were more crucial for survival and multiplication of aphids. A set of weather parameters *viz.*, temperature (maximum) 28°C and temperature (minimum) 16°C coupled with 66% relative humidity (RH) proved conducive for the multiplication of safflower aphid coinciding with reproductive stage of the crop.



	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9
Max. temp (°C)	28	27	28	29	26	32	25	26	29	32	28	28	31	32	34
Min. temp (°C)	16	14	11	10	13	16	19	13	14	21	19	17	17	16	17
RH (%)	73	73	66	71	70	83	72	63	55	55	54	52	55	60	62
Rainfall (mm)	0	0	0	0	0	0	0	0	0	[illegible]	0	25	0	0	0

Fig. 1. Influence of crop phenology on aphid (*U. carthami*) and its predator (*M. sexmaculatus*) in safflower (*Carthamus tinctorius*)

Predatory coccinellid beetle (*M. sexmaculatus*) population was observed starting from initiation of aphid infestation till its disappearance on the crop which suggested that it has a greater potential in containing the population of aphids under field conditions (Fig. 1). Moreover, the coccinellid population @ 3-4 beetles/aphid colony was enough for drastic reduction in aphid population below economic threshold. Present findings are in the concurrence with the previous studies (Upadhyay *et al.*, 1980, Devkumar *et al.*, 1986, Awasthi and Agrawal 1995, Arya *et al.*, 1996, Singh *et al.*, 2000). It is inferred that when the natural population of 3-4 coccinellid beetles/aphid colony was observed in the field condition, it was not required to follow any insecticidal measures for the control of safflower aphid.

In a field study conducted during 2001-02 to find out the influence of crop phenology on population dynamics of aphid (*U. compositae*) and its predator (*M. sexmaculatus*) in safflower, severe infestation of aphid reached during pre-flowering stage when the crop was of 50 days old. Crop phenology of two months i.e., 50^{th} standard week (SW) of 2001 to 6^{th} SW of 2002 was crucial for survival and multiplication of safflower aphid. The temperature ranging from 16 to 28°C coupled with 66% RH proved conducive for aphid multiplication coinciding with crop reproductive stage. Population of predatory coccinellids @ 3-4 beetles/aphid colony was enough to deplete drastically the aphid population below economic threshold and it was *not required to follow any insecticidal measures for the* control of safflower aphid.

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Short communication

Variability among isolates of *Fusarium oxysporum* f.sp. *carthami* from Maharashtra state

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Safflower (*Carthamus tinctorius* L.) is cultivated as an important *rabi* oilseed crop in Maharashtra state. The wilt disease caused by *Fusarium oxysporum* f. sp. *carthami*, is one of the major diseases noticed on safflower grown in Maharashtra, Karnataka and Andhra Pradesh. The disease was recorded for the first time in India by Singh *et al.* (1975). Now, it has become a serious disease in all safflower growing areas of India. The disease causes yield loss up to 93% in susceptible varieties (Sastry and Ramchandram, 1994). It is a destructive soil and seed-borne disease. A variety which exhibits resistance in one area may show susceptibility in another area indicating variability in the pathogen.

In the present study, the report on cultural, morphological and pathogenic variability among the *Fusarium oxysporum* f sp. *carthami* isolates in India. An extensive survey was conducted during *rabi*, 2004-05 all over the Maharashtra state and the wilted plant samples were collected and the isolation of causal agent was carried out. A total of 68 isolates were obtained. The morphological, cultural and pathogenic variability amongst the isolates of *Fusarium oxysporum* f. sp. *carthami* collected was studied.

The pathogenicity of all *Focr* isolates was confirmed by Koch's postulates. For morphological characterization, the size of microconidia and macroconidia was measured. The presence of chlamydospores was also recorded. For cultural study, the growth rate and type of mycelium was recorded on PDA medium.

For studies on pathogenic variability, ten seeds of four varieties *viz.*, Nira (susceptible), Bhima (local), A-1 (national check) and NARI-6 (non-spiny tolerant) and two hybrids of safflower *viz.*, NARI-NH-1 and DSH-129 (tolerant hybrids) were sown in earthen pots containing inoculum with three replications. The number of wilted plants was recorded. The varietal reaction was assessed as per scale of Anonymous, 2005 i.e., Immune/wilt free (I) no wilting, Resistant ® <1% wilting, Moderately Resistant (MR) 1-10% wilting, Tolerant (T) 11-20% wilting, Susceptible (S) 21-50% wilting and Highly Susceptible (HS) >50% wilting.

