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Dr. K. Virupakshappa, Project Director, Directorate of Oilseeds Research, Hyderabad passed away on 16 June, 1998 leaving behind his family, a score of admirers and the oilseeds fraternity in deep sorrow.

He received his masters degree in Agriculture from the college of Agriculture, Dharwad and obtained his Ph.D from the University of Agricultural Sciences, Bangalore in 1983. He had a brilliant academic career and received Gold medals and Karnataka State award. He served the UAS, Bangalore for fourteen years as a researcher and teacher before becoming project coordinator (Sunflower) in which capacity he worked for more than 7years and took over as the project Director, DOR on 30 June 1997.

He contributed immensely to the growth and development of sunflower in the country through collection, conservation, evaluation and utilization of germplasm which resulted in evolving elite varieties and hybrids. During his tenure as project coordinator (Sunflower), sunflower hybrids like LSH-1, LSH-3, KBSH-1 were released which became very popular. Dr. Virupakshappa had to his credit more than 100 research papers published in national and international journals of repute. He has guided many MSc and Ph.D students in Agriculture.

The sudden and untimely demise of this distinguished Agricultural Scientist is a loss to the oilseeds family in particular and the Indian Agricultural Research system in general. He leaves behind his wife and four daughters. The Indian Society of Oilseeds Research conveys its deep condolences to the bereaved family of Dr. K. Virupakshappa, an embodiment of simplicity, humility and dedication.

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INTEGRATED NUTRIENT MANAGEMENT FOR PRODUCTION SUSTAINABILITY OF OILSEEDS - A REVIEW

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ABSTRACT

Intensive agriculture with very high nutrient turn over in soil plant system coupled with low and imbalanced fertilizer use results in deterioration of native soil fertility and poses a serious threat to long term sustainability of crop production. In India, although fertilizer consumption has crossed 13.5 million tonnes ($N + P_2O_5 + K_2O$) during 1994-95, it is still much below the estimated nutrient removal of 22-24 million tonnes leaving a gap of about 10 million tonnes. This gap is likely to widen further to 18 million tonnes, by the turn of the century. Long term studies in many cropping systems have clearly indicated that neither chemical fertilizers nor organic sources of nutrients could sustain high productivity of intensive cropping systems. Nevertheless, integrated use of fertilizers and organic sources has helped in maintaining yield stability through correction of marginal deficiencies of secondary and micro nutrients, enhancing the efficiency of applied nutrients and providing favourable soil physical environment. This paper critically reviews the existing information on different components of integrated nutrient supply and management in oilseeds and oilseeds based cropping systems in India and indicates the possibilities of mobilising nontraditional nutrient sources towards increasing oilseeds production.

Key words: Nutrient management, sustainability, oilseeds.

India has 20.8% of the world's area under oilseeds but accounts for less than 10% of world's production to meet the needs of about 16% of the world's population. Oilseeds in India, form the second largest agricultural commodity after cereals sharing 13% of the country's gross cropped area and accounting for nearly 5% of gross national product and 10% of the value of all agricultural commodities.

The oilseeds scenario of India has undergone a dramatic change in recent years due to various incentives and institutional support given by the Government for the development of this sector, following the constitution of the Technology Mission on Oilseeds (TMO). Between 1985-86 and 1996-97, the area under oilseeds increased from 19.02 to 25.50 million hectares, production increased from 10.83 to 22.50 million tonnes, productivity increased from 570 to 882 kg/ha and the level of self sufficiency increased from 69 to 87%. Despite such impressive achievements in the oilseeds sector, the import of edible oils during 1996-97 was nearly 15 Lakh tonnes costing more than Rs. 3000 crores as against 10.79 Lakh tonnes of oil imported during 1985-86 costing Rs. 789 crores. There seems to be a tremondous pent up demand for edible oils which is turning into effective demand with increasing purchasing power. The Total edible oil consumption is projected to increase at 5.5 to 6% per annum, of which about 2% will be on account of rise in population and the rest due to increase in purchasing power. There is an urgent need to step up oilseeds production on a sustainable basis to meet the needs of increasing population and expanding demands. However, with chances on area expansion being limited, oilseeds production increases have to come primarily from land saving technologies, highlighting a combination of high yielding plant types, standard agronomic practices and balanced plant nutrition attained through

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integrated nutrient supply systems.

Oilseeds crops are energy rich crops, and obviously the requirement of major nutrients including secondary and micronutrients is very high (Table-1). Considerable variations in nutrient removal occur from situation to situation depending on crop productivity, soil fertility, amount of crop residues left over in the field and their composition. The estimated nutrient ($N + P_2O_5 + K_2O$) removal by nine annual oilseed crops during 1994-95 comes to 2.562 million tonnes (Table 2). Some of the cropping systems involving oilseeds may remove as much as 400 to 800 kg nutrients ($N + P_2O_5$ K_2O)/ha/year under high productivity conditions (Table 3). Unless the soils are replenished with all the nutrients taken up by the crops, there will be persistant nutrient exhaustion posing a great threat to sustainable oilseeds production. Since chemical fertilizer alone will not be able to meet the total nutrient needs, integrated use of all potential sources of plant nutrients seems to be the only option to maintain soil fertility and crop productivity.

Integrated Nutrient Supply and Management (INSAM) in Oilseeds

INSAM is an age old practice but its importance was not very much realised in pre-green revolution era due to low nutrient demands of traditional agriculture. This approach aims at efficient and judicious use of all the major sources of plant nutrients in an integrated manner, so as to get maximum economic yield without any deleterious effect on physico-chemical and biological properties of the soil. Thus, the basic concept underlying the principles of INSAM is the maintenance and possible improvement in soil fertility for sustained crop production on a long-term basis.

INSAM has assumed great importance in recent years because with high nutrient turnover in soil-plant system under intensive farming, neither the chemical fertilizers nor organic/ biological sources alone can achieve production sustainability. Long-term studies carried out mostly in cereal based cropping systems have indicated

Table 1 : Average nutrient removal by oilseed crops/t yield under field conditions

Crop	Kg uptake/t produce						g uptake/t produce			
	N	P_2O_5	K_2O	S	Ca	Mg	Zn	Fe	Mn	Cu
Groundnut	58.1	19.6	30.1	7.9	20.5	13.3	109	2284	93	36
Mustard	32.8	16.4	41.8	17.3	42.0	8.7	100	1123	95	17
Raya	64.5	20.6	53.4	16.0	56.5	9.5	58	635	169	21
Taramira	70.0	26.0	61.1	20.7	19.3	9.3	16	708	153	29
Soybean	70.7	30.9	57.7	6.7	14.0	7.6	77	346	83	30
Safflower	38.8	8.4	22.0	12.6	-	-	-	-	-	-
Sesame	51.7	22.9	64.0	11.7	37.5	15.8	168	793	115	117
Sunflower	63.3	19.1	12.6	11.7	68.3	26.7	47	1075	-	-
Linseed	60.0	18.6	54.0	5.6	31.2	13.1	46	664	177	30
Castor	40.0	9.0	16.0	-	-	-	-	-	-	-

Source : Tandon and Sekhon, 1988; Pasricha and Tandon, 1993.

Table 2 : Estimated nutrient removal by oilseed crops during 1994-95.

Crop	Production (m.t.)	Nutrient uptake (000't)			
		N	P_2O_5	K_2O	S
Groundnut	8.26	480	162	249	65
Rapeseed-mustard	5.88	193	96	246	102
Sesame	0.62	32	14	40	7
Soybean	3.67	260	113	212	25
Linseed	0.32	19	6	17	2
Safflower	0.42	16	4	9	5
Sunflower	1.20	76	23	151	14
Castor	0.85	41	18	57	11
Niger	0.20	14	3	11	2
Total	21.42	1131	439	992	233

Source : Hegde, 1997.

Table 3 : Nutrient uptake in some cropping systems involving oilseeds

Cropping System (t/ha)	Nutrient uptake (kg/ha)			
	N	P_2O_5	K_2O	Total
Sorghum-Groundnut (3.6) (2.2)	216	74	184	474
Maize-Mustard (3.0) (2.0)	127	70	177	374
Cotton-Sunflower (2.0) (1.8)	203	90	376	669
Soybean-Patato-Wheat (1.5) (26.0) (4.0)	305	177	345	827
Sorghum-Sunflower-Groundnut (4.0) (1.5) (2.0)	301	121	385	807

Source : Hegde *et al.*, 1992.

that even with so called balanced use of NPK fertilizers, high yields could not be maintained over years because of emergence of secondary and micro-nutrient deficiencies and deterioration in soil physical environment (Nambiar and Abrol, 1984, Hegde, 1992). Nevertheless, integrated use of fetilizers and organic manures/biological sources helped in maintaining yield stability in most agroecoregions through correction of marginal deficiencies of secondary and micro nutrients, enhancing efficiency of applied nutrients and providing favourable soil physical conditions. The interactive advantages of combining organic and inorganic sources of nutrients in INSAM have proved superior to the use of its each component separately (Roy, 1992).

The major components of INSAM are fertilizers, organic manures (FYM/compost), legumes, crop residues/recyclable wastes and biofertilizers. These sources posses great diversity in terms of chemical and physical properties, nutrient release efficiencies, positional availability, crop specificity and farmer acceptability. Therefore, the combination of different components to ensure optimum supply of nutrient supply to a given cropping system involving oilseeds depends on several ecological and socio-economic factors.

Chemical fertilizers in INSAM

Fertilizer is the important component of INSAM in oilseeds. Inadequate and/or imbalanced use of fertilizers has been identified as one of the critical constraints holding oilseeds production. Yield increases ranging from 26 to 300% with fertilizer application alone have been recorded in rainfed areas (Subba Rao, 1994) which constitute about 75% of the total area under oilseeds. With fertilizers, on an average contributing upto 50% rise in productivity, their importance in any strategy to meet the challenges on rising demand for oilseeds can hardly be emphasised. Our dependence on fertilizers as a source of nutrients even in oilseeds is increasing because of the need to supply large amounts of nutrients (Table 4). While the use of fertilizers is the quickest and surest way of boosting oilseeds production, the following issues related to present fertilizer scenario in the country needs special attention.

Inadequate domestic availability

The fertilizer consumption during 1994-95 was 13.5 million tonnes ($N + P_2O_5 + K_2O$) with $N : P_2O_5 : K_2O$ ratio of 8.9:2.8:1.0 as against the ideal ratio of 4:2:1. The total plant nutrient uptake by all agricultural crops is estimated to be 22 to 24 million tonnes leaving a gap of nearly 10 million tonnes. This gap is likely to increase to 16 million tonnes by 2000 AD (Hegde and Dwivedi, 1993). Although a part of this nutrient gap is bridged from non-chemical sources like organic and biofertilizers, the foreign exchange constraint will not permit import of fertilizers in large quantities.

Low fertilizer use efficiency

Hardly 30-40% of nutrients applied through fertilizers are utilized by the crops and the remaining are lost through various pathways such as leaching, volatalization, surface runoff, soil erosion and fixation. Less than 15% of nutrients absorbed by oilseed crops is contributed by fertilizers while the rest is contributed from soil reserves, organic manures, biological sources and residues and wastes (Table 5). The declining efficiency of fertilizers is of great concern. In a country like India, where nearly 75% of the farmers operate small and marginal holdings and are resource poor, fertilizer nutrient wastage arising from inefficient use will prove prohibitively expensive, and thus can be ill afforded. Further, any inefficient use of fertilizer nutrients can produce adverse effects on the environment casting additional doubt on the long-term sustainability of oilseeds production. In-efficient use of fertilizer nutrients is likely to be triggered also by policies favouring lower prices of certain nutrients and leaving others unattended. There are several well-proven scientific practices through which the efficiency of applied fertilizers can be increased which need to be popularised among oilseeds farmers.

Use of high analysis fertilizers

Traditional low analysis fertilizers like ammonium sulphate, single super phosphate, calcium ammonium nitrate, potassium sulphate which used to supply NPK in past, also added inadvertantly considerable amounts of secondary and micronutrients. At present, emphasis is laid on use of chemically pure, high analysis fertilizers such as area, diammonium phosphate and muriate of potash, which are practically devoid of nutrients other than NPK. Continuous use of these fertilizers coupled with heavy offtake of secondary and micronutrients by exhaustive production systems has led to emergence of multi-nutrient deficiencies. Now, deficiency of secondary nutrient like S and micronutrient like Zn are reported from large areas besides deficiencies of NPK (Table 6).

Response of oilseeds to fertilizers

For leguminous oilseeds like groundnut and soybean, the main nutrients from fertilizer management point of view are P, S, Ca and Zn, as these crops can meet a large part of their nitrogen needs through biological N fixation. For rapeseed-mustard, application of N, P, S and in increasing cases Zn and to some extent B play a key role in stepping up the yields. For safflower and sunflower, the major requirements are N, P and S in certain cases. In course textured soils at high yield levels and where leaching is of major concern, K application becomes critical. Iron assumes importance in alkaline-calcareous soils and Mo in very acid soils, particularly for groundnut and soybean.

All oilseed crops have shown response to fertilizer nutrients. Significant increases in yield due to application of one or more nutrients in different agro-ecoregions have been reported by several workers (Tomar *et al.* 1980; Daulay and Singh, 1982; Ankineedu *et al.*, 1983; Takkar and and Nayyar, 1984; Pasricha and Aulakh, 1986; Pasricha *et al.*, 1987; Agasimani and Hosmani, 1989; Saini, *et al.*, 1989., Tandon 1990; Pasricha and Tandon, 1993; Gangasaran and Rana, 1994). These reports clearly indicate that in several parts of the country, there are nutrient deficiencies and/or responses (hidden hungers) of N, P, K, S and the micronutrients like Zn, Mn, Fe and B (in a limited way in a few pockets) in one or the other oilseed crops. Thus, sustainability considerations demand that these nutritional disorders should be taken care of in the management of oilseeds crops.

Fertilizer management on a system basis

Cropping system rather than an individual crop and the farming system rather than an individual field, are the focus of attention in INSAM. The low level of utilization of nutrients supplied through fertilizers and manures calls for choosing appropriate combination of sequence of crops to effectively utilise the nutrients for long-term sustainability. Specific attention needs to be given to harness the residual effect of fertilizers containing P (Table 7) and K so that application of these nutrients can be phased to get maximum benefit. In wheat-groundnut, maize-groundnut and raya-groundnut cropping systems, groundnut crop was observed to thrive on residual effect when wheat, maize and raya received recommended fertilizers (Subba Rao, 1994). It is also possible to get a changing pattern of response to applied fertilizer nutrients even with balanced fertilization due to buildup/depletion of several nutrients which have a direct bearing on crop response and productivity of oilseeds. Therefore, there is a strong need to continuously monitor the soil for possible changes in nutrient status so that those nutrients which are in short supply can be supplemented to increase overall nutrient use efficiency.

Organic manures

Organic manures have been time tested materials for improving the fertility and productivity of soils. It is only during the last 15-20 years that these have been incorporated into INSAM for intensive cropping sequences in contrast to the subsistence level production of the past. Use of organic manures has been

Table 4 : Fertilizer nutrient requirements of oilseed crops during 1994-95 based on average fertilizer recommendations

Crop	Area (m.ha)	Nutrient uptake (000't)		
		N	P_2O_5	K_2O
Groundnut	7.92	158	396	238
Rapeseed-mustard	6.23	312	187	187
Sesame	2.03	61	41	20
Soybean	3.99	120	239	120
Linseed	0.96	29	19	10
Safflower	0.77	31	23	15
Sunflower	1.97	79	118	59
Castor	0.79	47	32	24
Niger	0.59	12	6	-
Total	25.26	849	1061	673

Source : Hegde, 1997.

Table 5 : Nutrient removal by oilseed crops and net contribution of fertilizers to it in India (1994-95)

Nutrient	Uptake (000't)	Fertilizer use (000't)	Fertilizer use efficiency (%)	Contribution to uptake	
				Fertilizers (%)	Others (%)
N	1131	424	50	18.7	81.3
P_2O_5	439	318	30	21.7	78.3
K_2O	992	134	50	6.8	93.2
S	233	13	25	1.4	98.6
Total	2795	889		13.5	86.5

Source : Hegde, 1997

Table 6 : Nutrient status of Indian soils

Nutrient	Status
N	Low 228 districts, medium 118 districts, high 18 districts
P	Low 170 districts, medium 184 districts, high 17 districts
K	Low 47 districts, medium 192 districts, high 122 districts
S	Deficient in 50% of soils (125 districts)
Zn	Deficient in 50% of soils
Mg	All acidic soils
Fe	Upland calcarecus soils
B	Parts of Bihar, Karnataka and West Bengal

Source : Tandon, 1992

continuously declining in Indian agriculture due to a variety of reasons. We have ignored the exploitation of the potential of organic manures and their synergistic effect with chemical fertilizers for increasing productivity, sustainability of agriculture and improving soil health and environmental security. The potential nutrient availability from major organic sources is estimated at 10.5 to 16.2 million tonnes, out of which only 3.9 to 5.7 million tonnes is available for agricultural use (Table 8). Vast potential lies in the country for production and use of FYM and composts. The potentials of rural and urban compost in India is estimated to be 600 and 16 million tonnes, respectively, out of which only 279.7 and 6.6 million tonnes was actually produced during 1991-92. Thus, the average consumption has been about 2 tonnes/ha/year. Even this much is not available for oilseeds as organic manures are mostly diverted to high value crops like fruits, vegetables, potato, sugarcane and plantation crops.

Despite limited data, the role of organic manures in oilseeds production is being increasingly recognised. In groundnut, application of FYM @ 7.5 t/ha increased the pod yield by 60% over control and 27% over 25:50:25 NPK kg/ha (Agasimani and Hosmani, 1989). Phosphorus enriched manure had significant influence on the yield of groundnut (Das *et al.* 1992). Poultry manure appeared to increase the pod yields of groundnut much more than did FYM and pig manure when applied along with SSP or SSP + RP (Das *et al.* 1992). Sagare *et al.* (1992) reported that highest pod yield of 1.65 t/ha and oil yield of 0.81 t/ha was obtained from application of 25 kg N + 50 Kg P_2O_5/ha as enriched FYM. With enriched FYM, NPK uptake also increased. Sukhija *et al.* (1985) found beneficial effect of application of 50 kg N + FYM on seed yield and quality of mustard. In sunflower, application of FYM @ 10 t/ha increased the seed yield by 28.7 and 28.4% at Bangalore and Coimbatore, respectively. At Tikamgarh, Tiwari *et al.* (1995) obtained 28.7% higher yield of sesame due to application of 2.5 t FYM/ha along with recommended NPK. Castor yields were comparable with the treatments of 25% N through mustard cake + 75% N through urea and 75% N through mustard cake + 25% N through urea under irrigated conditions at Sardar Krushinagar (DOR, 1992).

The results of All India Coordinated Research Project on Long Term Fertilizer Experiments at Jabalpur and Ranchi clearly indicated the benefits of the application of FYM (supplying 38 N, 8 P_2O_5, 30 K_2O, kg/ha) to soybean superimposed over either 100 or 150% recommended NPK over a 13 to 16/17 year period (Anonymous, 1992). The soybean yields with 100% recommended NPK + FYM were greater than those obtained with even 150% NPK in all the years of study.

Organic manures besides supplying nutrients to the current crop, very often leave substantial residual effect on the succeeding crops in the system and this residual effect lasts often for several seasons.

Organic manures are not just sources of nutrients, they have profound, even sometimes the dominant effect on soil physical properties resulting in better structure, greater water retention, more favourable environment for root and pod growth and better infiltration of water. The beneficial effects of such properties on crop yields has rarely been given due economic importance.

