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Contents

Research Papers

(Contd...)

Official publication of
The Indian Society of Oilseeds Research, Hyderabad
***J. Oilseeds Res.*, 19(1) : 1-156 (June, 2002)**

Short communications

J. Oilseeds Res., **19(1)**: 1-5 (2002)

Review article

Erucic acid heredity in oilseed *brassicas* : A review

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Abstract

The oil from conventional varieties of the rapeseed mustard is considered to be of inferior quality due to the presence of about 50% erucic acid. The attempts at genetic elimination of this major oil constituent got impetus from the identification of low erucic acid genetic stocks of *Brassicanapus* and *Brassica rapa* (syn. *campestris*) during early sixtees. At present, all varieties of edible brassica oilseeds in developed countries contain <2% erucic acid in oil. Genetic studies have revealed that the higher values of erucic acid in digenomic brassicas are controlled by two genes with multiple alleles acting additively and showing no dominance for high erucic acid value has been reported. The gene(s) controlling erucic acid levels have now been mapped in *B.rapa* and *B.napus*.

Key words: *Brassica*, rapeseed-mustard, oil quality, erucic acid, genetics

Oil quality is determined by relative amounts of saturated, monosaturated and polyunsaturated fatty acids. The fatty acids are long chain single carboxyl group containing organic acids. Conventional varieties of rapeseed-mustard contain about 50% erucic acid in the oil. However, nutritional and end use requirements spawned international efforts to genetically eliminate this undesirable constituent from oilseed *Brassica*. This culminated in the commercialization of '00' or canola quality varieties of oilseed rape and turnip rape during 1970's. In the present write up an attempt has been made to summarize; the current status of knowledge with regard to heredity of erucic acid and to find out molecular markers closely linked to genes controlling the erucic acid content in *Brassica* oilseeds.

Erucic acid - synthesis

In the biosynthetic pathway, erucic acid is the end product, derived through the chain elongation of oleic acid (Jonsson, 1977). It is synthesized ;by chain elongation of oleoyl-CoA via eicosenoic acid. The enzyme oleoyl elongase is present in high erucic acid varieties but is absent in low erucic acid strains. The conversion of oleic acid to erucic acid occurs in a particular fraction containing chloroplasts and plastids in the developing seeds (Agarwal and Stumpf, 1985).

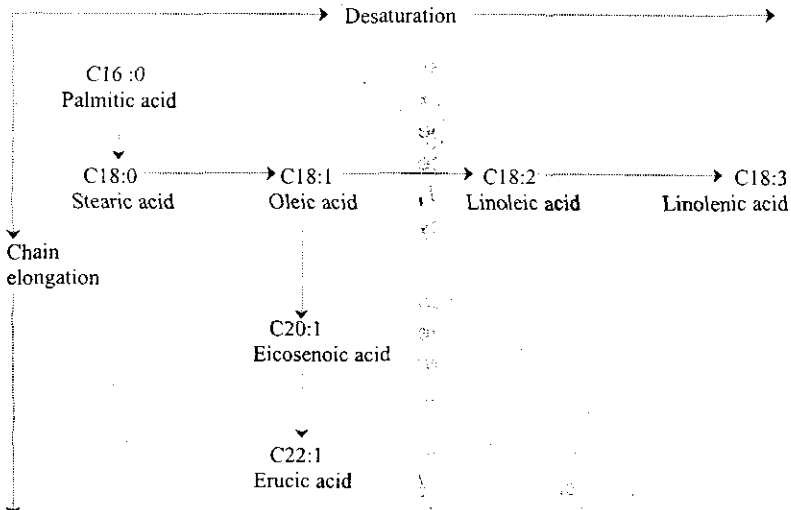

Fig. 1 Biosynthetic pathway to main fatty acids (Jonsson, 1977)

Variation for erucic acid

Low erucic acid strains having genetic blocks in the biosynthetic pathway towards eicosenoic acid and erucic acid were initially identified for the first time in Canadian varieties of summer rape (Stefansson *et al.*, 1961) and summer turnip rape (Downey, 1964). Later on similar strains were identified in Indian mustard (*B.juncea)* germplasm by Kirk and Oram (1981) in Australia. They attempted repeated selfings followed by selection of individual seeds having much reduced levels (<2%) of erucic acid. These genotypes were named as ZEM 1 ;and ZEM 2. Besides the native variability, mutagenesis was used successfully to induce zero erucic acid mutants in *B.rapa* L. var. *annua* (Laakso *et al.*, 1986). Interspecific hybridization has also been used to transfer/combine desirable fatty acid composition. Shopta and Podkolzine (1982) were successful in combining three swede rape (*B.napus*) varieties free of erucic acid with low linolenic acid (<4%) through hybridization between zero erucic acid *B. napus* and *B. juncea*. Roy (1984) selected a line Onap J, with erucic acid content of less that 0.5%, from a cross between the Indian mustard (*B.juncea*) variety BJ 168 and swede rape (*B.napus*) variety Cresus-0-precose. Interspecific hybridization between *B.juncea* cv. RLM 198 x *B.napus* cv. Oro and *B.juncea* cv. RLM 619 x *B.rapa* cv. Tobin was also used in India. Plants combining lower erucic acid value along with good agronomic attributes could be identified in the first cross. One genotype IS 77 had <18% of erucic acid in combination with excellent yield potential. This genotype was later found to be a chromosome substitution line of *B.juncea* having one pair of C genome chromosomes substituting possibly a pair of A genome chromosomes of *B.juncea* (Banga, 1988).

Isolation of fertile zero-erucic acid segregants of *B.juncea* has also been reported from an intergeneric cross (*Eruca* sativa x *B.rapa*) x *B.juncea* (Agnihotri *et al.*, 1995). However, the development of zero erucic acid genotypes from an interspecific cross can not be explained on the basis of available scientific knowledge. Moreover, as *E.sativa* was the female parent in the cross *(E.sativa x B..rapa)*, these zero erucic acid derivatives must be carrying *Eruca sativa* cytoplasm, which is known to induce cytoplasmic male sterility in *Brassica* (Mekinyanon *et al.*, 1995). Incidently, zero erucic acid genotypes reported by Agnihotri *et al.* (1995) are fully fertile.

As the Indian germplasm of *B.juncea* showed limited variability (39.6-59.3%) for erucic acid (Banga, 1996), the major emphasis, in India has been on exploitation of low erucic acid genotypes (ZEM 1 & ZEM 2) from Australia. Hybridization involving these low erucic acid strains and agronomically superior Indian mustard varieties led to identification of several low erucic acid strains namely PBCM 3590, PBCM 1156-6, Heera and Moti etc. (Malode *et al.*, 1995; Banga, 1996). The zero erucic acid genotypes bred in India are now being used to transfer this character into commercial varieties of *B.juncea* like Varuna, RL 1359, RLM 619, Pusa bold etc. Selfing coupled with half seed selections resulted in the identification of genotypes with diverse fatty acid composition. Consistent efforts at improving the agronomic base of 'o' erucic acid selections have helped in development of some strains like YSRL 9-18-2 which has performed creditably in All India Coordinated trials in the states of Punjab, Haryana, Rajasthan, Uttar Pradesh and Madhya Pradesh.

Inheritance of erucic acid

***B. napus*:** Downey and Craig (1964) and Harvey and Downey (1964) were the first to link fatty acid composition in oilseed rape and turnip rape with the genotype of the embryo rather than to maternal parent. The analysis of the individual seeds in the segregating generations further revealed that erucic acid content is controlled by two additive genes without dominance. Kondra and Stefansson (1965) included eicosenoic acid content also in their investigations. They found that the same gene controlled synthesis of both eicosenoic acid and erucic acid. However, these genes showed additive effects with regard to the erucic acid but dominant effect with regard to eicosenoic acid. These results were later confirmed suggesting that each allele contributes a 7.5% increase in erucic acid content. The number of alleles and the effect of these alleles on erucic acid have been a subject of considerable discussion. Harvey and Downey (1964) observed that in summer rape the allele found to control the production of erucic acid at each of the two loci, in heterozygous condition, increased the content by 9-10%. According to Krzymanski and Downey (1969), allele present in *B.napus* var. Bronowski yielded only about 3.5% erucic acid in heterozygous condition. Levels upto 50% of erucic acid are controlled by three alleles at each locus, which contributed 0.4 and 12.5%. Jonsson (1977) reported that erucic acid content in rape is controlled by multiple alleles with homozygosity levels between 5-10%, 10-35% and more than 35%. These levels were controlled by alleles at one, one or two and two loci respectively. He also reported that for erucic acid content upto 30%, allels showed additive effects and erucic acid had positive correlation with eicosenoic acid, while at higher concentration partial dominance was common and erucic acid had negative correlation with eicosenoic acid. Anand and Downey (1981) identified five genes and designated them as e, Ea, Eb, Ec, and Ed. These acted in an additive manner and resulted in erucic acid levels of <1,10,15,30 and 35% respectively.

Control by two additively acting genes, giving in heterozygous condition 9-10 or 10-12% erucic acid has also been suggested (Morice, 1974). Similar conclusions

were also obtained through study of fatty acid composition in seeds of microspore derived spontaneous diploids from crosses between high and low erucic acid plants. Contrarily, the occurrence of a single gene controlling high erucic acid content in *B.napus* was observed by Chen *et al.* (1988). Liu and Liu (1989) reported that erucic acid and eicosenoic acid are genetically governed by genotype of embryo without maternal effects. They further mentioned that erucic acid content is controlled by two pairs of dominant genes with overlapping effects and the genetic behaviour of erucic acid fitted into an additive model, with additive effects being predominant.

B. rapa: Simple monogenic control with partial dominance for high erucic acid value was indicated in monogenomic species of *B.rapa* (Dorrell and Downey, 1964). These results were later confirmed by Davik and Heneen (1996) who further suggested that high erucic acid gene seemed to function more efficiently in the yellow *sarson* cytoplasm, which suggested maternal differences. The low erucic acid segregatnts occurred in greater frequencies where modern low erucic acid cultivars were used as female parent. Some researches have shown overdominance (Moller *et al.*, 1985).

B. carinata: Zero erucic acid lines of *B.carinata* have now become available (Alonso *et al.*, 1991; Fernandez-Escobar *et al.*, 1988). Two genes with no dominance and additive gene action for erucic acid content have been suggested (Fernandez-Escobar *et al.*, 1988).

B. juncea: Two genes, showing no dominance and acting in additive manner were previously demonstrated in *B.juncea* (Kirk and Hurlstone 1983). The elaborate studies conducted at Dept. Plant Breeding, PAU, Ludhiana, revealed a continuous variation and class overlap in F_2 from zero erucic acid x high erucic acid crosses. This did not permit formation of discrete classes and fitting the data into classical Mendelian segregation ratios. However, the F_2 data from the cross between zero erucic acid x high erucic acid parents revealed an excellent fit to the theoretical 15:1 ratio of dignenic inheritance with additive gene effects if only two classes, one with high erucic acid (.>3%) and another with low (<3%) erucic acid were considered. Absence of dominance was indicated by lack of differences between F_1 and F_2 mean. The analysis of backcross seeds supported the contention of digenic inheritance. The test cross showed a segregation of 3:1 for erucic acid containing vs erucic acid free classes. Based on the current segregation data the genotype of erucic acid trait in commercial Indian cultivars RL 1359 and PBR 91 was postulated to be $E_1E_1E_2E_2$ whereas the erucic acid free genotypes (QM 14, NQM 11) were proposed to have the genetic composition of $e_1e_1e_2e_2$. Recognizing the amphidiploid nature of *B.juncea* (AABB), it is imperative that the genes for high erucic acid in this crop may have come from both the diploid progenitors namely *B.rapa* (AA) and *B.nigra* (BB). Our results suggested that inspite of a long history of the amphiploidy in the crop, both the genes are active since a digenic inheritance for erucic acid was demonstrated. Further a monogenic inheritance for high erucic acid content in *B.rapa* (Chen *et al.*, 1988) supported this conviction. None of the previous studies provided any evidence for the genome specificity of erucic acid conferring alleles E_1 and E_2. There is, however, a general agreement that E_1 and E_2 contribute 12.0 % 20.0% erucic acid levels respectively. This accounts for≈64.0% erucic acid in high erucic acid genotypes ($E_1E_1E_2E_2$) of the Indian varieties of mustard. Thus, theoretically, erucic acid level of 32.0 % is likely in the F_1($E_1e_1E_2e_2$) of crosses between low erucic acid and high erucic acid genotypes. This postulate is in agreement with the F_1 mean of 29.3 ± 1.4 % obtained in our experiments.

The evidence for genomic specificity of E_1 and E_2 allele in *B.juncea* was provided by the analysis of individual F_2 seeds of a cross, NQM 11 x CCWF 16. This is a low x intermediate erucic acid cross. The individual F_2 seeds of this cross segregated in 1:2:1 ratio of high: intermediate: low erucic acid. This indicated a monogenic additive inheritance of erucic acid level in CCWF 16. CCWFD 16 carrying 25.6 % erucic acid level was developed by introgressing zero erucic acid allele from *B.rapa* (AA) cv. Candle into *B.juncea* (AABB) cv. WF1. Inspite of repeated selections in backcross generation, it was not possible to achieve erucic acid levels lower than 25.6%. Therefore the intermediate erucic acid level in this genotype resulted from the substitution of high erucic acid allele with low erucic acid allele in A-genome as pairing is more likely between chromosomes belonging to same genome. Little or no pairing is expected between chromosomes belonging to A and B genomes. Thus 25.6% erucic acid in this genotype was due to one of the allele (E_1 or E_2) located on *B.nigra* genome (B) chromosome. It is proposed that the each dominant allele present on A genome contributes≈20% to total erucic acid in *B.juncea* against ≈ 12% of the dominant allele located on (B) genome chromosome. Unequal contribution of E_1 and E_2 alleles to erucic acid level has also been suggested in *B.napus* L.(Jourdenn *et al.*, 1996).

Molecular mapping of loci controlling erucic acid level

As indicated earlier, the analysis of erucic acid content is generally carried out on individual seeds lusing half seed technique. However, the use of such results for genetic interpretation is constrained by the continuous distribution of erucic acid content having a partial overlap of homozygous and heterozygous genotypic classes in

segregating progenies. The use of molecular markers is expected to be useful in early screening of homozygous and heterozygous genotypes. In addition such markers are likely to be more useful for screening of the doubled haploid plants regenerated from microspore derived embryos. There is now a greater realization of industrial value of high erucic acid varieties. Transfer of high erucic acid character using conventional backcross method coupled with half-seed analysis for selection of individuals for next cycle of backcrossing is difficult because of partial overlap of high erucic acid homozygous class and the intermediate one containing heterozygous. Molecular markers can be of immense value for use in backcross programmes targeted at transfer of high erucic acid.

Teutonico and Osborn (1994) mapped a single locus controlling the erucic acid level in *Brassica rapa*. Thormann *et al.*, (1996) were successful in mapping loci controlling the concentration of erucic acid in seed oil of *B.napus* by analyzing the oil composition of 99 F_1 derived doubled haploid lines obtained from a cross between cv. Major (having high level of erucic acid) and cv. Stellar (having low level of erucic acid). They also identified two regions that accounted for nearly all of the phenotypic variation in erucic acid concentration. These two regions represented the two major genes as previously hypothesized to control this trait (Kondra and Stefansson, 1995). Attempts have also been made to link random amplified polymorphic DNA (RAPD) markers to map the two genes involved in determining the erucic acid contents (Jourdenn *et al.*, 1996). The two genes were successfully localized in two independent linkage groups through a quantitative trait loci (QTL) approach. A close association was found between individual plant genotype and erucic acid content of the doubled haploid progeny. Further it was shown that two genes do not contribute uniformly to the erucic acid level.

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J. Oilseeds Res., **19**(1): 6-10 (2002)

Selfcompatibility and autogamy in sunflower, *Helianthus annuus* L. genotypes

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Abstract

A total of 22 sunflower, *Helianthus annuus* L. genotypes comprising inbreds, hybrids and open pollinated varieties were evaluated for self compatibility during rainy and summer seasons. Evaluation was based on percent seed set, autogamy and self-compatibility under different treatments, *viz.*, cloth bag, cloth bag+ assisted pollination, cloth bag+bulk pollen pollination and open pollination. In both the seasons, hybrids were comparatively more self compatible than inbreds and open pollinated variety. KBSH-1, DSH-255 AND MSFH-17 amongst hybrids and X-13, DSF-2, NDOL-3 and TS-42-2-8 amongst inbreds were found to have higher self compatibility. Incompatible genotypes exhibited higher self compatibility when pollen was made available by way of manual pollination. Importance of evaluating the lines for self compatibility in sunflower improvement has been discussed.

Key words: Sunflower, self-compatibility, autogamy, self-fertility, pollination methods

Introduction

Sunflower (*Helianthus annuus* L) is a cross pollinated crop. Honey bees are major source for ensuring cross pollination. A wide variability existed among sunflower for self fertility (Fick, 1978). Cross pollination in sunflower is also attributed to the self incompatibility mechanism operating in the crop. The degree of incompatibility varies with genotype, environmental factors, location, pollination etc. (Vranceanu *et al*., 1978; Robianson, 1980). Hence self fertility of sunflower lines as well as hybrids is the most important trait from the view point of breeding which is decisive factor for yield under less favourable weather conditions. In heterosis breeding programmes, development of inbreeds with high self-fertility is desirable as it is reflected in hybrid performance. The present study aims to assess self fertility of sunflower genotypes over two seasons considering various parameters.

Material and Methods

The base material involved 22 genotypes *viz.,* 17 inbreds comprising of five maintainer, eight restorer and four mutant lines derived from Morden, four hybrids and one open pollinated variety (Morden). Five maintainer lines used for the study were MDOL-2, DSF-2, NDOL-3, 4546-B and 822-B. Eight pollen fertility restorers included in the study were RLC-4, RHA-274, V-20, IX-11, X-13,VI-60,IV-65, and IV-55. Four mutant lines *viz.,* TS-84, TS-42-2-8, TS-10, and TS-31-2 and four hybrids included for the study were KBSH-1, DSH-255, MSFH-17 and DSH-1. All the genotypes were sown in July1999 and January 2000 by adopting split plot design and replicated three times. Each genotype had two rows of 5 m length in which the four treatments were allotted within the two rows each at random the inter and intra row spacing of 60 cm and 30 cm were given respectively. In each genotype, four pollination methods were imposed by allotting three random plants under each pollination method which were tagged. Pollination methods imposed were cloth bag, cloth bag + assisted pollination, cloth bag + pollination with bulk pollen of sister lines and open pollination. The bagging treatments were imposed as soon as the first ray floret opened in a capitulum. In respect of treatment cloth bag + assisted pollination, the cloth bag was smeared gently on the head itself with a view to ensure pollen movement within the capitulum. In treatment cloth bag +bulk pollen pollination heads were pollinated with bulk pollen of sister lines by camel hair brush and later the heads were again covered with cloth bag. Assisted pollination and pollination with bulk pollen of sister lines was carried out daily from the day of anthesis till end of flowering between 8.30 a.m. to 11.00 a.m. uniformly in all genotypes. Seed set percentage, autogamy and self compatibility were calculated as per Roath and Miller, 1982 and George *et al.,* 1980.

Results and Discussion

The differences due to genotypes and pollination methods and their interactions were significant for seed set,

autogamy and self incompatibility. Percent seed set was more in summer as compared to rainy season irrespective of pollination methods (Table 1). This could be ascribed to the adequate pollination brought out by the pollinating agents and also due to congenial weather prevailing during summer season as compared to rainy season. Amongst the pollination treatments, the mean percent seed set was high in open pollination followed by cloth bag with bulk pollen pollination, cloth bag with assisted pollination and cloth bag in both the seasons. Percent seed set under open pollination recorded significant differences over other pollination methods. Percent seed set is determined to a large extent by the population of pollinators in the vicinity of the crop (Seetharam,1982). In case of cloth bag with assisted pollination and cloth bag with bulk pollen pollination the seed set as higher compared to cloth bag imposed treatment. This might be due to artificial pollination enabling pollen transfer from a floret to the stigmatic surface of neighbouring florets within the capitulum. Higher seed set in open pollination could be due to pollen movement effected by insect pollinators. *Helianthus* species are obligate out crosser and prefer alien pollen for pollination and seed set. In could be opined that lower seed set under self pollination (cloth bag) was mainly due to lack of pollen transfer to the stigmatic surface and self incompatibility nature.

Table 1 Influence of pollenation methods on per cent seed set in 22 sunflower genotypes during rainy and summer seasons

Genotype	Rainy season					Summer season				
	Cloth bag	Cloth bag + Assisted pollination	Cloth bag + Bulk pollen pollination	Open pollination	Mean	Cloth bag	Cloth bag + Assisted pollination	Cloth bag + Bulk pollen pollination	Open pollination	Mean
Hybrids										
KBSH-1	83.38	87.24	88.28	84.60	88.37	89.36	91.80	83.96	95.66	82.70
DSH-255	78.30	83.18	88.81	83.48	85.47	80.85	81.82	83.08	84.32	81.55
MSFH-17	75.73	85.73	88.50	88.30	84.35	88.17	88.71	82.00	84.11	91.45
DSH-1	71.18	80.34	87.00	90.51	82.50	79.83	88.14	88.00	92.56	86.83
Mean	76.65	83.13	87.94	92.99	85.17	86.03	90.12	92.21	94.16	90.63
Inbreds										
RLC-4	49.48	70.17	75.33	87.80	70.70	80.47	82.95	84.70	89.28	84.34
RHA-274	68.82	80.28	86.72	90.19	81.70	75.82	88.95	84.83	92.07	83.44
V-20	70.87	88.58	88.08	90.52	84.15	81.70	71.64	82.40	86.87	75.58
IX-11	71.14	86.21	89.40	90.82	84.41	84.35	86.61	98.85	83.58	88.85
K-13	81.83	86.67	90.00	94.49	88.47	85.82	87.89	89.73	92.78	89.05
VI-60	68.53	77.00	85.67	90.81	80.52	70.03	75.61	80.15	81.79	76.89
IV-65	34.20	68.56	72.08	89.58	65.60	73.49	78.75	87.40	91.77	82.85
IV-55	63.83	71.03	75.05	84.49	73.63	80.34	87.82	91.14	93.46	88.19
NDOL-2	52.05	68.33	78.18	88.78	71.33	74.76	85.75	89.45	93.11	85.77
DSF-2	78.15	80.54	91.32	93.18	88.05	88.84	91.28	97.57	93.53	91.51
NDOL-3	79.78	81.99	88.59	94.13	85.62	80.49	84.33	85.84	89.88	84.94
4546-B	70.81	71.58	77.95	91.48	77.98	77.92	88.84	90.64	94.28	87.37
822-B	30.63	74.02	88.19	93.23	74.02	82.56	88.61	88.27	94.39	88.03
TS-84	35.24	58.66	71.57	82.98	62.11	73.57	77.55	91.53	94.26	84.23
TS-42-2-8	71.10	81.18	90.73	91.80	83.70	87.47	91.28	92.72	94.91	91.59
TS-10	35.31	68.49	78.79	83.73	64.58	74.28	77.35	84.18	90.42	81.56
TS-31-2	83.71	73.85	81.13	98.30	76.75	81.20	86.34	89.36	93.10	87.99
Mean	**60.91**	**75.90**	**82.42**	**89.78**	**77.75**	**78.41**	**83.67**	**87.89**	**91.67**	**85.42**
Population										
Morden	58.11	88.81	78.54	85.40	72.96	74.44	80.00	89.28	93.02	86.13
Grand mean	*63.69*	*76.89*	*83.25*	*90.17*	*78.50*	*79.61*	*84.95*	*88.82*	*92.23*	*86.40*

	Rainy season				Summer season			
	SEm±	CD (P=0.05)	CD(P=0.01)	CV (%)	SEm±	CD (P=0.05)	CD (P=0.01)	CV (%)
Between two mains	0.983	2.806	3.75	4.34	0.236	2.099	2.886	2.05
Between two sub-means	0.304	1.017	1.343	3.77	0.254	8.71	0.937	2.39
Between two sub-means at the same main	1.700	4.772	0.298		1.191	3.33	4.395	
Between two main means at same or different sub-means	1.775	4.964	6.551		1.267	3.543	4.676	

Goud *et al.*, (2000) stated that foreign pollen play significant role in breaking the barriers of self incompatibility. Nasir and Syed (1992) have reported that bagging had detrimental effect on seed set. Considering the mean per cent seed set across pollination methods and genotypes, hybrids registered relatively higher seed set followed by inbreds in both the seasons. This could be due to chances of carrying more number of self compatible alleles by a hybrid compared to inbreds.

Likewise, autogamy per cent was higher in summer (82.26%) compared to rainy season (70.32%) for the genotypes studied suggesting the seasonal influence on autogamy. Similar observations were made by earlier workers (Robinson, 1980; Swamy Gowda and Giriraj, 1989; Nasir and Syed, 1992). According to Miller and Fick (1997) the degree of self-incompatibility and self fertility depends on three conditions, *viz.*, genetic control, environment and morphology of floral structures. The self incompatibility in sunflower was sporophytic in nature and determined by two pairs of dominant alleles (S), one of them controlling the pollen traits and the other pistil characteristics (Ivanov, 1975). In the present study genotypic differences and seasons influenced degree of autogamy in the genotypes studied. Amongst the hybrids, KBSH-1 and MSFH-17; and amongst inbreds, X-13, NDOL-3, TS-42-2-8 recorded higher autogamy. Open pollinated varieties in general are self-incompatible (Shivaraja *et al.*, 1988) as is evident from the present study also. The open pollinated variety, Morden recorded 69.2 and 79.3% autogamy in rainy and summer seasons, respectively.

A genotype is considered as self fertile if it sets seed under bagging. George *et al.* (1980) opined that this method does not reflect potential self-pollination and therefore suggested to consider manual pollen transfer in assessing self compatibility of genotypes. In the present study, self-compatibility was estimated for two pollination methods, *viz.*, cloth bag with assisted pollination and cloth bag with bulk pollen pollination. The hybrids recorded higher self compatibility followed by inbreds across the pollination methods in both the seasons (Table 2). Similar results were earlier reported by Swamy Gowda and Giriraj (1989). Between the two pollination methods, cloth bag with bulk pollen pollination recorded higher self-compatibility compared to cloth bag with bulk pollen pollination recorded higher self-compatibility compared to cloth bag with assisted pollination suggesting higher compatibility reaction of pollen bulked from sister lines. Cloth bag with bulk pollination method differed significantly over cloth bag with assisted pollination. The self-compatibility was more in summer than in rainy season suggesting influence of seasonal factors. It is generally observed that the incompatibility reduced at higher temperature. Also, bright sunshine and lower RH during summer promoted easy pollen transfer. Low level of self-compatibility in monsoon season was presumably due to higher relative humidity and low temperature prevailing in bagged condition. In contrast, Pinthus (1959) found that low temperature conditions favoured higher production of selfed-seed. The high oleic acid content (OL alleles) was reported to have negative association with self-compatibility and positive association with earliness (Fernandez-Martinez *et al.*, 1993).

In the present study these two traits have not been measured. Giriraj (2001) suggested to assess relationship of oleic acid content with self compatibility. In a study, Skoric *et al.* (1980) laid emphasis on chemical composition of pollen for forecasting the level of self-fertility in sunflower inbreds. It was of interest to note that the genotypes which had low autogamy recorded higher estimates of self compatibility. It implied that a genotype which was incompatible exhibited higher self compatibility when pollen was made available by way of manual pollination. Goerge and Shein (1980) attributed variable seed set to bee attractiveness among the hybrids. It therefore, necessitated development of self-fertile populations or hybrids to alleviate the dependency on bees for good seed set (Roath and Miller, 1982). Selection for self-fertility enables to accumulate self compatible genes in germplasm lines (Fick and Zimmer, 1976; Vranceanu *et al.*, 1978; Swamy Gowda and Giriraj, 1989). In the present study, amongst inbreds, X-13, DSF-2, NDOL-3 and TS-42-2-8 were found to possess high degree of self-compatibility and these lines could be utilised in heterosis breeding programmes for the development of self-fertile hybrids.

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Table 2 **Influence of pollenation methods on autogamy and self-compatibility (%) in 22 sunflower genotypes during rainy and summer seasons**

Genotype	Rainy season				Summer season			
	Cloth bag + Assisted pollination	Cloth bag + Bulk pollen pollination	Mean	Autogamy (%)	Cloth bag + Assisted pollination	Cloth bag + Bulk pollen pollination	Mean	Autogamy (%)
Hybrids								
KBSH-1	92.24	93.34	92.79	88.13	95.97	98.22	97.10	93.41
DSH-255	89.02	95.12	92.07	81.61	97.34	98.69	98.02	92.19
MSFH-17	87.53	92.75	90.14	81.14	96.39	98.61	97.50	93.69
DSH-1	88.77	97.21	92.99	78.65	93.86	96.14	94.60	86.04
Mean	**88.38**	**94.60**	**92.00**	**82.38**	**95.69**	**97.92**	**96.80**	**91.33**
Inbreds								
RLC-4	79.96	85.83	82.89	56.31	92.91	94.89	93.90	90.13
RHA-274	89.03	96.16	92.60	77.16	87.92	92.26	90.09	82.35
V-20	95.65	97.94	96.80	78.33	82.58	95.86	88.82	71.23
IX-11	94.82	88.50	98.71	78.34	92.55	92.98	94.82	90.14
K-13	91.72	96.21	93.97	86.61	94.78	96.24	95.76	92.56
VI-60	84.89	94.34	89.62	75.48	92.45	98.84	95.23	85.62
IV-65	74.41	80.45	77.43	38.46	85.80	95.23	90.51	80.86
IV-55	84.07	88.85	86.46	75.73	93.96	97.53	95.74	85.98
NDOL-2	74.70	88.06	81.38	58.63	92.10	96.87	94.88	80.23
DSF-2	96.10	98.01	97.85	83.88	97.59	98.98	98.29	94.77
NDOL-3	87.10	92.00	89.55	84.76	84.68	96.37	95.53	90.35
4546-B	78.29	85.21	81.75	77.46	94.90	96.13	94.82	82.63
822-B	79.38	95.68	87.53	42.45	92.87	93.52	92.79	87.48
TS-84	70.82	86.43	78.63	42.87	82.28	97.11	89.70	78.66
TS-42-2-8	88.45	98.84	93.65	77.48	96.19	97.71	86.95	82.18
TS-10	81.80	84.57	93.18	42.29	85.59	93.13	89.38	82.15
TS-31-2	83.64	91.90	87.77	72.19	94.89	95.99	95.44	82.23
Mean	**84.41**	**91.70**	**88.06**	**66.90**	**91.19**	**95.99**	**93.59**	**86.38**
Population								
Morden	80.51	91.96	86.23	69.18	92.50	95.96	93.78	79.26
Grand mean	85.14	92.24	88.69	70.32	92.87	96.30	94.18	86.26

	Rainy season				Summer season			
	CV (%)	SEm±	CD (P=0.05)	CD (P=0.01)	CV (%)	SEm±	CD (P=0.05)	CD (P=0.01)
Between two mains	1.39	3.96	5.29	3.83	1.03	2.94	3.92	2.68
Between two sub-means	0.32	0.92	1.23	2.97	0.20	0.56	0.75	1.69
Between two sub-means at the same main	1.52	4.33	5.78		0.92	2.62	3.50	
Between two main means at same or different sub-means	1.75	5.00	6.68		1.22	3.47	4.63	

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Identification of restorers and maintainers for different CMS sources in sunflower, *Helianthus annuus* L.

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Abstract

Five cytoplasmic male sterile lines each belonging to a different cytoplasmic source (CMS) were crossed with fifty inbreds to identify fertility restorer lines for each CMS source. Most of the lines restored fertility for classical *petiolaris* cytoplasm PET1. Only a few could restore fertility on new CMS sources. Out of fifty inbreds tested twenty one were found to be restorers for CMS PET 1 while others behaved as maintainers. Only three inbreds could restore fertility on CMS I and two inbreds (DSI 2 and DRS 5) were found to be partial restorers and remaining forty five inbreds behaved as maintainers for CMS I. Only two inbreds each could effectively restore fertility on GIG 1, PET 2 and PF cytoplasm. From the study, a few effective restorers could be identified for the newly developed CMS sources for the first time in India, which can be exploited in developing hybrids with better heterosis possessing alternate cytoplasm

Key words: Sunflower, maintainer, restorer, CMS sources

Introduction

In sunflower, hybrids are superior over open pollinated cultivars in terms of higher yield, increased self fertility and resistance to diseases (Miller, 1987). The first cytoplasmic male sterile source, *H. petiolaris* was discovered by Leclercq (1969), for which the genes for fertility restoration were identified subsequently by Kinman (1970). This lead to the exploitation of hybrid vigour and commercial hybrid seed production in sunflower. From 1972 onwards several hybrids were developed and released for commercial cultivation, but all the hybrids invariably possess the PET 1 cytoplasm (Friedt, 1992; Vishnuvardhan Reddy,1999). In order to diversify the cytoplasmic base, attempts were made and several new cytoplasmic male sterile sources have been identified .But using these diverse CMS sources, hybrids could not be developed because of the non-availability of effective restorers for these new CMS sources. In view of the limitation, an attempt was made at the Directorate of Oilseeds Research, Hyderabad, India, to identify restorers for the newly developed CMS resources

Materials and methods

Five diverse CMS sources viz., PET 1 the traditional cytoplasmic source, CMS I from *H.lenticularis*, CMS PF from *H.petiolaris fsp fallax*, CMS PET 2 from *H.petiolaris* and CMS GIG1 from *H.giganteus* and fifty diverse inbreds developed through intra and inter specific hybridization, mutation breeding and selection were used to identify restores lines for different CMS sources. Each of the fifty inbreds were crossed to all five CMS sources during *rabi* 1998 and the resulting F_1 s were tested during *kharif* and *rabi* 1999 - 2000. 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 in a row. Plants were classified as male fertile/male sterile based on anther dehiscence and pollen shedding at anthesis stage. Pollen fertility was also confirmed in laboratory using acetocaramine 1% staining pattern.

Results and discussion

The maintainer/restorer reaction of the inbreds for different CMS sources has been presented in Table 1. In general most of the inbreds tested behaved as maintainers for the new CMS sources. Even the identified effective restorers of the traditional PET 1 cytoplasm, behaved mostly as maintainers. Results indicated that out of 50 test inbreds, 21 were found to be restorers for the traditional PET-1 cytoplasm, while remaining behaved as maintainers. Only three inbreds could restore fertility on CMS I, two inbreds (DSI 2 and DRS 5) behaved as partial restorers and the remaining 45 inbreds behaved as maintainers for CMS I. Of three inbreds which restored fertility for CMS I, two inbreds (M 1019 and M 307-2) behaved as maintainers for the traditional cytoplasm PET 1 indicating the existence of diversity between the two cytoplasms, which confirmed a similar study of Vishnuvardhan Reddy (1999). For the CMS PF, two inbreds (87R-23-2 and DRS 4) could effectively restore fertility while six inbreds (M 1008,DSI 2, DRS 2, DRS 5,

6D-1, PAR 1084) could partially restore and the rest behaved as maintainers. The inbred line DRS 4 restored fertility on CMS PF while it could only maintain PET 1. One inbred 87R-23-2 behaved as partial restorer and two inbreds (DRS 2 and DRS 3) as effective restorers for cytoplasm PET 2, while rest were found to be maintainers. DRS 3 could restore fertility in both PET 1 and CMS PET 2 but DRS 2 acted as maintainer for PET 1 but could restore fertility for CMS PET 2 which confirmed the earlier report of Vishnuvardhan Reddy (1999). Two inbreds, DRS 1 and DRS 2 effectively restore fertility on GIG 1 cytoplasm. While 87R-23-2 and M1008 were partial restorers. All the inbred lines known to be the restorers for CMS PET 1 were found to be maintainers for CMS GIG 1 except DRS 1.The data clearly indicates that the majority of the inbreds tested behaved as maintainers for the new CMS sources. Similar results of differences in fertility restoring genes for different CMS background have been reported by Whelan (1980) and Virupakshappa *et al.* (1991). The restorers for the traditional PET1 cytoplasm behaved mostly as maintainers for the new CMS sources and none of the inbreds under study was identified to restore fertility on all five CMS sources. The restorer for one CMS source behaved as maintainer for other source and vice-versa, confirming the diversity among the CMS sources. The restorers identified will help in exploitation of new CMS sources for hybrid development with better heterosis and diversity of cytoplasm in sunflower. The identified maintainers after testing for their combining ability and agronomic performance will be converted into new CMS lines for their utilization in hybrid breeding programmes for developing diverse hybrids with better heterosis and resistance to diseases and insect pests.

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Table 1 **Maintainer /restorer behaviour of the inbreds for different CMS sources in sunflower**

Inbred	CMS PET1	CMS I	CMS PF	CMS PET2	CMS GIG1
RHA274	R	M	M	M	M
RHA265	R	M	M	M	M
RHA298	R	M	M	M	M
RHA271	R	M	M	M	M
RHA278	R	M	M	M	M
RHA341	R	M	M	M	M
RHA342	R	M	M	M	M
RHA363	R	M	M	M	M
M1024	M	M	M	M	M
M1019	M	R	M	M	M
M1008	M	M	PR	M	PR
M1015	M	M	M	M	M
DSI 2	R	PR	PR	M	M
DSI 4	M	M	M	M	M
DSI 9	M	M	M	M	M
DSI 16	M	M	M	M	M
M733	M	M	M	M	M
DSI 27	M	M	M	M	M
DSI 29	M	M	M	M	M
DSI 44	M	M	M	M	M
DSI 46	M	M	M	M	M
DSI 54	M	M	M	M	M
M725	R	M	M	M	M
DSI 74	M	M	M	M	M
DSI 68	M	M	M	M	M
DSI 81	M	M	M	M	M
DSI 56	M	M	M	M	M
DSI 72	R	M	M	M	M
DSI 86	R	M	M	M	M
M307-2	M	R	M	M	M
DSI 90	M	M	M	M	M
DSI 103	M	M	M	M	M
DSI 107	M	M	M	M	M
DSI 111	M	M	M	M	M
DSI 120	M	M	M	M	M
DSI 123	M	M	M	M	M
87R-23-2	R	M	R	PR	PR
DRS1	R	M	M	M	R
DRS2	M	M	PR	R	R
DRS3	R	M	M	R	M
DRS4	M	M	R	NS	M
DRS5	R	PR	PR	M	M
6D-1	R	M	PR	M	M
ACC1439	R	M	M	M	M
RES834	R	M	M	M	M
TUB1789	R	M	M	M	M
PAR1084	R	R	PR	M	M
M1026	M	M	M	M	M
M1005	M	M	M	M	M
HAM 180	R	M	M	M	M

M - Maintainer R - Restorer PR - Partial restorer NS - Not studied

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Analysis of genetic diversity and contribution of yield components towards total diversity in Indian mustard [*Brassica juncea* (Linn.) Czern & Coss]

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Abstract

Mahalanobis's D^2 statistics was applied to assess the genetic divergence of 36 genotypes of Indian mustard [*Brassica juncea* (*Linn.*) *Czern & coss*] selected form different geographical regions. These genotypes were grouped into nine clusters among which cluster II included the largest number of 17 genotypes followed by cluster I with 7 genotypes, cluster III with 5 and cluster VI with 2 genotypes. Five clusters namely IV, V VII VIII and IX had single genotypes each. The maximum divergence was revealed between cluster III and V, whereas, it was minimum between cluster VI and IV. The cluster II and V were also distantly placed from the other 7 clusters. Genotypes from divergent clusters should be considered for hybridization rather than those genotypes from the same cluster or minimum divergent clusters. Diverse genotypes can also be used for conversion in male background for exploiting heterosis. Also one male sterile line was in a distinct cluster and can contribute to high heterosis.

Key words: Indian mustard, genetic divergence, D^2 statistics

Introduction

Rapeseed-mustard is one of the most important group of oilseed crops. Brassicae members are next to groundnut with a total production of 6.94 million tonne. Among these, Indian mustard [*Brassica juncea* (Linn) Czern & Coss] is the most important crop grown during *rabi* season. Continued artificial selection in segregating generations has not led to significant improvement of yield levels. Therefore, the situation warrants the exploitation of heterosis either by using effective male sterility system or by developing heterotic cross combinations for further yield enhancement.

The level of heterosis as well as selection advance in segregating generations depend upon the genetic diversity among the parents rather than geographical diversity. Therefore, the choice of diverse parents with good GCA is a prerequisite for an efficient hybridization programme. The heterosis component is largely dependent on parental diversity as suggested by several workers in both self and cross-pollinated crops.

The concept of genetic divergence provides an idea about the genetic diversity among the parents. The multivariate analysis is of immense importance to assess the diversity and the relative contribution of different characters to total divergence besides enabling the grouping of genotypes in different genetic diversity groups. In the present investigation genetic divergence among the selected genotypes from different geographic regions has been worked out by using Mahalanobis's D^2 statistics in order to produce superior heterotic cross combinations for further breeding programme.

Materials and methods

The present investigation was conducted on 36 genotypes of Indian mustard in which 8 were from IARI, Delhi (VSL 5, NPJ 30 NPJ 35, DLM 55, Strain 23, Strain 26, AD 2041, DBS 10); 5 from NBPGR, New Delhi(NKG 207, IB 618, IB 642, NIC 11703, BEC 201AB); 3 each from Pusa Bihar (PSR 18, PAMT 34, PSMT 40) and Kangra (RCC 462, RCC 5, KBJ 3); 2 each from PAU, Ludhiana (YSRL 10, RL 1359) and S.K. Nagar (SKM 93-28, SKM 92-66); and one each from Pantnagar (PRG 904), Faizabad (NDR 8208), CCSHAU, Hisar (RH 9303); and BARC, Bombay (TM 38). The seven commercial varieties (Varuna, Kranti, Pusa Bold, BIO 772, RH 30, PR 45 and Prakash) and two male sterile line Prakash (*B.tournifortii*) and *B.oxyrohina* were included.

The genotypes were grown in randomised block design with three replications during *rabi*, 1996-97 at IARI, New Delhi. The observations were recorded on five randomly selected plants in each genotype for 12 quantitative traits namely, days to 50% flowering (DF), days to maturity (DM), main shoot length (MSL), number of primary branches (PB), number of secondary branches (SB),

number of siliquae on main shoot (SQ.MS), number of seeds per siliqua (S/SQ), harvest index (HI), seed yield (SY), test weight (TW) and NMR oil content per cent (OC). The genetic divergences were estimated using Mahalanobis's D^2 statistics (1936) followed by Rao's (1952) clustering pattern.

Results and Discussion

The analysis of variance (Table 1) exhibited the presence of significant differences among the genotypes in respect of all characters except test weight. The D^2 values (divergence)for all possible pairs of genotypes were worked out and on the basis of the D^2 values, the 36 genotypes have been grouped into nine clusters (Table 2). The cluster II including 17 genotypes has been found to be the largest group. Cluster I, III and VI had 7,5 and 2 genotypes, respectively. On the other hand, five clusters (IV, V, VII, VIII and IX) included only one genotype each. The divergence within and between clusters indicated divergence among the genotypes of same cluster and distance between the genotypes of different clusters, respectively.

Table 2 Group constellation of the Indian mustard genotypes

Clusters	Number of genotypes	Genotypes included
I	7	Varuna, Kranti, SKM 92-66, Strain 23, BIO 772, DBS 10, Pusa Bold
II	17	PSR 18, SKM 93-28, VSL 5, NPJ 30, NPJ 35,RH 9303, NDR 8208, TM 38, YSRL 10, DLM 55, Strain 26, PSMT 40, RL 1359, RCC 462, NKG 207, IB 618, NIC 11703
III	5	PSMT 34, IB 642, PRG 904, KBJ 3, *B.oxyrrhina* A
IV	1	RH 30
V	1	AD 2041
VI	2	PR 45, Prakash
VII	1	RCC 5
VIII	1	Prakash A
IX	1	BEC 201AB

The perusal of the table 3 would reveal that maximum and minimum intra-cluster distance was observed between the genotypes falling in cluster VI (3.19) followed by cluster II (4.05). Maximum statistical distance was observed between cluster III & V (16.69) followed by cluster V & VIII (4.52), I & IV (4.56) and III & IV (4.81) also showed low intercluster distance amongst them and suggesting similarities in genetic background. When the clusters were compared for inter cluster divergence it was observed that the cluster II and V were close to each other, but distantly placed from the clusters I, III, IV, VI, VII, VIII. The cluster mean (Table 4) for seed yield ranged from 42.0 g in cluster IX to 8.33 g in cluster VIII. The test weight ranged from 3.70 g (cluster VII) to 6.35 g (cluster IX). For oil content V had the maximum of 41.5% and cluster VIII had the minimum of 34.6%. The cluster IX recorded maximum mean values for seed yield oil content and for yield contributing traits such as test weight, main shoot length, number of primary branches and number of secondary branches.

Contribution of characters to total divergence : The contribution of characters towards total divergence was carried out in terms of number of times it appeared in first rank (Table 5). The single major character for adaptation days to maturity has the highest contribution of 47.14 % to total divergence. The other major yield components namely, plant height (10%), harvest index (8.41%), main shoot length (7.46%) and test weight (5.41%) made considerable contribution to discriminate the genotypes in terms of total divergence. Murthy and Arunachalam (1966) observed maturity, plant height, number of primary branches and number of seeds/siliquae to be the largest contributors to total genetic diversity in *Brassica* and Linseed. On the contrary, the other characters have given very little contribution to total divergence for enabling clear discriminating the genotypes.

Table 5 Contribution of different characters towards total divergence

Source	Times ranked first	Percent of contribution
Days to 50% flowering	18	2.86
Days to maturity	297	47.14
Plant height	63	10.00
Main shoot length	47	7.46
Number of primary branches	14	2.22
Number of secondary branches	23	3.65
Number of siliquae on main shoot	10	1.59
Number of seeds per siliqua	28	4.44
Harvest index	53	8.41
Seed yield	22	3.49
Test weight	34	5.40
NMR oil content percent	21	3.33

The genetic diversity has a direct relation to the success of effective breeding programme. The diversity present in the material can be utilized for hybridization programme for developing heterotic cross combinations or to effect further selection to combine specific and special characters observed in different groups. From the present investigation, it was observed that the four widely cultivated varieties (Varuna, Kranti, Pusa Bold, BIO 772) occupied position in the same cluster whereas, other two variety PR 45 and Prakash formed a separate cluster and variety RH 30 alone formed a separate cluster. The result also revealed that one male sterile *B. oxyrrhina* A clubbed with other genotypes but Prakash A had its own cluster. Most of the important breeding lines from different geographic region came into single major cluster (cluster II). Thus the geographic diversity alone is not an index of parental diversity, it also implies that it is not the

geographic origin but selection pressure, which played an important role in s\determining genetic closeness and divergence among parents. Anand and Rawat (1984) drew similar conclusions while studying the genetic divergence of Indian mustard for a set of 50 geographically diverse lines. Gupta *et al.* (1991) also reported no correlation between geographical and genetic diversity. Singh and Gupta (1985), Pradhan *et al.* (1993) and Ali *et al.* (1995) also suggested the use of diverse parents for hybridization programme.

Multivariate analysis based on Mahalanobis's D^2 statistic proved to be a very potential tool for differentiating the mustard genotypes into distinct groups. A comparison of cluster means among the group for different characters indicated substantial genetic diversity present in the genotypes studied. D^2 statistics analysis also highlighted the importance of yield contributing characters for discrimination of the genotypes in terms of total genetic divergence present in the mustard genotypes. Among the group cluster III & V exhibited the highest intercluster divergence and the hybridization between the genotypes of these two clusters would help to create variability for further selection. The perusal of the results indicated that the cluster II and V though close to each other (5.32) but both these clusters exhibited considerable inter-cluster divergence from cluster I, III, IV, VI, VII and VIII. Results suggested that genetic variability could be created by using the genotypes of cluster II & V for hybridization with the genotypes of cluster I, III, IV, VI, VII and VIII. The genotypes from diverse clusters should be used rather than the genotypes of cluster having minimum divergence for creating variability and heterotic cross combination for further selection to be effective in subsequent generations.

Based on the genetic diversity of the component characters, it is suggested that genetic variability for seed yield could be created by crossing the genotypes Strain 26 x BIO 772, Strain 23 x Prakash, NPJ 30 X PR 45, SKM 93-28 X Kranti, RCC-5 X Varuna. For oil content the cross between RL 1359 X Varuna, AD 2041 x RH 30, RCC 5 X Pusa Bold, Strain 26 x Pusa Bold could be effective for creating considerable amount of variability to effect further selection for improvement of oil content. It may be inferred from the present study that the lines with high genetic divergence are likely to produce potential crosses for exploitation of hybrid vigour for commercial production.

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Table 1 Analysis of variance of the different characters studied

Source	df	Mean sum of square											
		DF	DM	PH	MSL	PB	SB	SQ/MS	S/SQ	HI	SY	TW	OC
Replication	2	4.72	68.88	2177.38	348.72	8.89	52.93	155.82	5.81	0.0092	1935.08	0.000015	1.085
Treatment	3	46.90*	12.64*	326.92*	107.7*	1.90*	18.07*	54.54*	3.32*	0.0026*	153.28*	0.0675	9.27*
	5												
Error	7	5.55	6.55	64.35	30.71	0.77	10.49	23.88	0.95	0.0007	70.33	0.0049	2.77
	0												

*Significant at 5% level of significance

Note : DF = Days to 50% flowering, DM = Days to maturity, PH = Plant height, MSL = Main shoot length, PB = Number of primary branches, SB = Number of secondary branches, SQ/MS = Number of siliquae on main shoot, S/SQ = Number of seeds per siliqua, HI = Harvest index, SY = Seed yield, TW = Test weight and OC = NMR oil content per cent.

Table 3 Intra (underlined) and Inter-cluster distance (D^2 values) of the nine clusters

Cluster	I	II	III	IV	V	VI	VII	VIII	IX
I	3.73	14..44	5.43	4.56	15.55	6.26	5.16	8.39	9.63
II		4.05	15.72	14.59	5.32	13.97	14.19	14.64	8.67
III			3.47	4.81	16.69	5.63	5.17	7.24	11.57
IV				0.00	15.81	4.17	5.45	5.60	9.78
V					0.00	15.41	15.40	16.10	10.64
VI						3.19	4.69	4.52	8.48
VII							0.00	7.74	9.21
VIII								0.00	10.25
IX									0.00

Table 4 Cluster means of nine clusters for different characters

Cluster	Character											
	DF	DM	PH	MSL	PB	SB	SQ/MS	S/SQ	HI	SY	TW	OC
I	82.09	156.28	167.00	67.15	5.57	14.29	42.09	13.48	0.27	27.57	5.40	40.60
II	8363	155.86	171.02	67.11	5.47	14.71	43.82	14.29	0.25	28.19	5.05	38.31
III	81.33	153.13	167.24	66.03	4.93	12.47	40.60	15.87	0.27	20.56	4.60	38.89
IV	86.33	152.00	182.07	70.00	5.67	12.00	45.67	14.33	0.23	22.67	5.15	39.89
V	79.00	152.00	147.67	60.27	4.67	12.33	40.00	14.00	0.29	17.53	4.60	41.50
VI	89.00	156.17	183.10	62.27	5.83	16.67	42.17	15.17	0.25	26.13	4.25	36.16
VII	82.33	155.33	167.60	54.80	5.33	15.00	43.67	14.17	0.26	30.87	3.70	36.20
VIII	94.67	155.00	178.00	59.80	5.33	10.00	34.33	14.17	0.19	8.33	4.15	34.60
IX	87.00	155.00	192.03	73.00	6.45	16.67	45.00	14.00	0.24	42.00	6.35	37.08

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Inheritance of components of horizontal resistance to *Alternaria brassicae* (Berk.) Sacc. in Indian mustard, *Brassica juncea* (L.) Czern and Coss.

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Abstract

Two relatively resistant parents of Indian Mustard *Brassica juncea* (L.) Czern and Coss., Bio 8 (3) and Line 81, were selected and crossed to Alternaria susceptible parents Pusa Basant, Pusa Bahar, and Line 113 to produce six crosses. Six generations (P_1, P_2, F_1, F_2, B_1, and B_2) of six crosses were planted under timely sown (TS) and late sown (LS) conditions to find out the genetics of components of resistance to Alternaria. The mean of six generations recorded for time of appearance of Alternaria on leaf (TOAP), rate of disease increase (r), area under disease progress curve (AUDPC), final intensity of Alternaria on plant (FIAP), and final intensity of disease on pods (FIDP) were subjected to scaling tests to detect epistasis and to estimate m, d, h, i, j, and l parameters. Dominance (h) and additive x additive (i) had predominant role in the inheritance of TOAP, r, AUDPC, FIAP, and FIDP, whereas additive x dominance (i) was important for AUDPC, FIAP, and FIDP.

Key words: Mustard, *Brassica juncea*, genetics, *Alternaria brassicae*, resistance

Introduction

Rapeseed mustard constitute an important group of oilseeds second to groundnut in area, production, and productivity in India. Causes of lower yields are a number of biotic and abiotic factors. Estimates of yield losses due to Alternaria blight caused by *Alternaria brassicae* (Berk.) Sacc., varied between 10 to 70% in different species of these crops (Kolte, 1985;1991; Saharan and Chand, 1988). Genetics of resistance to Alternaria blight is governed by a single dominant gene in the cultivar RC 781 of Indian mustard (Tripathi *et al.*, 1978; 1980). However, the resistance of cultivar RC 781 has broken down. There is a lack of information on the genetics of parameters of horizontal disease resistance in mustard, which is essential for development of Alternaria blight resistant genotypes. Therefore, the present investigations were carried out to find the resistant genotypes to Alternaria blight and to study the inheritance of components of its resistance.

Materials and methods

Twelve cultigens of Indian mustard *B. juncea*, tolerant to *Alternaria brassicae*, [DYS-7-1, UDN 23, DYS-25-10, UDN-26, UDN-67, 51=D 418/MHTE 23-3, 81=D 128/D 313, 87=Kranti/D 246, 113=PR 45/D 403//D 326, 174=D 313/HTA-11-1, 348=HC 951/K-133//W 246 and Bio 8 (3)], along with susceptible checks (Pusa Bahar, Pusa Basant and Pusa Bold) were evaluated in a replicated trial for their reaction to *Alternaria* under artificial epiphytotic conditions at the experimental farm of IARI, New Delhi during *rabi* season.

Two resistant parents, Bio 8(3) and Line 81, were selected and crossed as male parents to susceptible female parents, Pusa Basant, Pusa Bahar, and Line 113. Six generations of the six crosses Pusa Basant/Bio 8(3) (C_1), Pusa Basant/Line 81 (C_2), Pusa Bahar/Line 81(C_3), Pusa Bahar/Bio 8(3) (C_4), Line 113/Bio 8(3) (C_5) and Line 113/Line 81 (C_6) were grown in randomised block design with two replications during *rabi* season in rows of 2.25 m long with spacing of 30 x 15 cm between lines and plants. The experiment was planted on two sowing dates i.e., timely and late. An artificial epiphytotic of *Alternaria* blight was created to facilitate the screening of various populations. Besides this infector rows of highly susceptible lines were planted in and around the experimental plots. Inoculum was sprayed twice for screening at 30 days interval.

From the middle rows of each replication five plants each from P_1, P_2 and F_1, 40 plants from F_2 and 20 plants each from B_1 and B_2 were randomly selected in each cross. Observations were recorded on time of appearance of

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disease (TOAP) in days when lesion first appeared on any leaf of plant from sowing, number of lesion (NOL) by counting total number of lesions on two leaves on which the lesions first appeared in succession of the sampled plants, average size of lesions (mm) (SOL) by measuring the diameter of first two spots in two perpendicular directions and then averaging it, area under disease progress curve (AUDPC) = Time interval [½ (sum of first and last disease scores) + (sum of all in between disease scores)] Pandey *et al.* (1989), rate of increase of disease (r) by dividing the difference between maximum number of lesions and number of lesions at first observation by scoring interval (days), final intensity of disease on plant (FIAP) (0-5 scale) (Kant, 1997) and final intensity of disease on pods (FIDP) (0-3 scale) (Kant, 1997).

The data were subjected to A, B and C scaling tests (Mather, 1949) to detect the presence of epistasis. The adequacy of additive dominance model was tested by the joint scaling test (Cavalli, 1952). The gene effects were studied as per Cavalli (1952) and Hayman (1958).

Results and discussion

The results of the present investigation indicated dominance of alleles for resistance in parents Bio 8 (3) and Line 81, which had lesser numbers of disease lesions (Fig 1) and smaller size of lesions (Fig 2) as against remaining parents.

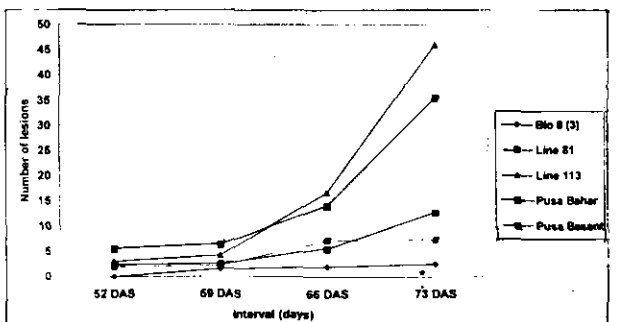

Fig 1. Increase in number of lesions of Alternaria on mustard genotypes

DAS= Days after sowing

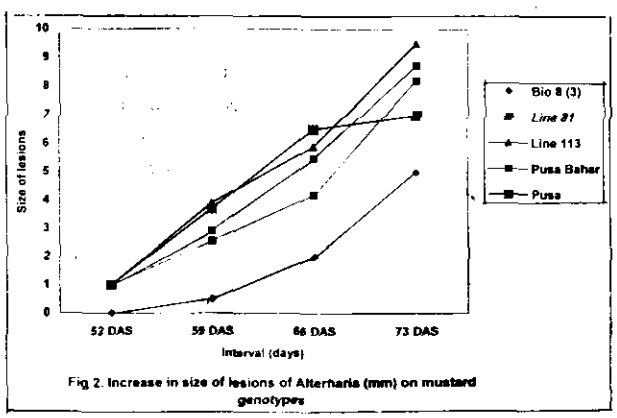

Fig 2. Increase in size of lesions of Alternaria (mm) on mustard genotypes

DAS= Days after sowing

The inheritance of different components of horizontal resistance appeared to be rather complex (Table 1 to Table 3). The inheritance pattern varied with the cross, character and sowing condition under consideration. In most of the cases better estimates of gene effects were found tin (LS) condition, probably due to better expression of disease. A comparison of F_1s with mid parent indicated, in general, a high degree of internal cancellation of gene effects. B_2 means indicated that a second dose of the resistant parent tends to accumulating genes for resistance or lowering expression of disease.

Dominance (h) was found to be more important for the inheritance of TOAP. Cross Pusa Basant/Bio 8(3) and Line 113/Bio 8(3) had both h and i component significant and in desirable direction in (LS) condition. A five parameter model having m = origin, d = additive, h = dominance, i = additive x additive and j = additive x dominance was found adequate to explain the inheritance of TOAP. Therefore, dominance of late appearance of *Alternaria* could be utilized in hybrid development programme. Interaction component i being a fixable component may be exploited in selection programme by transgressive breeding.

Dominance (h) was more important than additive (d) and was in desirable direction for rate of disease increase (r) (Table 1). The rate of increase of *Alternaria* blight indicated multiplication of the disease infection per unit of time and suggested the slow or fast disease reaction of the plants to disease. Lower values would be desirable for selection programme. Negative estimates of h in most of the cases indicated dominance of negative alleles at most of the loci though not able to surpass the lower level in some cases. Pusa Basant/Bio 8(3), Pusa Bahar/Bio 8(3) and Line 113/Bio 8(3) crosses had significant h and i in desirable direction in (LS) condition. Dominance x dominance (l) component was in desirable direction and significant in Pusa Basant/81 and Pusa Bahar/Bio 8(3) crosses. Many workers have demonstrated reduced severity of disease by lower infection rate (r) in different crops. However, low infection rate of resistant cultivars have been reported to be an important component of horizontal resistance in Indian mustard by Saharan and Kadian (1983) and Kadian (1983).

Dominance (h) and additive x additive (i) both were found significant and in desirable direction in Pusa Basant/Bio 8(3) and Line 113/Bio 8(3) crosses in (LS) condition for area under disease progress curve (AUDPC). The h and i components can be exploited through biparental matings or recurrent selections. However, the significance of i component in many cases also suggested that increased manifestation of this character can be achieved through selection programmes. However, additive x dominance (j) was significant and in desirable direction in (TS) condition

in the same crosses. Mani (1991) suggested important role of h and i for AUDPC along with complementary epistasis in case of white rust of Indian mustard. He also found AUDPC as an important parameter in differentiating the genotypes possessing slow and fast rusting behaviour.

Interaction effects were found more important than the main effects for the inheritance of final intensity of *Alternaria* on plant (FIAP) (Table 2). The FIAP is of practical value under field condition to differentiate between resistant and susceptible genotypes. Dominance (h) and additive x additive (i) were found significant and in desirable direction in Pusa Basant/Bio 8(3) and Pusa Bahar/Bio 8(3) crosses. Additive x dominance (j) was important in direction and magnitude in five out of six crosses. The significance of h and i components indicated that biparental mating or recurrent selection could be resorted to improve this character. However, presence of duplicate epistatis may hinder the progress in the selection. Katiyar and Chamola (1995) reported a cultivar selected in the F_7 generation of a cross *Brassica carinata* x *Brassica juncea* showing stable and good resistance to *Alternaria* with only a few small lesions developed on the leaves at completion of fruiting compared with numerous large lesions occurring at flowering on *B. juncea*. Gulati *et al.* (1985) reported final intensity of disease on plant as a criterion for selection under field condition in case of yellow rust of barley. They showed direct relationship between final intensity of disease and AUDPC. Mani (1991) also confirmed these findings in case of white rust of mustard.