Sixty eight isolates of *Fusarium oxysporum* f. sp. *carthami* were studied for their colony growth (growth rate on PDA), nature of mycelium, size of microconidia and macroconidia (Table 1). The growth rate on PDA indicated that 23 isolates showed slow growth rate (< 50 mm colony diameter), 29 showed medium growth rate (51-70 mm) and 16 were fast growing isolates (71-90 mm). Two types of mycelial growth *viz.*, appressed and fluffy were recorded; 39 isolates had appressed growth and 29 isolates had fluffy type growth. The morphological study revealed variation in size of micro and macroconidia among the 68 isolates. The size of microconidia ranged from 2.8 to 26.6 µm in length, whereas that of macroconidia ranged from 10 to 48 µm in length. Out of 68 isolates, 43 isolates produced macroconidia and on the basis of size of macroconidia, the isolates were grouped into three. Twenty isolates produced small sized macroconidia (5-20 µm), 15 produced medium (21-35 µm) while 8 had large sized macroconidia measuring 36-50 µm length, respectively. Rest of the 25 isolates produced microconidia and on the basis of size, they were grouped into three. Eight isolates produced small sized microconidia (1-10 µm), 11 produced medium (11-20 µm) while 6 had large sized microconidia measuring 21-50 µm length. The grouping of the *Focr* isolates on the basis of size of macro and microconidia was done.

There was variation in all 68 *Focr* isolates of *Fusarium oxysporum* f. sp. *carthami* in respect of cultural characters, colony diameter and size of microconidia and macroconidia. These results also support the observations of Ingole (1995).

In pathogenic variability tests, the isolates of *Fusarium oxysporum* f. sp. *carthami* from different geographical areas showed a wide range in their pathogenicity. All the 68 *Focr* isolates were found pathogenic to the safflower varieties *viz.*, Nira, Bhima, A-1 and NARI-6 and hybrids *viz.*, NARI-NH-1 and DSH-129 tested. The varieties Nira and Bhima recorded susceptible (21-50% wilting) to highly susceptible (> 50% wilting) wilt reaction to all the *Focr* isolates tested. Out of 68 isolates, 21 isolates showed tolerant reaction on variety A-1 with wilting in the range of 11-20%. The rest of the isolates recorded susceptible (21-50% wilting) to highly susceptible (> 50% wilting) reaction on A-1. The non-spiny variety NARI-6 recorded moderately resistant (1-10% wilting) to tolerant (11-20%

wilting) reaction while the hybrids *viz*., NARI-NH-1 and DSH-129 exhibited tolerant reaction (11-20% wilting) against all the *Focr* isolates tested.

The present investigation indicated the variation among the *Fusarium oxysporum* f. sp. *carthami* isolates in respect of morphology, cultural characters and ability to cause wilt. The varieties A-1 and NARI-6 have shown differential reaction to the pathogen isolates.

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Table 1 Grouping of *Fusarium oxysporum* f.sp. *carthami* isolates on the basis of morphological and cultural characters obtained from Maharashtra states

Growth rate & colony diameter (mm)	Conidia		Nature of mycelium (Growth Pattern)	Isolate Number (ZARS, Solapur)
	Category	Size (µm)		
a) **Microconidia**				
Slow (<50 mm)	Small	1-10 µm	Appressed	125,144,161,432
	Medium	11-20 µm	Appressed	133,225,645
	Medium	11-20 µm	Fluffy	208,652
	Large	21-50 µm	Appressed	367
	Large	21-50 µm	Fluffy	654
Medium (51-70 mm)	Small	1-10 µm	Appressed	177,187,279
	Medium	11-20 µm	Appressed	155,224
	Medium	11-20 µm	Fluffy	278
	Large	21-50 µm	Fluffy	656
Fast (71-90 mm)	Small	1-10 µm	Appressed	119
	Medium	11-20 µm	Appressed	229
	Medium	11-20 µm	Fluffy	221,222
	Large	21-50 µm	Appressed	602
	Large	21-50 µm	Fluffy	650,732
b) Macroconidia				
Slow (<50 mm)	Small	5-20 µm	Appressed	412,626,742
	Small	5-20 µm	Fluffy	448,743
	Medium	21-35 µm	Appressed	157,303,321
	Medium	21-35 µm	Fluffy	44
	Large	36-50 µm	Appressed	193,379
	Large	36-50 µm	Fluffy	281
Medium (51-70 mm)	Small	5-20 µm	Appressed	404,413,466,473,**519**,**520**, 531
	Small	5-20 µm	Fluffy	25,409.441,751
	Medium	21-35 µm	Appressed	258,322,348
	Medium	21-35 µm	Fluffy	47,152,170,184,263
	Large	36-50 µm	Appressed	28
	Large	36-50 µm	Fluffy	190,207
Fast (71-90 mm)	Small	5-20 µm	Appressed	475,476
	Small	5-20 µm	Fluffy	515,752
	Medium	21-35 µm	Fluffy	174,180,181
	Large	36-50 µm	Appressed	27,395