The composition of organic manures vary greatly. Current recommendations based on casual evaluation of FYM/compost in terms of tonnes/ha with very little or no emphasis on the quality aspect are many times misleading. There are proven scientific ways for improving the quality of organic manures which need to be popularised amongst the farmers. The quality can be substantially enhanced by enrichment of the manure during decomposition with cheaper indigenous materials. Rock phosphate enriched compost, popularly known as phospho-compost contains more than

1% P_2O_5 as against **0.3 - 0.6% in** usually prepared rural compost.

Besides FYM and compost, there are several other organic sources with good nutrient potential. However, there is hardly any information on their integration in oilseed production. There is a need to integrate with different organic manures available in specific agro ecoregions with chemical fertilizers for cropping systems involving oilseeds.

Crop Residues and Recyclable Wastes

The country has large potential of crop residues and other farm/industrial wastes with good manurial value (Table 9). Although most of the crop residues with feed value are needed to support huge livestock population, some residues available in specific locations/situations can be made use of as a source of plant nutrients because either they are not preferred as animal feed or their transport to needy areas is not economically viable. Crop wastes and residues are renewable and readily available but they are limited and scattered. In addition to improving the soil properties, conserving soil moisture and suppressing weeds, application of crop residues may partially substitute the chemical fertilizers. Of the nutrients taken up by cereal crops, on an average, 25% N and P, 50% S and 75% of K is retained in crop residues making them valuable nutrient sources. Gaur and Mukherjee (1979) observed 95.5% increase in pod yields of groundnut, over control, with the application of 5 t/ha of wheat straw, which also improved the seed oil content. On acid soils, the incorporation of biodigested slurry @ t/ha and Rhizobium treatment had augmented symbiotic efficiency and resulted in 39.2% higher pod yield of groundnut over control (Ponniah *et al.* 1991). Application of coirpith inoculated with *Pleuroteus* sp. + NPK increased the pod yield whereas uninoculated coirpith was not effective (Nagarajan *et al.* 1986). In sunflower, incorporation of crop residues @ 5 t/ha on vertisols has been demonstrated. Incorporation of pigeonpea stalks has resulted in 44% increase in yield over control and further, there was improvement in the water holding capacity of the soil (Reddy and Sudharkarababu, 1996).

Crop residues, besides supplying nutrients to the current crop, leave substantial residual effect on succeeding crops in the system (Table 10). Organic N is slowly mineralised and about 30% N is generally available to the first crop. About 60-70% P and 75% of K also is likely to become available to the first crop and the rest to subsequent crops (Gaur, 1992). Besides supplying nutrients, crop residues and wastes favourably influence physical, chemical and biological properties of the soil.

The amount of stubbles left in the field after the harvest of some of the cereals and pulses may range from 0.2 to 1.5 t/ha. Before planting next crop, in many cases, these stubbles are collected and burnt as they are difficult to decompose, leading to a significant loss of nutrients. There is need to devise appropriate management practices to make use of these stubbles in INSAM of cropping systems.

The inconsistent crop responses to incorporation of crop residues under different situations may well be expected due to varying pace of immobilizations-mineralization cycle, particularly that of N.

There are many recyclable wasts of agricultural and industrial origin such as sugarcane trash, potato haulms, nonedible cakes, tobacco and tea wastes, cotton wastes, press mud, forest litter, water hyacinth, wastes from food processing industries etc. However, practically there is no information on their integration with fertilizers in the oilseeds production.

Legumes

Legumes have been known for their soil

Table 7 : Residual effect of P applied to first crop of groundnut on pod yield and oil content of third crop of groundnut in groundnut-maize-groundnut sequence.

P_2O_5 (kg/ha)	Pod yield (q/ha)	Oil content (%)
0	15.6	42.8
20	17.7	44.3
40	18.9	45.9
60	21.0	45.8
CD(5%)	1.0	0.9

Source : Reddy et al., 1990.

Table 8 : Potential and possible nutrient (NPK) availability from major organic resources

Resources	Nutrients (m.t)	
	Potential	For agriculture use
Crop residues	5.6 - 8.7	1.7 - 2.6
Animal dung	3.4 - 5.7	1.0 - 1.7
Night Soil	1.5 - 1.8	1.2 - 1.4
Total	10.5 - 16.2	3.9 - 5.7

Source : NAAS. 1996

Table 9 : Nutrient potential of crop residues, agricultural and industrial wastes.

Crop	Quantity (million tonnes)	Nutrients/ year (000't)			
		N	P_2O_5	K_2O	Total
Crop residues	273.3	1283.1	1965.6	3903.9	7152.6
Potato haulms	12.0	294.0	12.0	225.0	531.0
Sugarcane trash	30.0	56.0	15.0	99.0	170.0
Forest litter	18.7	99.7	37.4	99.7	236.8
Nonedible oil cakes	0.4	12.0	5.0	12.0	29.0
Sewage sludge	0.5	5.1	2.9	2.8	10.8
Press mud	3.2	33.3	79.4	55.4	168.1
Water hyacinth	73.0	72.0	14.0	84.0	170.0
Domestic waste water	6351.0*	317.6	139.7	190.5	647.8
Industrial waste water	66.2*	2.9	0.9	1.3	5.1

*Million cubic metres per annum
Source : Juwarkar *et al.*, 1992, Hegde and Dwivedi, 1993.

recuperation power since time immemorial. Legumes can form an important component of INSAM in oilseeds when grown as a sequence crop, intercropped with non-leguminous oilseeds or when introduced as a green manuring crop in a cropping system.

Legumes grown in sequence

Nodulating legumes benefit the succeeding nonlegume crops in terms of increased yields in comparison with the yield of nonlegumes after non legumes or non-nodulating lines of legumes (Wani and Lee, 1992). Such increased yields are attributed to enrichment of soil N due to N2 fixation and the N conserving effect of legumes. However, all such benefits can not be explained by N effect alone, and several factors viz., improved soil physical, chemical and biological properties, reduced weed and diseases severity and insect infestation, etc. are responsible. If a cereal or a non-legume crop succeeds Kharif groundnut, 20-25 kg N/ha can be reduced and no phosphorus application is required if groundnut has already been supplied with P. In case of legumes being succeeding crops, only phosphorus @ 15-20 kg/ha is suggested (Reddy and Sudhakarababu, 1996). The nitrogen requirement of mustard in different double cropping systems at Hisar revealed that the highest yield was obtained with 120 kg N/ha. However, the response to N application in mustard declined after 40 kg kg N/ha if the preceding crops were groundnut, castor, sesame and pigeonpea while after pearlmillet, there was good response upto 80 kg N/ha (Kumar and singh, 1988). A 50% reduction (15-25 kg N/ha) in N application to safflower was suggested if the proceeding crop is a grain legume receiving its full complement of fertilizers (Hegde, 1995).

The long-term fertilizer trial on sunflower based sequences at Hyderabad revealed that groundnut and castor crops are efficient in utilising the residual fertility from proceeding sunflower. After third cycle of different sunflower based crop sequences, sunflower yields at 50% recommended fertilizers, when rotated with groundnut, was comparable with that at 150% recommended fertilizers in sunflower-sunflower sequence (Reddy and Sudhakarababu 1996).

Groundnut and soybean crops being legumes, account for nearly 50% of the area under oilseeds in the country. These crops in sequence with other nonlegumes, can help in saving N fertilizer to the extent of 30 to 40 kg N/ha. In other nonleguminous oilseeds, inclusion of leguminous crop in the sequence may help to economise N fertilizer requirement to the extent of 20-40 kg N/ha. In a country where the average consumption of plant nutrients is very low and still lower in oilseeds, the residual fertility build up due to legumes is obviously a major contribution which must be fully exploited for increasing oilseeds production.

Legumes as intercrops

A leguminous crop like cowpea can be grown as an intercrop for a 6 week period and incorporated *in situ* as green manure. Results of such a study were reported by Vijayalakshmi (1983) from Hyderabad for castor. The data indicate that over years, 10 kg N + green manuring (5 t/ha) was as good as 40 kg N/ha in red sandy loam soil. The contribution of intercropped cowpea green manured *in situ* could be upto 30 kg N/ha. Groundnut + pigeonpea inter-cropping produces higher yields due to less competition for soil P because pigeonpea as a sole crop or in intercropping system with mungbean and maize prefers Al-P while with groundnut, prefers Ca-P (Subba Rao, 1994). There are also beneficial effects of inter-cropping leguminous oilseeds like groundnut and soybean in cereal crops (Hegde and Pandey, 1992).

Nitrogen economy through intercropping legumes is yet to be assessed in different intercropping systems. Although many legumes have been identified for intercropping in oilseed crops, no information is available on the N economy achieved through these systems.

Legumes as green manures

Before introduction of chemical fertilizers, green manuring with leguminous crops was invariably practised with most crops. However, with the easy availability of chemical fertilizers and crop intensification, the practice of green manuring was almost given up. Of late, there has been revival of interest in green manuring with an indication of unsustainable yield levels due to continuous use of only chemical fertilizers. At present, green manuring is practised on about 6.7 million hectares. Sunnhemp and sesbania are the most common green-manure crops in India, while clusterbean, Egyptian clover or berseem and cowpea are also used occasionally. Large amount of green biomass of narrow C:N ratio when incorporated into the soil during green manuring definitely contributes sizeable amounts of plant nutrients, particularly N and brings improvement in soil physical conditions.

Green manuring significantly improved the yields of *toria* at all the fertilizer N levels (Pasricha *et al.*, 1988). Addition of green manure (5 t/ha) resulted in *toria* yield (10.48 g/ha) equal to that obtained with 60 kg N/ha (10.49 q/ha). Green manuring along with inorganic N led to an additional yield of toria ranging from 5.6 to 8.3 q/ha. Beneficial effect of green manuring to *raya* was also reported (Pasricha *et al.*, 1987). At Ludhiana, clusterbean green manuring gave similar yield of mustard as that of N alone @ 100 kg/ha. In maize-mustard system, average direct effect of green manuring on maize was a yield increase of 763 kg/ha, equivalent to 42 kg N/ha through chemical fertilizers and a further increase of 145 kg N/ha in mustard yield through its residual effect (Pasricha *et al.*, 1987). Incorporation of sunnhemp or *Leucaena* loppings resulted in yield of safflower similar to that obtained from 37.5 : 25 NP, kg/ha and increased oil and protein content in seeds.

While green manuring practice has both direct and residual benefit on oilseeds, the point for consideration is whether the farmers would be willing to forego a crop merely for growing a green manure crop. Many a times, farmers are not willing to spare their meagre land resources and inputs for raising a green manure crop as it neither provides food nor immediate income. Where intensive cultivation and growing more than one or two crops is aimed at, green manures will have no scope in cropping systems. Instead, the oilseeds crops are better intercropped or be intercropped with other crops to achieve the same objective of green manuring atleast partially. Fresh loppings of perennial leguminous trees such as *Leucaena* grown on hedge rows and field bunds may be used for incorporation into the soil as a source of N for nonleguminous oilseeds.

Biofertilizers

Biofertilizers have an important role to play in improving the nutrients supply and their availability in crop production. They help in increasing the biologically fixed atmospheric N and enhancing native P availability to crops. Among the biofertilizers for increasing N supply to oilseeds crops, N-fixing bacteria viz., *Rhizobium*, *Azotobacter* and *Azospirillum* are important. The availability of P is improved by P solubilising microorganisms (PSM) and mycorrhizae.

Rhizobium

There is scope for exploiting the ability of leguminous oilseeds-groundnut (112 to 152 kg N/ha) and soybean (49 to 130 kg N/ha) to fix atmospheric N to meet in part or fully N requirement (Wani and Lee, 1992). But these crops too need starter doses of N (15-20 kg/ha) through fertilizers to be effective as N fixer. Inoculation with efficient *Rhizobium* strain specific to each crop is very essential for the N gains and better crop yields. In groundnut, new *Rhizobium* strains IGR-6 and IGR-40 were found to be tolerant to Thiram and hence seed treatment with fungicide and inoculation of *Rhizobium* can go together (Reddy and Sudhakarababu, 1996). *Rhizobium* inoculations have proved beneficial where these crops are cultivated for the first time and every time in rice-fallow situations. However, for the *Rhizobium* to be effective, the soils should have no deficiency of P, Ca and Mo.

Response of groundnut to *Rhizobium* inoculation was 272 kg/ha averaged over 29 trials (ICAR, 1987). Results from Junagarh (Gujarat) indicated 15 to 30% increase in summer groundnut yields with *Rhizobium* inoculation (NRCG, 1988). At Akola (Maharashtra), seed inoculation with rhizobium + 4 g Mo/kg seed increased groundnut yield significantly (Wankhade *et al.*, 1992). In Kharif groundnut, 13 to 53% increase in yields were reported with rhizobial inoculations (Anonymous, 1993). In soybean, *Rhizobium* inoculation along with 30 kg N/ha produced the highest yield and nitrogen dose less or greater than 30 kg N/ha caused significant reduction in yield (Tiwari *et al.*, 1988). Significant response to rhizobial inoculation in soybean was reported by many workers (Bisht and Chandel, 1991; Dehatonde and Shava, 1992; Vara *et al.*, 1994). Pelleting of *Rhizobium* inoculated seeds with CaCo3 significantly increased the yield of soybean (Prabhakaran and Sivasubramanian, 1991).

Responses to *Rhizobium* inoculation under field conditions have been quite variable depending on soil conditions, quality of inoculum and effectiveness of native population. Use of *Rhizobium* cultures in groundnut and soybean has not spread to the extent desired as there is no quality control in commercially produced inoculants and farmers are not fully convinced of its usefulness.

Azotobacter and Azospirillum

Among other important groups of bacteria, *Azotobactor* is free-living N fixer while *Azospirillum* fixes N in loose association with plant roots. Not many reports are available on the usefulness of these microorganisms in augmenting N supplies to oilseeds. In mustard, seed inoculation with *Azotobacter* and *Azospririllum* increased the seed yield equivalent to that obtained with 25 to 30 kg/ha of fertilizer N and Azospirillum was slightly more efficient than Azotobacter (Chauhan *et al.*, 1995 a,b). In groundnut, significant increase in pod yield was reported due to seed inoculation with *Azospirilllum* (Balasubramanian and Palaniappan, 1994) and combined inoculation of *Rhizobium* and *Azospirillum* had no additional advantage. *Azospirillum* seed treatment in sesame and *Azotobacter* in toria and sunflower might reduce the N requirement of these crops by almost 50% (Reddy and Sudhakarababu, 1996).

Inconsistency in crop responses to *Azotobacter* and *Azospirillum* has been more common than *Rhizobium* and the responses depended on crops and their cultivars, locations, season, crop management practices, bacterial strains, soil fertility and native microbial population.

Phosphate solubilizers

Most of the soil phosphorus is in unavailable form while the P requirement of oilseed crops is high. In recent years, several strains of P solubilising bacteria and fungi have been isolated. In groundnut significant increases in pod yield due to seed inoculation of P solubilizers like *Pseudomonas striata* and *Paecilomyces fussispores* have been reported (Mehta *et al.*, 1995). Combined application of PSB inoculation with FYM was better than PSB alone in irrigated groundnut (Balasubramanian and Palaniappan, 1994). In sesame, use of PSB (100 g/kg seed) in conjunction with neem cake, castor cake or FYM gave higher yields (DOR, 1994).

Vescicular-arbuscular mycorrhizae (VAM), a kind of symbiosis between plant roots and certain fungi, substantially enhances P availability and its uptake by the crops and found beneficial particularly on P deficient soils. VAM inoculations increased the yields of groundnut by 14.5% in Kharif and 27.8% in rabi season in sandy loan soils at Tirupati (Anonymous, 1993). In another study, 26.4% increase in soybean and 20.9% increase in groundnut yields were reported with inoculation of VAM, *G. fasciculatum* (Wani and Lee, 1992). However, this increase had decreased to 18.5 and 10.1% respectively when inoculated in combination with *Rhizobium*. Because of problems in isolation and multiplication of pure strains of VAM fungi, it has not been possible yet to use this potential biofertilizer on a large scale.

Wider acceptability of biofertilizers among the oilseeds farmers is constrained because of inconsistent responses and problems associated with the availability, transport, storage and handling. The production and distribution of different biofertilizers in the country (Table 11) can hardly meet the requirement of less than 10% of the cropped area. The success rate in case of any biofertilizer in terms of significant increase in yield ranges from 30 to 65%. In order to improve the consistency in response, greater research thrust is needed on isolation and multiplication of strains which can compete with indigenous ones and adapt to a wide range of soil and climatic conditions. There is also need to bring biofertilizers under quality control to ensure that the inoculums farmers use conform to certain minimum standards.

Conclusions and Future Research Priorities

Integrated nutrient management holds great promise in meeting the growing nutrient demands of intensive agriculture. It can also help in maintaining production sustainability without deterioration in the quality of plant's environment. Despite many constraints like use of cattle dung as fuel, increasing competitive value of crop residues as animal feed, extra cost and time required for raising green manure crop, poor and inconsistent responses to biofertilizers etc, efforts must be made to develop agro-ecoregion specific practical recommendations for different oilseeds and oilseeds based cropping systems utilizing the already generated data on different components of INSAM. An example of possible INSAM package for meeting the nutrient needs of irrigated sunflower during *rabi* season in Andhra Pradesh is given in Table 12.

Nutrient application rates with most oilseed formers are well below the optimum and various organic sources and biofertilizers can help to take these towards the optimum level and to that extent supplement fertilizers. These sources will be able to substitute part of the fertilizer, particularly N, where farmers have reached the optimum level of nutrient application. For most farming conditions, packages of INSAM should be assembled within the overall limits of recommended nutrient application rates and not in a haphazard manner. Blueprints for INSAM need to be developed in a realistic manner and little purpose will be served by loading all available components into a package. The assembling of package must be more in the form of alternative options. The package must integrate the comparative advantages of diverse sources of nutrients for more efficient and cost-effective nutrient management.

While possibilities for INSAM are real and attractive, most nutrient packages for high yields of oilseeds required to meet the needs of the expanding population from non-expanding area, will continue to be fertilizer driven. This assessment in no way underestimates the importance of other nutrient sources, most of which are gainfully integrable. Many research gaps remain to be filled and the following are some of important future research priorities :

1. There is a need to prepare an inventory of promising organic and biological sources under different agro-ecoregions involving diverse farming situations.

Table 10: Residual effect of rice straw applied to first crop of groundnut on pod yield and oil content in third crop of groundnut in groundnut-maize-groundnut sequence.

Rice straw (t/ha)	Pod yield (q/ha)	Oil content (%)
0	16.2	43.4
2	17.8	44.3
4	18.6	45.2
6	20.6	46.0
CD(5%)	*1.0*	0.9

Source : Reddy *et al.*, 1990.

Table 11: Production and distribution of biofertilizers in India (1994-95)

Product	Production (tonnes)	Distribution (tonnes)
Rhizobium	1191.55	1355.17
Azotobacter	1352.42	971.58
Azospirillum	632.45	523.58
Blue Green Algae	0.92	0.11
Acetobacter	25.43	17.35
Phosphate Solubilisers	1917.07	1786.50
Total	5119.84	4654.29

Source : FAI. 1996.

Table 12 : Some alternate strategies for meeting nutrient needs through INSAM for rabi sunflower in A.P.

Alternative	Nutrients (kg/ha) $N : P_2O_5 : K_2O$	Fertilizers	privious legume	FYM (4 t/ha)
1	60 : 90 : 30	60 : 90 : 30	-	-
2	60 : 90 : 30	40 : 90 : 30	20 : 0 : 0	-
3	60 : 90 : 30	40 : 78 : 10	-	20 : 12 : 20
4	60 : 90 : 30	20 : 78 : 10	20 : 0 : 0	20 : 12 : 20

2. Efforts must be made to assemble agro-ecoregion specific INSAM packages for various oilseed crops utilizing the available information. To fill the information gaps, wherever needed, plan new experiments on well definded bench mark sites.

3. There is a need to develop methodologies for quantifying the non-nutritional benefits of using organic sources of nutrients.