Dominance (h) though non-significant was of considerable magnitude and in desirable for final intensity of disease on pods (FIDP) (Table 3). FIDP is of great importance in disease like *Alternaria*, which, when in severe form on pods may lead to shriveling of grains and thereby ultimately leading to reduced oil content. Interaction components were of more importance than main effects. Component i was significant and in desirable direction in Pusa Basant/Bio 8(3) and Pusa Basant/Line 81. However, component j was important in magnitude and direction in Pusa Basant/Line 81 and Line 113/Bio 8(3). Tripathi and Kaushik (1984) reported that intensity of seed infection varied with number of lesions per siliqua in case of rapeseed and mustard. More significance of disease on pods than that of on the leaves was reported by Chahal and Kang (1979). Relation between the infection units on seed pods and loss in seed yield compared with that from healthy pods was reported by Singh and Bhowmik (1985). In such cases it may be possible to expect improvement for this trait in hybrid breeding.

Broadly it can be concluded that dominance (h) had a predominant role in genetic control of later TOAP, lesser r, AUDPC, FIAP and FIDP, whereas additive x dominance (j) was predominant for lesser AUDPC, FIAP and FIDP. Biparental mating or hybrid breeding may be an appropriate strategy to exploit these kinds of gene effects. Additive x additive (i) interaction effects had a major role in later TOAP, lesser r, AUDPC, FIAP and FIDP. This indicated the possibility of selecting for transgressive segregants. In general, crosses with Bio 8(3) showed better expression of resistance and the cross Pusa Basant/Bio 8(3) appeared to be the best cross combination with all the components of horizontal resistance in a desirable direction.

Table 1 Estimates of gene effects ± SE for different components for rate of increase of disease (r)

Cross	Condition	m	d	h	i	j	l	χ^2
C1	TS	0.45**±0.07	0.08±0.04	-0.17±0.11	-0.18*±0.08	-0.14±0.15	-	0.63
	LS	0.88**±0.16	0.08±0.06	-1.38**±0.40	-0.49**±0.15	-0.03±0.15	0.79**±0.24	-
C2	TS	0.36**±0.05	-0.01±0.05	0.13±0.09	-	-	-	4.04
	LS	0.15±0.19	0.09±0.07	0.95±0.52	0.24±0.17	-0.23±0.20	-0.84**±0.33	-
C3	TS	0.37**±0.07	-0.02±0.05	0.08±0.13	-	-	-	1.95
	LS	0.36±0.25	-0.03±0.04	0.08±0.09	-	-	-	4.66
C4	TS	0.17±0.15	0.07±0.05	1.22**±0.41	0.41**±0.14	-0.06±0.15	-0.81*±0.29	-
	LS	0.77**±0.17	0.03±0.04	-1.13**±0.43	-0.43*±0.16	0.52*±0.14	0.70*±0.29	-
C5	TS	0.24**±0.03	0.05±0.03	0.11±0.07	-	-	-	1.75
	LS	0.38**±0.03	0.07±0.03	-0.11±0.06	-	-	-	4.79
C6	TS	*0.34*±0.05*	*-0.05±0.04*	*-0.06±0.10*	-	-	-	-
	LS	0.64±0.10	0.02±0.06	-0.04*±0.14	-0.34**±0.11	-0.03±0.18	-	0.10

C1 = Pusa Basant/Bio 8(3); C2 = Pusa Basant/Line 81; C3 = Pusa Bahar/Line 81; C4 = Pusa Bahar/Bio 8(3); C5 = Line 113/Bio 8(3); C6 = Line 113/Line 81
TS = Timely sown; LS = Late sown *, ** significant at 5% and 1% level

Table 2 Estimates of gene effects ± SE for different components for final intensity of *Alternaria* on plant (FIAP)

Cross	Condition	m	d	h	i	j	l	χ^2
C1	TS	3.70**±0.21	0.71**±0.10	0.15±0.30	0.23±0.23	-2.49**±0.41	-	1.77
	LS	4.70**±0.29	-0.10±0.10	-2.00*±0.82	-0.60*±0.27	0.10±0.30	1.40*±0.56	-
C2	TS	3.58**±0.18	0.35**±0.09	0.91**±0.32	0.67**±0.19	-0.90**±0.28	-	0.01
	LS	3.91**±0.07	0.08±0.07	0.13±0.15	-	-	-	3.76
C3	TS	3.15**±0.34	-0.10±0.16	2.65**±0.97	0.65*±0.30	-0.15±0.41	-1.60*±0.68	-
	LS	4.13**±0.03	0.08±0.08	-0.25±0.23	-0.15±0.12	-0.13±0.12	0.00±0.40	-
C4	TS	4.58**±0.14	0.33*±0.16	-0.94*±0.22	-1.02**±0.21	-0.53±0.47	-	2.59
	LS	4.94**±0.40	0.05±0.10	-2.57*±1.16	-0.69±0.39	-0.96**±0.41	1.73*±0.78	-
C5	TS	4.03*±0.04	0.13±0.17	0.05±0.40	-0.05±0.39	-0.58*±0.20	-0.20±0.74	-
	LS	3.84**±0.05	0.01±0.05	0.68**±0.23	0.76**±0.22	0.13±0.08	-0.73*±0.32	-
C6	TS	4.80**±0.49	0.35**±0.09	-2.20±1.26	-0.55±0.48	-0.85*±0.39	1.70*±0.82	-
	LS	4.10**±0.04	0.10±0.07	-0.03±0.27	-0.38±0.22	-0.04±0.08	0.86±0.46	-

C1 = Pusa Basant/Bio 8(3); C2 = Pusa Basant/Line 81; C3 = Pusa Bahar/Line 81; C4 = Pusa Bahar/Bio 8(3); C5 = Line 113/Bio 8(3); C6 = Line 113/Line 81
TS = Timely sown; LS = Late sown * ** significant at 5% and 1% level

Table 3 Estimates of gene effects ± SE for different components for final intensity of disease on pods (FIDP)

Cross	Condition	m	d	h	i	j	l	χ^2
C1	TS	0.30±0.18	0.28**±0.09	-0.53±0.30	0.55**±0.19	-0.51±0.27	-	2.16
	LS	0.92**±0.14	0.19*±0.08	-0.16±0.23	-0.64**±0.15	0.34±0.25	-	0.35
C2	TS	0.72**±0.13	0.20*±0.09	0.19±0.21	0.19±0.16	-0.69**±0.25	-	0.09
	LS	1.02**±0.17	-0.10±0.10	-0.42±0.25	-0.42±0.21	-0.40±0.30	-	0.10
C3	TS	0.80**±0.04	0/05±0.09	0.30±0.27	0.10±0.25	-0.05±0.13	0.20±0.45	-
	LS	0.89**±0.07	0.05±0.06	-0.04±0.14	-	-	-	3.18
C4	TS	0.59**±0.07	0.28**±0.07	0.18±0.13	-	-	-	4.67
	LS	0.50**±0.06	0.29**±0.05	0.21±0.13	-	-	-	9.06
C5	TS	0.39**±0.05	0.10±0.11	-0.10±0.36	0.35±0.31	-0.15±0.14	-0.50±0.61	-
	LS	0.08±0.19	0.31**±0.07	0.54±0.32	0.35±0.20	-0.77**±0.26	-	1.52
C6	TS	0.83**±0/04	0.03±0.09	0.20±0.29	0.15±0.26	-0.13±0.12	-0.10±0.49	-
	LS	0.75**±0.09	0.00±0.06	0.22±0.18	-	-	-	1.86

C1 = Pusa Basant/Bio 8(3); C2 = Pusa Basant/Line 81; C3 = Pusa Bahar/Line 81; C4 = Pusa Bahar/Bio 8(3); C5 = Line 113/Bio 8(3); C6 = Line 113/Line 81
TS = Timely sown; LS = Late sown *, ** significant at 5% and 1% level

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Induced variation in quantitative characters in Indian mustard [*Brassica juncea* (L.) Czern & Coss]

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Abstract

Four cv. of Indian mustard (*Brassica juncea* (L.) Czern & Coss) namely, RH 30, RH 819, Varuna and Kranti were treated with varying doses of gamma rays and EMS, solely as well as in combinations for induction of variation in quantitative characters. Observations were recorded on twelve morphological traits in the M_2 generation and mean, range, genetic variance, coefficient of variation and heritability in broad sense were calculated. Magnitude of induced variation was found to depend upon the mutagen used, character under study and the genotypic background of the variety. RH 819 and Varuna were found to be suitable base material for the improvement in the quantitative traits through mutations.

Key words: Indian mustard, gamma rays, EMS, genotypic variance, mutation

Introduction

Brassicas are the second most important oilseed crops in India and the significant improvement in it's production has considerably reduced the pressure on the import of edible oil. In recent years Indian mustard (*B. juncea*) has emerged as a competent crop to wheat and pulses under rainfed and semi irrigated conditions. Though the productivity of Indian mustard in India has considerably improved in the last decade but it is still very low in comparison to many European countries. To meet the growing demand of increasing population, it is necessary to produce the genotypes/cultivars with high yield potential, which in turn depends upon the availability of genetic resources and variability. Mutation breeding in collaboration with other plant breeding tools can pay the dividends by creating useful genetic variability (Konzak *et.al*, 1984; Chopra and Sharma, 1985). Crucifies are known to react favorably to mutagenic treatment which is proved by the number of varieties developed through mutation breeding (Bhatia *et. al.*, 1999). A number of workers have used either physical or chemical mutagens solely and very few have used the both in combination in Indian mustard. The present study was undertaken for evaluation of the technical feasibility and perspective role of combined mutagenesis by physical and chemical mutagens for extending the genetic variability of quantitative character in Indian mustard.

Material and Method

The experimental material comprised four Indian mustard cv. *viz.* RH 30, RH 819,Varuna and Kranti. Mature and well filled seeds of these cvs. were irradiated with 60, 80, 100 and 120 KR doses of gamma rays. For giving the ethyle methane sulphonate treatment, the seeds of each cv. presoaked in water for 12 hours were immersed in freshly prepared 0.5, 0.6, 0.7 and 0.8% of EMS for 4 hr with intermittent shaking. Combined treatment was given by first irradiating the seeds with 80 KR of gamma rays and then soaking in water for 12 hr and then giving the respective EMS treatment for 4 hr. The seeds after chemical treatment were thoroughly washed under running tap water and this way 48 treatment combinations were generated which along with four control were laid into randomized block design at research farm of CCS, HAU Hisar. All recommended package and practices were followed to raise a good crop. The M_1 plants were harvested and bulked treatment wise to raise the M_2 generation. The M_2 generation was also laid down into RBD with three replications. The plot size was six rows of 5 m length spaced at 30 x 10 cm between rows and plants, respectively. To study the nature and magnitude of induced polygenic variability observations were recorded on 12 characters of economic importance(Table1 & 2). The variability parameters like mean, genotypic variance, coefficient of variation and heritability were estimated as per standard formulae.

Result and discussion

Gamma rays irradiation, EMS treatment and their combinations induced genetic changes in quantitative characters which were expressed as change of mean, range and other variability parameters. In general the mutagenic treatment had an adverse effect on the means

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Table 1 Estimates of genotypic variance, range and heritability (broad sense) for various quantitative characters in M_2 generations of cv RH 819

Treatment		Days to 50% flowering	Days to maturity	Plant height (cm)	Fruiting zone length (cm)	No. of primary branches	No. of secondary branches	Main shoot length (cm)	No. of siliqua on main shoot	Siliqua length (cm)	Seeds/ siliqua	1000 seed weight	Seed yield/ plant
Control													
	GV	-	0.39	66.15	40.73	0.52	13.42	-	4.93	-	0.39	0.001	17.01
	Range	54-65	133-137	124-208	44-100	4-10	2-22	49-88	26-62	3.6-4.8	8.0-14.4	3.9-5.1	4.0-34.0
	H^2	-	21.12	11.02	16.86	16.34	35.72	-	5.56	-	12.97	3.98	20.09
Gamma rays													
60 KR	GV	10.50	12.75	559.90	68.97	7.36	141.26	9.79	3.77	0.07	1.95	0.13	558.05
	Range	54-72	130-141	114-240	44-110	3-18	1-49	40-88	23-60	3.2-4.8	5.0-13.4	3.3-5.7	3.0-122.0
	H^2	46.45	89.69	51.18	25.57	73.26	85.40	5.76	4.31	31.63	42.54	28.82	89.18
80 KR	GV	4.73	10.33	332.34	309.19	1.89	12.15	70.17	-	0.17	2.05	0.19	29.63
	Range	56-73	130-140	108-208	41-135	3-12	1-25	48-112	27-54	3.2-5.4	5.8-13.0	2.8-5.0	4.0-36.0
	H^2	28.10	87.26	38.36	60.63	41.28	32.90	30.49	-	51.76	43.71	37.23	30.45
100 KR	GV	6.50	5.08	229.34	67.81	0.91	44.42	-	46.32	0.25	4.07	0.17	598.91
	Range	52-73	130-139	131-242	41-100	3-11	4-37	36-88	12-61	2.8-5.1	4.8-15.2	3.7-5.8	2.5-112.0
	H^2	34.94	77.61	30.05	25.25	25.36	64.78	-	35.64	61.89	60.61	34.48	89.80
120 KR	GV	6.81	7.93	302.03	106.07	2.93	33.37	19.15	83.82	0.36	7.69	0.09	156.32
	Range	55-73	130-140	100-213	46-113	3-11	1-31	40-92	20-68	3.0-5.6	3.4-17.8	3.8-5.2	2.0-56.5
	H^2	36.00	84.41	36.13	34.57	52.18	58.01	10.69	50.06	70.73	74.42	21.70	86.50
EMS													
0.5%	GV	4.68	1.79	-	149.10	2.81	21.51	95.01	79.81	0.35	0.70	0.01	113.01
	Range	57-73	133-138	138.229	56-140	2-12	3-29	26-90	14-63	3.1-5.6	7.4-15.4	3.4-4.4	4.5-47.5
	H^2	27.89	54.99	-	42.62	51.14	47.11	37.26	48.63	70.01	21.03	3.02	55.80
0.6%	GV	5.31	7.15	326.70	294.05	3.85	32.35	-	60.64	0.24	0.73	0.17	134.69
	Range	56-73	131-141	11-221	54-130	3-13	1-31	42-81	16-61	3.0-5.4	8.0-16.0	3.7-5.6	4.0-62.0
	H^2	30.49	83.00	37.96	59.43	58.91	57.26	-	42.03	61.35	21.54	34.75	66.51
0.7%	GV	4.15	2.15	700.96	210.23	2.59	37.33	90.76	22.86	0.21	1.87	0.15	79.94
	Range	57-69	135-141	78-222	41-117	3-12	2-34	27-100	27-75	3.0-5.3	5.4-14.4	3.5-5.0	1.5-49.5
	H^2	25.54	59.43	56.76	51.15	49.10	60.72	36.19	21.46	57.88	41.47	31.99	54.16
0.8%	GV	1.93	2.05	414.86	239.83	2.53	43.07	47.68	142.24	0.17	0.40	0.33	122.57
	Range	54-69	134-139	124-220	41-120	4-13	1-37	28-85	12-71	3.2-5.2	7.6-14.0	3.5-5.2	2.0-57.0
	H^2	13.76	58.27	43.72	54.43	48.46	64.08	22.96	62.97	52.61	13.11	50.53	64.43
Gamma rays + EMS													
80 KR+0.5 %	GV	5.12	4.15	-	219.83	11.47	11.98	61.36	24.13	0.58	3.80	0.12	7.75
	Range	54-73	134-14	135-218	38-115	1-17	1-22	43-98	29-63	2.8-6.1	6.4-14.6	3.7-5.3	1.5-35.0
	H^2	29.73	73.92	-	52.26	79.01	33.15	27.73	22.39	79.46	58.98	27.04	10.27
80 KR+0.6 %	GV	6.56	2.27	125.24	132.92	4.71	10.37	-	-	0.29	4.16	0.62	336.88
	Range	58-73	137-143	150-232	40-127	3-14	1-20	45-91	29-63	2.6-5.2	3.2-12.2	3.8-6.2	1.5-103.0
	H^2	35.15	60.76	19.00	39.85	63.65	30.04	-	-	65.63	61.13	66.03	83.20
80 KR+0.7 %	GV	7.32	11.75	-	354.35	4.22	35.46	36.05	65.57	0.44	15.68	0.23	225.91
	Range	54-75	134-147	148-218	36-142	3-15	1-34	33-80	23-66	1.6-5.2	0.8-18.8	3.8-5.2	0.2-83.0
	H^2	37.68	88.91	-	63.83	61.13	59.49	18.39	43.1	74.59	85.58	42.16	76.90
80 KR+0.8 %	GV	23.33	8.48	792.02	234.33	4.12	33.47	15.63	100.71	0.46	4.40	0.23	233.35
	Range	52-75	130-138	96-240	26-128	2-14	1-33	32-84	4-66	2.0-5.8	1.5-15.2	2.9-4.8	1.0-82.0
	H^2	65.83	85.27	59.73	53.85	60.52	58.09	8.90	54.63	75.40	62.46	41.84	76.95

Table 2 Estimates of genotypic variance, range and heritability (broad sense) for various quantitative characters in M_2 generations of cv Varuna

Treatment		Days to 50% flowering	Days to maturity	Plant height (cm)	Fruiting zone length (cm)	No. of primary branches	No. of secondary branches	Main shoot length (cm)	No. of siliqua on main shoot	Siliqua length (cm)	Seeds/ siliqua	1000-seed weight (g)	Seed yield per plant (g)
Control													
	GV	6.51	-	10.06	-	-	-	-	-	-	-	-	-
	Range	53-65	132-135	120-190	52-100	3-8	1-15	54-88	19-49	3.6-5.0	7.0-12.4	4.0-4.7	3.0-22.5
	H^2	34.97	-	1.85	-	-	-	-	-	-	-	-	-
Gamma rays													
60 KR	GV	4.83	3.80	-	-	0.67	34.46	-	-	0.21	1.50	0.06	-
	Range	54-64	134-140	120-214	53-98	2-12	1-38	54-90	23-44	2.0-5.2	3.2-12.0	3.9-5.0	1.0-27.0
	H^2	28.53	72.20	-	-	20.07	58.80	-	-	58.15	36.26	15.52	-
80 KR	GV	8.11	4.49	215.83	19.18	2.35	12.83	27.74	-	0.18	1.95	0.18	130.86
	Range	52-68	133-141	115-225	60-117	3-11	1-23	53-110	27-57	2.8-4.8	4.2-13.0	3.7-5.2	1.5-57.5
	H^2	40.12	75.40	28.78	8.72	46.66	34.70	14.77	-	54.16	42.51	36.05	65.90
100 KR	GV	19.19	6.59	336.06	-	1.42	-	-	10.45	0.36	2.93	0.29	12.23
	Range	50-73	132-140	106-217	55-116	4-10	3-21	36-86	21-64	2.4-5.4	4.8-13.0	3.4-5.6	3.5-49.0
	H^2	61.31	81.81	38.62	-	34.62	-	-	11.15	70.74	52.61	47.11	15.31
120 KR	GV	5.52	6.13	-	10.76	0.64	9.72	21.09	13.70	0.96	4.40	-	-
	Range	55-70	132-141	146-210	57-112	3-9	1-23	51-100	21-61	3.0-6.5	2.4-14.6	3.9-5.7	2.5-33.0
	H^2	31.31	80.72	-	5.08	19.26	28.70	11.65	14.07	86.41	62.49	-	-
EMS													
0. 5 %	GV	3.68	2.73	235.74	141.97	4.87	147.64	-	-	0.26	3.64	0.09	329.36
	Range	57-72	134-140	115-230	44.116	3-14	1-61	42-85	27-59	2.4-5.1	3.2-14.0	3.5-4.8	3.5-82.0
	H^2	23.32	65.11	30.62	41.42	64.47	85.94	-	-	63.71	57.92	23.02	82.95
0.6 %	GV	2.89	2.58	-	6.33	0.65	11.06	-	-	-	0.25	0.02	-
	Range	54-66	132-138	112-176	47-100	3-9	1-21	39-81	22-46	3.4-4.9	7.1-13.6	3.5-4.3	1.5-20.5
	H^2	19.28	63.78	-	3.05	19.52	31.41	-	-	-	8.60	8.28	-
0.7 %	GV	1.74	1.20	9.92	20.43	0.99	12.09	-	-	0.04	0.84	1.16	-
	Range	53-69	132-137	110-187	46-102	3-10	1-25	51-88	20-52	3.4-5.0	5.6-13.4	4.0-5.4	2.0-28.5
	H^2	12.58	45.07	1.82	9.24	27.00	33.36	-	-	19.59	24.11	26.54	-
0.8 %	GV	3.37	10.98	16.87	-	1.26	3.86	109.20	71.05	0.45	1.95	0.60	-
	Range	52-65	130-144	137-233	43-92	4-13	4-27	28-87	9-62	2.4-5.6	4.8-14.0	2.2-5.3	4.0-26.0
	H^2	21.78	88.24	3.06	-	31.94	13.78	40.57	45.93	75.04	42.46	65.81	-
Gamma rays + EMS													
80KR+0.5%	GV	13.64	25.09	57.25	81.91	4.27	96.30	43.48	22.29	0.22	3.67	0.45	269.24
	Range	50-73	131-147	130-220	42-100	1-11	1-53	34-90	32-75	3.0-5.0	3.2-15.0	3.3-5.5	3.5-80.0
	H^2	52.98	94.48	9.68	28.97	61.39	79.95	21.37	21.04	59.61	58.12	58.47	79.91
80 KR+0.6 %	GV	-	1.08	178.61	-	2.64	-	77.02	45.88	0.36	10.05	0.14	-
	Range	53-63	133-137	125-207	55-100	2-12	1-16	47-105	5-56	1.6-5.2	0.5-15.2	4.0-5.4	0.2-26.0
	H^2	-	42.42	25.06	-	49.54	-	32.49	35.43	70.77	79.18	30.66	-
80 KR+0.7 %	GV	26.57	1.25	-	94.70	0.74	0.83	-	-	0.47	5.94	0.41	-
	Range	51-73	134-139	133-210	40-112	4-11	2-20	44-82	21-48	2.0-5.8	3.4-13.6	3.2-5.4	4.0-30.0
	H^2	68.69	45.96	-	32.05	21.66	3.33	-	-	75.88	69.91	56.26	-
80 KR+0.8 %	GV	0.47	8.70	-	214.42	4.18	69.65	-	12.47	0.36	7.87	0.89	173.62
	Range	54-69	135-145	112-200	46-120	2-12	1-37	47-84	22-60	2.2-4.8	2.6-14.4	3.7-5.4	1.0-64.0
	H^2	3.75	85.59	-	51.65	60.88	74.25	-	12.97	70.58	74.85	54.85	71.96

of various characters. In mutation breeding programme the breeders are more interested in the extent of variability, which is more reflected, by range and variance. Two cvs. RH 819 and Varuna (Table1 & 2) appeared to be more vulnerable to mutagenesis as reflected by change in their mean, range and magnitude of variance for various characters. The change in mean value was generally accompanied with increase in range and variance for the most of characters. For flowering and maturity little scope existed for selection of early types as increase in variance in the most of population was due to expansion of range toward lateness except in the population of 100 KR of cv. RH 30. The increase in variance for primary and secondary branches in mutagenised population of cv. RH 30 (data not presented), RH 819 (Table 1) and Varuna (Table 2) was due to expansion of range in desirable direction and thus giving scope for selection of improved types. Scope for improvement also existed for main shoot length and number of siliquae on the main shoot in the same populations whereas for number of seeds per siliqua, 1000 seed weight and pod length desired type of variant were found in the mutagenised population of RH 819 and Varuna only. The increased magnitude of variance for seed yield was observed in the most of mutagenised population of RH 819 and Varuna and that too in the desirable direction. The coefficient of variation as it eliminated the effect of units of measurement for various characters revealed the greater variation for primary branches, secondary branches and seed yield (Table 1 & 2). These characters are controlled by quite complex genetics system involving the large number of genes and therefore, giving the more chances for micro mutation. The differential effect of mutagen was evident from the present experiment as combination treatments in general were more potent in inducing the variation for various quantitative characters. The maximum genetic variance for seven characters in Varuna and Kranti each were found in one of the combination treatments. EMS was the next potent mutagen in term of induced genetic variance whereas the gamma rays was least effective. It is thus clear that direction and frequency of micro mutation depends upon the genotype of the character under study and the mutagen used. RH30 and RH 819 were more amenable with combination treatment whereas Varuna was more sensitive to EMS. The negligible genetic change in the cv. Kranti was quite amazing. Such a differential response of the varieties in the M_2 generation was also reported by Rao and Siddiq (1977), Mahla (1988) and Solanki(1991). The low heritable variation induced by gamma rays might be the result of predominately cryptic chromosomal changes or other induced changes of non-fixable nature (Siddiq *et. al.*,1973). Fruiting zone length and main shoot length appeared to be the characters least affected by the mutagenic treatment. It may be either due to the equal frequency of mutation in positive and negative direction as suggested by Oka *et.al* (1958) or due to less mutable nature of their loci. The heritability estimates were quite high for maturity secondary branches, siliqua length, 1000 seed weight, seed per siliqua and seed yield thereby suggesting the affectivity of selection based on the phenotype. Many workers like Kumar and Das (1977), Mahla (1988) and Labana *et.al.*, (1990) have also reported high heritability estimates for these characters.

The studies showed the significance of proper selection of genotype for mutation breeding programme as RH 819 and Varuna proved to be more suitable base. Similarly it is also concluded that it would be more pertinent to use the combination of physical and chemical mutagens for Brassicas.

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Genotype-environment interaction and stability of yield and yield components in groundnut (*Arachis hypogaea* L.)

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Abstract

The phenotypic stability of 34 groundnut (*Arachis hypogaea* L.) genotypes grown over four environments was estimated for yield and seven yield related traits. The mean squares due to genotypes, environments and genotype x environment were found highly significant for all the characters. The linear and non-linear components of genotype x environment interactions were also significant against all the characters. The magnitude of linear variance was significantly high against non-linear variance for number of primary branches, number of secondary branches and pod number. TCF 1717 had very high pod yield and was stable for yield, number of primary branches, shelling percentage and seed per pod. G-64-206 had high pod yield and was stable for pod yield, primaries number, pod number, shelling percentage and seed per pod. ICGPRS 221 also had high pod yield and was stable for yield, maturity days, 100 seed weight and seed per pod.

Key words: Genotype x environment interaction, stability, adaptability, yield components, *Arachis hypogaea*

Introduction

In any breeding programme it is necessary to screen and identify phenotypically stable genotypes for yield which could perform more or less uniformly under different environmental conditions. It is an established fact that yield is a complex character (Whitehouse *et al.*, 1958) and largely depends upon its component characters, with an interaction with the environment resulting into the ultimate product, i.e. yield. So for breeding a stable variety it is necessary to get the information on the extent of genotype x environment interaction (GEI) for yield and its component characters. In the present investigation, 34 groundnut genotypes were evaluated at four diverse environments to analyse the extent of GEI and to find out the stability and adaptability of these varieties in respect of yield and its component characters.

Materials and methods

The experimental materials included 34 bunch type of groundnut genotypes (Table 2). These were evaluated at four different agro climatic zones of Wes Bengal, viz. Coochbehar (Tarai Zone), Suri (Red Laterite Zone), Daspur (Old Alluvial Zone) and Kalyani (New Alluvial Zone) during the summer season. The experimental materials were sown in randomized block design with three replications. Seeds of each entry were grown in 3 rows, each 5 cm long, spaced 40 cm apart and 12.5 cm plant to plant distance was maintained. Normal agronomic practices were followed to obtain a good crop.

Observations were recorded on 10 plants, selected randomly from each genotype of each replication on number of primary branches, number of secondary branches, pod number, pod weight (g), 100 seed weight (g), shelling (%) and seed per pod. The days to maturity were judged from the yellowing of lower leaves of plants and recorded accordingly. The data on number of secondary branches were subjected to log transformation to reduce the heterogeneity of error variance and that of shelling (%) to angular transformation before statistical analysis. The mean data were subjected to stability analysis following the model of Eberhart and Russell (1966).

Results and Discussion

The analysis of variance (Table 1) revealed the existence of substantial variability among the genotypes tested. The significance of mean square due to GEI for all the characters revealed that the genotypes interacted significantly with the environments. The partitioning of GEI showed that both linear and non-linear (pooled deviation) components of interactions were highly significant for all the characters and they ultimately brought about the total interaction. Yadav and Kumar (1978) confirmed the present observations for maturity days only. However, Kumar *et al.* (1984) observed significant GEI for yield and yield related and quality characters. The significant amount of linear variance of GEI against as compared to non-linear component for

number of primary branches, number of secondary branches and pod number could be accounted mainly by the linear regression. In this regard, Patil *et al* (1983) reported that both linear component and deviation from linearity were responsible for the difference in stability for seed yield among the varieties.

The phenotypic stability of genotypes was measured by mean performance over environment (x), the regression coefficient (b) and the deviation from regression (δ^2di). In Eberhart and Russell (1966) model b is considered as a measure of responsiveness and δ^2di; as a measure of stability. The xi, bi and δdi of the genotypes for different characters were presented in the tables 2,3 and 4 respectively.

The genotype EC 24389 had the highest pod yield (11.6g) but unstable as from its significant δ^2di. TCF 1717 showed very high yield (10.6 g) and non significant δ^2di. Nearly unit response (b=0.97) of TCF 1717 indicated its wide adaptability to all environments in this regards. Non significant δ^2di, above average response (bi>1) and considerably high mean performance of ICGPRS 221 and G-64-206 indicated their adaptability for favourable environment. Three genotypes ICG (FDRS) 34, ICGPRS 194 and ICG (FDRS) 23 were highly responsive (bi significantly greater than one) and stable (δ^2di nonsignificant) but showed below average mean performance. These findings revealed their poor adaptability to the better environments. Among the average responding group (bi=1), ICG (FDRS)-1 possessed least and non significant δ^2di (0.05) but its poor mean performance (x) suggested the poor adaptability to all kind of environments. ICG 9393, ICG (FDRD) 34 and Godjah showed considerable degree of stability (δ^2di nonsignificant) but bellow average mean pod yield and bi<1 revealed their poor adaptability specifically to unfavourable environments.

The bi value of ICG (FDRS) 34 and ICGPRS 221 were significant less than unity for maturity days and they possessed non significant δ^2di. They were also late in maturity. So, they might be adapted to poor environment for this trait. Four seeded Red Type exhibited non significant δ^2di with simultaneously above average response (b>1) and early maturity indicated its suitability for better environment.

Twenty five genotypes were stable for number of primary branches as evidenced from their non significant δ^2di. Among them, EC 24389' had significant bδ (1.49*) but low xi revealed its poor adaptability to favourable environment. Whereas, JSP8 and ICEU 86011 δ had above average response (bi>) and high mean xi suggesting their suitability for better environment. ICGPRS 194 and ICG (FDRS) 61 were the most desirable genotypes as widely adapted to all environments due to their high Xi, non significant and nearly unit response for this trait. Godjah, JL 59, AK-12-24, TCF 1717, IARI 731, Exotic 6, Gorpada, EC 259627, BPE 510, Four seeded Red Type, OG-85-2, Kadiri 104, OG-85-1 and JL 24 possessed non significant δ^2di. So, all of them were stable for said character. Among them JL 59 only had b<1 simultaneously with high mean performance revealed its adaptability specifically to poor environment for this trait concerned.

G-64-206, GBPRS 45, ICC (FDRS) 61, JSP8 and EC 24389 attained nearly average response for number of secondary branches but their δ^2di were significant. Among the high performing genotypes, ICGS 15, BPE 510, ICGS 24 and Godjah had bi>1 and were highly stable (non-significant δ^2di). So these genotypes were adapted specifically to favourable environment. Kadiri 104, Four seeded red type and ICG (FDRS) 23 has nonsignificant δ^2di and bi<1, so they were suitable specifically for poor environment. Rest of the genotypes were unstable for this trait.

Eleven genotypes were stable for pod number (non-significant δ^2di). Among them ICG (FDRS)1 and OG-85-1 had bi>1 and xi revealed their poor adaptability to better environment. ICGS 11, EC 24389 and Gorpada possessed very high pod number but they were unstable (δ^2di significant). G-64-206 and JL 24 had high mean performance, non-significant δ^2di and nearly unit response indicated their wider adaptability for all environments. BPE 510, ICG (FDRS) 34, JSP 8 and IC 1536 were showed poor adaptability to poor/unfavourable environment due to their bellow population mean pod number (12.5). While Four seeded Red Type adapted specifically to poor/unfavourable environments in this regard.

Nineteen genotypes were stable for 100 seed weight. Among them, ICGS 15 was the lone genotype widely adapted to all environments for its nearly unit response (b=0.97) and above average mean performance for this trait. Among the high performing genotypes ICGS 225, ICGS 24, ICGPRS 221, BPE 510 and OG-85-1 showed a high degree of stability with bi>1. So, they were adapted specifically to better environment. Gorpada and Four Seeded Red Type had negative bi value and non significant δ^2di suggested their adaptability specifically to poor environment. In addition to these ICG 9393 and ICG 9395 were also adapted to poor environment (non-significant δ^2di and bi<1) for this trait. EC 24389, IARI 731, Godjah and AK-12-24 were also stable but poorly adapted to poor/unfavourable environments due to their poor mean performance for the same.

Twenty two genotypes had nonsignificant δ^2di for shelling %. Among them, AK-12-24 and Godjah possessed nearly

unit response, and high mean shelling %. So, they were the most desirable types for wider adaptability for this trait. JL 59, Exotic 6, ICGPRS 225 and ICGS 24 were stable and possessed above average response simultaneously with high xi values revealing their adaptability specifically to better environment. IC 1536, EC 259627 and EC 24389 possessed negative bi value and a good stability (δ^2di non-significant) indicated their high suitability for poor/unfavourable environment. Moreover, TCF 1717, ICG 9395, 9CG (FDRS) 34, Gorpada and ICG 9393 were also desirable types for poor environment for the said character.

In respect of seed/pod, Exotic 6 and ICG 9395 were highly stable (non-significant δ^2di) and possessed nearly unit response (bi=0.94 respectively). Exotic 6 had high mean performance, therefore, it was widely adapted to all environments, whereas, ICG 9395 showed poor adaptability to all environments due to its poor mean performance for the said character. EC 24389, G-64-206, ICG (FDRS) 34 and ICG (FDRS) 43 possessed above average response high mean performance and non-significant S2di, therefore, all of them were adapted specifically to rich/better/favourable environments. Non significant S2di, bellow average response and high mean performance of Godjah, EC 259627, Four seeded Red Type, ICG 9422 and AK-12-24 revealed their adaptability specifically to unfavourable environments for seed/pod. ICGS 24, IARI 731, IC 1536, JL 59, JSP 8, OG-85-24, ICG (FDRS) 61, ICGPRS 221 and TCF 1717 were also stable as evidenced from their non-significant δ^2di but showed poor adaptability due their poor mean performance for the said character.

If is concluded that the stability of yield is imparted in TCF 1717 though the stability of number of primary branches, shelling % and seed/pod; in G-64-206 through number of primary branches, pods number, shelling % and seed/pod; in ICGPRS 221 through number maturity days, 100 seed weight and seed/pod; in Gorpada through number of primary branches, number of secondary branches, 100 seed weight, shelling % and seed/pod; in ICG 9393 through number of primary branches, pod number, 100 seed weight, shelling % and seed/pod and in ICG (FDRS) 34 through maturity days, pod number, 100 seed weight, shelling % and seed/pod. Therefore, the stability of yield in different groundnut genotypes were ultimately imparted through the stability of their different components characters in additive fashion.

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Table 1 Pooled Analysis of variance for different characters

Source	d.f.	Characters							
		Pod yield (g)/ plant	Days to Maturity	No. of Primary branches/plant	No. of Secondary branch/plant	Number of pods/plant	100 seed mass (g)	Shelling (%)	Seed/ pod
Genotypes (G)	33	10.40**	70.33**	7.18**	0.09*	28.45**	25.30**	0.003*	0.096**
Environments (E)	3	89.31**	4090.67**	31.33**	0.62**	394.31**	254.93**	0.030**	0.089**
G X E	99	5.03**	17.03**	1.14**	0.03**	10.12**	17.05**	0.002**	0.015**
G X E (Linear)	33	5.46**	18.68**	1.71**	0.04**	15.48**	17.76**	0.003**	0.017**
Pooled Deviation	68	4.68**	15.74**	0.83**	0.02**	7.23**	16.21**	0.002**	0.013**
Pooled Error	264	0.55	0.48	0.32	0.002	1.00	2.85	0.001	0.006

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

Table 2 Mean performance (x̄) of the 34 genotypes for seven characters

Genotype	Pod yield (g)/plant	Maturity days	Primary branch/ plant	Secondary branch/ plant	Pod number/ plant	100 seed Weight (g)	Shelling percentage	Seed/ pod
EC 24389	11.6	115.6	5.7	3.9	18.3	26.0	69.1	1.70
Gorpada	9.6	117.1	4.7	2.4	15.2	24.7	66.4	1.66
Godjah	7.8	120.3	4.8	3.3	13.7	22.8	67.9	1.75
G-64-206	9.8	118.9	6.0	3.5	14.5	25.5	65.8	1.72
Fourseeded Red	9.6	116.2	5.6	4.1	14.4	26.2	65.9	1.67
Exotic 6	11.0	116.5	5.5	3.9	16.4	25.2	65.1	1.75
EC 259627	9.4	118.6	5.4	2.8	15.1	26.2	67.7	1.65
ICGS 24	9.0	123.2	7.4	2.5	13.4	31.9	65.7	1.44
ICG 9393	8.1	121.7	5.3	2.3	11.8	27.8	66.3	1.65
ICG 9395	8.2	118.8	4.9	2.4	11.5	28.9	66.0	1.63
ICG 9422	7.8	117.7	5.4	3.4	11.9	26.1	65.7	1.68
ICGS 15	7.8	117.3	5.4	4.7	11.5	27.1	63.4	1.59
IARI 731	10.1	115.2	5.0	4.2	16.5	23.5	63.3	1.65
IC 1536	8.7	116.1	5.5	2.9	11.8	29.8	64.0	1.63
JL 59	6.2	124.8	7.1	5.1	10.6	25.5	67.0	1.53
ICG (FDRS) 23	7.2	127.1	8.6	4.6	9.4	25.6	64.0	2.15
ICG (FDRS)1	7.6	122.2	5.5	2.1	13.1	22.5	63.2	1.82
ICG (FDRS)61	6.3	124.0	6.4	5.3	10.3	26.7	61.4	1.59
ICG (FDRS)34	7.9	125.3	6.5	1.8	9.7	24.9	64.8	2.10
ICG (FDRS)43	8.1	122.9	7.3	3.2	12.2	25.4	60.1	1.72
ICGS 11	9.4	124.2	7.1	2.0	15.3	27.6	62.5	1.47
ICGPRS 194	5.2	129.7	8.1	4.0	9.1	26.1	60.6	1.48
ICGPRS 221	8.7	128.2	5.5	0.6	15.3	27.4	64.4	1.41
GBPRS 45	5.6	126.3	7.8	6.4	8.9	26.2	62.9	1.53
ICGPRS 225	8.9	129.2	10.6	6.8	12.9	30.1	66.8	1.59
JSP 8	5.0	124.2	8.8	7.4	7.2	28.0	58.6	1.57
AK-12-24	8.1	119.1	4.7	2.3	14.6	22.3	65.7	1.67
OG-85-2	7.1	118.8	5.4	4.5	9.3	31.3	64.8	1.61
JL 24	9.7	118.9	5.4	3.0	12.7	33.1	65.8	1.56
BPE 510	8.4	122.9	5.6	3.8	11.9	28.3	64.0	1.62
TCF 1717	10.6	120.7	5.8	3.2	16.1	28.2	65.0	1.60
Kadiri 104	8.3	124.3	4.7	3.5	12.0	25.9	64.3	1.80
ICEU 86011	5.8	128.5	6.6	1.7	7.9	26.0	63.2	1.79
OG-85-1	9.0	119.0	5.9	4.8	12.1	28.8	62.2	1.68
Population/Grand Mean	8.3	121.6	6.2	3.1	12.5	26.8	64.5	1.65

1-15 NRCG, Junagadh, 16-25 ICRISAT, Hyderabad, 26-34 OUA&T, Bhubaneshwar

Table 3 Regression coefficients (b) of individual genotypes for different characters

Genotype	Pod yield (g)/plant	Maturity (days)	Primary branch/ plant	Secondary branch/ plant	Pod number/ plant	100 seed Weight (g)	Shelling (%)	Seed/ pod
EC 24389	1.16	1.20	1.49*	1.08	1.08	0.06	-1.07	1.37
Gorpada	1.81	1.00	0.38	2.12	1.08	-0.02*	0.12**	0.57
Godjah	0.45	1.14	0.45	2.11	0.75	0.39	0.95	0.15
G-64-206	1.55	1.18	1.08	0.98	1.02	1.17	1.70	1.46
Fourseeded Red	1.54	1.14	0.27*	0.70	0.60	-0.40	2.37	-0.32
Exotic 6	1.48	1.39	0.82	1.37	0.37	-0.02	1.90	0.94
EC 259627	0.51	1.03	0.27	1.47	1.00	1.92*	-0.63	0.36
ICGS 24	0.54	1.12	1.80	1.34	1.02	2.92	1.43	1.57
ICG 9393	0.63	1.18	1.16	2.10	0.46	0.05	0.03	0.08
ICG 9395	0.36	0.97	0.88	2.15	0.49	0.01	0.51	0.93
ICG 9422	1.14	1.25	1.83	1.18	0.56	-0.16	0.09	0.35
ICGS 15	0.35	1.43	1.21	1.63	0.51	0.97	0.33	1.90*
IARI 731	1.74	1.21	0.68	1.40	1.18	0.43	1.98	1.54
IC 1536	0.40	1.09	0.71	1.23	0.44	0.32	-0.44	1.23
JL 59	-0.18	1.19	0.35	0.28	0.02	0.75	3.46*	2.62
ICG (FDRS) 23	2.25*	0.84	1.08	0.76	1.87	0.79	1.03	1.97
ICG (FDRS)1	0.98	0.71	1.16	-0.12	1.33	1.11	2.22	2.62
ICG (FDRS)61	1.01	0.81	1.10	1.03	1.21	1.29	2.56	-1.03
ICG (FDRS)34	0.34	0.59*	1.55	-1.22	0.53	1.04	0.76	5.35
ICG (FDRS)43	1.61*	0.86	1.06	0.32	2.01*	0.81	0.90	1.68
ICGS 11	3.74	0.79	1.99	0.50	3.25	0.32	0.71	1.74
ICGPRS 194	2.07*	1.01	1.06	1.83	2.12	1.36	-0.44	0.40
ICGPRS 221	1.26	0.49**	0.85	-0.42	1.71	2.35*	2.28	-1.02*
GBPRS 45	-0.48	0.90	1.27	1.03	0.10	0.97	-0.26	-1.69
ICGPRS 225	-0.32	0.67	4.16	0.35	-0.04	3.07**	1.57	1.88
JSP 8	-0.02	0.88	1.42	0.94	0.41	1.73	1.36	3.03
AK-12-24	0.75	1.04	0.44	2.32	1.13	0.86	1.03	-1.05
OG-85-2	0.92	0.89	0.47**	0.26	0.92	3.00	1.64	2.09
JL 24	1.34	1.31	-0.03	1.77	1.04	0.72	1.68	1.20
BPE 510	0.32	0.93	0.72	1.65**	0.70	1.74	1.21	1.12
TCF 1717	0.97	0.61	0.79	1.27	1.33	1.09	0.84	0.59
Kadiri 104	1.04	1.13	0.15	0.22	1.42	1.14	1.33	-2.27
ICEU 86011	0.98	0.97	1.71	-1.20*	0.93	1.02	-0.72	2.11
OG-85-1	1.75	1.03	-0.37	1.51	1.40	1.15	1.58	0.53

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

Table 4 Deviation from regression (δ^2_{di}) of individual genotypes for different characters

Genotype	*Pod yield* (g)/plant	*Maturity* (days)	Primary branch/ plant	Secondary branch/ plant	Pod number/ plant	100 seed Weight (g)	*Shelling* (%)	Seed/ pod
EC 24389	4.12**	1.05*	-0.29	0.05**	23.01**	4.91	0.000	0.008
Gorpada	15.81**	1.74*	0.09	0.01**	31.02**	-2.31	0.001	0.016*
Godjah	0.22	7.05**	0.01	0.00	2.75*	-1.92	0.00	0.006
G-64-206	0.89	6.89**	0.21	0.01**	-0.01	20.00**	0.002*	0.000
Fourseeded **Red**	2.27**	0.71	-0.27	0.00	0.90	2.87	0.001	-0.002
Exotic 6	2.87**	4.11**	0.08	0.02**	3.07*	16.99**	0.000	-0.005
EC 259627	1.53*	7.07**	-0.14	0.02**	5.19**	-2.49	0.001	-0.003
ICGS 24	6.45**	1.74*	3.40**	0.00	9.06**	2.90	0.001	0.004
ICG 9393	0.32	17.25**	0.08	0.02**	0.52	4.33	0.001	0.014*
ICG 9395	11.61**	1.30*	-0.17	0.01*	12.76**	1.16	0.000	-0.004
ICG 9422	3.97**	26.33**	-0.14	0.04**	9.48**	5.86*	0.001*	-0.005
ICGS 15	9.99**	15.84**	-0.11	0.00	7.46**	1.77	0.003**	-0.006
IARI 731	1.90*	7.05**	-0.08	0.01*	-0.82	-0.82	0.001	0.009
IC 1536	5.01**	2.49**	0.91*	0.02**	0.97	140.69**	0.000	0.011
JL 59	6.38**	14.40**	*0.02*	*0.09***	8.58**	28.19**	*0.000*	*-0.004*
ICG (FDRS) 23	-0.10	37.39**	3.96**	0.00	2.74*	7.49*	0.000	0.007
ICG (FDRS)1	0.05	26.30**	0.22	0.03**	2.63*	1.81	0.002*	0.0026**
ICG (FDRS)61	2.85**	34.46**	0.21	0.01**	9.68**	3.04	0.002*	0.002
ICG (FDRS)34	0.69	0.64	1.71**	0.71**	-0.55	-2.13	0.000	-0.001
ICG (FDRS)43	-0.41	1.04*	0.89*	0.03**	0.68	32.58**	0.000	-0.002
ICGS 11	10.26**	20.85**	1.28**	0.01**	17.73**	26.66**	0.003**	0.028**
ICGPRS 194	-0.26	25.21**	0.43	0.06**	3.19*	27.31**	0.009**	0.025**
ICGPRS 221	-0.25	-0.37	1.01*	0.02**	3.44*	-0.97	0.006**	0.005
GBPRS 45	0.45	15.92**	1.70**	0.07**	2.92*	12.56**	0.000	0.019*
ICGPRS 225	24.18**	21.49**	1.27**	0.01*	10.69**	-2.46	0.000	0.040**
JSP 8	1.76*	35.87**	0.11	0.02**	0.56	43.84**	0.008**	-0.009
AK-12-24	8.07**	11.21**	-0.05	0.05**	16.54**	-0.09	0.001	-0.003
OG-85-2	3.17**	14.55**	-0.30	0.01**	1.31	21.70**	0.001*	-0.003
JL 24	3.19**	10.24**	0.42	0.08**	-0.75	20.94**	0.0001*	-0.0011
BPE 510	4.55**	6.33**	0.26	0.00	0.12	3.16	0.000	0.018**
TCF 1717	-0.07	32.78**	*-0.06*	*0.01**	9.07**	*15.92***	*0.001*	*0.008*
Kadiri 104	2.88**	71.91**	0.30	0.00	2.90*	-0.61	0.001	0.016**
ICEU 86011	4.28**	10.81**	0.27	0.01**	8.70**	19.75**	0.003**	0.022**
OG-85-1	1.55*	30.18**	0.35	0.01**	1.13	0.37	0.001*	0.013*

*,** significant **at 5% and 1% level**, respectively

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Genetics and inter-relationship of oil and protein content in crosses involving confectionary genotypes of groundnut (*Arachis hypogaea* L.)

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Abstract

Genetic analysis of oil and protein content was performed on 28 non-reciprocal diallel set of crosses involving eight bold seeded virginia groundnut genotypes. Estimates of genetic components of variance indicated that dominance genetic effects were significant for oil content while additive and dominance components were significant for protein content in F_1 and F_2 generation. However, the dominance components were greater in magnitude than additive components suggesting the preponderance of dominance in governing these two important quality attributes. The average degree of dominance (H1/D) 1/2 was found in the range of over dominance for oil and protein content having unequal frequency of dominant and recessive genes with more number of dominant genes. Heritability estimates in narrow sense was low for oil and high for protein content in both the generations. Correlation studies indicated a positive and significant relationship between pod yield and protein and were negative between oil and protein. Reciprocal recurrent selection scheme for developing bold seeded confectionery genotypes having high protein and low oil was suggested.

Key words: Genetic analysis, components of variance, groundnut

Introduction

Groundnut is a premier oilseed crop of India. The seeds contain 31-55 % oil and 16-34 % protein. More than 80% of groundnut production in the country is used for extraction of oil and about 1% is exported for confectionery (HPS) purposes. With the changing scenario in the global trade in general, and agriculture in particular, the emphasis in the national programme and elsewhere is now focused on the development of bold seeded groundnut genotypes having low oil and high protein and sugar contents matching with the international trade requirements and standards.

Before formulation of suitable strategies to breed varieties with specific requirements like confectionery groundnut, understanding the relationship and genetic systems governing oil and protein contents are very essential. Although several studies have been conducted using small seeded genotypes, studies pertaining to the genetics of these quality parameters involving the bold seeded genotypes are rather scanty (Dwivedi *et al.*, 1989). Hence, a study was conducted with 28 non-reciprocal diallel crosses involving bold seeded confectionery grade virginia genotypes of groundnut through Hayman's (1954) approach.

Materials and methods

Twenty-eight non-reciprocal diallel crosses involving eight bold seeded genotypes *viz.* ICGV 94196, ICGV 94222, JSSP (HPS) 8, JVB 229, CSMG 9101, GG 20, ICG (CGS) 49 and ICGV 91089 were effected during *kharif* 1998. The F_1's and F_2's were raised separately along with the parents in a randomized block design with four replications during the summer and *kharif* seasons of 1999, respectively at Gujarat Agricultural University, Junagadh. Each replication in F_1 consisted of single row of 4 m length while the F_2's were raised in plots of 4 rows of 4 m length. A spacing of 20 cm between plants and 60 cm between rows was uniformly maintained for F_1's as well as in F_2's. All the recommended package of practices for raising a good crop was followed.

Data on pod yield and protein and oil contents were recorded on randomly selected plants in F_1 and on 50 plants in F_2 generation for each cross. Protein content was estimated based on total Nitrogen content of seed by micro-kjeldal method (Jackson, 1967), and oil content was estimated following specific gravity method as proposed by Misra *et al.* (1993). The data were analysed by using Hayman's (1954) approach. Correlation coefficients were obtained following the method of Dewey and Lu (1959). Genetic components of variance, additive (D) and non-additive (H_1 and H_2) were worked out as per the method suggested by Hayman (1954). Heritability estimates (in

narrow sense) were worked out for the two traits following the method of Crumpeker and Allard (1962).

Results and discussion

Genetic analysis of oil content indicated that non-fixable genetic components of variance (H_1 and H_2) were significant while fixable genetic component (D) was non significant in both F_1 and F_2 generations indicating the preponderance of non-additive genetic variance in the inheritance of oil content. While both additive and non-additive genetic variances were important in the inheritance of protein content, the non-additive genetic variance was higher in magnitude than the additive component in the two generations studied.

The positive values of 'F' and the KD/KR ratio exceeding unity further supported our observation of the preponderance of dominance variance in the inheritance of oil and protein contents.

The average degree of dominance (H1/D) 1/2 for oil and protein content was in the range of over dominance (values exceeding unity) in both F_1 and F_2 generations. Hayman (1954) indicated that interacting (non-allelic) dominant loci would result in apparent over dominance as observed in the present study. For both oil and protein contents, the genes with positive and negative effects were asymmetrically distributed as seen from the H2/4H1 ratio, which was less than 0.25.

The review of previous studies on genetics of oil and protein contents was conflicting. Predominance of both, additive genetic effects (Layrisse *et al.*, 1980; Bansal *et al.* 1992) and non-additive gene effects (Makne and Bhale, 1987) was observed for oil content. Protein content was reported to be governed by additive gene effects (Layrisse *et al.*, 1980; Makne and Bhale 1987; Bansal *et al.*, 1992).

The heritability estimates for oil content were low and high for protein content in both the generations. Such an observation, where preponderance of dominance genetic effects manifested in the inheritance of these two traits, yielding extreme values of heritabilities may arise due to over dominance or linkage in repulsion phase of favorable or detrimental genes in the partial to complete dominance range or due to epistatic interactions (Layrisse *et al.*, 1980). Hence to isolate superior genotypes with high protein or oil contents, early generation selection may be ineffective and may be postponed to later generations.

Inter relationship estimates ('r' values) between pod yield and protein content indicated a significant positive value (r=0.52) while it was negative (r = -0.64) and significant between pod yield and oil. Interestingly oil and protein contents exerted a strong negative relationship (r = -0.74). Thereby indicating that conscious selection for the one would automatically results in the reduction in the other. Layrisse *et al.* (1980) obtained significant and positive correlation for pod and kernel yield with oil and protein percent. Holley and Hammons (1968), Huang (1975) and Tai and Young (1975) reported negative correlations of pod and kernel yield with oil and protein and between oil and protein contents.

Hence it is suggested that to breed special purpose varieties like confectionery grade bold seed groundnuts having high protein and low oil content, breeding procedures which effectively mop up non-additive variance like biparental mating or reciprocal recurrent selection scheme as followed in soybean (Brim and Burton, 1979) for simultaneous improvement of yield and protein, may be adopted.

Table 1 Estimation of genetic components of variance for oil and protein content in groundnut

Characters		Genetic components of variance										
		D	H1	H2	h2	F	$(H1/D)^{\frac{1}{2}}$	H2/4H1	KD/KR	$h^2/H2$	Heritability %	t^2
Oil	F1	2.15 ± 1.55	11.21*±3.57	9.99*±0.11	0.50±0.08	1.63±0.67	2.28	0.22	1.40	0.05	18.26	6.004
	F2	2.16±0.98	54.67±9.02	36.67**±7.85	0.05±1.32	7.76±4.64	5.04	0.18	2.11	0.001	17.99	3.263
Protein	F1	35.40**±8.11	76.83*±18.65	64.18**±16.23	36.12*±10.88	12.75±19.17	1.47	0.21	1.28	0.56	35.54	6.153
	F2	35.40**±4.70	324.58**±43.20	194.37**±37.58	17.63*±6.30	127.22*±22.20	3.03	0.15	3.92	0.09	66.71	0.061

*, ** significant at P=0.05 and 0.01 %, respectively

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Genetic divergence for seed yield and other characters in sesame (*Sesamum indicum* L.)

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Abstract

Studies on the genetic divergence of 50 genotypes of *Sesamum indicum* L. for eight characters led to their grouping into eight clusters. Grouping of genotypes in to different clusters was not related to their geographic origin. The genotypes from different geographic locations were grouped into one cluster while genotypes of the same geographic origin showed genetic diversity. The diversity among the genotypes, measured by intercluster distances was adequate for improvement by hybridization and selection. Based on mean performance, genetic distance and clustering pattern, hybridization involving genotypes ES-14-1-84, ES-14-2-84, ES-14-4-84 and EC-377016 are likely to give desirable segregants. Among eight characters studies for genetic divergence, capsules/plant contributed maximum, accounting for (39.02%) of total divergence followed by seed yield/plant (28.65%).

Key words: Divergence, sesame, genetic distance, hybridization

Introduction

The development of new varieties is mainly governed by the magnitude of genetic diversity in the base material and extent of variability for the desired characters. Genetic variability and divergence are of greatest interest to the plant breeder as these play a vital role in framing a successful breeding programme. The nature and magnitude of genetic divergence in a population is essential for selection of diverse parents which upon hybridization leads to a wide spectrum of gene recombinations for quantitatively inherited traits. The present study has been undertaken with 50 sesame germplasm lines to understand the nature and magnitude of genetic divergence and the characters contributing to genetic diversity by using D^2 statistics.

Materials and methods

Fifty exotic germplasm lines including two indigenous released varieties (RT-46 and TC-25) were grown in randomized block design with two replications at Agriculture Research Station, Mandor. Each plot consisted of single row of 2.5 m length spaced at 30 cm and plants within rows at 15 cm. Observations were recorded on five randomly selected plant of each genotype per replication for eight characters. The analysis of variance was carried out for all the characters individually. Multivariate analysis was done as per Mahalanobis D^2 statistics as described by Rao (1952) and the genotypes were grouped into different clusters following Tocher's method described by Rao (1952).

Results and discussion

The analysis of variance for each individual showed highly significant differences among the genotypes for all the characters studied. The pooled divergence for all the characters within the lines, tested by the Wilk's criterion, was significant. Hence the analysis of genetic divergence among genotypes used in the study was considered relevant.

The multivariate analysis giving the D^2 values between 50 genotypes revealed that all these genotypes can be grouped into eight clusters (Table 1). Among these, cluster I consisted of 23 genotypes followed by cluster II (19), V and VI (2 each) and clusters III, IV, VII and VIII with one genotypes each. Interestingly, the related genotypes and the lines of same country were distributed in different clusters. The results indicated that genetic divergence is not related to geographical diversity corroborating earlier findings of Thangavelu and Rajasekaran (1983). Further, it also suggested that selection pressure which played a greater role in determining the genetic closeness/ divergence among the varieties. Similar conclusions were made by Bhatti (1970) who suggested that genetic drift and selection forces under diverse environments could cause even greater diversity than the geographical diversity.

Table 1. Distribution of sesame genotypes into different clusters

Cluster	No. genotype	Genotype	Origin
I	23	ES-22(B), ES-11, ES-18(B), ES-24, EC-377137, ES-10	USA
		ES-196-1-84, ES-6(A), ES-6(B), ES-237, ES-251-1-84	Venezuela
		ES-3-1-84	Turkey
		ES-175-2-84, ES-175, ES-175-1-84, EC-357032	Korea
		EC-376961, EC-355659, EC-355663, EC-355665, EC-**376962**	Thailand
		EC-357323, EC-357302	Myanmar
II	**19**	ES-21-1-84	USA
		ES-249, ES-266, ES-242, ES-347, ES-6-1-84, ES-8, ES-**269, ES-245-1-84**	Venezuela
		ES-379-1-84, ES-4, ES-379-3-84	Turkey
		ES-343-1-84, EC-376966	Korea
		EC-357310	Myanmar
		TC-25, RT-46	India
		ES-2(B), ES-2(C)	Nairobi
III	1	EC-355654	Thailand
IV	1	EC-370663	Turkey
V	2	Es-14-4-84, EC-3**77016**	USA
VI	2	ES-8-2-84, ES-12	USA
VII	1	ES-14-184	USA
VIII	1	ES-14-2-84	USA

The intercluster distances were greater than intercluster distances, revealing that considerable amount of genetic diversity existed among the genotypes studied (Table 2). Cluster VI showed maximum intracluster distances. Intercluster distance is the main criterion for selection of genotypes using D^2 analysis. Genotypes belonging to the clusters with maximum interclusters distance are genetically more divergent and hybridization between genotypes of divergent clusters are likely to produce wide variability with desirable segregants (Dhamu *et al.*, 1983). The maximum intercluster distance was recorded between cluster III and VIII (41.44) while the distance was minimum between II and IV (12.00).

Cluster VII recorded highest mean for seed yield/plant, capsules bearing, plant height, early flowering and late maturity (Table 3). Cluster VIII recorded high mean seed yield and highest plant height. Cluster V recorded highest capsules/plant and medium plant height. Thus, the genotypes of outstanding mean performance from these three clusters may be identified as potential parents and could be utilized in hybridization programme for developing new varieties.

The characters contributing maximum to the divergence i.e. capsules/plant (39.02%), seed yield/plant (28.65%), capsules bearing plant height (18.37%) and plant height (7.51%) should be given more emphasis for the purpose of further selection and choice of parents for hybridization (Table 4). Similar results were also reported by Dhamu *et al.*, 1983.

Table 2 Intracluster (in bold) and intercluster distance among eight characters in sesame

Cluster	I	II	III	VI	V	VI	VII	VIII
I	9.74	15.8	13.21	23.14	29.24	24.88	31.48	35.42
II		8.37	22.69	12.00	18.03	21.30	21.60	22.81
III			0.00	29.69	36.38	24.37	36.08	41.44
IV				0.00	16.34	21.26	13.02	15.13
V					7.97	30.97	25.61	15.73
VI						12.22	19.32	26.88
VII							0.00	15.44
VIII								0.00

Table 3 Character means in different clusters of sesame genotypes

Character	I	II	III	IV	V	VI	VII	VIII
Days to flowering	40.04	39.68	44.0	37.0	38.5	41.0	36.0	36.0
Days to maturity	83.44	82.84	85.0	85.0	85.0	84.0	85.0	85.0
Plant height	79.49	106.69	38.0	111.4	113.8	8.2	132.6	138.8
Branches per plant	3.35	4.10	2.0	3.2	5.1	3.1	1.4	3.8
Capsules bearing plant height	38.0	57.36	21.3	84.4	65.5	40.3	92.8	80.4
Capsules per plant	32.26	53.59	17.50	53.4	98.5	26.2	40.6	83.6
1000-seed weight	1.56	1.88	2.14	2.93	2.56	2.22	2.22	2.92
Seed yield per plant	1.14	3.03	2.00	4.84	3.82	7.71	7.99	7.64

Table 4 Ranks of contribution of the eight characters towards divergence

Character	Number of time rank	Contribution (%)
Days to flowering	26	2.12
Days to maturity	18	1.47
Plant height	92	7.51
Branches per plant	23	1.88
Capsules bearing plant height	225	18.37
Capsules per plant	478	39.02
1000-seed weight	12	0.98
Seed yield per plant	351	28.65

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Assessment of yielding ability of Trombay groundnut (*Arachis hypogaea*) varieties through growth analysis

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Abstract

Two groundnut varieties, TAG 24 and TG 26 developed at this Centre were released for commercial cultivation. Using growth analysis, the different traits for the high yielding ability of these varieties were studied in comparison with popular cultivars, TMV 2 and JL 24. Enhanced source capacity by way of increased number of leaves, leaf weight and leaf area per plant was observed in TAG 24 and TG 26. They recorded superior pod yield at all stages of crop growth, which was due to maximum number of pegs, pods and seeds and increased seed weight. They registered greater growth rates of crop, pod, seed, oil accumulation rate and oil yield. Estimates indicated that TAG 24 and TG 26 had enhanced partitioning efficiency as well as higher harvest index, which facilitated them for better diversion of photo-assimilates towards final economic products, seed weight and oil content.