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Short communication

Economics of oil palm, *Elaeis guineensis* Jacq. nursery maintenance in Andhra Pradesh

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Oil palm is an introduced crop to India for commercial cultivation to bridge the gap in the vegetable oil demand and supply in the country. Based on the Chaddha Committee Report (Anonymous, 1988) on identification of potential areas for oil palm cultivation in the country, the areas have been earmarked and allotted to various companies for the development and processing of oil palm. Raising the oil palm nursery for distribution to the farmers is a part of area expansion programme for the processing companies.

Oil palm nursery maintenance involves various operations involving labour and input materials apart from permanent assets like irrigation system and generator set. The cost involved for the production of quality seedlings depends on both the recurring and non-recurring expenses for the period of 12 to 18 months. Production of oil palm planting material in the nursery is a regular and prerequisite activity for the area expansion. Since Technology Mission on Oilseeds, Pulses and Maize (TMOP&M) is promoting oil palm cultivation in India by giving subsidies on the planting material it has become mandatory to fix the price for nursery plant. Very little work was carried out by Varghese and Nampoothiri (1988) and Vasanthakumar (1992) in this direction. However, no such work has been carried out for Andhra Pradesh conditions, which is having the largest area under oil palm cultivation in India. Hence, the present study was taken up to calculate the actual cost of production of nursery by considering all the operations being followed to produce quality seedlings into consideration.

Information was collected from different oil palm development and processing companies involved in nursery maintenance located in Andhra Pradesh including AP Oil Fed which is being run by state government. The information thus collected was analysed after comparing the event wise cost of cultivation. Cost of cultivation for indigenous as well as imported seedlings was calculated separately. The labour wages were calculated based on the rates fixed by State Government of Andhra Pradesh in its latest Gazette (Anonymous, 2004). Similarly the price of sprouts of both indigenous and imported was taken as actuals based on the information provided by individual firms. The prices of all other commodities that are commonly used in nursery raising were taken based on the existing market rates. For imported sprouts, the customs duties, handling and post-entry quarantine charges were calculated based on the existing norms. The cost of diesel generation set and irrigation system was calculated based on the existing market rates. The life span for irrigation system and diesel generator was considered at five and ten years, respectively. The cost of fuel for generator and electricity charges were calculated based on the rates that exist during the study period. The cost of cultivation was calculated for the production of one lakh nursery seedlings during a period of 18 months. It is further calculated for the maintenance of two stage nursery i.e., primary nursery, which lasts for five months and secondary nursery that lasts for a maximum period of 13 months. All the regular operations that are to be followed in both primary as well as secondary nursery as per international standards as well as the demand of local conditions were taken into account. To maintain one lakh nursery seedlings, four persons were ear marked one each as nursery incharge, nursery supervisor and two persons for watch and ward for a period of 18 months. The electricity charges for operating the irrigation system were calculated at Rs. 5000/month. The success of production for indigenous and imported seedlings was considered as 80 and 85%, respectively based on the information collected from processors. This was mainly based on the experience they had in raising both type of seedlings during the last ten years.

For the convenience sake the total cost aspects were classified into two categories as recurring and non-recurring expenses. Under non-recurring the cost of diesel generator set, irrigation system, etc., were considered. The recurring expenses were further classified as wages and cost of inputs. Items like sprouts, fertilizers, pesticides, fuel, poly bags, FYM and soil, etc., were included under cost of inputs whereas labour wages, handling charges and customs duty, etc., under wages. The work efficiency of the labour was calculated based on the amount of work they undertake on an average basis for different aspects.

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However, variation is shown based on the nature of work that is carried out. The justification for every work and its labour requirement in the form of man days was also given. The rate of interest on the capital amount spent in maintaining the nursery is calculated at 12%. A depreciation of 10% was calculated based on the life span of the material on machinery used in the maintenance. The details of the labour utilization are shown separately for individual works. The information thus collected was analysed for drawing the conclusions. The details of the entire operation were analysed critically by keeping the recurring and non-recurring items separately. By this way the cost of both indigenous and imported seedlings were calculated. The details are given in Table 1 with the comments/remarks for every work. From these it is observed that the average cost of production of oil palm seedling was varying between indigenous as well as exotic origin mainly due to the variation in the cost of sprouts import duties, survival of seedlings (%) and the interest on the cultivation cost. The operations that were observed during the course of cultivation were found absolutely needed and accordingly the cost was calculated.