4. Different industrial wastes with potential manurial value need to be characterised.

5. More field data on *in situ* decomposition of crop residues including stubbles in relation to soil properties and crop productivity are needed on short, medium and long term basis.

6. Research on INSAM in relation to soil moisture management deserves greater attention and priority for sustainable productivity.

7. Research on residual effect of various organic sources under different environments and management practices needs to be initiated.

8. Biofertilizer technology needs to be refined to make it more acceptable to farmers. Microbial strains which can compete with indigenous ones and work efficiently over a wide range of soil-climatic conditions need to be isolated and multiplied.

9. Large scale on-farm testing of different components of INSAM is necessary to convince the farmers of the effectiveness of INSAM in oilseeds.

10. Mass awareness on conservation of organic sources and their recycling needs to be improved and promotional literature should be prepared in simple language and made available to the farmers and extension personnel in addition to some adaptive research, demonstrations and specific training programmes.

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ANALYSIS OF PHENOTYPIC STABILITY FOR YIELD AND YIELD ATTRIBUTES IN NIGER (*Guizotia abyssinica* Cass)

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ABSTRACT

The stability parameters for eight attributes related to quality and productivity performed in twenty niger (*Guizotia abyssinica* Cass) genotypes are reported. Significant differences were observed among the genotypes and environments. No genotype showed average stability for all traits. Phule-1 and GA-10 were stable for yield per plant. Similarly, N-5 and ONS-8 were noted to be the most stable selections for 1000 seed weight while for oil content NBC-2 and KEC-7 showed stability over a wider range of environment where as for harvest index the most suitable genotypes were RCR-290 and KEC-7.

Key words : Niger, stability, yield, yield attributes.

INTRODUCTION

Niger varieties show a wide range of fluctuations in their performance. Some genotypes perform well over a wide range of environments while others require specific environmental conditions to express their full genetic potential. It is extensively grown as a rainfed crop in marginal and submarginal lands of Bihar plateau. Fluctuating yields in different crop growing situations necessitates the use of stable performing genotypes for popularising its cultivation in this region.

MATERIALS AND METHODS

Twenty niger genotypes obtained from different sources were sown at University Farm, Ranchi in randomised block design with three replications in four environments during *Kharif* 1988. Each genotype was sown in 5 rows spaced at 30 cm with a plant spacing of 10 cm. The observations on plant height, capitulum diameter, 1000 seed weight, yield per plant, days to 50 per cent flowering, days to maturity, oil content and harvest index were recorded on five randomly selected competitive plants. The analysis proposed by Eberhart and Russell (1966) and Perkins and Jinks (1968) were used to study phenotypic stability.

RESULTS AND DISCUSSION

Twenty selections were used for computing stability parameters based on two models. Both the models used in the analysis are associated with each other, so that mean and squared deviation from regression (S^2di) are similar and the regression coefficient of the perkins - Jinks model is equivalent to b^E-1, b^E the regression coefficient of the Eberhart Russell model. Consequently, the ranking pattern of the genotypes under the perkins - Jinks model will be similar to the pattern obtained with the Eberhart - Russell model.

The experimental results indicated significant differences for most of the characters except for capitulum diameter, yield per plant and harvest index. Genotype x environment interaction was significant for 1000 seed weight, days to 50 per cent flowering, days to maturity and oil content when tested against pooled error but not significant for yield as reported by Verman and Manoharan, 1993 in groundnut. It was observed that the average performance of the genotypes with regard to 1000 seed weight, days to 50% flowering, days to maturity and oil content. Similar results were reported by Verma *et al.*, (1994); Verma and Mahto (1994) and Mahto *et al.*, (1994). Environment (linear) was significant for plant

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height, days to 50% flowering, days to maturity and oil content. Genotype x environment (linear) interaction was significant for all characters except yield per plant, oil content and harvest index which might be responsible for high adaptation in relation to yield attributing traits in niger (Table-1). The linearity was predominant for grain yield, harvest index and oil content. Similar results were obtained by Verma *et al.*, (1994) for days to maturity, Verma and Mahto (1994) for plant height and days to maturity and Mahto *et al.*, (1994) for 1000 seed weight, days to 50% flowering, plant height and days to maturity in linseed.

The variance due to pooled deviation (non linear) was also significant for most of the characters. Such non linear deviation may be of practical value to construct and test the unity of multiple regression models to know critically the complex mechanism of adaptation. A variety is likely to be stable over different environments if it shows high mean value (above average performance) unit regression coefficient (bi) with lowest deviation (non significant) from the linear regression (bi). The genotypes phule-1, GA-10, GA-1, CHH-2, NBC-2, KEC-1, IGP-76, RCR-140 and BNC-120 had non significant deviation from regression with the regression coefficient approaching unity for yield per plant but most stable was phule-1 and GA-10 (Table-2). BNS-1, Goudaguda, N-5, DHL-2 and ONS-8 showed stable response for days to 50 percent flowering. NBC-2 is most important genotype as it is stable for capitulum diameter, seed yield per plant as well as oil content reported (Verulkar and Updhayay 1989). Goudaguda was stable for plant height, days to 50% flowering and days to maturity. ONS-8 showed its stability for capitulum diameter, 1000 seed weight and days to 50% flowering, whereas N-5 was stable for plant height, days to 50% flowering and 1000 seed weight.

Normal sown fertilizer environment was favourable for plant height, capitulum diameter, yield per plant, days to 50% flowering, days to maturity and harvest index (Table - 3). Late sown fertilizer environment was favourable for 1000 seed weight and harvest index.

Table 3. Environmental indices for yield and quality characters in niger.

Sl. No.	Characters	Normal sown		Late sown		General mean of character
		Ferti lizer	Non Ferti lizer	Ferti lizer	Non Ferti lizer	
1.	Plant height (cm)	23.977	6.936	-12.857	-18.052	53.624
2.	Capitulm diameter (cm)	0.0311	-0.004	-0.0036	-0.0226	0.9655
3.	1000 seed weight (gm)	-0.2115	-0.0248	0.038	0.2106	4.08
4.	Yield per plant	0.243	0.351	-0.284	-0.308	0.945
5.	Days to 50% flowaring	4.71	8.44	-6.686	-6.47	51.97
6.	Days to maturity	2.5	1.53	-1.06	-1.1	102.75
7.	Oil content	0.949	1.129	-0.866	-1.212	42.294
8.	Harvest index	-0.0707	-0.0245	0.0665	0.0183	0.2647

Table 1. Pooled analysis of variance for different characters.

Characters	Eberhart and Russel model (1966)							Eberhart and Russel model (1968)				
	Genotypes (G)	Environment (E)	GxE	E (Linear)	GxE (L)	Pooled deviation	Pooled error	Genotypes	Environment	GxE	Hetrerogenity between regression	Ramainder
d.f.	19	3	57	1	19	38	152	19	3	57	19	19
Plant height	13.49*	7469.21**	9.63	22407.6**	119.31**	18.621	9.14	13.49*	7466.33	9.63	22407.62**	20.628
Capitulum diameter	0.015**	0.01*	0.002	0.03	0.004*	0.0012	0.002	0.015	0.01	0.002	0.08	0.002
1000 seed weight	0.11**	0.67**	0.70**	2.02	8.890*	0.41	0./032	0.11**	0.66**	0.70*	2.02	0.43
Yield per plant	0.0331*	2.31*	0.027	6.94	0.048	0.024	0.018	0.033	2.31	0.027	8.94	0.026
Days to 50% flowering	16.87**	1201.86**	3.90*	3603.57**	3.230*	4.024	1.757	16.87*	1157.58**	3.90**	3603.57**	4.821
Days to maturity	112.85*	61.81**	4.009*	194.43**	6.193*	2.764	3.149	112.85**	60.39**	4.007*	194.43**	2.782
Oil content	0.92**	29.57**	0.663**	88.7*	0.704	0.612	0.057	112.85**	29.39**	0.660**	88.70**	0.635
Harvest index	0.0017*	0.0545	0.0021	0.179	0.0015	0.25*	0.009	0.0017*	0.059	0.002	0.179	0.0024*

*, ** Significant for 5% and 1% probability levels, respectively.

Table 2. Mean performance and stability parametrers for different characters in rainfed niger.

Genotypes	Plant height				Capitulum diameter				1000 seed weight			
	xi	b_E	B_p	S^2di	xi	b_E	B_p	S^2di	xi	b_E	B_p	S^2di
RCR-290	53.79	1.016	0.016	1.217	0.887	0.3230	-0.6770	-0.0015	4.06	1.532**	0.532**	-0.0331
BNS-1	54.65	1.118	0.118	-5.786	0.943	0.2027	-0.7973	-0.0013	3,90	0.195	-0.805	-0.0211
Phule-1	51.40	0.968	-0.032	-7.249	0.998	1.6789	0.6789	-0.0042	4.16	2.036*	1.036*	0.3000
Goudaguda	52.15	1.093	0.093	-6.119	1.018	0.6345	-0.3645	-0.0010	3.88	0.867**	-0.133**	-0.0090
ONS-2	52.73	1.040	0.040	-8.789	0.937	-2.4919**	-3.4919**	0.0007	3.94	1.378	0.372	-0.0209
RCR-317	52.68	0.976	-0.024	-2.768	1.005	2.5134**	1.5134**	-0.0019**	4.34	-0.028**	1.028**	-0.0041
GA-10	55.11	1.168	0.168	1.572	1.035	4.3833**	3.4833	0.0001	4.02	1.784**	0.784**	-0.0171
GA-1	52.58	0.933	-0.067	3.775**	0.958	2.1176**	1.1176**	-0.0017	4.22	0.043	-0.951	-0.1140
N-5	53.85	1.004	0.004	-2.352	0.541	0.2267	-0.7733	-0.0019	3.94	0.997	-0.003	-0.0031
ONS-4	57.50	1.162*	0.162*	6.404**	1.015	3.9770**	2.9760**	-0.0008	4.15	0.607	-0.393	0.2022**
CHH-2	52.25	0.980	-0.020	-7.309	0.868	-1.9648**	-2.9648**	-0.0007*	4.03	0.846	-0.154	-0.0071
NBC-2	53.10	0.865*	-0.135*	-7.612*	0.925	1.0120	0.0120	-0.0014	4.36	2.036**	1.036**	-0.2690
KEC-1	54.45	1.002	0.002	-4.530	1.042	0.4198	-0.5802	-0.0005	4.14	0.953	-0.047	-0.0035**
IGP-76	53.91	0.955*	-0.045*	2.102	0.970	-0.0675	-1.0675	-0.0014	4.34	0.337	-0.663	0.1245*
RCR-140	52.15	1.005	0.005	3.73	0.888	0.5044	-0.4566	-0.0012	4.36	0.408	-0.596	0.6689
BNC-120	51.91	0.918	-0.082	-6.765	1.014	2.0803	1.0803	0.0034	4.04	1.645	0.645	0.0010
N-71	52.34	0.861	-0.139	-0.923	0.927	-0.0297**	-1.0297**	0.0008	4.24	1.570	0.570	0.0907**
KEC-7	55.28	1.095	0.095	0.352*	0.944	1.7209	0.7209	-0.0012	3.89	1.760**	0.760**	0.0254
DHL-2	51.71	0.819	-0.181	-5.582	0.893	0.4600	-0.5400	-0.0019	4.29	0.148	-0.852	0.2706**
ONS-8	58.08	1.022	0.022	33.825	1.078	2.1981	1.1981	-0.0013	4.04	0.903	-0.097	0.0305
GM	53.62				0.965				4.08			
SEM±	2.12	0.113			0.119	1.203			0.07	0.211		

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

Table 2. Continued.

Genotypes	Yield per plant				Days to 50% flowering				Days to maturity			
	xi	b_E	B_P	S^2di	xi	b_E	B_P	S^2di	xi	b_E	B_P	S^2di
RCR-290	1.054	1.5115	0.5115	-0.0107**	40.00	1.1044	0.104	1.033	99.41	1.334	0.334	-2.433*
BNS-1	0.567	1.8400**	0.8400**	-0.0156	51.33	1.0640	0.064	-0.892	100.16	2.221*	1.221*	-2.423
Phule-1	0.831	1.0168	0.0168	0.0101	50.58	0.8322**	-0.178**	-1.148**	104.08	-0.010	-1.010	-1.330
Gouda guda	0.293	0.4584**	-0.5416**	-0.0147	54.41	0.8836	-0.117	1.452	106.83	1.133	0.133	-1.596
ONS-2	0.280	1.1346**	0.1346**	-0.0134**	52.83	1.1841	0.184	13.230	102.75	1.287**	0.287**	6.273
RCR-317	1.104	1.6142	0.6142	0.0648**	50.41	1.1217	0.121	-0.798**	102.50	-1.126	-2.126	4.283**
GA-10	0.859	1.0632	0.0632	0.0011	56.33	1.0271	0.027	14.583**	108.30	0.405**	-0.595**	-2.053
GA-1	1.009	1.1157	0.1157	0.0233	51.33	0.9307	-0.070	2.039	108.25	1.594	0.594	-2.135**
N-5	0.984	1.2860	0.2860	-0.0122**	52.91	1.1019	0.109	-0.204	95.41	1.483	0.483	-1.143**
ONS-4	1.000	1.0888	0.0888	0.0235*	54.58	1.2919*	0.291*	-0.990**	101.83	2.227	1.227	-2.769
CHH-2	0.917	1.1228	0.1228	0.0035	53.33	0.8411	-0.169	1.363	105.41	0.663	-0.337	5.753
NBC-2	1.061	0.9169	-0.0831	0.0060	49.83	0.8333	-0.117	-0.608*	100.83	0.810**	-0.189**	-2.179**
KEC-1	0.829	0.4090	-0.5910	-0.0079	51.88	1.1041**	0.104**	0.734*	89.83	-0.929	-0.071	-0.179*
IGP-76	0.860	0.8629	-0.2371	0.0049	50.16	0.8379	-0.163	1.306**	108.83	0.374**	-0.626**	-2.603
RCR-140	0.901	0.9568	-0.0432	0.0064	51.00	1.0917**	0.091**	5.591**	104.08	1.594	0.594	2.753**
BNC-120	0.831	0.3889	-0.4110	-0.0191	51.91	0.9100	-0.090	1.959**	99.11	0.263	-0.737	-1.603
N-71	1.035	0.9686	0.0314	-0.0091**	50.00	1.0240	0.024	4.830**	103.08	0.892**	-0.108**	-1.533**
KEC-7	0.989	0.6876	-0.3124	0.0039**	50.00	1.0240	0.024	3.830*	103.08	0.892	-0.108	-2.533
DHL-2	1.042	1.2030	0.2030	0.0120**	52.66	0.8903	-0.110	-1.140	109.91	0.610**	-0.390**	-2.583
ONS-8	0.936	1.0143	1.0143	0.4220**	52.92	0.9016	-0.099	-1.216	113.25	1.609	0.609	0.253*
GM	0.945				51.97				102.75			
SEM±	0.143	0.158			00.392	0.150			5.101	0.103		

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

Table 2. Continuted.

Genotypes	Oil Content (%)				Harvest index			
	xi	b_E	B_p	S^2di	xi	b_E	B_p	S^2di
RCR-290	42.50	0.8813*	-0.1187*	1.325**	26.40	1.0334	0.0334	0.00140
BNS-1	42.13	0.8007*	0.1993*	1.421**	26.80	1.4174	0.4174	0.00007**
Phule-1	42.45	1.2581**	0.2581**	0.803*	26.40	0.8165	-0.1385	0.00002
Gouda guda	41.72	1.0849**	0.0849**	0.376*	24.50	0.7449	-0.1385	0.00099**
ONS-2	42.15	0.6209	-0.3791	0.053	23.50	0.6147	-0.2551	0.00317
RCR-317	42.23	0.9806**	-0.0194**	0.329**	24.10	0.6876	-0.3125	0.00011**
GA-10	42.32	1.1628**	0.1628**	-0.054	28.90	1.5051	0.5051	0.00777**
GA-I	41.92	0.3398	-0.6607	1.390**	29.90	1.4033**	0.4033**	0.00024
N-5	42.30	1.1620**	0.1620**	0.090	26.90	0.778	-0.0222	0.00016**
ONS-4	41.60	0.5514	0.4486	-0.251	24.80	0.6898	-0.3112	0.0153**
CHH-2	42.52	0.6422	-0.3578	0.415*	25.70	1.5224	0.5224	0.00344
NBC-2	43.01	0.6670	-0.3330	0.129	30.20	1.4919	0.4919	0.00048
KEC-1	42.33	1.1660**	0.1660**	0.345*	28.80	1.6241	0.6241	0.00104**
IGP-76	41.55	1.4306**	0.4306**	0.310	26.50	0.9386	-0.0614	0.00307**
RCR-140	43.12	0.9095	-0.0905	0.221	28.50	1.1168	0.1168	0.00158*
BNC-120	41.82	1.8705**	0.8705**	0.228	22.20	0.3326**	-0.6674**	0.10756
N-71	43.38	1.7660**	0.7660**	0.561**	25.50	0.4807	-0.5193	0.00054
KEC-7	42 60	0.6009	-0.3991	0.041	27.90	0.0271	-0.9729	0.00068
DHL-2	42.13	0.8419*	-0.1581*	1.290**	25.90	0.4893	-0.5107	0.00092**
ONS-8	42.37	1.2615**	0.2615**	1.923**	27.00	1.3708**	0.3708**	0.00020
GM	42.29				26.50			
SEM±	0.78	0.350			1.359	0.589		

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

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GENETIC DIVERGENCE AND HETEROSIS IN SESAME (*Sesamum indicum* L).

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ABSTRACT

Analysis of genetic diversity using Mahalanobis D^2 analysis was carried out on 65 genotypes of sesame and were grouped into eight clusters. The intracluster distance was maximum in cluster VI and minimum in cluster III. The inter cluster distance ranged from 13.29 (I & V) to 30.62 (III & IV). Highly divergent cluster relationships were found in cluster III with clusters V and VIII. Extent of heterosis was studied in a diallel cross for yield and its components. The best hybrid combination for grain yield was TNAU 22 X Corge Borege 11. Inter relationship for heterosis was observed for number of primary branches, total number of capsules and seed yield. In general, fair agreement between the degree of heterosis and distance between the parental clusters was observed. The diversity estimated by generalized distance showed a good measure of heterosis for seed yield. For number of capsules and seed yield crosses between highly divergent parents recorded higher magnitude of heterosis, mostly in positive direction.

Key Words : Cluster, genetic divergence, heterosis, parents, sesame

INTRODUCTION

Sesame (*Sesamum indicum*) is self pollinated and one of the important multipurpose oilseed crop grown throughout the tropics and sub tropics. Critical choice of the parents in yield improvement breeding programmes is important. The selection of parents is generally based on the mean performance of the parents and genetic diversity of characters. Examination of genetic diversity among yield components in sesame and heterosis has been done by early workers (Sodani, 1990, Mahapatra *et al.*, 1993). The objective of the present study was to estimate genetic diversity among sesame cultivars, know the amount of variability available for different characters and to determine the extent of heterosis in crosses for quantitative characters.