Key words: Groundnut, *Arachis hypogaea*, partitioning efficiency, growth rate, harvest index, oil accumulation

Introduction

For increasing yield in self-pollinated crops, it has been suggested to select plants with superior biomass accumulation, high harvest index (HI) and optimum crop maturity (Wallace *et al.*, 1993). In groundnut (*Arachis hypogaea* L.) differences in yielding ability among cultivars were attributed to (i) differences in photosynthetic efficiency of leaf canopies by assessing through crop growth rate, (ii) partitioning efficiency and (iii) duration of pod filling (Duncan *et al.*, 1978). Further, studies indicated four aspects that promote higher yields, namely (i) a rapid expansion phenophase, (ii) a short podding phenophase, (iii) a long filling phenophase and (iv)a high partitioning of assimilates to pods (ICRISAT, 1980). New groundnut cultivars have higher reproductive efficiency, more number of flowers, pods, seeds and total dry matter than older ones (Coffelt *et al.*, 1989; Seaton *et al* ., 1992). Major genotypic yield differences were primarily related to partitioning of assimilates to pod, seed growth rate and timing of seed filling (Williams *et al.*, 1975; Duncan *et al.*, 1978; ICRISAT, 1980; Pixelly *et al.*, 1990; Wheeler *et al* ., 1997).

In India, TMV 2 and JL 24 are popular cultivars. Two varieties TAG 24 (Patil *et al* ., 1995) and TG 26 (Kale *et al.*, 1997) developed at this Centre were released for cultivation during 1991 and 1996,, respectively. TAG 24 produced higher yield over JL 24 and TMV2 and other popular checks over the years and locations (Kale *et al* 1999). In the present study, high yielding ability of TAG 24 and TG 26 was studied through growth analysis by comparing with the JL24 and TMV2.

Materials and methods

Field experiment was conducted in a randomized complete block design with five replications at this Centre during summer, 1999 under irrigation. Weather conditions were warm and humid. Four varieties i.e., TAG 24, TG 26,, TMV2 and JL24 were planted in six rows of 7.5m length with 30 cm x 10 cm spacing. One meter segment of row from each replication of each variety was harvested at 30,53,73,86,95,108 and 118 days after sowing (DAS), to take observations on vegetative (VDM), pod (PDV) and total dry matter (TDM). Three plants per replication at each harvest were selected randomly and plant height, leaf area, number of leaves, pegs, pods and seeds were recorded. Leaf area was calculated by Biovis Image Plus software of digital analysis (M/s Expert Vision Labs. Pvt. Ltd., Mumbai). To arrive at mean leaf area for each variety, leaf area at different growth stages from 30 to 118 DAS was pooled.

Crop growth rate (CGR), vegetative growth rate (VGR) and pod growth rate (PGR) were calculated by liner regression of TDM, VDM and APDM curves respectively, when they were in their corresponding linear phases (Duncan *et al.*, 1978), between 65 to 108 DAS. Similarly, plant height increase rate (PHIR) was estimated between 30 to 73 DAS. Seed growth rate (SGR) was derived by multiplying PGR and shelling %. Time to rapid pod

growth initiation was computed as the intercept of the liner regression of PDM with the time axis (Pixelly *et al*., 1990)

Partitioning of photo-assimilates to pod growth was estimated using glucose equivalent (GEQ) values of VGR and PGR. The GEQ values are 1.44 g/g synthesis of leaf, stem, peg and shell tissue and 2.47 g/g of seed (Hang *et al.*, 1984; Pixelly *et al.*, 1990). VGR and PGR were measured between 65 to 108 DAS. Harvest index (HI) was calculated as per Dwivedi *et al.*, (1998). The equations for the above calculations are as follows:

1. GEQ of VGR = VGR x 1.44
2. GEQ of PGR = [(PGR-SGR) x 1.4]+(SGR x 2.47)
3. Assimilate partitioning = GEQ of PGR/(GEQ of VGR + GGEQ of PGR)
4. HI = (PDM at 118 DAS x 1.67)/
   [(PDM at 118 DAS x 1.67)+(VDM at 118 DAS)]
5. Effective filling period = PDM/PGR

Seed oil estimation was made by Nuclear Magnetic Resonance spectrometer (Oxford MQA 6005 model, Oxford instruments UK Ltd., Oxan, UK) at 65,73,86,95,108 and 118 DAS. Oil yield was determined by converting seed weight with respective oil % at different growth intervals. Oil accumulation rate (OAR) was estimated by liner regression of oil yield curve between 65 to 108 DAS. All computations for CGR, VGR, PGR,, EFP, OAR, PHIR, partitioning and days to rapid pod growth initiation were done on individual replicate values, which were subjected to analysis of variance.

Results and discussion

TDM accumulation: Significant varietal differences were noticed for TDM at different stages of growth. From 65 to 118 DAS, TAG 24 recorded the highest TDM followed by TGH 26 and the lowest in TMV2 (Fig.IC). Maximum TDM was produced by TAG 24 (2471 g/m)^2 and TG 26 (2235g/m)^2 at 118 DAS while, JL24 (1881 g/m)^2 and TMV 2 (1674 g/m)^2 at 118 DAS. Increased TDM was attributed to higher photosynthetic rate (Lodha *et al.*, 1985) as well as increased nutrient acquisition and utilisation efficiency.

It is known that enhanced capacity of "source" components coupled with better diversion of photo-synthates are important during pod initiation and filling stages leading to rapid pod growth. At different stages of crop growth, there were no significant differences among the varieties for VDM (Fig.IB). During 65 to 95 DAS, higher values were recorded in TAG 24 and TG 26 over TMV2 and JL-24, for number of leaves (36-111% higher in TAG 24; 31-78% in TG 26), leaf weight/plant (0-113% higher in TAG 24; 0-73% in TG 26), leaf area/plant (0-40% higher in TAG 24; 4-40% in TG 26), indicating their superior "source" capacity. Leaf area plant^{-1} in TAG 24 and TG 26 was more due to increased number of leaves/plant than leaf size since they had smaller leaves. Leaf area index (LAI) increased upto 86 DAS in TG 26 and 95 DAS in TAG 24,, followed by a drop, while in JL 24 and TMV 2, it continued to increase until final harvest (Fig.2A). This early completion of leaf development in TAG 24 and TG 26 is an indication of their determinate habit and better translocation of photo-assimilates to the "sink". tag 24 and TG 26 had shorter plant height (Table 1) due to their shorter internodal length (TAG 24: 1.26±0.03; TG 26 : 1.28±0.04; JL24 : 1.62±0.04 and TMV 2 : 1.61±0.04 cm). Further, PHIR in TAG 24 was much slower than TMV 2 while, TG 26 and JL 24 were at par (Table 1). In wheat (Makunga *et al.*, 1978) and rice (Fageria, 1989), semi-dwarf cultivara partitioned proportionately more C14 and dry matter to ears than tall cultivars. The determinate habit and shorter plant height in TAG 24 and TG 26 appear to assist in increased photosynthate mobilisation towards pod growth.

Pod yield: In addition to greater capacity of "source", it is essential to have greater "sink" capacity to result in final higher economic product. Pod yields of TAG 24 and TG 26 were superior to TMV 2 and JL 24, registering 101-111% and 53-65% increase, respectively (Table 1) at 118 DAS. Higher pod yield in TAG 24 and TG 26 over JL 24 and TMV 2 was due to increased percentage of "sink" components (Table 1), namely number of pegs (26-52%), pods (49-73%) and seed (38-66%) plant and hundred seed weight (10-36%). Pod yields of TAG 24 peaked on 108 DAS, indicating its early maturity (Fig.IA).

Significant varietal differences were noticed for PDM at different stages of growth. Highest PDM was recorded in TAG 24 at all stages of crop growth followed by TG 26 and JL24 while in TMV 2 the lowest (Fig IA). This increased PDM was contributed at different growth stages by number of pages, pods and seeds/plant (Fig. 2B, C and D). Since there was a proportionate increase in both peg and pod number/plant in TAG 24 and TG 26 over JL 24 and TMV 2, there were no significant differences among the four varieties for peg to pod ratio (Table-1).

Growth rate: In the present study, there were significant varietal differences for CGR, PGR and SGR, which is in conformity with earlier reports (Pixelly *et al.*, 1990; Nigam *et al.*, 1994). However, VGR did not differ significantly (Table 2). This indicates that differences observed in CGR among varieties were largely due to PGR and SGR and not due to VGR. TAG 24 and TG 26 registered significantly greater CGR, PGR and SGR over JL 24 and TMV 2 (Table-2). Increased CGR, PGR and SGR in TAG 24 and TG 26 was further due to significantly higher PDM, number of pods and seeds/plant (Table-1). The CGR, PGR and VGR values for TAG 24 and TG 26 were higher than the values reported earlier (Willliams *et al.*, 1975; Pixelly *et al.*, 1990). Among these two, TAG 24 had superior GRR and SGR although both had similar CGR, which was ascribed to enhanced pod and seed yields and shelling % (Table-1).

Table 1 Yield and yield components of groundnut varieties at 118 days after sowing

Variety	Plant height (cm)	Leaf area (cm^2)	Peg to pod ratio	Shelling (%)	HKW (g)	Per plant number of		Pod yield (g/m^2)	Oil yield (g/m^2)
						Pods	Seeds		
TAG 24	41	31.3	0.49	71.5	40.0	49	73	1442	440
TG 26	43	36.0	0.42	68.2	36.5	45	70	1338	345
TMV 2	62	44.6	0.39	68.8	29.3	30	44	664	174
JL 24	53	43.7	0.39	68.6	33.0	28	50	870	227
CV%	5	4.0	14.1	1.1	12.4	11	7.5	12	15
CD (P=0.05)	4	2.1	NS	1.4	5.9	5.5	6.1	179	60
CD (P=0.05)	5	3.0	NS	2.0	NS	7.8	8.5	254	84

HJ/w: 100-seed **weight, NS**: Non-significant.

Partitioning to reproductive growth: Partitioning, an important determinant of genotypic yield potential is the division of daily assimilates between vegetative and reproductive parts (Duncan *et al.*, 1978). Varieties varied significantly for partitioning %. TAG 24 and TG 26 partitioned 12 to 16% more photosynthates to pods than JL 24 and TMV 2 (Table-2). Higher partitioning in TAG 24 and TG 26 was due to increased PGR only, since differences in VGR were not significant. Pixelly *et al.* (1990) reported higher partitioning due to greater PGR and lower VGR leading to greater pod yield in cv. Florunner. However, in the present study, TAG 24 and TG 26 maintained VGR along with other varieties but excelled in PGR resulting in higher CGR. Thus in true sense, for groundnut productivity, higher partitioning would be ideal if both CGR and PGR were higher. Earlier studies noted that major groundnut yield differences were associated with differences in partitioning of daily assimilates to pods (Duncan *et al.*, 1978; ICRISAT, 1980; Pixelly *et al.*, 1990) A stepwise genetic improvement in groundnut at Florida was achieved in 30 years mainly by increasing partitioning from 40% to 98% in new variety (ICRISAT, 1980).

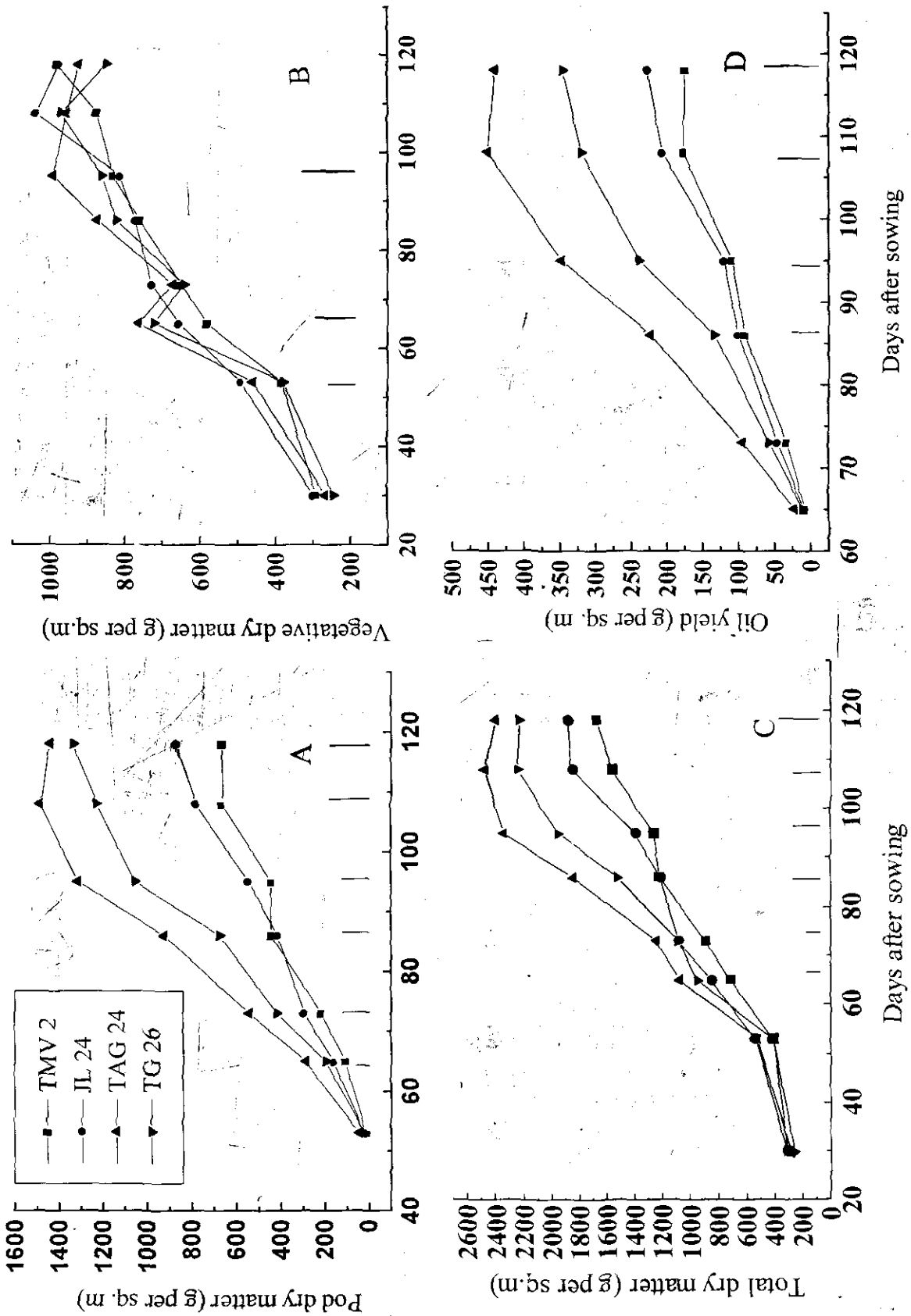
Table 2 Growth analysis parameters in groundnut varieties

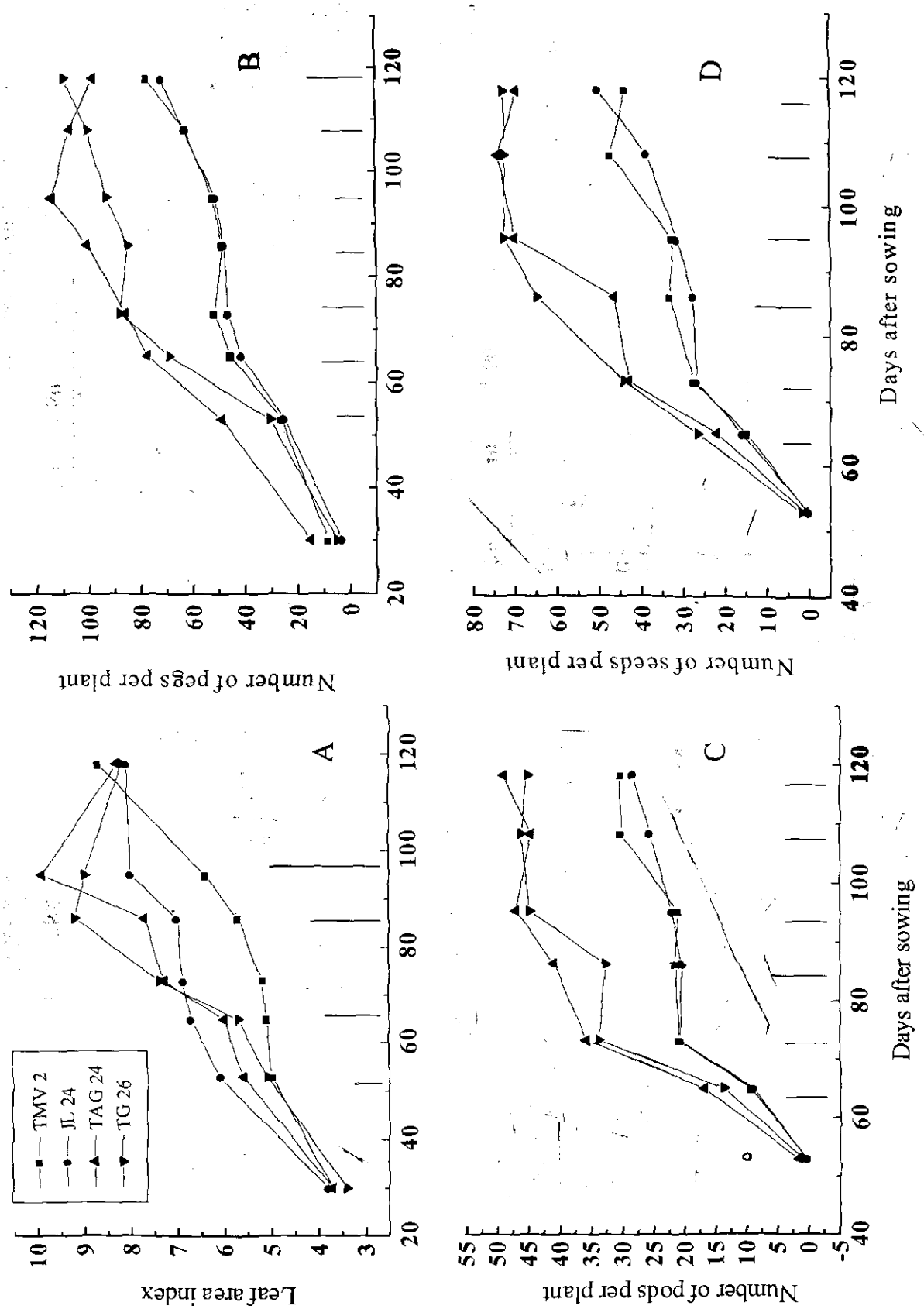
Variety	PHIR (cm/d^1)	CGR ($g/m^2/d$)	VGR ($g/m^2/d$)	PGR ($g/m^2/d$)	SGR ($g/m^2/d$)	Partitioning (%)	HI	OAR ($g/m^2/d$)	EFP (d)	DRPGI (d)
TAG 24	0.34	35.4	6.5	29.0	20.7	87.4	0.72	10.27	59.8	56.0
TG 26	0.48	32.0	6.7	24.8	16.9	84.6	0.72	7.40	61.0	58.0
TMV 2	0.64	19.5	7.0	12.3	8.5	72.6	0.53	3.88	60.8	56.0
JL 24	0.49	22.0	8.2	13.7	9.3	71.3	0.60	4.37	65.4	58.0
CV%	15.1	12.5	18.8/	10.9	11.4	6.0	4.40	10.60	5.2	3.2
CD (P=0.05)	0.10	4.5	NS	3.0	2.2	5.2	0.04	0.94	NS	NS
CD (P=0.05)	0.14	6.4	NS	4.2	3.0	7.3	0.05	1.32	NS	NS

PHIR: Plant height increase rate; CGR: Crop growth rate: VGR: Vegetative growth rate;
PGR: Pod growth rate: SGR: Seed growth rate; HI:Harvest index; OAR:Oil accumulation rate;
EFP: Effective filling period; DRPGI: Days to rapid pod growth initiation; NS: Non-significant

EFP and days to rapid pod growth initiation did not differ significantly among varieties (Table-1) Values of EFP were comparable with the values reported earlier while, days to rapid pod growth initiation were 2-4 days earlier (Pixelly *et al.*, 1990). On the other hand, Wheeler *et al.* (1997) found that genotypic differences for pod yield were primarily due to differences in the timing of seed filling rather than differences in the rate of dry matter partitioning to pods.

Harvest index: HI being a static end season computation, it also measures partitioning of assimilates, which in turn had greater effect on pod yield in groundnut (Duncan *et al.*, 1978; ICRISAT, 1980). Hence, for genetic improvement of groundnut, genotypes with higher biomass and HI were essential (Lodha *et al.*, 1985; Dwivedi *et al.*, 1998). The differences in the HI were due to differences in the duration between flowering and initiation of seed filling which is important for groundnut


TMV 2
JL 24
TAG 24
TG 26
A
B
C
D
Pod dry matter (g per sq. m)
Vegetative dry matter (g per sq.m)
Total dry matter (g per sq.m)
Oil yield (g per sq. m)
Days after sowing
Days after sowing


A
B
C
D
TMV 2
JL 24
TAG 24
TG 26
Leaf area index
Number of pegs per plant
Number of seeds per plant
Number of pods per plant
Days after sowing
Days after sowing

yields since, longer duration was associated with smaller estimates of HI (Stirling and Black, 1991; Wheeler *et al* 1997). In the present study, TAG 24 and TG 26 showed 20 and 35% superior HI over JL 24 and TMV 2 (Table-2). Genotypic variation for HI had reported in groundnut earlier (Wheeler *et al.*, 1997; Dwivedi *et al.*, 1998). Higher TDM along with higher HI in TAG 24 and TG 26 indicated better acquisition, mobilisation and utilisation of photoassimilates towards seed development.

Oil accumulation: Oil %, oil yield and OAR differed significantly among varieties. TAG 24 recorded significantly superior oil accumulation since beginning of crop growth (Fig.ID). It had 48.3% oil as compared to 45.0% in other varieties. At 118 DAS. Oil yield in TAG 24 was superior followed by TG 26 (Table-1). JL 24 and TMV 2 were at par for oil yield. Further, TAG 24 also recorded high OAR, followed by TG 26 (Table-2). Since, 80% of Indian groundnut is crushed for oil purpose and groundnut continued to remain preferred vegetable oil, TAG 24 and TG 26 may help in contribution of oil production.

In groundnut, a wide array of components influence pod yield. In the present study, superior pod yields in TAG 24 and TG 26 were mainly contributed by i)higher PDM due to greater number of seeds and pods and higher seed weight, ii)superior PGR and CGR, iii)higher partitioning efficiency and HI, iv)higher TDM, vf)more number of leaves resulting in greater photosynthetic capacity and vi)determinate habit and shorter plant height assisting better assimilate mobilisation. Due to the above traits, these two varieties appear to possess ideal plant type for the inclusion in future groundnut breeding efforts.

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Effect of moisture regimes in conjunction with nitrogen levels on consumptive use in summer sunflower, *Helianthus annuus* L.

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Abstract

Results of an experiment on sunflower conducted at Water Management Project Farm, Gujarat Agricultural University, Navsari during summer seasons of 1994, 1995 and 1996 revealed that the highest consumptive use of water was 520 mm with $I_{1.0}$ level. Lesser irrigation in treatment $I_{0.6}$ reduced the consumptive use by 33% and yield by 9.8% compared to $I_{1.0}$ treatment. There was no noticeable effect of nitrogen application on consumptive use of water in sunflower.

Key words: Moisture regime, consumptive use, nitrogen

Introduction

Sunflower is an important oilseed crop grown successfully in South Gujarat. Due to availability of canal water farmers are growing two rice crops *viz.*, *kharif* and summer in this region which may lead to the problems of high water table and secondary salinization. Sunflower, being a low water requiring and salt tolerant crop can minimize the aforesaid problems. Irrigation and nitrogen play an important role in the ultimate productivity of a crop. The importance of consumptive use of water is well known, which indicates a measure of the true water needs throughout its growth period. The information regarding this was lacking and hence this experiment was conducted.

Materials and methods

A field experiment was conducted at Water Management Project Farm, Gujarat Agricultural University, Navsari during the summer seasons of 1994, 1995 and 1996. The soil was clayey containing 0.41% organic carbon, 360 kg/ha total nitrogen, 31 and 452 kg/ha available P_2O_5 and K_2O, respectively, soil had 7.4, 0.15 ds/m, 1.48 mg/m, 31% and 18%, pH, electrical conductivity, bulk density, field capacity and permanent wilting point, respectively. The treatments consisted of three irrigation regimes (IW/CPE ratios of 0.6, 0.8 and 1.0 with 6 cm depth at each irrigation) and three levels of nitrogen (40, 60 and 80 kg/ha). The experiment was conducted in a Randomized Block Design and replicated four times. Sunflower variety EC-68414 was sown on 18,20 and 14 February and harvested on 25,20 and 25 May in three consecutive years. Crop was sown in rows 45 cm apart and after a week thinned to keep one plant at 20 cm. Half dose on nitrogen and full phosphorus (60 kg/ha) were applied at the time of sowing as basal dose. Remaining half dose of nitrogen was given one month after sowing in all three years. The quantity of irrigation water was measured with the help of Parshall flume. Profile soil moisture depletion (0-120 cm) and consumptive use of water worked out as per procedure suggested by Dastane (1972). No rainfall was received during crop life period in all three years.

Results and discussion

Moisture regime: The treatment $I_{0.6}$, $I_{0.8}$ and $I_{1.0}$ received 6, 8 and 9 irrigations and total quantity of irrigation water applied was 360, 480 and 540 mm whereas the values of consumptive use of water were 348, 446 and 520 mm in IW/CPE ratio of 0.6, 0.8 and 1.0, respectively. This would imply that the consumptive use of water increased with increase in level of irrigation as expected. This would have been due to improvement of plant water status, decrease in stomatal resistance and greater vapour gradient between canopy air above crop level under moist conditions than under moisture stress. The increase in ET with increase in level of irrigation was also reported by Sinha and Singh (1977) and Shinde *et al.* (1987). The seed yield of summer sunflower was significantly higher in 1.0 IE/CPE ratio in which 49.4% more consumptive use of water was recorded as compared to $I_{0.6}$ treatment. These observations are in accordance with Subramanian *et al.* (1979).

The mean water use efficiencies observed under treatment $I_{0.6}$, $I_{0.8}$ were 3.13 and 2.95 kg/ha/mm, respectively (Table 1). Unlike consumptive use of water, the water use efficiency decreased with increasing level of irrigations. Though the increasing frequency of irrigation

also increased the yield but since the quantity of water used was in greater proportion than the increase in yield, hence the productivity decreased sharply with increased frequency of irrigation. The results corroborate the findings of Khanvilkar *et al.* (1987) and Shinde *et al.* (1987).

Effect of nitrogen: Treatment N_{40}, N_{60} and N_{80} resulted in 434, 438 and 439 mm consumptive use of water, respectively. The seed yield of sunflower was recorded 1216, 1484 and 1616 kg/ha in above there treatments, respectively. The effect of nitrogen on seed yield of sunflower was found non-significant. The values of consumptive use of water in N_{40}, N_{60} and N_{80} treatment were almost at par. This might be due to the fact that nitrogen level failed to reach the level of significance in this experiment. Singh *et al.* (1977) also reported that nitrogen levels without irrigation did not influence the total consumptive water use as the magnitude of consumptive use is largely determined by the variation in soil moisture condition.

Water use efficiencies were recorded 2.8, 3.4 and 3.7 kg/ha/mm in N_{40}, N_{60} and N_{80} treatments, respectively. Thus, the water use efficiency was increased as the seed yield increased numerically in respective treatment.

On the basis of present investigation, it could be concluded that the consumptive use of water in sunflower was recorded as 348, 446 and 540 mm in $I_{0.6}$, $I_{0.8}$ and $I_{1.0}$ treatments, respectively. Treatments $I_{0.6}$, $I_{0.8}$ and $I_{1.0}$ received 360, 480 and 540 mm of the quantity of irrigation water in 6,8 and 9 number of irrigations, respectively. It could be concluded that the consumptive use of water increased with increasing quantity of irrigation water. The water use efficiency decreased with increasing quantity of irrigation water. The reverse trend was observed in case of nitrogen application.

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Table 1 Effect of moisture regimes and nitrogen levels on consumptive use of water, water use efficiency and seed yield of summer sunflower (Pooled over three years)

Treatment	Seed yield (kg/ha)	No. of irrigation	Irrigation water applied (mm)	Consumptive use of water (mm)	Water use efficiency (kg/ha/mm)
Moisture regimes					
$I_{0.6}$	1385	6	360	348	2.9
$I_{0.8}$	1395	8	480	446	3.1
$I_{1.0}$	1536	9	540	520	2.9
SEm±	33	-	-	-	-
CD (P=0.05)	92	-	-	-	-
Nitrogen levels (kg/ha)					
N_{40}	1216	-	460	434	2.8
N_{60}	1484	-	460	438	3.4
N_{80}	*1616*	-	*460*	*439*	*3.7*
SEm±	33	-	-	-	-
CD (P=0.05)	NS	-	-	-	-

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Effect of planting density on yield attributes, yield and nutrient uptake of restorer lines of sunflower, *Helianthus annuus* L. hybrid

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Abstract

A field trial was carried out Banaras Hindu University Research Farm during winter seasons (*rabi*) of 1996-97 and 1998-99, to study the effect of planting density on yield, its attributes and nutrient uptake of different restorer lines (male parental line) of sunflower hybrid. Among the three restorer lines 6D-1 produced higher uptake of N, P, K and boron. Plant spacing 40 x15 cm recorded 63.40%, 50.86% and 20.02% more seed yield than 70 x 20 cm and 50 x 15 cm spacing, respectively. However, maximum N, P, K and boron content was observed with wider plant spacing due to higher individual biomass production (seed + stalk). Further, in the regression analysis plant population was found to have a linear relationship with seed yield (Y = 3.73 + 4.52 x).

Key words: Sunflower, restorer line, planting density, nutrient uptake

Introduction

Introduction of hybrids in sunflower has gained momentum and during the last decade its area under cultivation has increased from 0.6 to 2.0 m ha (Giri, 1996). However, for hybrid seed production inbred parental lines are the pre-requisite and its success primarily depends upon the higher seed multiplication ratio of parental lines as every year fresh seeds are required for production of hybrids. There is a misconception that technology generated for composite and hybrids so far is equally effective for inbred lines also, but, this is not true. Since inbreds are brought to near homozygous level after successive generation of selfing, they lose vigour due to inbreeding depression and consequently become less efficient in metabolic activities. This implies that inbreds require different package of practices for their proper growth and development. Keeping this in view a field trial was conducted to study the effect of planting density on the performance of different restorer lines of sunflower hybrids.

Material and methods

The experiment was carried out in the Research Farm of Banaras Hindu University during winter season (*rabi*) of 1996-97 and 1998-99. The trial consisting of three restorer lines of sunflower hybrids (P-35R, AK-1R and 6D-1) and four spacings (40 x 15 cm, 50 x 15 cm, 60 x 20 cm and 70 x 20 cm) was laid out in a split plot design with four replications by keeping restorer lines in the main plot and spacing in sub-plot. A common dose of nutrient (90, 75, 60, 15 kg N, P_2O_5, K_2O and Borax/ha) was applied through urea, di-ammonium phosphate and muriate of potash. N was applied in three equal splits i.e, half at the time of sowing and the rest at 40 and 75 days after sowing in equal halves, while P, K and Borax were all applied as basal. The crop was sown on November 13th in 1996-97 and on November 21st in 1998-99 in the same plot. All package of practices were followed to raise a good crop of sunflower. The soil was loamy in texture with a pH 7.3 and low in available N (196 kg/ha) and medium in available P (10.6 kg/ha) and K (224 kg/ha). Nitrogen in plant was analysed by colorimetric method (Baethgen and Alley, 1989) while Vanado Molybdo phosphoric yellow colour method using Bathen's reagent (Bhargava and Raghupathi, 1993) was employed for phosphorus estimation in plant. Total potassium was determined with the help of flame photometer (Bhargava and Raghupathi, 1993) and total boron was estimated by Azomethen - H method (Sippola and Ervco, 1977).

Results and discussion

Yield attributes: From Table 1 it may be inferred that restorer line 6D-1 recorded significantly higher capitulum weight, number of seeds/head, 1000-seed weight and seed yield/plant, but remained at par with P-35R and AK-1R in capitulum diameter during both the years. Overall 6D-1 recorded 24.7% and 12.6% more seed yield/plant than P-35R and AK-1R. The higher values in yield attributing characters in 6D-1 might be due to its more adoptive morphological character and better potential over the rest.

Table 1 ***Effect of treatments on yield attributing characters*** **(pooled of 2 years 1996-97 & 1998-99)**

Treatment	Capitulum diameter (cm)	Capitulum weight (g)	No. of seeds/head	1000 seed wt. (g)	Seed yield/plant (g)
Restorer lines					
P-35R	8	32	326	40.9	10.2
AK-1T	9	34	352	39.8	11.3
6D-1	9	34	366	44.1	12.7
$S\bar{d}$	0.12	0.29	3.07	0.27	0.24
CD(P=0.05)	0.29	0.71	7.52	0.66	0.59
CV (%)	5.55	3.48	3.54	2.58	8.52
Plant spacing					
40 x 15 cm	8	29	315	38.4	9.9
50 x 15 cm	8	32	340	39.9	10.9
60 x 20 cm	9	36	363	43.1	12.2
70 x 20 cm	10	37	373	44.9	12.6
$S\bar{d}$	0.17	0.31	3.11	0.54	0.21
CD(P=0.05)	0.34	0.64	6.39	1.10	0.43
CV (%)	6.64	3.23	3.10	4.48	6.34

Plant spacing caused significant differences in all the yield attributing characters and were more pronounced at wider plant spacing (70 x20 cm). Since 70 x 20 cm spacing provided wider area/ plant for its growth and development, it produced bigger and heavier capitulum with more number of seeds. Similar results were reported by Hegde and Havanagi (1987) and Rajpur *et al.* (1994).

Further restorer lines were found to interact significantly with spacing in bringing about changes in seed yield/plant. Seed yield/plant was inversely proportional to the plant population in all the restorer lines. Overall 6D-1 produced the highest seed yield/plant (14.01 g) at 70 x 20 cm spacing while P-35R recorded the lowest yield (9.00 g/plant) at 40 x 15 cm spacing.

Seed and stalk yield: The seed and stalk yield was significantly higher with 6D-1 during both the years of experimentation and were followed by AK-1R and P-35 R (Table 2). The magnitude of increase in seed yield with 6D-1 was 55.49% and 12.57% over P-35R and AK-1R, respectively. The corresponding increase in stalk yields was 34.31% and 10.52% over P-35 R and AK-1R,

Plant spacing caused significant differences in seed and stalk yield. A progressive increase in yield with the narrow spacing was observed. 40 x 15 cm spacing recorded highest seed yield (11.39 q/ha pooled) and remained significantly superior over other spacings tried. Overall 40 x 15 cm spacing recorded 63.4%, 50.86% and 20.02% more seed yield than 70 x 20 cm, 60 x 20 cm and 50 x 15 cm, respectively. Hegde and Havanagi, 1987; Bindra and Kharwara, 1994 also reported an increase in seed yield of sunflower by increasing the plant population.

Further, both these variables were found to interact significantly with each other in changing the yield. The restorer line 6D-1 produced the highest yield at 40 x 15 cm spacing during both the years and was followed by AK-1R and P-35 R at same spacing.

Plant population of restorer lines of sunflower was found to have a linear relationship with seed yield ($\hat{Y}$=3.73+4.52x) indicating that there might be further scope of increasing yield by increasing the plant population.

Table 2 Effect of treatments on seed and stalk yield (kg/ha)

Treatment	Seed yield (kg/ha)			Stalk yield (kg/ha)		
	1996-97	1998-99	Pooled	1996-97	1998-99	Pooled
Restorer lines						
P-35R	699	649	674	2068	1891	1979
AK-1R	970	893	931	2418	2393	2405
6D-1	1094	1002	1048	2666	2651	2658
$S\bar{d}$	27	21	20	41	31	23
CD (P=0.05)	67	51	48	99	75	68
CV (%)	8.34	6.98	9.87	4.82	3.77	4.72
Plant spacing						
40 x 15 cm	1177	1101	1139	2777	2617	2997
50 x 15 cm	996	902	949	2535	2344	2439
60 x 20 cm	782	727	755	2188	2210	2199
70 x 20 cm	730	662	696	2035	2077	2056
$S\bar{d}$	38	22	23	67	56	38
CD (P=0.05)	78	45	45	136	115	79
CV (%)	10.1	6.3	8.9	6.8	5.9	5.7

Nitrogen content and uptake: At harvest N content and uptake was found to be quite high in seed than stalk (Table 3). Significantly higher N content in seed (2.64%) and stalk (0.41%) was observed with 6D-1 over P-35 R and AK-1 R. This was mainly because total bio-mass (seed+stalk) was more in 6D-1 than over two restorer lines.

At wider plant spacing the N content in both seed and stalk was significantly higher than closely spaced planting. Availability of more space/plant might have led to greater N concentration in stalk and seed. This was in conformity with the findings of Mathers and Stewart (1982). However, in total N uptake higher plant population recorded higher values due to higher total dry matter production by closely spaced planting.

Table3 Effect of treatments of N, P, K, Boron content in seed and stalk and total uptake (pooled of 2 years 1996-97 & 1998-99)

Treatment	N content (%)		N uptake (kg/ha)	P content (%)		P uptake (kg/ha)	K content (%)		K uptake (kg/ha)	B content (ppm)		B uptake (g/ha)
	Seed	Stalk	Total	Seed	Stalk	Total	Seed	Stalk	total	Seed	Stalk	Total
Restorer lines												
P-35R	2.49	0.37	26.48	0.69	0.15	8.60	0.79	1.26	38.87	30.60	24.87	69.67
AK-1R	2.57	0.40	37.07	0.72	0.17	12.12	0.84	1.33	52.27	32.59	25.86	92.59
6D-1	2.64	0.41	42.80	0.78	0.18	14.58	0.89	1.37	60.07	32.23	25.50	101.98
$S\bar{d}$	0.003	0.002	0.51	0.004	0.001	0.19	0.004	0.005	0.70	0.31	0.23	0.70
CD (P=0.05)	0.007	0.006	1.25	0.010	0.013	0.46	0.009	0.010	1.70	0.77	0.57	1.72
CV (%)	1.43	2.43	5.79	2.43	3.27	6.41	1.87	1.27	5.53	3.96	3.67	3.19
Plant spacing												
40 x 15 cm	2.52	0.38	43.50	0.70	0.16	15.33	0.83	1.32	60.18	31.50	24.51	102.19
50 x 15 cm	2.54	0.38	37.71	0.71	0.16	12.30	0.84	1.32	52.88	31.69	25.49	92.40
60 x 20 cm	2.59	0.39	31.22	0.74	0.17	10.39	0.84	1.33	45.80	32.14	25.88	81.23
70 x 20 cm	2.60	0.40	29.38	0.76	0.17	9.84	0.85	1.33	42.74	32.02	25.90	76.51
$S\bar{d}$	0.006	0.004	0.68	0.006	0.006	0.26	0.006	0.007	0.79	0.35	0.32	1.53
CD (P=0.05)	0.013	0.008	1.39	0.012	NS	0.52	0.001	NS	1.62	NS	0.65	3.13
CV (%)	1.87	3.63	6.64	2.74	8.83	7.50	2.38	1.86	5.43	3.79	4.29	6.00

NS = non significant

Phosphorus content and uptake: Restorer line 6D-1 recorded significantly higher P content in seed (0.18%) and stalk (0.78%) over other two restorer lines (Table 3). Total uptake of phosphorus by 6D-1 was maximum followed by AK-1R and P-35R.

Wider spacing (70 x 20 cm) showed significantly higher phosphorus content in seeds while in stalk it was statistically at par with narrow plant spacing. Sarmah *et al.* (1995) also found that higher plant population had lower phosphorus content in seed. Similarly significant differences in P uptake due to different spacing were also found. There was a progressive decrease in P uptake with the increase in plant spacing and the maximum uptake was observed at the lowest plant population.

Potassium content and uptake: Potassium content in seed and stalk was significantly higher with restorer line 6D-1 followed by AK-1R and P-35R, respectively. The consequent effect of higher K content was reflected in total uptake also, where 54.54% more uptake of K by 6D-1 over P-35R was observed.

Although K content due to plant spacing did not differ significantly in stalk, it was significant in seed and the maximum content was found with 70 x 20 cm spacing which was in conformity with the findings of Kharwara and Bindra (1992). However, in total uptake higher plant population recorded higher values as it was influenced by higher bio-mass (seed+stalk) population.

Boron content and uptake: AK-1R registered significantly higher content of boron in seed (32.6 ppm) and stalk (25.9 ppm) than P-35R but remained statistically at par with 6D-1. However, total uptake of boron was highest in 6D-1 (101.9 g/ha) followed by AK-1R (92.6 g/ha).

Plant spacing caused significant differences in boron concentration in stalk only. Maximum boron content was found with 70 x 20 cm (25.0 ppm) while minium was with 40 x 15 cm (24.51 ppm) spacing. Total boron uptake decreased with increased spacing and similar trend was observed in N, P and K uptake. It can therefore, be included that under the agro-climatic zone of Varanasi parental line 6D-1 of sunflower hybrid performed best at 40 x 15 cm spacing.

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Production potentials of sunflower and pigeonpea under different soil depths

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Abstract

The studies on production potentials of sunflower and pigeonpea in sole and intercropping systems (2:1) under different soil depths were conducted during 1992-1995 in rainfed Alfisol watershed area at CRIDA, Hyderabad. The results indicated that sunflower and pigeonpea crops in sole and intercropping system responded positively to the increment in soil depth under rainfed environment. Response to soil depth in sunflower was higher than pigeonpea. Intercropping of sunflower and pigeonpea (2:1) is more stable and recorded higher seed equivalents and gross returns than respective sole crops over the years. The yield advantage in intercropping system increased with increase in soil depth upto 30 cm and decreased from 30-45 cm.

Key words: Sunflower, pigeonpea, intercropping, seed equivalents, net returns

Introduction

The yields of sunflower can be stabilized with intercropping of long duration pulse crop like pigeonpea. The potentials of sunflower based intercropping in rainfed environment are dependent on available soil moisture and nutrients stressed in a particular soil depth and type. Hence a study was conducted to investigate the interactive effects between soil depth, rainfall, and crop growth in Alfisols under rainfed environment.

Material and Methods

The experiment was conducted on an Alfisol watershed at Hayatnagar Research Farm of CRIDA, Hyderabad, India. The general physiography of watershed is characterized by gentle slopes (2-5%) with highest elevation of 520 m. The average soil depth in upper, middle and lower basins of micro- catchment was 8 cm + 4.3 cm (D_1), 15 cm + 4.5 cm (D_2) and 30 cm + 12 cm (D_3) respectively. Sole crops of sunflower (MSFH-8) and pigeonpea (LRG-30) and sunflower + pigeonpea (2:1) were grown in upper, middle and lower portions of the watershed area from 1992 to1995 during *kharif*. The pigeonpea in sole and intercropping systems was grown at 90 cm x 20 cm apart while sunflower was grown at 30 cm x 20 cm. Ten kg N and 30 kg P_2O_5 /ha was applied uniformly to both the component crops in different systems as basal. Sunflower in different cropping systems received an additional dose of 40 kg N/ha as top dressing in the form of urea at 30-45 and 60-75 days after sowing. These treatments were tested in randomized block design with four replications. The rainfall and potential evapo-transpiration were recorded daily and rainfall use efficiency (RUE) and moisture adequacy index (MAI) was calculated according to Mahendra Singh and Joshi (1997). Dry matter, leaf area index (LAI) and nitrogen uptake were recorded at different phenological stages of component crops. The yield and economic advantages were estimated through LER values and grain equivalents.

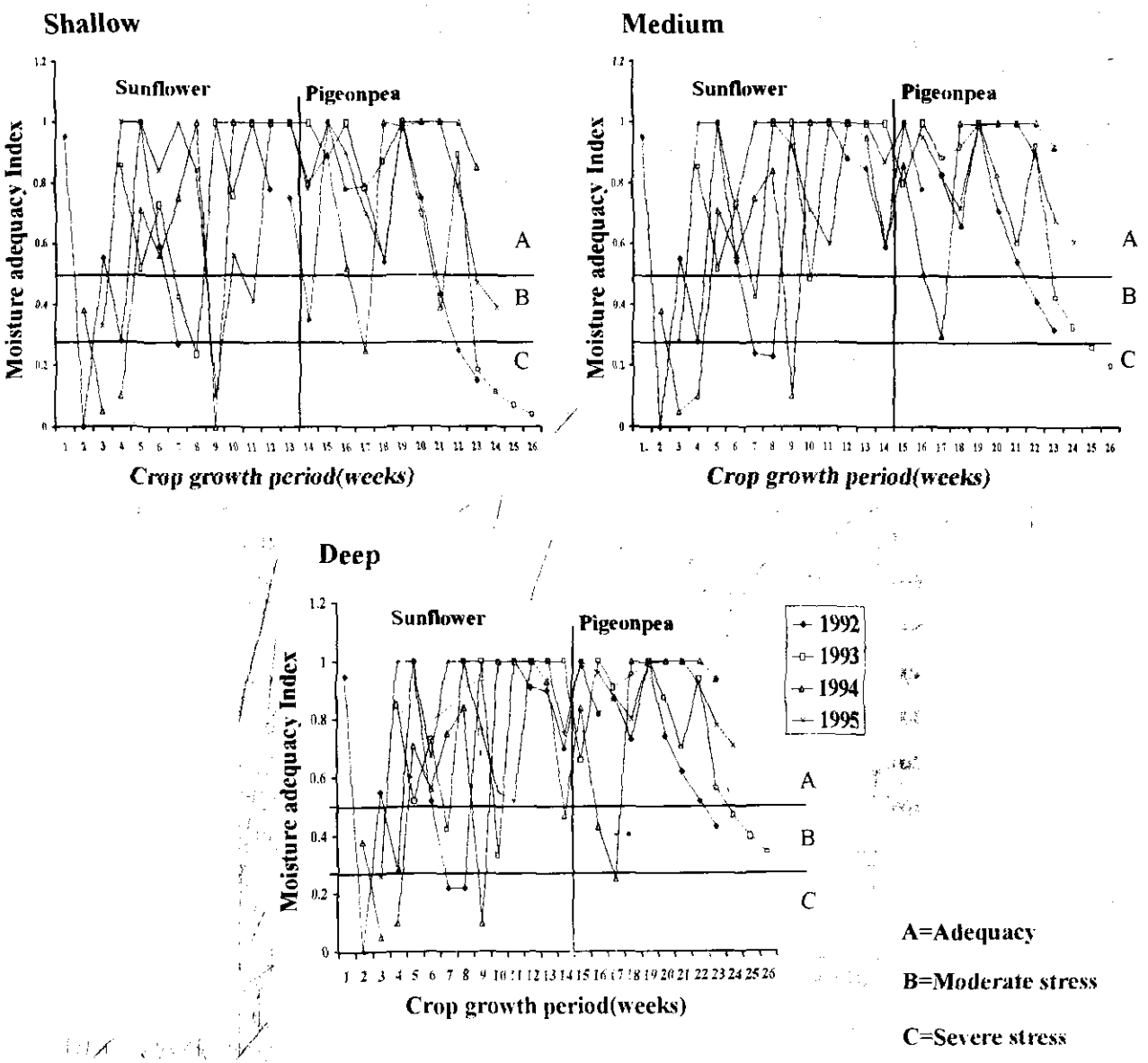
Results and Discussion

Rainfall pattern: The sunflower crop received an amount of 380,515,294 and 501 mm of rainfall in 1992,93,94 and 95 respectively during its life cycle while component crop pigeonpea received 465,644,631 and 733 mm, respectively during 1992,93,94 and 95.

During 1994, crops of sunflower and pigeonpea in sole and intercropping system experienced severe moisture stress at both vegetative and flowering stages at all soil depths.

Yield of sunflower was considerably reduced due to severe moisture stress at the time of grain filling and continuous rainfall during flowering in 1995. Distribution of rainfall was more favourable for sunflower in deeper soils. In pigeonpea severe moisture stress at the time of grain formation influenced its yield potential. However, 40 mm of rainfall received during the month of November helped increase the yields of pigeonpea (Fig 1).

Fig 1: Influence of soil depth on moisture availability in Sunflower and Pigeonpea

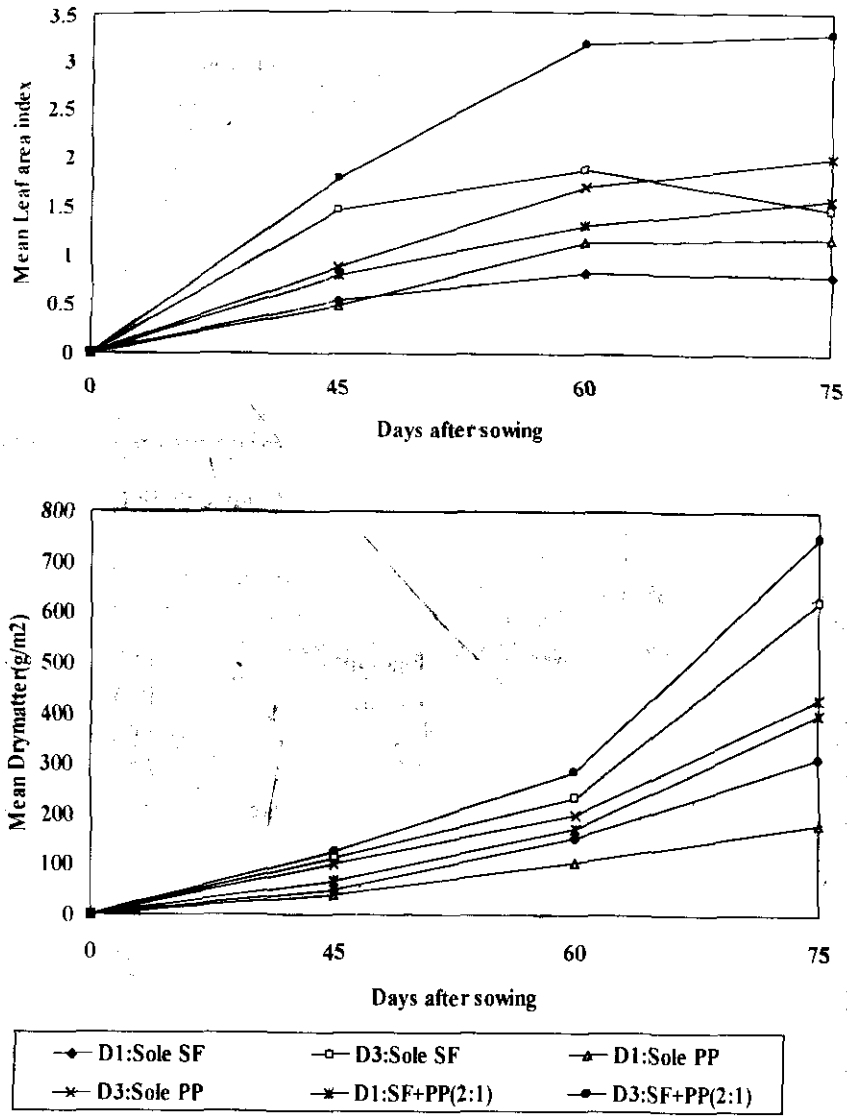


Soil depth in relation to crop growth and yields: In 1992, sunflower in different cropping systems experienced severe moisture stress at all soil depths during early vegetative phase i.e.2-3 weeks after sowing (WAS) and in medium and deep soils during reproductive phase (7-9 WAS). Pigeonpea component in different cropping systems experienced severe moisture stress at flowering and grain formation stages.

In 1993, sunflower component in different cropping systems underwent severe moisture stress at 3 WAS in shallow soil depths while moderate stress was experienced at reproductive phase (7WAS) in all soil depths. Pigeonpea suffered moderate and severe moisture stress during 1993 at vegetative and pod formation stages respectively at shallow soil depth. In medium and deep soils moderate stress was noticed at reproductive stage of the crop.

The growth components *viz.*, LAI and drymatter in sunflower and pigeonpea in sole and intercropping systems increased significantly with increment in soil depth. In sunflower, in different cropping systems LAI increased up to 75 days after sowing (DAS) and later decreased; while in pigeonpea LAI increased upto 120 DAS at all soil depths. Pigeonpea and sunflower in intercropping system produced higher combined LAI and drymatter as compared to the irrespective sole crops at different growth stages in all years. It indicated efficient use of rainfall and light interception by component crops (Fig 2).

Fig 2: Mean growth parameters of sunflower and pigeonpea as influenced by soil depth in different cropping systems



SF=Sunflower
PP=Pigeonpea

D1:<15 cm
D3:30-45 cm

The seed yield of sunflower in sole and intercropping systems significantly increased with increase in soil depth (15-45 cm) in the watershed. The seed yield of sunflower was higher by 147 and 225% in 15-30 and 30-45 cm soil depth, respectively over the soil depth of 15 cm. The influence of soil depth on seed yield of sole sunflower was highest in 1993 followed by 1994 due to better distribution of rainfall for sunflower. The influence of soil depth on productivity of pigeonpea was slightly less when compared to sunflower. On an average, the seed yield of sole pigeonpea was enhanced by 232 and 502 kg/ha in soils having depth ranging 15-30 and 30-45 cm, respectively compared to <15 cm depth. The influence of soil depth on pigeonpea was highest in 1994 and 1995 due to better distribution of rainfall. The seed yields of sunflower and pigeonpea in intercropping system was significantly influenced by deeper soil depth of 30-45 cm; while the yields with shallow and medium soil depth were statistically on par (Table 1). Significant increase in seed yields of chickpea, soybean and sorghum, pearl millet and castor were noticed due to variation of soil depth due to higher moisture and nutrient use efficiencies (Piara Singh *et al.*, 1999).

Table 1 Influence of soil depth on yield of sunflower and pigeonpea in sole and intercropping systems

		Sunflower seed yield (kg/ha)					Pigeonpea seed yield (kg/ha)				
		1992	1993	1994	1995	Mean	1992	1993	1994	1995	Mean
Sole Crop	D_1	179	312	470	401	341	130	145	318	830	356
	D_2	*291*	*1126*	*1300*	*677*	*845*	200	190	741	1222	*588*
	D_3	375	1845	1694	950	1211	350	206	890	1986	858
Intercrops	D_1	143	204	277	260	221	105	120	202	440	217
	D_2	203	909	1204	435	437	162	145	475	856	410
	D_3	259	1314	1462	630	916	220	162	523	1283	547
CD (P=0.05)		*18*	*62*	*52*	*44*	*NS*	*66*	*39*	*41*	*70*	*NS*
Depths		22	76	63	54	288	60	33	36	61	199
Crops x Depths		31	109	NS	76	NS	104	66	71	122	NS

Intercropping of sunflower and pigeonpea recorded higher sunflower seed equivalents at all soil depths compared to sole crops over the years. At shallow soil depth (<15 cm) *sunflower and pigeonpea intercropping systems produced* higher sunflower seed equivalents of 37 and 16%, 35 and 74% in medium soil depths (15-30 cm) and 27 and 58% in deeper soils (30-45 cm) than sole crops of sunflower and pigeonpea, respectively. In 1992, sunflower seed equivalents were significantly higher in intercropping than sole crop at all soil depths while in 1993 intercropping of sunflower and pigeonpea seed equivalents were on par with respective sole crop seed equivalents at all soil depths. However, in 1995, where the rainfall distribution was favourable to both sunflower and pigeonpea, sunflower seed equivalents in sole pigeonpea and intercropping were higher compared to sole sunflower at all soil depths (Table 2). This was due to better seed yield of sunflower and pigeonpea in intercropping because of their temporal complementarity (Gouri *et al.*, 1997).

Nitrogen uptake: The nutrient uptake in different cropping systems showed that nitrogen uptake in seed of sunflower and pigeonpea in sole and intercropping systems increased with increase in soil depth. Sole *sunflower grown at D_3 recorded higher nitrogen uptake by* 305 and 53% compared to the sole sunflower at D_1 and D_2 soil depths respectively; while sole pigeonpea recorded higher nitrogen uptake by 217 and 87 % compared to sole pigeonpea grown at soil depth ranging < 15cm and 15-30cm, respectively. Among the *intercropping systems*, sunflower+pigeonpea (2:1) raised at D_3 recorded 295 and 56 % more nitrogen uptake than that of system raised at shallow (D_1) and medium soil depth (D_2) respectively.

Rainfall use efficiency: Intercropping of sunflower+ pigeonpea (2:1) at shallow soil depth increased RUE of seed by 9 and 58 % compared to sole sunflower and pigeonpea. At medium soil depth, intercropping system (sunflower+pigeonpea 2:1) recorded higher RUE of seed by 14 and 146 % compared to respective sole crops of sunflower and pigeonpea. At deeper soil depth, increment of RUE of seed was noticed by 22 and 86 % in intercropping system when compared to sole crops of *sunflower and pigeonpea system. (Nam et al., 1993).*

Yield and Monetary advantages

Net returns: Sunflower+ pigeonpea (2:1) in sole and intercropping systems provided increased net returns/ hectare with increment in soil depth over the years (Table 2). *The sole sunflower raised at 30-45 cm* soil depth increased the net returns/hectare from Rs. 670/- to Rs. 8600/- per ha as compared to the crop raised at <15 cm (D_1) and 15-30 cm (D_2), respectively. On an average intercropping of sunflower+ pigeonpea (2:1) recorded higher net returns/ hectare (Rs. 8483/ha) as compared to sole crops of sunflower (Rs.4856/ha) and pigeonpea (Rs.3731/ha).

Table 2 Influence of soil depth on sunflower seed equivalents, net returns and RUE in sole and intercropping systems

Treatment	Sunflower seed equivalents (kg/ha)					Net returns (Rs/ha)					RUE (kg/ha/mm)				
	1992	1993	1994	1995	Mean	1992	1993	1994	1995	Mean	1992	1993	1994	1995	Mean
Sole Sunflower															
D_1	179	312	476	401	341	-926	496	1700	1411	670	0.47	0.61	1.19	0.80	0.77
D_2	291	1126	1300	677	849	-254	7004	10000	4447	5299	0.77	2.19	3.30	1.35	1.90
D_3	375	1845	1694	950	1216	250	12760	13940	7450	8600	0.99	3.58	4.30	1.90	2.69
Sole Pigeonpea															
D_1	172	145	318	979	404	-960	-840	180	5205	896	0.28	0.24	0.48	1.13	0.53
D_2	266	190	741	1442	660	-400	-480	4410	10497	3507	0.43	0.32	1.12	1.66	0.88
D_3	466	206	890	2343	976	800	-352	5900	20811	6790	0.75	0.40	3.0	2.70	1.70
Sunflower + Pigeonpea (2:1)															
D_1	283	324	479	779	466	-802	96	1290	5300	5884	0.61	0.60	1.01	1.12	0.84
D_2	418	1049	1678	1445	1148	14	5892	13290	11841	7759	0.88	2.01	3.77	2.03	2.17
D_3	552	1476	1985	2144	1539	814	9308	16350	20751	11806	1.15	2.82	4.50	4.62	3.27
CD (P=0.05) Crops	30	48	40	62	NS	180	384	295	782	NS	0.08	0.27	0.11	0.09	0.65
Depths	30	48	40	62	368	180	384	385	782	2858	0.08	0.27	0.11	0.09	0.65
Crops x Depths	52	83	68	109	NS	NS	565	679	1501	NS	NS	0.47	0.18	0.16	NS

Land Equivalent Ratio (LER): LER values worked out on the basis of corresponding soil depth indicated that, intercropping of sunflower with pigeonpea (2:1) on an average recorded higher yield advantages by 42 % compared to the sole cropping of pigeonpea and sunflower over the years. The yield advantages with intercropping system increased with increment of soil depth upto 30cm and decreased from D_3 soil depth. At shallow soil depth, the yield advantage based on corresponding soil depth was highest in 1992 followed by 1993. At medium (D_2) and higher (D_3) soil depth, the yield advantage was highest during 1993 and 1994. Considering the maximum soil depth, intercropping of sunflower+pigeonpea (2:1) at 30-45 cm only gave the yield advantage to the tune of 39% compared to the sole crops of sunflower and pigeonpea. At shallow (D_1) and medium soil depth (D_2) sole cropping systems were found to be advantageous than intercrop system (Fig 3).