The cost of each seedling of oil palm that is ready for planting into the main field was calculated based on the survived seedlings at the end of 18 months period after taking all the expenses including interest on capital amount into consideration. Accordingly it is arrived at Rs. 51/- for indigenous seedling and Rs. 67/- for imported seedlings (Table 1).

Table 1 Glance on cost economics of oil palm nursery maintenance for a period of 18 months (for 1 lakh seedlings either indigenous or imported)

Name of the head	Cost (Rs.)	
	Indigenous	Imported
Cost of sprouts	1000000	2070000
Duties and handling	10000	20700
Cost of poly bags (small and big)	592000	592000
Land lease	200000	200000
Cost of irrigation system	67200	67200
Cost of generator	30000	30000
Cost of generator fuel	189000	189000
Cost of soil and filling material		
Stage I	55000	55000
Stage II	218750	218750
Shading	200000	20000
Fertilizer		
Stage I	37312	37312
Stage II	203000	203000
Borax	33000	33000
Magnesium sulphate	30000	30000
Pesticides		
State I	44700	44700
Stage II	16740	16740
Mulching	6000	6000
Miscellaneous	18000	18000
Electricity charges	900000	90000
Labour charges for all the above works	996501	996501
Total cost of cultivation	3857203	5271576
Interest on the cost (@ 12%)	462864.36	632589.12
Cost of cultivation for 80% seedlings of indigenous and 85% of exotic (20% and 15% mortality)	4628643.6	6062312.4
Grand total of the cost of cultivation	5091507.96	6694901.52
Cost of one sprout	50.9150796 or 51/-	66.9490152 or 67/-

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Short communication

Characterisation of certain newly developed linseed, *Linum usitatissimum* L. genotypes for seed oil content and oil quality

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Linseed, *Linum usitatissimum* L. is one of the important oilseed crop of India and stands next to rapeseed-mustard in *rabi* oilseeds in area and production. Of the two technical oil bearing crops *viz.*, linseed and castor, linseed accounts for about 60%. Linseed has hither to been valued for its industrial applications. Its importance is further increased owing to its demand as functional food due to the presence of Omega -3- fatty acid (an essential fatty acid) found in abundance in linseed oil. Some of the newly developed genotypes were therefore screened for their oil content and oil quality characteristics so as to select high oil containing genotype(s) suitable for industrial and/or edible purposes. With this objective, an experiment was carried out during 2006 at Oilseed farm of C.S. Azad University of Agriculture and Technology, Kanpur with 50 linseed genotypes sown in Randomized Block Design in three replications. After harvesting seeds were analyzed for various biochemical parameters. Oil content in seeds was extracted by Soxhlet extraction method (AOAC ,1970), fatty acid composition of oil was determined by GLC using capillary column, methyl esters were prepared by trans-esterification (Luddy *et al.*,1968), refractive index was found out by Abbe's refractometer (AOAC ,1970), acid value was estimated by the method of Cox and Pearson (1962), saponification value was determined as per method given in AOAC (1970), Iodine Value was estimated by the method described by Jamieson (1943), MUFA/PUFA ratio and NQI of oil were calculated as suggested by Carpenter *et al.* (1976).

Oil content among the genotypes varied significantly from 24.8 to 46.3% with the mean value of 38.2% (Table 1). The highest value was given by the genotype GS-145. The other promising genotypes which recorded more than 42% oil were 9X16, EC-1626 and EC-23203. Variation in oil content in linseed genotypes has also been reported earlier (Naqvi *et al.*, 1987; Kamlesh *et al.*, 2002).

The quality of oil and its application, whether for edible or for industrial purposes solely depends upon its fatty acid composition. The major fatty acids found in linseed oil, in present study, were palmitic, stearic, oleic, linoleic and linolenic. These fatty acids offered an overall range of variation as: palmitic from 2.9 to 8.4%, stearic from 3.3 to 8.9%, oleic from 15.8 to 43.9%, linoleic from 9.3 to 20.3% and linolenic acid from 20.7 to 60.9%.

With regard to saturated fatty acids, two entries namely 9X16 and 16XRR-9 recorded >8% palmitic acid and three entries namely 16XRR-9, EC-1626 and ES-13219 recorded >8% stearic acid (Table 3). As far as unsaturated fatty acids is concerned about six germplasm *viz.*, EC-1626, EC-41494, ES-1531, ES-13219, and EX-3 recorded >40% oleic acid. With decrease in linoleic acid a corresponding increase in oleic acid was observed. Eight entries recorded >15% linoleic acid. They were: 9X16,A-495, EC-22848, EC-41551, EC-41572, EC-110288, Omega-1 and GS-87. Out of these lines Omega-1 recorded highest value (20.3%). Regarding linolenic acid, fifteen genotypes recorded >55% linolenic acid. Their oil was well suited for industrial purpose. Four lines recorded about 30% linolenic acid. None of these entries contained low linolenic acid suitable for edible purpose. Variability in fatty acid profile of linseed oil has also been reported by many workers (Green and Marshall, 1991, Kamlesh *et. al.*, 2002 and Vajpeyi and Srivastava, 2005).