MATERIALS AND METHODS

The experimental material for D^2 analysis comprised 65 genotypes which were selected based on mean performance. They were both of Indian and exotic in origin maintained in the germplasm of School of Genetics, TNAU, Coimbatore. The genotypes were sown in randomized block design with three replications in 4.5 m long rows spaced at 45cm. Plant to plant distance within a row was 15 cm. All the recommended package of practices were followed to raise a good crop. Five plants were randomly chosen to record observations on fifteen characters viz., plant height, number of nodes, number of primary branches, number of secondary branches, number of nodes to first capsule, internodal length, number of capsules on main stem, number of capsules per plant, length of capsule bearing portion, 1000 seed weight, number of seeds per capsule, capsule length, capsule breadth, seed yield and oil content. The data were subjected to multivariate analysis using Mahalanobis generalized distance D^2 (Mahalanobis, 1936) and clustering of genotypes was done by Tocher's method (Rao, 1952). Based on genetic distance between the clusters they were classified into four divergent classes DC1, DC2, DC3, DC4 as suggested by Arunachalam and Bandyopadhyay (1984). In the present study these classes were classified as very highly divergent, highly divergent, moderately divergent and closely

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related. In continuation, eight genotypes one each from eight clusters viz., TNAU 22, Margo 7, NALNS 221/32-3, Col, DT 9-9-6//P5, Si 1225, Corge Borege 11 and TMV 5 were selected based on mean performance and crossed in a group of 8 x 8 diallel mating design. The 56 hybrids along with 8 parents were grown in a randomized block design during rabi 1991. Each plot was 4.5 m long row and the plant spacing within a row was 10cm. Observations were recorded on five randomly selected plants for 15 characters. The F_1 performance was used to estimate the heterosis over midparent (MPH) and better parent (heterobeltiosis, BPH) and economic heterosis (EH) (i.e., comparison of F1 with the standard variety Col and 't' test of significance was done.

RESULTS AND DISCUSSION

Genetic Diversity

The D^2 values were computed for all possible 1516 pairs of variants. The highest D^2 value of 1259.67 was observed between Co 1 and NAL NS 221/32-3 and lowest of 12.71 between NAL 78-221/43-14 and Corge Borege 113. The 65 genotypes were grouped into eight clusters on the basis of D^2 values (Table 1). Cluster I was the largest one comprising 30 genotypes, cluster II with 17, cluster III and cluster IV with two genotypes each, cluster IV with five genotypes, cluster V with seven genotypes and clusters VII and VIII with one genotype each. Cluster VI had the maximum intra-cluster generalised distance of 13.44 and the cluster III the minimum of 5.35. The inter-cluster distance considered based on mean standard deviation of D^2 values (Arunachalam and Bandyopadhyay, 1984) ranged from 13.29 (between I and V) to 30.62 (between cluster III and IV) and classified into four divergent classes (Table 2).

Highly divergent relationships were found in cluster III with clusters V and VIII, I with III, II

Table 1. Clustering pattern of 65 sesame genotypes

Cluster number	Number of genotypes	Genotypes
Cluster I	30	TNAU 22, TNAU 12, TNAU 17, VS 81, TSS 6(TN), DT/9-8-7/P8, DT/9-8-6/P9, DT/9-9-7/P8, DT/9-6-7/P3 (Venezuela), NAL 79-111/4-12, NAL 78 - 221/32/1, NAL 78-221/31-4, NAL 78-221/43-1, NAL 78-304/43-10, NAL/78-221/43-18, NAL 79-111-4-11, NAINS-221/32-2 (Tanzania), Si 1121 (Japan), Si 1278 (Maharashtra), Si 1513, Si 1107 (Sudan), Si 1033, Si 1366 (AP), DT/9-8-6/P-17 (Chile), RJS 1(Rajasthan), Corge Borege/8, Corge Borege/12 Corge Borege/113, Cianuo 33-13, Cianno 27-3(*)
Cluster II	17	Margo 7 (Venezuela), Corge Borege GA 15, ES12*ES 22, Corge Borge/14 (USA), Paiyur 1, TMV6, TNAU 10, VS 27, TMV 3, NAL 78-221/43 - Cianno 33-5, TMV 4, TSS11, NAL 78-304/43-3, NAL 78-304/43-13.
Cluster III	2	NAL NS 79-111/4-11, NAL NS 221/32/3
Cluster IV	5	Co 1, Si 1169, Si 1056, Si 1274, Cianno 27-1
Cluster V	7	DT/9-9-6/P5, DT/9-6-5/P2, DT-9-6-7, DT/9-3-4/P5, VS 117, DT/9-6-4/P8, DT/9-9-2/P2
Cluster VI	2	Si 1225, RJS 18
Cluster VII	1	Corge Borege 11
Cluster VIII	1	TMV 5

Table 2. Intra (diagonal) and inter cluster average of D^2 and D (Within parenthesis) values and the extent of diversity among cluster of 65 genotypes in sesamum

Cluster	I	II	III	IV	V	VI	VII	VIII
I	143.360 DC_4 (11.984)	316.20 DC_3 (17.78)	414.54 DC_2 (20.36)	256.04 DC_3 (16.00)	176.62 DC_4 (13.29)	216.79 DC_4 (14.72)	324.86 DC_3 (18.02)	225.56 DC_3 (15.02)
II		146.66 DC_4 (12.11)	769.44 DC_1 (27.74)	215.27 DC_4 (14.67)	346.32 DC_4 (18.61)	516.47 DC_2 (22.73)	268.86 DC_3 (16.40)	299.21 DC_3 (17.30)
III			28.65 DC_4 (5.35)	937.69 DC_1 (30.62)	531.56 DC_2 (23.06)	316.50 DC_3 (17.79)	849.25 DC_1 (29.14)	601.84 DC_1 (24.53)
IV				121.77 DC_4 (11.03)	385.46 DC_4 (19.63)	510.21 DC_3 (22.59)	348.61 DC_3 (18.13)	455.49 DC_2 (21.34)
V					150.52 DC_4 (12.27)	365.94 DC_3 (19.13)	645.09 DC_1 (25.40)	321.73 DC_3 (17.94)
VI						180.50 DC_4 (13.44)	543.19 DC_2 (23.31)	388.89 DC_3 (19.72)
VII							0	236.17 DC_3 (15.37)
VIII								0

DC_1 : Very highlydivergent = 610.17 and above
DC_2 : Highly divergent = 405.68 to 610.16
DC_3 : Moderately divergent = 201.19 to 405.67
DC_4 : Closely ralated = below 201.19

with VI, IV with clusters VI and VIII and VI with VII. Cluster II was highly divergent from cluster III.

Cluster mean for seed yield ranged from 5.36g in cluster VII to 1.33g in cluster VI. The 1000 seed weight ranged from 3.15 g (cluster VI) to 3.62g (cluster III). For oil content cluster II had the minimum of 44.47% and cluster VIII had the maximum of 47.05% (Table 3). Cluster VII recorded maximum for seed yield, plant height, number of capsules on main stem and per plant. The characters contributing maximum to D^2 values are given greater emphasis for deciding on the clusters for the purpose of future selection and choice of parents for hybridization. The highest contributor was total number of capsules (40.48%). Other characters were seed yield, number of capsules on main stem, capsule breadth, number of primary branches and number of seeds/capsule. In the present study, three standard varieties of Tamil Nadu, TMV 5, Col and TMV 3 were included in three different clusters (IX, IV and II). Thus clustering pattern was not related to geographical origin corroborating earlier findings (Thangavelu and Rajasekaran, 1983). It also implies that it was not the geographic origin but selection pressure which played an important role in determining genetic closeness and divergence among parents.

Heterosis

Heterosis over mid and better parent exhibited a wide range for seed yield and its attributes. For seed yield per plant 25 and 8 crosses out of 56 crosses showed significant positive heterosis over better and economic parents respectively. TNAU22 *Corge Borege 11 and TNAU 22* NALNS221-3 showed maximum heterosis over better parent (heterobeltiosis). Such crosses can be utilized in future breeding programmes. The heterosis for seed yield ranged from 1% to 112% (MPH), - 18% to 107% (BPH) and from -33% to 44% (over Co 1). Maximum heterosis for this character was manifested in cross TNAU22*Corge Borege 11. The magnitude of heterosis and heterobeltiosis for oil content, harvest index and dry matter production was high in TNAU 22*Corge Borege 11 TNAU 22*MARGO 7, TMV 5, *Col. For seed yield TNAU 22*Corge Borege 11 showed significant positive heterosis which appeared to be due to high heterotic manifestation in number of capsules per plant and number of branches per plant. High value of heterosis for seed yield, dry matter production, harvest index, number of secondary branches and total number of capsules may be due to dominant or epistasis or interaction gene effects. For oil content, 27 crosses showed significant heterosis over better parent but the extent of heterosis was limited. TNAU 22 * Corge Borege 11, TNAU 22 * TMV 5, Corge Borege 11 * TMV 5, Si 1225 * Co 1 and TMV 5 *Co 1 were the best hybrids exhibiting very high mean for seed yield, total number of capsules, 1000 seed weight and number of primary branches and heterosis capable of givining maximum transgressive segregants. Interrelationship for heterosis was observed for number of primary branches, total number of capsules and seed yield. The results of the present study are in agreement with earlier findings of Singh *et al.*, (1986) and Fatteh *et al.*, (1995). Similar heterotic effects of yield components on yield were also observed by Sasikumar and Sardana (1990). Whitehouse *et al.*, (1958) and Grafius (1959) suggested that there could be no separate gene system for yield per se, as yield was an end product of the multiplicative interaction between its various components. Thus in the present study and in most of the cross combinations, heterosis for yield could be determined by estimating heterosis for individual yield components. Hybrid vigour of even small magnitude for individual yield components may have additive or synergistic effect on the end product. Similar heterotic effect of yield components on yield was observed in tomato (Williams, 1959) and oats (Hathcock and Daniel, 1973). Evidently high manifestation of heterosis for yield and its component characters may be due to non-additive gene effects in the parents. Additive and non-additive gene effects

Table 3. Cluster mean for various Characters in 65 genotypes of sesame

Sl. No.	Characters/ Clusters	I	II	III	IV	V	VI	VII	VIII	Percent Contribution to diversity
1.	Plant height	58.96	69.09	44.28	69.42	45.38	43.10*	99.67+	71.0	0.67
2.	Number of nodes	19.43	21.39	27.80	20.78	15.28*	31.95+	26.07	22.8	2.21
3.	Number of primary branches	3.18	3.60	0*	3.95+	3.46	2.97	3.47	3.93	8..31
4.	Number of secondary branches	0.93	1.16	0*	1.75+	1.43	0.7	0.8	0.47	3.89
5.	Number of nodes to first capsule	3.10	3.44	1.58	3.44	2.98	1.35*	3.87+	3.33	0.19
6.	Internodal length	3.21	3.38	2.17*	3.92	3.44	2.85	6.3	6.9+	1.44
7.	Number of capsules on main stem	14.94	16.53	17.30	17.03	9.76*	18.67	19.20+	17.07	6.20
8.	Number ofcapsules per plant	42.14	50.48	33.95	48.41	26.16*	32.0	84.87+	59.13	40.48
9.	Length of capsule bearing portion	36.63	52.51	19.35*	55.83+	31.23	24.65	52.47	32.17	0.14
10.	1000 - seed weight	3.39	3.41	3.62+	3.37	3.23	3.15*	3.40	3.30	0.58
11.	Number of seeds per capsule	54.52	55.04	53.95*	55.10	55.17	54.04	54.40	57.17+	10.57
12.	Capsule length	1.67	1.77	1.65	1.63	1.83	1.52*	1.61	1.84+	0.04
13.	Capsule breadth	0.47	0.48	0.49	0.45	0.53*	0.45	0.44+	0.53	4.18
14.	Seed yield	2.42	4.53	2.33	1.95	1.62	1.33*	5.36+	4.55	19.33
15.	Oil Content	45.05	44.47*	44.53	46.02	45.25	45.11	45.16	47.05+	1.73

+ Maximum * Minimum

Table 4. Range and first two hybrids with heterosis (%)over mid parent and better parent insesame

Characters	Range		Heterosis			
	Midparent	Better parent	EH	MP	BP	
Plant height (cm)	-15 to 73	-22 to 60	-22 to 60	29	19	TNAU 22 x TMV5, TNAU 22 X Corge Borege 11
Number of nodes	-35 to 58	-28 to 71	-28 to 71	11.5	21.5	Corge Borege x Col, TNAU 22 x Corge Borege 11, DT 9-9-6/P5xTNAU 22 Dt 9-9-6/P-5 x Si 1225.
Number of primary 221/	-41 to 58 branches	-49 to 56	-53 to 15.0	8.5	3.5	TNAU 22 x Corge Borege 11, Col x Nal NS-32-3, DT 9-9-6/P-5 x Si. 1225.
Number of capsules on main stem	-42 to 49	-37 to 47	-47 to 32	3.5	5	TNAU 22 x TMV5, TNAU 22 x Corge Borege 11
Number of secondary branches	-58 to 155	-58 to 95	-64 to 8.0	48.5	18.5	NAL-NS-221/32-3xsi 1225, TNAU 22 x TMV5, TNau 22 x Si. 1225.
Length of capsule bearing portion (cm)	-23 to 57	-29 to 39	-36 to 24	17	5	TMV5 Co.1, TMV 5 x Corge Borege 11, Col x Margo7, TNAU 22 x TMV 5.
Total number of capsules	-35 to 61.0	-41 to 52	-37 to 78	13.0	5.5	TNAU 22 x TMV5, TNAU 22 x Corge Borege 11, Margo 7 x Corge Borege 11.
Number of seeds per capsule	-7 to 13.0	-11 to 8.0	12 to 3.0	3	-1.5	TMV5 x Col, Si 1225 x DT 9-9-6 P-5, TMV 5 x TNAU 22
1000 seed weight (g)	-6.0 to 26.0	-21 to 24	-25 to 10.0	10	-1.5	Margo 7 x Col, Margo 7 x Si 1225, Col x Corge Borege 11.
Seed yield (g)	0.3 to 131	0.56 to 104	-10 to 44	67	52.28	Margo 7 x TMV5, TNAU 22 x Corge Borege 11, TNAU 22 x NAL NS 221/32-3. Si 1225 x Co.1
Total DMP (g)	-24.0 to 126	-28 to 104	-33 to 101	51	38	Corge Borege 11 x Col, TNAU 22, TMV 5, TNAU 22 x Corge Borege 11, Col x Margo 7.
Harvest index	-7.0 to 8.2	-10 to 55	-24 to 45	37.5	22.5	TNAU 22 x Margo 7, TMV 5 x Col, TNAU 22 x NAL NS. 221/32-3.

for yield and its attributes have been reported in sesame. Thus the present study provides ample scope for exploitation of hybrid vigour for commercial production and pure line isolations among heterotic F_1 progenies.

In general, fair agreement between the degree of heterosis and distance between the parental clusters was observed. For number of capsules and seed yield, crosses between highly divergent parents recorded higher magnitude of heterosis mostly in positive direction. High heterosis was observed between less divergent crosses in respect of dry matter production and such crosses showed negative heterosis for harvest index (HI) which resulted in poor heterosis for seed yield. Cluster means showed that mean seed yield and capsules per plant was high and oil content moderate in clusters VII and VIII and the hybrids between the genotypes of these clusters recorded high seed yield and high oil content. Thus the diversity estimated by generalized distance showed a good measure of heterosis for seed yield. The crosses between the parents with high dry matter and low harvest index and those with low dry matter and high HI resulted in maximum seed yield.

It may be inferred from the present study that the varieties with high, moderate divergence as measured by D^2 values or by the yield performance in respect of yield and its components are likely to produce potential crosses. In general, highly heterotic crosses were high yielding and number of capsules was related to heterosis for yield. The hybrids TNAU22*Corge Borege 11, TNAU 22 *TMV 5, Si 1225 * Co 1, TMV 5 *Co 1 and Corge Borege 11 * TMV 5 having high heterotic effects in desired direction for most of the characters with increase in seed yield over Co 1 to the extent of 12% may prove their worth if evaluated on large scale. In addition it also shows that while selecting parents for hybrid breeding, programmes on basis of genetic divergence and their cluster mean performance needs to be considered.

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POPULATION IMPROVEMENT IN SESAME

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ABSTRACT

In the study conducted to assess the populations built for yield and its attributes, seven populations recorded increased seed yield. Large values of Gcv were observed in segregating generation (F_2 and BCF_1) for seed yield and number of capsules. The study also revealed the changes in correlations to *favourable direction* for yield and its attributes. Increase in GCV for seed yield was accompanied with decrease in GCV for plant height, number of branches and number of capsules. High intensity of positive association of seed yield with its attributes in both the populations was observed. Hence improvement in these populations will result in superior recombinants and intermating among the populations will be more effective for future breeding programmes.

Key words: Sesame, population improvement

INTRODUCTION

Intercrossing and recurrent selection to pool the desirable genes from the selected plants in the early segregating generations in self pollinated crops has been suggested (Palmer, 1953 and Joshi and Dhawan, 1966). An appraisal of significant work in sesame would be valuable to breeders. Due to repeated selections followed by rapid homozygosity, there is loss in genetic variability and poor recombination. The high genotype environment interaction also hinders the full exploitation of genetic variability of yield and its attributes. Under such circumstances population improvement through intermating procedures can be followed for sesame improvement (Redden and Jensen, 1997 and Jensen, 1970). Several comprehensive breeding systems have been proposed to systematically develop and exploit variability in plant populations (Compton 1968, Jensen, 1970). Population improvement is applicable to both outcrossing and self pollinating species and is a powerful tool in crop improvement. In the present study attempts were made to develop populations with broad genetic base which can be exploited for improving yield level and oil quality in sesame.

MATERIAL AND METHODS

Fifty varieties with wide spectrum of variation in different quantitative characters were evaluated in a randomised block design with four replications in plots of 5 rows and a spacing of 45x30 cm. Based on *per se* performance, five parents viz., col, TSS 4, Si 1484, Si 1125 and Si 1003 were selected and twenty effective crosses, to create base population, were made during July 1986. The five parents along with 20 hybrids were evaluated in a randomised block design with three replications in plots of 30 rows of 4.5m length and a spacing of 45x30 cm. Data on plant height, number of branches, number of capsules per plant, and seed yield were recorded. Back cross was affected by crossing the F_1's to both the parents (40 BC_1's). A low selection pressure of 5% was adopted within a population to select the best BC_1 populations.

Five parents, 20 F_2's and 40 BC_1 populations were raised in plots of 4.5x2.25 m with a spacing of 45x30 cm and were evaluated during July, 1987. The back cross progenies were selfed to develop BCF_2 and were evaluated during January 1988. By applying a selection pressure of 5% (single plant with capsules less than 50 were rejected), 16 F_2

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and 32 BCF_2 base populations were selected. These were evaluated in a randomised block design with two replications in January, 1989 and September, 1989 and random mating was carried out among the populations. The intermated populations were evaluated in a randomised block design with three replications. Simple correlation coefficients were calculated for F_2's as well as back cross progenies. Phenotypic and genotypic variances were worked out (Johnson *et al.*, 1955). Heritability in broad sense was worked out as by Lush, 1949.

RESULTS AND DISCUSSION

Among the hybrids, mean number of capsules ranged from 93.8-160.8 and seed yield between 8.7 and 5.5 g/plant. Si 1125 x TSS 4 recorded the maximum yield of 15.5 g, excelling Co 1 by 31.4%. Co 1 x Si 1003 (24.6%), TSS 4 x Co 1 (15.3%), TSS 4 x Si 1003 (11.0%), Si 1125 x Co 1 and Si 1125 x Si 1003 (3.4%) were other high yielding hybrids. Among the back cross populations highest mean value for plant height was recorded by (Co 1 x Si 1125) x Co 1. (Si 1225 x TSS 4) x TSS 4 recorded the maximum seed yield of 9.5 kg followed by (Si 1225 x TSS 4) x Si 1125. Among the F_2 populations, highest mean value for number of capsules was recorded by TSS 4 x Co 1. Of the 40 BC_1F_1 populations six populations exceeded Co 1 by 1.0-32.7% . (TSS 4 x Si 1003) x TSS 4 recorded the highest seed yield (13.0 g) followed bv (TSS 4 x Co 1) x TSS 4 (11.5 g) and (Si 1003 x TSS 4) x TSS 4 (10.8 g). Seven populations were found to record 9.0-42.7% increased seed yield over the general mean.