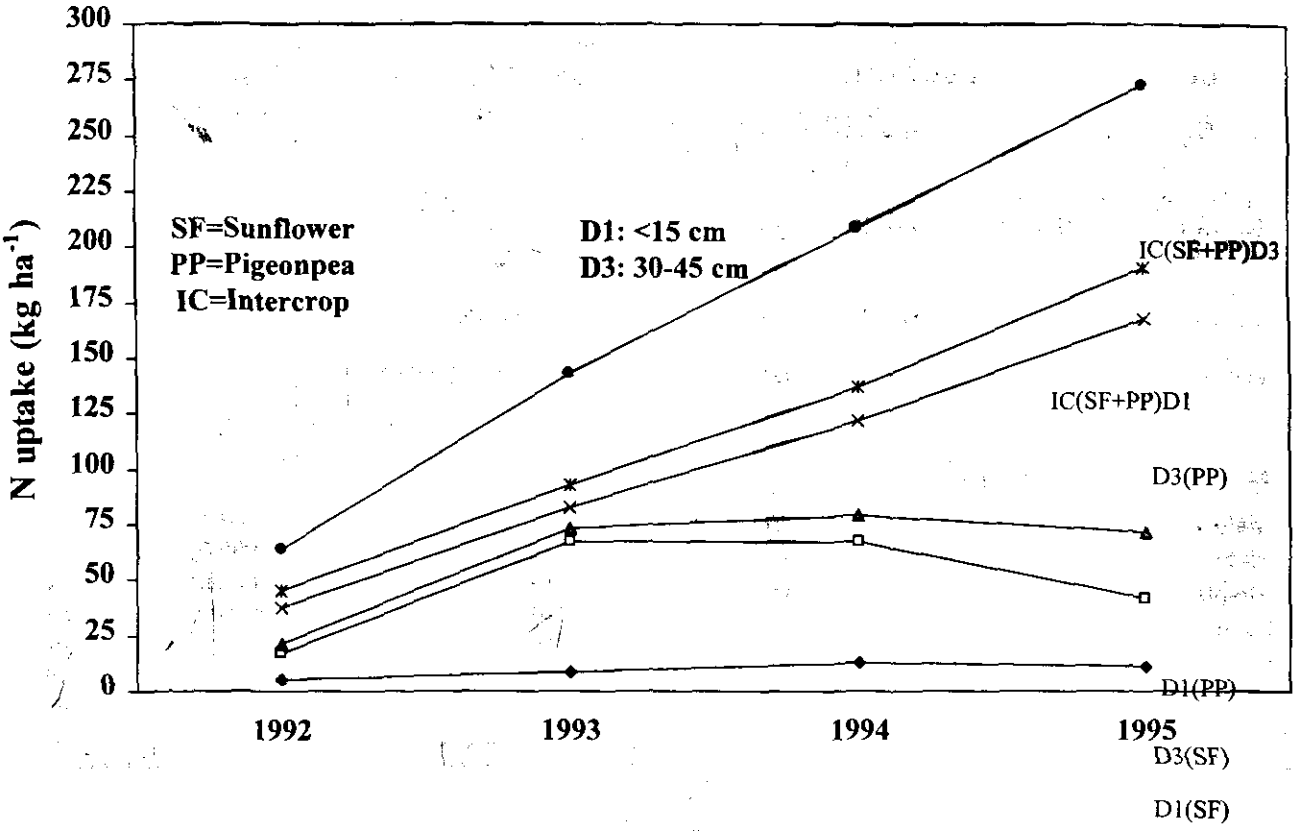


Fig 3: Effect of soil depth on Nitrogen uptake in sunflower and pigeonpea in sole and intercropping systems

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Effect of irrigation scheduling on water use efficiency and productivity of winter sunflower (*Helianthus annuus* L.)*

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Abstract

A field experiment was conducted taking 'Morden' variety of sunflower (*Helianthus annuus* L.) in vertisols of Jabalpur (MP) during winter season 1995-96 and 1996-97 to evaluate the appropriate irrigation schedule for increased water use efficiency (WUE) and seed yield. Results revealed that irrigation scheduling based on critical phenological growth stages of crop was better than the other criteria like IW/CPE ratio and depletion of soil moisture. Crop irrigated thrice at 8-9 leaf, flowering and grain filling stages (applied at 30,55 and 75-day stages) resulted in higher WUE and seed yield. Missing irrigations at 8-9 leaf and flowering stages resulted in more reduction of WUE and seed yield.

Key words: Irrigation schedule, phenological growth stages, soil moisture depletion, IW/CPE ratio

Introduction

Sunflower (*Helianthus annuus* L.) acreage is increasing in Madhya Pradesh, particularly as winter crop under irrigated agro-ecosystem. Scheduling of irrigation for a particular crop can be decided on the basis of several approaches like critical phenological growth stages of crop or IW/CPE ratio or soil moisture depletion pattern for efficient utilization of water (Hegde, 1988, Venkanna *et al.*, 1994 and Vivek *et al.*, 1994). Not much work on winter sunflower in relation to irrigation scheduling has been reported. Thus, the present study was aimed to find out an appropriate and efficient irrigation schedule for increased seed yield.

Materials and methods

The field experiments were conducted on sunflower cv. 'Morden' during winter season of 1995-96 and 1996-97 on vertisols of Jabalpur (MP). The soil of the experimental field was clay-loam in texture, near neutral in reaction (pH 7.5) having low available N (228 kg/ha)P_2O_5 (15 kg/ha) and medium available K_2O (421 kg/ha) contents. The field capacity and permanent wilting point of soil at 0-30 cm soil profile was 33.6 and 20.1% respectively. The crop during its growth period received a rainfall of 215 and 68 mm in the first and second years, respectively. Twelve treatments consisted with three criteria for deciding irrigation schedule and four irrigation frequencies were tested in randomized block design with four replications. First criterion of scheduling irrigation was based on depletion of available soil moisture (ASM) as 20, 30, 40 and 50 % depletion of ASM. Second criterion was based on IW/CPE as 1.0, 0.8, 0.6 and 0.4 IW/CPE. Third criterion was based on moisture stress at phenological growth stages as three irrigations at 8-9 leaf (E) + flowering (F) + grain filling (G) stages, 2 irrigations at E + F, 2 irrigations at E+ G; and 2 irrigations at F + G. Measured quantity of irrigation water was applied in each plot as per treatments by using a V-notch of 50 mm size in the irrigation channels. In first irrigation, 75 mm water was applied and then subsequent irrigations received 50 mm water as per treatments. The number of irrigations applied and seasonal consumptive use of water as per procedure of Dastane (1972) under different treatments are given in Table 1. A uniform dose of 80 kg N + 60 kg P_2O_5 + 40 kg K_2O/ha was applied to each treatment through urea, single super phosphate and muriate of potash, respectively. Full quality of P and K fertilizers and half quantity of N was applied as basal and remaining half quantity of N top dressed immediately after first irrigation

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as per treatment. During first year, top dressing of N was done immediately after rains at 25-day growth stage.

Results and discussion

Seed yield: Seed yields were almost comparable with various irrigation frequencies which were decided on the basis of three different criteria of scheduling irrigation during first year (1995-96) except 2 or 1 irrigation given at 30 or 50% depletion of ASM (Table 1). The rainfall during crop season of this year nullified the effect of irrigation schedules. But in second year, the lowest irrigation frequency (only one irrigation) at 50% depletion of ASM or 0.4 IW/CPE produced the lowest seed yields which increased by increasing the irrigation frequencies at 40,30 and 20% depletion of ASM or at 0.6, 0.8 and 1.0 IW/CPE with non significant differences between the closer frequencies.

Table 1 Seed yield and water use efficiency of sunflower under different irrigation schedules

Treatment (Irrigation scheduling)	Head size (cm)		Seeds/head (No.)		100-seed weight (g)		Seed yield (Kg/ha)			Seasonal consumptive use (mm/ha)		
	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1995-96	1996-97	Mean	1995-96	1996-97	Mean
20 % SMA (1)	12.20	13.20	438	470	44.00	46.25	821	1145	983	299 (2.74)	327 (3.50)	313 (3.12)
30 % SMA (2)	12.40	12.90	421	463	43.25	45.00	698	1015	856	299 (2.34)	281 (3.61)	290 (2.97)
40 % SMA (3)	12.80	12.55	410	436	44.25	44.50	898	858	851	306 (2.76)	234 (3.66)	270 (3.21)
50 % SMA (4)	12.20	10.52	372	366	43.50	42.50	630	596	613	257 (2.45)	188 (3.17)	223 (2.81)
1.0 IW/CPE (1)	13.05	12.82	421	465	44.50	45.25	813	1051	932	294 (2.76)	328 (3.20)	311 (2.98)
0.8 IW/CPE (2)	12.90	12.35	422	459	44.75	44.75	873	931	902	297 (2.94)	282 (3.30)	289 (3.12)
0.6 IW/CPE (3)	12.80	12.01	421	439	44.25	44.50	804	862	833	302 (2.66)	236 (3.65)	269 (3.15)
0.4 IW/CPE (4)	12.80	10.50	434	373	44.00	43.50	834	650	744	304 (2.75)	189 (3.44)	246 (3.09)
E + F + G (3)	13.20	13.15	433	468	45.15	45.00	808	1106	952	301 (2.68)	279 (3.96)	290 (3.32)
F + G (2)	12.70	12.44	430	436	45.00	44.50	863	857	860	304 (2.83)	230 (3.73)	267 (3.28)
E + G (2)	13.10	12.18	433	436	45.50	45.25	867	853	860	297 (2.82)	232 (3.68)	269 (3.25)
E + F (2)	13.50	12.55	421	457	43.75	44.50	808	926	867	309 (2.71)	237 (3.90)	273 (3.30)
SEm±	0.72	0.72	4.5	1.4	0.73	0.29	036	21	-			
CD (P=0.05)	NS	2.06	12.9	4.0	NS	0.84	103	62	-			

1 = E-8-9 leaf stage, F - Flowering, G - Grain filling, SMD - Soil moisture depletion, IW/CPE - Irrigation water / Cumulative pan evaporation ratio.
2 = Number of irrigation applied under different treatments was one in 1995-96 except to treatment No. 4 where no irrigation was given but number of irrigation applied under different treatments during 1996-97 are given in parenthesis
3 = Data in parenthesis under CUW column are water use efficiency (kg/ha/mm)

Crop irrigated at all important phenological growth stages (E+F+G) produced significantly maximum seed yield which reduced by missing the irrigations at any one of these stages during second year only. The reduction in seed yield was more pronounced by missing irrigation at 8-9 leaf (E) or flowering (F) stages that of grain development (G) stage. Improved yield attributing characters viz. head size, number of seeds/head and 100 - seed weight under higher irrigation frequencies than lesser irrigation frequencies attributed to increased seed yields. Similar results have been reported by several workers from different regions of the country (Choudhary and Patel, 1994; Sharma, 1994; Reddy and Kumar, 1997).

Water use efficiency (WUE): The seasonal consumptive use of water (CUW) and WUE were similar under all irrigation schedulings during first year except to irrigations scheduled at 50% depletion of ASM, which had lesser values. But during second year, higher irrigation frequencies needing more irrigation water than lower

frequencies resulted into higher CUW and WUE. On the basis of two year mean data, three irrigations applied at important growth stages (E+F+G) resulted to higher WUE than other irrigation scheduling with the same frequencies or even four irrigations given at 1.0 IW/CPE or 20% depletion of ASM. The increased seed yields with irrigations applied at all critical growth stages resulted to higher WUE due to efficient utilization of irrigation water. These results are in close conformity with the findings of Nimbal and Doddamani (1993).

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Increase in yield of Indian mustard in semi-arid environment using *Azotobacter chroococcum* as inoculant

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Abstract

***Azotobacter chroococcum* HT54, a high temperature resistant mutant was tested as an inoculant on four cultivars of Indian mustard, *Brassica juncea viz.* Kranti, RH 30, RN 393 and Varuna under semi arid environmental conditions during 1996-97 and 1997-98 at CCS HAU Regional Research Station, Bawal. Among the various yield parameters studied, data with regard to grain yield, oil content and oil yield were found to be significantly higher due to inoculation. As a whole, variety RH 30 was found to show best response, followed by Kranti and RN 393. However, yield obtained during the year 1997-98 was poor under both inoculated and uninoculated conditions as compared to those of 1996-97 due to severe cold and fog conditions.**

Key words: *Azotobacter chroococcum, Brassica juncea*, biofertilizers, semi-arid tropics, thermotolerant

Introduction

Indian mustard [*Brassica juncea* (L.) Czern & Coss] is an economically important oilseed crop. In India, so far, emphasis has been put on the development of high yielding, fertilizer responsive varieties. The potential of *Azotobacter chroococcum* as a biofertilizer to increase crop productivity of various cereals, oilseeds and vegetables has been known since long (Subba Rao, 1982; Narula and Yadav, 1989; Pandey and Kumar, 1989; Lakshminarayana *et al.*, 1992). Its usefulness has been largely attributed to a number of characters like nitrogen fixation, ammonia excretion, production of vitamins and growth hormones (Shende *et al.*, 1977; Martinez-Toledo *et al.*, 1988); antifungal substances (Sharma *et al.*, 1986); siderophores (Suneja and Lakshminarayana, 1995).

In major parts of Rajasthan and South-Western Haryana, Indian mustard is cultivated as a rainfed crop. Present day high yielding varieties require high levels of N fertilizers which may ultimately deteriorate soil health. Use of microbial inoculants such as *Azotobacter* suitably developed for the arid crops can increase the crop yields while contributing towards soil health and sustainability of agriculture. Higher amount of sunlight available under tropical conditions generally favours higher photosynthetic rate of plants leading to greater excretion of the root exudates and thus favouring proliferation of various rhizospheric bacteria (Odu, 1977).

Studies carried out in our laboratory on metabolic analogue resistant mutants of *A. chroococcum* have revealed that a methyl ammonium chloride resistant mutant (Mac 27) and methyl alanine resistant mutant (Mala 27) increased grain yields in Indian mustard over uninoculated control under irrigated conditions (Narula *et al.*, 1993). As a part of improvement of the performance of *A. chroococcum* as biofertilizer, we developed high temperature (42°C) resistant mutants and tested on different crops including bajra. One of the high temperature mutants (HT 54) was tested on Indian mustard under rainfed conditions at CCS Haryana Agricultural University, Regional Research Station (RRS), Bawal during *rabi* seasons of 1996-97 and 1997-98.

Materials and methods

HT 54, used in the present studies, a spontaneous resistant mutant capable of growing at 42°C to 45°C, was procured from the culture collection of Department of Microbiology, CCS HAU, Hisar. It was derived from Mac 68, a mutant spontaneously resistant of methyl ammonium chloride, a derivative of high nitrogen fixing ammonia excreting local soil isolate of *A. chroococcum* (Anand *et al.*, 1998). It was grown in Jensen N free broth for four days at 30°C to get maximum growth (10^8 to 10^9 cells/m).Carrier based culture was prepared by mixing the broth to charcoal powder. The culture packets were then stored in a refrigerator.

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Seeds of Indian mustard, *B. juncea* var. Kranti, RH 30, RN 393 and Varuna were treated with the culture following standard procedure. Uninoculated controls were treated with fine charcoal powder alone (not having culture inoculant). Experiment was conducted at RRS, Bawal under All-India Co-ordinated Project (AICRP) Trials. The geographical location of Bawal is latitude- 28.1°N, longitude-76°35'E and height above MSL is 266 mts. It was done in randomized block design (RBD) with three replications of each with and without the inoculant. Plot size was 4.5 x 5.0 m and spacings between row to row and plant to plant were 45 and 15 cm, respectively. Basal fertilizer dose at the time of sowing was 40 kg N and 20 kg P_2O_5/ha. Five plants were randomly selected for recording the data on days to 50% flowering, number of primary and secondary branches/plant, siliqua length (cms) and number of seeds/siliqua, days to maturity, seed yield (kg/ha), 1000-seed weight (g), oil content (%) and oil yield (kg/ha) were determined. Oil content was determined from the bulk seed of individual entry by Nuclear Magnetic Resonance (NMR) technique using MK III A Newport Analyser. Rhizospheric soil samples were collected at the time of flowering and viable count of *A. chroococcum* was determined by dilution plate technique using Jensen agar plates.

Results and Discussion

All the four cultivars of *B. juncea*, namely Kranti, RH 30, RN 393 and Varuna responded to inoculation in both the years. In general, all the four varieties gave better response with *A. chroococcum* (HT 54) inoculation (Table1 and 2) in terms of yield attributes viz. days to 50% flowering, number of primary branches and secondary branches, days to maturity, siliqua length, seeds/siliqua and 1000-seed weight. Although results were not significant in some cases, they were significant in terms of grain yield, oil content and oil yield during both the years.

Table 1 **Effect of inoculation of *Azotobacter chroococum* (HT54) on growth, morphological and yield attributes of different cultivars of Indian mustard (*Brassica juncea*) under rainfed conditions**

Cultivar	Days to 50% flowering		No. of primary branches pl		No. of secondary branches pl		Days of maturity		Siliqua length (cm)		Seeds/ siliqua	
	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98
Kranti	51* (52.1)**	74 (73.0)	6.6 (6.8)	7 (6.4)	14 (15.0)	9 (8.0)	145 (146.3)	142 (144.0)	4.4 (4.2)	4.8 (4.9)	14 (13.1)	12 (11.8)
RH 30	47 (48.0)	70 (71.5)	6 (4.6)	6 (5.4)	11 (10.9)	8 (8.2)	148 (150.1)***	142 (143.6)	4.5 (4.3)	5.9 (5.8)	13 (11.8)	11 (10.9)
RN 393	51 (5.17)	74 (74.0)	6 (4.4)	5 (4.8)	11 (6.4)	8 (7.6)	150 (151.3)	144 (145.5)	4.8 (4.4)***	5.7 (5.5)	15 (13.9)	12 (11.9)
Varuna	47 (49.6)	71 (72.7)	6 (5.1)	5 (4.8)	9.9 (10.2)	8 (7.4)	150 (152.0)	145 (145.0)	4.8 (4.7)	4.9 (4.9)	13 (13.7)	10 (9.2)
SEm±	0.46	0.79	0.44	0.39	1.92	0.38	0.87	0.32	0.11	0.09	0.41	0.36
CD (P=0.05)	1.46	2.53	1.40	1.24	6.15	1.22	2.77	1.02	0.33	0.31	1.31	1.16
CV (%)	1.85	2.18	15.87	13.46	34.90	9.45	1.17	0.44	4.51	3.71	6.05	6.43

* Each value is a mean of three replications
** Result in parenthesis indicates control value
*** Represents significant value

Table 2 **Effect of inoculation of *Azotobacter chroococcum* (HT 54) on seed yield and oil content of different cultivars of Indian mustard (*Brassica juncea*) and survival count of inoculant bacteria**

Cultivar	1000 seed weight (g)		Seed yield (kg/ha)		Oil content (%)		Oil yield (kg/ha)		Survival of the bacteria at flowering stage	
	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98	1996-97	1997-98
Kranti	3.73* (3.40)**	3.57 (3.42)	1037 (998)***	627 (540)***	42.4 (39.5)***	36.1 (36.0)	440.5 (394.9)***	226.6 (194.5)*	$1.7x10^5$ ($7.4x10^4$)	$2.1x10^5$ ($6.7x10^4$)
RH 30	6.69 (6.40)	4.61 (4.40)	877 (706)***	599 (519)***	43.0 (39.7)***	36.6 (36.0)***	377.4 (280.7)***	219.8 (187.4)***	$2.3x10^5$ ($5.9x10^4$)	$2.7x10^5$ ($7.3x10^4$)
RM393	4.26 (3.34)***	3.55 (3.41)***	1000 (881)***	587 (503)***	39.8 (38.8)***	35.9 (35.4)***	398.9 (342.3)***	210.6 (178.4)***	$2.9x10^5$ ($6.8x10^4$)	$3.4x10^5$ ($6.5x10^4$)
Varuna	6.41 (5.98)	4.28 (4.20)	950 (884)***	567 (494)***	40.7 (39.1)***	36.7 (36.1)***	372.5 (359.0)	208.3 (178.0)***	$3.4x10^5$ ($7.1x10^4$)	$3.7x10^5$ ($5.9x10^4$)
SEm±	0.19	0.09	11.39	6.65	0.55	0.184	0.93	2.01		
CD (P=0.05)	0.61	0.31	36.40	21.40	1.76	0.56	15.76	6.41		
CV (%)	7.45	4.82	8.41	2.33	2.71	0.97	7.73	1.92		

* Each value is a mean of three replications
** Result in parenthesis represents control value
*** Represents significant value

The mean data in terms of yield during both the seasons showed that Kranti exhibited best response out of four cultivars taken under inoculated as well as under uninoculated conditions (Table 2). As a whole, RH 30 was found to be the best, followed by Kranti and RN 393. Varuna showing least response to inoculation. The performance of four cultivars in 1997-98 was slightly inferior as compared to that of 1996-97 owing to severe cold damage and fog as well as attack of white rust and *Alternaria* blight. Counts of *A. chroococcum* showed variation in inoculated and uninoculated plots, as shown in the Table 2.

Narula *et al.* (1993) observed 44 to 89 % increase in seed yield in *B. juncea* cv., Kranti after inoculation with different mutants of *A. chroococcum* under irrigated conditions along with decreased disease incidence. Experiments in terms of N economy conducted in mustard and wheat revealed that *A. chroococcum* can serve as a useful inoculant (Lakshminarayana, 1993). The present field experiment conducted on mustard have shown that a high temperature resistant mutant of *A. chroococcum* increased the seed yield under semi-arid environment.

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Effect of different levels of irrigation and nitrogen on yield and oil content of Indian mustard (*Brassica juncea*)

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Abstract

A field experiment was conducted during the winter season of 1996-97 and 97-98 at NRCRM, Bharatpur to study the effect of different levels of irrigation and nitrogen on the yield and oil content of Indian mustard (*Brassica juncea*). Two irrigations at 30 and 60 days after sowing increased growth characters and seed yield significantly than one or no irrigation. Application of nitrogen showed linear increase of growth, yield attributes and seed yield up to 120 kg N/ha. However, significant effect was noted up to 120 kg N/ha.

Key words: Mustard, *Brassica juncea*, irrigation, nitrogen level

Introduction

Scheduling irrigation at an appropriate time is one of the most important factor for proper nutrient utilization and realization of high yield of mustard crop. Besides this, most economically viable nitrogen dose at a given irrigation level also needs to be worked out. Hence an experiment was conducted to study the effect of irrigation scheduling and nitrogen on yield and oil content of mustard.

Materials and Methods

A field experiment was conducted during the winter season of 1996-97 and 1997-98 at the Research Farm of NRCRM, Bharatpur, Rajasthan. The soil was sandy loam with pH 6.5, organic carbon 0.31 % and had available N, P_2O_5 and K_2O status of 221, 9.2 and 311 kg/ha, respectively. The experiment was laid out in split-plot design with three replications. The treatments comprised four levels of irrigations (no irrigation, one irrigation at 30 DAS, two irrigations at 30 and 60 DAS and three irrigations at 30, 60 and 90 DAS) as main-plot and five levels of nitrogen (0, 40, 80, 120 and 160 kg N/ha) as sub-plot treatments. Mustard variety PCR-7 (Rajat) was sown on 20th October during both years at 30cm x 10cm spacing with fertilizer dose as per treatments. To maintain the plant to plant distance (10 cm) thinning was done at 25 DAS. Nitrogen and phosphorus were applied as basal. All other recommended cultural practices and plant protection measures were followed. Observations on plant height and yield attributes (siliquae/plant, seeds/siliqua and 1000-seed weight) were recorded. The seed and straw yield were also recorded and oil yield was calculated using oil content and seed yield data.

Results and discussion

The growth parameters and seed yield were higher in the second year (1996-97) than in the first year due to favourable temperature and less infestation of insect pest and diseases.

Irrigation: The differential irrigation treatments exhibited significant effect on yield attributes as well as seed yield of mustard during both the years. Two irrigations (30 and 60 DAS) and three irrigations (30, 60 and 90 DAS) did not show any significant difference in seed yield, but had significant superiority to one or no irrigation in both the years. During 1996, significantly lowest seed yield was recorded with no irrigation. Thus, two irrigations out yielded one and no irrigation. This may be ascribed to increased branches/plant, siliquae/plant, seed/siliqua (Table 1). Yadav *et al.* (1999) observed the highest seed yield of mustard with two irrigations at pre-flowering and seed development stages. The beneficial effect of irrigation on growth and yield of mustard was also reported by Singh *et al.* (1994). Irrigation levels were non significant for oil content, highest oil content was recorded in no irrigation treatment followed by one, two and three irrigations.

Nitrogen: Application of nitrogen significantly increased the seed yield of mustard up to 120 kg/ha. All the yield attributes except the siliqua length in the second year (1997-98) increased significantly with increasing levels of nitrogen up to 120 kg/ha, which ultimately resulted in significant increase in seed yield. Similar observations

were also reported by Singh and Singh (1998) and Sharma (1994). Oil content gradually decreased with increase in rate of nitrogen fertilization.

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Table 1 Effect of levels of nitrogen and irrigation on growth and yield attributing characters of Indian mustard

Treatment	Branches/plant			No. of siliquae/plant			Seeds/siliqua			Seed yield (kg/ha)			Oil content (%)			Harvest index (%)		
	96-97	97-98	Mean	96-97	97-98	Mean	96-97	97-98	Mean	96-97	97-98	Mean	96-97	97-98	Mean	96-97	97-98	Mean
Irrigation levels																		
I_0	9	10	10	108	181	145	10.6	11.5	11.0	521	1022	771	36.1 (188)	40.6 (415)	38.3 (301)	23.61	24.33	24.0
I_1	13	11	12	194	190	192	11.8	11.7	11.7	1318	1150	1234	35.9 (473)	40.5 (466)	38.2 (469)	26.18	25.27	25.7
I_2	15	12	14	196	193	195	11.9	11.8	11.8	1742	1275	1508	35.9 (625)	39.7 (506)	37.8 (565)	27.01	26.05	26.3
I_3	16	13	15	198	194	196	12.2	12.0	12.1	1806	1336	1571	35.6 (643)	39.7 (530)	37.6 (586)	26.96	26.00	26.5
CD (P=0.05)	1.9	1.0	-	2.2	1.7	-	0.5	0.2	-	82	63	-	NS (47)	NS (60)	-	0.8	1.03	-
Nitrogen levels (kg/ha)																		
N_0	9	10	10	176	181	178	11.3	11.5	11.4	693	900	796	36.5 (253)	40.6 (365)	38.5 (309)	25.23	24.59	24.9
N_{40}	12	11	10	191	188	189	11.8	11.6	11.7	1259	1087	1173	36.2 (456)	40.4 (439)	38.3 (447)	25.88	25.19	25.5
N_{80}	14	12	13	194	191	193	11.9	11.7	11.8	1449	1222	1335	35.9 (520)	40.0 (489)	37.9 (504)	26.71	25.62	26.2
N_{120}	15	12	14	198	194	196	12.0	11.9	11.9	1641	1364	1502	35.6 (584)	39.9 (544)	37.7 (654)	26.99	26.09	26.5
N_{160}	16	12	14	199	195	197	11.8	11.9	11.8	1687	1406	1564	35.2 (594)	39.6 (557)	37.4 (575)	26.31	25.67	26.0
CD (P=0.05)	1.4	0.6	-	1.5	1.1	-	0.2	0.2	-	102	134	-	NS (61)	NS (52)	-	0.27	1.80	-

I_0 - No irrigation; I_1 - one irrigation at 30 DAS; I_2 - two irrigations at 30 and 60 DAS and I_3 - three irrigations at 30, 60 and 90 DAS
Figures in parenthesis indicates oil yield (kg/ha).

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Performance evaluation of planting and weeding equipments for rainy season groundnut

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Abstract

Evaluating the efficacy of planting and weeding equipments for rainy season groundnut in a sandy loam soil overall performance of groundnut planter was remarkably better than sowing of seeds behind the plough in terms of germination. The overall performance index of wheel finger weeder (2304) was the highest compared to that of rotary peg weeder (976), fork weeder (674) and manual hand weeding (571) in groundnut.

Key words: Groundnut, performance index, weeding, equipment

Introduction

Groundnut is grown popularly in western undulating zone of Orissa in medium lands and sandy soils of river banks during rainy season as a rainfed crop. But its production is low in comparison to coastal zone due to difference in soil type and poor crop management. Farmers generally sow the seeds behind the plough which lead to poor germination, scattered plant population, higher weed density and ultimately poor crop yield.

Similarly weed management, though one of the important production factor, is neglected by farmers due to non availability of manual labour at the time of weeding or the higher cost involved with it. This crop is exposed to maximum weed competition during early growth stages due to late emergence and establishment (Kulandaivelu and Morachan, 1981). Therefore this experiment was planned to evaluate planting and weeding equipments for groundnut in this region to maximise the productivity and profitability.

Materials and methods

Field experiment was carried out in a Split Plot Design at Regional Research and Technology Transfer Station, Bhawanipatna, Orissa during rainy season of 1994, 1995 and 1996, with two planting methods (main plot) and four weeding methods (sub-plot).

The soil of the experiment site was sandy loam. The test crop groundnut CV.JL-24 was sown during last week of June and Harvested during last week of October for all the three years of experimentation. An uniform fertilizer dose of 20:40:40 kg NPK/ha was applied at the time of sowing. Weeding operation was carried out at 25 DAS. The groundnut planter used in this experiment was a two-row hand drawn type having cup type seed metering mechanism. The furrow opener are of shovel type and row to row spacing was 22 cm. Similarly, the rotary peg weeder was a ,manually operated push-pull type single row weeder having the pegs on the rotor. The fork weeder was a manual pull type weeder having five numbers of fingers and suitable for upland row crops whereas the wheel finger was a manual push-pull type single wheel weeder having five numbers of tynes which uproot and cut the weed in upland row crop.

Observations on germination, field capacity of various equipments, weeding index, damaged plants, performance index of weeding equipments and crop yield were recorded:

Germination percentage	-	Number of seeds germinated out of 100 seeds sown.
Field capacity	-	Actual rate of coverage of a equipment in a particular time expressed in ha/hr.
Weeding index (%)	-	$W_1 - W_2/W_1 \times 100$ Where, W_1 - no. of weeds per unit area before weeding W_2 - no. of weeds per unit area after weeding
Performance index (PI)	-	It is a measure of functional effectiveness of the tool which is directly proportional to the quality, quantity and inversely proportional to the power requirement (Biswas, 1990).

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$$= a \times e \times q / p$$

Where, a - Field capacity of a particular tool in ha/hr.
q - 100 - percent crop plants damaged by operating the tool.
e - Weeding index in percent
p - Power requirement of the tool in Ps.

(Here it was assumed the power requirement of all the manual weeders as 0.05 Ps.)

The data was statistically analysed and the Least Significant Difference (LSD) was worked out at 5% level of probability where 'F' test exhibited significant difference (Chandel, 1978).

Results and discussion

The germination i.e. 95.3 % was more in case of sowing with planter because the seeds were dropped at an optimum depth of 4.23 cm. However, in case of sowing behind the plough the germinations was 83% as the seeds were dropped by a person at different depth and not in an uniform manner depending on the furrow depth ultimately resulting in lower germination (Table 1).

Table 1 Germination (%) of Groundnut and field capacity (ha/hr) by different sowing methods

Year	Germination (%)		Field capacity (ha/hr)	
	P_1	P_2	P_1	P_2
1994	84	96	0.039	0.055
1995	81	94	0.037	0.054
1996	84	96	0.038	0.055
Mean	83	95.3	0.038	0.055
Operational Cost (Rs./ha)	P_1 - 106.18	(Sowing behind the plough)		
	P_2 - 254.84	(Sowing by planter)		

Moreover, the groundnut planter had better land coverage (0.055 ha/hr) compared to sowing behind the plough (0.038 ha/hr). Therefore, during labourer scarcity period the groundnut planter could be used in this region for better germination and rapid land coverage.

Similarly, evaluating different weeding equipments, it was observed that the actual field capacity was highest in case of wheel finger weeder followed by rotary peg weeder and fork weeder (Table 2). The field capacity of wheel finger weeder was found higher due to its design i.e. movement of a single wheel with five tynes attached. But in case of manual weeding the field capacity was lowest because of the cumbersome nature of uprooting weeds by hand. Weeding index was highest with manual weeding as less number of weeds were left in the field and among mechanical weeders the wheel finger weeder was the best as it moved between rows smoothly than other weeders. Similarly, least number of plants were damaged through manual weeding as maximum care was taken during the operation followed by wheel finger and rotary peg weeder because of smoothness in operation between the rows. From the overall performance index (PI) it was concluded that wheel finger weeder was the best with 2304 followed by rotary peg weeder i.e. 976 PI. The operational cost was also lowest in case of wheel finger weeder and highest in case manual weeding.

Table 2 Relative performance of different weeding implements (av. of 3 years)

Treatment	Field capacity (ha/hr)	Weeding index (%)	Plants damaged (%)	Performance index	Operational cost (Rs./ha)
W_1 - Hand weeding	0.003	97.86	2.76	571	3120
W_2 - Weeding by Fork weeder	0.005	73.16	7.86	674	2623
W_3 - Weeding by Rotary Peg weeder	0.007	74.14	5.94	976	2464
W_4 - Weeding by WHEEL Finger weeder	0.015	80.02	4.02	2304	2168

Groundnut seeds yield was significantly affected due to both the planting and weeding equipments. The average seed yield was significantly increased by the use of groundnut planter over sowing behind the plough in 1994 and 1996, however it was at par during 1995 (Table 3). This higher seed yield associated with groundnut planter might be due to better germination, plant growth and maintenance of optimum plant population compared to sowing behind the plough. Among weeding treatments fork weeder recorded significantly lower seed yield (av. 695kg/ha) compared to other methods as it damaged maximum number of plants and allowed more number of weeds to compete with crop plants. Rotary peg weeder though recorded higher seed yield than fork weeder, it was

significantly lower than hand weeding and wheel finger weeder both of which were at par. This was attributed to less damage to crop plants and less crop-weed competition. The interaction effect was found to be non significant.

It was concluded that sowing by groundnut planter and weeding by wheel finger weeder was not only time saving but also produced higher seed yield, cost effective and can be used by the farmers of this region.

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Table 3 Effect of planting and weeding equipments on seed yield of groundnut (kg/ha)

Treatment	1994		1995		1996		Mean		Grand mean
	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	
W_1 - Hand weeding	1195	1324	1342	1348	1218	1354	1252	1342	1297
W_2 - Weeding by Fork weeder	646	758	686	788	600	690	644	745	695
W_3 - Weeding by Rotary Peg weeder	1006	1054	1084	1075	972	950	1021	1026	1024
W_4 - Weeding by Wheel Finger weeder	1141	1276	1424	1482	1129	1251	1231	1336	1284
Mean	997	1103	1134	1173	980	1061	1037	1112	-
CD (P = 0.05)									
Main plot (P)	0.82		0.65		0.51		0.62		
Sub plot (W)	1.08		1.56		1.20		1.13		
Interaction (P x W)	NS		NS		NS		NS		

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Growth and yield of groundnut **under different cropping systems and *nutrient management practices***

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Abstract

The results of a field experiment conducted during *kharif* 1999 on performance of groundnut under different cropping systems with integrated nutrient management revealed that significantly higher pod yields were recorded under *alleycropping systems* with *Dalbergia*(1158 kg/ha) and *Leucaena* (1148 kg/ha) under sole cropping of groundnut (1002 kg/ha). Though green leaf manuring and 20 kg N/ha produced higher yields independently but conjunctive application of green leaf manure at 20 kg N/ha resulted in significantly higher yield (1442 kg/ha) than application of 40 kg N/ha alone (1128 kg/ha). Both drymatter production and crop growth rate were found significantly higher under alleycropping systems. Much increased values of drymatter and crop growth rate were recorded at 20 kg N/ha with green leaf manuring. Alleycropping systems, green leaf manuring and combined application of green leaf manuring with 20 kg N/ha resulted in lower diffusive resistance and better transpiration rate of groundnut which led to increased stomatal conductance and promoted the growth of the groundnut.

Key words: *Alleycropping, Dalbergia, Leucaena*, green leaf manuring

Introduction

Groundnut is the principal oilseed crop in India, predominantly grown in dry lands. However, its productivity is far below in India compared to world average. Impoverished soils with low efficiency of applied fertilizers and poor management practices are the bottlenecks for low productivity of groundnut. Use of green manures and other organic sources to meet the nutrient requirement of crop would be an inevitable practice in years to come for sustainable agriculture in dry lands. Availability of eco-friendly tree leaves in conjunction with inorganic fertilizers also have the immense potential of supplementing a part of nitrogen and other nutrient through efficient mineralization to the associated crops in tree based cropping systems (Subba Reddy *et al.*, 1991). However, the integration of groundnut in association with *Dalbergia and Leucaena* based cropping systems is not fully exploited, hence the present study was initiated.

Materials and Methods

A field experiment was conducted at Student's Farm, College of Agriculture, Rajendranagar, Hyderabad during rainy season *kharif* of 1999 to study the performance of rainfed groundnut under different cropping systems to organic and inorganic sources of nitrogen. The experiment was laid out in a double split plot design with three replications (Table 1). The site of the experiment was under 10 years old plantations of *Dalbergia* and *Leucaena* spaced at 4 x 3 m, which were pollarded at an height of 3 m and designated as alley cropping system. After pollarding, the entire area of each plantation was divided into two equal halves of three alley each and one was incorporated with respective pollarded foliage (GLM), whereas the second half was not applied with green leaf materials (NGLM). An equal open area (without tree) was selected nearby which was applied with GLM of respective species and without GLM and designated as sole cropping systems i.e., SCD and SCL. Simultaneously phosphorus at recommended dose of 60 kg/ha was applied for better decomposition of applied tree foliage. The nitrogen fertilizer was applied as per the treatments through urea after two weeks of germination for efficient utilization. Gypsum at 500 kg/ha was applied with first flower appearance for better peg penetration and pod filling. The soil of the tree area was medium to high in organic carbon (0.73-0.81 %), medium in available N, P and K (290, 29.1 and 219 kg/ha, respectively) while the open area was low in organic carbon (0.29 %) and available N (150 kg/ha). The plot size was 4 m x 6 m. Groundnut crop variety cv. Vemana (K-134) was sown by hand dibbling in lines at a spacing of 30 x 10 cm on 10th July, 1999 and harvested on 28th October, 1999.

Results and Discussion

Dry matter production (kg/ha): All the treatments under study effected the dry matter production of groundnut significantly (Table 1). DAC recorded higher dry matter production as compared to LAC however, both treatments were superior to SCD and SCL. Much less dry matter production was found under sole cropping without green leaf and fertilizer application. High drymatter under DAC and LAC could be due to increased leaf area and LAI coupled with less soil compaction. Dry matter production of groundnut increased by 36.1 % with green leaf manuring over without green leaf manuring. Improvement of soil physical conditions with better nutrient status due to green leaf application could be the reason.

Nitrogen application of 40 kg/ha resulted in much higher dry matter production compared to N_{20} and N_0. The increased leaf size due to increased N supply might be potential source for greater photosynthesis and better growth of groundnut.

In interaction between cropping systems and green leaf manuring, maximum dry matter production was recorded under DAC with green leaf manuring followed by LAC.

Table 1 **Dry matter production (kg/ha), crop growth rate (g/m²/day) and pod yield (kg/ha) of groundnut at different stages as influenced by cropping systems, green leaf manuring and nitrogen levels**

Treatment		Dry matter production 90 DAS				Crop growth rate 60-90 DAS				Pod yield (kg/ha)			
		N_0	N_{20}	N_{40}	Mean	N_0	N_{20}	N_{40}	Mean	N_0	N_{20}	N_{40}	Mean
DAC	GLM	2797	4189	4886	3957.3	2.00	3.02	3.64	2.90	998	1515	1380	1298
	NGLM	1803	2904	3592	2766.3	1.38	2.67	2.84	2.23	801	1032	1225	1019
	Mean	2300	3547	4236	3362.8	1.64	2.89	3.24	2.66	900	1273	1303	1158
LAC	GLM	2510	3697	4396	3534.3	2.10	3.12	3.76	3.00	970	1519	1355	1281
	NGLM	1754	2673	3367	2598.0	1.68	1.94	2.44	2.00	797	1040	1210	1016
	Mean	2132	3185	3882	3066.2	1.84	2.53	3.15	2.57	884	1280	1283	1148
SCD	GLM	2364	3341	3916	3207.0	2.01	2.67	3.35	2.69	910	1373	1226	1170
	NGLM	1510	2481	3165	2364.3	1.01	1.84	2.67	1.80	601	864	1039	835
	Mean	1937	2880	3541	2786.7	1.57	2.21	2.91	2.20	756	1119	1133	1002
SCL	GLM	2320	3141	3895	3119.7	1.78	2.45	2.93	2.32	933	1359	1211	1168
	NGLM	1510	2418	3165	2364.3	1.00	1.84	2.67	1.80	601	864	1039	835
	Mean	1915	2780	3530	2742.5	1.34	2.10	2.85	2.16	767	1112	1125	1001
Means of N levels		2071	3098	3798	2989.7	1.67	2.41	3.00	2.32	826	1196	1211	1078
Mean of GLM		2497.8	3592.0	4273.3	3454.3	1.93	2.86	3.47	2.97	953	1442	1293	1229
Mean of NGLM		1644.3	2603.3	3322.3	2523.3	1.21	2.15	2.61	2.00	700	950	1128	926

	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
Between cropping system (F_1)	14.43	35.30	0.10	0.23	25.07	61.35
Between green leaf manures (F_2)	18.44	42.52	0.6	0.14	11.85	28.02
Between nitrogen levels (F_3)	33.81	69.05	0.13	0.28	27.11	55.08
Between $F_1 \times F_2$	36.88	75.30	0.12	0.25	23.69	NS
Between $F_1 \times F_3$	67.63	138.10	0.27	0.55	54.21	NS
Between $F_2 \times F_3$	47.82	NS	0.19	NS	38.33	77.89
Between $F_1 \times F_2 \times F_3$	95.64	NS	0.38	0.78	76.66	NS

DAC = *Dalbergia* alley cropping
LAC = *Leucaena* alley cropping
SCD = Sole cropping with *Dalbergia* green leaf manuring
SCL = Sole cropping with *Leucaena* green leaf manuring
GLM = Green leaf manuring
NGLM = No green leaf manuring

Crop growth rate (g/m^2/day): Significantly higher crop growth rate 2.66 g/m^2/day was observed under DAC over SCD and SCL, however, it was comparable with LAC (2.5 g/m^2/day). CGR was recorded less values for LAI under control, indicating advantage in alley cropping resulting higher dry matter due to improved site conditions (Table 1). Likewise application of green leaf manuring resulted in significantly higher crop growth rate of over without green leaf manuring which could be due to higher plant dry matter resulting from increased mineralization of nutrients and better nitrogen use efficiency.

Similarly, nitrogen application of 40 kg N/ha produced CGR of groundnut with an increase of 24.06 and 90.44 % over N_{20} and N_0 respectively. More dry matter with increased uptake of nutrients could have resulted in higher CGR at higher doses of nitrogen.

Among the interactions, green leaf manuring with 40 kg N/ha produced maximum CGR under LAC and DAC, however, it was comparable with CGR produced at 20 kg N/ha with green leaf manuring under these alley cropping systems, indicating the advantage of conjunctive use of organic and inorganic nitrogen fertilizers coupled with site improvement under alley cropping systems. Present findings are in confirmity with Pandey *et al.* (1998).

Physiological parameters: The physiological parameters under study (Table 2) were significantly influenced by cropping systems. Leaf temperature (LT) under DAC and LAC were significantly higher than SCD and SCL. This could be due to optimal use of resources in alley cropping might have resulted in higher photosynthesis activities and evolving of heat energy in mesophyll of groundnut leaf. Relative humidity was superior under *Dalbergia* alley cropping (45%) as compared to all other cropping systems. Lower bulk density and better aggregate stability under *Dalbergia* alley cropping with increased water retention capacity are the reasons ascribed. However, the values of diffusive resistance were found less (0.432 and 0.438 S/cm) while transpiration rate was more (32.95 and 32.83 µg/S/cm^2) under DAC and LAC respectively as compared to SCD and SCL. The reason might be due to normal stomatal opening for better exchange of gases. Similar findings was observed by Kanchana (1998).

Table 2 Physiological parameters of groundnut at 60 DAS as influenced by cropping systems, green leaf manuring and nitrogen levels

Treatment		LT (°C)	RH (%)	DR (s/cm)	TR (ug/s/cm^2)
	GLM	34.52	46	0.404	34.73
DAC	NGLM	33.40	43	0.460	31.28
	Mean	33.96	45	0.432	33.05
	GLM	34.26	44	0414	34.67
LAC	NGLM	33.25	42	0.463	31.19
	Mean	33.76	43	0.438	32.83
	GLM	33.73	41	0.417	33.26
SCD	NDLM	32.22	37	0.503	28.45
	Mean	32.97	39	0.460	30.86
	GLM	33.92	41	0.417	33.40
SCL	NGLM	32.22	37	0.503	28.45
	Mean	33.07	39	0.460	30.98
Mean of	GLM	34.11	43	0.413	34.00
	NGLM	32.77	40	0.482	29.70

	SEM±	CD(P=0.05)	SEm±	CD(P=0.05)	SEm±	CD(P=0.05)	SEm±	CD(P=0.05)
Between cropping systems (F_1)	0.09	0.21	0.18	0.44	0.003	0.008	0.18	0.44
Between green leaf manures (F_2)	0.05	0.12	0.16	0.37	0.003	0.008	0.16	0.37
Between nitrogen levels (F_3)	0.09	0.19	0.14	0.28	0.006	0.012	0.14	0.28
Between $F_1 \times F_2$	0.10	0.21	0.32	0.65	0.007	0.014	0.32	NS
Between $F_1 \times F_3$	0.19	NS	0.28	0.57	0.012	NS	0.28	NS
Between $F_2 \times F_3$	0.13	0.27	0.20	0.40	0.008	0.017	0.20	NS
Between $F_1 \times F_2 \times F_3$	0.26	NS	0.39	0.80	0.016	0.033	0.39	NS

Green leaf manure application had contributed to maintain normal temperature (34.1°C) and relative humidity (43 %) over without green leaf manuring (32°C and 40 % respectively). Similarly transpiration rate was also found to be higher under green leaf manure application. However, the values of diffusive resistance (DR) were found much less with green leaf manure (0.413 S/cm^{-1}) as compared to without green leaf manure. Better values of all these parameters with green leaf manuring might be due to normal growth of groundnut with better photosynthetic activity. The results are in accordance with the findings of Bheemaiah et al. (1998a and b).

Pod yield (kg/ha): Pod yield of groundnut was influenced significantly by all the treatments under study. Cropping systems with values of 1159 kg/ha in DAC, 1149 kg/ha in LAC found higher than SCD (1002 kg/ha) and SCL. Green leaf manuring at 5 tonnes/ha resulted in significantly higher pod yield of 1229 kg/ha over no green leaf manuring (926 kg/ha). Nitrogen at 20 kg/ha produced pod yield of 1196 kg/ha, which was on par with 40 kg N/ha (1210 kg/ha) and significantly higher when compared to 0 kg N/ha (926 kg/ha).

Application of 20 kg N/ha with GLM produced superior yield of 1442 kg/ha over N_{40} with GLM (1293 kg/ha) and without GLM (1128 kg/ha).

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Quality studies of some sesame (*Sesamum indicum* L.) seeds : oil, protein and fatty acids

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Abstract

Seeds of eight sesame genotypes namely RT-274, TKG-21, RS-160, OS-10, OS-18, ORM-17, JTS-8 and TC-25 were studied for some nutritional constituents *viz.*, 1000 seed weight, protein content, oil content fatty acid composition of the oil, oil stability index and nutritional quality index. TKG-21 was the best for most of the quality characters. Oil content was higher in JTS-8 (56%) and TC-25 (56%). The best quality oil was of TKG-21, with 54% oil in its seeds. This genotype was having the most stable (OSI = 1.199) and nutritionally best (NQI = 4.99) quality oil besides having 41.3% protein in its meal.

Key words: *Oil, protein, fatty acids, sesame*

Introduction

Sesame (Sesamum indicum L.) is perhaps the oldest oilseed known and used by man (Joshi, 1961 and Weiss, 1971). The crop has a large diversity in cultivars and cultural systems (Sharma, 1997). *Sesame seed is a valuable nourishing food and is also used as a flavouring* agent. Sesame oil has desirable fatty acid composition and excellent stability against oxidative rancidity. Sesame has been described as the "**Queen of Oilseeds**" because of the excellent qualities of the seed, oil and meal (Wealth of India, 1968). The seed samples of sesame were taken from the Advance Varietal Trial of All India Coordinated *Research Project (Sesame). Since these entries were* found promising in respect of other characteristics *viz.*, grain yield, resistance to diseases and pests, an attempt has been made to assess the biochemical composition in terms of oil content, oil quality and protein content.

Materials and methods

Eight sesame entries namely RT-274 (white), TKG-21 (white), RS-160 (white), OS-10 (black), ORM-17 (black), JTS-8 (white) and TC-25 (white) were sown in randomized block design in three replications during *kharif* 1999 at the Experimental Farm of Linseed Research Station, Mauranipur, Jhansi of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. After the harvest of the crop seed samples were collected from all the three replications. The chemical estimations were done in triplicate and average of the three values was taken. Thousand seed weight was recorded.

Oil content in seeds was estimated by Soxhlet extraction procedure (AOAC,1970). Fatty acid composition of the oil was done by Gas Liquid Chromatography using DEGS column and FID detector. Methyl esters of the oil were prepared by the method of Luddy *et al.* (1968). Oil Stability Index (OSI) and Nutritional Quality Index (NQI) of the oil were calculated from the fatty acid composition of the oil as per Carpenter *et al.* (1976), Nitrogen content in defatted cake (meal) was analyzed by Kjeldahl method (AOAC, 1970). It was then multiplied by the factor 5.30 to get protein percentage.

Results and discussion

The variation in the 1000 seed weight amongst sesame genotypes has been found to be non-significant. However, the test weight varied from 2.70 - 3.27 g and the entry RS-160 recorded highest test weight of 3.27 g (Table-1). A variation in test weight has also been reported (Wealth of India, 1968). Likewise protein content in defatted meal varied significantly within the genotypes, the range of variation being 41.30 - 42.03%. The genotype ORM-17 (42.03%) gave highest protein content (Table-1) A variation in protein content has been reported (Patil *et al.*, 1994; Rajeswari and Ramaswamy, 1994, Lee and Lee, 1995). Sesame protein constitutes a valuable supplement to pulse proteins, which contain adequate amount of lysine but are normally deficient in sulphur containing amino acids.

A significant variation of 46 to 56% in oil content was observed (Table-1). Among the genotypes the highest value exhibited by the entry JTS-8. A wide variation in oil content in sesame has also been reported by several workers (Tashiro *et al.*, 1990; Rajeshwari and Ramaswamy, 1994; Patil *et al.*, 1994).

Sesame is nutritionally important as it contains high *linoleic acid, which is an essential fatty acid.* The genotypes under study were found to have high nutritional value containing high oleic (36-50%) as well as linoleic (35-42%) acids in oil. The genotypes *viz.*, ORM-17, OS-10 and TKG-21 had high linoleic acid *i.e.*, 40% and above, TKG-21 was found to be the best in respect of oleic acid *content (50%). High content of oleic and linoleic acids in* sesame oil have also been reported by several workers (Nagraj, 1991; Muralidharadu, 1994; Lee and Lee, 1995; Baydor, 1996; Bakhali *et al.*, 1998).

The data revealed (Table-1) *a significant* variation (1.003 to 1.99) in Oil Stability Index (OSI). The genotype TKG-21 showed *highest O/L ratio.* The Nutritional Quality Index (NQI) also varied significantly from 1.33 to 4.99, the *highest value being given by the genotype* TKG-21. Hence, the best oil from nutrition point of view was found *to be from the genotype* TKG-21. TKG-21 had the best quality characters. Although, the entries JTS-8 and TC-25 gave *highest oil content* but the best quality oil was given by TKG-21. This genotype also yielded most stable and *nutritionally best quality oil than the others.* However, ORM-17 yielded highest protein content in its meal.

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Table 1 Quality characteristics of seed and oil of some sesame genotype

Entries	1000 seed wt (g)	Protein content (%)	Oil content (%)	OSI *18:1/18:2*	NQI *18:2/Sat* F.A.	Fatty acid composition			
						Palmitic	Stearic	Oleic	Linoleic
RT-274	3.0	35.12	54	1.199	2.05	11.16	6.98	44.65	37.21
TKG-21	3.2	35.02	54	1.199	4.99	6.21	2.13	50.00	41.64
RS-160	3.3	35.40	53	1.193	1.69	15.28	5.95	42.86	35.90
OS-10	2.7	35.54	46	1.101	2.75	11.47	3.24	44.71	40.59
OS-18	2.8	35.26	48	1.130	2.05	15.92	2.65	43.21	38.22
ORM-17	2.7	35.64	46	1.047	3.50	9.18	3.06	44.90	42.86
JTS-8	3.0	35.23	56	1.003	1.33	17.05	10.10	36.49	36.36
TC-253.3	3.3	34.81	56	1.066	1.77	17.54	3.90	40.55	18.01
Mean	2.99	35.25	51.6	1.117	2.51	12.47	4.75	43.42	38.85
SEm±	NS	0.153	0.72	0.001	0.043	0.845	0.200	14.23	0.782
CD (P=0.05)	-	0.358	1.54	0.003	0.092	1.812	0.429	2.65	1.675

Note - *OSI = Oil Stability Index,* NQI = Nutritional Quality Index

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Integrated nutrient management in sesame (*Sesamum indicum* L.) for Kymore plateau zone of Madhya Pradesh

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Abstract

An investigation was carried out at Jabalpur (Madhya Pradesh) to determine the integrated nutrient management in sesame cv. TKG-22 during *kharif* season of 1999 and 2000. Application of 50% N through urea + 50% N through FYM + 50% P and 100% K through fertilizers + Phosphorus Solubulizing Bacteria (PSB) @ 500 g/ha produced the highest seed yields mainly due to superiority in growth parameters (plant height, branches/plant) and yield attributing characters (capsules/plant, test weight of seeds and seed yield/plant). It also fetched the highest monetary returns with maximum benefit : cost ratio.

Key words: Farm yard manure, compost, biofertilizer, net monetary returns, sesame

Introduction

Sesame (*Sesamum indicum* L.) is mostly grown on marginal and submarginal lands of Madhya Pradesh with very low productivity (247 kg/ha). Integrated use of organic manures, inorganic fertilizers and biofertilizers proved quite promising for sustainable high productivity by improving soil physical conditions (Subba Rao, 1994). Available information on this subject is scanty for the agro-climatic area of the Kymore Plateau Zone of Madhya Pradesh. Present investigation has been undertaken to find out the suitable integrated nutrient management for increased and sustainable productivity of sesame in this region.

Material and methods

Field experiments were conducted on sesame cv. TKG-22 at the research farm of J.N.Krishi VishwaVidyalaya, Jabalpur during *kharif* season of 1999 and 2000. The soils of experimental field was clay loam, neutral in reaction (pH) and low in organic carbon (0.19), available N (220 kg/ha), available P_2O_5 (7.85 kg/ha), available sulphur (6.8 kg/ha) and high in available K_2O (345 kg/ha). The rainfall was 1740 and 1059 mm during the crop season in the two consecutive years. Twelve treatments consisted with control were tested in randomised block design with three replications (Table-1). The Compost and FYM were applied at the time of final seed bed preparation as per treatments. *Azotobactor* and *Azospirillum* were applied through seed inoculation whereas, Phosphorus Solubulizing Bacteria (PSB) was applied (500 g/ha) at the time of sowing. Sowing was done in rows 30 cm apart on July 15th, 1999 and July 6th, 2000. The data on yield attributes and seed yield were recorded at harvest and finally economics of the treatments was worked out.

Results and discussion

Two years data and pooled mean indicated that seed yield significantly varied due to different treatment (Table 2). All treated plots gave significantly higher seed yields than control mainly due to significant superiority in growth parameters *viz.*, plant height and branches/plant and yield attributes *viz.*, capsules/plant, seed yield/plant and test weight of seeds (Table-1). Among various integrated nutrient management practices, 50% N through urea + 50% N through FYM + 50% P and 100% K through fertilizers + PSB (T_9) produced the highest seed yields among all the treatments. Integrated use of 50% N through urea + 50% N through compost or FYM along with recommended P and K fertilizers (T3 and T4) gave almost comparable seed yields to 100% NPK through fertilizers (T2). Thus, 50% of recommended N through fertilizers could be substituted through FYM or compost without sacrificing the seed yield of sesame. Integration of *Azospirillum* or *Azotobactor* inoculants with 50% N and 100% P, K fertilizers (T_5 and T_6) significantly gave lesser seed yields than T_2 (100% NPK). The seed yields were at par between T_7 and T_8 when 50% and 100% recommended P was curtailed with the inoculation of PSB. It indicated the beneficial effect of PSB in P deficient soils (Arunachalam and Venkatesan, 1984). Inoculation of two or three biofertilizers with 50% each of N,P and 100% K fertilizers under T_{10}, T_{11} and T_{12} produced the seed yields equivalent to those obtained with T_2 (100% NPK). Thus, nearly 50% N and P could be derived with the inoculation of effective biofertilizers. Similar beneficial effect of biofertilizers in sesame have been reported by Mondal *et al.*, (1992), Balasubramanian and Palaniappan (1994) and Reddy and Sudhakarababu, (1996).

Table 1 Growth parameters and yield attributing characters as influenced by integrated nutrient management in sesame

Treatment	Plant Height at Harvest (cm)			Number of branches/plant			Number of capsules/plant			Test wt(g)			Seed yield/plant(g)		
	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean	1999	2000	Mean
Control (No nutrient application)	81	108	94.5	2.86	2.40	2.63	34	45	39.5	2.5	2.9	2.7	4.0	5.0	4.5
100% NPK (60:40:20 kg/ha)	89	121	105.0	3.46	3.06	3.26	52	49	50.5	2.6	3.1	2.9	4.7	5.8	5.2
50% N*+50%N Through FYM+P&K recomended	88	129	108.5	3.66	3.00	3.33	45	58	51.5	2.6	3.1	2.8	4.8	8.6	6.7
50% N*+50%N Through compost+P&K recommended	88	120	104.0	3.60	3.00	3.30	50	53	51.5	2.6	3.1	2.8	4.6	5.5	5.1
50% N*+ *Azotobactor* +P&K recommended	86	121	103.5	3.66	2.73	3.19	46	55	50.5	2.6	3.1	2.8	4.7	5.5	5.1
50% N*+ *Azotobactor*+ P&K recommended	87	125	106.0	3.53	2.66	3.09	45	58	51.5	2.6	3.0	2.8	4.7	5.5	5.1
100% N*+PSB+50% P and 100% K recommended	86	123	104.5	3.40	3.53	3.46	47	66	56.5	2.6	3.1	2.8	4.9	5.9	5.4
50% N+ No P and 100% K recommended*	86	129	107.5	3.33	3.53	3.43	52	61	56.5	2.6	3.1	2.8	4.7	5.8	5.3
50%N*+50% N through FYM+PSB+50% P and K recommended	90	136	113.0	3.66	3.60	3.63	54	73	63.5	2.7	3.2	2.9	5.3	6.1	5.7
50%N*+ *Azospirillum*+ *Azotobactor* +PSB+50% P & K recommended	85	122	103.5	3.26	3.06	3.16	44	66	55.0	2.6	3.1	2.8	4.7	5.8	5.3
50%N*+ Azotobactor +PSB+50% P and 100% K recommended	83	118	100.5	3.40	3.13	3.26	41	62	51.5	2.6	3.1	2.8	4.7	5.8	5.3
50%N*+ *Azospirillum*+ *Azotobactor* +PSB+50% P & K recommended	85	124	104.5	3.43	3.0	63.24	37	64	50.5	2.6	3.1	2.8	4.8	5.8	5.3
SEm±	3.7	6.1		0.26	0.22		3.6	4.6		0.15	0.07		0.02	0.23	
CD(P=0.05)	NS	NS		0.75	0.64		10.6	13.6		0.44	0.19		NS	0.67	

** N through urea*

Table 2 Seed yield and economic returns of sesame as affected by integrated nutrient management

Treatment	Seed ;yield (kg/ha)		Pooled Mean	Net Return (Rs/ha)			B:C ratio		
	1999	2000		1999	2000	Mean	1999	2000	Mean
Control (No nutrient application)	305	520	412	1850	6150	4000	1.43	2.44	1.93
100% NPK (60:40:20 kg/ha)	891	1297	1094	12150	20270	16210	3.14	4.57	3.85
50% N*+50%N Through FYM+P&K recommended	942	1487	1214	12850	23750	18300	3.14	4.96	4.05
50% N*+50%N Through compost+P&K recommended	1047	1340	1193	14930	20790	17860	3.48	4.45	3.96
50% N+ Azotobactor +P&K recommended*	802	1133	967	10530	17150	13840	2.91	4.11	3.51
50% N+ Azotobactor*+ P&K recommended	813	1170	991	10750	17890	14320	2.95	4.24	3.59
100% N*+PSB+50% P and 100% K recommended	967	1370	1168	13570	21630	17600	3.35	4.74	4.04
100% N*+PSB+No P and 100% K recommended	911	1293	1102	12960	20600	16780	3.46	4.91	4.18
50%N*+50% N through FYM+PSB+50% P and K recommended	1071	1560	1315	15510	25290	20400	3.62	5.27	4.44
50%N+Azospirillum+Azotobactor*+PSB+50% P & K recommended	812	1213	1012	10880	18900	14890	3.03	4.52	3.77
50%N*+ *Azotobactor* +PSB+50% P and 100% K recommended	725	1217	971	9160	19000	14080	2.71	4.55	3.63
50%N*+ *Azospirillum* +PSB+50% P&K	746	1287	1016	9580	20400	14990	2.79	4.82	3.80
SEm±	39	36	50						
CD(P=0.05)	120	104	155						

* N through urea, Sale price of sesame **Rs.20/kg**

Treatment T_9 (50% N through urea + 50% N through FYM) fetched the highest net monetary return (Rs.20,400) and profitability (4.4) on the basis of pooled data of both years. Other treatments like T_3, T_4, T_7 and T_8 also proved superior to T_2 (100% NPK) in this regard. Reduction in cost of cultivation without sacrificing in the seed yields with the integration of biofertilizers resulted in better economic returns to that of T_2 (100% NPK).