A variability of 1.475 to 1.482 in refractive index of oil from different linseed genotypes has been observed, the highest value was recorded by the genotype EI-5611 and lowest by Eita (Table 1). A large variability (123-199) in saponification value of oil from different genotypes is also observed in the present study. The highest value was given by the genotype SLS-27 and lowest by GS-135. High saponification value is desirable for industrial uses. The genotypes best suited for industrial purpose were: 16XRR-9, 302-63-32, A-449, CI-1894, EC-110288, Eita, Ex-3, SLS-27 and OS-68. Variability in saponification value has also been reported by several workers (Vashistha *et al.*, 1990).

As far as oil stability is concerned, it was judged by two parameters *viz.*, acid value and MUFA/ PUFA ratio. Acid value of various linseed genotypes also varied significantly from 0.4 to 2.5 with mean value of 1.2, highest and the lowest values being given by the genotypes GS-85 and EC-4149, respectively. Acid value depicts the amount of free fatty acids present in oil. Hence the higher the acid value, the more readily the oil will get rancid.

Table 1 Variation in oil content and fatty acid profile and oil quality characteristics of linseed genotypes

Genotype	Oil (%)	Fatty acid composition (%)					Oil quality characteristics					
		Palmitic	Stearic	Oleic	Linoleic	Linolenic	Sap value	Acid value	Refractive index	NQI*	MUFA/ PUFA	Iodine value
9 X 12	41.1	7.8	7.8	34.6	17.3	32.5	170	1.0	1.478	1.11	0.69	145
9 X 16	42.5	8.4	6.9	38.6	15.6	30.5	183	1.0	1.478	1.02	0.84	140
16 X RR-9	36.4	8.4	8.9	38.0	10.7	34.0	195	1.2	1.480	0.62	0.85	140
18 X B-1	39.0	6.7	6.1	19.3	12.3	55.6	178	1.3	1.481	0.96	0.28	184
107-DOOMA	39.2	7.6	7.0	39.5	13.1	32.9	188	1.7	1.478	0.90	0.86	143
302-63-32	36.3	7.7	5.0	18.9	10.9	57.5	198	0.7	1.481	0.86	0.28	186
A-445	38.8	5.8	4.3	15.8	13.3	60.9	175	0.7	1.482	1.31	0.21	196
A-449	40.6	5.0	4.5	18.1	13.2	56.9	194	0.7	1.481	1.40	0.26	188
A-453	39.3	7.1	3.9	19.9	13.1	56.2	189	1.3	1.480	1.20	0.29	187
A-495	37.6	6.3	6.0	37.6	15.3	34.9	176	0.9	1.479	1.25	0.75	150
A-809	37.2	6.4	5.1	20.6	12.6	55.2	181	0.8	1.480	1.09	0.30	184
CI-1639	42.0	4.4	4.8	24.7	10.3	55.9	187	0.9	1.475	1.12	0.37	185
CI -1894	36.8	6.6	6.3	20.3	11.4	55.4	191	1.0	1.478	0.88	0.30	182
CI -1971	36.2	5.6	5.3	18.0	13.7	57.5	178	0.8	1.477	1.26	0.25	190
EC-1626	42.3	6.5	8.2	43.9	11.4	30.0	178	0.6	1.476	0.77	1.06	136
EC-22848	39.7	5.9	5.8	36.8	16.5	35.0	188	0.6	1.479	1.42	0.71	152
EC-23203	42.2	6.1	4.0	21.1	12.3	56.5	144	0.7	1.481	1.22	0.31	188
EC-41494	41.3	6.4	5.6	40.2	13.3	34.5	164	0.4	1.478	1.11	0.84	148
EC-41551	40.5	6.6	5.7	41.3	15.8	30.7	182	0.5	1.478	1.29	0.89	143
EC-41572	37.7	7.1	7.1	36.6	15.1	34.2	170	0.5	1.478	1.06	0.74	147
EC-110288	41.2	3.3	6.0	19.9	15.7	55.2	194	1.0	1.481	1.70	0.28	189