Analysis of variance indicated that the populations differed significantly among them. Even though PCVs were higher than GCV for all the characters, the low margin of difference between them indicated that the phenotypic variability is a reliable measure of genotypic variability except for seed yield in F_2 where the difference was high. Large values of GCV were

Table 1. Genetic parameters of segregating populations for different characters

		Range	Mean± SE	PCV %	GCV %	h^2	GA	GV%
Plant height (cm)	P	96.9-111.2	103.0±12.4	27.41	15.55	32.19	8.73	22.57
	F_2	83.8-102.1	101.2±10.8	16.88	12.90	53.60	7.98	10.80
	BC	84.2-104.6	98.6±93.6	17.00	12.92	22.38	8.38	22.85
Number of branches	P	8.5-12.0	10.5±3.5	32.94	25.31	59.02	2.18	38.69
	F_2	5.5-8.1	9.86±2.9	15.60	8.84	35.40	2.58	20.77
	BC	6.0-9.8	6.80±3.1	20.38	20.01	52.18	1.81	37.33
Number of Capsules	P	91.9-135.8	110.7±30.9	31.24	30.38	94.58	24.69	72.7
	F_2	39.5-100.1	98.2±8.6	36.61	26.26	55.39	19.54	24.0
	BC	41.1-92.8	72.8±20.8	33.62	26.83	35.88	16.13	30.4
Seed Yield	P	8.5-14.9	10.89±3.5	26.06	20.53	62.05	11.53	72.35
	F_2	6.3-15.3	11.86±2.8	32.22	22.58	50.13	14.59	22.98
	BC	6.5-13.0	8.68±3.0	34.53	27.68	31.86	9.97	18.40

observed in F_2 and BCF_1 for seed yield per plant (22.58 in F2 and 27.688 in BCF_1), total number of capsules (26.86 in F2 and 26.88 in BCF_1). Lower values of GCV were observed for plant height and number of branches. Similar results were reported by Baruah and Goud (1993). Heritability values were in the range of 30-60% in F_2 and BC_1F_1 populations. In F_2 heritability for plant height, number of capsules and seed yield was to a tune of 50%. High heritability with high genetic advance was observed in F_2 for plant height, number of capsules and seed yield. This might be mainly due to additive gene effects. Similar results of nature were reported by Bhele *et al.*, (1987).

A comparison of correlation coefficients in the F_2 and BCF_1 revealed that number of correlations change to favourable direction for yield and its attributes. Plant height showed significant correlation for number of branches and number of capsules in BCF_1 population. Similarly genotypic correlation coefficient for seed yield and plant height was non-significant, but positively correlated with number of branches and capsules (Table 2).

In F_2 population plant height showed significant, positive correlation with number of capsules and negative correlation with number of branches. Seed yield was positively correlated with number of branches and capsules.

Reddy and Haripriya (1991) found that number of capsules, number of branches and plant height had strong positive correlations among themselves. A change from significant negative to significant positive correlation was observed in F_2 and BC_1F_1 population for total number of capsules. Non altered association was observed for plant height. These associations particularly in desirable direction will be useful for selection of desirable traits for sesame improvement. The intensity of positive association of seed yield with its attributes was high in both the populations. In general, desirable recombinants with high seed yield, number of branches and more number of

Table 2. Genotypic correlations among different characters

Seed		X_1	X_2	X_3	X_4
Seed yield	P	1	0.55	0.53	-0.34
(X_1)	F_2	1	0.017	0.26	0.16
	BC	1	-0.04	0.08	-0.07
Plant height	P	1	1	0.15	-0.13
(X_2)	F_2		1	-0.22	0.16
	BC		1	0.570	-0.68
Number of branches	P			1	-0.06
	F_2			1	-0.04
(X_3)	BC			1	0.039
Number of Capsules	P				1
	F2				1
(X_4)	BC				1

capsules were realised from the present study. The increase in correlation coefficients is expected if linkages were in repulsion phase. The decrease in GCV for plant height, number of branches, number of capsules might be due to change in gene frequency and possible breaking of linkage disequilibrium (Miller and Rawlings, 1967). Increase in GCV for seed yield may be due to forced recombinations and release of potential variability is generally existing (Sharma *et al.*, 1979) because of break up of tight linkages. Intermating reduces genetic drift and unfavourable correlated responses by maintaining genetic variability in populations. Similar results were reported in wheat by Nanda *et al.*, 1990. Mather pointed out that individual selections from population for further inbreeding and evaluation would contain most of the desirable genes from more than one or two cultivars. In the present investigation individual selections, from F2 and BCF generation resulted in development of types with desirable genes.

It can be concluded from the above findings that it would be rewarding to improve the BC_1, F_1, F_2 populations through intermating and recurrent selection for higher yield levels and oil content. The next phase should involve selection of lines which are superior high yielders, so as to exploit the recombination through internaive programme and develop populations with desirable genes for yield and quality and for release of improved sesame cultivars.

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ALLELOPATHIC EFFECTS OF TREE LEAVES ON THE GROWTH AND YIELD OF SUNFLOWER

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ABSTRACT

The effect of fresh leaves of acasia, peltophorum, polyalthia, eucalyptus, delonix, neem, thespesia, Pongamia and soapnut was tested in sunflower by applying 20 g leaves kg-1 of sandy soil in a pot culture experiment. The tree leaf application increased the plant height, number of leaves, leaf area, drymatter content of different plant parts, number of seeds per capitulum, test weight and the grain yield. The treatment effects varied considerably. Neem leaf effect was superior followed by delonix. thespesia and pongamia in most of the characters studied. The remarkable increase in growth and yield of sunflower caused by tree leaf application may be due to the allelochemicals and their influence on release of mineral nutrients from the soil.

Key words : Acasia, allelopathy, delonix, eucalyptus, neem, peltophorum, polyalthia, pongamia, soapnut, sunflower.

INTRODUCTION

Trees in the tropics produce every year a large quantity of foliage which is a potential source of nutrients for field crops. The use of green manure in crop production is well known (Tamhane. *et al.*, 1970). Leaves of trees are shown to possess allelopathic properties (Rice, 1984). Mostly the tree leaves were shown to have inhibitory influence on the growth and development of other plants because of the presence of allelochemicals in the leaves (Kohil *et al.*, 1988). Since allelopathy is defined as the direct or indirect harmful or beneficial effects of one plant on another through the production of chemical compounds that escapes into the environment (Rice, 1984), leaves of some tree species may have beneficial effects on other plants. This has been proved by the application of neem leaves to maize and sunflower (Mastanamma, 1995; Mastanamma and Narayanan, 1996). The results obtained from the application of neem leaves induced us to study the effects of leaves obtained from other tree species on the growth and yield of sunflower which is one of the potential oilseed crops of India.

MATERIALS AND METHODS

The experiment was conducted in earthen pots containing 3 kg sandy soil. Soil application of fresh leaves of the following tree species was tested against no leaf application.

Acasia (*Acasia auriculiformis* A. Cunn.), Peltophorum (*Peltophorum ferrugianum* (D.C.) Backer), Polyalthia (*Polyalthia longifolia*) (Sonner) Thw.), Eucalyptus (*Eucalyptus maculata* Hook), Delonix (*Delonix regia* Baj.), Neem (*Azadirachta indica* A. Juss.), Thespesia (*Thespesia populnea* L.), Pongamia (*Pongamia pinnata* (L.) Pierre) and Soapnut (*Sapindus trifoliatus* Hiern).

Fresh leaves were collected from the trees on 15 December, 1995, chopped into pieces, incorporated into the soil (60 g pot^{-1}) and allowed to decompose by watering the pots for a fortnight. Each treatment had four replications. No fertilizer was applied to the pots. In each pot five seeds of sunflower (Pioneer - 6460) were sown and the seedlings were thinned to one per pot after a week. The plant height, number of leaves and leaf area were recorded at 10 days interval. The plants were

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grown upto maturity and sampled. Leaf area, dry weight of plant parts, yield components and final yield were measured. The data were analysed statistically following a completely randomized design.

RESULTS AND DISCUSSION

The fresh leaves of the nine tree species showed an initial growth promotion in terms of height of sunflower even after 10 d from sowing (Table 1). Later on the effects were more pronounced and the leaf treatments showed differential response in the growth of sunflower. The plant height was maximum in treatments with Delonix, Neem, Thespesia and Pongamia leaves during the subsequent periods of observation. There was a significant reduction in plant height due to leaf treatments of soapnut, Eucalyptus, Polyalthia, Peltophorum and Acasia which were on par with each other. The control plants were significantly small showing remarkable effects of fresh leaf application on the elongation of sunflower. Such growth promotion in height of plants was obtained by Wali and Totawat (1992) when neem cake coated urea was applied to maize. Plant height was thus increased by fertilizer application whereas the same effect was realized by application of fresh tree leaves to sunflower plant in this study.

Similarly the number of leaves per plant was significantly increased over the control plants at all intervals of observation. Here again the leaf treatments of Delonix, Neem, Thespesia and Pongamia were superior to other leaf treatments which were significantly better than control plants. Apart fom the number of leaves per plant, the area of leaves was significantly more than that of the control plants (Fig 1). Leaf expansion in plant is generally promoted by better nutrition and growth regulators. Thus it appears that the leaves applied to the soil would have contributed the macro and micronutrients and also the plant growth regulators which in turn might have promoted the growth in terms of height, number of leaves and leaf area (Table 2).

The drymatter of root, stem, leaf and capitulum were significantly increased by the leaf application. Incorporation of leaves of neem, Delonix, Thespesia, Pongamia and Acasia recorded significantly more dry matter than Eucalyptus, Polyalthia, Peltophorum and soapnut (Table 2).

The neem leaf application provided substantially higher grain yield of sunflower than all other leaf treatments. The yield was significantly more in Delonix, Thespesia and Pongamia leaf treatments than Peltophorum, Polyalthia and Eucalyptus leaf treatments. The yield increases were due to the increase in number of seeds per capitulum and the test weight (Table 3).

The study shows that tree leaves have differential effects on the growth and development of sunflower plant. Among the trees neem appears to be superior to others. However, Delonix, Thespesia and Pongamia leaf treatments also showed better effects on sunflower.

Table 3. Effect of tree leaves on the yield and yield *components of sunflower.*

Treatment	No. of seeds/ capitulum	100 seed weight (g)	Seed yield/ plant (g)
Control	54	1.5	2.7
Acasia	115	3.9	3.3
Peltophorum	88	3.1	3.5
Polyalthia	90	3.3	3.6
Eucalptus	85	3.0	3.5
Delonix	200	9.4	4.7
Neem	240	12.9	5.4
Thespesia	205	9.6	4.6
Pongamia	205	9.7	4.7
Soapnut	105	3.5	3.4
CD (0.05)	27	0.4	0.2

Table 1. Effect of application of fresh leaves of trees on plant height (cm) and number of leaves of sunflower

Treatment	Plant height (Days after sowing)					Number of leaves/plant (Days after sowing)				
	10	20	30	40	50	10	20	30	40	50
Control	2.9	7.9	16.0	24.3	37.0	1.8	2.8	7.3	9.0	9.3
Acasia	4.0	10.8	28.2	61.5	82.7	2.0	3.5	8.8	10.5	11.7
Peltophorum	4.0	10.5	24.7	54.1	75.5	2.0	3.6	9.3	10.3	11.2
Polyalthia	3.3	8.9	25.4	52.6	71.0	2.0	3.5	8.8	10.1	11.5
Eucalyptus	4.2	8.5	23.9	54.9	74.0	2.5	3.7	8.6	10.4	12.1
Delonix	4.3	13.7	34.8	63.1	83.6	3.8	5.5	10.3	13.3	14.5
Neem	4.6	14.6	36.0	70.1	85.9	4.0	6.3	11.3	14.3	15.0
Thespesia	4.3	13.5	33.3	64.6	85.3	3.6	5.0	10.5	13.5	15.1
Pongamia	4.1	13.1	34.7	60.8	80.9	3.5	5.3	10.5	13.8	14.9
Soapnut	3.8	8.7	24.4	48.8	71.3	2.5	3.8	8.7	10.5	11.3
CD(0.05)	0.9	2.2	4.9	10.8	9.0	1.1	0.9	1.3	2.2	1.9

Treatment	Leaf area (cm^2 $plant^{-1}$)						Dry weight (g $plant^{-1}$)				
	10	20	30	40	50	At harvest	Root	Stem	Leaf	Capitulum	Whole plant
Control	16.5	38.9	68.2	111.9	91.1	67.0	0.3	0.6	0.4	8.8	10.5
Acasia	34.7	89.9	241.5	312.0	293.8	206.5	5.3	7.3	3.4	17.3	34.7
Peltophorum	26.3	85.3	259.5	311.8	291.7	217.3	2.8	4.9	2.6	11.8	21.8
Polyalthia	27.9	86.9	244.8	302.5	289.1	191.0	2.4	3.4	2.4	11.1	20.8
Eucalyptus	30.1	77.3	254.5	307.3	285.7	221.0	2.4	3.4	2.4	11.1	20.8
Delonix	51.7	112.6	419.5	535.3	436.9	386.0	5.4	8.2	3.3	18.0	34.6
Neem	76.9	215.9	518.0	667.0	555.6	474.8	8.8	8.9	3.7	20.9	40.8
Thespesia	57.9	110.5	406.0	537.3	431.5	396.8	4.8	8.4	3.5	19.3	33.7
Pongamia	56.8	116.4	409.6	547.3	434.9	381.8	4.4	8.5	3.3	18.6	22.9
Soapnut	26.2	79.9	256.0	306.8	283.2	206.8	2.5	4.3	2.4	12.6	21.9
CD (0.05)	12.6	19.5	19.4	17.6	9.5	64.9	0.7	2.9	0.6	2.0	2.5

The reasons for such promotive effects caused by leaves of trees may be due to the allelochemicals present in them. The effect of these chemicals may be direct or indirect on the growth and development of sunflower plants. These chemicals may be acting as a growth regulator or making the unavailable mineral nutrients in the soil available or an additive effect of both. Murthy *et al.*, (1990) from an incubation study concluded that the leaf sources of siris (*Albizia lebek*) and neem (*Azadirachta indica*) were significantly superior to subabul (*Leucaena leucocephala*) with reference to available nitrogen. Tamhane *et al.*, (1970) reported that fresh organic matter make phosphorus readily available in acid soil. Short term application of crop residues raised the potassium concentration into the sufficiency range (Rabefka *et al.*, 1994). These results of various workers indicate that the promotive growth effect obtained in sunflower may be due to indirect effect of making the native nutrients available. However we can not exclude the possibility of the direct effect of fresh leaves as a source of nutrients and plant growth regulators.

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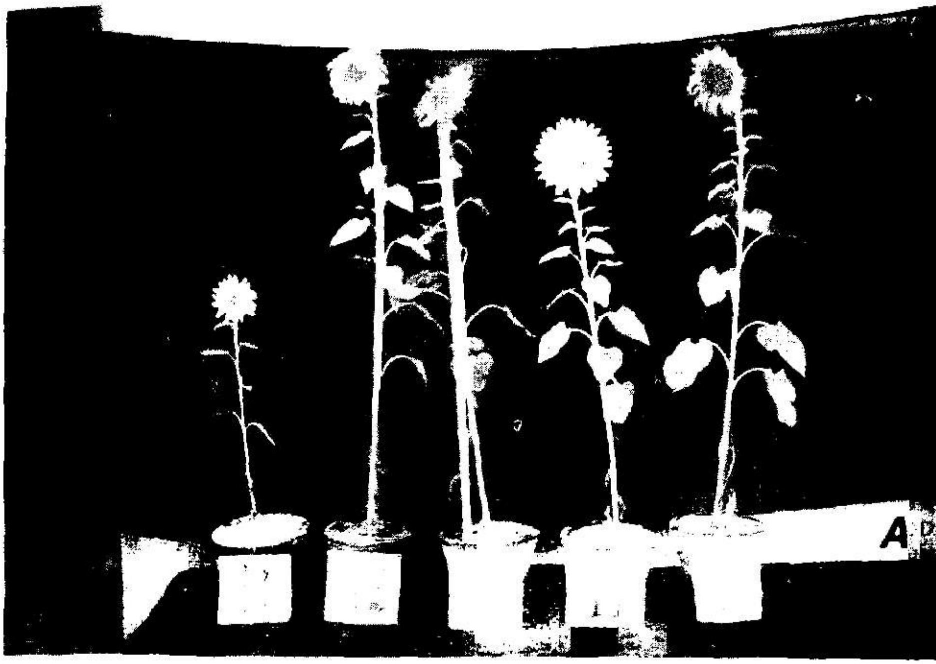
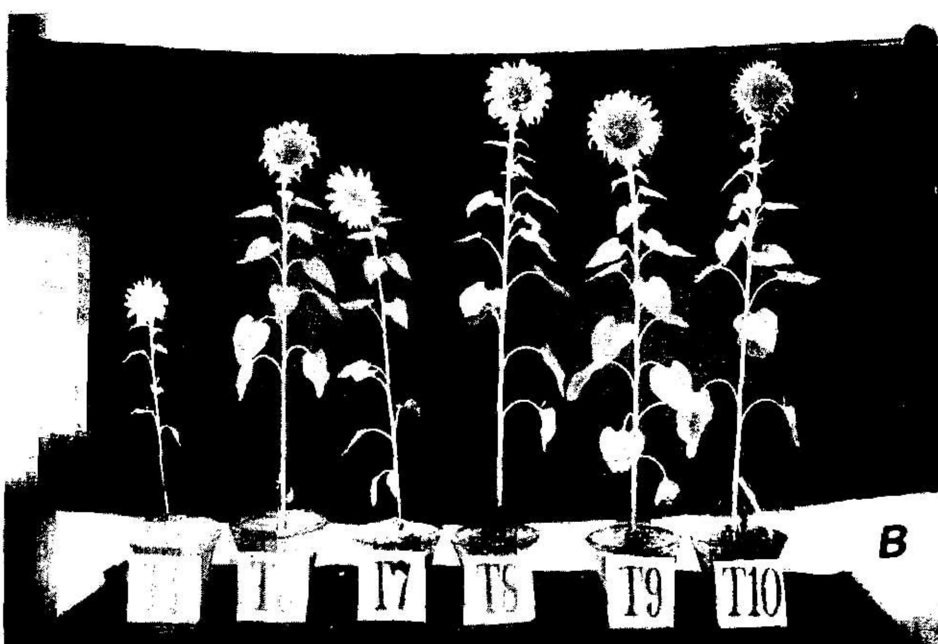


A. T1- Control; T2- Acasia; T3-Peltophorum; T4-Soapnut; T5-Neem



B. T1-Control; T6-Eucalyptus; T7-Polyalthia; T8-Thespesia; T9-Delonix; T10-Pongamia

Fig. 1: Tree leaf effects on sunflower

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STUDIES ON COMBINING ABILITY FOR NUMBER OF PRIMARY BRANCHES IN THREE-WAY CROSSES OF GROUNDNUT

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ABSTRACT

Sixty 3-way cross hybrids derived from six parents were tested in a randomised block design with three replications. The mean data on number of branches were analysed as per triallel analysis model. *General-line effect of* first and second kind indicated that JL 24 was a good grand parent. The estimates of 2-line specific effect of first kind suggested ICGS 44 x ALR 2, JL 24 x GG 2 and JL 24 x Co 2 as good grand parents for 3-way crosses. The order effect in 3-way crosses was evident as seen in the triplet (GG 2 x Co 2) x JL 24 which showed the highest positive three-line specific effect, but the same parents in the triplets (JL 24 x GG 2) x Co 2 and (JL 24 x Co 2) x GG 2 exhibited either low or negative estimates. Thus the number of primary branches can be successfully combined in 3-way hybrids by crossing selected parents in a particular order.

Key words : Groundnut, 3-way cross, order effect, line effect.