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Effect of sources and levels of sulphur on seed and oil yield of safflower (*Carthamus tinctorius* L.)

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Abstract

Response of rainfed safflower cv. Bhima to different level and sources of sulphur was investigated during 1996-97. Applied sulphur significantly increased the seed and oil yield of safflower over control . Among the levels , sulphur application at 45 kg/ha, produced significantly higher seed yield than that of 15 kg/ha. *Sulphur application through ammonium sulphate,* recorded significantly higher seed yield as compared to other sources *viz.*, single super phosphate, elemental sulphur and gypsum . Applied sulphur brought significant improvement in the heat soluble sulphur content of the soil .

Key words: Sulphur, seed and oil yield, safflower, rainfed

Introduction

Safflower *(Carthamus tinctorius* L.) an important *rabi* oilseed crop is grown on either conserved or residual soil moisture. For centuries, it has been under cultivation in India either for its orange red dye (Carthamin) extracted from its colored florets and its much valued oil. Besides its adaptability to dryland condition, safflower produces oil rich in polyunsaturated fatty acids (linoleic acid 78%) which play an important role in reducing the cholesterol level in the human blood. Safflower yield is improved but has not reached the potentiality. Fertilizer is one of the important inputs for increasing safflower yield (Sharma, 1993; Mane and Jadav 1994). Global reports of sulphur deficiency and consequent crop response particularly in oilseeds led to find out the effect of different levels and sources of Sulphur application to rainfed safflower grown particularly in salt affected area of Bhal and Coastal Zone of Gujarat.

Materials and methods

A field experiment was laid out in factorial randomised block design with three replications at Regional Research Station, Gujarat Agricultural University, Arnej during winter season of 1996-97 to 1998-99 to find out the effect of sources and levels of sulphur on seed and oil yield of safflower grown on conserved soil moisture.

The treatments consisted of three levels of Sulphur (15, 30 and 45 kg/ha) and four sources *viz*; Ammonium Sulphate (24% S), Single Super Phosphate (12% S), Elemental Sulphur (commercial grade 86% S) as well as Gypsum (15% S) and the control. In all 13 treatments were tried and statistical analysis was carried out as per factorial concept using control v/s rest technique.

The soil was clay in texture with 220 kg/ha available nitrogen, 21 kg/ha available P_2O_5, 775 kg/ha available K_2O and 11 ppm Heat Soluble Sulphur. The soil was alkaline in reaction with EC 0.31 ds/m and pH 8.49. The rains received during monsoon 1996, 1997 and 1998 amounted 563, 995 and 768 mm distributed in 37, 44 and 36 rainy days respectively.

Results and discussion

Application of Sulphur to Safflower brought significant increase in seed and oil yield in second and third year of the study as well as on pooled basis. Among the sources of sulphur, ammonium sulphur remarkably increased the seed and oil yield over the other sources in all the years of the experimentation (Table 1). In pooled data of three years, ammonium sulphate was found significantly superior source in respect of seed and oil yield improvement. This might be due to water soluble and readily available sulphate from ammonium sulphate. The other sources of sulphur *viz*, single super phosphate, elemental sulphur and gypsum remained at par in their effect on production of seed and oil yield of safflower during individual years as well as on pooled basis.

The data presented in table 2 indicated significant improvement in oil content of seeds due to sulphur application over control in 1997 and 1998 as well on pooled basis. Singh and Sahu (1986) also recorded increased oil content in oilseed by increased S-application as a result of glycosides which on hydrolysis increased oil

content. However, none of the sources of sulphur showed *significant effect on oil content in safflower.*

Determination of sulphur status of soil in terms of heat soluble sulphur, applied sulphur brought significant improvement over no sulphur application. None of the sources of sulphur application showed its superiority (Table 2).

Sulphur levels: Sulphur applied at 45 kg/ha significantly increased the seed yield over the lower levels during second and third year of the study. In the pooled data, sulphur application at 45 and 30 kg/ha found equally effective in increasing seed yield but produced higher seed yield than that of 15 kg/ha. These findings are in *agreement with Kar and Babulkas (1999). Sulphur* application at 45 kg/ha recorded significantly the highest yield over the lower levels during second and third year of the study as well as on pooled basis.

Different levels of sulphur, did not bring significant change in oil content of safflower seeds (Table 2). Higher level of *sulphur significantly improved the heat soluble sulphur* content of soil over the lower levels in 1996. In second year, the higher and middle level remained at par but significantly improved the heat soluble sulphur status of soil over the lower level. Similar trend was observed in pooled data.

Economics: *Among different levels, 45 kg S/ha showed* the highest additional profit of Rs. 4485/ha with net ICBR value of 1:14.42 (Table 3). On the other hand the highest value of net ICBR (1:26.26) was obtained with the lower *level of sulphur i.e 15 kg S/ha.*

Among the various sources, Ammonium sulphate secured the highest additional net profit (Rs. 5214/ha) whereas Gypsum showed the highest value of net ICBR (1:45.67).

It is therefore concluded that sulphur application had a marked effect on seed yield of safflower. Among the levels, 45 kg/ha recorded the highest seed yield but remained at par with 30 kg/ha in pooled results. Among the various sources, Ammonium Sulphate recorded significantly highest seed yield and additional net profit. Gypsum realised maximum return per rupee invested being a low cost input.

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Table 1 Effect of levels and sources of sulphur on seed oil yield of safflower

Treatment	Seed yield (kg/ha)				Oil yield (kg/ha)		
	1996	1997	1998	Pooled	1997	1998	Pooled
Control vs. Sulphur							
Control	1338	598	753	896	161	203	182
Sulphur	1631	986	1116	1244	269	310	290
F-test	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
Sulphur level (kg/ha) (L)							
15	1528	903	1027	1153	246	284	265
30	1667	986	1092	1248	269	303	286
45	1698	1068	1230	1332	293	342	317
SEm±	86	25	24	31	7	7	5
CD (P=0.05)	NS	74	72	87	19	20	13
Sources of sulphur (S)							
AS	1784	1137	1269	1397	313	354	333
SSP	1561	931	1087	1193	255	302	278
ES	1584	946	1053	1194	258	291	275
Gypsum	1594	929	1056	1193	252	292	272
SEm±	99	29	28	36	8	8	5
CD (P=0.05)	NS	85	83	101	22	23	15
L x S interaction	NS	NS	NS	NS	NS	NS	NS

Table 2 Effect of levels and sources of sulphur on oil content of safflower and heat soluble sulphur content (ppm)

Treatment	Seed yield (kg/ha)			Oil yield (kg/ha)		
	1996	1997	Pooled	1997	1998	Pooled
Control vs. Sulphur						
Control	26.92	26.98	26.95	7.48	5.47	7.47
Sulphur	27.33	27.74	27.54	13.68	10.15	11.91
F-test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
Sulphur level (kg/ha) (L)						
15	27.30	27.67	27.48	11.10	7.58	9.34
30	27.27	27.75	27.51	13.33	11.56	12.44
45	27.41	27.79	27.60	16.61	11.30	13.96
SEm±	0.08	0.10	0.06	0.91	0.97	0.66
CD (P=0.05)	NS	NS	NS	2.66	2.84	1.89
Sources of sulphur (S)						
AS	27.31	27.86	27.68	14.26	11.25	12.75
SSP	27.38	27.75	27.56	13.63	8.38	11.00
ES	27.24	27.68	27.46	13.92	11.79	12.86
Gypsum	27.17	27.66	27.41	12.90	9.17	11.03
SEm±	0.09	0.12	0.07	1.05	1.12	0.77
CD (P=0.05)	NS	NS	NS	NS	NS	NS
L x S interaction	NS	NS	NS	NS	NS	NS

Table 3 Economics of different sources and levels of sulphur

Treatment	Seed yield (kg/ha)	Addl. yield (kg/ha)	Addl. income (Rs/ha)	Addl. cost (Rs/ha)	Addl. profit (Rs/ha)	ICBR	
						Gross	Net
Control	896	-	-	-	-	-	-
Sulphur levels (kg/ha)							
15	1153	257	2827	103.69	2723.31	1:27.26	1:26.26
30	1248	352	3872	207.38	3664.62	1:18.67	1:17.67
45	1332	436	4796	311.07	4484.93	1:15.42	1:14.42
Sources of sulphur							
AS	1397	501	5511	297.12	5213.88	1:18.55	1:17.55
SSP	1193	297	3267	180.00	3087.00	1:18.15	1:17.15
ES	1194	298	3278	282.40	2995.60	1:11.61	1:10.61
Gypsum	1193	297	3267	70.00	3197.00	1:46.67	1:45.67

Price of produce : Safflower seed Rs. 11.00/kg
Cost of sources : AS (Ammonium sulphate) Rs. 4.06/kg
SSP (Single super phosphate) Rs. 3.08/kg
ES (Elemental sulphur) Rs. 8.00/kg
Gypsum Rs. 0.35/kg

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Performance of niger (*Guizotia abyssinica* L. Cass) influenced by inorganic fertilizers, FYM and biofertilizers in different soil types

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Abstract

The investigations were carried out on Alfisols of *Semiliguda (Orissa), Haplustalf at Kanke (Jharkhand)* and Vertisols of Igatpuri (Maharashtra) and Chhindwara (MP) to study the response of niger to inorganic fertilizers with farm yard manure (FYM) and biofertilizers during 1998-99 and 1999-2000. Results revealed that application of 100% recommended N through urea integrated with PSB inoculation *recorded maximum seed yield at all locations except* at Chhindwara where application of 50% N through urea + 50% N through FYM gave the highest yield. Former treatment proved to be more remunerative than others at all locations.

Key words: *Farm yard manure, Inorganic fertilizers,* Biofertilizers, Niger

Introduction

Niger is an important oilseed crop cultivated mainly in tribal areas of Madhya Pradesh, Orissa, Maharashtra, *Bihar and Andhra Pradesh. It is mostly grown in hill tops,* slopes and in marginal, submarginal lands with negligible input leading to very low productivity (Sharma, 1993). *Nutrient stress is one of the most important factors for its* low productivity, because several workers have reported the positive response of this crop to fertilizers (Mamatha *et al.*, 1994), organic manure (Ram *et al.*, 1992) and even to biofertilizers (Haldar *et al.*, 1997 and Hegde, 1998). Hence, a multilocation investigation was undertaken in different soil types of the country to see the influence of inorganic fertilizer with the integrated use of FYM and biofertilizers on the performance of niger under rainfed conditions.

Materials and methods

A multilocation study was undertaken under All India Coordinated Niger Improvement Project at four locations in different soil types viz; Alfisol at Semiliguda (Orissa), Haplustalfs at Kanke (Bihar), Vertisol at Igatpuri *(Maharashtra) and Chhindwara (Madhya Pradesh).* The experiment was conducted during *kharif* season for two years (1998-99 and 1999-2000) at Semiliguda, Kanke, Igatpuri and only one year (1999-2000) at Chhindwara. The characteristics of soils for different locations are give in Table 1.Twelve treatments comprising of control (no fertilizer), recommended dose of N,P, K through fertilizers *and combination of recommended 50 or 100% N through* urea + FYM, seed treatment with *Azotobactor, Asopirillum* and soil application with phosphorus solubilizing bacteria *(PSB) were tested in a randomised block design with* three replications. The recommended dose of P and K fertilizers was applied to all plots on the basis of *recommended doses of N. The varieties used were GA-10* at Semiliguda, IGP-76 at Igatpuri, Birsa Niger-1 at Kanke and CHH-5 at Chhindwara. Economics were worked out over 2-year yield data except one year data of Chhindwara.

Table 1 Characterisation of experimental site

Characterisation	Location			
	Chhindwara *(MP)*	Kanke *(Bihar)*	Semiliguda *(Orissa)*	Igatpuri *(MS)*
Soil taxonomy	Haplustalf	Haplustalf	Haplustalf	Haplustalf
Soil texture	Sandy clay loam	Sandy clay silt	Sandy loam to clay loam	Sandy loam
pH	7.4	6.9	5.2	5.8
Organic C (%)	0.60	0.48	0.25	0.22
E.C. (Ds/m)	0.26	0.48	0.20	0.20
Available N (kg/ha)	240	194.0	210	120
Available P (kg/ha)	17.0	22.8	8.0	8.0
Available K (kg/ha)	422	306	208	210

Results and discussion

Seed yields: Seed yields of niger significantly varied due to different treatments at all the locations (Table 2). Seed yields were maximum with 100% recommended nitrogen through urea + soil application of PSB(T_7) on Alfisol of Semiliguda (468 kg/ha), Haplustalf at Kanke (499 kg/ha), and Vertisol of Igatpuri (423 kg/ha) which were at par to *100% recommended NPK (T_2) at all the locations.* Application of 50% N through urea +50% N through FYM (T_6) or inoculation of seeds with *Azospirillum* (T_4) *Azotobactor* (T_5) *also proved equally good to it at* Semiliguda. All treatments receiving 100% N through urea alone or in combination with other biofertilizers or FYM were also comparable to it for seed yields at Kanke and

Table 2 Productivity, net monetary return and benefit cost ratio of *niger* at locations under various treatments

Treatment	Yield (kg/ha)				Net returns (Rs/ha)				*B:C ratio*			
	Semiliguda	Kanke	Igatpuri	Chhindwara	Semiliguda	Kanke	Igatpuri	Chhindwara	Semiliguda	Kanke	Igatpuri	Semiliguda
T_1 Control (no manures and fertilizer)	145	260	188	331	50	1580	820	2965	1.02	1.87	1.41	2.75
T_2 Rec. N, P and K as per regional recommendation	338	474	387	498	1226	3708	3632	4770	1.43	2.50	2.66	2.76
T_3 100% N through urea + 50% N through FYM	180	396	389	456	-382	2478	3439	4086	0.84	1.92	2.43	2.85
T_4 50% N through urea + *Azospirillum*	420	376	360	440	3090	2888	3290	4645	2.58	2.44	2.55	3.37
T_5 50% N through urea + *Azotobactor*	336	374	361	440	2082	2862	3312	4645	2.06	2.43	2.56	3.37
T_6 50% N through urea + 50% N through FYM	386	413	349	546	2270	3269	2929	5881	1.96	2.55	2.27	3.55
T_7 100% N through urea + PSB	468	499	423	532	3592	4413	4072	5910	2.76	3.12	2.78	3.68
T_8 100% N through FYM + PSB	225	441	389	465	-9	3407	3303	4427	0.99	2.46	2.30	2.73
T_9 50% N through FYM + PSB	203	364	329	432	160	2622	2626	4256	1.07	2.23	2.13	2.91
T_{10} 50% N through FYM + *Azospirillum* + PSB	223	386	275	398	374	2882	1809	3726	1.16	2.34	1.78	2.66
T_{11} 50% N through urea + *Azotobactor* + PSB	206	384	263	414	428	2918	1742	4175	1.20	2.37	1.78	3.05
T_{12} 50% N through urea + *Azotobactor* + *Azospirillum* + PSB	184	406	314	440	144	3158	2390	3205	1.06	2.48	2.03	2.54
SEm±	46	28	23	17								
Cd (P=0 05)	131	80	65	50								

Cost of niger seed is Rs. 1500/- per quintal at Igatpuri and Chhindwara, Rs. 1300/- per quintal at Kanke and Rs. 1200/- per quintal at Semiliguda.
Recommended dose of N:P:K was 20:0:0, 20:20:20, 40:40:00 and 30:30:15 kg/ha at Igatpuri, Kanke, Semiliguda and Chhindwara, respectively.

Igatpuri . But on Vertisol at Chhindwara, the highest seed yield (546 kg/ha) was noted under recommended 50% N through Urea+50% N through FYM (T_6) and closely followed by 100% recommended N through Urea+Soil application of PSB (T_7) 532 kg/ha and 100% NPK through fertilizer (T_2) 498 kg/ha. Treatments receiving phosphorus solubilizing bacteria (PSB) increased the availability of phosphorus in the soils which resulted in increased seed yields almost at all the locations. Similar results were also reported by Tomar *et al.* (1996) and Dubey (1997). Application of 100% recommended NPK (T_2) gave almost similar seed yield to those obtained with 50% recommended N through urea+seed inoculation of *Azospirillum* or *Azotobactor* (T_4 or T_5) at all the locations. These results indicated the beneficial effects of bacterial inoculation and confirmed the views of Haldar *et al.* (1997).But supplementation of PSB with seed inoculations over T_4 and T_5 under T_{11} and T_{12} resulted in declining trend of seed yields at all the locations except at Chhindwara.

Heavy fertilization as 100% N through urea+ 50% N through FYM (T_3) did not show remarkable increase in seed yield over 100% recommended NPK (T_2) at all locations and even a significant reduction was noted at Semiliguda. Excessive N supplied to crop under T_3 resulted in less seed yield due to poor seed ssetting.

Economics: Maximum net returns of Rs 3592/-, 4413/-, 4072/- and 5910/- per hectare and higher benefit: cost ratios of 2.76, 3.12, 2.78 and 3.68 were recorded at Semiliguda, Kanke, Igatpuri and Chhindwara centres, respectively. The net profit varied among the locations for each treatment because of differences in seed yields and value of produce at different locations. The order of treatments was almost similar for seed yields at different locations the rang of profit was minimum under each treatment of Semiliguda because of lesser market value of produce . On the contrary , the rang of profit for each treatment was maximum net return and benefit: cost ratio was recorded under 100% recommended dose of nitrogen through urea along with soil application of phosphorus solubilizing bacteria (PSB) at all the locations.

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Adaptability analysis in niger, *Guizotia abyssinica* Cass.

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Abstract

Adaptability analysis for seed yield and other seven yield components was studied for twelve genotypes of Niger, *Guizotia abyssinicas* Cass over six environments. Significant differences were observed for genotypes and environment, suggesting presence of substantial variability among the genotypes and environments studied. Genotype x environment interaction was observed for all characters studied. However, the linear components has contributed major share. The genotypes *viz*; IGP-76 and IGPN-28 were found responsive and stable for seed yield, days to flower, days to maturity and branches/plant. The correlation among stability parameters indicated that they appeared to be under the control of different gene or genes in combination in Niger.

Key words: Stability, G x E interaction, niger

Introduction

The Niger (*Guizotia abyssinica* Cass), minor oilseed crop of India is gaining importance in Indian oilseeds scenario due to its export value. During 1995-96 Niger was exported to the extent of 9300 MT with a value of Rs. 21.35 crores (Shrivastava, 1999). The varietal adaptability to the environmental fluctuations is important for stabilization of crop production, both over locations and seasons. Thus, stability reflects the suitability of a variety for general cultivation over wide range of environments. In the evolutionary terms, the breeders' objective is to produce populations / varieties that are better adapted in a given environment (Simmonds, 1962). Therefore, efforts are required to increase production and productivity of Niger crop across the diverse environments by providing seed of suitable varieties.

Materials and methods

The experimental material comprised of twelve genotypes of Niger. They were evaluated in randomised block design with three replications over three locations in Maharastra and three micro-environments at Igatpuri. Three sowing dates at an interval of one month with first sowing in July constituted the micro-environments. Thus, their performance was studied over six environments under rainfed condition during *Kharif 1998-99*. Each plot consisted of six rows of 5 m length at 30 cm apart. Recommended package of practices were followed to raise healthy crop. The data on yield parameters and oil content were recorded and subjected to stability analysis as per Eberhart and Russel (1966).

Results and discussion

The highly significant differences of variances due to genotypes and environments indicated the presence of substantial genetic variability (Table 1). The mean square due to environment + (G x E) was highly significant for all characters. The highly significant mean square due to environment linear indicated difference between environments and their considerable influence on all characters. Both linear and nonlinear components of G x E interaction were significant for all traits. However, linear component was higher in magnitude suggesting the differential yield potential of genotypes in different environments and feasibility of stable performing varieties of Niger across the environments. Preponderance of linear G x E interaction was in general agreement with those of earlier workers Verulkar and Upadhyay (1989), Upadhyay (1993), Kumar *et al.*, (1993) and Patil and Purkar (2000), However, Upadhyay (1993) have reported importance of nonlinear G x E interaction for days to flower and maturity. On the contrary Kumar *et al.*, (1993 and 1994) have reported significant role of nonadditive component of G x E interaction for days to flower. Similarity Joshi and Patil (1982) have reported significant nonadditive component of G x E interaction for seed yield. The significant pooled deviation was observed for all characters except branches/plant and capsules/pant.

All the parameters of stability for all characters studied are presented in Table 2. Out of 12 genotypes studied, eight genotypes were significant for regression coefficient and two were significant for deviation from regression for seed yield, suggesting the preponderance of linear components of G x E interaction; indicating that the prediction can be

possible over environments. Genotypes IGP - 76, IGPN - 9610 AND IGPN - 9628 were found responsive and better adapted (average stability) across the environments. However, the genotypes i.e., IGPN-9629, Phule-4 and Un-4 were observed specifically adapted to rich environment (below average stability). Whereas, the genotypes GA - 10 and IGPN - 9605 were specifically adapted to poor environment (above average stability).

Stability parameters for plant height suggested that nine genotypes showed affinity with linear component of G x E interaction, indicating predominant role of additive component in the inheritance of this trait, as was also reported by Verulk[illegible] and Upadhyay (1989), Upadhyay (1993) and Kumar *et al., (1993, 1994 and 1998).* Therefore the genotypes IGP - 76 and IGPN - 9628 were most responsive and better adapted to all environments (average stability). While the genotypes Phule - 4 and IGPN - 9605 were responsive and adapted to favourable environment (below average stability). Whereas, the genotype IGPN-9611 was found adapted to unfavourable environment (above average stability).

Table 1 ANOVA for stability in Niger

Source	df	Mean sum of square							
		Seed yield (q/ha)	Plant height (cm)	Days to flower	Days to maturity	Branches/ plant	Capsule/ plant	Seeds/ Capsule	Oil content (%)
Genotypes	11	01.72*	169.79**	177.96**	157.76**	006.00*	0179.45**	0190.50**	026.75**
Environments	05	15.65**	022.84*	870.46**	2134.00**	023.83**	1310.11**	0288.42**	084.39**
Genotype x Environment	55	00.36*	032.73*	018.16**	0020.21**	000.42*	0011.97*	0015.95**	007.31**
Environment + (G x E)	60	01.63*	727.15**	089.18**	0196.36**	002.36**	0120.15**	00038.66**	013.73**
Environment linear	01	78.25**	418.28**	000.43	0106.70**	119.19**	6550.00	1442.12**	421.9**
G x E linear	11	01.14*	033.09*	054.21**	0042.32**	000.90*	0017.17*	0050.44**	029.28**
Pooled deviation	48	00.15*	029.92*	008.38**	0013.45**	000.27	0009.78	0006.72*	001.67*
Pooled error	132	00.03	009.26	000.91	0001.49	000.12	0004.47	0002.58	000.29

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

With regards to days to flower eight and four genotypes were significant for linear and nonlinear component respectively, as was also reported by Verulkar and Upadhyay (1989). However, Kumar *et al.*, (1993, 1994 and 1998) have reported importance of nonlinear component of G x E interaction for this trait. The genotypes viz., IGPN - 9628, IGPN - 9610 and IGP - 76 were found most responsive and better adapted across the environment (average stability). While the genotypes *viz.*, IGPN - 9628, Phule - 4 and UN-4 were found responsive and adapted to rich environment (below average stability).

With regards to days to maturity, nine and five genotypes were significant for linear and nonlinear component respectively, suggesting predominance of linear component of G x E interaction Verulkar and Upadhyay (1989) and Kumar *et al.*, (1993. 1994 and 1998), Hegde *et al.*, (1999 a, b and 2000) and Patil *et al.*, (2000) also reported the similar results. However, Upadhyay (1993) has reported predominance of nonlinear component of G x E interaction. Considering the individual parameters of stability, it revealed that the genotypes *viz.*, IGPN - 9628, IGPN - 9610 and IGP - 76 were found most responsive and adaptable to all environments (average stability). Whereas, the genotypes *viz*, IGPN - 9629, Phule-4 and IGPN - 9611 were found responsive and specifically adapted to favourable environment (below average stability). The genotype DHL-1 was found specifically adapted to unfavourable environments (above average stability).

For branches/plant, capsules/plant and seeds/capsule, nine and four were significant for linear and nonlinear component of G x E interaction respectively. This indicated the major role of additive gene action in the inheritance of these component traits. Verulkar and Upadhyay (1989) and Upadhyay (1993) have also reported the same type of results. Considering the individual parameter of stability, it was evident that the genotypes i.e., IGP - 76 and IGPN - 9628 were most responsive and adaptable to all environments (average stability) for these component traits. The genotype GA - 10 was found responsive and adapted to rich environment for branches/plant, while it was responsive and adapted to poor environment for seeds/capsule. The genotype IGPN - 9629 was found responsive and stable for rich environment for all these component traits. The genotype UN - 4 was found responsive and stable under poor environmental condition for branches/plant.

Nine genotypes for linear component and three genotypes for nonlinear component were significant for oil per cent suggesting preponderance of linear component of G x E interaction for oil content. This indicated that the

prediction can be possible across the environment. Thus, these results are in line with Upadhyay (1993), Kumar *et al.*, (1993, 1994 and 1998), Patil and Purkar (2000) and Patil *et al.*, (2000) On examination of individual parameters of stability, it revealed that the genotypes IGPN - 9628 and IGP - 76 were most responsive and stable (average stability); whereas, k the genotypes Phule-4, IGPN-9611 and GA-10 were found responsive and stable (below average stability) under rich environment conditions.

Simple correlation coefficient among all three parameters of stability for all characters was calculated and presented in Table 2. Significant positive correlation between mean performance and regression coefficient was observed for all characters except days to maturity and branches/plant , suggesting that the genotypes with high mean value for these traits were in general responsive to favourable environment . The mean performance was significantly and negatively correlated with regression coefficient for days to maturity, indicating that the early maturing genotypes were responsive to favourable environment. Non-significant correlation of regression coefficient with deviation from regression for all characters were indicative of the fact that the nonlinear component of G x E interaction of a genotype was independent of its linear response. Accordingly, stability parameters appeared to be governed by different gene or genes in combination in Niger.

It is concluded that the Niger genotypes IGP-76 and IGPN-9628 were most responsive and stable for all characters across the environments while, IGPN-9610 for seed yield, days to flower, days to maturity and branches/plant. Thus, these genotypes can be utilized as parents in breeding programme for converging the stability character.

Table 2 Estimates of different stability parameters in Niger

Genotype	Seed yield (q/ha)			Plant height (cm)			Days to flower			Days to maturity		
	$\bar{X}$	bi	$\bar{S}^2di$	$\bar{X}$	bi	$\bar{S}^2di$	$\bar{X}$	bi	$\bar{S}^2di$	$\bar{X}$	bi	$\bar{S}^2di$
IGPN-9628	2.9	0.99*	0.28*	89.6	1.03*	2.79	58.9	0.95*	0.28	95.5	0.98*	0.14
IGPN-9629	1.8	1.18**	0.01	91.2	0.97*	10.17*	64.5	1.04*	0.17	101.2	1.02*	0.22
Phule-4	1.5	1.07*	0.09	89.3	1.05*	4.94	61.0	1.30**	0.63	97.7	1.17**	0.39
UN-4	1.8	1.18**	-0.01	96.7	0.85	4.85	57.3	1.46**	0.47	94.2	1.23**	0.34
IGPN-9611	1.8	1.28**	0.06	90.9	0.88	1.93	64.5	0.99*	0.90	101.2	1.04*	0.33
IGPN-9610	2.2	1.02*	0.07	92.6	0.88	6.56	64.0	0.94*	0.17	101.3	0.98*	0.26
DHL-1	2.0	1.43**	0.14	86.5	1.11**	18.14*	66.8	0.69	10.11*	104.2	0.84	1.22*
NO-71	1.1	0.40	1.22*	92.5	1.05*	27.05*	63.9	0.49	23.90*	100.3	0.57	3.42**
GA-10	1.4	0.82	0.03	95.1	1.07**	18.45*	69.5	0.73	11.02*	105.3	0.90*	1.77*
IGP-76	1.7	0.93*	0.02	101.0	0.90*	1.92	72.5	0.97*	0.46	108.4	0.99*	0.35
IGPN-9605	1.8	0.85	0.11	80.9	1.03*	7.28	53.7	0.81	0.23	91.1	0.87	1.04*
IGPN-9612	0.8	0.76	0.08	85.7	1.14*	19.85*	57.1	1.59**	9.75*	94.5	1.36**	2.94*
Mean	**1.7**	**1.01**		**100**	**1.00**		**62.81**	**1.00**		**99.6**	**1.00**	
S.Em ±												
Correlations												
X	-	0.72*	-0.18	-	0.88*	-0.28	-	0.89*	-0.55	-	0.80*	-0.70
bi	-	-	-0.20	-	-	-0.19	-	-	-0.40	-	-	0.62

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

Table 2 contd....

Genotype	Branches/plant			Capsules/plant			Seeds/capsule			Oil content		
	$\bar{X}$	bi	$\bar{S}^2di$	$\bar{X}$	bi	$\bar{S}^2di$	$\bar{X}$	bi	$\bar{S}^2di$	$\bar{X}$	bi	$\bar{S}^2di$
IGPN-9628	6.53	0.95*	0.01	31.5	1.01*	0.08	27.6	0.98*	00.08	41.6	0.98*	0.98
IGPN-9629	4.58	1.27**	-0.01	21.1	1.04*	0.28	15.8	1.37**	00.28	40.1	1.54**	1.48
Phule-4	4.92	1.43**	0.49*	21.9	0.96*	36.14*	19.2	1.10**	01.14	41.5	1.39**	0.43
UN-4	3.98	0.68	0.24*	18.4	1.27**	24.98*	13.2	1.55**	13.92*	36.8	1.88**	2.01*
IGPN-9611	4.17	1.06*	-0.01	18.1	1.16**	4.10	28.4	1.31**	04.10*	38.8	1.98**	1.02
IGPN-9610	4.53	0.93*	0.06	20.7	1.25**	7.17*	22.5	1.23**	07.17*	38.5	2.39**	3.69*
DHL-1	3.85	1.23**	0.08	24.7	1.00	2.42	20.5	1.17**	02.42	39.7	0.57	1.29
No.71	3.84	0.75	0.68**	13.7	0.64	4.17*	20.9	1.09*	04.17*	36.1	0.25	3.00*
GA-10	4.34	1.21**	0.08	15.3	0.87	2.03	18.9	0.89	02.03	37.0	1.76**	0.16
IGP-76	5.23	0.93*	0.09	21.1	1.01*	1.02	22.4	0.94	01.99	42.9	0.95*	0.02
IGPN-9605	3.90	1.03*	0.03	15.7	0.95*	3.45	15.6	0.49	02.52	37.8	0.78	1.49
IGPN-9612	2.33	0.86	0.71*	10.8	0.86	2.52	8.8	-0.23	03.45	39.4	1.05	0.94
Mean	**4.30**	**1.00**		**19.4**	**1.00**		**20.0**	**1.00**		**39.2**	**1.01**	
SEm±												
Correlation												
X	-	0.89*	-0.24	-	0.78*	-0.42	-	-0.60	-	0.89*	-0.28	-0.28
bi	-	-	-0.20	-	-	-0.24	-	-	-0.46	-	-	-0.24

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Role of weather parameters on population build up of mustard aphid, *Lipaphis erysimi* (Kaltenbach)*

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Abstract

To study the role of different weather parameters on population build up of mustard aphid, *Lipaphis erysimi* (Kaltenbach) experiments were conducted at Pulses and Oilseeds Research Station, Berhampore, West Bengal, India during *rabi* season for three consecutive years, i.e., 1992-93 through 1994-95. The population of mustard aphid was recorded in yellow coloured iron tray placed on four corners of experimental field throughout the cropping season. The correlation coefficients between different weather parameters and aphid population were observed to be non-significant for three years. The stepwise regression analysis showed that temperature and relative humidity have played an important role for appearance of alate aphid in field.

Key words: Weather parameters, population, mustard aphid, regression

Introduction

Oilseed crops play a vital role in national economy of India. Rapeseed-mustard are the second most important edible oilseed crops after groundnut in India which account for nearly 27.5% of the total oilseeds production and 13% of the gross cropped area in the country. The present production scenario of edible oilseeds has immensely helped the country to save the valuable foreign exchange. However, the situation is alarming in the state of West Bengal. Presently the state's production of oilseeds can meet only 42% of her own requirement. Rapeseed-mustard alone command 75% of total oilseed area and 81% of total oilseed production in West Bengal and ranked first in hectarage and production.

Among the biotic stresses, the insect-pests and diseases cause maximum damage to the yield potential of rapeseed-mustard crops (Bakhetia and Sekhon, 1989). Out of more than 30 insect pests found to be associated with rapeseed-mustard crops in India, mustard aphid *Lipaphis erysimi* (Kalt.) is reported to be serious (Rohilla *et al.*, 1987; Bakhetia and Sekhon, 1989).

Environment plays an important role in influencing the multiplication of mustard aphid. The multiplication of the aphids had been observed to be favoured by the moist and cloudy weather. Consequently with the occurrence of favourable weather conditions for a longer period of time, a severe outbreak of aphids could be apprehended (Brar and Sandhu, 1976). Of the various climatic factors fog, frost, rain, severe cold and heat weave have reported to be important natural mortality factors of the aphids. In the present article, efforts have been made to assess the impact of different weather parameters on population dynamics of mustard aphid *L. erysimi*.

Materials and methods

The experiment was conducted at Pulses and Oilseeds Research Station Berhampore, West Bengal during *rabi* seasons of 1992-93, 1993-94 and 1994-95. The population of aphid was recorded by using yellow coloured iron tray filled with water of 43 cm x 30 cm x 10 cm in size and placed at a height of 152 cm in the four corner of the experimental plot throughout the crop season. The population of aphids alates was counted and the tray was refilled with fresh water for new catches everyday. The different weather parameters were obtained from the meteorological observatory of the Research Station.

The stepwise linear regression analysis was done to predict the contribution of different weather parameters to maximum per cent of variability. The package on which the analysis was done is BMDP 1998 Statistical Software, Inc., Los Angeles, U.S.A.

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Results and discussion

During 1992-93: The population of aphid is the one and only effect (univariate) and possible causes are environmental variables, i.e., temperature (maximum and minimum), relative humidity (morning and evening), rainfall (mm), cloud intensity and sunshine hours (multivariate) which were correlated and found that all of them had non-significant impact on aphids population. Considering the causes individually relative humidity (morning) affected the aphid number the most with multiple "R" square value being 0.42. Eliminating the effect of relative humidity (morning) from aphid population, partial correlation was computed (Table 1). This indicated that important factor in presence of relative humidity (morning) was rainfall. These two variables together recorded R^2 value of 0.54. Next important factor temperature (maximum) in the presence of relative humidity (morning) and rainfall jointly gave the multiple R^2 value of 0.61. Similarly sunshine hours in association with all the factors affected the aphid number least with R^2 value of 0.85.

During 1993-94: The relative humidity (evening) affected the aphid numbers appreciably with R^2 value of 0.53 (Table 2). Next the sunshine hours in the presence of relative humidity (evening) contributed R^2 value of 0.54. It is evident from the table that next important factor was rainfall and in the presence of relative humidity (evening) and sunshine hours jointly gave the multiple R^2 value of 0.58. The same value of R^2 was obtained with above variables and relative humidity (morning). Relative humidity (evening), sunshine hours, rainfall and relative humidity (morning) along with temperature (maximum) recorded R^2 value of 0.60 which was also same when temperature (minimum) was included in it.

During 1994-95: The R^2 value of 0.12 was recorded when temperature (minimum) affected the aphid number the most (Table 3). Next important factor in the presence of temperature (minimum) was relative humidity (morning) and both these variables presented R^2 value of 0.42. Sunshine hours affected the aphid population least which all the variables recorded R^2 value of 0.99.

It is further revealed that relative humidity (morning) was positively correlated with the development of mustard aphid population on *Brassica* cultivars and the relative humidity (evening) on the other hand was negatively associated with mustard aphid development in all the years of observations (Tables 1,2&3). The relative humidity (morning), temperature (maximum), rainfall and cloud intensity were the four components that appeared to have comparatively effective contribution in determining growth of mustard aphid in plants over other components. The present findings are in complete agreement with that of Ram and Gupta (1987) who observed that the development of mustard aphid was favoured by temperature (maximum and minimum) and relative humidity (morning). Mild showers and overcast weather resulting in an increase of mustard aphid population corroborates the findings of Atwal *et al.* (1971); Saharia (1984); Jaglan *et al.* (1988); Bakhetia and Sekhon (1989) and Bishnoi *et al.* (1992).

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Table 1 Stepwise regression for estimating effects of weather parameters on mustard, aphid during 1992-93

Variables entered	Multiple R-Square	Regression Equation	Partial correlation with remaining variables						
-	-	3.015	X_3 0.644	X_5 0.392	X_1 -0.253	X_2 0.015	X_6 - 0.397	X_7 0.239	X_4 -0.234
X_3	0.42	58.762-0.602*X_3		X_5 0.459	X_1 0.384	X_2 0.061	X_6 -0.348	X_7 0.438	X_4 -0.289
X_3,X_5	0.54	53.002+0.581*X_3+4.997* X_5			X_1 0.404	X_2 0.085	X_6 -0.283	X_7 0.349	X_4 -0.378
X_3,X_5,X_1	0.61	48.087 -0.598* X_3+4.778* X_5+0.268* X_1				X_2 -0.661	X_6 -0.527	X_7 0.538	X_4 -0.428
X_3,X_5,X_1,X_2	0.78	40.278+0.608* X_3+3.716* X_5+ 1.048* X_1 -0.821* X_2					X_6 0.536	X_7 -0.299	X_4 0.312
X_3,X_5,X_1,X_2,X_6	0.84	40.215-0.802* X_3+ 5.033* X_5 + 2.356* X_1-2.603* X_2 + 3.086* X_6						X_7 -0.023	X_4 0.615
X_3,X_5,X_1,X_2,X_6,X_7	0.85	39.614 - 0.793* X_3 + 5.086* X_5 + 2.372* X_1 - 2.620* X_2 + 3.016* X_6 -0.072* X_7							X_4 0.679

* If relative humidity (evening) is introduced within regression equation, the reliability of the effect of temperature (minimum) is uncertain

Table 2 Stepwise regression for estimating effects of weather parameters on mustard, aphid during 1993-94

Variables entered	Multiple R-Square	Regression Equation	Partial correlation with remaining variables						
-	-	2.183	X_4 -0.731	X_7 0.344	X_5 0.701	X_3 0.446	X_1 -0.533	X_2 0.199	X_6 -0.702
X_4	0.53	-4.165 + 0.146*X_4		X_7 0.153	X_5 0.177	X_3 0.139	X_1 0.020	X_2 0.008	X_6 -0.134
X_4,X_7	0.54	-4.355+0.138*X_4+2.226* X_7			X_5 0.158	X_3 0.055	X_1 -0.106	X_2 -0.123	X_6 -0.068
X_4,X_7,X_5	0.58	-2.700+0.088* X_4+0.279* X_7+0.259* X_5				X_3 0.231	X_1 -0.023	X_2 -0.069	X_6 0.381
X_4,X_7,X_5,X_3	0.58	-24.024-0.173* X_4-0.016* X_7+ 0.615* X_5 +0.275* X_3					X_1 0.222	X_2 -0.185	X_6 0.314
X_4,X_7,X_5,X_3,X_1	0.60	-26.572-0.089* X_3+0.109* X_7 + 0.589* X_5+0.483* X_3 - 0.528* X_1						X_2 -0.039	X_6 0.288
X_4,X_7,X_5,X_3,X_1,X_2	0.60	-25.038 + 0.119* X_4 + 0.089* X_7 + 0.583* X_5 +0.513* X_3 - 0.722* X_1 +0.154* X_2							X_6 0.291

Table 3 Stepwise regression for estimating effects of weather parameters on mustard, aphid during 1992-93

Variables entered	*Multiple* R-Square	Regression Equation	Partial correlation with remaining variables						
-	-	3.486	X_2 -0.355	X_3 0.349	X_7 -0.221	X_6 0.278	X_5 0.162	X_4 -0.255	X_1 -0.052
X_2	0.12	10.633-0.593*X_2		X_3 0.583	X_7 0.119	X_6 0.043	X_5 0.246	X_4 -0.146	X_1 0.146
X_2,X_3	0.42	-97.477+1.006*X_2+1.231* X_3			X_7 0.535	X_6 -0.078	X_5 0.437	X_4 0.191	X_1 0.133
X_2,X_3,X_7	0.59	-133.145 -2.212* X_2+1.703* X_3+3.934* X_7				X_6 0.782	X_5 -0.117	X_4 -0.093	X_1 0.581
X_2,X_3,X_7,X_6	0.84	-206.277-2.797* X_2+2.202* X_3+ 11.228* X_7 +2.854* X_6					X_5 0.854	X_4 -0.101	X_1 0.100
X_2,X_3,X_7,X_6,X_5	0.96	-204.791-0.848* X_2+ 1.839* X_3 + 6.555* X_7+4.558* X_6 + 2.769* X_5						X_4 -0.835	X_1 -0.827
X_2,X_3,X_7,X_6,X_5,X_4	0.98	-186.817-0.520* X_2 + 1.617* X_3 + 6.541* X_7 +4.848* X_6 + 3.307* X_5 -0.129* X_4							X_1 -0.320
X_2,X_3,X_7,X_6,X_5,X_4,X_1	0.99	-196.001-0.071*X_2 + 1.674*X_3 + 6.342*X_7 + 5.519*X_6 + 3.510*X_5 - 0.073*X_4 - 0.341*X_1							

X_1 = Temperature°C (maximum), X_2 = Temperature°C (minimum), X_3 = Relative humidity% (morning), X_4 = Relative humidity% (evening), X_5 = Rainfall (mm/week), X_6 = Cloud intensity, X_7 = Sunshine hours (hr/day)

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Determination of economic threshold level of mustard aphid, *Lipaphis erysimi* (Kaltenbach) on rapeseed-mustard in West Bengal

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Abstract

The economic threshold level (ETL) of mustard aphid *Lipaphis erysimi* (Kaltenbach) was determined on rapeseed-mustard at Pulses and Oilseeds Research Station, Berhampore, West Bengal during *rabi* season of 1992-93, 1993-94 and 1994-95. Two varieties from *Brassica juncea* (RW white flower glossy stem and T6342) and one from *Brassica campestris* var. Yellow sarson (B 9) were taken in the experiment and oxydemeton methyl (0.025%) was used as the protectant against aphids. The average yield loss due to aphid infestation with respect to varieties RW white flower glossy stem, B 9 and T6342 varied between 3.0% to 44.8%, 3.6% to 53.9% and 2.5% to 50.5%, respectively. The loss in yield increased as the exposure period to aphid infestation increased. Highest yield of 1454 kg/ha was obtained with completely protected treatment irrespective of varieties. The ETL of four spray schedule of mustard aphid was found to be 18.7, 25.6 and 37.9 aphids/plant for the varieties RW flower glossy stem, B9 and T6342, respectively.

Key words: Economic threshold level, mustard aphid, rapeseed and mustard

Introduction

Yield loses in rapeseed mustard due to aphids ranged between 24 to 90% in different mustard growing areas of the country. Since there was variation in intensity of aphid attack, the timing of insecticide application has to be location specific (Bakhetia and Singh, 1992). Threshold levels of any pest are likely to be influenced by number of factors i.e., variety and stage of the crop, biology and behaviour of the target pest, dose of pesticide, prevailing price of pesticides and the produce, weather conditions etc. (Newson *et al.*, 1980; Singh *et al.*, 2000). The EIL of mustard aphid ranging between 9.4 to 13.3 aphids and 15.2 to 23.5 aphids/15cm long terminal shoot on mustard was reported for oxydemeton methyl at 0.025 and 0.05 % (Misra and Singh, 1986).However Singh and Malik (1998) reported 20.4 and 15.4 aphids/plant on mustard as EIL and ETL, respectively. Similarly Kumar *et al.*(2000) reported EIL of 28.3 and ETL of 15.6aphids/plant in variety Varuna. In this study efforts have been made to determine ETL against mustard aphid in West Bengal.

Material and methods

The studies were conducted at Pulses and Oilseeds Research Station, Berhampore, West Bengal during *rabi*, 1992-93 through 1994-95. Three varieties of rapeseed-mustard i.e. two from *B. juncea* (RW-white flower glossy stem and T 6342) and one from *B. campestris*, var. yellow sarson B-9 were used in the experiment. The experiment was sown on November, 20th in all the three seasons in split plot design with varieties in main plot and schedule of oxydemeton methyl 0.025% in sub-plots. Population of mustard aphid was recorded prior to and after each insecticide treatment from 10cm central twig of ten randomly selected plants in each replication. The ETL of mustard aphid was calculated as per (Stone and Pedigo, 1972; Singh and Singh 1987).

Results and discussion

The average yield loss due to different exposure periods of aphid infestation varied between 2.5 to 53.9% for the three varieties (Table 1). In general yield loss increased as the exposure period to aphid infestation increased. A pooled analysis over three varieties and three years indicated highest cost-benefit ratio of 1:9.02 with (T_6) Table 2. Highest yield of 1454 kg/ha was obtained with (T_1) irrespective of varieties.

Determination of economic threshold level (ETL): The impact of mustard aphid on yield of rapeseed mustard genotypes through regression analysis (Y = a+bx)could be determined as follows :

	V_1	V_2	V_3
Constant (a)	12.22	12.70	13.71
Standard error	1.09	1.35	1.43
R^2	0.76	0.80	0.77
X Coefficient (b)	-0.06	-0.05	-0.03
Standard error of coefficient	-0.01	0.01	0.01

V_1 Y = 12.22 – 0.06x; V_2 Y = 12.70 – 0.05x; V_3 Y = 13.71 – 0.03x
Grain threshold (GT) = 1.18

Cost of plant protection/ha (labour+pesticides) 1152 and cost of 1 q of produce (market price) 980

E.I.L. = GT / Regression coefficient, (Stone and Pedigo, 1972)

EIL for V_1 = 1.176/0.063 = 18.7 aphids/plant (10 cm long twig)
EIL for V_2 = 1.176/0.046 = 25.6 aphids/plant (10 cm long twig)
EIL for V_3 = 1.176/0.031 = 37.9 aphids/plant (10 cm long twig)

The present findings corroborate with (Singh and Singh, 1987; Singh and Malik,1998; Atwal and Singh,1990) who observed 9-50 aphids/plant as EIL of mustard aphid.

Table 1 Average aphid population and yield of three varieties of rapeseed-mustard

Treatment	Average aphid population/plant for three years (pooled average)			Average yield (kg/ha) (pooled average over three years)			Yield loss (%)		
	V_1	V_2	V_3	V_1	V_2	V_3	V_1	V_2	V_3
T_1	0.1	0.1	0.1	1352	1455	1555	-	-	-
T_2	0.1	0.2	0.3	1311	1402	1516	3.0	3.6	2.5
T_3	0.5	2.2	1.8	1254	1297	1422	7.2	10.9	8.6
T_4	1.3	9.2	5.4	1198	1165	1333	11.4	19.2	14.3
T_5	3.1	17.5	13.7	1149	1066	1252	15.0	26.7	19.5
T_6	9.1	29.5	35.3	10.76	9.12	1146	20.4	37.3	26.3
T_7	23.6	80.5	81.6	9.48	8.85	1055	29.9	39.2	32.2
T_8	75.7	117.9	174.6	877	746	896	35.1	45.7	42.4
T_9	88.2	146.1	195.3	746	670	769	44.8	53.9	50.5

V_1 = RW white flower glossy stem; V_2 = B-9; V_3 = T 6342

T_1 = Complete protection (control; four sprays);
T_2 = One week exposure to aphid infestation followed by four sprays
T_3 = Two weeks exposure to aphid infestation followed by three sprays
T_4 = Three weeks exposure to aphid infestation followed by three sprays
T_5 = Four weeks exposure to aphid infestation followed by two sprays
T_6 = Five weeks exposure to aphid infestation followed by one spray
T_7 = Six weeks exposure to aphid infestation followed by one spray
T_8 = Seven weeks exposure to aphid infestation followed by one spray
T_9 = Complete exposure to aphid infestation (no spray)

Table 2 Economics of aphid control at different levels of population on three rapeseed-mustard varieties

Treatment	Average Aphid Population/ Plant	No of Spray	Yield (kg/ha)	Yield Loss (%)	Cost benefit ratio
T_1	0.1	4	1454	-	1:4.7
T_2	0.1	4	1409	3.09	1:43
T_3	1.4	3	1324	8.94	1:5.3
T_4	5.0	3	1232	15.26	1:4.3
T_5	10.1	2	1156	20.49	1:5.8
T_6	22.4	1	1045	28.10	1:9.0
T_7	56.7	1	963	33.76	1:6.4
T_8	103.9	1	840	42.22	1:2.5
T_9	127.9	-	728	49.93	-

Cost of the produce Rs. 980/q
Insecticide Rs. 220/litre
Three labours for spraying one hectare @ Rs. 30/day

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Screening of *Brassica* germplasm for resistance to mustard aphid, *Lipaphis erysimi* (Kalt.)

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Abstract

Screening of 2270 lines of Indian mustard (*Brassica juncea* L.) for their resistance to the mustard aphid, *Lipaphis erysimi* (Kaltenbach) was carried out at Ludhiana and Bathinda in Punjab on the basis of aphid infestation index (A.I.I.), aphid population/ plant and percentage or plants harbouring aphid colonies. None of the entries registered the least susceptible group on the basis of all the three parameters at either location. However several genotypes were graded in the resistant group on the basis of two parameters in either year or one parameter in both the years. The entries showing low to moderate level of resistance to the mustard aphid included: JMG 134, JMG 293, JMG 386 CSR 61, CSR 128, CSR 136, CSR 147, CSR 148, CSR 1055, CSR 1244, B 89, DN 379, CS 404 at Ludhiana and CSR 1086 and R 7006 at Bathinda. These lines can be used in the breeding programmes aimed at developing resistant varieties through the conventional and/or novel approaches of breeding for pest and disease resistance.

Key words: *Lipaphis erysimi, Brassica juncea*, host plant resistance, Indian mustard

Introduction

The mustard aphid, *Lipaphis erysimi* (Kaltenbach) is a serious pest of *Brassica* oilseeds in all the agroclimatic zones, wherever these crops are grown in India (Bakhetia, 1991; Arora, 1999). It inflicts heavy yield losses ranging from 9-95 % in different varieties of rapeseed-mustard depending on various biotic and abiotic factors in different years and locations. A limited number of genotypes possessing low to moderate level of resistance to the mustard aphid have been identified so far (Sekhon and Ahman 1992; Bakhetia and Singh 1993; Chander 1993, Bakhetia and Arora 1995; Arora 1999; Singh 2000). Thus large scale screening of the germplasm for tapping the good sources of aphid resistance, assumes a great significance especially for a breeding project aimed at developing aphid resistant varieties of Indian mustard.

Materials and methods

The studies were conducted at Ludhiana and Bathinda centres of Punjab Agricultural University. A total of 2270 genotypes of *Brassica juncea* received from the Project Coordinator (rapeseed-mustard) under All India Coordinated Research Project on Oilseeds (ICAR) located at Haryana Agricultural University, Hisar (Now at Bharatpur, Rajasthan) were sown in unreplicated single rows of 4 m length during late November at Ludhiana and 5 m length during first fortnight of December at Bathinda in 1991-1992 and again in 1992-93. Out of these, 1836 and 2229 lines showing good germination during 1991-92 and 1992-93, respectively, were evaluated for aphid resistance at Ludhiana. At Bathinda 1523 lines in the first year and 1914 during second year were evaluated. At both the locations, observations were recorded on aphid infestation index (A.I.I.) by scoring the aphid injury in plants on a 0-5 scale (Bakhetia and Sandhu, 1973). Each plant was observed and given a definite grade; 0 referred to plants free from aphid infestation and 5 to severe stunting of plants curling, crinkling and yellowing of almost all leaves, no flowering and pod formation, plants full of aphids. The weighted mean of the score of all the plants in each genotype was taken as the A.I.I. of that genotype. At Ludhiana, additional data on aphid population per 10 cm top portion of central shoot, and the percentage of plants harbouring aphids were also recorded based on five randomly selected plants in each entry (Bakhetia and Sandhu, 1973). The data were collected during February and March, when there was moderated to heavy infestation of the aphid in the field. The genotypes were grouped into 4 categories on the basis of each of above stated three parameters, with a view to identify more promising lines from all angles.

Results and Discussion

During 1991-92, the aphid incidence remained low almost throughout the season, except, a fairly good infestation late in the season i.e., near maturity of the crop. Hence observations were recorded during the second week of

March. There was variability in *L.erysimi* infestation in different genotypes between years as well as between locations. However, the number of entries falling under class-1, representing the least susceptible group, was less than 10 % of the total entries showing A.I.I. up to 1.0 at Ludhiana are given in Table 1. Of these, 30 entries had A.I.I. below 1.0 and another 49 entries had the A.I.I. of 1.0. The lowest A.I.I.(0.2) was scored by CSR-70.

Table 1 **List of genotypes of Indian mustard (*B.juncea*) showing aphid infestation index (A.I.I.) Up to 1.0**

Genotypes showing A.I.I. below 1.0			Genotype showing A.I.I. as 1.0	
Acc. No.	Entry	A.I.I.	Acc. no	Entry
8	JMG-12	0.43	22	JMG 55
9	JMG-14	0.73	30	JMG 69
27	JMG-65	0.71	31	JMG 70
51	JMG-95	0.86	33	JMG 74
66	JMG-112	0.71	63	JMG 109
121	JMG-200	0.60	71	JMG 121
144	JMG-236	0.60	117	JMG 195
148	JMG-240	0.80	121	JMG 200
177	JMG-291	0.61	122	JMG 201
179	JMG-329	0.40	127	JMG 208
220	JMG-386	0.40	129	JMG 210
248	JMG-415	0.80	133	JMG 217
275	CSR-12	0.6	150	JMG 244
287	CSR-40	0.8	178	JMG 293
301	CSR-61	0.8	219	JMG 285
308	CSR-70	0.2	314	CSR 79
310	CSR-73	0.6	321	CSR 92
317	CSR-82	0.4	338	CSE 127
322	CSR-94	0.8	363	CSR 164
323	CSE-96	0.6	366	CSR 168
325	CSR-100	0.8	431	CSR 274
331	CSR-115	0.6	434	CSR 270
339	CSR-127	0.6	500	CSR 427
340	CSR-128	0.8	505	CSR 443
341	CSR-170	0.8	518	CSR 472
434	CSR-279	0.8	519	CSR 474
440	CSR-287	0.8	547	CSR 530
1878	RC-822	0.8	781	CSR 1034
1909	SRM-29	0.8	851	CSR 1162
			958	B 447
			1273	B 8907
			1292	RLC 1036
			1352	EC 287711
			1567	CS 336
			1650	RC 125
			1656	RC 134
			1801	RC 412
			1808	RC 412
			1809	RC 420
			1821	RC 422
			1833	RC 442
			1864	RC 1674
			1992	RC 808
			2072	RC 955
			2195	RC 1053
			2229	RC 1269
			2229	RC1376
			2250	RC 1457
			2255	SRM 45

During 1992-93, the population build-up of the mustard aphid on different genotypes was noticed early i.e., during January-February. Only 14 entries showed an A.I.I. up to 1.0 (Table 2). The lowest A.I.I. (0.6) was recorded in two genotypes namely, CSR 147 and RH 8701. The only entry registering the A.I.I in category during both the years was CSR-128 which scored the values of 0.8 and 1.0 A.I.I. during 1991-92 and 1992-93, respectively.

Based on aphid population data, 125 entries harboured up to 25 aphids/plant during the first observation recorded on February 12-14, 1993. But at the time of second observation (March, 1993) only 7 entries harboured up to 50 aphids/plant. The minimum of 20 aphids/plant were recorded in JMG-135 followed in ascending order of aphid population on B-379, RSM 58, RC 1156, RC1237, RC 818 and JMG 130.

Since none of the genotypes could register in the least susceptible group on the basis of all the three parameters employed during either year, it is summarised that not even a single genotype out of the evaluated germplasm of Indian mustard possessed a high level of resistance to the mustard aphid. However, the genotypes (JMG 134, JMG 293, JMG 386, CSR 61, CSR 128, CSR136, CSR 147, CSR 148, CSR 1055, CSR 1086, CSR 1244, B 89, DN 379, CS 404, R 7006) falling in the lowest category on the basis of two or three parameters in either year or even one parameter in both the years were considered as more promising. These entries showed low to moderate level of resistance against the mustard aphid, which needs further confirmation through testing under artificial infestation in the screen-house. There is a dire need to pool the resistance sources identified earlier (Weising *et al.*, 1988; Arora 1999; Singh, 2000) along with those identified in the present studies and utilise them in developing aphid resistant varieties through the conventional and novel approaches.

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Table 2 List of genotype of Indian mustard (*B.juncea*) showing A.I.I.up to 1.0 and the corresponding aphid population and per plant infestation in each genotype

Acc No.	Genotype	A.I.I.	Aphid population/plant		Per cent plants attacked
		(22 to 27.2.93)	(12 to 17.2. 93)	(2.to 4.3.93)	(12 to 17.2.93)
189	JMG 349	1.0	95.2	574.0	70
190	JMG 352	1.0	65.2	370.0	50
192	JMG 354	1.0	93.4	354.4	50
193	JMG 355	0.8	64.6	420.0	80
299	CSR 57	0.8	132.0	430.0	100
336	RK 919003	1.0	128.0	323.8	100
340	CSR 128	1.0	188.0	276.4	90
345	CSR 136	1.0	125.0	336.8	60
351	CSR 147	0.6	109.0	328.0	90
352	CSR 148	1.0	75.0	214.8	20
362	CSR 163	0.8	132.0	201.0	100
792	CSR 1055	1.0	69.6	-	30
1181	RH 8701	0.6	61.0	310.1	90
1183	B 351	1.0	66.2	293.14	100

Total genotypes tested = 2229

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Preliminary studies on development of resistance to insecticides in *Spodoptera litura* (F.) in Northern Karnataka*

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Abstract

Bioassay studies conducted on the nine populations of tobacco caterpillar, *Spodoptera litura* (F.) collected from different areas of the pesticide use history of Northern Karnataka, Honnavar population was highly susceptible to all the four insecticides studies. Dharwad population showed high resistance ratio of 32.72 folds to monocrotophos compared to Honnavar population. Whereas other populations recorded 1.47 to 10.67 folds resistance to monocrotophos. Similarly, resistance to endosulfan was more in Manvi population and it ranged between 2.09 and 7.43 folds. Resistance to quinalphos was of moderate level and it ranged from 1.49 to 2.67 folds. Cypermethrin resistance ratios ranged from 1.08 to 1.96 folds when compared with Honnavar population and was the least among all the four insecticides studied.

Key words: *Spodoptera litura*, resistance, monocrotophos, quinalphos, endosulfan, cypermethrin

Introduction

Tobacco caterpillar, *Spodoptera litura* (F) is one of the major defoliator pests of groundnut in india under irrigated situation.*S.litura* is the first lepidopteran pest to develop resistance to insecticides in India (Srivastava and Joshi, 1965). Added to this, in recent times the situation has further worsened as it has developed resistance to commonly used insecticides (Ramakrishan *et al.*, 1984; Mayuravalli *et al.*, 1987; Armes *et al.*, 1997). Even though the control failures and resistance problems were not encountered by the farmers of North Karnataka till middle of nineties, monocrotophos, the insecticide which is used to a greater extent in groundnut and other crop ecosystems was found to be ineffective in controlling the pest (Anon., 1999). With this background, a study was made in the Department of Agricultural Entomology, College of Agriculture, Dharwad during 1998-99 cropping seasons on resistance levels in the nine populations of *S.litura* collected from groundnut growing areas of Northern Karnataka.

Material and Methods

Groundnut growing areas of Northern Karnataka were divided into three regions based on the insecticide consumption *viz.*, high (five to six sprays), medium (three to four sprays) and low (one to two sprays) pesticide usage areas. Sufficient numbers of egg masses were collected from these areas seprately, on hatching, the larvae were reared on castor leaves in the plastic tubs (45 cm x 15cm) covered with a muslin cloth. Larvae were reared up to third instar which were used for bioassay studies.

Four commonly used insecticides were selected for determining the resistance *viz.*, moonocrotophos, endosulfan, quinalphos and cypermethrin. The commercial grade formulations of above insecticides were serially diluted in AR grade acetone in volumetric flasks to obtain a range of concentrations that gave mortalities ranging from 20-80%.

The toxicant solutions were applied topically on the thoracic dorsum of third instar larvae (each larva weighing 35-42 mg) using Arnold's microapplicator. One micro litre (µl)of toxicant was applied for each larva. Acetone blank served as a control. Thirty (third instar) larvae were dosed for each concentration. After dosing, larvae were maintained on castor leaf discs in peti dishes (10cm x 1.5cm). The mortality was recorded daily for six days and final mortality assessment was made for each concentration and corrected mortality was computed as per Abbot's (1925). Dose mortality regressions were computed by Probit analysis (Finney, 1952) using MLP (Most Likelihood Program) software (Ross, 1987). The resistance ratios (RRs) were calculated at LD_{50} by taking the Honnavar population as the reference population in

* Part of M.Sc. (Ent) Thesis of senior author.

the absence of a standard susceptible population, as it showed lowest LD_{50} values for all the four test insecticides.

Results and discussion

Data on the intrinsic toxicity of test Insecticides against nine ectotypes of *S.litura* are presented in the Tables 1,2,3 and 4.