EI-5611	39.2	3.4	5.0	21.8	13.6	56.3	188	0.9	1.482	1.63	0.31	190
Eita	38.8	6.4	4.6	20.6	11.1	57.4	196	1.0	1.482	1.01	0.30	187
ES-1531	39.6	6.0	6.1	40.2	14.1	33.6	182	1.1	1.479	1.17	0.84	147
ES-13219	38.4	7.4	8.4	42.5	10.3	31.5	197	0.9	1.479	0.65	1.02	137
EX-3	41.6	6.0	6.7	43.7	14.0	29.7	190	0.9	1.479	1.10	1.00	140
GS-27	40.7	2.9	6.5	21.8	13.6	55.3	162	0.9	1.477	1.45	0.32	187
GS-51	39.7	7.4	5.0	40.9	13.4	33.3	166	0.5	1.477	1.09	0.88	146
SLS-27	30.0	5.5	3.8	24.3	13.8	52.6	199	1.9	1.477	1.47	0.37	183
Omega-1	31.9	6.5	3.3	23.1	20.3	46.8	187	2.4	1.480	2.06	0.34	178
GS-68	39.6	5.8	5.2	29.1	9.3	50.7	198	1.6	1.478	0.85	0.49	174
GS-69	40.6	5.8	5.8	29.0	14.4	44.9	181	2.0	1.479	0.16	0.49	168
GS-82	37.5	6.7	5.0	32.1	11.9	44.3	163	1.5	1.478	1.02	0.57	164
GS-85	37.0	5.8	5.1	26.5	12.3	50.2	181	2.5	1.481	1.13	0.42	176
GS-87	35.9	5.6	4.1	33.8	16.1	40.4	171	1.5	1.475	1.66	0.60	163
GS-100	41.8	6.5	4.5	26.8	14.0	48.2	178	1.2	1.478	1.28	0.43	174
GS-105	26.6	7.2	4.6	28.8	13.2	46.2	156	2.3	1.478	1.12	0.49	169
GS-109	24.8	6.6	5.3	38.7	12.3	37.1	130	1.4	1.478	1.03	0.78	152
GS-110	36.2	7.4	6.4	28.4	14.7	43.1	147	1.2	1.478	1.07	0.49	163
GS-111	36.8	6.4	7.8	31.1	12.2	42.6	162	1.2	1.477	0.86	0.57	159
GS-119	39.5	7.1	6.1	23.8	12.4	50.6	185	0.8	1.479	0.94	0.38	175
GS-121	37.8	6.5	5.0	28.8	12.3	47.5	171	1.0	1.478	1.08	0.48	171
GS-122	35.8	6.3	4.8	34.9	11.9	42.1	160	1.4	1.479	1.08	0.65	161
GS-129	34.3	5.9	5.3	30.4	14.4	43.9	148	1.5	1.479	1.28	0.52	166
GS-134	40.8	6.6	6.9	32.3	15.0	39.2	165	1.3	1.477	1.11	0.60	157
GS-135	40.9	5.7	4.9	25.4	13.2	50.9	123	1.4	1.478	1.24	0.40	178
GS-145	46.3	7.0	4.9	20.6	12.0	55.6	160	0.9	1.477	1.01	0.31	184
GP-164	39.0	5.9	6.6	34.1	10.6	43.0	157	1.3	1.478	0.85	0.64	160
IC-59202	37.4	7.9	3.7	26.2	12.2	50.0	156	1.6	1.478	1.06	0.42	175
ILS-43	31.9	5.5	4.6	29.3	13.3	47.3	181	1.4	1.478	1.31	0.48	172
SEm±	0.29	0.25	0.23	0.30	0.34	0.34	0.29	0.35	0.31	0.26	0.24	0.40
CD (P=0.05)	0.57	0.49	0.46	0.58	0.66	0.66	0.57	0.68	0.62	0.52	0.47	0.79

Table 2 Summary of results

Parameter	Range of variation	Promising genotypes
Oil content (%)	24.8 - 46.3	GS-145, 9X16, EC-1626 and EC-23203.
Fatty acid profile		
Palmitic acid (%)	2.9 - 8.4	16 X RR-9, 9X16
Stearic acid (%)	3.3 - 8.9	16 X RR-9, EC-1626 and ES-13219
Oleic acid (%)	15.8 - 43.9	EC-1626, EC-41494, ES-1531, ES-13219 and EX-3
Linoleic acid (%)	9.3 - 20.3	9X16, A-495, EC-22848, EC-41551, EC-41572, EC-110288, Omega-1 and GS-87.
Linolenic acid (%)	29.7 - 60.9	A-445
Saponification value	123 - 199	SLS-27, 16XRR-9, 302-63-32, A-449, CI-1894, EC-110288, Eita, Ex-3, SLS-27 and OS-68.
Acid value	0.4 - 2.5	GS-85, EC-1626, EC-22818, EC-23203, EC-41494, EC-41551, EC-41572, GS-51,
Refractive index	1.475 - 1.482	EI-5611 and Eita
NQI	0.16 - 2.06	Omega-1
MUFA / PUFA	0.21 - 1.06	EC-1626 and A-445
Iodine value	136 - 196	A-445