INTRODUCTION

Number of primary branches is one of the important yield contributing parameters of goundnut (Chandola *et al.* 1973 and Dholaria *et al.* 1973). A knowledge of the combining ability of the parents is essential to formulate any breeding programme. In groundnut mostly single crosses have been effected. But there is a need to broaden the initial genetic base by adopting multiple crosses also, so that the adaptability and stability of performance can be incorporated from different genetic sources. In the process of widening the initial genetic base, 3-way crosses are the next logical step to single crosses (Arunachalam *et al.* 1985). The theoritical aspects of triallel analysis has been dealt with by Rawlings and Cockerham (1962), Hinkelmann (1965) and Ponnuswamy *et al.*, (1974). However, information on combining ability and order effects of parents for 3-way crosses is meagre in groundnut. Hence, the present study was undertaken.

MATERIALS AND METHODS

All possible three-way crosses involving 6 divergent groundnut cultivars *viz.*, ICGS 44, Girnar 1, ALR 2, JL 24, GG 2 AND Co 2 were raised in a randomised block design with three replications during the *Kharif* season of 1994 at the Regional Research Station, Vridhachalam. Each genotype was raised in ten rows of 3 m length each. The inter and intra-row spacings were 30 and 15 cm, respectively. Data on number of primary branches were recorded on 15 randomly selected plants in each plot. Mean data were subjected to statistical analysis (Ponnuswamy, 1972). Considering Yijk1 as the measurement recorded on a triallel cross G(ij) k, the statistical model takes the following form:

$$Y_{ijkl} = m + b_l + G_{(ij)k} + e_{ijkl}$$
$$= m + b_l + g_{ij} + g_k + f_{(ij)k} + e_{ijkl}$$
$$= m + b_l + h_i + h_j + d_{ij} + g_k + s_{ik} + s_{jk} + t_{ijk} + e_{ijkl}$$

where,

Y_{ijkl} = phenotypic value of the triallel cross, ij th cross (grand parents) mated to k th parent, in the i th replication.

m = general mean

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b_i = effects of ith replication

$G_{(ij)k}$ = cumulative effect of the triallel cross (ij)k, where i and j are grand parents and k is the parent

g_{ij} = average effect of F_1 hybrids

h_i = general line effect of ith parent as grand parent (first kind general line effct)

d_{ij} = two-line (i x j) specific effect of first kind (grand parents)

g_k = general line effect of k as parent (second kind effect)

$f_{(ij)k}$ = non-additive effect of F_1 (i x j) hybrid with both parents

s_{ik} = two-line specific effect where i is half parent and k is the parent. Hence specific effect of second kind

t_{ijk} = three-line specific effect

e_{ijkl} = error effect

RESULTS AND DISCUSSION

The analysis of variance for 3-way crosses (triallel cross analysis) showed that the general line, 2-line (both first and second kind) and 3-line specific effects were significant (Table 1). General-line effect of first and second kind (hi and gi) indicated that JL 24 was the only parent which showed good general combining ability of both kinds showing that JL 24 was a good grand parent as well as parent. Whereas, ICGS 44 exhibited general combining ability of first kind only and hence it behaved as a good grand parent only.

The estimates of 2-line specific effect of first kind (dij) were positive and significant for the crosses ICGS 44 x ALR 2, JL 24 x GG 2 and JL 24 x Co 2 suggesting their superiority as good grand parents for 3-way crosses. Similarly, 2-line specific effect of second kind (sij) was the highest in the crosses Girnar 1 x GG 2 followed by ICGS 44 x ALR 2 and ALR 2 x Co 2 and the reciprocal effects (S_{ji}) were positive and significant for Co 2 x Girnar 1, GG 2 x ALR 2 and Co 2 x JL 24 crosses (Table 2).

Table 1. Mean squares for number of branches in groundnut.

Source of variation	d.f.	M.S
General-line effect of first kind (hi)	5	1.70*
General-line effect of second kind(gi)	5	3.42**
2-Line specific effect of first kind (dij)	9	2.96**
2-Line specific effect of second kind (Sij)	19	1.72*
3-Line specific effect (tijk)	21	1.74*
Crosses	59	1.92**
Error	118	0.42

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

The estimates of 3-line specific effects (tijk) were highly positive and significant in nine combinations (Table 3). The order effect in 3-way crosses is evident as seen in (GG 2 x Co 2) x JL 24 cross which showed the highest positive 3-line specific effect, but the same parents in crosses (JL 24 x GG 2) x Co 2 and (JL 24 x Co 2) x GG 2 showed either low or negative estimates. The superiority of 3-line specific effects in 3-way crosses for number of primary branches may be due to involvement of at least one parent (JL 24) showing better general combining ability (general line effect), with the restriction that it should be placed in a specific position in the 3-way cross. Thus the desirable characteristic can be successfully combined in 3-way hybrids by crossing selected parents in a particular order. This aspect needs the maximum attention from the breeding point of view.

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Table 2. Estimates of general-line and 2-line specific effects for number of branches in groundnut.

Lines	General lines effects First kind (hi)	General lines effects Second kind (gi)	1	2	3	4	5	6
			2 line specific effects Sij (upper half) and Sji (lower half) (figures in the brecket corresponds to dij)					
1	0.25**	0.03	-	0.16 (0.23)	0.46** (0.85)**	-0.14 (0.18)	0.14 (-0.37)*	-0.63** (-0.90)**
2	-0.40**	0.01	0.10	-	-0.45** (0.01)	-0.30* (-0.44)**	0.63* (-0.03)	0.01 (0.23)
3	0.06	-0.12	0.15	-0.14	-	0.07 (-0.56)**	-0.40** (-0.27)	0.30 (-0.04)
4	0.23**	0.33**	-0.06	-0.32**	0.23	-	0.02 (0.39)*	0.13 (0.42)**
5	0.15	0.07	-0.16	-0.40**	0.36**	0.03	-	0.17 (0.28)
6	-0.29**	-0.33**	-0.03	0.71**	-0.61**	0.33**	-0.40**	-
	SE(hi)=0.09;	SE(gi)=0.11;	SE(Sij)=0.14;		SE(dij)=0.15			

**, * Significant at 1 and 5 per cent level respectively. 1. ICGS 44; 2. Girnar 1; 3. ALR 2; 4. JL 24; 5. GG 2; 6. Co 2

Table 3. Estimate of 3-line specific effects (t_{ijk}) for number of branches.

Grnad parental lines		Parental lines 1	2	3	4	5	6
1	2	-	-	-1.09**	0.57**	0.40	0.11
1	3	-	0.43*	-	0.30	-0.06	-0.67**
1	4	-	-0.44*	0.33	-	-0.31	0.42
1	5	-	-0.15	0.07	-0.04	-	0.13
1	6	-	0.17	0.69**	-0.83**	-0.03	-
2	3	-0.67**	-	-	0.38	0.08	0.20
2	4	0.28	-	0.56*	-	-0.61**	-0.23
2	5	0.38	-	0.17	-0.46**	-	0.09
2	6	0.00	-	0.35	-0.49**	0.13	-
3	4	-0.15	-0.50*	-	-	0.50*	0.15
3	5	0.26	0.16	-	-0.74**	-	0.31
3	6	0.55*	-0.09	-	0.06	-0.52*	-
4	5	-0.11	0.51*	-0.04	-	-	-0.35
4	6	-0.01	0.44*	-0.85**	-	0.42	-
5	6	-0.54*	-0.52*	-0.20	1.26**	-	-

SE (tijk) = 0.22 **, * Significant at 1 and 5 per cent level respectively.

Note: 1. ICGS 44; 2. Girnar 1; 3. ALR 2; 4. JL 24; 5. GG 2; 6. Co 2

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STABILITY OF MALE STERILITY IN DIVERSE CYTOSTERILE SOURCES OF SUNFLOWER (*Helianthus annuus* L.)*

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ABSTRACT

Stability of male sterility in three diverse cytoplasmic male sterile (CMS) lines of Sunflower viz., *Helianthus petiolaris* (CMS-F), *Helianthus petiolaris* ssp. fallax (CMS-PF) and *Helianthus annuus* ssp. *lenticularis* (CMS-I) was assessed by studying pollen and seed fertility under 12 planting dates covering *Kharif, Rabi* and Summer seasons. The results revealed that CMS-I was unstable and produced fertile pollen as much as of 7.18 per cent and seed set of 3.9 per cent when planted in summer months (February, march and April). In contrast, CMS-F and CMS-PF sources were stable in all sowing dates throughout the year.

Key words : Sunflower, stability, sterility, fertility, diversification.

INTRODUCTION

The discovery of cytoplasmic male sterility in Sunflower (Leclercq, 1969) and subsequent identification of fertility restoration (Kinman, 1970) has resulted in large scale production of hybrids and their exploitation since 1972. In India, the first Sunflower hybrid was released in 1980 for large scale cultivation (Seetharam, 1980). However, the use of one single source of cytoplasmic male sterility which is designated as CMS-F for commercial production of sunflower hybrids in the entire world resulted in genetic uniformity for the cytoplasmic background in the crop. Prevalence of genetic uniformity of this kind over a large area could result in genetic vulnerability of hybrids if the cytoplasm becomes susceptible to a new strain of disease or pest. Among several strategies to overcome this problem, diversification of CMS source itself is possibly the cheapest and most effective method. During the last 15 years several new sources of CMS have been identified in addition to CMS-F. (Serieys, 1987; Jan and Rutger, 1988; Havekes *et al.*, 1991 and Miller *et al.*, 1992) and some of these new sources are available in India also. Nevertheless, the basic information on genetic differences, breeding value and stability of male sterility of these new sources is lacking to include them in the breeding programmes.

Stability of male sterility of a new CMS line over a wide range of agroclimates is one of the basic pre-requisites before its large scale utilization in the breeding programmes. Keeping this in view, two new CMS sources *viz.*, *Helianthus petiolaris* ssp. fallax (CMS-PF) (Serieys, 1987) and *Helianthus annuus* ssp. *lenticularis* (CMS-I) (Heiser, 1982) were evaluated for the stability of male sterility character by growing in 12 planting dates in three seasons - *Kharif, Rabi* and Summer, in comparison with the widely used cytoplasmic male sterile source *Helianthus petiolaris* (CMS-F) (Leclercq, 1969).

MATERIALS AND METHODS

Three CMS lines - HA 234A, HA 274A and HA 265A representing diverse cytoplasms CMS-F, CMS-PF and CMS-I, respectively were grown at monthly intervals by making 12 successive

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plantings from April 1992 to March 1993 at Gandhi Krishi Vignana Kendra, Banglore. Plantings were made in the first fortnight of each month by growing each line in three rows of 4.5 m length with spacing of 60 cm between rows and 30 cm between plants within a row. The crop was raised under irrigation adopting the recommended cultivation package.

Pollen and seed fertility were assessed in 10 random plants of each line. Pollen fertility was studied by preparing anther smears in 2 per cent acetocarmine stain. Deeply stained and well filled pollen grains were taken as fertile pollen, while poorly stained and shrivelled pollen grains were counted as sterile. At least 10 microscopic fields were observed for each line and pollen fertility was expressed in percentage. For the study of seed fertility all plants were selfed in musline cloth bags before anthesis. The seed set was assessed at harvest by taking actual counts of filled seeds to the total number of florets present and expressed in percentage.

RESULTS AND DISCUSSION

The data on pollen fertility and seed fertility are presented in Table 1. From the results it was evident that the new CMS source CMS-I was unstable as it produced fertile pollen to a maximum of 15.21 per cent. The seed set in this line on selfing ranged from 0.00 to 3.9 per cent in different planting dates. On the contrary, CMS-F and CMS-PF did not produce fertile pollen or set seeds in any of the sowing dates in all the three seasons. The production of fertile pollen in CMS-I was seen particularly in the crop sown in February, March and April which flowered in the months of March, April and May, respectively. Pollen and seed fertility was highest in the April sown crop. The data on weather parameters during crop growth period (Table 2) revealed that the higher mean maximum temperatures and marginally lower relative humidity (49%) prevailed during the months of March, April and May.

Reports on the influence of temperature on male sterility in Sunflower (Seetharam and Satyanarayana, 1980), Sorghum (Brooking, 1979), Rice (Pradhan and Jachuck, 1991; Mishra and Pandey, 1993), Brassica (Polowick and Sawhney, 1990) and in many other crops suggested that higher temperatures during the crop growth specially during flower bud development could be

Table 1. Pollen fertility (PE) and Seed fertility (SF) in three diverse CMS sources of Sunflower in different planting dates.

Planting month/ season	CMS sources					
	CMS-F		CMS-PF		CMS-I	
	PF	SF	PF	SF	PF	SF
April 1992	0.00	0.00	0.00	0.00	7.18 (15.21)	0.88 (3.90)
May 1992 to January 1993	0.00	0.00	0.00	0.00	0.00	0.00
February 1993	0.00	0.00	0.00	0.00	3.56 (8.98)	0.19 (2.04)
March 1993	0.00	0.00	0.00	0.00	4.70 (8.62)	0.34 (1.90)

Note : Figures in the parenthesis indicate the maximum pollen/seed fertility recorded in some plants.

Table 2. Meteorological observations during crop growth period (April 1992 to March 1993)

Month	Temperature (oC)		Relative humidity (%)	Precipitation (mm)
	Maximum	Minimum		
April 1992	34.00	19.30	49.00	10.00
May	32.00	20.30	65.00	167.70
June	28.40	19.40	75.00	167.60
July	27.10	18.80	77.00	135.80
August	27.10	18.90	85.00	98.60
September	27.20	18.60	73.50	194.20
October	27.30	18.30	72.00	107.60
November	26.50	17.50	70.50	70.80
December	24.50	17.30	65.00	0.00
January 1993	27.70	12.60	54.50	0.00
February	29.00	14.50	50.50	0.00
March	31.60	18.90	55.00	5.80

the cause for break down of male sterility. Low relative humidity coupled with high temperature has been suggested as the likely cause for break down of male sterility in pearl millet (Vittala Rao, 1969; Reddy and Reddy, 1972). In the present study, production of fertile pollen grains and seed set in CMS-I was probably due to higher temperatures and low relative humidity during the crop growth period (March, April and May). However, further studies are required for the precise understanding of the role of temperature, relative humidity and other factors in reversion of male sterility.

The CMS source, CMS-F which is extensively used in commercial hybrid production now all over the world was stable in all the planting dates. The other newly identified CMS source CMS-PF which also exhibited stable performance in different planting seasons could be effectively used as an additional source in the heterosis breeding programmes after identifying suitable restorers. This would help in CMS diversification for which efforts are already on.

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STUDIES ON GENETIC VARIABILITY AND INTERRELATIONSHIP IN SAFFLOWER

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ABSTRACT

In safflower substantial genetic variability was observed for all the characters studied. High heritability coupled with high genetic advance was observed for seed yield/plant, days to maturity, seeds/capitulum and capitula/plant suggesting importance of additive gene action. Significant positive correlation among the characters viz; 100 seed weight, capitula/plant, primaryand secondary branches/plant and seeds/capitulum and their positive association with seed yield/plant was observed; indicating that these are the major yield components in safflower. The character 100 seed weight exerted higher direct effect on seed yield/plant.

Key words : Correlation, path analysis, safflower.

INTRODUCTION

Genetic variability and correlation co-efficient among seed yield and yield attributes helps in constructing a suitable plant type, combining desirable expressions of different yield traits and path analysis reveals the cause and effect relationship. Accordingly, the present study was undertaken in one hundred and fifty germplasm lines of Safflower.

MATERIALS AND METHODS

The material for the present study consisted of germplasm collection of one hundred and fifty lines and five released varieties as checks. They were evaluated in augmented randomised block design with two replications during *rabi* 1995-96. Each line was represented by two rows of five meter length with 45 x 20 cm. spacing. The observations were recorded on randomly selected ten competitive plants from each line in each replication for seed yield/plant and eight yield component characters. The data were subjected to analysis of variance and computation of genotypic co-efficient of variation (*gcv*), phenotypic co-efficient of variation (*pcv*) following Burton (1952). Heritability in broad sense was estimated as per Burton and De Vane (1953) and genetic advance in percentage of mean (*ga*) according to Johnson *et al.* (1955). Genotypic correlations were worked out by following standard procedure. The path co-efficient analysis was carried out by following Dewey and Lu (1959).

RESULTS AND DISCUSSION

Analysis of variance revealed the presence of substantial genetic variability in the germplasm lines studied. The magnitude of genotypic variance and genotypic co-efficient of variation were low as compared to that of phenotypic variance and phenotypic coefficient of variation indicating that apparent variability is not only due to genotype but also due to influence of environment. The gcv and pcv were high in magnitude for seed yield/plant, capitula/plant, primary branches/plant and seeds/capitulum; where as they were low for days to maturity, days to flower and 100 seed weight. Similar findings were reported by Narkhede *et al.* (1985), Ghongade *et al.* (1993) and Singh *et al.* (1993).

High heritability estimates were observed

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for seed yield/plant (89%), days to maturity (77%), seeds/capitulum (63%), days to flower (56.5%) and capitula/plant (53.6%). The characters viz; 100 seed weight (43.6%) and primary branches/plant (37.8%) showed moderate heritability whereas, lowest heritability was observed for plant height (27.5%) and secondary branches/plant (22.50%). Ramesh *et al.* (1980), Narkhede *et al.* (1985), Ghongade *et al.* (1993) also reported similar results.

High heritability coupled with high genetic advance was observed for seed yield/plant, days to maturity, seeds/capitulum and capitula/plant; suggesting the importance of additive gene action for their inheritance (Burton, 1952). This also supports the observations reported by Thombare and Joshi (1977), narkhede *et al.* (1985), Ghongade *et al.* (1993) and singh *et al.*(1993).

Correlation studies showed that seed yield/ plant has significant positive correlation with 100 seed weight, capitula/plant, primary and secondary branches/plant and number of seeds/capitulum. A positive relationship among the yield attributes indicated that they had certain inherent relationship with seed yield/plant. Thus, the results are in conformity with those of Mathur *et al.* (1976) and Ekshinge *et al.* (1994) and at variance with those of Ranga Rao and Ramachandram (1977), Makne *et al.* (1979) and Kotecha (1981) who reported nonsignificant negative association of seeds/capitula with seed yield. The characters viz; days to flower and days to maturity, which showed highly significant positive correlation with each other showed nonsignificant negative association with seed yield/plant; indicating that early flowering and early maturing genotypes of safflower would give more yield. Argikar *et al.* (1957) and Ashri (1975) also observed negative correlation of days to flower with seed yield. Prasad *et al.* (1994) reported negative correlation of days to maturity with seed yield. A positive association among the characters viz; 100 seed weight, capitula/plant, primary and secondary branches/ plant and seeds/capitulum and their positive association with seed yield/plant was observed; indicating these are the major yield attributes in safflower. The present results are in agreement with those of Mathur *et al.* (1976) and Singh *et al.* (1993).

Path coefficient analysis, a standardised partial regression coefficient which splits the correlation coefficient into measures of direct and indirect effects revealed that 100 seed weight has exerted maximum direct effects (0.565) on seed yield and it was followed by capitula/plant (0.501), primary branches/plant (0.422), secondary branches/plant (0.395) and seeds/capitulum (0.340) (Table 3). Plant height (0.238), however had moderate direct effects on seed yield. All these direct effects were in accordance with their association with seed yield/plant. The characters days to flower and days to maturity have shown negative direct effects and their correlation with seed yield/plant was also negative. On the basis of correlation and path coefficient analysis, it could be suggested that while selecting for seed yield, due emphasis should be laid on the characters viz; 100 seed weight, capitula/plant, primary and secondary branches/plant; while for early maturity background, selection would be based on days to flower, days to maturity, 100 seed weight and capitula/plant.

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Table 1. Estimates of variability parameters in safflower.