Resistance to monocrotophos: Dharwad population exhibited highest resistance ratio (32.72 folds) with LD_{50} of 77.04µg/g body weight of larvae followed by Manvi (25.12). Belgaum (23.74) and Hospet (17.31) with corresponding RRs of 10.67, 10.08 and 7.35, respectively. LD_{50} values of populations from low pesticide pressured areas did not vary much (Table1)

The resistance ratio to monocrotophos in Dharwad population (32.72) was very high compared to 3.6 and 9.4 folds in Guntur strain (Surendra Reddy and Reddy, 1984 and Reddy and Devaprasad, 1991) and 1.7 folds in Bapatla strain (Mayuravalli *et al.*, 1987). In support of the our findings Armes *et al* (1997) has reported 2 to 362 folds resistance to monocrotophos in 22 strains collected from Andhra Pradesh. The present levels of resistance can also be compared with 4 to 29 folds resistance reported in 10 strains collected from cotton ecosystem (Kranthi *et al.*, 2001)

Resistance to quinalphos: There was no distinctive difference in the RRs among the populations of *S.litura* (Table-1). However, highest LD_{50} value of 5.01 µg/g body weight of larvae was recorded in Hospet population (RR 2.67) followed by dharwad, Ankola and Manvi populations. The LD_{50} values and Rrs of rest of the populations ranged from 1.88 to 3.42 µg/g body weight of larvae and 1.49 to 1.49, respectively.Likewise Surendra Reddy and Reddy (1984) noticed 2.1 fold resistance to quinophos in Guntur strain. Resistance levels of 1-2o folds in comparison to a susceptible strain from Bangalore in 10 strains of *S.litura* collected from cotton ecosystem (Kranthi *et al.*, 2001) can be compared with the present findings.

Table 1 Toxicity of monocrotophos and quinalphos to different ecotypes of *S. litura* (F.)

Population	Monoctotophos						Quinalphos					
	LD_{50}/g/g body weight	95% Fiducial limits µg/g		Slope (b)	Hetero-genelty (x^2)	RR* (at LD_{50}	LD_{50}/g/g body weight	95% Fiducial limits µg/g		Slope (b)	Hetero-genelty (x^2)	RR* (at LD_{50}
		Lower	Upper					Lower	Upper			
a Honnavar	2.35	0.97	3.65	1.40	7.55	-	1.88	1.21	2.47	2.52	2.82	-
a Karwar	3.46	2.66	4.28	3.17	2.80	1.47	3.42	2.40	4.51	2.07	3.90	1.82
a Ankola	4.00	2.66	4.94	2.23	3.26	1.70	4.26	3.22	5.43	2.49	2.49	2.27
a Kumta	3.97	3.35	5.08	3.97	2.98	1.68	3.37	2.43	4.38	2.25	3.19	1.80
a Bhatkal	5.01	3.87	6.26	2.89	11.14	2.13	3.22	2.32	4.16	2.30	2.04	1.71
b Dharwad	77.04	15.12	152.27	1.05	13.83	32.72	4.34	3.42	5.34	3.24	1.02	2.31
b Belgaum	23.74	17.43	31.34	2.09	7.05	10.08	2.79	1.92	3.63	2.30	2.40	1.49
cHospet	17.31	13.69	21.88	3.23	1.75	7.35	5.01	3.92	6.17	3.20	9.08	2.67
c Manvi	25.12	19.33	31.45	2.80	2.02	10.67	4.11	3.08	5.13	2.94	2.16	2.19

* Resistance ratio = LD_{50} of X population/LD_{50} of Honnavar population

a = Low pesticide usage area (one to two sprays)

b = Medium pesticide usage area (Three to four sprays)

c = High pesticides usage area (four to six sprays)

Resistance to endosulfan: There was a moderate level of resistance to this insecticide (Table-2). In Manvi population, the LD_{50} was highest 37.73 µg/g body weight of larvae with RR of 7.43 folds followed by Hospet (23.84 and 4.70) and Ankola (16.52 and 3.26) populations Rest of the populations had mild level of resistance (2.08 to 2.31 fold). Present results are agreement with the findings of Surendra Reddy and Reddy (1984), Wehereas Reddy and Devaprasad (1991) reported 14.3 fold resistance in the Guntur strain. Armes *et al.* (1997) has reported 1 to 29 fold resistance to endosulfan. High levels of 85 to 91 folds resistance was reported in Tenali strain (Ramakrishan *et al.*, 1984) and 85.94 folds in Bapatla strain (Mayuravalli *et al.*, 1987) This variation may be due to the enormous quantity and indiscriminate use of these insecticides in Andhra Pradehs, where farmers experienced the control failures in groundnut ecosystems (Ramakrishnan *et al.*, 1984) which is not noticed in Northern Karnataka.

Resistance to cypermethrin: Marginal differences in the LD_{50} values were observed among the populations to cypermethrin (Table-2). However, Manvi population recorded highest LD_{50} value of 1.53 µg/g body weight of

larvae with RR of 1.96 closely followed by Dharwad (1.44 & 1.84) population. Earlier Mayuravalli *et al.* (1987) has reported 1.64 folds resistance in Bapatla strain. While, 0.2-197 folds resistance was reported in 22 strains collected from different parts of Andhra Pradesh during 1991-96 (Armes *et al.*, 1997)

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Table 2 Toxicity of monocrotophos and quinalphos to different ecotypes of *S. litura* (F.)

Population	Monoctotophos						Quinalphos					
	LD_{50} µg/g body weight	95% Fiducial limits µg/g		Slope (b)	Hetero-genelty (x^2)	RR* (at LD_{50}	LD_{50} µg/g body weight	95% Fiducial limits µg/g		Slope (b)	Hetero-genelty (x^2)	RR* (at LD_{50}
		Lower	Upper					Lower	Upper			
a Honnavar	5.77	3.30	6.63	2.49	3.63	-	0.78	0.52	1.06	1.87	1.38	-
a Karwar	10.54	8.37	13.10	2.62	5.84	2.08	0.85	0.61	1.57	2.87	3.93	1.08
a Ankola	16.53	13.39	19.42	3.83	5.42	3.26	0.93	0.69	1.19	2.41	2.00	1.19
a Kumta	10.91	8.37	13.10	3.62	5.84	2.15	0.93	0.25	1.42	2.30	1.41	1.19
a Bhatkal	12.14	8.75	12.54	2.68	4.85	2.39	1.38	0.41	2.42	1.25	1.98	1.76
b Dharwad	11.73	8.96	14.94	2.48	4.81	2.31	1.44	0.31	1.86	2.74	2.40	1.84
b Belgaum	10.54	6.78	13.63	2.33	4.08	2.08	1.21	0.43	1.80	1.81	2.82	1.54
cHospet	23.84	18.47	29.77	2.83	1.91	4.70	1.24	0.54	1.76	2.14	2.41	1.56
c Manvi	37.73	28.21	49.96	2.07	2.82	7.43	1.53	0.41	2.42	1.25	1.98	1.96

* Resistance ratio = LD_{50} of X population/LD_{50} of Honnavar population
a = Low pesticide usage area (one to two sprays)
b = Medium pesticide usage area (Three to four sprays)
c = High pesticides usage area (four to six sprays)

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Evaluation of some insecticides for toxicity to egg and larval parasitoids of castor semilooper, *Achaea janata* Linn.*

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Abstract

Investigations were carried on toxicity of 13 insecticides to egg parasitoid (*Trichogramma chilonis* Ishii) and larval parasitoid (*Microplitis maculipennis* Szepligate) of castor semilooper, *Achaea janata* Linn. *in vitro* and *in situ* conditions at the University of Agricultural Sciences, Dharwad, Karnataka. Fenvalerate (dust and spray), phosalone, monocrotophos, profenofos and acephate proved to be relatively safer to developmental stages of *T.chilonis*,(54 to 86% adult emergence) while methyl parathion, carbaryl and quinalphos were harmful. Phosalone, carbaryl, profenofos, acephate ,fenvelarate (spray and dust), were relatively safer (70 to 85 % adult emergence) from treated cocoons whereas methyl parathion (5.0%), alphamethrin (11.7%) and quinalphos(33.3%) were highly toxic to *M.maculipennis*. All insecticides were highly toxic to adult parasitoids of both *T.chilonis* and *M. maculipennis*.

Keywords: Castor, *Achaea janata*, *Trichogramma chilonis*, *Microplitis maculipennis*, toxicity

Introduction

Castor semilooper, *Achaea janata* Linn is one of the major defoliators of castor crop.It is attacked by a good number of natural enemies. Among them, egg parasitoid, *Trichogramma chilonis* Ishii, larval parasitoid, *Microplitis maculipennis* Szepligate and some of the microbial agents exert greater biological resistance in the succession and population dynamics of the pest. Parasharya *et al.*(1988) reported 92.2 % parasitisation of eggs of castor semilooper by *T.chilonis* and *Telenomus* sp at Anand, Gujarat. Similarly, Gaikwad and Bilapate (1992) reported 68.2 and 77.31 % parasitisation by *M.maculipennis* in Maharashtra. Though many insecticides have been evaluated against castor semilooper the information on toxicity to it's bio control agents is lacking. In this direction the present investigations were aimed at evaluating commonly used insecticides against castor semilooper in castor ecosystem so as to identify safer insecticides for its parasitoids.

Materials methods

Thirteen insecticides were evaluated for their toxicity against parasitoids of castor semlooper in the laboratory as well as in the field conditions (Table 1).

Mass production of parasitoids: The cultures of *T.chilonis* , *M.maculipennis* , *A. janata* and *Corcyra cephalonica* were maintained at 27±1°C and 60±5 % RH. *T. chilonis* were multiplied on eggs of *C.cephalonica* cultured on broken jowar following the well laidout procedure. The adults of *M.maculipennis* emerged from field collected parasitoid cocoons served as initial stock culture. Twenty five II instar larvae of *A. janata* in group, along with castor leaves were provided for parasitisation to 15 parasitoids in a glass lantern cage provided with 10 % honey. After four hours exposure the larvae were taken out and reared in a plastic container till cocoon(pupa) formation stage of the parasitoid. Cocoons were then placed in lantern glass cage with 10 % honey for adult emergence.

Toxicity to parasitoids: Contact toxicity of insecticides to newly emerged adults of *T. chilonis* and *M.maculipennis* was determined by dry film method. Fifty adults of *T. chilonis* and ten adults of *M. maculipennis* were used for each treatment with three replications. Mortality counts were taken at 12 and 24 h after exposure. Insecticides were evaluated by using 1, 3 and 7

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days old *T. chilonis* parsitised *C.cephalonica* eggs and five day old cocoons of *M. maculipennis*. The toxicity of insecticides to bio agents in the field was also assessed by observing adult emergence from 50 parasitised eggs and 20 cocoons of *M. maculipennis* collected from insecticides treated castor plots and untreated check. Field experiments were conducted at MRS, UAS, Dharwad during 1995 on castor variety RC-8 raised at 60 x 45 cm spacing over 3.6 x 3.6m size plots following recommended package of practices except plant protection measures. Experiments were conducted in RBD with three replications. Data were analysed after arc sine transformation and subjected to Duncan's Multiple Range Test (DMRT).

Results and discussion

Toxicity to egg parasitoid *T. chilonis:* All insecticides were harmful to adult parasitoids at 12 h. In the next 12 h adult mortality increased to 100% in all treatments (Table.1). Further, the toxicity of these chemicals on different developmental stages indicated that as the stage advanced from day old to seven days after parasitisation, the emergence per cent in all cases increased except in fenvalerate, phosalone, quinalphos, methyl parathion and endosulfan. In field treated parasitoid eggs, the parasitoid emergence per cent varied from 19.3 to 75.3 % as compared to 97.3 % in control. However, fenvalerate, phosalone ,*monocrotophos, profenofos and acephate* were found safer in conserving parasitoid (54.0 to 86% adult emergence) compared to methyl parathion, quinolphos and carbaryl. Psesent studies are in line with those of Lingappa *et al.* (1972); Patil *et al.* (1990) and Prem Chand *et al.* (2001) who expressed that ,generally larval and pupal stages of parasitoids are more tolerant than adult stages.

Toxicity to larval parasitoid *M. maculipennis:* All the test insecticides were found to be highly toxic after 24 hr as the mortality was 100 % in all treatments (Table.2) However emergence of adult parasitoids from laboratory and field treated cocoons varied from 5 to 83.3 and 11.7 to 85.0 %, respectively. Methyl parathion was highly toxic with least adult emergence both in laboratory (5%) and field (11.7%) followed by alphamethrin (11.7 and 5.0%), quinalphos (33.3 and 33.3%) and endosulfan (35.7 and 36.7%). The present findings got support from the observations of Powell and Scott, 1985; Bull *et al.*, 1987; Elezen *et al.*, 1989.

***Table 1 Effect of insecticides* on egg parasitoid *T. chilonis* under laboratory and field conditions**

Treatment	Laboratory					Field
	Toxicity to adults (% mortality)		Adult emergence from parasitised eggs (%)			Adult emergence from parasitised eggs (%)
	12 h	24 h	1 day old	3 day old	7 day old	
Endosulfan (0.07%)	92.7 c	100.0 a	29.3 fg	38.0 de	22.0 l	34.0 g
Methyl parathion (0.05%)	100.0 a	100.0 a	16.7 fg	26.0 f	4.7 j	19.3 l
Monocrotophos (0.05%)	94.7 b	100.0 a	55.3 cd	39.3 de	78.0 c	58.0 d
Profenofos (0.05%)	100.0 a	100.0 a	44.7 def	38.0 de	60.0 e	45.3 e
Quinolphos (0.05%)	100.0 a	100.0 a	20.0 gh	28.7 f	6.0 j	24.7 h
Acephate (0.075)	100.0 a	100.0 a	43.3 de	40.7 d	54.0 f	47.3 e
Fenvalerate (0.01%)	100.0 a	100.0 a	38.0 f	78.7 b	65.3 d	63.3 c
Fenvalerate D (0.04%)	100.0 a	100.0 a	69.3 b	84.0 b	86.0 b	75.3 b
Alphamethrin (0.01%)	100.0 al	100.0 a	30.0 fg	34.7 e	51.3 f	38.0 f
Mixture of profenofos + cypermethrin (0.025%)	100.0 a	100.0 a	34.0 f	35.3 e	42.0 g	36.7 fg
Methomyl (0.006%)	100.0 a	100.0 a	14.0 hi	19.3 g	21.3 l	24.0 h
Carbaryl (0.168%)	100.0 a	100.0 a	8.7 l	18.3 g	22.0 l	24.7 h
Untreated check	4.0 d	7.3 b	97.3 a	96.0 a	94.7 a	97.3 a

In columns the means followed by same letter do not differ significantly as per DMRT.

Table 2 Effect of synthetic insecticides on larval parasitoid *M. maculipennis* under laboratory and field conditions

Treatment	Laboratory			Field
	Toxicity to adults (% mortality)		Adult emergence from treated cocoons (%)	Adult emergence from treated cocoons (%)
	12 h	24 h		
Endosulfan (0.07%)	90.0 b	100.0 a	35.7 h	36.7 g
Methyl parathion (0.05%)	100.0 a	100.0 a	5.0 j	11.7 h
Monocrotophos (0.05%)	96.7 a	100.0 a	48.3 g	50.0 f
Profenofos (0.05%)	100.0 a	100.0 a	71.7 cd	76.7 cd
Quinolphos (0.05%)	100.0 a	100.0 a	33.3 h	33.3 g
Acephate (0.075%)	100.0 a	100.0 a	66.7 de	71.6 d
Phosalone (0.07%)	83.3 c	100.0 a	83.3 b	85.0 b
Fenvalerate (0.01%)	73.3 c	100.0	70.0 cde	70.0 de
Fenvalerate dust (0.4%)	83.3 c	100.0 a	70.0 cde	73.3 d
Mixture of profenofos + cypermethrin (0.025%)	100.0 a	100.0 a	11.7 l	15.0 h
Methomyl (0.006%)	100.0 a	100.0 a	56.7 f	61.7 e
Carbaryl (0.168%)	*100.0 a*	*100.0 a*	*76.7 c*	*81.7 bc*
Untreated check	0.0 d	0.0 b	100.0 a	98.3 a

In columns the means **followed by same letter** do not differ significantly as per DMRT.

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Biochemical basis of disease resistance in linseed, *Linum usitatissimum* L.

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Abstract

The biochemical components *viz.*, HCN, polyphenols, nitrogen, phosphorus and total sugars in the leaf tissues of 20 linseed cultivars including 19 from *Linum usitatissimum L.* and a highly resistant ornamental species, *Linum grandiflorum* were studied witth respect to resistance against major diseases. The resistant varieties namely, Ayogi, BAU-610, Kiran, KL-178 and *L.grandiflorum* contained high percentage of HCN, polyphenols and phosphorus. While leaves of susceptible lines *viz.*, C-429 and Chambal contained higher nitrogen and sugar. These components were higher in pre-infection stage than post-infection stage. Higher amount of HCN, polyphenols and phosphorus in resistant varieties imparted disease resistance in linseed.

Key words: Linseed, disease resistance, biochemical components, bud fly

Introduction

The correlation between biochemical components and disease resistance has been investigated in several crops (Reddy *et al.*, 1984; Singh and Parashar, 1984; Chattopadhyaya, 1989; Gupta *et al.*, 1990). Similar studies were conducted by Kakkar (1966) and Pandey *et al.* (1981) in linseed crop with respect to rust and powdery mildew diseases. The present investigation envisages the role of biochemical constituents *viz*, HCN, poly-phenols, nitrogen, phosphorus and total sugar contents in linseed varieties and the resistance against three major diseases *viz.*, wilt, powdery mildew, Alternaria blight and linseed budfly.

Material and methods

Out of the 20 genotypes, 19 were from *Linum usitatissimum* and one from *L. grandiflorum*. They were grown during three successive crop seasons (1993-1995) under the same agronomic parameters. Leaf samples were collected every year from each variety at 60 DAS for pre-infection stage and 110 DAS for post-infection stage. The randomly collected samples at each stage were mixed together to make a composite sample. The leaves were dried in oven at 70°C. They were then ground to fine powder in pestle and mortor, which were analysed for HCN, AOAC (1970), polyphenols, nitrogen (Swain and Hillis, 1959), phosphorus (Jackson, 1958) and sugar (Hedge and Hofreiter, 1962) contents.

Results and discussion

The resistant cultivars namely, Ayogi, Linum *grandiflorum*, KL-178 and Kiran were having higher HCN content (Table 1). On the contrary susceptible varieties *viz.*, C-429 and Chambal had very low HCN content in leaf tissues (2.28 and 2.55 mg/100g) dry weight, respectively. A negative correlation between HCN content and powdery mildew was observed by Pandey *et al.* (1981) in linseed varieties..

Polyphenol content was also higher in resistant cultivars *viz*, *Linum grandiflorum* (2.66 mg), BAU-610A (1.932 mg), KL-178 (1.89 mg) and Ayogi (1.8 mg) and lowest in highly susceptible variety C-429 (1.22 mg). Gupta *et al.* (1992) have also reported higher phenols in tolerant groundnut cultivars. Phenolic compounds are considered as one of the most important biochemical parameters responsible for disease resistance (Bashan, 1986; Chattopadhyay, 1989; Gupta *et al.*, 1990). The oxidation product of naturally occurring phenols are reported to inhibit pectinolytic enzymes (Prasad and Shambulingappa, 1986). The total polyphenols were higher in preinfection than post infection stage in the present study. The decrease in polyphenols in second stage might be due to oxidation of polyphenols into quinones. The polyphenols act as hydrogen donors/acceptors in oxidation-reduction reactions and their involvement in resistance by oxidation to quinones, which are more toxic to microorganisms as per (Bajaj *et al.*, 1983). Arora (1983) in *Vigna radiata* infected with *Rhizoctoria solani* and Gupta *et al.* (1990) in mustard against *Alternaria* leaf spot reported higher concentration of phenolic compounds in healthy than diseased leaves. However, in some studies phenolic contents have been found to increase after infection (Sridhar and Ou, 1974; Vidyasekharan, 1974; Sharma *et al.*, 1983).

A similar relationship was found between phosphorus content and disease resistance. The resistant cultivars namely, BAU-610A, Flake-1, R-552 and *Linum grandiflorum* contained higher phosphorus content. It is in support of the findings of Gupta *et al.* (1992) in groundnut leaves. Although phosphorus content was higher in pre-infection stage than post-infection stage, the difference was very narrow. On the contrary, inverse relationship was observed between nitrogen and sugar content with disease tolerance. In the present investigation higher nitrogen content was recorded in susceptible varieties, C-429 (7.7%), Chambal (7.0%) and moderately resistant variety Shubhra (6.1%) whereas a highly resistant line *i.e.*, *Linum grandiflorum* contained lowest nitrogen content (2.4%). Our findings are in agreement with the findings of Gupta *et al.* (1992) who reported that nitrogen content was lower in tolerant than susceptible groundnut cultivars, which decreased after infection of leaf spot. The reduction in N content after infection might have occurred due to disruption of cell structure coupled with enhanced activity of proteolytic enzymes (Nayudu and Walker, 1961). Prasad and Shambulingappa (1986) found almost same quantity of nitrogen on resistant susceptible cultivars of *Helianthus annuus* in relation to rust. Nagaraj *et al.* (1989) reported higher protein content in leaves of resistant groundnut cultivars. Sugar content was also higher in susceptible varieties C-429 (5.2%) and Chambal (4.5%) than resistant varieties and the highly resistant variety *Linum grandiflorum* contained lowest (2.9%) sugar content. Sugar content also decreased in second stage. Lower sugar content in leaves of tolerant groundnut cultivars than susceptible ones has been reported by Gupta *et al.* (1992).

Table 1 Biochemical constituents in leaves of linseed genotypes (Average of three seasons, 1993 to 1995)

Varieties/ Entries	Resistance Status	HCN Content (Mg/100g of dry weight)		Polyphenols (Mg/100g of dry weight)		Nitrogen Content %		Phosphorus content		Sugar (%)	
		Ist Stage	IInd Stage	Ist Stage	IInd Stage	Ist Stage	IInd Stage	Ist Stage	IInd Stage	Ist Stage	IInd Stage
NP (RR) 65	W	2.95	2.06	1.56	1.98	4.75	3.91	0.27	0.22	3.3	2.8
R-552	W	3.89	2.97	1.73	1.43	5.00	3.52	0.40	0.31	2.9	2.1
Kiran	W, PM	4.04	3.05	1.65	1.41	5.41	4.03	0.33	0.26	3.0	2.6
Jawahar-23	W	2.75	1.61	1.60	1.10	5.64	4.25	0.24	0.14	-	-
Ayogi	HR	4.94	3.11	1.81	1.25	4.91	3.62	0.27	0.18	3.7	2.7
BAY-610A	AB, M	3.91	2.37	1.93	1.65	3.53	2.78	0.20	0.15	3.5	2.7
ES-44	AB, PM	3.18	2.23	1.50	1.04	5.45	4.16	0.27	0.22	2.8	2.2
ACC 2921	AB, PM	2.57	1.92	1.73	1.27	5.68	4.30	0.26	0.17	2.5	1.3
KL-168	AB	3.12	2.45	1.69	1.29	5.38	4.33	0.20	0.15	2.6	1.3
KL-178	PM, R	4.11	3.39	1.89	1.56	4.76	3.83	0.57	0.32	2.9	1.6
LCK-8776	PM	2.67	2.02	1.60	1.24	4.86	3.91	0.29	0.16	3.1	2.6
A-4-3-2	PM	3.10	2.30	1.58	1.20	4.61	4.00	0.33	0.25	2.8	2.3
Flake-1	PM	2.71	2.55	1.41	1.11	5.40	4.11	0.38	0.32	3.2	2.7
KL-1	AB, R	2.55	2.27	1.61	1.19	4.72	3.69	0.27	0.18	-	-
Garima	R	3.07	2.52	1.36	1.16	5.15	3.92	0.27	0.22	3.2	2.9
Neela	B.fly	2.94	2.47	1.51	1.12	5.24	4.30	0.29	0.16	2.9	2.5
Shubhra	MR	2.80	2.03	1.57	1.25	6.10	5.03	0.25	0.23	3.5	3.0
C-429	HS	2.28	1.61	1.22	1.00	7.79	5.71	0.28	0.21	5.2	4.3
Chambal	HS	2.55	1.75	1.19	0.96	7.00	5.71	0.22	0.20	4.5	2.5
Linum grandiflorum	HR	4.70	3.23	2.66	1.71	2.43	1.97	0.34	0.26	2.9	2.2

W = Wilt; PM = Powdery mildew; AB = Alternaria blight; R = Rust; B.fly = Budfly; HR = Highly resistant

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Physiological manipulation of sex expression in a pistillate line of castor (*Ricinus communis* L.)

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Abstract

Castor (*Ricinus communis* L.) pistillate line VP-1, is generally sown in summer to induce environmentally sensitive, temperature dependent(>32°C) interspersed staminate flower (ISF) character for its maintenance, which is not cost effective. Hence, an experiment was conducted for two years during *kharif* 1996 and 1997 to induce ISF character in normal *kharif* season by physiological manipulation of sex expression with growth regulators and chemicals. The growth regulators/chemicals included were gibberellic acid (GA 25, 50, 75, 100 ppm) and silver nitrate (25, 50, 75, 100, 250, 500, 1000 ppm), urea (2%). These chemicals were sprayed at primary (18 Days after emergence) and secondary spike initiation stages (50 DAE). The studies indicated that ISF production was more with application of GA and silver nitrate up to 100 ppm in secondary, tertiary and quarternery spike orders during October, November and December months.

Key words: Sex expression, GA, silver nitrate, ISF, *castor*, *Physiological manipulation*

Introduction

The development of pistillate line of castor (*Ricinus communis* L.), VP-1 (S-type, environmentally sensitive) in mid 70's has not only resulted in dramatic breakthrough on varietal front, but also led to spectacular improvement in area, production and productivity of castor in the country, especially in Gujarat. The pistillate character, which is polygenically controlled, is highly unstable. Depending on management levels, time of planting, nutrition and other environmental factors, it can revert at any stage to monoecism.

Until recently, castor breeders in the country had no other alternative but to consciously retain 20-25% monoecists in the female population to provide unrestricted pollen supply to the pistillate line, thereby leading to problem of high percentage of monoecists, early revertants (40-65%) in seed production plots and associated/attendant problems such as frequent rouging, low genetic purity, high cost of production, low yields, high risk of rejections etc.

The refined/modified seed technology developed at Directorate of Oilseeds Research by Ramachandram and Rao (1988) utilizing environmentally sensitive gene (s) for interspersed staminate flower (ISF) character provided very high recovery of pistillate plants (90-100%) in the seed production plots as compared to 40-65% observed in the conventional method.

Unlike conventional method, where both the female and hybrid seed production are organized in the normal crop season i.e. *kharif* or *rabi*, the modified method of seed production for pistillate line should be taken up in summer when the day temperatures are above 32°C which allows maximum expression of environmentally sensitive gene for ISF.

One of the disadvantages of the above method, however, is its dependence for the production of nucleus, breeder and foundation seed in summer season which otherwise entails relatively more costs/unit of produce than regular season. There are problems of irrigation availability, high temperatures, desiccating winds, low yields etc.

Simple methods/systems, which could induce at will, directed sex reversion in the main/regular season but yet give high recovery of females (95% and above) comparable to that of refined systems would therefore be highly welcome.

Available literature suggested that application of growth regulators can alter the sex expression in cucurbits (Yang *et al.*, 1985) and in castor (Lazika, 1959; Shifriss, 1961). Hence experiments were conducted to study the influence of exogenous application of growth regulators and chemicals on production of ISF in VP-1 during normal *kharif* season.

Materials and methods

An observation trial was conducted with VP-1 during 1995-96 at the research farm of Directorate of Oilseeds Research, Hyderabad with two dates of sowing, different growth regulators at different concentrations and at different stages of crop growth. Better production of ISF was observed when the crop was sown during the first fortnight of July and spraying at primary (18 Days after emergence) and secondary (50 DAE) spike initiation stages. Based on these results, a replicated trial with three replications was conducted during kharif 1996 and 1997. The treatments were imposed on one row plots having 10 plants at a spacing of 90 x 60 cm. Different growth regulators/chemicals i.e. gibberellic acid @ 25, 50, 75, 100 ppm, silver nitrate @ 25, 50, 75, 100, 250, 500 ppm and urea 2% were sprayed at primary (18 Days After Emergence) and secondary (50 DAE) spike initiation stages. Staminate flower number was recorded on 10 plants in each replication at 10 days interval. Number of ISF produced during the entire crop growth period was added and total number of ISF in 10 plants as mean of two years (1996-97 and 1997-98) is presented.

Results and discussion

Total number of ISF produced was more with application of GA and silver nitrate up to 100 ppm (Table.1). No. of spikes showing ISF and average number of ISF/spike which showed ISF is also more with application of GA and silver nitrate up to 100 ppm. As the sexual differentiation is closely associated with hormonal and genetic programmes, the realization of this depends on a combination of endogenous and environmental factors. Masculinization by GA was associated with increased growth rate i.e. stem elongation (Khrayanin and Chailakhyan, 1988). Silver ions block the action of ethylene in plants or react with ethephon to prevent ethylene evolution or may have inhibited the absorption of ethephon by plants (Beyer, 1976). ISF production is more in secondary, tertiary and quaternary spike orders compared to primary and pentenary spike orders.

Table 1 Effect of growth regulators/chemicals on ISF production on VP-1 pistillate line of castor

Treatment	Total no. of ISF	No. of spikes showing ISF	Average no. of ISF/spike	Increase in ISF (%) over control	Spike orders				
					Primary	Secondary	Tertiary	Quarternery	Pentenary
GA-25 ppm	126	20	6	152	10	31	77	8	-
GA-50 ppm	183	22	8	232	-	116	45	21	-
GA 75 ppm	139	16	9	248	7	55	136	33	8
GA-100 ppm	136	14	10	288	30	62	14	30	-
$AgNO_3$ 25 ppm	234	31	8	204	-	16	58	126	34
$AgNO_3$ 50 pm	398	28	14	468	51	179	98	15	55
$AgNO_3$ 75 ppm	124	19	7	260	4	21	26	51	22
$AgNO_3$ 100ppm	151	23	7	164	3	9	77	44	18
$AgNO_3$ 250 ppm	57	13	4	76	10	12	16	19	-
$AgNO_3$ 500 ppm	18	14	5	80	-	10	3	5	-
Urea 2%	80	18	4	76	2	4	34	21	19
Water	56	4	4	60	7	0	25	20	4
Control	10	4	3		3	4	2	-	1
Mean	132	17.0	7.0						
SEm±	4.55	1.61	0.81						
C.D (P=0.05)	13.27**	4.69**	2.4**						

Similar response was noted by Ram and Sett (1980) in castor with application of silver nitrate and cobalt chloride. Silver nitrate and GA are recommended for masculinizing plants in the course of hybrid seed production in cucumber (Tarakanov *et al*; 1985). They increased the pollen production and improved the quality of pollen. $AgNO_3$ @ 300 ppm produced male flowers when sprayed at weekly intervals starting from 1st leaf stage in the crop (Kasrawi, 1988).

Though mean temperatures were less during October, November, December compared to August and September, ISF production was more during these months which showed the response to growth regulators in manipulation of sex expression during low temperature period.

Therefore, it is concluded that sprays at primary and secondary spike initiation stages in July 1st fortnight sown crop increased the production of ISF in castor. Application of GA and silver nitrate up to 100 ppm showed better response. ISF production was more during October, November and December months.

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Table 2 **Number of ISF produced *during different months***

Treatment	Aug.	Sept.	Oct.	Nov.	Dec.
GA 25 ppm	-	2	41	70	13
GA 50 ppm	-	-	61	77	45
GA 75 ppm	-	-	78	37	17
GA 100 ppm	-	30	52	43	11
Ag No_3 25 ppm	-	16	55	93	70
Ag No_3 50 ppm	50	7	154	118	69
Ag No_3 75 ppm	-	-	73	42	9
Ag No_3 100ppm	-	8	100	66	35
Ag No_3 250ppm	-	1	20	8	28
Ag No_3 500ppm	-	-	10	-	8
Urea 2%	-	6	26	22	26
Water	-	-	21	27	8
Control	3	4	-	2	1
Temp. (°C)					
Max.	29.2	30.8	29.5	29.7	28.3
Min.	23.1	21.9	20.3	15.2	13.1
Mean	26.1	26.3	24.9	22.8	20.7

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Short communication

Discrimination of soybean cultivars [*Glycine max* (L.) Merrill] by electrophoresis of seed proteins

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Identification and characterisation of crop varieties/ genotypes is fundamental to several aspects of seed trade. The traditional methods usually recording of morphological characters or descriptors. Sometimes due to environmental influences the expression of morphological characters is not proper. Moreover, it may be difficult to distinguish closely related varieties by morphological characterisation alone. The use of protein electrophoresis is a well established and reliable method for varietal identification(Pathak and Chattopadhyay, 1989). Therefore the present investigation was conducted to assess the electrophoretic variation in 24 varieties of soybean, which are under active seed production chain.

Pure seed of 24 soybean varieties (Table 1) was obtained from breeders of different stations. Twenty-five seeds of each variety were grounded in a mortar and pestle after removing their seed coat and defatted by a mixture of Chloroform, Methanol and Acetone in 2:1:1 ratio respectively. One ml Tris-Glycine extraction buffer (pH 8.3) was added to 0.1 g of defatted powder and left over night. After extraction the mixture was clarified by centrifugation at 10,000 RPM for 10 minutes at 4°C. The clean suspension obtained was taken out and 10% SDS (10) and mercaptoethanol (10) with pyronine-G (tracking dye) was added to it. 10 μl of this suspension was loaded into discontinuous SDS polacrilamide (SDS-PAGE) gel having a constitution of 5% stacking and 12.5% running gel (Dadlani and Varier, 1993). Coomassie brilliant blue (0.1%) stained gels were scored for presence and absence of bands for each variety for comparison. The protein bands were numbered from cathode end and their Relative mobility (RM) and Similarity index (SI) between two samples were measured.

Total 24 bands were obtained in 24 SDS-PAGE electrophorogrames (Table 2, Fig 1). It was recorded that five bands (1=0.3260, 2=0.3586, 10=0.5869, 11=0.6304 and 17=0.8043) were common to all varieties under the study. These bands can serve as a source of reference for inter-gel or inter laboratory comparison. Besides it was interesting to note that band 7 (0.4565) was present only in three varieties, JS 71-05, MACS 13 and MACS 57, whereas, band 19 (0.9347) was found in JS 72-280, NRC 2, NRC 7 and NRC 12, these two bands can be used in discriminating the above varieties from the others.

Table 1 List of varieties used in the study with their parentage and source

Variety	Parentage	Source
Bragg	*Jackson X D 49-2491*	*USA*
JS 71-5	Selection from Lee type	JNKVV (MP)
JS 72-280	EC 14437 X Bragg	JNKVV (MP)
JS 75-46	Improved pelican X Semmes	JNKVV (MP)
JS 80-21	JS 71-5 X PK 73-94	JNKVV (MP)
JS 335	JS 78-77 X JS 71-5	JNKVV (MP)
KB 79	Hardee X monetta	Banglore
MACS 13	Hampton X EC 7034	Pune (MS)
MACS 57	JS 2 X Improved pelican	Pune (MS)
MACS 58	JS 2 X Improved Pelican	Pune (MS)
MACS 124	JS 2 X Improved Pelican	Pune (MS)
MACS 450	Bragg X MACS 111	Pune (MS)
MAUS 2	Selection from SH 84-14	Pune (MS)
MAUS 47	PH 73-7 X Hardee	Pune (MS)
Monetta	EC 2587	USA
NRC 2	Induced mutant of Bragg	Indore (MP)
NRC 7	Selection from S 69-96	Indore (MP)
NRC 12	Mutant 95-10 (Parent Bragg)	Indore (MP)
NRC 37	Gaurav X Punjab 1	Indore (MP)
PK 416	UPSM 534 X S 38	Pantnagar
PK 472	Hardee X Punjab 1	Pantnagar
PK 564	(UPSM 534 X S 38) Bragg	Pantnagar
PK 1024	PK 308 X PK 317	Pantnagar
PK 1029	PK 262 X PK 316	Pantnagar

Similarly, absence of a particular band (s) (Table 2) may also be used as an effective criterion for discriminating the genotypes. In the present study 4th band (o.4130) was present in all the varieties except JS 72-280 and PK 1029. Eight band (0.5000) is absent only in PK 416. Band no. 19 (0.9347) is absent in variety JS 72-280 and PK 416. Similar observations were recorded by Barrat (1980) and Hussain *et al* (1989) in *Vicia faba* and lentil respectively.

Table 2 SDS-PAGE banding pattern in twenty four varieties of soybean

Varieties	Bands																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Bragg	+	+	-	+	-	-	-	+	+	+	+	+	+	-	-	-	+	-	+	-	+
JS 71-5	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	-	+	+	+
JS 72-280	+	+	-	-	+	-	-	+	-	+	+	+	+	-	-	-	+	+	-	-	+
JS 75-46	+	+	-	+	+	+	-	+	+	+	+	+	+	-	+	+	+	-	+	+	+
JS 80-21	+	+	+	+	-	-	-	+	+	+	+	+	+	-	+	+	+	-	+	+	+
JS 335	+	+	-	+	-	-	-	+	+	+	+	+	+	-	+	-	+	-	+	-	-
KB 79	+	+	-	+	-	-	-	+	+	+	+	+	+	+	-	+	+	-	+	+	+
MACS 13	+	+	-	+	-	-	-	+	+	+	+	+	+	-	-	-	+	-	+	-	-
MACS 57	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	-	+	+	+
MACS 58	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	-	+	+	+
MACS 124	+	+	+	+	+	-	-	+	+	+	+	+	+	-	+	+	+	-	+	+	+
MAUS 450	+	+	-	+	+	-	-	+	-	+	+	+	+	-	-	+	+	-	+	+	+
MAUS 2	+	+	-	+	-	-	-	+	-	+	+	-	+	-	-	-	+	-	+	-	+
MAUS 47	+	+	-	+	-	-	-	+	-	+	+	+	+	+	-	-	+	-	+	+	+
Monetta	+	+	-	+	-	-	-	+	-	+	+	-	+	+	+	-	+	-	+	+	+
NRC 2	+	+	-	+	-	-	-	+	-	+	+	+	+	-	+	-	+	+	+	+	+
NRC 7	+	+	-	+	-	-	-	+	-	+	+	+	+	+	-	-	+	+	+	+	+
NRC 12	+	+	-	+	+	-	-	+	+	+	+	-	+	-	-	+	+	+	+	+	+
NRC 37	+	+	-	+	-	-	-	+	-	+	+	-	+	+	-	-	+	-	+	-	-
PK 416	+	+	+	+	-	-	-	-	-	+	+	-	-	-	-	-	+	-	-	-	-
PK 472	+	+	+	+	+	-	-	+	+	+	+	-	+	+	+	+	+	-	+	+	-
PK 564	+	+	+	+	-	-	-	+	+	+	+	-	+	-	-	-	+	-	+	-	-
PK 1024	+	+	-	+	-	-	-	+	+	+	+	+	+	-	-	+	+	-	+	+	+
PK 1029	+	+	+	-	+	+	-	+	+	+	+	+	-	-	+	+	+	-	+	-	-

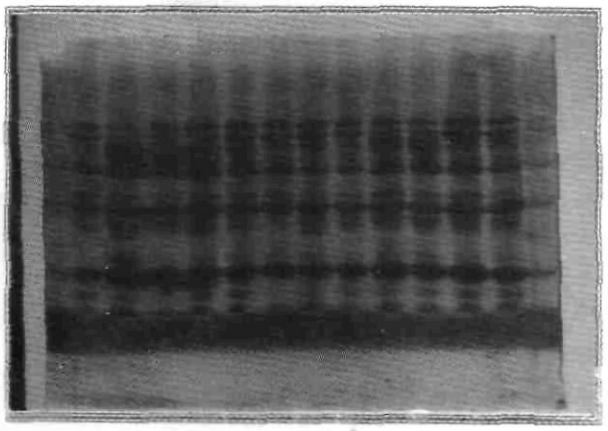

Fig 1 SDS-PAGE electrophoregrams of seed proteins in soybean varieties (1-12)

Similarity index (SI) was calculated to have an idea of evolutionary relationships among the genotypes under study. SI values ranged from 33.34% (JL 75-46 - PK 416) to 100% (MACS 57 - MACS 58) indicating very high variability among these varieties (Table 3). The observations revealed presence of similar bands in varieties MACS 57 and MACS 58 (the sister lines selected from same parent JS 2 X improved Pelicon) but intensity of proteins differed in it. A very high SI value i.e. 100% in (MACS 57 - MACS 58), 94.11% (JS 80-21 - MACS 124 and MACS 58 - PK 472), 93.34% (KB 79-PK 1024 (Bragg - MACS 13 and JS 335 - MACS 13) and 90% (JS 71-5 - MACS 57 and JS 71-5 - MACS 58), indicated a high degree of similarity among the varieties demonstrating close evolutionary relationship among them. Similar observations were reported in cowpea and pea also while using SI as a criteria for establishing an evolutionary relationships among different species (Gomathinayagam

and Ramaswamy, 1994; Goyal and Sharma, 1998). Contrary to this relatively poor SI values were obtained among PK 416 *vs* all other varieties (range 33.34-54.54) except PK 564 (63.63). This could be possible because of parentage of PK 416 (UPSM 534 X S 38) are not used in any other variety, except PK 564 {(UPSM 534 X S 38) X Bragg}. Overall, differential protein pattern and SI values *confirmed the usefulness of SDS-PAGE* technique of protein variability in distinguishing soybean genotypes as well as in establishing evolutionary relationships.

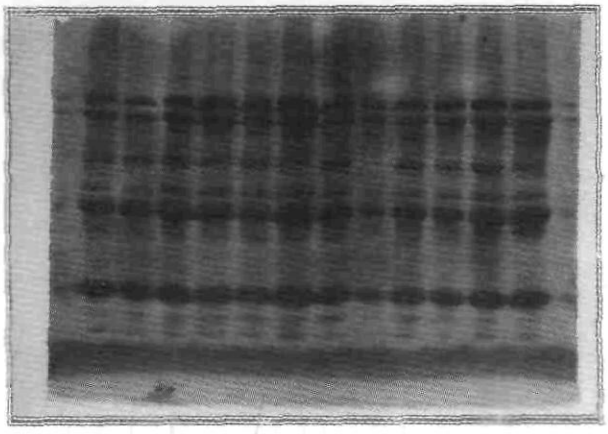

Fig 2 SDS-PAGE electrophoregrams of seed proteins in soybean varieties (13-24)

***Table 3* Similarity index (SI) among twenty-four soybean genotypes**

Varieties	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	JS 71-5	JS 72-280	JS 75-46	JS 80-21	JS 335	KB 79	MACS 13	MACS 57	MACS 58	MACS 124	MACS 450	MAUS 2	MAUS 47	Monetta	NRC 2	NRC 7	NRC 12	NRC 37	PK 416	PK 472	PK 564	PK 1024	PK 1029
Bragg	55.00	64.28	70.58	75.00	84.61	80.00	91.67	63.15	63.15	70.58	68.75	83.34	78.57	66.67	73.34	73.34	64.70	69.23	46.15	64.70	76.92	85.71	52.94
JS 71-5		50.00	80.00	75.00	55.00	70.00	50.00	90.00	90.00	80.00	78.94	52.63	68.42	68.42	65.00	65.00	66.67	52.63	36.84	75.00	50.00	65.00	65.00
JS 72-280			*55.56*	50.00	53.34	52.94	57.14	50.00	50.00	55.56	62.50	61.53	60.00	50.00	56.25	56.25	50.00	50.00	38.46	50.00	46.67	56.25	47.05
JS 75-46				83.34	70.58	77.78	64.70	89.47	89.47	88.89	77.78	58.82	66.67	66.67	72.22	63.15	83.34	50.00	33.34	73.68	55.56	82.35	72.23
JS 80-21					75.00	82.35	68.75	75.00	84.21	94.11	82.35	62.50	70.58	70.58	76.47	66.67	68.42	52.94	43.75	88.23	68.75	87.50	66.67
JS 335						68.75	91.67	63.15	63.15	70.58	58.82	69.23	66.67	66.67	73.34	62.50	55.56	69.23	46.15	75.00	76.92	73.34	62.50
KB 79							73.34	70.00	70.00	77.78	76.47	66.67	86.67	75.00	70.58	81.25	72.23	66.67	37.50	72.23	62.50	93.34	52.63
MACS 13								57.89	57.89	64.70	62.50	75.00	71.42	60.00	66.67	66.67	58.82	75.00	50.00	58.82	83.34	78.57	56.25
MACS 57									*100.00*	*89.47*	*78.94*	*52.63*	60.00	60.00	65.00	*57.14*	75.00	45.00	36.84	84.21	57.89	73.68	73.68
MACS 58										89.47	72.94	52.63	60.00	60.00	65.00	57.14	75.00	45.00	36.84	84.21	57.89	73.68	73.68
MACS 124											88.23	58.82	66.67	66.67	72.23	63.15	73.68	50.00	41.17	94.11	64.47	82.35	72.24
MAUS 2												*66.67*	*75.00*	*64.70*	*70.58*	*70.58*	*72.23*	*56.25*	46.67	72.23	62.50	81.25	64.70
MAUS 47													76.92	76.92	71.52	71.42	62.50	81.81	54.54	52.94	75.00	71.42	41.17
Monetta														85.71	80.00	92.85	42.85	76.92	42.85	61.12	60.00	80.00	42.10
NRC 2															80.00	80.00	61.12	76.92	42.85	70.56	60.00	68.75	35.00
NRC 7																86.67	66.67	60.00	40.00	57.89	56.25	75.00	47.36
NRC 12																	66.67	71.42	40.00	57.89	56.25	75.00	40.00
NRC 37																		52.94	35.29	68.42	58.82	*76.47*	*42.85*
PK 416																			54.54	62.50	75.00	60.00	41.17
PK 472																				43.75	63.63	40.00	40.00
PK 564																					68.75	66.67	66.67
PK 1024																						66.67	56.25
PK 1029																							55.56

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Short communication

Fertility restoration on *cms* lines in sunflower (*Helianthus annuus* L.)

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Sunflower (*Helianthus annuus* L.) is an important oilseed crop in India. It occupies an area of 2093 thousands million ha with production of 1185 thousands tonnes. The average productivity is 566 kg/ha (Damodaram and Hegde, 2000). Hybrids occupies about 60% of the total area cultivated in India. The identification of new restores and maintainers for the available cytoplasmic male sterile line is important in the heterosis breeding programme of sunflower. In the present study, an attempt has been made to assess the restoring ability of 20 genotypes of sunflower on 5 cms lines.

Twenty genotypes of sunflower (consisting of 6 maintainers, 3 restores, 4 inbreds and 7 germplasm lines) were crossed with five cytoplasmic genic male sterile lines and 74 hybrids were obtained. All the hybrids were evaluated in RBD replicated twice at Department of Oilseeds, Tamil Nadu Agricultural University, Coimbatore during *rabi* 2000-01. Each hybrid was sown in 4 m row adopting 60 x 30 cm spacement. The fertility restoration was observed at the time of flowering.

The results on fertility restoration in each hybrid are presented in Table 1. The results revealed that 2A x FMS 338 B, 5A x GP 270, 207A x FMS400B, 207A x GP 270, 821A x 2B, 821A x 5B, 821A x 234B, 821A x RHA 272, 821A x RHA 274, 821A x EC 6841/2, 821A x TNAU SUF 15/1, 821A x GP 86, 821A x GP 161, 821A x GP 255, 821A x GP 270 and 821A x GP 3361 showed sterility. These hybrids were backcrossed with the respective parents for conversion of the respective cms lines into new genetic background.

The results indicated that out of 20 male used in the study, GP 270 for 5A, 207A and 821A; GP 255 for 207A and 821A; FMS400 B for 207A and 821A behaved as maintainer. It indicated that the maintainer FMS 400 B also contains maintainer genes for 207 A and 821 A but not for 234 A. Hence the cytoplasm of 207 A, 821 A and FMS 400A may be of similar type but different from the cytoplasm of 234 A. It also reveals that only 28% of the males restored fertility in the cms line 821A and indicating the chances of obtaining restorer for 821A may be less when compared to other four cms lines.

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Table 1 Fertility restoration on cms lines of sunflower (*Helianthus annuus* L.)

	Maintainer lines						Restorers			Inbreds				Germplasm lines						
% Sterile plants	1B	2B	5B	234B	FMS 338 B	FMS 400 B	6D-1	RHA 272	RHA 274	1381/7	EC 68414/2	EC 68415/1	TNAU SUF 15/1	GP 86	GP 93	GP 161	GP 255	GP 270	GP 324	GP 336
2A	-	-	-	-	S	-	F	F	-	-	F	-	-	F	-	-	F	-	F	F
5A	F	F	-	F	-	F	-	F	F	F	-	F	F	F	F	-	F	S	-	F
207A	-	F	F	F	-	S	F	F	-	F	F	F	F	F	F	F	S	S	F	F
234A	F	F	F	-	F	-	F	F	F	F	F	F	F	F	-	F	F	F	F	F
821A	F	S	S	S	-	S	F	S	S	F	S	-	S	S	F	S	S	S	F	S

- indicates that crosses were not tested

J. Oilseeds Res., **19**(1): 111 (2002)

Short communication

Studies on exploitation of useful heterosis in sesame (*Sesamum indicum* L.)

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The exploitation of hybrid vigour is one of the important breeding techniques to have a quantum jump in yield The F_1 population exhibiting heterosis for seed yield has been reported by Gupta (1980), Shrivas and Singh (1981) and Baviskar *et al.* (1998). Shrivas and Singh (1981) recorded the predominance of negative heterosis in sesame. The present study was undertaken to gain greater insight into the extent of heterosis in a large number of crosses involving diverse genotypes.

Forty genotypes used as a pollen parents were crossed with promising strains JLT-26 (w) and TC-25 in two groups. The crosses were effected during *Kharif* 1997 by *hand emasculation and pollination. The resulted hybrids* (41. With JLT-26(w) and 18 with TC-25) were raised along with the checks *viz.*, Tapi and TC-25 in two replications in single row trial of 3 m length with spacing of 45 x 15 cm during *Kharif* 1998, in the experimental field of Oilseeds Research Station, Jalgaon. The F_1's were evaluated for seed yield and yield attributes. Heterosis was calculated over check, Tapi.

In all the F_1's crosses (JLT-26 (w) as female parent) there was a significant difference between yield and its contributing characters. The F_1's like JLT-26 (w) x SIK 004 (218.17), JLT-26 (w) x RT-54 (194.73), JLT-26 (w) x Guj. Til No.2 (179.98), JLT-26 (w) x MT-2 (179.54), JLT-26 (w) x RT -55 (178.45) and JLT-26 (w) x T-10=A (178.28) recorded more than 178% heterosis. The highest 218% heterosis exhibited by JLT-26 (w) x SIK 004 for seed yield with 53.9 capsules/plant, 2.8 branches/plant and 3.48 g test weight. The standard heterosis in above combinations ranged from - 72.8 to 218.2 % for seed yield. Similar result were obtained by Shrivas and Singh (1981).

While the 18 F_1's crosses on TC-25 as female parent showed the differences between yield and its contributing characters among the hybrids found to be non significant. Some of the hybrids like TC-25 x RT-54 (218.70), TC-25 x RP-293 (221.45), TC-25 x MT-2 (226.21), TC-25 x TRS-16 (246.20), TC-25 x SIK-113 (276.52) and TC-25 x JLT-54 (286.05) exhibited high standard heterosis. The cross TC-25 x JLT-54 showed highest heterosis for seed yield with maximum number of capsules being 42/plant and test weight more than 3 g. The range of heterosis in above combinations was observed to be from-8.15 to 286% for seed yield. The above results are in concurrence with the results of Baviskar *et al.*, (1998).

For capsules/plant more than 30% heterosis was observed in crosses and highest heterosis (69%) was observed in JLT-26 (w) x T-10-A on JLT-26 (w) female while on the female TC-25, highest heterosis was observed in the cross TC-25 x JLT-54 (47.55%) followed by TC-25 x SIK-113 (41.95%).

Highest heterosis for 1000 seed weight observed in cross JLT-26 (w) x Guj. Til-1 (44.35%) followed by JLT-26 (w) x TRS-13 (35.40%) while in TC-25 crosses it was highest in TC-25 x JLT-54 (4.4%) which was beneficial for seed yield.

The yield contributing traits i.e., number of branches/plant showed highest heterosis on JLT-26 (W) female parent in cross JLT-26 (W) x T-10-A (32%) followed by JLT-26 (W) x RT-55 and JLT-26 x G.Til (28% each) and more than 12% heterosis was observed in 16 crosses. While highest heterosis for branches/plant was recorded in TC-25 x JLT-54 and TC-25 x MT-2 (13.04% each) followed by TC-25 x Yuzhi-8 (8.7%) on TC-25 female parent.

The study revealed that the sesame crosses JLT-26 (W) x SIK 004 (218%) and TC-25 x JLT-54 (286%) showed significant standard heterosis for seed yield. These combinations are worth exploiting.

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J. Oilseeds Res., **19**(1): 112 (2002)

Short communication

JNC-6 - A high yielding composite variety of niger [*Guizotia abyssinica* (L.f.) Cass.] identified

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Niger [*Guizotia abyssinica* (L.f.) Cass.] also known as *Ramtil*, is considered as the lifeline of tribal agriculture and economy in India. JNC-6 is the first composite variety of niger identified at national level through All India Coordinated Research Project on Sesame and Niger, after a gap of a decade or so. JNC-6 has been developed for general cultivation in Madhya Pradesh, Bihar, Maharashtra, Karnataka and Rajasthan under rainfed situations in *kharif* season.

The variety involves seven diverse genotypes representing different eco-geographic regions of the country, thus pooling together the genes for high yield and wider adaptability from divergent sources into a single composite. The parents of JNC-6 include No.5, an old variety of Madhya Pradesh; BNS-1, a popular variety from Jharkhand; No.71, a variety grown in Andhra Pradesh, Phule-4 from Maharashtra, RCR-238 from Karnataka; UN-4 from Rajasthan and DN-36, a germplasm line. Developed at ZARS, JNKVV, Chhindwara centre of All India Coordinated Research Project on Sesame and Niger by Dr. R.K. Reddy and his team, the variety was thoroughly tested for its performance at all India level in All India Coordinated Niger trials during the last six years from 1995 to 2000. JNC-6 consistently out yielded all the existing varieties during the test period.

Based on the performance at 38 locations, JNC-6 has recorded an average yield of 454 kg/ha against 397 kg/ha of IGP-76, the national check variety intended to be replaced (Table 1). Thus the variety showed an overall improvement of 14.4% in seed yield with superiority ranging from 8.6 to 23.9% over the years. JNC-6 also contains marginally higher, 38% oil in its seeds against 37.2% of IGP-76. Consequently, JNC-6 recorded an average superiority of 16.9% in oil yield over the national check with a range of 11.0 to 25.9% superiority in oil yield during the same period. This performance is significant as the genetic variability, the basis for crop improvement, in niger is very low.

Table 1 Performance of JNC-6 in AICRP trials

Variety	95-96	96-97	97-98	98-99	99-00	00-01	Mean
Locations	5	8	6	5	7	7	(38)
Yield (kg/ha)							
JNC-6	441	549	390	430	435	477(1)	454
IGP-76(NC)	378	443	350	396	390	426	397
Increase (%)	16.7	23.9	11.4	9.0	11.5	12.0	14.4
Locations	2	2	1	4	5	4	(15)
Oil yield (kg/ha)							
JNC-6	175	214	144	147	171	187	173
IGP-76(NC)	111	170	129	130	154	162	148
Increase (%)	24.1	25.9	11.6	13.0	11.0	15.4	16.9
Locations	2	2	1	4	5	4	(15)
Oil (%)							
JNC-6	39.6	38.9	36.9	34.2	39.3	39.1	38.0
IGP-76(NC)	37.4	38.4	36.8	32.9	39.6	38.0	37.2

The JNC-6 variety is characterized by a plant height of 100-140 cm with 8-10 primary branches, 40-45 productive capitula, 95-100 days maturity period, 4.2 g 1000 seed weight and 38% good quality oil in its seed. It is distinguishable from other varieties by light green foliage with light purplish stem at maturity and canary yellow ray florets.

As compared to the national and local checks, this variety is much less vulnerable to major pests like niger caterpillar, semilooper and hairy caterpillar and diseases like *Cercospora* leaf spot, *Alternaria* leaf spot and powdery mildew which adversely affect the yield of niger (Table 2).

Table 2 Reaction of JNC-6 to major diseases (pooled mean) in 1999 to 2001

Variety	Increase (%)		
	Cercospora leaf spot	*Alternaria* leaf spot	Powdery mildew
JNC-6	1.11	T	0.67
IGP-76 (National check)	1.50	1.33	1.00
Oootacamund (Local check)	2.30	1.66	1.33

0 = No disease (Immune); 1 = 1 to 10% (Resistant); 2 = 11-25% (Moderately Resistant); 3 = 26-50% (Moderately Susceptible); 4 = 51-50% (Susceptible); 5 = 70-100% (Highly susceptible)

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Short communication

Effect or organic sources and fertiliser levels on growth, yield and yield attributes of soybean intercropped with maize in Northern transitional tract of Karnataka

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Area under soybean is increasing every year as a sole as well as an intercrop with maize (Chandel *et al.*, 1993). Intercropping has received more attention as a way to increase productivity of crop per unit area and time. Nutrient management in maize + soybean intercropping system is of special significance as both the crops are high yielding and nutritive. This can be achieved through integrated nutrient management practices involving both organic and inorganic sources. Further, the information on nutrient requirement of soybean, as an intercrop in maize is not available. With this background experiment was conducted.

The field experiment was conducted at the Main Research Station, University of Agricultural Sciences, Dharwad on vertisol with pH 7.7, EC 0.28 dS/m, organic carbon 0.55%, available N 210 kg/ha, P_2O_5 29 kg/ha and K_2O 313 kg/ha under rainfed conditions during *kharif*, 1999. The experiment composed of 14 treatment combinations including three organic sources (FYM, vermicompst and poultry manure) and three inorganic fertility levels to soybean (100% [100:50:25 NPK kg/ha] 75% and 50% RDF) compared with sole maize and sole soybean. Application of 100% (25:35:25 NPK kg/ha) recommended dose of fertilizer (RDF) to maize was kept same for all the treatments. The experiment was laid out in a randomized block design with three replications. The inorganic fertilizers were drilled in the soil as per the treatment combinations at the time of sowing and top dressed to maize at 30 DAS. For sole maize (60 cm x 30 cm) and sole soybean (30 cm x 10 cm) recommended spacing was followed. In intercropping system a row proportion of 1:2 (maize : soybean) with spacing of 90 cm x 20 cm for maize was adopted.

Application of organic manures significantly affected the plant height, number of leaves/ plant, number of branches/plant, total drymatter production at harvest and leaf area (Table 1). Among the organic manures, application of FYM @ 7.5 t/ha and poultry manure @ 2.5 t/ha recorded significantly higher growth attributes as compared to vermicompost and control and were on par with each other. Similar results were also reported by Bisht and Chandel (1996). Fertilizer levels applied to soybean had significant influence on the growth attributes of soybean. Application of 100% NPK (RDF) recorded significantly higher growth attributes as compared to 50% RDF and was found on par with 75% RDF except number of branches/plant and total drymatter production at harvest which were significantly superior over 75% RDF Similar results indicating the effect of fertility levels on various growth components in soybean were reported by Dube and Pal (1995). However, all the growth attributes of intercropped soybean were significantly lower than those of sole soybean. The results are in conformity with findings of the Kushwaha and Chandel (1997).

Significantly higher number of pods/plant, seed weight/plant, 100-seed weight were recorded with application of organic manures over control (Table 1). Among the organic manures, application of FYM recorded significantly higher yield and yield attributes as compared to vermicompost and control and was on par with poultry manure. The superiority in yield attributes was mainly due to improvement in growth parameters. Application of organic manures has increased the total drymatter production and its accumulation in various plant parts. The significant improvement in leaf area and drymatter accumulation in leaf was noticed with application of organic manures, which resulted in greater assimilation of photosynthates and their accumulation in yield components. Organic matter content in soil with the application of organic manures was significantly improved which has favourable effect on modifying the soil environment to hold more water and nutrients, better aeration and microbial activity. These have direct influence on uptake of nutrients and improvement in growth and yield components and ultimately yield of soybean. These results are in conformity with the findings of Jain and Tiwari (1995).

Table 1 **Plant height, number of leaves/plant, number of branches/plant, total drymatter production (TDMP), leaf area, number of pods/plant, seed weight/plant, 100 seed weight, seed yield and haulm yield of soybean as influenced by organic manures and fertilizer levels in maize + soybean intercropping system**

Treatment	Plant height at harvest (cm)	No. of leaves 60 DAS	No. of branches at harvest	TDMP at harvest (g/plant)	Leaf area dm^2/plant at 60 DAS	No. of pods/plant	Seed weight/plant (g)	100 seed weight (g)	Seed yield (kg/ha)	Haulm yield (kg/ha)
Organic source (O)										
FYM (7.5 t/ha)	46	14	4.1	12.5	9.8	27	6.0	12.2	637	1272
Vermicompost (2.5 t/ha)	42	12	3.5	11.3	9.2	25	5.0	11.5	566	1188
Poultry manure (2.5 t/ha)	44	14	4.0	12.1	9.8	27	5.7	12.2	627	1269
Control	37	11	3.2	9.8	8.4	22	4.1	10.8	422	1099
SEm±	0.71	0.4	0.15	0.21	0.28	0.59	0.14	0.20	8	29
CD (P=0.05)	2.07	1.1	0.43	0.62	0.81	1.73	0.42	0.59	23	84
Fertility levels (F)										
100% RDF (M) + 100% RDF (S)	44	14	4.3	12.1	9.8	27	5.4	12.0	628	1268
100% RDF (M) + 75% RDF (S)	43	13	3.7	11.4	9.4	26	5.2	11.5	574	1207
100% RDF (M) + 50% RDF (S)	40	11	3.1	10.8	8.7	24	4.9	11.4	487	1147
SEm±	0.61	0.32	0.13	0.18	0.24	0.51	0.12	0.17	7	25
CD (P=0.05)	1.79	0.94	0.38	0.54	0.70	1.49	0.36	0.50	20	73
Cropping system										
Intercrop (mean)	42	13	3.7	11.4	9.3	25	5.2	11.7	563	1207
Sole crop	35	18	6.8	15.4	12.9	40	7.0	13.5	1259	2336
SEm±	1.22	0.64	0.26	0.37	0.48	1.02	0.25	0.35	14	50
CD (P=0.05)	2.52	1.33	0.53	0.76	0.99	2.11	0.51	0.72	28	103
Interaction (OxF)										
SEm±	1.23	0.65	0.26	0.37	0.48	1.02	0.25	0.35	14	50
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

M = Maize; S = Soybean; RDF = Recommended dose of fertilizer; DAS = Days after sowing; NS = Non-significant
RDF (M) = 100 : 50 : 25 NPK kg/ha; RDF (S) = 25 : 35 : 25 NPK kg/ha

Application of 100% NPK (RDF) recorded significantly higher seed yield, haulm yield and yield attributes as compared to 75% and 50% RDF. Significant and positive correlation was observed between the yield and yield attributes *viz.*, number of pods/plant, seed weight/plant and 100-seed weight. Prasad *et al.* (1993) also indicated the beneficial effect of fertilizers on yield and yield attributing characters of soybean. Sole crop of soybean recorded significantly higher yield and yield attributes compared to intercrop mean. The results are in conformity with the Kushwaha and Chandel (1997).