Hence, the genotypes namely EC-1626, EC-22818, EC-23203, EC-41494, EC-41551, EC-41572, GS-51, were found to be the promising ones as they showed lower acid values. MUFA/PUFA ratio varied significantly from 0.21 to 1.06 with a mean value of 0.54 the highest and the lowest values being given by the genotypes EC-1626 and A-445, respectively.

It is, therefore, concluded that the genotype GS-145 was found to be the best in terms of oil content; other high oil yielding genotypes were 9X16, EC-1626, & EC-23203. The genotype A-445 excelled in most of the oil quality parameters and was found to be the most suitable one for yielding industrial purpose oil. Besides, 15 more genotypes which recorded >55% linolenic acid were recommended for industrial applications (Table 2). EC-1626 yielded oil which has the best storability. Oil from Omega -1 is the best among the rest genotypes for nutritional purposes.

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Short communication

Training needs of castor growers : An assessment study

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In Tamil Nadu, Salem and Namakkal districts are the major castor cultivating areas. Castor is grown in this region as sole crop or as an inter crop with finger millet, groundnut etc. Though castor cultivation does not involve adoption of very complex technologies, there is a need for continuous up gradation of the knowledge and skills of castor growers. Imparting training would also bring the necessary feedbacks from castor growers to the scientists and thus plan for more intensive and need based training to the castor growers. This study thus focuses on the awareness and adoption levels of various technologies among castor growers and also assesses the training needs of castor growers.

The data for the study were collected from three villages namely Panamarathupatti, Gangavelli and Namagiripettai of Salem and Namakkal districts based on the area under cultivation. From each village, 15 castor growers were randomly selected. The sample size was thus 45 and the data were collected by personal interview method during September, 2005. Data on mass media participation and training attended etc., by the sample castor growers were also collected. The degree of awareness and adoption levels was measured in this study as the extent to which the respondents were familiar and adopt the various technologies that are being recommended. Six major technologies are being disseminated to castor growers. Thus in the first stage, the extent of awareness and adoption of each technology by the sample castor growers was judged on a two point continuum. A score of "two" was assigned to respondents who said 'Yes' (Aware) and "one" for respondents who said 'No' (Not Aware). In the second stage, the awareness and adoption indices were constructed by suitably modifying formula:

$$AW_i = \frac{\sum_{t=1}^{6} T_t}{12} x 100$$

Where,
Awi= Awareness of individual technology by ith castor grower (I = 1 to 45)
ADi = Adoption of individual technology by ith castor grower (I = 1 to 45)
Tt = Technology (t= 1 to 6)

Based on the scores obtained from the above procedure, using the cumulative frequency distribution, the castor growers were categorized into less, moderate and high levels of awareness and adoption.

The awareness and adoption levels of the various technologies and training needs of the castor growers are discussed below.

The Table 1 implies that 69% of respondents had moderate to high levels of awareness due to more participation of the castor growers in training programmes and information seeking behaviour. It is also observed that 62% of the castor growers had moderate to high adoption level followed by less (38%) level of adoption. Higher the trainings participation and information seeking behaviour of the farmers would have enabled them to procure enough castor production technologies for their continued adoption. Thus, the trainings and information seeking behaviour of the farmers played a major role in higher level of awareness and adoption levels among castor growers.

Table 1 Awareness and adoption level of castor growers

Category	Awareness		Adoption	
	Number	Per cent	Number	Per cent
Less	14	31	17	38
Moderate	24	53	21	47
High	7	16	7	16
Total	45	100	45	100

Besides, the technology-wise adoption and awareness levels were also measured to identify gaps in each technology.

Table 2 shows that majority of the castor growers 58% adopted hybrids like TMVCH 1 and GCH 4. About 56% of the castor growers adopted application of NPK as basal and N as top dressing in two equal splits. Application of gypsum was practiced by about 56 per cent of the castor growers and a spacing of 90x90 cm was adopted by only 49% of the castor growers. Adoption of seed treatment with *Pseudomonas fluorescens* was 47% and application of Carbendazim @ 1 g/l of water was only 40%.

Thus adoption level in choice of hybrid was relatively higher than the other recommended technologies. Moreover, a considerable gap between the level of awareness and adoption were found. More intensive technical guidance would bridge such gaps as adoption required more knowledge and skills Sathiyanarayanan, (1991).