Character	Range	Mean	Variance		Coefficient of variation		Heritability (%)	Genetic advance as % of mean
			Genotypic	Phenotypic	Genotypic	Phenotypic		
Plant height	40-80.5	40.25	28.0	102.3	9.6	18.2	27.5	26.9
Primary branches/plant	5-15	8.0	3.2	6.8	20.5	31.1	37.8	**28.5**
Secondary branches/plant	4-18	10.0	5.4	11.5	10.4	18.5	22.5	**24.6**
Capitula/plant	6-33	19.0	21.6	71.7	20.5	36.6	53.6	**54.9**
Seeds/capitulum	12-32	22.0	27.4	41.9	20.3	27.8	63.0	**61.4**
100 Seed weight (g)	3.5-7.5	5.9	13.5	26.8	8.1	11.9	43.6	**31.7**
Days to flower	55 - 95	75.0	30.4	58.9	7.5	9.6	56.5	12.4
Days to maturity	110 - 160	135.0	30.2	60.3	6.3	9.4	77.0	64.5
Seed yield/plant (g)	4.7 - 40.0	19.2	70.2	31.0	28.9	40.2	89.0	45.0

Table 2. Estimates of genotypic correlations in safflower.

Character	Plant height(cm)	Primary branches/ plant	Secondary branches/ plant	Capitula/ plant	Seeds/ capitulum	100 seed weight(g)	Days to flower	Days to maturity	Seed yield/ plant(g)
Plant height	1.000	-0.105	0.300	-0.230	0.590*	0.149	0.295	0.383	0.355
Primary branches/plant	-	1.000	0.709**	0.801**	0.195	0.425*	-0.067	-0.149	0.543*
Secondary branches/plant	-	-	1.000	0.930**	0.735**	0.430	-0.282	-0.175	0.495*
Capitula/plant	-	-	-	1.000	0.630*	0.449*	-0.159	-0.165	0.677*
Seeds/capitulum	-	-	-	-	1.000	0.275	-0.113	-0.278	0.398*
100 seed weight	-	-	-	-	-	1.000	-0.145	-0.195	0.795**
Days to flower	-	-	-	-	-	-	1.000	0.718**	-0.313
Days to maturity	-	-	-	-	-	-	-	1.000	-0.301

*, ** Significant at five percent and one percent level. respectively.

Table 3. Direct and indirect effects of various characters on seed yield in safflower.

Character	INDIRECT EFFECTS VIA								genotypic correlation with seed yield
	Plant height	Primary branches/	Secondary branches/	Capitula/ plant	Seeds/ capitulum	100 seed weight	Days to flower	Days to maturity	
Plant height	0.238	-0.019	0.024	0.116	0.036	-0.054	-0.014	0.028	0.355
Primary branches/plant	0.015	0.422	0.049	0.095	-0.016	-0.007	-0.007	-0.008	0.543*
Secondary branches/plant	0.020	0.080	0.395	-0.002	-0.002	0.008	-0.002	-0.002	0.495*
Capitula/plant	-0.002	-0.106	0.101	0.501	-0.030	0.053	0.080	0.079	0.677*
Seeds/capitulum	0.018	-0.010	0.016	0.041	0.340	-0.050	0.026	0.017	0.398*
100 seed weight	-0.017	0.039	-0.015	0.550	-0.020	0.565	0.090	0.098	0.795**
Days to flower	0.006	0.005	0.006	-0.029	-0.016	-0.019	-0.273	0.007	-0.313
Days to maturity	0.002	0.003	0.002	-0.011	-0.013	-0.019	-0.016	-0.250	-0.301
Residual effect = 0.070									

*, ** significant at five percent and one percent level respectively.

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ANALYSIS OF CHARACTERS CONTRIBUTING TO SEED YIELD IN INDIAN MUSTARD (*Brassica juncea* L. ZERN AND COSS)

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ABSTRACT

Interrelationship among different characters were determined both by simple correlation and path coefficient analyses, using six diverse genotypes of Indian mustard (*Brassica juncea* L.) at RARS, R.S. Pura. The characters viz. plant height (cm), primary branches per plant, secondary branches per plant, siliqua length (cm), number of seeds per siliqua, number of siliqua per plant, seed weight (g) and seed yield (g) were studied by sowing on three different dates with three spacings. Data revealed that correlation between them were close and positive in all the genotypes. Path analysis, further, showed that all attributes had direct and indirect influences on seed yield. The maximum direct influence was obtained from number of siliqua per plant. Hence primary branches, secondary branches, number of seeds per siliqua, number of siliqua per plant and seed weight are the major yield contributing parameters.

Key words : *Indian mustard, correlation, path co-efficients, seed yield.*

INTRODUCTION

Correlation of agronomic and morphological characters with seed yield in different crops have been reported by several workers. Although these estimates are helpful in determining the components of complex traits such as yield, they do not provide an exact picture of the relative importance of direct and indirect influences of each of the component characters towards this trait. Path coefficient analysis developed by wright (1921, 1923), which are simply standardized partial regression analysis appears to be helpful in partitioning the correlation coefficient into direct and indirect effects. The present study was, therefore, designed to collect the information to findout the association of yield and important productive functions including the yield components of a number of elite varieties of different growth duration when planted on different dates and space so that Brassica breeders may be benefited.

MATERIALS AND METHODS

The present investigation was carried out on clay soil at Regional Agriculture Research Station of Sher-e-Kashmir University of Agricultural Sciences and Technology, R.S. Pura, Jammu during *rabi* season of 1993-94 and 1994-95. The experiment was conducted in split-plot design with three replications, keeping three dates of sowing (October, 5, October, 20 and November, 5) in main plot, and three spacings (30,40 and 50 cm) and six genotypes of Indian mustard viz. (Pusa Bold and RLM-619 (Mid early), RL-1359 and RH-30 (Medium) and Prakash and RLM-198 (late)) as sub-plot treatments. Ten competitive randomly selected plants were tagged in the middle three rows of each genotype for taking observations on plant height (X_1), primary branches per plant (X_2), secondary branches per plant (X_3), siliqua length (X_4), number of seeds per siliqua (X_5), number of siliqua per plant (X_6), seed weight (X_7) and seed yield (X_8). Correlation and path analyses were calculated as per the procedure given by Singh and choudhary (1977).

RESULTS AND DISCUSSION

There can be several approaches to the problem of identification of ideal plant type. Statistical approach of factor analysis (Lawley and Maxwell, 1963), a comparison of plant morphology of a set

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of high yielding lines with that of low yielding one (Singh *et al.*, 1969), and model building or construction of ideotype after identification of morphological frame work through correlation analysis and path analysis are some of the ways by which one can identify the model plant characteristics. The various components of yield very often exhibit considerable degree of association among themselves and with the yield. This character association is attributed to three factors, viz., linkage, pleiotropy and physiological association necessitated by developmental and biochemical path ways. A perusal of Table 1 revealed that correlation values between seed yield and other contributing characters except plant height were significant in all the genotypes. It means that selection for one will automatically consider the other variables (Singh *et al.*, 1969, Shivahare *et al.*, 1977 and Chauhan *et al.*, 1978). The primary branches per plant was observed to have a highly significant and positive association with plant height, secondary branches per plant and number of siliqua per plant while secondary branches per plant had significant and positive association with number of siliqua plant. The positive association was also found between number of seeds per siliqua and siliqua length and number of siliqua per plant. Further, number of siliqua had significant and positive association with seed weight in all the genotypes. The aforesaid results are in conformity with the findings of Gupta, 1972; Labana *et al.*, 1977; Shivhara *et al.*, 1977 and Tak, 1976. Hence primary branches per plant, secondary branches per plant, siliqua length, number of seeds per siliqua, number of siliqua per plant and seed weight appear to be the most important selection criteria for increasing seed yield in Indian mustard. The character siliqua length showed high positive significant association with number of seeds per siliqua in all the genotypes except Prakash. The direct and indirect effects of these characters on seed yield (Table 2), showed that in early medium and medium group of varieties the direct positive effect was depicted by number of siliqua per plant followed seed weight and seed weight followed primary branches per plant respectively while indirect effect through other characters was high. Tak (1976) and Shivahare et al. (1977) reported similar results. The direct positive effect was also found where seed weight followed number of siliqua per plant in one variety of late maturity group and number of siliqua per plant followed number of seeds per siliqua in another variety.

On the basis of these results, it can be concluded that seed yield can be improved by making selection through number of primary branches, number of seeds per siliqua, number of siliqua per plant and 1000 seed weight in Indian mustard.

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Table 1. Total correlation co-efficient between and among different characters of Indian mustard (*B. juncea*) Varieties (Pusa bold, RLM 619, RL-1359 above the diagonal and RM-30, Prakash, RLM - 198 below the diagonal).

	Plant height (cm)	Primary branches per plant	Secondary branches/ plant	Siliqua length (cm)	Number of seeds per siliqua	Number of siliqua per plant	1000-seed weight (g)	Seed yield
Plant height (cm)		.7126**	.0921	.1996	.3922	.2603	.4152	.3155
		5992 **	.3526	.2126	.1085	.0813	.2314	.1893
		.6384 **	.0285	.0658	.1993	.3006	.3018	.1679
Primary branches per plant	.6113 **		.5015	.3151	.1012	.9110 **	.1683	.6500 **
	.4808 *		.6616 *	.1225	.2618	.6850 **	.4415	.4565 *
	.5206 *		.4505 *	.3819	.4415	.7916 **	.4695 *	.4949 *
Secondary branches per plant	.2119	.5916 **		.3125	.4381	.6402 **	.3814	.6901 **
	.2883	.4683 *		.4315	.4050	.5097 *	.1915	.5068 *
	.3266	.5325 *		.0412	.7417 **	.7711 **	.1282	.4570 *
Siliqua length (cm)	.0919	.3119	.2316		.7138 **	.4414	-.4662 *	.4702 *
	.2116	.1917	.1845		.6115 **	.4002	-.2512	.4824 *
	.2211	.3766	.0995		.8525 **	.4165	-.3015	.4655 *
Number of seeds per siliqua	.3662	.0294	.3100	.4555 *		.5201 *	.1613	.7277 **
	.1111	.4260	.3545	.4413		.4811 *	.3018	.5127 *
	.1911	.2018	.3811	2995		.5610	-0.728	.5187 *
Number of siliqua per plant	.5321 *	.6127 **	.8131 **	.3110	.5351 **		.4805 *	.8612 **
	.1019	.4793 *	.5515 *	.0515	.1112		.5512 *	.7311 **
	.0516	.5011 *	.4818 *	.4105	.2995		.7436 **	.7091 **
1000 seed weight (g)	.0317	.1330	.5118 *	-.6131 **	.5006 *	.4693 *		.4849 *
	.4515 *	.5420*	.2883	.1125	.1519	.5015 *		.4963 *
	.1621	.2554	.4351	-.1713	.2710	.2889		.4649 *
Seed yield	.4829 *	.6594 **	8260 **	.1526	.4883 *	.7666 **	.8409 **	
	.3505	.6780 **	.6809 **	.4682 *	.8026 **	.9159 **	.5342 *	
	.4126	.6411 **	4565 *	.4604 *	.4701 *	.7231 **	.6013 **	

Table 2. Direct (diagonal) and indirect effect of the seven characters on the seed yield of Indian mustard varieties.

Characters	Plant height (cm) X_1	Primary branches per plant X_2	Secondary branches/ plant X_3	Siliqua length (cm) X_4	Number seed per siliqua X_5	Number of siliqua per plant X_6	Seed weight (g) X_7	Correlation of seed yield
1	2	3	4	5	6	7	8	9
A) Puss Bold								
X_1	.0851	-.1425	.0144	.0409	.0479	.1696	.1001	.3155
X_2	.0606	-.2000	.0783	-.0646	.0124	.5935	.0406	.6500**
X_3	.0078	-.1003	.1561	.0641	.0535	.4170	.0919	.6901**
X_4	.0170	-.0630	.0480	.2050	.0872	.2875	-.1124	.4702*
X_5	.0334	-.0202	.0684	.1463	.1221	.3388	.0389	.7277**
X_6	0.222	-1822	.0999	.0905	.0635	.6515	.1158	.8612**
X_7	.0353	.0337	.0052	-.0956	.0957	.3130	.2410	.4849*
B) RLM-619								
X_1	.1115	-.1628	.0710	.0532	.0056	.0416	.0742	.1893
X_2	.0668	-.2801	.1333	.0306	.0135	.3509	.1415	.4565*
X_3	.0393	-.1853	.2015	.1079	.0209	.2611	.0614	.5068*
X_4	.0237	-.0343	.0869	.2501	.0315	.2050	-.0805	.4824*
X_5	.0121	-.0733	.0816	.1529	.0515	.2427	.0967	.5127*
X_6	.0091	-.1919	.1027	.1001	.0248	.5123	.1767	.7311**
X_7	.0258	-.1237	.0386	-.0628	.0155	.2824	.3205	.4963*
C) RL-1359								
X_1	-.2253	.0686	-.0042	.0060	.0832	.0786	.1611	.1679
X_2	.1438	.1075	-.0660	.0348	.1843	.2067	.1714	.4949*
X_3	-.0064	.0484	-.1465	.0038	.3097	.2013	.0468	.4570*
X_4	-.0148	0410	-.0060	.0912	.3558	.1074	-.1100	.4655*
X_5	-.0499	.0475	-.1087	.0778	.4175	.1465	-.0120	.5187*
X_6	-.0677	.0851	-.1130	.0380	.2342	.2611	.2714	.7091**
X_7	-.680	.0505	-.0188	-.0274	-.0305	.1941	.3650	.4649*

Table 2 continued

1	2	3	4	5	6	7	8	9
D) RH-30								
X_1	.0800	.2164	.0487	-.0131	.0483	.0886	.0140	.4829*
X_2	.0490	.3540	.1361	-.0444	.0039	.1020	.5880	.6594**
X_3	.0170	.2094	.2300	-.0330	.0409	.1354	.2263	.8260**
X_4	.0074	.1104	.0713	-.1425	.0600	.0518	-.0058	.1526
X_5	.0293	.0104	.0713	-.0649	.1318	.0891	.2213	.4883*
X_6	.0426	.2169	.1870	-.0443	.0705	.1665	.2074	.7666**
X_7	.0025	.0471	.1174	.0874	.0660	.0781	.4421	.8409**
E) Prakash								
X_1	.3011	-.0825	-.0461	.0477	.0779	.1070	-.0546	.3505
X_2	.1448	-.1715	-.0749	.0432	.2987	.5033	-.0656	.6780**
X_3	.0869	-.0803	-.1600	.0415	.2486	.5791	-.0349	.6809**
X_4	.0637	-.0329	-.0295	.2252	.3094	-.0541	-.0136	.4882*
X_5	.0335	-.0731	-.0567	.0993	.7012	.1168	-.0184	.8026**
X_6	.0307	-.0823	-.0882	-.0116	.0780	1.0500	-.0607	.9159**
X_7	.1359	-.0930	-.0461	.0253	.1065	.5266	-.1210	.5342*
F) RLM-198								
X_1	.1425	.1155	-.0256	.0512	.0282	.2180	.0790	.4126
X_2	.0742	.2218	-.1078	.0872	.0298	.2114	.1245	.6411**
X_3	.0465	.1181	-.2025	.0230	.0562	.2030	.2121	.4565*
X_4	.0315	.0835	-.0201	.2315	.0442	.1732	-.0835	.4604*
X_5	.0272	.0448	-.0772	.0693	.1475	.1264	.1321	.4701*
X_6	.0074	.1111	-.0974	.0950	.0442	.4220	.1408	.7231**
X_7	.0231	.0566	-.0881	-.0397	.0400	.1219	.4875	.6013**

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EFFECT OF IRRADIATIONS ON VARIABILITY AND CHARACTER ASSOCIATION IN SEGREGATING POPULATIONS OF SAFFLOWER (*Carthamus tinctorius* L.)

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ABSTRACT

The crossed seeds (F_0) of A2xA1 and A1x502-236 were subjected to 40 kr T-irradiation to compare the variability in irradiated F_2M_2 and F_3M_3 as against the variability in F_2 and F_3 generations. The values of mean and ranges were found to be relatively higher in F_2M_2 and F_3M_3 population over their respective control populations for most of the characters except hull content. The significant increase in variance of the characters in the F_3M_3 over F_3 was observed for mumber of capitula, hull content, oil content in cross A_2XA_1 and for number of seeds, oil content and 100-seed weight in cross A1x502-236. There was enhancement in the heritability also of few characters in cross A_2XA_1. The strong inverse relationship between seed yield and oil content in F_3 was reduced in F_3M_3 in the cross A1x502-236. Similary, the negative association between hull and oil content was reduced in F3M3. In general, positive associations of seed yield with most of the yield contributing traits improved in F_3M_3 population. The shifts in correlations from negative to positive or non-existence of association between undesirable combination of yield components due to irradiation suggest that it is helpful to break or weaken the close undesirable linkages to certain extent. The important shifts in direct and indirect effects of component traits like number of capitula, capitula weight, seed number, seed weight and hull content were observed on seed yield in one or the other cross.

Key words : Safflower, irradiation, variability, correlation, shifts.

INTRODUCTION

The simultaneous improvement for higher seed yield with oil content in safflower has been difficult owing to existence of undesirable associations between these traits, as well as among important yield traits (Parameshwarappa *et al.*, 1984; Ramachandram, 1985; Nei *et al.*, 1993). Recent studies suggest that intermating among the selected genotypes in a genetically wide cross (Prakash and Prakash, 1993 and Parameshwarappa *et al.*, 1997) or irradiation of hybrid seeds (Patil *et al.*, 1997) would help to break the undesirable linkages between closely related characters. This would make it possible to select genotypes with appropriate combination of characters like higher seed yield and oil content. The present investigation was carried out to know the extent of additional variability as well as the shifts in the direction and magnitude of correlations among characters of interest with irradiation followed by hybridization as compared to hybridization alone.

MATERIALS AND METHODS

Three morphologically distinct genotypes viz., A-1 (higher capitula number, thick hull, low oil and high yield), A-2 (low capitula number, reduced hull, high oil) and 502-236 (medium bold capitula, high oil) were used to develop two crosses viz., A-2xA-1 and A-1x502-236. A part of the F_0 seeds (crossed seeds) of these crosses were subjected to 40 kr T-irradiation and the remaining seeds were saved to raise the crop by pedigree breeding procedure. The irradiated F_0 seeds along with untreated one were grown in separate rows to obtain sufficient F_1M_1 and F_1 seeds, respectively. Both the populations were caged to prevent out crossing by bee activity

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and preliminary observations on germination. mortality and chlorophyll mutations were recorded on F_1M_1 lines of the crosses. The corresponding selfed seeds were utilized to grow a large F_2M_2 and F_2 population. In both the populations data on seven important quantitative characters including seed yield was recorded on 150 random plants. The standard statistical procedures were applied to compute the extent of variability for the characters studied. Finally 40 plants from each F_2 and F_2M_2 population were selected to grow their F_3 and F_3M_3 progenies. They were evaluated in a randomized block design with two replications at the Agricultural Research Station, Annigeri during *rabi* 1995-96.

The recommended agronomic practices were followed to raise the crop successfully. Observations on eight important quantitative characters including seed yield and oil content were recorded on five random plants in each treatment. The mean, range and correlations were computed for both the populations of the crosses to assess the extent of additional variability generated and possible shifts in correlation.

RESULTS AND DISCUSSION

The mean and range of various quantitative characters in respect of F_2M_2 and F_3M_3 generations compared to their corresponding selfed generations viz., F_2 and F_3, respectively is given in Table 1. The mean values for most of characters in F_2M_2 generation were higher as compared to F_2 generation. The increase in mean values of several characters with the use of different mutagenic agents in safflower has been reported by Mallikarjunaradhya (1977). As regards the comparison of F_3M_3 mean values over F_3 generation, there were no appreciable changes for most of the characters studied. The lack of mutagenic effects in causing the shifts in the mean values has been reported in rice (Saini and Sharama, 1970).