The results in the present study clearly brought out that application of FYM @ 7.5 t/ha and 100% recommended NPK of soybean in the maize + soybean intercropping system was found superior and recorded higher growth, yield and yield attributes of soybean.

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Short communication

Effect of aluminium on growth and nutrient content in groundnut

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Groundnut (*Arachis hypogaea* L.) grown in acid soil yielded less than the normal fertile soil. One of the probable reasons may be aluminium toxicity. In acedic soils, solubility of Al is more that results in its toxicity, which is growth limiting factor. Under acedic conditions aluminium can be toxic to plant even at sub micro molar level. The most conspicuous aluminium toxicity is reduction in root growth (Zhov – Rong *et al.*, 1998). Due to intensive leaching and presence of high amount of aluminium oxides, the soil shows a deficiency of nutrients such as N, P and K causing nutrient imbalance (Sehagal *et al.*, 1998). Hence, the present experiment was undertaken to investigate the effect of aluminium on growth and nutrient content in groundnut.

A laboratory experiment was carried out at Department of Plant Physiology, S.V. Agricultural College, Tirupati during *rabi* 2000-2001. The experiment was conducted in RBD with three replications. The seeds of cultivar JL.24 were sown in plastic troughs containing acid washed quartz sand and wetted with glass distilled water. The seven day old seedlings were transplanted to the plastic trough of one litre capacity, containing half strength hoagland nutrient solution. Nutrient solution was supplied one week after transplanting. The respective Al treatments were given to the plants along with nutrient solution (Table 1). The nutrient solution was changed at weekly interval. The plants were harvested at 30 days after transplanting. The data on plant height, root length and leaf area were recorded from the harvested plants. Later the plant parts were separated and dried in hot air oven at 80°C for 48 hours and dry weight, were recorded. The N in leaf, stem and root was estimated by Microkjeldhal method, P by vanedomolybdo phosphoric yellow color method and K by Flame photometer (Jackson, 1967).

There was a significant reduction in leaf number/plant, leaf area/plant, plant height and root length of groundnut cultivar under different levels of Al compared to control (Table 1). Leaf number decreased gradually with the increase in concentration of Al. The decrease in leaf number was more than 40 % at 40 ppm and was more than 75 % at 160 ppm Al compared to control. Same results were observed by Narayanan and Syamala (1987) in pigeonpea. Leaf area of plants decreased significantly with increase in Al concentration of all the treatments.

Table 1 Effect of aluminium on growth and development in groundnut at 30 DAT

Al level (ppm)	Plant height (cm)	Root length (cm)	Leaf number/plant	Leaf area (cm^2/plant)	Dry weight (g/plant)			
					Leaf	Stem	Root	Total dry matter
0	27	26	18	214.6	1.113	1.010	0.406	2.532
10	25	25	14	196.1	0.794	0.800	0.322	1.916
20	21	22	13	188.0	0.560	0.590	0.306	1.457
40	11	19	10	105	0.512	0.412	0.274	1.198
60	8	12	6	63.2	0.314	0.342	0.225	0.881
80	7	9	6	50.2	0.244	0.202	0.192	0.638
160	7	7.3	4	24.5	0.173	0.116	0.142	0.431
SEm±	0.22	0.39	0.50	1.445	0.022	0.023	0.009	0.024
CD (P=0.05)	0.68	1.2	1.56	4.453	0.067	0.07	0.029	0.074

Control plants (0 ppm Al) showed higher leaf area because of more number of leaves and it was reduced more than 50 % at 40 ppm and 85 % at 160 ppm. Similar decrease in leaf area was also reported by Neogy *et al.*, (1999) in mungbean. The reduced leaf number and leaf area of treated plants may be due to reduced gross photosynthesis. The reduction in plant height and root length was more than 50 % and 30 % at 40 ppm and

more than 70 % at 160 ppm Al, respectively compared to control. Root length decreased gradually with increase in Al concentration. Maximum root length was observed in control. Decreased root length at higher concentration was also observed by Zhov–Rong *et al.*, (1998) in groundnut. The main cause for tap root length restriction was due to rapid autolysis of roots tips of Al treated plants followed by disorganisation of plasma lemma which ultimately cause restriction in root elongation (Clarkson, 1965).

N, P and K content in different plants parts decreased with increase in Al (Table 2). Maximum, N, P and K content was observed in leaf, stem and root of control plant. The reduction in N content in stem and root was more than 60 % and 50 % at 160 ppm Al, The decrease in N concentration in different plant parts at increased Al was also reported by Pintro *et al.*, (1996) in corn. The N concentration in different plant parts decreased due to interference of aluminium in N metabolism and translocation of N within the plant. Phosphorus content in leaf reduced by 45 % at 80 ppm Al as compared to control whereas in stem the reduction was 41 % at 40 ppm Al compared to control. These results are in conformity with those of Wagatsuma and Kaneko (1987) in groundnut. The P content in different plant parts decreased due to interference of Al in P metabolism and translocation of P with in the plant. The leaf and stem K content was not affected upto 20 ppm Al level but drastic reduction in content of leaf and stem was observed at 160 ppm Al compared to control. These results are in agreement with those of Narayanan and Syamala (1987) in pigeonpea. According to Bennet *et al.*, (1985) Al interfered with root metabolisum, depressed active ion movement and lowered cation retention capacity of roots. It can be infered that Al at 40ppm caused 50% and at 160 ppm 70% reduction in leaf area, plant height, root length and NPK content in different plant parts in groundnut.

Table 2 Effect of aluminium on NPK content in different plant parts of groundnut

Aluminium level	Concentration of N (%)			Concentration of phosphorus (%)			Concentration of potassium (%)		
	Leaf	Stem	Root	Leaf	Stem	Root	Leaf	Stem	Root
0	2.80	1.92	2.10	0.85	0.87	1.20	2.6	2.4	2.8
10	2.66	1.88	1.68	0.80	0.86	1.20	2.5	2.4	2.7
20	2.57	1.74	1.62	0.75	0.72	1.10	2.3	2.1	2.5
40	2.18	1.34	1.45	0.57	0.51	0.83	1.8	1.6	1.0
60	1.93	1.20	1.39	0.52	0.47	0.74	1.5	1.3	1.6
80	1.43	0.94	1.21	0.46	0.43	0.65	1.2	1.2	1.4
160	1.10	0.59	1.00	0.27	0.21	0.44	0.8	0.9	1.1
SEm±	0.058	0.040	0.058	0.014	0.016	0.75	0.119	0.134	0.096
CD (P=0.05)	0.178	0.127	0.178	0.045	0.049	0.232	0.368	0.413	0.297

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Short communication

Response of sunflower (*Helianthus annuus* L.) to different levels of nitrogen during *rabi* in Northern Telangana

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In Northern Telangana (Andhra Pradesh) sunflower occupies 0.02 m ha area which accounts for 10% of total area in the state (Directorate of Economics and Statistics, 1999-2000). The studies conducted on sandy loam and slightly alkaline soil indicated that significant increase in yield of sunflower has been observed upto 80 kg nitrogen (N)/ha (Pasricha *etal.*, 1991; Legha and Giri, 1999; Narayana and Patel, 2000). However, Sindagi and Virupakshappa, 1987 and Rao *et al.*, 1993 found that application of 40-60 kg N/ha was profitable. As the nitrogen requirement for sunflower hybrids was not studied in this region, the present experiment was conducted to study response of hybrids and a variety to different levels during *rabi*.

Experiments were conducted during *rabi* (September - January) 1992-93 and 1993-94 at RARS, Jagtial, on red sandy loam soil having low organic carbon, pH 7.6, EC 0.22 mmhos/cm, available P_2O_5 7.25 kg/ha and available K_2O 373 kg/ha. Two hybrids, APSH 11 and MSFH 8 and a variety 'Morden' were tested for their response to 5 levels of nitrogen (Table 1). The trial was conducted in split plot design with sunflower hybrids and variety in main plots and N levels in sub-plots and replicated three times. A common level of 60 kg P_2O_5 and 40 kg K_2O/ha was applied uniformly to all plots. The entire dose of P_2O_5 and K_2O along with 1/3 N at sowing was applied. The remaining N in two equal splits was applied at 30 and 50 days after sowing. The crop was irrigated at seeding and later on at 15 days interval. The crop was sown on 9th October, 1992 and 28th September, 1993 at a spacing of 60 cm X 30 cm and harvested in first fortnight of January in both years.

There was no significant interaction effect between varieties and N levels on seed yield of sunflower. The difference in seed yield among variety and hybrids was not significant. The seed yield increased significantly upto 60 kg N/ha in both years. However, beyond 60 kg N/ha the increase in seed yield was non-significant though the increase in seed yield was upto 90 kg N/ha. The increase in yield was due to higher flower head diameter and more seeds/head at higher levels of N compared to '0' N application. The total dry matter production has also showed similar trend. The mean production efficiency of N was 5.5, 6.0, 5.1 and 3.5 kg seed/kg N applied at 30,60,90 and 120 kg N/ha respectively.

The regression analysis of N levels on the seed yield for two years was quadratic and found to be highly significant

$Y = 646.1 + 9.4\ X\ -05\ X\ 2\ R^2 = 0.983$ ..... 1992-93 - (i)
$Y = 527.7 + 7.6\ X\ -02\ X\ 2\ R^2 = 0.979$ ..... 1993-94 - (ii)

The results indicated that in Northern Telangana, application of 60 kg N/ha along with 60 kg P_2O_5 and 40 kg K_2O/ha during *rabi* under irrigated conditions in red sandy loam resulted in significantly increased yield of sunflower.

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Table 1 Effect of nitrogen levels on seed yield and its attributes in sunflower

Treatment	Head diameter (cm)		Filled seeds/head		1000 seed weight (g)		Seed yield (kg/ha)		Total drymatter (kg/ha)	
	1992-93	1993-94	1992-93	1993-94	1992-93	1993-94	1992-93	1993-94	1992-93	1993-94
Varieties										
APSH 11	14	12	348	288	50	58	926	789	3972	2537
MSFH 8	14	12	320	298	53	63	924	914	4471	2976
Morden	13	-	354	-	54	-	917	-	3612	-
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N levels (kg/ha)										
0	12	10	293	226	49	53	659	550	1690	1640
30	14	12	333	256	50	56	855	685	2106	2348
60	14	13	387	322	52	61	1017	911	2716	3107
90	14	13	378	327	58	65	1089	1043	2736	3260
120	14	12	393	334	53	65	992	1068	2807	3429
LSD (P=0.05)	1.0	1.0	60	70	3.9	70	189	197	805	503

J. Oilseeds Res., **19**(1): 119-121 (2002)

Short communication

Effect of sowing date and plant density on phenological behaviour, yield and its attributes in oilseed brassicae

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The final yield of a crop is highly dependent on the genetic constitution and the weather condition, which it encounters during its growth and development. Out of several approaches through which the relationship between weather parameters and crop production can be understood, the crop phenology, is an important aspect, since the biomass production and seed yield are greatly influenced by the prevailing environmental conditions during various crop phenophases. Scanty information exists in the literature, on the effect of different thermal environments on time of occurrence of various phenological events in brassicae. Therefore, a detailed study of crop phenology and yield and its attributes in relation to date of sowing and plant densities has been attempted in the present investigation.

Studies were conducted during *rabi* season of 1996-97 at the Research Farm CCS Haryana Agricultural University, Hisar (29° 10' N, 75° 46' E and 215.2 m a.m.s.l.). The experiment was laid out in split plot design with three replications. The experiment comprised of treatment combinations of three sowing dates *viz.*, Oct. 5th, Oct. 19th and Nov. 24th, two plant densities *viz.*, 30 cm x 15 cm and 40 cm x 20 cm in main plots and four varieties viz., Varuna, Laxmi, RH-30 (all belonging to *Brassica juncea*) and BSH-1 (*B.campestris* var. brown sarson) in sub-plots.

The soil of the test site was sandy loam, slightly alkaline (pH - 7.9) with poor in nitrogen content (195 kg/ha), medium in phosphorus (17 kg/ha) and rich in potash (360 kg/ha). Except the treatment differences, the crop was raised following the full package of practices recommended for brassicae crops in the region. For monitoring the phenological events, the crop was inspected on alternate days. From these observations, emergence (P_1), first flower open (P_2), 50% flowering (P_3), start of seed filling (P_4), end of seed filling (P_5) and physiological maturity (P_6) were identified in all the treatments. The seed yield and its attributes were recorded at harvest in all the treatments.

The calender of the occurrence of different phenological events as influenced by various treatments is presented in Fig.1. The crop duration was shortened in all the varieties with delay in sowing. The delayed sowing reduced the length of latter phenophases, after P_1 and P_2 the duration of which extended in the delayed sown crop. The slow and delayed emergence and flower appearance led to extended vegetative phase in the late sown crop. The delayed convergence of vegetative to reproductive growth under delayed sowing was the result of the fall in ambient air temperature (Prasad, 1989).

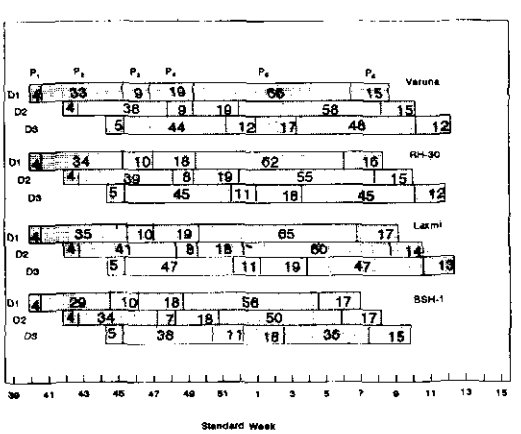

Fig.1: Influence of sowing dates on phenophase development in brassicae cultivars during 1996-97

Another important feature emerged during the study was the significant reduction in duration of P_5 in the delayed sown crop (the phenophase being most important period for development of sink in genus *Brassica*). The duration of P_6 in late sown crop was also shortened because of the forced maturity resulting due to higher day and night temperatures towards end March and April. The present results are in conformity with the earlier reports from Delhi having semi-arid climate where the delayed sowing caused increase in the duration of vegetative phase while duration of flowering, seed filling and maturity phases got reduced (Prasad, 1989).

Among the varieties, BSH-1 had the shortest crop duration irrespective of sowing date. The duration of P_2 and P_5 had higher variations among the varieties. The duration of various phenophases described above was within the range reported for *Brassica* spp. Under semi-arid environment of Delhi (Prasad, 1989).

The seed yield and its attributes as influenced by experimental treatments in two crop seasons are presented in Table-1. The delay in sowing affected the yield attributes along with the seed yield and harvest index (HI) adversely and the effect was significant during both years. The crop sown on Oct. 5th put forth the highest number of primary branches, produced maximum; number of siliquae/m^2, maximum seeds in a siliqua and boldest seeds which ultimately resulted in highest seed yield and harvest index among three sowing dates. The performance of crop sown on Nov. 5th was poor as it yielded only 1001 kg/ha owing to significantly poor yield attributes. Results of the present study are in agreement with the earlier reports of Jain *et al* (1986), Singh and Narang (1988) and Suresh *et al.* (1992).

There was no effect of plant densities on seed yield and its attributes. Non-significant differences between two plant densities could be expected because of higher buffering capacity of the *Brassica* spp., which by putting forth a higher number of primary, secondary and tertiary branches covered the available space (Patel *et al.*, 1980; Singh *et al.*, 1990).

Among the varieties, RH-30 and Laxmi recorded maximum seed yield and were significantly superior to Varuna and BSH-1 in both the years because of better yield attributes in the earlier two varieties. The poor development of yield attributes in BSH-1 was because of low yield potential, which had a short crop duration and poor edyotype with no secondary branches. The lower seed yield of Varuna among *B.juncea* cultivars was due to its low siliquae bearing and poor test weight. The total biomass production was highest in Laxmi followed by RH-30, Varuna and lowest in BSH-1. Almost similar result have earlier been documented by Suresh *et al.* (1992).

Table 1 Effect of sowing dates and plant densities on seed yield and its attributes in brassicae varieties (1996-97)

Treatment	Siliquae/m^2	Seeds/ siliqua	1000-seed weight(g)	Seed yield g/m^2	Primary branches	Seed yield (kg/ha)	Biological yield (kg/ha)	Harvest index
Sowing Dates								
5-10-96	3959	13	5.7	299	6	2510	1460	0.17
19-10-96	3705	13	5.3	258	6	2320	1360	0.17
5-11-96	2244	11	4.4	111	6	1010	880	0.11
CD(P=0.05)	186	0.6	0.4	17	NS	60	153	0.01
Plant Densities								
30x15cm	3237	12	5.1	216	6	1950	1280	0.15
40x20cm	3369	12	5.2	229	6	1940	1280	0.15
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Varieties								
Varuna	3357	12	5.6	236	7	2240	1240	0.18
RH-30	3546	12	6.2	2833	7	2390	1280	0.19
Laxmi	3670	13	5.7	276	7	2380	1370	0.17
BSH-1	2638	11	3.1	96	5	770	1140	0.07
CD (P=0.05)	198	1.1	0.4	15	0.3	100	125	0.01

I Varuna; RH-30; Laxmi (*Brassica juncea*)

II BSH-1 (*Brassica campestris* var. brown sarson)

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J. Oilseeds Res., **19**(1): 122 (2002)

Short communication

Performance of mustard under different dates of sowing in Bhal and coastal agro-climatic zone of Gujarat

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In Bhal and Coastal agro-climatic zone of Gujarat, mustard [*Brassica juncea* (L.) Czern & Coss] is a new introduction. Information on the behaviour of this thermo and photo sensitive crop under different planting dates is lacking. Hence an investigation was made to study the effect of dates of sowing on mustard yield in this region.

The experiment was conducted during the winter seasons of 1992-93, 1993-94 and 1994-95 at Regional Research Station, GAU, Arnej. The soil was salt affected having pH 8.3, and EC 1:2.5 0.42 ds/m, low in available N and P_2O_5 and high in available K_2O. Rainfall received during 1992-93, 1993-94 and 1994-95 was 620.5, 523.8 and 876.2 mm, respectively. No rain was received during life period of the crop in any of the years. Five dates of sowing (September 30th, October 20th, October 30th and November 10th were tried in R.B.D. with four replications. The seeds of mustard cv. GM-1 were dibbled by keeping a distance of 45 cm x 15 cm. Fertilizer 30 kg N + 15 kg P_2O_5/ha was drilled in the sub-surface moist layer locally known as '*Dhada*'.

The differences in plant stand due to different sowing dates were found significant during all the three years of experimentation (Table-1). Crop sown on October 20th recorded the highest plant stand at harvest during all the three years and in pooled analysis followed by October 30th sown crop. Plant stand in early sown crop (September 30th and October 10th) was adversely affected by high temperature 35°C prevailing at the time of sowing whereas, in delayed sowing plant stand was hampered due to poor soil moisture content at the time of sowing.

Seed yield of mustard was significantly influenced by sowing dates in all the years (Table-1). Planting done on October 20th gave the highest yield. It was at par with October 10th sowing during 1992-93 and 1994-95. Early or delayed sowings resulted in a significant yield reduction. This might be the fact that temperature and soil moisture played a major role for yield of mustard under conserved moisture condition. Rajput *et al.* (1991) also reported similar results.

It is therefore concluded that the period between 10th to 20th October was most suitable for sowing of mustard under conserved moisture conditions of Bhal and Coastal agro-climatic zone of Gujarat State.

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Table 1 Seed yield (kg/ha) and plant stand per net plot (14.58 m^2) of mustard as influenced by different dates of sowing

Sowing date	Years			Pooled
	1992-93	1993-94	1994-95	
30th September	95 (14)	312 (27)	427 (25)	278 (22)
10th October	676 (125)	526 (101)	842 (109)	681 (112)
20th October	748 (147)	835 (145)	855 (151)	812 (148)
30th October	414 (140)	661 (139)	517 (143)	531 (141)
10th November	262 (136)	372 (126)	179 (122)	271 (128)
S.Em±	62 (4)	52 (2)	35 (3)	70 (3)
C.D (P=0.05)	190 (11)	161 (5)	109 (8)	229 (9)

Figures in parenthesis are plant stand

J. Oilseeds Res., **19**(1): 123-124 (2002)

Short communication

Comparative performance of *Brassica* species to varying fertility levels under mid-hill conditions of Himachal Pradesh

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Rapeseed and mustard occupy an important place in the cropping pattern of Himachal Pradesh, particularly in mid-hill region. These *Brassica* species are exhaustive in nature with well developed root system, due to which their nutritional requirements are higher. Since information, on fertilizer management of new improved varieties under varying farming situations in mid-hills of Himachal Pradesh is meagre, the present investigation was therefore, undertaken.

A field experiment with 12 treatments consisting of three *Brassica species, viz.*, 'KBS-3' brown sarson (*Brassica campestris* L.), 'Sheetal' gobhi sarson (*Brassica napus* L.) and 'PCC-5' Ethiopian mustard or Karan rai (*Brassica carinata* A. Br.) with four fertility levels was conducted during *rabi* season of 1996-97 at the Experimental Farm of Agronomy Department, CSKHPKV, Palampur situated at 1290 m altitude (Table 1). The experiment was laid out in RBD with three replications. The soil of the experimental site was silty clay loam in texture having pH 5.6, organic carbon 0.78 % and available N, P, K and S being 382.5, 17.8, 293.5 and 52.4 kg/ha, respectively. Urea, single superphosphate and muriate of potash were used as source of N, P and K, respectively. The N was given in three splits i.e. half at sowing along with full dose of P_2O_5 and K_2O while remaining half of N was top-dressed in two equal splits at flowering and siliquae development stage, as per the treatments (Anon.,1999). The crop was sown on 18th October at row to row distance of 45 cm while plant to plant spacing of 20 cm was maintained after 20 DAS by thinning. The mean maximum temperature ranged between 12.1°C to 30.9°C whereas mean minimum temperature ranged between 2.9°C to 19°C on weekly data basis with 286.8 mm rainfall during the crop growth period. Out of the three *Brassica species*, 'KBS-3' brown sarson matured in 195 days while 'sheetal' gobhi sarson and 'PCC-5' Karan rai matured in 204 and 212 days, respectively.

Table 1 Effect of fertility levels on plant growth, yield attributes, yield, harvest index and economics of *Brassica* species

Treatment	Plant height (cm)	No. of primary branches/ plant	No. of siliquae/ plant	No. of seeds/ siliqua	1000-seed weight (g)	Yield (kg/ha)		Harvest index (%)	Net returns (Rs/ha)	Net returns/ Re-invested
						Seed	*Straw*			
***Brassica* species**										
Brassica campestris L.	119	8	287	17	3.7	1537	6648	19.12	15721	1.70
Brassica napus L.	127	7	300	19	3.7	1628	8276	16.32	18391	2.10
Brassica carinata A.Br.	169	11	394	14	4.4	1985	12188	13.96	26415	2.89
CD (P=0.05)	7.3	1.0	29.3	1.1	0.13	105	580	0.45	1691	0.20
Fertility levels (N : P_2O_5 : K_2O kg/ha)										
F_0 (Control)	109.3	6	162	15	3.7	802	4244	16.26	6716	0.99
F_1 (50 : 40 : 30)	132.2	8	270	16	3.9	1348	7612	16.02	14763	1.81
F_2 (100:60:45)	147.6	9	407	18	4.0	2240	10738	17.96	27273	2.96
F_3 (150:80:60)	164.9	11	470	18	4.1	2477	13554	15.63	31949	3.17
CD (P=0.05)	8.4	0.9	33.8	1.2	0.15	122	670	0.52	1953	0.24

Application of 150 kg N+80 kg P_2O_5+60 kg K_2O/ha significantly increased the plant height, primary branches/plant, siliquae/plant, seeds/siliqua and 1000-seed weight and finally the seed and straw yield (Table 1). Increase in fertility levels also resulted in consistent increase in harvest index from control to 100 kg N+60 kg P_2O_5+45 kg K_2O/ha while further increase in fertility level resulted in significant decrease in harvest index. The magnitude of increase in yield with the application of 150 kg N+ 80 kg P_2O_5+60 kg K_2O/ha compared to control, 50 kg N+40 kg P_2O_5+30 kg K_2O/ha and 100 kg N+60 kg P_2O_5+45 kg K_2O/ha was recorded 208.9, 83.8 and 10.6% in seed yield, and 219.4, 78.1 and 26.2 % for straw yield, respectively. Similar results were also reported by Ahmed *et al.* (1989) and Singh *et al.* (1994).

The economic returns increased with increase in fertility levels and significantly maximum net returns were obtained with application of 150 kg N+80 kg P_2O_5+60 kg K_2O/ha compared to lower doses. Similar trend was found with respect to net returns per rupee invested.

Brassica species, Karan rai produced significantly taller plants, more number of primary branches/plant, siliquae/plant and 1000-seed weight. Seed and straw yields were also found significantly higher in Karan rai followed by *gobhi sarson* and brown *sarson*, respectively. While harvest index was found significantly higher in brown *sarson* followed by *gobhi sarson* and Karan rai, respectively. However, number of seeds/siliqua were registered significantly higher in *gobhi sarson*. The increase in seed yield of Karan rai was found to the tune of 29.1 and 21.9 % over brown *sarson* and *gobhi sarson*, respectively. Ahmed *et al.* (1989) and Thakral *et al.* (1996) also recorded higher seed yield of Karan rai compared to brown sarson and gobhi sarson.

Net returns were found significantly highest in Karan rai followed by *gobhi sarson* and brown *sarson*, respectively.

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Short communication

Effect of nitrogen and *Azospirillum* on yield attributes and yield of sesame under rainfed conditions

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Nitrogen is one of the costly and expensive input for getting higher yields. In rainfed sesame, high cost of nitrogen fertilizers with low yielding crop necessiated to find cheap and non-renewable alternate resource through suitable biofertilizers. The application of which is one of the technologies in modern agriculture. These microbial inoculants have attained special significance in recent times. These are low cost, non-bulky agricultural inputs which could play a significant role in plant nutrition as a supplementary/ complementary factor. *Azospirillum* is a non-symbiotic associative micro-aerophilic nitrogen fixer. Hence, it was felt necessary to study the effect of nitrogen and *Azospirillum* on yield attributes and yield of sesame.

The experiment was laid out in a split - plot design, replicated thrice. The main - plot treatments consisted of three varieties *viz.*, Madhavi (V_1), VRI-1 (V_2) and TMV-3 (V_3) and sub-plot treatments consisted of six nitrogen levels *viz.*, No nitrogen (T_1), Azospirillum at 3 kg/ha as soil treatment (T_2) , recommended dose nitrogen 60 kg N/ha (T_3) Azospirillum + 50% recommended dose of nitrogen (T_4), *Azospirillum* + 75% recommended dose of nitrogen (T_5) and *Azospirillum* + 100% recommended dose of nitrogen (T_6). *Azospirillum* was applied @ 3 kg/ha as soil treatment by placement to all plots. The soil of the experimental site was red sandy loam in texture with pH 6.8 low in organic carbon (0.29%) and available N (138.7 kg/ha) and medium in P(10.2 kg/ha) and K (139.7 kg/ha). The fertilizers were applied by band placement in furrows made with hand hoe at a depth of 5 cm at the time of sowing. Sesame seeds were treated with Mancozeb (@ 3 gm/kg seed). The seeds are mixed with sand in the ratio of 1:3 to facilitate uniform distribution. The spacing adopted in sesame was 30 x 10 cm. Need based plant protection measures were adopted. The crop was harvested at physiological maturity.

The number of capsules/plant and number of seeds/ capsule were higher in Madhavi followed by TMV-3 and VRI-1. Lower number of capsules/plant might be due to its poor vegetative growth in terms of plant, LAI and dry matter accumulation during reproductive phase. Krishnae Gouda and Krishnamurthy (1977) also reported variation in number of capsules/plant in different varieties. Application of nitrogen at 60 kg N/ha resulted in more number of capsules and seeds per capsule which were at par with 45 kg N/ha + *Azospirillum*.

Due to sufficient nitrogen supply, vigorous growth and development of plant, better sink source relationship and capsule development might have ultimately resulted in more number of capsules/plant present findings are in agreement with Thakur and Borulkar (1980). During capsule formation stage heavy rains with high doses of fertilizers resulted in more disease and pest infestation. The phyllody incidence was more at 60 kg N/ha + *Azospirillum*.

Madhavi yielded higher followed by TMV-3 and VRI-1. The increase in seed yield was mainly due to number of capsules/plant, seeds/capsule and test weight. Significant differences were observed due to interaction of varieties and fertilizer treatments. Application of 60 kg N/ha gave higher seed yield which was on a par with 45 kg N/ha + *Azospirillum* and it was on a par with 30 kg N/ha + *Azospirillum*. Similar results were observed in all three varieties. The seed yield increased with 45 kg N/ha + *Azospirillum*, 30 kg N/ha + *Azospirillum*, the percent of increase was 97.5, 93.7 respectively over 60 kg N/ha alone. These results are in accordance with findings of Arunachalam and Venkatesan (1984). Stalk yield was significantly influenced due to varieties, fertilizers treatments and interaction. Maximum stalk yield of VRI-1 was due to more total drymatter production.

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Table 1 Yield attributes and yield as influenced by interaction of sesame varieties and fertilizer treatments

Treatment	Capsules/plant			Seeds/capsule			Seed yield Kg/ha			Stalk yield Kg/ha		
	V_1	V_2	V_3	V_1	V_2	V_3	V_1	V_2	V_3	V_1	V_2	V_3
T_1	10	8	9	17	13	14	103	100	103	220	227	226
T_2	11	9	10	20	17	16	123	115	115	233	280	241
T_3	30	20	23	32	25	27	400	267	347	548	850	721
T_4	25	19	21	28	23	26	375	240	330	497	682	586
T_5	27	20	23	29	23	27	390	258	342	536	761	707
T_6	19	14	17	25	23	23	328	210	285	615	869	729
	SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)		SEm ±	CD (P=0.05)	
V	0.10	0.43		0.19	0.76		1.74	6.81		2.07	8.13	
T	0.22	0.67		0.19	0.56		3.74	10.78		5.59	16.12	
T x V	0.39	1.16		0.32	0.97		6.48	18.68		3.64	27.93	
V x T	0.29	0.88		0.45	1.45		4.70	13.94		6.09	17.90	

No nitrogen (T_1); *Azospirillum* at 3 kg/ha **as soil treatment** (T_2); recommended dose of fertilizer nitrogen 60 kg N/ha (T_3), *Azospirillum* + 50% recommend dose of nitrogen (T_4), *Azospirillum* + 75% **recommended dose of** nitrogen (T_5); *Azospirillum* + **100%** recommended dose of nitrogen (T_6)
Madhavi (V_1); VRI-1 (V_2); TMV-3 (V_3)

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Short communication

Production potential of castor intercropping with legumes under rainfed conditions

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Castor is an important oilseed crop of Andhra Pradesh mainly cultivated in Nalgonda, Mahboobnagar and Rangareddy districts. The state ranks second in India next only to Gujarat occupying an area of 3.92 lakh hectares and producing 1.30 lakh tonnes of seed (Directorate of Economics and Statistics, 2000-01). The crop is unique in its adaptation to coarse textured soils with poor fertility and aberrant weather. This owes to its hardy growth with deep tap-root system. It is a long duration crop with slow growth habit in the initial stages and It is grown in wider rows. These features offer a potential scope to inter crop short duration and quick growing legumes to exploit the land and resources more efficiently. This warrants an evaluation of the compatibility *vs.* the competitive effects of different legumes for inter cropping in castor. Several research workers evaluated the influence of legume inter crop components on castor (Prasad and Verma, 1986; Prasad *et al.*, 1989; Rajput and Srivastava, 1996). However, the results of these investigations were highly inconsistent. This prompted an experiment to be conducted to explore the compatible legumes for intercropping in castor cv. Kranti.

The experiment was conducted at the College Farm, ANGRAU, Rajendranagar in the rainy season during 1997. The experiment site was sandy loam in texture. The soil was slightly alkaline with 8.0 pH and EC of 0.20 dS/m. The fertility status was low in available nitrogen (192.4 kg/ha N), medium in phosphorus (28.7 kg/ha P_2O_5) and potassium (302 kg/ha K_2O). The crop was sown on 2nd July, 1997. There was a rainfall of 494 mm in 29 rainy days during the crop growth period.

The experiment was laid out in randomised block design. Two rows of groundnut, green gram, black gram and soybean were intercropped in castor spaced at 90 x 20 cm and 3 rows of these components in 60 / 120 x 20 cm paired row planting of castor besides sole crop of castor grown in uniform 90 x 20 cm and paired row planting of 60 / 120 x 20 cm. The sole crops of legumes were the dummy treatments. There were three replications. The varieties chosen for groundnut, green gram, black gram and soybean were TMV-2, ML-267, T-9 and MACS-201 respectively. Castor cv. Kranti was fertilized with 60 kg N, 40 kg P_2O_5 and 20 kg K_20 /ha. Additional fertilizers were supplemented to groundnut, green gram or black gram in proportion to the intercrop density related to the sole crops ought to be fertilized with 20: 40: 20 kg / ha N , P_2O_5 and K_2O. The intercropped soybean was fertilized with proportionate dose scheduled for its sole density at 60:50:40 kg /ha N, P_2O_5 and K_2O. Black gram matured in 65 days, green gram in 85 days, soybean in 90 days and groundnut in 107 days. The castor beans were picked at 107, 124 and 138 days after sowing.

The spatial configuration of castor grown in equidistant or paired rows had no significant influence on the number of spikes / plant. The length of the primary, secondary or tertiary spikes, the number of capsules/spike and seed yield/spike were also unaltered (Table 1). This indicated that the pairing of rows did not increase the intra-specific competition. Thus the wider rows between the pairs provided a scope to accommodate more number of rows of intercrop components than in castor sown in equidistant rows. Intercropping reduced the number of spikes/plant of castor. The reduction was significant by intercropping groundnut, greengram, blackgram or soybean. The length of the primary and secondary spikes and number of capsules of these spikes were also significantly reduced by intercropping the legumes in paired rows of castor compared to sole castor. The intercropped groundnut was less harmful to castor than greengram or blackgram while soybean was most competitive. This trend was persistent both in equidistant and paired row planting pattern of castor. The seed yield / spike also reduced owing to the inter-specific competitive effect for resources that reduced the number of spikes and capsules / spike of the primaries and secondaries. The length of tertiary spikes, number of capsules and seed yield were less affected by intercropping groundnut, greengram or blackgram. But, the intercropped soybean significantly reduced these yield components in both equidistant and paired row planting of castor.

Table 1 Influence of intercropping legumes on yield components of castor

Treatment	No. of spikes/ plant	Length of spike (cm)			No. of capsules/spike			Seed yield/spike (g)			Total
		Primary	Secondary	Tertiary	Primary	Secondary	Tertiary	Primary	Secondary	Tertiary	
Equidistant rows											
Castror+groundnut	5.1	25.7	26.4	21.7	34.4	29.5	25.4	25.5	25.7	22.3	72.3
Castor + greengram	4.2	25.2	24.6	20.4	33.1	26.6	22.8	24.8	23.6	22.0	70.4
Castor + black gram	4.4	24.6	24.4	17.8	32.6	29.7	19.4	24.6	22.6	18.9	66.1
Castor + soybean	3.8	21.7	23.5	17.7	29.5	24.5	19.7	22.7	21.4	17.6	61.7
Paired rows											
Castor + groundnut	3.6	23.7	24.4	20.4	32.5	26.8	22.7	23.1	22.9	20.7	66.7
Castor + greengram	4.2	22.6	22.7	18.4	30.5	25.0	20.4	22.8	19.7	18.4	60.9
Castor + black gram	3.3	22.4	23.7	18.6	31.3	26.3	20.7	21.9	20.4	17.9	60.2
Castor + soybean	3.1	22.2	22.7	19.5	27.5	21.9	16.3	20.9	19.1	15.2	56.2
Castor uniform rows	4.7	27.3	30.7	22.6	38.5	33.5	23.9	30.5	24.3	23.6	78.4
Castor paired rows	5.9	29.6	31.0	25.7	40.6	33.1	28.1	32.4	28.5	26.8	87.7
SEm±	0.3	1.1	1.5	1.5	1.9	2.1	1.6	1.8	1.9	1.8	-
CD (P = 0.05)	0.9	3.4	4.6	4.5	5.7	6.3	4.6	5.2	5.5	5.2	-

The seed yield of castor was not significantly reduced by intercropping two rows of groundnut, greengram blackgram or soybean in equidistant rows. The yield of these intercrops was bonus (Table 2). The intercropping of two rows of groundnut in equidistant rows of castor was that most potential system. It provided maximum castor grain equivalent yield. The LER was also more i.e., 1.70. This indicated that the land was efficiently utilized to harvest 70% more production by intercropping groundnut in the otherwise unutilized row spaces of castor. The four legume intercrop components significantly reduced the yield of castor in paired row planting. This could possibly be due to the higher density of intercrop components between the paired rows of castor, which competed more stiff for resources and were thus more dominant than in equidistant rows. The effect of soybean was more serious than blackgram, greengram or groundnut. The yield of intercrops was also low in paired than in equidistant rows of castor. Hence, the low yield both of castor and intercrops in paired row than in equidistant rows of castor substantially reduce the castor equivalent yield. The LERs ranged from 1.38 to 1.50. They were low than in the equidistant rows.

The study highlighted that two rows of groundnut or alternatively greengram or blackgram can be intercropped in castor spaced at 90 x 20 cm to obtain bonus intercrop yield without affecting the yield of castor and thereby realized 52 –70 % more productivity from unit land area under rainfed conditions of Andhra Pradesh.

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Table 2 Effect of intercropping legumes on yield, castor equivalent and LER

Treatment	Yield (kg/ha)		Castor equivalent	LER
	Castor	Intercrop		
Equidistant rows				
Castor + groundnut	1789	930	3184	1.70
Castor + greengram	1733	577	2745	1.52
Castor + blackgram	1780	594	2894	1.53
Castor + soybean	1710	822	2482	1.50
Paired rows				
Castor + groundnut	1638	816	2863	1.50
Castor + greengram	1552	510	2445	1.32
Castor + black gram	1595	524	2578	1.35
Castor + soybean	1544	769	2265	1.38
Equidistant rows	1816			
Paired rows	1880			
Sole groundnut		816		
Sole greengram		996		
Sole black gram		1065		
Sole soybean		1485		
SEm±	41		43	0.02
CD (P = 0.05)	123		132	0.07

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Short communication

Screening of safflower (*Carthamus tinctorius* L.) genotypes for salinity tolerance

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Safflower (*Carthmus tinctorius* L.) Is an important oilseed crop of arid and semi arid regions of Maharashtra where salinity either in soil or irrigation water is commonly noticed. Since good water for reclamation of salt affected soils is not available in this region, breeding genotypes, combining high yields and tolerance to salinity is the only method of increasing safflower production. The present study was therefore undertaken to screen promising genotypes of safflower for different levels of salinity under laboratory conditions.

Twenty five safflower genotypes were selected for this study and the experiment was conducted in laboratory at room temperature in September, 2000. The salt solutions having electrical conductivity (EC) 4,6,8 dS/m at 25°C were prepared in distilled water by dissolving $NaHCO_3$, $NaSO_4$, $CaCl_2$ and $MgCl_2$ and the ratio of Cl : SO_4 : HCO_3 was maintained as 2:1:1 in each level (More and Malewar, 1988). The germination study was carried out in petri - dishes on cotton pads covered with filter paper. The twenty five seeds were placed in each dish. The treatment combinations of 25 varieties and 3 salinity levels were attained in completely randomised design with three replications. The laboratory study was carried up to 20 days. The germination count was taken 4th and 14th day and final count at 20th day. The observations on germination, shoot : root length ratio, relative water content and osmotic potential were recorded at 20th day after sowing.

The data on germination as influenced by levels of salinity (Table 1) revealed that most of the varieties of safflower germinated at EC 4 dS/m. PBNS-32 recorded highest germination (76%) followed by S-13-5 (70%) at EC 8 dS/m. Rai (1977) and Patil *et al.* (1992) also recorded reduction in germination of safflower at higher salinity levels.

The shoot : root length ratio at 20th day after sowing was low with PBNS-32 at all salinity levels. All genotypes recorded narrow shoot: root length ratio at lower levels of salinity. At EC 8 dS/m the genotypes PBNS-1-5-7, JSI-103 and Neera recorded more shoot : root length ratio as compared to other genotypes.

Relative water content of leaf tissue of safflower reduced with increasing levels of salinity. At EC 4 dS/m, PBNS-32 showed 95% relative water content and it was reduced to 88% at EC 8 dS/m. The relative water content of safflower genotypes ranged from 80 to 88% at EC 8 dS/m. The genotypes S-13-5, and S-13-6 recorded more than 85% relative water content in leaf tissue and rest of the safflower genotypes showed relative water content below 85% at salinity 8 dS/m.

Osmotic potential of leaf tissue sap was also highest with safflower genotypes PBNS-32 at all the salinity levels. The osmotic potential of leaf tissue decreased with increaseing salinity levels. Safflower genotype Neera recorded lowest osmotic potential of leaf tissue at all salinity levels. Repp *et al.*, (1959) reported that salinity tolerant plants ability to accumulate salts in cellular fluid leading to increased osmotic potential.

Thus the studies on screening of safflower genotypes for salt tolerance under laboratory conditions revealed that PBNS-32, S-13-6 HUS-305 and A-1 exhibited better performance than other genotypes at higher under NATP ROPS-16.

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Table 1 **Effect of different levels of EC on germination shoot : root length ratio, relative water content and osmotic potential at 20th day after sowing**

Genotype	Germination (%)			Shoot : root length ratio (cm)			Relative water content (%)			Osmotic potential (-bars)		
	4 dS/m	6 dS/m	8 dS/m	4 dS/m	6 dS/m	8 dS/m	4 dS/m	6 dS/m	8 dS/m	4 dS/m	6 dS/m	8 dS/m
A-1	91	87	69	0.46	0.70	0.75	86	84	82	9.18	12.17	17.46
HUS-305	89	86	69	0.41	0.50	0.79	93	87	85	4.34	09.45	10.06
BHIMA	80	78	50	0.43	0.74	0.35	86	84	82	9.49	12.55	18.04
MANJIRA	85	79	55	0.47	0.93	1.90	85	83	81	10.34	15.01	19.39
SHARDA	85	80	60	0.52	0.99	1.90	84	83	81	11.33	15.55	19.82
JSI-7	81	79	52	0.50	1.00	1.53	85	83	82	7.35	13.56	19.37
DSH-129	86	81	61	0.44	0.72	1.56	87	84	83	8.90	11.69	16.76
NEERA	85	79	57	0.55	2.14	2.90	85	83	80	13.22	16.18	20.32
PBNS-119	87	81	63	0.44	0.52	1.04	90	85	84	6.37	10.97	13.19
PBNS-12	89	81	69	0.43	0.53	0.54	89	84	84	7.06	11.04	14.04
PBNS-32	92	88	76	0.34	0.50	0.51	95	89	88	3.88	08.20	08.24
PBNS-28	89	86	69	0.41	0.54	0.65	91	86	85	5.15	10.08	11.50
TARA	87	83	66	0.42	0.54	0.97	90	85	84	6.01	10.66	12.61
S-13-5	91	83	70	0.37	0.50	0.59	95	88	86	4.15	08.60	09.04
JLSF-344	87	83	66	0.40	0.55	0.94	88	84	84	7.33	11.15	14.75
S-13-6	89	86	69	0.40	0.50	0.73	92	87	86	4.70	09.88	10.80
NARI-2	88	85	69	0.41	0.54	1.54	91	88	85	5.74	10.28	12.25
JSI-99	89	86	69	0.40	0.53	0.83	91	86	85	5.44	10.34	12.08
NARI-10	86	81	63	0.43	0.53	1.71	89	84	84	6.64	10.63	13.58
JSI-93	87	82	65	0.44	0.57	1.23	87	84	85	8.03	11.33	15.23
PBNS-10	87	83	66	0.44	0.55	1.68	87	84	83	8.35	11.47	15.51
JSI-97	87	84	66	0.45	0.54	1.48	88	84	84	7.66	11.29	14.97
JSI-103	87	81	65	0.45	0.57	2.31	87	84	83	9.59	13.04	18.52
PBNS-1-5-7	89	81	61	0.48	0.61	2.93	86	84	82	8.35	11.75	16.56
LOCAL	56	13	00	1.50	2.92	0.00	00	00	00	0.00	00.00	00.00
SEm ±	4.5	5.4	5.2	0.30	0.31	0.58	1.81	1.67	1.19	0.46	0.33	0.21
CD (P =0.05)	12.3	14.8	14.3	0.84	0.87	1.60	5.01	4.62	3.30	1.28	0.93	0.60

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Short communication

Productivity and economics of niger (*Guizotia abyssinica* Cass.) based intercropping systems in Satpura plateau zone of Madhya Pradesh

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Niger [*Guizotia abyssinica* (L.f.) Cass.] is generally grown as mixed crop with small millets or other crops to minimize the agricultural risks in Satpura Platue Zone of M.P., particularly under aberrant weather conditions. Suitable intercropping system can be more efficient practice of farming to maximize the productivity and profits besides minimization of agricultural risks (Kaushik *et al.*, 1980). Hence the present investigation was under taken to identify the suitable and remunerative niger intercropping system for the Zone.

Field experiments were conducted at Zonal Agricultural Research Station Chhindwara (MP) for three years during rainy season of 1994 to 1996. The soil of the experimental field was sandy loam with 7.0 pH having organic carbon (0.55%); low in available N (240 kg/ha) available P_2O_5 (18 kg/ha) and high in available K_2O (600 kg/ha) contents. The rainfall was 1108, 628 and 716 mm during crop seasons in 1994, 1995 and 1996 respectively. Ten treatments consisting of four sole croppings and six intercropping system *viz.*, intercropping of niger in *kodo, kutki* and *bajra* with 1:1 and 2:2 row proportion at 30 cm apart were tested in randomized block design with three replications. Crop varieties were CHH-1, JK-76, Dindori-1 and Nath Hybrid for niger, *kodo, kutki* and *bajra* respectively. Sowing of these crops was done on 18,29 and 31 July during 1994, 1995 and 1996 respectively by using 5,30,10 and 10 kg seeds/ha for the respective crops in their sole stands but quantity of seeds was adjusted proportionately to the area of the crop components in intercropping systems. A uniform fertilizer dose of 20 kg N+20 kg P_2O_5+10 kg K_20 ha was given to all treatments at the time of sowing. Advantages of each cropping systems were evaluated on the basis of niger equivalent, LER and monetary returns.

Grain yields

Seed yield of niger got reduced in all intercropping systems over its pure stand during each year but the reduction was maximum when it was intercropped with *bajra* (Table 1). As an intercrop *bajra* gave relatively higher grain yield than others by confirming the views of (Tiwari *et al.*, 1994; Thakur *et al.*, 1997). Seed yields of niger were maximum when intercropped with *kodo* under both (1:1 or 2:2 row) planting geometry during good rainfall year (1994 and 1995). *Kutki* as a intercrop also reduced the yield of niger over its pure stand but reduction in yields was almost similar to that of *kodo*. *Bajra* being a tall growing and dense canopy crop proved more aggressive (shading effect) hence it resulted for maximum reduction in yield of niger. Niger + *bajra* intercropping was on top during poor rainfall year, 1996.

Niger equivalent

Though seed yield of niger was quite low than the grain yields of *kodo, kutki* and *bajra* in their sole stands, niger being a high value crop had maximum niger equivalent. (Table 1). Intercropping of *kodo* with niger resulted into maximum niger equivalent during 1994 and 1996 among all the intercropping systems because of high yield of *kodo*. But niger + *bajra* was best during 1995 because of increased yield of *bajra* during 1995 under poor rainfall situation. However niger + *kodo* showed consistency by producing good niger equivalent. In general 2:2 row spatial arrangement gave higher niger equivalent than 1:1 row associations under all intercropping systems. Increased yields of associated crop almost with the same yield of main crop under 2:2 row proportion may be the reason for it.

Land equivalent ratio (LER)

All intercropping systems proved better than the sole stand of either crop in terms of yield. However, niger + *bajra* intercropping systems were inferior than others. Niger + *kutki* had the maximum LER'S which was comparable to niger + *kodo* intercropping system. Intercropping of niger + *kodo/kutki* were superior in 2:2 row proportion than 1:1 while results were reversed in case of niger + *bajra*.

Monetary advantages

Niger + *kodo* intercropping systems under both spatial arrangements gave significantly higher gross monetary return (Rs. 9673 and Rs.9451/ha) and net return (Rs.6907 and Rs. 6685/ha) than all other intercropping systems. But sole niger was at par to niger + *kodo* intercropping system. Niger + *kodo* intercropping under both row associations registered higher benefit cost ratio than sole niger. Niger + *kutki* also recorded the better benefit cost ratio after these treatments. Remaining treatments proved less remunerative than sole niger.

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Table 1 Grain yield and niger equivalent in niger based inter cropping systems

Intercropping system	Grain yield (kg/ha)						Niger equivalent (kg/ha)			
	1994		1995		1996		1994	1995	1996	Mean
	Niger	Intercrop	Niger	Intercrop	Niger	Intercrop				
Niger sole	898	-	602	-	772	-	898	602	772	757
kodo sole	-	2078	-	1993	-	1973	686	590	552	609
Kutki sole	-	1571	-	1448	-	1449	478	417	406	434
Niger + *Kodo* (1:1)	574	1166	405	978	494	783	959	671	714	781
Niger + *Kodo* (2:2)	579	1185	414	1005	511	775	990	683	728	800
Niger + Kutki (1:1)	*571*	*917*	*401*	*790*	*475*	*711*	*851*	*628*	*674*	*718*
Niger + *Kutki* (2:2)	580	890	411	805	488	695	851	641	683	725
Niger + *Bajra* (1:1)	435	1134	227	2396	258	1180	709	775	555	680
Niger + *Bajra* (2:2)	432	1056	217	2280	262	1142	729	794	569	697
CD (P=0.05)	-	-	-	-	-	-	63	100	56	-

Price (Rs/q) : 1994- niger, *kodo,kutki* and *bajra* - 1150, 380, 350 and 280; 1995- Niger, *kodo, kutki* and *bajra*- 1250, 370, 360 and 300.
1996- Niger, *kodo, kutki* and *bajra* - 1250, 350, 350,and 325

Table 2 Land equivalent ratio (LER) and economics of niger based intercropping system (mean of 3 years)

Intercropping system	Grain yield (kg/ha)		LER					
	Niger	Intercrop	Niger	Intercrop	Total	GMR (Rs/ha)	NMR (Rs/ha)	Benefit cost ratio
Niger sole	757	-	10	-	1.0	9173	6383	3.29
Kodo sole	-	2016	-	1.0	1.0	7395	4654	2.70
Kutki sole	-	1489	-	1.0	1.0	5259	2519	1.92
Bajra sole	-	2470	-	1.0	1.0	7574	4611	2.56
Niger +*Kodo* (1:1)	491	976	0.7	0.5	1.1	9451	6685	3.42
Niger +Kodo (2:2)	507	986	0.7	0.5	1.2	9673	6907	3.50
Niger +*Kutk* (1:1)	483	806	0.6	0.5	1.2	8698	5932	3.14
Niger +*Kutki* (2:2)	493	795	0.7	0.5	1.2	8784	6019	3.18
Niger +*Bajra*(1:1)	305	1570	0.4	0.6	1.0	8259	5383	2.87
Niger + *Bajra* (2;2)	307	1493	0.4	0.6	1.0	8772	5895	3.05
CD (P=0.05)	035	105	-	-	0.05	568	568	0.21

GMR - Gross monetary return, NMR - Net monetary return

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Short communication

PBS 23007 - A promising groundnut advanced breeding culture with multiple pest resistance

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A multiple pest resistant virginia groundnut (*Arachis hypogaea* L. sub sp. *hypogaea* var. *hypogaea*) culture PBS 23007 was developed at the National Research Centre for Groundnut (NRCG), Junagadh (latitude 21°31'N', longitude 70°36'E), following bulk-pedigree method of selection. It is a high yielding elite groundnut advanced breeding culture with multiple pest resistance. It is moderately resistant to early leaf spot (*Cercospora arachidicola Hori*), late leaf spot [*Phaeoisaripsis personata* (Berk, & M.A. Curtis) Van Arx; syn *Cercospridium personatum* (Berk. & M.A. Curtis) Deighton], rust (*Puccinia arachidis* Spegazzini), leaf miner (*Aproaerema modicella* (Deventer), tobacco caterpillar (*Spodotera litura* Fab.), gram pod borer (*Helicoverpa armigera* Hubner), leaf hoppers (*Empoasca kerri* Pruthi) and thrips (*Caliothrips indicus* Bagnall). It also suffers less seed infection due to *Aspergillus flavus* Link ex Fries colonization.

PBS 23007 originated from a single plant selection made in F_5 bulk of the cross GG 11 x NC Ac 2230. GG 11 is a high yielding popular virginia cultivar released for the Saurashtra region of Gujarat, India (Bandyopadhyay and Manivel, 2001). NC Ac 2230 is a mutant germplasm line of North Carolina State University, USA [received from ICRISAT, Hyderabad as ICG No 5041 (NRCG No.6686], belongs to the virginia group and have resistance to leaf hoppers and thrips (Anonymous, 1985). The single plant selection made in the F_5 generation was progeny rowed, and the selected plants at the time of harvest were grouped into two bulks based on their similarity in agronomic characters (including growth habit, yield, disease reaction etc.,). The two bulks were designated as B_1 and B_2 and were grown again. In subsequent generations, the process of selection and bulking was repeated until the selected bulks stabilized. The pedigree of the PBS 23007 is [GG 11 x NC Ac 2230]-F_5-P_1-B_2-B_1-B_1-B_1.

In six protected and replicated yield trials (four in *Kharif* and two in summer season) during 1994 to 1998 at NRCG, PBS 23007 had 24% higher pod yield than the check cultivar Kadiri 3 (Table 1). The average yield of PBS 23007 in these trails was 1933 kg/ha. The maximum yield realized was 3633 kg/ha.

In two trials conducted at NRCG in two *kharif* seasons (1996 and 1997) under fungicide free conditions, PBS 23007 obtained an average score of 4.4 for early leaf spot 4.5 for late spot and 4.9 for rust (Table 2), on a field scale of 1 to 9 (where 1= no disease, 9= 81-100% disease incidence, Subrahmanyam *et al.*, 1995), compared with rating of 6.0, 7.1 and 6.3 respectively, for Kadiri 3 (Samdur *et al.*, 1999a). PBS 23007 showed moderate resistance to *Aspergillus flavus* as it had 33% seed colonization under artificially inoculated condition compared to 70% in the check M 13.

PBS 23007 showed field tolerance to leaf miner in tests conducted for two *kharif* seasons (1995 and 1996) at NRCG (with an average field score of 3.2 compared with 7.2 for JL 24 on a scale of 1-9). PBS 23007 was screened along with other cultures inside net house under artificial condition for aphid and thrips in two-seasons (*kharif* 1997 and summer 1998). It had an average score of 2.8 on 1-5 scale (Bakhetia, 1980) for aphid incidence as against 4.0 for the susceptible check JL 24. When number of thrips' eggs per leaves was counted, PBS 23007 had 6.1 eggs/ leaf as against 8.9 eggs/leaf in the susceptible check JL 24 (Samdur *et al.*, 1999b).

PBS 23007 was screened together with other genotypes for gram pod borer and tobacco caterpillar in the laboratory under choice test by putting the genotypes in pairs. In all genotypes, two leaflets of similar maturity were allowed to be fed for 24 hours. Leaf area eaten was recorded in cm^2. Leaf damage was 48 and 50% for gram pod borer and tobacco caterpillar, respectively, as compared to 92 and 95% damage in the check NCAc 17090. Based on this test PBS 23007 was categorized as moderately resistant to gram pod borer and tobacco caterpillar.

Table 1 Performance of groundnut culture PBS 23007 and check cultivar Kadiri 3 in yield evaluation trials at NRCG, Junagadh

Genotype	Pod yield (kg/ha)						Mean
	Summer, 1994	*Kharif*, 1994	*Kharif*, 1996	Summer, 1997	*Kharif*, 1997	*Kharif*, 1998	
PBS 23007	3633	1235	1820	1740	1699	1471	1933
Kadiri 3	2722	1105	1630	1257	1350	1284	1558
Increase over Kadiri 3 (%)	33.47**	11.76	19.38*	38.42**	25.85*	22.35*	24.10**

* = *significant*, ** = *highly significant*

Table 2 Disease scores (on 1-9 scale) of culture PBS 23007 for major foliar fungal diseases

Genotype	*Kharif*, 1996			*Kharif*, 1997			Mean		
	ELS	LLS	Rust	ELS	LLS	Rust	ELS	LLS	Rust
PBS 23007	5.1	5.0	5.4	3.7	4.1	4.5	4.4	4.5	4.9
Kadiri 3	5.8	6.8	7.8	6.2	7.4	4.9	6.0	7.1	6.3
ICGS 44	6.1	7.2	7.3	6.1	7.8	7.4	6.1	7.5	7.4
SEm ±	0.2	0.3	0.3	0.3	0.3	0.2			
CD (P=0.05)	0.5	0.8	0.7	0.7	0.7	0.6			

ELS= early leaf spot, LLS= Late leaf spot

PBS 23007 has a decumbent-3 growth habit (*IBPGR and* ICRISAT, 1992), alternate branching, and small elliptic green leaves with acute leaf tip. It has 6 primary and 15-20 secondary branches. It matures in ≅ 118 days in the *kharif* and ≅ 125 days in summer at Junagadh. The pods are slightly reticulated and constricted with moderate beak. The pods are mostly two seeded (three seeded being occasional), with an average shelling outturn of 70%. The seed are rose in colour, weigh 47 g/100 seeds, and contain 52% oil and 22% protein.

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Short communication

Efficacy of different insecticides against leaf hopper, *Empoasca kerri* Pruthi on groundnut

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Groundnut crop at one or the other stage of its growth is subjected to an attack by various insect pests, such as leaf hopper (*Empoasca kerri* Pruthi), aphid (*Aphis craccivora* Koch.), thrips (*Caliothrips indicus* Bagnall), mite (*Tetranychus telarius* Linnaeus) and gram caterpillar (*Helicoverpa armigera* (Hubner) Hardwick) etc. Among these pests, leaf hopper is one of the most serious pests causing 40.34 % yield loss (Shetgar *et al.*, 1992a). Vyas (1983) reported 20.45 % loss due to this pest. However, 25 % loss in groundnut pod yield was recorded due to leaf hopper at Junagadh (Anonymous, 1994). A wide range of insecticides have used against this pest. Hence efforts have been made to evaluate most effective insecticides against this pest.

The field experiment was conducted during *kharif*, 1998 at College Farm, College of Agriculture, G.A.U., Junagadh. Eleven insecticides (Table 1) were evaluated along with untreated control in randomized block design with three replications having a plot size of 5.0m X 4.2m in GG-20 variety of groundnut. All the recommended agronomic practices were followed.

Table 1 Efficacy of different insecticides against jassid, *E. kerri*, on groundnut during kharif 1998

Treatment	Mean percent mortality of leaf hopper after hours or days							
	First spray				Second spray			
	1 day	3 days	5 days	7 day	1 day	3 days	5 days	7 days
Methyl-o-demeton 0.025%	76.45* (94.50)	75.83 (94.00)	74.17 (93.05)	73.24 (91.69)	74.98 (93.28)	75.16 (93.44)	74.04 (92.44)	73.65 (92.08)
Dimethoate 0.03%	73.58 (92.01)	71.89 (90.33)	71.84 (90.28)	72.25 (90.70)	74.28 (92.66)	73.04 (91.49)	72.51 (90.97)	72.86 (91.32)
Monocrotophos 0.04%	77.41 (95.25)	78.49 (96.02)	77.02 (94.95)	73.32 (91.76)	77.83 (95.55)	78.20 (95.82)	76.17 (94.28)	74.95 (93.26)
Endosulfan 0.07%	46.29 (52.24)	46.77 (53.08)	45.09 (50.16)	45.11 (50.19)	46.19 (52.08)	46.65 (52.88)	45.34 (50.60)	44.67 (49.43)
Imidacloprid 0.006%	79.66 (96.77)	79.99 (96.98)	79.68 (96.79)	80.06 (97.02)	79.76 (96.84)	79.30 (96.55)	79.79 (96.86)	78.88 (96.28)
Quinaphos 0.05%	39.41 (40.33)	44.43 (49.00)	31.72 (27.65)	29.18 (23.78)	34.42 (31.96)	38.09 (38.05)	38.46 (38.68)	36.03 (34.60)
Cypermethrin 0.009%	37.66 (37.33)	35.01 (32.91)	35.73 (34.10)	29.48 (24.21)	36.25 (34.97)	33.16 (29.91)	32.98 (29.63)	28.27 (22.43)
Fenobucarb 0.05%	70.91 (89.31)	71.22 (89.64)	71.79 (90.24)	69.54 (87.79)	70.65 (89.02)	71.40 (89.83)	70.80 (89.19)	69.41 (87.63)
Acephate 0.075%	53.10 (63.95)	56.46 (69.48)	61.50 (77.24)	67.03 (84.77)	53.34 (64.35)	56.09 (68.87)	60.79 (76.18)	66.68 (84.33)
Cartap hydrochloride 0.1%	62.62 (78.85)	67.27 (85.07)	66.71 (84.37)	67.68 (85.58)	63.92 (80.67)	65.31 (82.55)	66.53 (84.14)	67.69 (85.58)
Azadirachtin 0.00075%	31.91 (27.94)	33.19 (29.96)	35.85 (34.30)	34.76 (32.50)	31.99 (28.07)	34.36 (31.85)	34.47 (32.04)	37.80 (37.56)
SEm±	3.34	4.41	3.22	3.91	3.73	3.28	3.57	4.68
CD (P=0.05)	9.87	13.00	9.51	11.53	11.01	9.68	10.53	13.82
CV (%)	9.82	12.71	9.43	11.60	11.05	9.61	10.44	13.71

* *Arcsin √percentage* transformation. Figures in parentheses are retransformed values.