Table 2 Technologywise awareness and adoption level of castor growers

Technologies	Awareness		Adoption	
	Number	Per cent	Number	Per cent
T_1	33	73	26	58
T_2	29	64	25	56
T_3	27	60	25	56
T_4	26	58	22	49
T_5	23	51	21	47
T_6	21	47	18	40

Technology gaps: Table 3 exhibits that 42% of castor growers expressed selection of Hybrid - TMVCH 1 or GCH 4 technology gaps in the adoption of recommended technologies. Application of 45:15:15 kg NPK/ha as basal and top dressing of 30 kg N/ha in two equal splits during 30th and 60th DAS and basal application of Gypsum @ 200 kg/ha was 44% technology gaps. Spacing of 90x90 cm for castor crop to reduce botrytis was 51% technology gaps. Seed treatment with *Pseudomonas fluorescens* to control root rot and application of Carbendazim @1.0 g/l of water + additional dose of fertilizers (30:30:60 NPK/ha) to control grey rot were 53 and 60% technology gaps in the adoption of recommended castor technologies.

Table 3 Technologywise gaps in the adoption of recommended castor technologies

	Technologies	Per cent
T_1	Selection of hybrid-TMVCH 1 or GCH 4	4258
T_2	Application of 45:15:15 kg NPK/ha as basal and top dressing of 30 kg N/ha in two equal splits during 30th and 60th DAS	4456
T_3	Basal application of gypsum @ 200 kg/ha	4456
T_4	Spacing of 90 x 90 cm for castor crop to reduce *Botrytis*	5149
T_5	Seed treatment with *Pseudomonas fluorescens* to control root rot	5347
T_6	Application of carbendazim @ 1.0 g/l of water + additional dose of fertilizers (30:30:60 NPK/ha) to control grey rot	6040

Training needs: In this study the training needs of castor growers besides the conventional subject matters were also identified.

From Table 4 it could be inferred that about 96% of the castor growers had expressed the need for more intensive *training on plant protection technologies for control of Botrytis*, wilt and fruit rot diseases. Recently *Botrytis*, wilt and fruit rot damages were more occurrences due to climatic changes. The damages were observed about 10 to 15%. The castor growers currently are not storing the seeds or process them for extraction of oil since they lack knowledge and skill in post-harvest and value addition. Hence, there is need to impart training on post harvest management in terms of storing, hulling, cleaning and drying of seed materials. Since castor has many value added products after extraction of oil, and also has many medicinal usages, the training on these lines would further motivate the castor growers to go for large scale cultivation. Mehta (1983), Gupta (1998) and Lakra (2002) also indicated that the post harvest management and value addition played a major role in popularizing the technologies and through training, the farmers would adopt these technologies more intensively.

Table 4 Training needs of the castor growers

(n=45)

Training	Number*	Per cent
More intensive knowledge on control of *Botrytis*, wilt and fruit rot	43	96
Post-harvest technology in storing, hulling, cleaning and drying of seed materials	39	87
Value addition through extraction of oil and medicinal usage of oil	38	84

*Multiple responses

Summary and conclusion: Castor crop is grown predominantly in Salem and Namakkal districts of Tamil Nadu. The various technologies related to castor cultivation are disseminated by Tapioca and Castor Research Station, Tamil Nadu Agricultural University, Yethapur and later adopted by the castor growers. The study on assessment over the awareness and adoption of such technologies by the castor growers revealed considerable gap between awareness and adoption levels. Besides, the training needs of the farmers were assessed and it was found that in future, besides spread of production technologies, the focus of training should be also on post harvest management and value addition.

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BOOK REVIEW

Principals of Agronomy

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We have third revised edition, 2007 of the important book **"Principals of Agronomy"** by Dr. S.R. Reddy. The new edition has an abridged version of the latest book "Agrometerology" and a revised and simplified chapter on irrigation water management. In all, the book has 10 chapters i.e., Introduction, Agrometeorology, Soils and Tillage, Soil and Water Conservation, Dryland Agriculture, Mineral Nutrition, Fertilizers, Irrigation Water Management, Weed Management, Cropping Systems and Sustainable Agriculture running into 599 pages. A subject index is also given in the end, besides the references in the end of each chapter.

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Chapter : **Hanumantha Rao, C. and Chakrabarthy, S.K. 1997.** Castor. In *Efficient management of dryland crops: Oilseeds* pp.257-272 (eds. R.P. Singh, P.S. Reddy and V. Kiresur) Indian Society of Oilseeds Research, Hyderabad.

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