Uniformly two sprayings were done, first at 45 and second at 75 days after germination with the help of knapsack sprayer. The population was recorded from the three younger compound leaves on the main branch of ten randomly selected plants in morning hours before spraying and at 1 day, 3 days, 5 days, and 7 days after spraying. Corrected percent mortality due to treatment were calculated as per the formula modified by Henderson and Tilton (1955). The yield of pod and fodder was recorded from each net plot and the data were subjected to analysis of variance and cost benefit ratio was also worked out for each treatment.

It is evident from the results presented in Table 1 that application of imidacloprid 0.006 % was found significantly superior in reduction of population (96.28 to 97.02%), when the observations were recorded at 1 day, 3 days as well as 5 and 7 days after both the sprays. However, it was at par with the treatment of monocrotophos 0.4%, methyl-o-demeton 0.025% dimethoate 0.03% and fenobucarb 0.05% as they also gave 91.76 to 96.02, 91.69 to 94.50, 90.28 to 92.66 and 87.63 to 90.24% mortality of leaf hopper nymphs, respectively. Cartap hydrochloride 0.1% was found next in order of efficacy with 78.85 to 85.58 % mortality of the pest. Further, the treatment acephate 0.075% and endosulfan 0.07% were found moderately effective with 63.95 to 84.77 and 49.43 to 53.08% mortality of the pest. The remaining treatments *viz.*, quinalphos 0.05 %, azadirachtin 0.00075% and cypermethrin 0.009% were found less toxic to leaf hoppers as they registered 22.43 to 49.00% mortality. Wide rang of chemicals have been used by earlier workers (Patel and Vora, 1980; Patel *et al.*, 1989; Faquir, 1998).

The highest pod and fodder yields, being 1425 and 2208 kg/ha, respectively, were obtained form the plots treated with monoctotophos 0.04%. However, it was at par with imidacloprid 0.006%, methyl-o-demeton 0.025%, fenobucarb 0.05%, dimethoate 0.03%, cartap hydrochloride 0.1% and acephate 0.075% (Table 2). The increase in pod and fodder yield over control was also maximum (32.80 and 40.19 %, respectively) in the treatment with monocrotophos 0.04%. The highest cost benefit ratio was obtained in the treatment with monocrotophos 0.04% (1:10.68) and it was followed by methyl-o-demeton 0.025 % (1:9.20), dimethoate 0.03 % (1:8.35) and fenobucarb 0.05 % (1:7.70). The treatment of imidacloprid 0.006% (1:4.71) and acephate 0.075% (1:3.36) gave moderate cost benefit ratio. However, the remaining treatments showed comparatively lower cost benefit ratio.

Table 2 Yield and economics of different insecticidal treatments applied for the control of groundnut leaf hopper, *E. kerri*

Treatment	Cost of insecticides Rs/lit or kg	Total cost of insecticides including labour charge (Rs/ha)*	Average yield (kg/ha)		Per cent increase in yield		Total realization over control (Rs/ha)	CBR**
			Pod	Fodder	Pod	Fodder		
Methyl-o-demeton 0.025%	510	441	1366	2117	27.30	34.41	4058	1:9.20
Dimethoate 0.03%	240	364	1290	2010	20.22	27.62	3039	1:8.35
Monocrotophos 0.04%	290	455	1425	2208	32.80	40.19	4857	1:10.68
Endosulfan 0.07%	*225*	*595*	*1150*	*1785*	*7.18*	*13.33*	*1134*	*1:1.91*
Imidacloprid 0.006%	2400	988	1410	2185	31.41	38.73	4654	1:4.71
Quinalphos 0.05%	250	650	1105	1728	2.98	9.71	537	1:0.83
Cypermethrin 0.009%	550	318	1115	1745	3.91	10.79	674	1:2.12
Fenobucarb 0.05%	350	485	1342	2080	25.07	32.06	3733	1:7.70
Acephate 0.075%	600	780	1260	1950	17.43	23.81	2619	1:3.36
Cartap hydrochloride 0.1%	1000	2200	1275	1985	18.83	26.03	2835	1:1.29
Azadirachtin 0.00075%	300	1750	1095	1700	2.05	7.94	389	1:0.18
Control	-	-	1073	1575	-	-	-	-

* The labour charges has been calculated @ Rs.50/-ha/spray
** The price of groundnut pod and fodder has been calculated @ Rs.12/kg and Rs. 1/kg, respectively.

Considering the effectiveness, yield and economics of different insecticides, monocrotophos 0.04%, methyl-o-demeton 0.025%, dimethoate 0.03% and fenobucarb 0.05%were found superior than imidacloprid 0.006% and acephate 0.075% for the control of leaf hoppers. Upadhyay (1984) found that monocrotophos 0.05 % gave highest pod and fodder yields, however, dimethoate 0.03% was found most economical treatment. According to Purohit (1991), the highest yield of groundnut was recorded in methyl-o-demeton 0.025% followed by dimethoate 0.03%. Two applications of monocrotophos 0.04% was found superior in respect of pod and fodder yield as well as cost benefit ratio as reported by several workers Ghorpade and Thakur (1989), Shetgar *et al.* (1989 and 1992b) and Patil *et al.* (1992). Thus the findings are in accordance with the earlier reports.

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Short communication

Behavioural response of cabbage butterfly (*Pieris brassicae* L.) to different genotypes of rapeseed-mustard

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Cabbage butterfly (*Pieris brassicae* L.) is widely distributed in all the states in north and north eastern hill regions in India. This pest has a wide host range (Rataul 1959). The present studies on the oviposition and feeding response of *P.brassicae* were carried out to identify the resistant/tolerant genotypes of rapeseed-mustard.

Twelve genotypes of rapeseed-mustard belonging to *Brassica napus* (GSL-1, GSL-2 , PGSH-51 and PBCM-1159) *B. juncea* (purple mustard, NDRC-190, YSRLC-9-26, RL-1359 and PBCM-1159), *B.campestris* (TL-15 and BSH-1) and *B.carinata* (PC-5) were sown in earthen pots and in the field. In pots thinning was done and only one plant was retained per pot. Larvae of *P.brassicae* were collected from mustard fields and reared on fresh leaves of mustard in laboratory to get uniform aged larvae and adults for conducting the experiments on oviposition and feeding preferences during December 1999 to March 2000.

The oviposition preference of *P.brassicae* was studied on twelve different genotypes in a multiple choice test with four replications under the screen-house conditions. A total of 240 pots (5 pots/genotype/replication) each having one plant were placed randomly in a screen-house. There were four replications and five plants (pots) represented one replication. Twenty pairs (male and females) of adult butterflies collected from culture maintained in glass jars were released on the test plants at flowering stage. The position of the pots were changed daily. Egg laying was examined on all plants regularly after three days of release till the mortality of all the females. Egg distribution on upper and lower leaf surface, stem,, leaf petiole and inflorescence of *Brassica* genotypes was also examined.

The feeding preference of *P.brassicae* was studied in a multiple choice test with four replications under laboratory conditions. Leaf discs of known area of different genotypes were cut and placed at equal distance along the periphery of plastic tub (35 cms diameter, 1.25 cms depth) and fifty second instar larvae were released in the centre of each tub. The tub was covered with moist muslin cloth. Observations on feeding behaviour of the pest were recorded on number of larvae feeding on each genotype after 4, 6 and 8 hours of release. The leaf area consumed was also determined after two days by using the graphic method.

Oviposition preference of *P.brassicae*

The results indicated that the maximum eggs of *P.brassicae (26.9 eggs/plant) were recorded in month of* March while minimum (0.8 eggs/plant) in January irrespective of *Brassica* genotypes (Table-1). Mean number of eggs/plant (37.7) was maximum on GSL-1 followed by PC-5 (30.2), purple mutant (*B.juncea*) and GSL-2 (*B.napus*) were the least preferred genotypes for oviposition as these remained free from eggs throughout the season. During February, the females preferred to lay more eggs/plant (65.6) on *B.carinata* (PC-5) followed by *B.juncea* (31.6) YSRL-9-26. The oviposition on the remaining genotypes ranged from 0.1 to 8.9 eggs/plant which was statistically on par with each other. However, two genotypes namely Purple mutant and GSL-2 remained free from eggs of *P.brassicae* whereas six more genotypes i.e. TL-15 and BSH-1 (*B.campestris*), PBCM-1159 and NDRC-190 (*B.juncea*) and PGSH-51 and 124 (*B.napus*) were also less preferred for egg laying by the pest. During March significantly highest eggs/plant (150.7) were laid on GSL-1 (*B.napus*) a long maturity genotype which were on par with the number of eggs laid/plant on PC-5 (44.9) and RL-1359 (19.5). Therefore, purple mutant and GSL-2 were considered as non-preferred hosts whereas PC-5 and GSL-1 were considered as most preferred hosts, for oviposition by *P.brassicae*. Present findings are in line with Tiwari and Kashyap (1988) who reported that *P.brassicae* selected only cruciferous plants for egg laying and no eggs were laid on wheat, gram and pea. Maximum eggs were laid on cabbage while few eggs were recorded on sarson. Ives (1978) reported that *Artogeia rapae* preferred to oviposit on cabbage followed by kale, brussel sprouts and radish. Cabbage butterfly laid more eggs on savoy than on red and smooth green varieties (Latheef and Irwin, 1979).

Table1 Oviposition preference of *P.brassicae* on different genotypes of rapeseed mustard during 1999-2000

Genotype	Number of eggs/plant				Mean*
	December	January	February	March	
Brassica napus					
GSL-1	0.0	0.00	0.0(1.00)	150.7(9.84)	37.7
GSL-2	0.0	0.00	0.0(1.00)	0.0(1.00)	0.0
PGSH-51	0.0	0.00	3.9(1.76)	13.5(3.29)	4.3
PGSH-124	0.0	0.00	0.0(1.00)	28.4(3.42)	7.1
B. juncea					
Purple mutant	0.0	0.00	0.0(1.00)	0.0(1.00)	0.0
NDRC-190	6.2	2.30	7.4(2.68)	0.0(1.00)	3.96
YSRLC-9-26	12.5	3.15	31.6(5.14)	2.5(1.58)	12.4
RLC1359	0.0	0.00	8.9(2.27)	79.5(8.64)	22.1
PBCM-1159	0.0	0.00	1.6(1.43)	0.0(1.00	0.4
B.campestris					
TL-145 (*Toria)*	0.0	0.00	7.3(2.11)	0.0(1.00)	1.8
BSH-1 (Brown *Sarson*)	0.0	0.00	5.8(2.27	3.5(1.71	2.3
B.carinata					
PC-5	6.9	3.50	65.6(8.04)	44.9(6.53)	30.2
CD (P=0.05)	NS	NS	(2.23)	(3.34)	-
Mean	2.1	0.8	10.9	26.9	-

* Mean of four replications each based on 5 plants; **Parenthesis are** √(n+1) transformations.

Oviposition sites of P.brassicae:

Mean number of eggs 23.3 on lower surface and 2.3 on upper surface were recorded in March. However, only 11.56,, 5.6, 3.8 and 1.6 eggs were recorded on the upper surface of leaves on the genotypes PC-5, YSRLC-9-26,, PGSH-51 and PBCM-1159, respectively in February. In March, on genotype GSL-1, out of 150.67 eggs 130.45 eggs were recorded on lower surface while 4.00 on upper surface of leaf. Similarly, in other genotypes too lower surfaces of leaf was ;more preferred for egg laying. Similar results were obtained by Stewarts and Sears (1988) as they recorded about 91% of eggs of *Artogeia rapae* on lower surface of cauliflower leaves. However, Rataul (1959) reported that eggs were laid on both upper and lower surface of leaves by *P.brassicae*. No egg laying was observed on leaf petiole, inflorescares and stem except few eggs noted on stem of GSL-1 during March. In December and January, negligible egg laying was noted.

Feeding preference of *P.brassicae* larvae

However, differences were statistically non-significant which indicated that larvae were non selective in their behaviour and all the genotypes were equally preferred for feeding by the larvae.

After 6 hours: The number of larvae feeding on each genotype was minimum (1.58) on PGSH-51 and PBCM-1159 and maximum (6.75) on RL-1359 but differences were statistically non-significant. Hence, none of the genotype could be designated as preferred/non preferred by the larvae.

After 8 hours: Feeding preference after 8 hours of release, was more or less the same as observed at 6 hours after release of the larvae. The minimum (1.33) number of larvae were recorded on PBCM-1159 and maximum (7.08) on RL-1359.

The pooled analysis of data indicated significant differences among different genotypes for feeding preference. The minimum number of larvae (1.41) were recorded on PBCM-1159 which was statistically on par with PGSH-51(1.64), Purple mutant (1.81) and BSH-1(2.03), hence were considered as the least preferred genotypes. The maximum number of larvae (5.92) were found feeding on NDRC-190 which was on a par with RL-1359 (5.69) and GSL-1 (5.03). Accordingly, these genotypes proved as highly preferred hosts. Remaining genotypes were moderately preferred. Tiwari and

Kashyap (1988) also reported *P.brassicae* larvae preferred *B.campestris* Var. *sarson* followed by *B.juncea* var.*botrytis* and *B.juncea* for feeding. Likewise, Verma *et al.* (1981) found that red leaved varieties "Red Pickling" and "Large Blood Red" had good tolerance to caterpillars of *P.brassicae*.

Leaf area consumed after 2 days

The leaf area consumed after 24 hours of release of larvae was minimum (3.86 mm^2) in Purple mutant followed by PSH-51 (5.08 mm^2),, BSH-1 (5.25 mm^2) and PBCM-1159 (5.46 mm^2) These genotypes were categorized as least preferred. The maximum area (7.28 mm^2) consumed was recorded on NDRC-190 which was designated as the highly preferred genotype.

It is concluded that *P. brassicae* larvae remained confined to a particular genotype on which they initially seittled as there was negligible inter genotype movement of larvae except in case of RL-1359, in which number of initially attracted larvae were 3.50 which rose to 6.75 larvae at 6 HAR and 7.08 at 8 hours after release (HAR). Taking this as an exception in general it was confirmed that the food selection was not exercised by the larvae of *P.brassicae*. Mitchell (1977) also reported that larvae were non selective in their choice of food plants. Latheef and Irwin (1979) also found that there were no significant difference in the feeding performance of cabbage butterfly among Kale, Indian mustard and turnip. Myers (1985) also reported, host selection took place at egg laying and larvae did not select plants but grew better on the plants where the eggs were laid by female butterfly.

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J. Oilseeds Res., **19**(1): **141** (2002)

Short communication

Susceptibility of mustard genotype to leaf webber, *Crocidolomia binotalis* Zeller

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The larvae of mustard leaf webber, web the leaves together and feed on them from the lower surface. They destroy the inflorescence, tender pods and the skin of the stem, often completely skeletonising them (Atwal, 1976). The mustard leaf webber is one of the major pests causing considerable pod damage (13.2 to 81.8 %) to the mustard crop especially in South India (Reddy and Ali, 1977).

The field trials were conducted at the Farm, College of Agriculture, Gujarat Agricultural University, Junagadh during *rabi* 1995-96 and 1996-97. Eight genotypes *viz.*, Gujarat Mustard-1 (GM-1), Varuna, Bio-902, MJ-91-149, MJ-93-197, MJ-94-205, MJ-91-149, MJ-93-46, MJ-94-205, SKM-93-46 and SKM-92-66 were sown in a randomized block design with three replications. The plot size was 4.00 x 0.90 m, row to row distance was 45 cm and plant to plant distance was maintained at 15 cm. Observations were recorded at weekly intervals starting from germination till the crop maturity. Ten plants were randomly selected from each plot to record the number of larvae of mustard leaf webber.

Looking to the overall mean incidence of leaf webber presented in (Table 1) variety Varuna and genotype SKM-92-66 were least susceptible to this pest as they registered less than 1 larva/10 plants and were at par with each other. On the other hand, the genotype MJ-93-197 was the most susceptible as 6 larvae/10 plants. However, this genotype remained at par with SKM-93-46, MJ-91-149 and MJ-94-205. Remaining cultivars *viz.*, Bio-902 and GM-1 were moderately susceptible to leaf webber with 4 larvae/10 plants each.

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Table 1 Population of leaf webber, *Crocidolomia binotails* Zeller on different genotypes of mustard (1995-96 and 1996-97) Pooled data

Genotype	Mean larvae/10 plants during different week after sowing								Mean population
	4th	5th	6th	7th	8th	9th	10th	11th	
GM-1	0.97*ab (0.54)	1.22ab (0.99)	1.68a (2.32)	1.89bc (3.07)	2.56cd (6.05)	2.67b (6.63)	3.03b (8.68)	1.56ab (1.93)	1.96b (3.34)
Varuna	0.71a (0.00)	0.71a (0.00)	0.94a (0.38)	0.94a (0.38)	1.13a (0.78)	1.45a (1.60)	1.73a (2.49)	1.11a (0.73)	0.92a (0.35)
Bio-902	0.71a (0.00)	0.97ab (0.54)	1.03a (0.66)	1.14ab (0.80)	2.19bc (4.30)	2.88bc (7.79)	3.47bc (11.54)	1.98bc (3.42)	1.91b (3.15)
MJ-91-149	0.71a (0.00)	0.88ab (0.27)	0.88a (0.27)	1.31ab (1.22)	2.46cd (5.55)	3.59c (12.39)	3.92c (14.87)	2.25c (4.56)	2.23bc (4.47)
MJ-93-197	1.13b (0.78)	1.43b (1.54)	1.67a (2.29)	2.17c (4.20)	2.91cd (7.97)	3.41bc (11.13)	4.10c (16.31)	2.01bc (3.54)	2.49c (5.70)
MJ-94-205	0.71a (0.00)	1.07ab (0.64)	1.35a (1.32)	2.24c (4.52)	2.68cd (6.68)	3.15bc (9.42)	3.47bc (11.54)	2.11bc (3.95)	2.20bc (4.34)
SKM-93-46	0.79a (0.12)	1.16ab (0.85)	1.33a (1.26)	2.22c (4.42)	3.07d (8.92)	3.59c (12.39)	3.85c (14.32)	2.36c (5.07)	2.47c (5.60)
SKM-92-66	0.79a (0.12)	0.94ab (0.38)	1.05a (0.60)	1.45abc (1.60)	1.50ab (1.75)	1.69a (2.36)	1.84a (2.89)	1.20a (0.94)	1.22a (1.00)
SEm. ±	0.09	0.17	0.23	0.22	0.22	0.23	0.22	0.16	0.15

* Figures in parentheses are retransformed values of $\sqrt{X + 0.5}$

Figures with same alphabet in respective columns did not differ significantly at (P=0.05) as determined by Duncan's New Multiple Range Test

J. Oilseeds Res., **19**(1): **142-143 (2002)**

Short communication

Effect of reducing sugars on mustard aphid, *Lipaphis erysimi* (Kalt.) fecundity in mutants of *Brassica juncea* (L.) Czern & Coss.

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Several factors are responsible in determining the host by an insect-pest (Painter,1951) but presence or absence of specific food material in respect of quality or quantity in the host is very important factor for consideration. Therefore, to understand the aphid-plant relationship in *Brassica juncea (L.)* Czern & Coss, the effect of reducing sugars in relation to mustard aphid (*Lipaphis erysimi (Kalt.)*) resistance was investigated on elite mutants after induction of variability through physical and chemical mutagenesis.

Three genetically diverse varieties of Indian mustard, *viz.* RH-30, RH-8113 and Kranti were used for the present study. The physical mutagen (gamma rays 80, 100 and 120 kR) and chemical mutagen (ethyl methyl sulphonate, 0.75, 1.00 and 1.25%) and their combinations were used to induce the variability for the metric, biochemical traits and aphid resistance. Three hundred treated seeds of each of 30 treatments including three controls were sown in a randomized block design with three replications (100 seeds/replication/treatment). M_2 generation (seed from M_1 bulk) was raised. Selection was done in M_2 generation and advanced to M_3 generation to see the stability of induced variability for the said characters. The dried seeds of the identified elite mutants and control were analysed as per Hulme and Narain (1931) for estimation of reducing sugars. Since, the aphid feeds on inflorescence and siliquae so the biochemical constituents of the seed are directly influenced by the pest feeding. Hence dry seeds are used for estimating the reducing sugars.

For fecundity estimation of mustard aphid on M_3 generation, five gravid females of the pest were taken from laboratory reared population. Such females were released individually on leaf discs of 2.5 x 2.5 cm size for each identified mutant in small petri dishes. The fecundity of females on each mutant was observed for 10 days. Later on the average fecundity/female/day mutant/control was calculated to know the relationship with reducing sugars.

Results revealed that in M_2 generation, the treatment in varieties RH-30 and RH-8113 did not show increase in reducing sugars over the control (Table 1). Treatment 60 kR+0.5% EMS in variety RH-30 had significant reduction in values for reducing sugars as against control. Four treatments in variety RH-8113 and five in Kranti also showed reduction. The range observed for this attribute was from 3.7 % (120 kR in Kranti) to 5.1 % (Control, RH-8113).

In M_3 generation, none of the treatments in any of the variety could exceed the control for reducing sugars content. Two treatments, 120 kR and 60 kR+0.5 % EMS in RH-30 had significantly lower mean values than the control. Only one treatment, 80 kR in RH-8113 exhibited significantly lower percentage of reducing sugars than the control. In Kranti, all treatments had lower values than the control. This character ranged from 3.7 % (60 kR+0.5% EMS in RH-30) to 5.0 % (control, RH-8113).

The content of reducing sugars in treatment 60 kR+0.5% EMS (P_1) in RH-30 increased in M_3 generation and also the aphid population/fecundity. The control (Variety, RH-8113) had the highest reducing sugars content and so also the aphid population and the average fecundity. Also, in variety Kranti, the control has the higher content of reducing sugars and the average fecundity. Other treatments except a few had low content of reducing sugars and hence the average fecundity of the pest. A very high correlation existed between M_2 and M_3 generation of the mutants and no correlation existed with the reducing sugar content. The content has been influenced by the infestation of mustard aphid in both the generations.

The amount of reducing sugars favoured the average fecundity of mustard aphid. More reducing sugars in dry

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seeds was found associated with high aphid population/fecundity, while seven mutants (100 kR and 0.75% EMS in RH-30, 100 kR and 120 kR in RH-8113 and 80 kR, 40 kR + 0.625% EMS and 50 kR + 0.375% EMS in Kranti) have low reducing sugar content, were highly resistant to mustard aphid. Malik (1981) observed more reducing sugars in susceptible genotypes, whereas Kundu and Pant (1967) did not find any correlation between two factors. Contrary to the present findings, Gill and Bakhetia (1985) observed significant negative correlation between reducing sugars and aphid population in *Brassica napus*.

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Table 1 Reducing sugar and fecundity of mustard aphid (*Lipaphis erysimi* Kalt.) in M_2 and M_3 generations of identified mutants

Variety		Treatment	Reducing sugar		Average fecundity/female/day on M_3 generation
			M_2 generation	M_3 generation	
RH-30	Gamma rays	80 kR	4.83	4.70	5.60
		100 kR	4.38	3.93	5.60
		120 kR	4.67	4.47	5.64
	EMS	0.70%	4.59	4.54	5.76
	Gamma rays+EMS	40 kR+0.625%	4.36	-	-
		50 kR+0.375%	4.20	-	-
		60 kR+0.500%	3.84	4.31 (P_1)	6.84
				3.68 (P_2)	5.29
	Control		4.49	4.56	5.86
RH-8113	Gamma rays	80 kR	4.31	4.29	4.42
		100 kR	5.01	5.87	5.54
		120 kR	4.51	4.57	6.24
	EMS	0.75%	4.65	4.56	6.23
	Gamma rays+EMS	40 kR+0.625%	4.48	-	-
		50 kR+0.375%	5.00	4.99	5.92
		60 kR+0.500%	4.80	-	-
			5.15	5.01	7.27
Kranti	Gamma rays	80 kR	4.36	4.34	6.05
		100 kR	4.05	-	-
		120 kR	3.69	3.48	6.96
	Gamma rays+EMS	40 kR+0.625%	4.19	4.23	5.75
		50 kR+0.375%	4.18	4.19	5.18
		60 kR+0.500%	3.83	3.83	5.25
	Control		4.67	4.79	6.74
	CD (P=0.05)		0.44	0.45	0.58

r_{23} = 0.1246 NS r_{13} = 0.063 NS r_{12} = 0.847 * (sig)

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J. Oilseeds Res., **19**(1): 144-145 (2002)

Short communication

Impact of different dates of sowing on the incidence of *Caliothrips indicus* (Bagnall) on linseed

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Linseed is grown for its seed which is rich in oil (33-47%) and fibre. All parts of the linseed plant are utilized commercially either directly or after processing. The linseed oil is non edible and due to its quick drying property about 80% of linseed oil is used for preparation of paints, varnishes, printing ink, oil cloth, soap, patent leather and water proof fabrics. Linseed oil is also used in the process of cementing of roads and in antibiotics in U.S.A.. The residue cake remaining after the oil extraction contains about 3% oil and 36% protein (Gill, 1987). In India, Madhya Pradesh ranks first in yield and acerage, followed by Uttar Pradesh and Maharashtra. In M.P. the average productivity of linseed is 334 kg/ha as against Chhattisgrarh, which is very low. It is a major crop grown as "Rice-utera" and also as a main crop during "*rabi*" season in Chhattisgarh (Damondaram, and Hegde, 1999). Several insect-pests infest the crop from vegetative to maturity causing considerable damage (Rai, 1976; Deshmukh *et al.*, 1992) of which *Caliothrips indicus* (Thysanoptera : Thripidae) is recognized as a key pest causing 37.5% loss in yield (Rawat and Kaushik, 1983).

A field experiment was carried out during *rabi* season of 1998-99 at the Indira Gandhi Krishi Vishwavidyalaya, Raipur in split plot design with four dates of sowing as main plot treatment and two varieties Kiran and Neelum as sub-plot treatments. The sowing was done at fortnightly interval from 5th November to 20th December. Each treatment was replicated three times in a plot size of 5 m x 2.5 m. Thrips population was recorded per plant by shaking five randomly selected spots/plot on white card sheet measuring 25 cm x 20 cm. After harvest the grain yield was also recorded.

The different dates of sowing have marked influence on the incidence of thrips and yield of the crop (Table 1 and 2). Among four dates of sowing, the 5th November sown crop had least thrips population (2.09 thrips/plant). Thereafter, with subsequent delay in sowing, the thrips population was increased. The 20th December sown crop received highest thrips population (5.58 thrips/plant). There was significant difference in thrips population among all the sowing dates. Between two varieties, Kiran was less susceptible with 3.20 thrips/plant as compared to Neelum having 4.09 thrips/plant. Similar observation was recorded by Gandudey (1987) that early sown crop was comparatively less attacked by thrips as compared to late sown crop. Considering the impact of sowing dates variation on the yield of linseed it was found that maximum yield 1227 kg/ha was obtained with sowing of crop on 5th November. There is significant difference in yield when compared with other late sown crop. The lowest yield (521 kg/ha) was recorded when the crop was sown on 20th December. Similarly Pal *et al.* (1978) observed at Kanpur that linseed sown on 3rd November gave highest yield 1068 kg/ha as against lowest yield of 253 kg/ha in 15th December sown crop. Similarly 1610 and 1250 kg/ha yield was recorded from crop sown on 10th October and 20th November, respectively (Anonymous, 1983).

It is therefore evident that early sowing of linseed (5th November) not only escaped from heavy incidence of thrips which is one of the major constraint in linseed production but also helped to get maximum yield (1227 kg/ha).

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Table-1 Impact of different sowing dates and varieties of linseed on thrips incidence

Date of sowing	Thrips population/plant		
	Kiran	Neelum	Mean
5th November	1.96 (1.57)	2.21 (1.65)	2.09 (1.61)
20th November	2.56 (1.75)	3.21 (1.93)	2.89 (1.84)
5th December	3.44 (1.98)	4.59 (2.26)	4.05 (2.12)
20th December	4.82 (2.31)	6.34 (2.62)	5.58 (2.47)
Mean	3.20 (1.90)	4.09 (2.12)	3.64 (2.01)

CD (P=0.05)	i)	Dates of sowing	=	0.30
	ii)	Varieties	=	MS
	Iii)	Interactions	=	NS

Table 2 Impact of different sowing dates and varieties on grain yield (kg/ha) linseed

Date of sowing	Yield (kg/ha)		
	Kiran	Neelum	Mean
5th November	1367	1087	1227
20th November	1259	887	1073
5th December	1061	511	786
20th December	671	370	521
Mean	1090	714	902

Cd (P=0.05)	i)	Dates of sowing	=	2.5
	ii)	Varieties	=	1.3
	iii)	Interactions	=	NS

J. Oilseeds Res., **19**(1): **146-147 (2002)**

Short communication

Estimation of yield loss and determination of economic threshold of sesame shoot webber and capsule borer *Antigastra catalaunalis* (Dup.)

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Sesame (*Sesamum indicum* L) is an important oilseed crop. Damage caused by a host of pests is the limiting factor for productivity. Of the 67 insect pests reported on the crop (Kumar and Gorel, 1995), shoot webber and capsule borer, *Antigastra catalaunalis* (Dup) is the most detrimental entailing heavy yield loss. This loss can be minimized by maintaining pest population well below economic threshold (ET) utilizing various suitable methods. Further, ET of a pest is quite useful in developing a cost effective management strategy. Various authors over time and space used different parameters such as number of damaged leaves, flowers and capsules, per cent damage at various stage of the crop, etc in estimation of ET for the sesame shoot webber and capsule borer. But information on larval population and yield loss at different stages of the crop growth is lacking. Therefore, the present investigation was undertaken to establish the relationship between *A. catalaunalis* larval population and loss at vagetative and reproductive stage and to determine ET at both stages.

Two field experiments were conducted during *Kharif* 1999 and 2000 at Regional Research Station, Vriddhachalam to ascertain the ET for *A. catalaunalis* at vagetative and reproductive stage of the crop. TMV 3 was sown in plots of 5 x 4 m with a spacing of 30 x 30 cm and replicated four times. All the recommended package of practices were followed. Different larval densities were maintained by spraying endosulfan 35 EC @ 1.5 lit/ha at different intervals. The yield data were correlated with population densities by using a simple correlation equation Y = a + bx. Economic threshold was calculated as per Norton (1976).

Sprayings of endosulfan 35 EC @ 1.5 a.i/ha at different days after sowing (DAS) in the vegetative stage of the crop resulted in the graded levels of shoot webber population which varied from 0.40/m^2 to 1.50/m^2 as against 3.50 /m^2 in the untreated control. The controlling efficiency of different spraying schedules ranged from 57.14 to 88.57 % with a mean of 74.14%. The yield of sesame in different levels ranged from 120 to 699 kg/ha. (Table 1). Keeping the larval population/m^2 as the independent variable (x) and yield (kg/ha) as the dependant variable (y), a simple linear regression was worked out and the equation developed was 7.41 - 0.81 q (x) which implied that there would be a loss of 18 kg/ha of sesame seed yield for increase of one larvae/m^2 in the vegetative stage of the crop. The ET in the vegetative stage of the crop was determined as 10 larvae/m^2.

During the reproductive stage, the graded level of larval population varied from 0.50 to 2.20/m^2 as against 3.78 in the untreated control. The control efficiency of different spraying schedules ranged from 41.80 to 86.77% with mean being 67.20%. The yield ranged from 102 to 800 kg/ha. The simple linear regression worked for the reproductive stage was Y = 8.67 - 2.02 q2 (x) which implied that there would be a loss of 200 kg of sesame seed yield/ha for increase in are larvae/m^2. The ET in the reproductive stage was 2 larvae/m^2.

Economic Threshold (ET) for sesame shoot webber and capsule borer, *A. catalaunalis* was estimated during *kharif* 1999 and 2000 at Regional Research Station, Vriddhachalam. It was found that for increase in one larvae/m^2 the yield loss was 18 and 2000 kg/ha during vegetative stage and reproductive stage of the crop respectively. The ET in the vegetative stage of the crop was 10 larvae/m^2 whereas it was 2 larvae/m^2 in the reproductive stage.

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Table 1 Larval population of *A. catalaunalis* and yield of sesame during vegetative and reproductive stages

Spraying given at	Mean no. of larvae/m^2	Control efficiency (%)	Yield (kg/ha)
Vegetative stage			
15 DAS	0.40	88.57	690
20 DAS	0.45	87.14	684
27 DAS	1.20	65.71	530
35 DAS	1.50	57.14	480
Control	3.50	Mean 74.14	120
Reproductive stage			
40 DAS	0.50	86.77	800
48 DAS	0.70	81.48	732
55 DAS	0.90	76.19	638
62 DAS	1.90	49.74	460
71 DAS	2.20	41.80	460
Control	3.78	Mean 67.20	102

DAS = Days After Sowing

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Short communication

Effect of fungicides in management of collar rot disease (*Aspergillus niger* V. Teighem) of groundnut

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Groundnut is one of the important oilseed crops of the world. In India 4.13 % of the total cultivated area is occupied by groundnut with 59% of the total oilseed production (Anonymous,. 1999-2001). Adverse effects due to *Aspergillus niger* on groundnut were earlier reported (Jain and Nema, 1952; Chohan and Gupta, 1968; Chohan, 1969). The disease is becoming a serious problem in many districts of Andhra Pradesh. In the present study, experiments were conducted to study the efficacy of different fungicides as seed treatment in preventing the attack of the seed by *A. niger* causing rotting and death of seed as well as collar rot infection on the emerged seedlings under *in vitro* conditions.

Seven fungicides *viz.*, carbendazim, benomyl, copper oxychloride, captan; mancozeb, carboxin and ziram were tested under laboratory conditions for their effect on the growth of *A. niger* by adopting poisoned food technique (Nene and Thapliyal, 1971). The colony diameter of and % inhibition of growth over control in each treatment was recorded over control as per the given formula:

$$\text{Per cent inhibition of growth} = \frac{\text{Radial growth in Control} - \text{Radial growth in Treatment}}{\text{Radial growth in control}} \times 100$$

Under pot culture studies one hour before sowing, surface sterilized groundnut seeds (variety TMV-2) were soaked in the spore suspension of *A. niger* for five minutes. About 10 ml of the spore suspension ($2x10^6$ spores/ml) was used for soaking 30 seeds for 15 minutes. The spore treated seeds were air dried and later treated with different fungicides.

Treated seeds were sown in earthen pots (30 cm diameter) containing sterilized soil. Five treated seeds were sown per pot, 5 replications were maintained for each treatment. Surface sterilized and uninoculated seed served as control. The pots were watered regularly. Observations were made on number of seeds germinated, seedlings showing collar rot, mean shoot and root length, fresh and dry weight of seedlings and number of nodules per seedlings at 30 DAS. The collar rot infection and effect on growth were calculated using the following formulae.

$$\text{Collar rot infection (\%)} = \frac{\text{No. of seedlings with collar rot infection}}{\text{No. of seedlings emerged}} \times 100$$

$$\text{Reduction in disease(\%) over control} = \frac{\text{X in control} - \text{X in inoculated seedling in each replication}}{\text{X in control}} \times 100$$

Where x may be root length (cm), shoot length (cm), fresh wt (g), dry wt (g) or nodule number

The results revealed that, when the concentration of the fungicide was increased from 0.1 to 0.2 % the growth of *A. niger* was found to be reduced to 3.9 and 3.6 cm, respectively (Table 1). Among the fungicides carbendazim followed by benomyl were significantly superior to the rest of the fungicides by reducing the growth of *A. niger* to 0.1 cm each from 8.5 cm in control, followed by captan, carboxin, ziram, copper oxychloride and Mancozeb.

Table 1 Effect of fungicides on the growth of *Aspergillus* niger *in vitro*

Treatment	Colony diameter* (cm)			
	Concentration of the fungicide			Mean
	0.1%	0.2%	0.3%	
Carbendazim	0.1	0.1	0.1	0.1
Benomyl	0.2	0.1	0.1	0.1
Copper oxychloride	6.2	5.2	3.7	5.1
Captan	0.8	0.6	0.5	0.7
Mancozeb	7.5	7.2	5.1	6.6
Carboxin	3.4	2.9	1.4	2.6
Ziram	4.6	4.0	2.6	3.7
Control	8.5	8.5	8.5	8.5
Mean	3.9	3.6	2.7	
	SEm±		CD (P=0.05)	
Treatments	0.07		0.21	
Concentrations	0.05		0.13	
Interactions	0.13		0.35	

* *Mean of five replications*

All the fungicides showed increased effect with increase in their concentrations.

These results were in agreement with the findings of Kodmelwar *et al.* (1977), Gupta and Chohan (1971) and Shekhawat *et al.*, (1986) who observed total inhibition of growth of *A. niger* by Bavistin, Benlate, Ceresan and captan at 2000 ppm. Inhibition of growth of *A. niger* by carbendazim, benomyl and ethyl mercuric chloride at 1500 ppm. was reported (Shekhawat *et al.*, 1986).

Pot culture studies revealed that all the fungicides except copper oxychloride resulted in increased seed germination compared to control (Table 2). However, only benomyl and carbendazim were found statistically superior to other fungicides and control recording 96 and 72% seed germination.

Benoyml and carbendazim treatments resulted in minimum collar rot infection of 0.1 and 4% respectively compared to other treatments. The fungicides were also found to show significant effect on the health of seedlings. Captan followed by mancozeb treated seeds recorded maximum dry matter content. Mancozeb was found to be good in increasing the nodule number recording 12.9 nodules/seedling as against 2.8/seedling in control. Marked increase in shoot length (23.9 cm) was observed in the case of carbendazim treated seeds as against 15 cm in control. Further it can be concluded that benomyl (0.2%), carbendazim (0.2%) and Mancozeb (0.25%) were best as seed treatment fungicides in checking the collar rot infection and promoting seedling growth in groundnut.

Table 2 Effect of seed treatment with fungicides on seedling health of groundnut under artificial inoculation conditions

Treatment	Germination (%)	Collar rot infection (%)	Shoot length (cm)*	Root length (cm)*	Fresh weight (g)*	Dry weight (g)*	Nodule No.*
Carbendazim (0.2%)	72.0 (63.9)	4.0 (5.8)**	23.9	15.5	6.7	1.5	5.5
Benomyl (0.2%)	96.0 (84.2)	0.1 (0.6)	19.7	15.4	8.7	1.7	6.5
Copper oxychloride (0.3%)	32.0 (31.1)	60.0 (53.9)	23.6	12.6	8.7	2.0	2.0
Captan (0.3%)	52.0 (46.4)	48.3 (44.0)	18.9	11.6	12.1	3.1	7.3
Mancozeb (0.25%)	56.0 (48.5)	28.3 (23.3)	21.2	16.1	10.4	2.2	12.9
Carboxin (0.2%)	60.0 (51.0)	43.3 (41.1)	17.9	14.8	6.0	1.1	4.3
Ziram (0.3%)	56.0 (48.5)	46.7 (40.1)	20.9	19.2	5.8	1.4	7.3
Control	32.0 (33.9)	66.7 (57.6)	15.0	12.4	5.2	0.8	2.8
SEm±	8.5	12.4	2.5	1.3	2.0	0.37	2.1
CD (P=0.05)	24.69	36.00	7.20	3.63	5.65	1.07	6.03

* mean of five replications
** figures in parenthesis are arc sine transformed values

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Short communication

Varietal response and influence of different sowing dates on the incidence of sunflower necrosis disease

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Sunflower (*Helianthus annuus* L.) suffers from major fungal diseases such as *Alternaria* blight, rust, downy mildew and head rot resulting in extensive yield losses. In the recent past i.e., 1997 onwards, a new disease of viral origin named as necrosis disease observed around Bangalore for the first time in India (Anonymous, 1999a). Within a year this disease spread like a wild fire and virtually threatened sunflower cultivation in major sunflower growing states particularly Andhra Pradesh, Karnataka and Maharashtra. Chander Rao *et al.* (2000) reported that the intensity of the disease varied from 30 to 100% in Andhra Pradesh.

Sunflower cultivation in Maharashtra is mainly restricted to Marathwada region. Surveys conducted revealed that necrosis disease has appeared in epiphytotic proportion with a high intensity from 20 to 80% (Anonymous, 1998, 1999b, 2000). Therefore, the present studies were endeavoured to find out the influence of sowing dates on the necrosis disease on various cultivars of sunflower.

Fifteen hybrids/varieties of sunflower were sown on monthly basis starting from July to February during 1999-2000 and 2000-2001 (Table 1). A plot size of 3 x 4.20 m^2 was maintained for each hybrid/variety with a spacing of 60 x 30 cm.

Observations on fortnightly basis were recorded on total number of healthy and infected plants with necrosis disease in each sowing date for each hybrid/variety.

Sunflower sown in July, August, January and February had maximum disease incidence. However, September, October, November and December sowings showed, relatively lower necrosis incidence i.e., less than 4%.

Necrosis incidence was higher i.e., up to 16% during 2000-01. Lowest incidence of 6% was observed on the hybrid POC-6360. The hybrid KBSH-50 showed maximum disease incidence of 16%. As regards influence of sowing dates, it was revealed that July and August sowings had maximum incidence of necrosis disease. However, sowing from September onwards through December had the low incidence of the disease.

Mean incidence of necrosis disease in various months of year indicated that July, August, January and February sowings had high disease incidence. However, September, October, November and December sown crops had recorded lowest disease incidence indicating that these months could be exploited for sunflower sowings in order to minimize/avoid necrosis disease incidence. Out of all the genotypes POC-6360 and Mahabeej-917 were found to have some promise against this disease.

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Table 1 *Influence of different sowing dates on the incidence of sunflower necrosis disease*

Genotype	Disease incidence (%) - Month																Mean (%)
	July		Aug.		Sept.		Oct.		Nov.		Dec.		Jan.		Feb.		
	99-00	00-01	99-00	00-01	99-00	00-01	99-00	00-01	99-00	00-01	99-00	00-01	99-00	00-01	99-00	00-01	
MSFH-17	34	6	11	38	3	21	0	10	-	0	0	2	25	4	12	2	10
Morden	18	22	22	32	6	3	5	9	5	0	2	0	12	2	4	3	9
KBSH-1	8	13	13	51	3	0	1	6	2	0	0	2	17	0	9	0	8
GAU-15	27	9	20	40	3	6	5	5	8	2	0	3	27	2	11	2	11
TNAU-7	22	9	25	43	3	4	1	11	4	0	0	4	28	3	12	3	11
ZSH-9760	27	7	12	41	0	5	2	0	0	2	0	0	21	0	13	3	8
JKSF 51	25	-	2	-	0	-	3	-	6	6	0	0	10	10	13	13	-
POC-6360	6	9	5	47	0	3	0	0	6	0	0	0	14	2	8	4	6
PAC-1091	-	14	3	54	1	11	5	6	4	0	0	5	28	2	19	3	11
Mahabeej-917	-	20	-	65	-	6	-	0	-	0	-	2	-	2	-	2	7
Sungene-85	-	9	-	70	-	6	-	2	-	0	-	0	-	3	-	2	11
KBSH-48	-	15	-	39	-	8	-	2	-	2	-	5	-	2	-	4	10
KBSH-50	-	28	-	52	-	13	-	6	-	4	-	4	-	1	-	18	16
KBSH-41	-	10	-	35	-	6	-	2	-	-	-	-	-	-	-	-	13
KBSH-42	-	13	-	59	-	9	-	8	-	1	-	1	-	0	-	19	14
KBSH-44	-	7	-	44	-	6	-	7	-	0	-	12	-	8	-	-	12
Mean	20	13	13	47	2	7	2	5	4	0	0	3	20	2	11	5	-

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Short communication

Control of sunflower downy mildew, *Plasmopara halstedii* through seed treatment

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Downy mildew disease incited by *Plasmopara halstedii* (Ferl.) Berl. and De-Toni is a potentially destructive disease of sunflower (*Helianthus annuus* L.). The sunflower was introduced in India around 1969 and along with its seed import Ramnath *et al.* (1981) intercepted downy mildew oospores on the seeds imported from Bulgaria. Later, Mayee and Patil (1987) reported its occurrence for the first time from the Marathwada, which is a major sunflower growing region in India. Thereafter the disease was monitored through regular surveys in this region, and it was observed that the disease is of regular occurrence. Extensive survey reports revealed that about 33 % sunflower fields had downy mildew incidence with a maximum intensity of up to 30% in Maharashtra. Similarly, sunflower variety Morden which is popular with farmers was found to be severely affected due to the downy mildew disease (Shirshikar, 1997).

Recently the liquid formulation of Metalaxyl (Apron X L 35 ES) as a seed dresser has been made available in India. It is expected that this formulation being in liquid form would be easier for seed treatment during seed processing in seed industry. It was therefore, decided to find out the effective dose of this formulation and to compare its performance with the presently recommended fungicide against sunflower downy mildew disease.

A field experiment was undertaken during *kharif*, 2000 with downy mildew susceptible variety, Morden. The experiment was sown on 15th September, 2000 in a downy mildew sick plot developed at Oilseeds Research Station, Latur (MS). A spacing of 60 x 30 cm between rows x plants was maintained with 3.60 x 5.40 m^2 net plot size. The experiment had five treatments and replicated four times (Table 1).

Observations on number of plants infected with downy mildew disease and healthy plants in each treatment were recorded on monthly basis.

Maximum disease incidence of 90.01% recorded in untreated control as against the lowest of 7.40% in Apron XL 35 ES @ 3 ml/kg of seed. However, it was on par with Apron 35 WS @ 6 g/ha of seed and Apron XL 35 ES, 2 ml/kg of seed with 12.8 and 13.6% disease incidence, respectively. Consequently, maximum yield of 955 kg/ha was recorded with Apron XL 35 ES @ 3 ml/kg of seed which was significantly superior over the rest of the treatments. However, the standard check Apron XL WS @ 6 g/kg seed yielded 828 kg/ha.

It is therefore, recommended that Apron XL 35 ES @ 3 ml/kg of seed can be used as a seed dresser for the effective control of downy mildew disease of sunflower.

Table 1 Evaluation of liquid formulation of Metalaxyl (Apron XL 35 ES) as a seed dresser for the control of sunflower downy mildew

Treatment	Downy mildew incidence (%)	Yield (kg/ha)
Untreated control	90.0 (73.5)*	142
Apron XL 35 ES 35 g a.i./100 kg seed (1 ml/kg seed)	18.8 (25.5)	623
Apron XL 35 ES 70 g a.i./100 kg seed (2 ml/kg seed)	13.6 (21.3)	754
Apron XL 35 ES 105 g a.i./100 kg seed (3 ml/kg seed)	7.4 (15.5)	955
Apron 35 WS 210 g a.i./100 kg seed (6 g/kg seed)	12.8 (20.7)	828
SEm±	3.1	39.2
CD (P=0.05)	9.4	120.8
CV (%)	19.8	11.9

* Angular transformations.

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Short communication

Response of castor genotypes to castor semilooper, *Achaea janata* Fab.

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Castor semilooper, *Achaea janata* Fabricius is the most destructive pest of castor in North Gujarat (Tahilliani, 1985). Heavy incidence of the semilooper in early seedling stage may destroy the whole crop forcing resowing. Severe outbreak at later stage results in complete defoliation and subsequently consumption of tender capsules also. The ultimate losses in seed yield have been estimated to the tune of 61.32%. Indiscriminate use of pesticides may result in several environmental problems and therefore it is imperative to develop alternative eco-friendly techniques which can be fitted in Integrated Pest Management modules. Pest resistant line is one of such tools with no recurring cost, safe and easy to adopt.

In order to find out the resistant genotypes, sixteen castor lines were screened under field conditions at Main Castor Research Station, Gujarat Agricultural University, Sardar Krushinagar during 1994-95. Two rows of each genotype were sown 90 cm apart. The number of castor semilooper larvae present on five plants in each genotype was recorded at the time of peak infestation.

Incidence of the pest was lower (0.2 larvae/plant) in four genotypes *viz.*, SKI-137, SKI-143, SKI-139 and F_1 of 48-1 x VI-9, whereas it was highest (14.4 larvae/plant) in VP-1 with an average incidence of 2.8 larvae/plant (Table 1). The castor genotypes were grouped into four categories of resistance by comparing the mean incidence of each genotype with mean incidence and standard deviation.

Category	*Semilooper population/plant*
Resistant (R)	<2.8 (less than mean incidence)
Less susceptible (LS)	>2.8-<6.7($\bar{x}$ + 1 SD = 2.8+3.9 = 6.7)
Moderately susceptible (MS)	>6.7-<10.6($\bar{x}$ + 2 SD = 2.8 + 7.8 = 10.6)
High susceptible (HS)	> 10.6

Based on this method, the genotype were assigned the rank for reaction against *A. janata*. The perusal of the results clearly indicated that 11 genotypes *viz.*, SKI-137, SKI-139, SKI-143, 48-1 x VI-9 (F_1), SKI-130, SKI-133, SKI-134, SKI-147, SKI-25, SKI-109 and SKI-122 proved resistant against semilooper and remaining five genotypes proved susceptible to this insect. Among the susceptible genotypes, SKI-48 and VP-1 x SKI-52 (F_1) proved less susceptible (LS) whereas SKP-1 was moderately susceptible (MS) and VP-1 was highly susceptible (HS) to *A. janata* damage. Resistant genotypes may be incorporated in breeding programme to evolve resistant genotypes resistant to semilooper.

Table 1 Reaction of certain lines of castor against *Achaea janata* F.

Lines	Mean larvae/ plant	Grade	Morphological characters
VP-1	14.4	HS	G^3, Cup shaped, dwarf
SKP-1	7.2	MS	M^3, Cup shaped, dwarf
SKI-130	0.4	R	G^2, PB, E, Flat leaves
SKI-133	0.4	R	G^3, PB, MD, Flat leaves
SKI-134	0.4	R	G^3, PB, Flat leaves
SKI-137	0.2	R	G^2, PB, MD, Flat leaves
SKI-139	0.2	R	M^2, PB, E, Flat leaves
SKI-143	0.2	R	M^3, Flat leaves
SKI-147	0.4	R	M^3, PB, Flat leaves
48-1 x VI-9 (Hybrid)	0.2	R	M^2, MD, Flat leaves
SKI-109	1.2	R	G^3, PB, E, Flat leaves
SKI-122	1.4	R	MD, M^3, Flat leaves
SKP-25	0.6	R	R^1, E, Flat leaves
SKP-48	5.2	LS	M^2, cup shaped, condensed nodes
SKP-49	6.8	HS	M^3, cup shaped, condensed nodes
VP-1 x SKI-52 (hybrid)	6.0	LS	MD, M^3, PB, Flat leaves
Mean	2.8		
S.D ±	3.9		

M^1 = Mohagany stem, Single bloom; M^2 = Mohagany stem, Double bloom; M^3 = Mohagany stem, Triple bloom; MD = Medium dwarf; PB = Profuse branching; E = Early; G^3 = Green stem, triple bloom; R^1 = Red stem, single bloom

Castor lines susceptible to semilooper had cup shaped leaves, whereas, resistant lines possessed flat leaves. This leaf character may be used to identify castor lines resistant to *A. janata*.

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Short communication

Effect of cropping systems and nitrogen levels on growth, yield and economics of rainfed castor intercropped with *Melia azedarach* Linn.

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Arable farming dominated the agriculture during the last three decades, specially in drylands with low and unstable often times, uneconomic yields. Almost all rainfed ecosystems are badly suffering from poor management practices and often subjected to the process of land degradation. It is estimated that out of 328 million ha of India's geographical area, about 175 million ha (53%) is subjected to soil erosion and some kind of land degradation. Castor, predominantly being a rainfed crop is subjected to all these hazards of production practices and producing very poor yields. To boost the castor yields var. Kranti was released recently which is becoming popular amongst the dryland farmers. It was felt necessary that suitable technology is to be developed to sustain the castor yields either through improved management practices or through cropping systems approach. Integration of crop with the tree in the form of agroforestry is regarded as best alternative to sustain the crop yields in drylands. *Melia azedarach* is one of the most suitable species for integration because of its fast, straight growing habit and multiple uses of providing poles, margosa oil and green leaf manure. To find out the compatibility of castor with *Melia*, the present study was initiated.

The field experiment was carried out during *kharif*, 1998 at Students Farm, College of Agriculture, Rajendranagar, Hyderabad. The experimental site of the study was red sandy loam with low in organic carbon (0.18%) and available nitrogen (215 kg/ha) and medium in available P and K (16 and 152 kg/ha, respectively). There were three cropping systems as main plots and four levels of nitrogen as sub-plots (Table-1). The area was under three years old *Melia azedarach* plantations spaced at 6 x 2 m and 6 x 2 x 2 m under single row and paired row planting respectively. The tree area was divided suitably to accommodate four levels of nitrogen with a plot size of 6m x 6m. For sole cropping, a plot near by was selected with equal plot size to accommodate four levels of nitrogen. The castor var. Kranthi was sown on July 4th, 1998 at 60 x 60 cm in both the tree areas and open area applying P and K as basal each @ 60 kg/ha while nitrogen was applied as per treatments. The crop was harvested on December 7th, 1998 and January 25th, 1999 in two pickings i.e. at 155 and 204 DAS.

Table 1 **Drymatter (kg/ha) leaf area index and nitrogen, phosphorus and potassium uptake (kg/ha) of castor as influenced by cropping systems and nitrogen levels**

	Cropping systems (CS)	Dry Matter (kg/ha)	Leaf area index	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)
Cropping systems (CS)	Single row intercropping (SI)	565	0.39	30.2	3.8	28.1
	Paired row intercropping (PI)	1051	0.49	35.5	4.9	30.0
	Sole cropping (SC)	1584	0.62	42.4	4.8	25.0
	SEm±	2.91	0.06	1.1	0.2	0.4
	CD(P=0.05)	8.06	0.17	2.9	0.7	1.0
Nitrogen levels (N)	N_0	75	0.08	16.3	1.6	12.9
	N_{40}	1024	0.39	34.0	3.8	22.5
	N_{80}	1407	0.59	40.7	5.3	36.6
	N_{120}	1761	0.93	53.0	6.4	38.6
	SEm±	4.39	0.02	0.65	0.32	0.85
	CD(P=0.05)	9.23	0.05	1.36	10.67	1.78
Interaction	*CS x N*					
	SEm±	6.31	0.10	1.94	0.49	0.96
	CD (P=0.05)	13.95	NS	4.80	NS	NS

The dry matter production was influenced significantly by both cropping systems, nitrogen levels and their interaction (Table-1). Sole cropping of castor resulted in higher dry matter production of 1584 kg/ha which was superior to intercropping with *Melia* under both the planting patterns of paired row (1051 kg/ha) and single row (565 kg/ha) at 120 DAS. Competition for light under intercropping is the reason ascribed for low dry matter production (Bheemaiah *et al.*, 1996).

Application of N_{120} kg/ha produced dry matter of 1761 kg/ha which was found better than N_{80} (1407 kg/ha) and much higher than N_{40} and N_0. The increase in dry matter production in higher doses of nitrogen application might be due to increased availability of nutrients (Balasubramanian and Palaniayappan, 1996). The interaction effect was found significant producing maximum dry matter production at N_{120} under sole cropping (2356 kg/ha and was equally better under paired row inter cropping (2047 kg/ha).

Leaf area Index (LAI) under sole cropping (0.62) was superior as compared to paired row inter cropping and single row inter cropping (Table-1). Lower values of LAI under inter cropping with *Melia* might be due to dense shade effect reducing photosynthetic activity of castor crop. The results of present study confirm the findings of Madhusudhan (1977). Significant differences were observed in LAI of castor due to nitrogen application, with higher values of 0.93 LAI with 120 kg N/ha as compared to other levels of nitrogen, which might be due to better translocation of nutrients and water (Madhusudan, 1997). However, interaction effects were not significant.

Cropping systems had significant influence on uptake of N,P and K, which was higher under sole cropping of castor as compared to paired row as well as single row inter cropping (Table-1) Higher dry matter production presumably resulted in greater uptake of N.P and K under sole cropping.

Likewise differences in N,P and K uptake were found significant due to application of nitrogen being maximum under higher dose i.e. 120 kg/ha.

Row wise yields of castor (g/plant): Row wise yields of castor differed significantly due to cropping systems and number of rows of crop (Table-2). Fifth row of castor away from the trees recorded higher yield which differed significantly from the rest of the rows. Lower seed yield of castor near Melia might bed due to competition from the tree specially for light and water including nutrients. Such results in agroforestry systems were reported by Mathew *et al.* (1992) and Okorio *et al.* (1994).

Likewise sole cropping of castor produced more yield/plant as against under inter cropping with trees both the single row planting and in paired row planting.

Interaction effects were found significant with maximum row wise yield under sole cropping but very low row wise yields were recorded in the first row near the tree under SI and PI.

Table 2 Row wise yield (g/plan) of castor as influenced by interaction between cropping systems and nitrogen levels

Treatment	Cropping systems			Mean
	SI	PI	SC	
First	3.4	5.8	14.6	7.9
Second	3.7	6.4	14.6	8.3
Third	6.7	10.8	14.7	10.7
Fourth	7.9	13.9	14.7	11.8
Fifth	8.2	13.6	14.8	12.2
Mean	6.0	9.9	14.7	
	SEm±	CD (P=0.05)		
Cropping systems(CS)	0.5	1.44		
Rows (R)	0.10	0.21		
Interaction				
CS x R	1.04	2.82		

Seed yield (kg/ha): Significantly higher yields of castor were obtained under sole cropping (Table-3). However paired row inter cropping was better than single row inter cropping. The results are in conformity will the findings of Bheemaiah *et al.*, 1988.

Significant difference in seed yield (413 kg/ha) was observed due to application of N_{120} as against the remaining doses. Poor nutrient availability at lower doses of nitrogen might have reduced the growth of castor and ultimately the yield. Interaction effects were also significant.

Table 3 Seed yield (kg/ha) of castor as influenced by interaction between cropping systems and nitrogen levels

Treatment	Nitrogen levels (kg/ha)				Mean
	N_0	N_{40}	N_{80}	N_{120}	
SI	33	126	216	273	162
PI	63	237	350	419	367
SC	125	414	507	549	398
Mean	74	259	358	414	
	SEm±	CD (P=0.05)			
Cropping systems(CS)	16	45			
Nitrogen levels (N)	1124				
Interaction CS x N	30	72			

Net returns (Rs/ha): Sole cropping of castor produced significantly higher net returns of Rs.2,656/ha and better *B:C ratio* than intercropping with *Melia* under single row planting (Rs.403/ha) and paired row planting (Rs.950/ha) indicating single row intercropping had much deleterious effects on associated castor and *proved uneconomical* (Table-4). Similar results were reported by Rao *et al.* (1990). Likewise application of nitrogen at 120 kg/ha resulted in maximum net returns of Rs.2642/ha as compared to other levels of nitrogen indicating profitability of recommended dose of nitrogen.

Table 4 Net returns (kg/ha) as influenced by interaction between cropping systems and nitrogen levels

Treatment	Nitrogen levels (kg/ha)				Mean
	N_0	N_{40}	N_{80}	N_{120}	
SI	-1858(-0.81)	-812(-0.33)	212(0.08)	848(0.31)	*-403(0.19*
PI	-1481(-0.50)	635(0.36)	1949(0.75)	2696(0.98)	950(0.37)
SC	-675(-0.29)	2932(1.20	3986(1.55)	4381(1.59)	2656(1.01)
Mean	-1138(-0.53)	918(0.37)	*2049(0.79)*	*2642(0.96)*	
		SEm±	CD (P=0.05)		
Cropping systems (CS)		221.44	-614.72		
Nitrogen levels (N)		153.66	322.84		
Interaction					
CS x N		405.98	984.50		

* Benefit cost ratio. *Cost of Cultivation* ***of castor/hectare at*** N_0 *Rs.2300,* N_{40} *Rs.2450,* N_{80} *Rs.2600 and at* N_{120} *Rs.2750*

Response of castor to nitrogen application: The quadratic analysis showed that the economic optimum dose of nitrogen under sole cropping was 96 kg/ha and found increasing under *Melia* intercropping as for (SI) 184 kg/ha and 131 kg/ha under PI indicating to get optimum yields of castor the dose of nitrogen needs to be increased above the recommended dose as the *Melia* trees might also be competing for nitrogen applied.

It is therefore concluded that intercropping of castor with *Melia azedarach* was not found compatible resulting in reduction in seed yield due to competition during the initial period of tree plantation. However, this could be compensated in the long run with value added tree products in the form of fuel,, fodder, oil cake and timber or by following tree pruning after their establishment to reduce the competition between inter crops for light, nutrients and water.

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Contents

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(Contd... inside)

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