Although considerable shifts in the mean values between different generations were lacking, there were changes in the range of the characters. For most of the characters, the upper limit of the range was higher in both F_2M_2 and F_3M_3 generations indicating that irradiation was responsible for the additional variability created.

The variance, heritability and genetic advances worked out for the characters are presented in Table 2. The magnitude of genotypic as well as phenotypic variance was higher in F_3M_3 for all the characters except seed number in cross A2xA1, and for number of capitula, capitula weight and capitula size in cross A1x502-236. This is also evident from the relatively higher values of genotypic and phenotypic coefficients of variation. The enlargement of variability in the form of wider range of the characters and coefficient of variation in the F_3M_3 indicate that hybridization with irradiation has generated additional variability as compared to hybridization and selfing alone in F_3.

The role of irradiations has also been reflected by the changes that occurred in the heritability of the characters in F_3M_3 . Highest increase in the heritability from F_3 to F_3M_3 was noticed in case of number of capitula (14.7 to 57.4) followed by capitula weight (42.4 to 63.4) and capitula size (61.1 to 72.3) in cross A2xA1 whereas oil content recorded the highest heritability in cross A1x502-236 (44.6 to 70.4). There was also decrease in the heritability of characters like number of capitula, capitula weight and capitula size in cross A1x502-236. Almost similar trend was noticed in the estimates of genetic advance of the characters in both the crosses.

The genotypic correlations worked out separately for F_3M_3 and F_3 populations are presented in Table 3. It was observed that the relationship between seed yield and oil content was negative but non-significant in both the crosses in F_3. Whereas, it was changed to positive

Table 1. Mean and ranges for different characters in safflower.

Character	Crosses	Mean		Range	
		F2 & F2M2	F3 & F3M3	F2 & F2M2	F3 & F3M3
No. of Capitula	I F_3	13.08	11.70	11.00-28.00	11.20-17.60
	F_3M_3	14.90	12.38	13.00-29.20	10.33-20.20
	II F_3	14.24	16.01	10.00-25.00	10.00-28.80
	F_3M_3	17.40	13.48	11.00-27.20	9.20-21.00
Capitula weight	I F_3		23.19		16.50-34.60
	F_3M_3	——	26.10	——	19.00-39.00
	II F_3		32.12		13.80-42.00
	F_3M_3		25.67		15.20-37.00
Capitula size	I F_3	2.30	2.19	2.00-2.80	1.92 - 2.30
	F_3M_3	2.34	2.22	2.10-3.00	1.90-2.54
	II F_3	2.22	2.20	1.95-2.40	1.98-2.34
	F_3M_3	2.32	2.26	2.12-2.50	2.00-2.44
Seed number	I F_3	30.08	26.11	11.00-40.00	19.30-28.80
	II F_3M_3	32.38	27.02	12.20-43.00	20.80-39.20
	II F_3	28.24	26.70	10.00-35.00	19.80-38.80
	F_3M_3	29.80	27.61	12.00-29.00	20.80-42.00
100-seed weight	I F_3	5.14	4.46	3.90-6.06	3.36-6.00
	F_3M_3	5.58	5.28	4.34-7.84	3.89-6.36
	II F_3	4.84	5.66	4.00-7.15	3.65-6.80
	F_3M_3	47.84	46.68	41.20-49.80	42.80-48.40
Hull content	I F_3	47.30	44.83	42.40-47.20	42.10-51.60
	F_3M_3	44.53	45.91	40.00-48.00	40.00-50.60
	II F_3	49.21	47.15	42.80-51.20	43.20-51.00
	F_3M_3	47.84	46.68	41.20-49.80	42.80-48.40
Oil content	I F_3	30.22	30.62	28.77-37.72	29.10-33.18
	F_3M_3	31.88	30.64	29.00-36.71	29.12-34.00
	II F_3	29.20	30.44	27.40-33.70	29.05-33.10
	F_3M_3	30.40	30.03	27.02-35.25	29.25-33.46
Seed yield	I F_3	18.38	13.09	12.80-27.20	9.00-19.20
	F_3M_3	21.24	13.82	12.00-28.00	10.00-23.40
	II F_3	17.24	16.34	12.00-22.00	11.30-24.00
	F_3M_3	20.80	19.00	15.00-27.00	11.60-24.80

Cross I .... A-2xA-1; Cross II A-1x502-236

and significant side in F_3M_3 *of cross A-1x502-236*, thus indicating the possibility of simultaneously improving both the traits through selection. Several *studies indicate* the inverse relationship between these traits in the *conventional* breeding programmes involving hybridization and selfing (Parameshwarappa, 1984; Ramachandram, 1985).

The association of seed yield with other yield components in F_3M_3 was strengthened. For *instance, the correlation* of yield with number of capitula (0.63), capitula weight (0.711) and 100-seed *weight (0.36)* in cross A2xA1 and only for capitula size (0.44) in cross A1x502-236 have changed favourably. Thus selection for these traits would lead to higher seed yield.

Among the important yield traits, proportion of hull determines both seed yield and oil content. Hull content is strongly associated with seed yield but negatively with *oil content* as noticed in F_3 of cross A1x 502-236. Similar

Table 2. Parameters of genetic variability for different characters in F_3 and F_3M_3 populations of safflower

Characters	Crosses	Number of capitula	Capitula weight	Capitula size	Seed number	Seed weight	Hull content	Oil content	Seed yield
Genotypic variance	I F_3	0.56	5.54*	0.014	14.83	0.42	2.27	0.89	3.15
	F_3M_3	3.97**	17.64	0.016	13.82	0.62	5.14**	1.65*	6.90
	II F_3	7.64	3.69	0.006	12.26	0.53	4.49	0.46	11.11
	F_3M_3	1.24*	12.74	0.003	17.34*	2.82*	4.63	0.88*	12.30
Phonotypic Variance	I F_3	3.84	13.06	0.029	25.94	0.47	2.71	1.35	5.24
	F_3M_3	4.91	27.77**	0.022	24.02	0.63	5.58*	2.17*	9.47
	II F_3	14.55	45.47	0.013	19.68	0.64	5.26	1.04	14.59
	F_3M_3	6.12	22.15	0.009	22.56	2.84**	4.91	1.25	14.95
GCV	I F_3	6.43	10.14	5.41	14.75	14.56	3.36	3.06	13.52
	F_3M_3	16.10	16.08	5.80	13.75	15.02	4.94	4.21	18.15
	II F_3	17.27	19.73	3.59	13.11	12.91	4.49	2.25	17.57
	F_3M_3	8.21	13.91	6.92	15.10	9.37	4.61	3.12	21.46
PCV	I F_3	16.76	15.58	6.82	19.51	15.43	3.67	3.80	17.50
	F_3M_3	21.25	2.19	5.37	18.15	15.42	5.15	4.83	22.20
	II F_3	23.82	2.67	4.41	16.62	14.18	4.87	3.37	20.11
	F_3M_3	16.41	18.34	61.10	17.22	9.66	4.75	3.72	23.66
h^2	I F_3	14.70	42.40	72.30	57.20	89.00	83.70	65.60	60.10
	F_3M_3	57.40	63.40	44.80	27.50	95.00	92.20	76.00	66.20
	II F_3	52.50	82.90	34.10	62.30	82.90	85.20	44.60	76.10
	F_3M_3	25.00	57.50	8.67	76.90	94.20	94.30	70.40	82.20
GA	I F_3	5.04	13.12	10.36	22.49	28.25	6.33	5.12	21.69
	F_3M_3	25.12	26.36	5.00	21.46	30.30	9.78	7.53	30.53
	II F_3	25.70	37.01	9.00	21.31	24.20	8.54	3.08	31.52
	F_3M_3	8.45	21.73		27.27	18.70	9.21	5.39	40.08

* - Significant at 5% level ; ** - Significant at 1% level ; Cross I - A2xA1; Cross II - A-1x502-236

association between these traits was reported by Parameshwarappa (1984). In F_3M_3, it was changed to non-significance indicating that irradiation was helpful to overcome the existing unfavourable inverse relationship between such closely linked characters. However, there was lack of shifts in the association between hull content and oil content in both the crosses except that strong and negative relationship noticed in cross A-1 x 502-236 was lowered in magnitude. The negative relationship existing between number of capitula and size of capitula, number of capitula and seed

Table 3. Genotypic correlations among different characters in F_3M_3 and F_3 pouplations of safflower crosses

Characters	Crosses	Capitula weight	Capitula size	Seed number	100 Seed weight	Hull content	Oil content	Seed yield
Number of capitula	I F_3	0.914**	-0.104	-0.419	0.101	-0.154	0.594**	0.235
	F_3M_3	0.592*	-0.598**	-0.152	-0.068	-0.240	0.070	0.638**
	II F_3	0.419	0.021	-0.065	0.364*	0.583**	-0.327*	0.850**
	F_3M_3	0.789	-0.179	-0.216	0.102	0.187	0.129	-0.161
Capitula weight	I F_3		0.139	0.73	0.174	0.222	-0.161	0.549**
	F_3M_3		0.029	0.258	0.218	-0.055	-0.055	0.711**
	II F_3		0.047	-0.164	0.197	0.369*	-0.173	0.583**
	F_3M_3		0.109	0.040	0.119	0.171	0.148	0.113
Capitula size	I F_3			0.752**	-0.598**	-0.159	0.093	0.296
	F_3M_3			0.784**	0.140	0.349*	0.059	0.047
	II F_3			0.885**	-0.587**	0.145	0.337	0.109
	F_3M_3			0.892**	-0.156	-0.104	0.074	0.447*
Seed number	I F_3				-0.612**	0.027	0.228	0.384*
	F_3M_3				-0.059	0.478**	0.059	0.334*
	II F_3				-0.476**	-0.122	0.337	0.002
	F_3M_3				0.086	-0.282	0.074	0.286
100-seed weight	I F_3					0.191	-0.338*	-0.045
	F_3M_3					0.222	-0.416**	0.369*
	II F_3					0.295	-0.155	0.286
	F_3M_3					0.258	-0.284	-0.260
Hull content	I F_3						-0.187	0.033
	F_3M_3						-0.255	0.127
	II F_3						-0.567**	0.456**
	F_3M_3						-0.174	-0.059
Oil content	I F_3							-0.222
	F_3M_3							0.018
	II F_3							-0.070
	F_3M_3							0.435**

* - Significant at 5% level, ** - Significant at 1% level

number was not changed in F_3M_3 in either crosses. The association of capitula size with seed weight in F_3 is reported to be negative (Ramachandram and Gouda, 1982). Therefore, genotypes with bolder capitula possess smaller but more number of seeds per capitula. In view of shifts in the magnitude of negative association between these two traits in F_3M_3 towards desirable direction, it should be possible to construct plant types with bolder capitula having more number of bolder seeds per capitula to realize higher seed yield. This was also evident from the reduction in the magnitude of inverse relationship between seed number and seed weight in both the crosses (0.059 and 0.086). Shifts in the association of other combination of characters were noticed either in direction or magnitude or both in F_3M_3 indicating the role of irradiation in changing the nature of correlations between the characters.

The direct and indirect effects of various yield components towards seed yield (Table 4) indicated that the contribution of capitula weight increased from 0.53 in F3 to 1.79 in F3M3. The increase in contribution of number of capitula (1.31), capitula size (1.47), 100-seed weight (0.52) in cross A-2xA-1 and oil content (0.43) in cross A-1x502-236 was observed indicating that irradiations would also alter the contribution of characters towards seed yield. The shifts in the magnitude and direction of indirect effects of the characters on seed yield has also been observed.

In general, the irradiation of crossed seeds (F_0) has brought about smaller but additional variation in the characters, which otherwise would not have been possible through mere selfing and selection. The additional variability released by use of irradiation, probably has been the result of rare recombinations between highly linked characters and cryptic variations brought about by point mutations in the minor genes governing the traits. Thus combination of hybridization and mutations has been helpful to change the nature of associations between the linked traits and thus, providing opportunities to combine high seed yield and oil content in safflower.

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Table 4. Genotypic Path analysis in F_3M_3 and F_3 population of safflower

Characters	Crosses	No. of capitula	Capitula weight	Capitula size	Seed number	100-Seed weight	Hull content	Oil content	Correla-tion
Number of capitula	I F_3	-0.165	0.563	0.010	-0.188	0.004	0.030	-0.041	0.235
	F_3M_3	1.319	-0.038	-0.881	0.084	0.035	-0.061	0.018	0.638**
	II F_3	1.021	0.223	-0.045	-0.105	-0.206	0.754	-0.138	0.850**
	F_3M_3	-0.606	1.417	0.263	-0.293	-0.023	0.080	0.077	-0.161
Capitula weight	I F_3	-0.151	0.616	-0.014	0.033	0.007	-0.044	0.011	0.549**
	F_3M_3	0.781	-0.064	0.043	-0.142	0.113	0.011	-0.014	0.711**
	II F_3	0.427	0.533	-0.999	-0.268	-0.077	0.477	-0.073	0.583**
	F_3M_3	-0.479	1.795	-0.159	0.055	-0.26	0.073	0.088	0.113
Capitula size	I F_3	0.017	0.085	-0.100	0.337	-0.023	0.031	-0.006	0.296
	F_3M_3	-0.789	-0.002	1.473	-0.433	-0.075	0.089	0.013	0.047
	II F_3	0.022	0.025	-2.119	1.441	0.332	0.188	0.079	0.109
	F_3M_3	0.109	0.195	-1.463	1.212	0.035	-0.045	0.074	0.447**
Seed number	I F_3	0.069	0.045	-0.076	0.449	-0.023	-0.005	-0.016	0.384*
	F_3M_3	-0.201	-0.016	1.155	-0.552	-0.031	-0.122	0.014	0.369*
	II F_3	-0.066	-0.088	-1.876	1.628	0.269	-0.158	0.142	0.002
	F_3M_3	0.131	0.073	-1.305	1.360	-0.019	-0.121	0.044	0.286
100-Seed weight	I F_3	-0.017	0.107	0.060	-0.275	0.038	-0.038	0.025	-0.045
	F_3M_3	0.090	-0.014	-0.212	0.033	0.520	0.057	-0.107	0.369*
	II F_3	0.371	0.073	1.243	-0.775	-0.566	0.381	-0.065	0.286
	F_3M_3	-0.062	0.213	0.229	0.117	-0.222	0.110	-0.169	-0.260
Hull content	I F_3	0.025	0.137	0.016	0.012	0.007	-0.197	0.013	0.033
	F_3M_3	-0.317	-0.003	0.515	-0.264	0.116	0.256	-0.065	0.127
	II F_3	0.595	0.197	-0.308	-0.199	-0.167	1.294	-0.240	0.456**
	F_3M_3	-0.113	0.308	0.153	-0.383	-0.057	0.428	-0.103	-0.059
Oil content	I F_3	-0.098	-0.099	-0.009	0.102	-0.014	0.037	-0.069	-0.222
	F_3M_3	0.094	0.004	0.077	-0.030	-0.216	-0.065	0.257	0.018
	I F_3	-0.334	-0.092	-0.395	0.548	0.088	-0.733	0.423	-0.070
	II F_3M_3	-0.078	0.265	0.182	0.101	0.063	-0.074	0.595	0.435**

Deagonal - Direct effect
Cross I - A-2xA-1
Cross II - A-1x502-236

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

Residual Factors
F_3 - 0.499
F_3M_3 - 0.028
II F_3 - 0.408
F_3M_3 - 0.811

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CORRELATION AND PATH ANALYSIS IN SUNFLOWER (*Helianthus annuus* L.)

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ABSTRACT

The cause and effect relationship of oleic acid with other fatty acids and five agronomic traits was assessed among 45 hybrids and 10 inbred lines of a diallel cross. Days to 50 percent flowering was found to be positively correlated with oleic acid. None of the fatty acids showed significant association with oil yield/plant. oleic acid showed a strong negative association with linoleic acid. Though linoleic acid had a direct negative effect of considerable magnitude on oleic acid, days to 50% flowering, days to maturity and steric acid indirectly influenced the oleic acid through linoleic acid.

Key words: Sunflower, correlation, path analysis, oleic and linoleic acid.

INTRODUCTION

High oleic sunflower seed oil is considered superior both from stability and nutritional point of view. Besides conferring stability to oil during frying, refining and storage, decrease in cholesterol level and low density lipoproteins and maintaining the concentrations of high density lipoproteins has been attributed to this mono-unsaturated oil (Yodice, 1990). In the present study an attempt was made to assess the nature and magnitude of correlation of oleic acid with other fatty acids and some agronomic traits through path analysis.

MATERIALS AND METHODS

The experimental material consisted of 10 inbred lines (PISF9, PISF67, SF9, PISF118, PISF119, PISF16, PISF29, PISF74, PISF47 AND SF14) and their 45 one way diallel crosses grown in a randomised complete block design with three replicates, at experimental farm of Punjab Agricultural University, Ludhiana during spring, 1995. The crosses were made during 1994 by inducing male sterility by swabbing the floral heads at star bud stage with 100 ppm GA_3, in the morning for three consecutive days. Each single row plot was 3.3 m long. Spacing of 60 x 30 cm was followed. Observations were recorded on nine agronomic and quality traits (Table 1). Days to maturity were recorded on plot basis. Composite seed sample from five randomly selected competitive plants of each genotype from each replication was used to record 100-seed weight, oil content and fatty acid composition. Seed oil content on dry seed weight basis was determined by Nuclear Magnetic Resonance. Oil yield/plant was computed as function of seed yield/plant x oil content per cent. The lipids were extracted from the seeds following cold percolation method (Floch et al., 1957). The lipids were converted into their methyl esters following the procedure outlined by Luddy *et al.*, (1968). Methyl esters thus prepared were subjected to gas liquid chromatography. The peaks obtained were identified using internal standard fatty acids. The relative proportion of different fatty acids was worked out from the area of peaks. The formulae suggested by Aljibouri *et al.*, (1958) were adopted for calculating genotypic, phenotypic and environmental correlation coefficients. The path coefficient analysis was computed following Dewey and Lu (1959).

RESULTS AND DISCUSSION

The genotypic correlations (Table 1) were, in general, higher than the corresponding phenotypic correlations. However, a good correspondence

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Table 1. Genotypic, phenotypic and environmental correlations among different traits in sunflower

Character	Correlation	Days to maturity	100-seed weight	Oil content	Oil yield per plant	Palmitic acid	Stearic acid	Oleic acid	Linoleic acid
Days to 50% flowering	P	0.720**	0.075	0.263	-0.268*	0.009	-0.022	0.420**	-0.428**
	G	0.654**	0.083	0.248	-0.194	-0.020	-0.003	0.317*	-0.317*
	E	0.035	0.237	0.010	0.301*	-0.118	0.139	-0.229	0.267
Days to maturity	P		0.129	0.222	-0.096	-0.073	-0.202	0.177	-0.168
	G		0.123	0.193	-0.065	-0.056	-0.179	0.141	-0.132
	E		0.066	-0.155	0.106	-0.049	-0.048	-0.014	0.027
100-seed weight	P			-0.188	0.235	0.034	0.076	0.021	-0.017
	G			-0.168	0.225	-0.018	0.066	0.010	-0.002
	E			0.323*	0.231	-0.268*	-0.019	-0.077	0.133
Oil content	P				0.291*	-0.330*	0.093	-0.063	0.076
	G				0.284*	-0.208	0.066	-0.048	0.063
	E				0.324*	-0.030	-0. 87	0.050	0.009
Oil yield per plant	P					-0.084	0.098	-0.099	0.136
	G					-0.049	0.108	-0.110	0.132
	E					-0.005	0.151	-0.150	0.123
Palmitic acid	P						-0.028	-0.092	0.025
	G						-0.094	-0.006	-0.067
	E						-0.235	0.111	-0.203
Stearic acid	P							0.201	-0.220
	G							0.091	-0.108
	E							-0.309*	0.295*
Oleic acid	P								-0.993**
	G								-0.990**
	E								-0.981**

G, genotypic; P, phentypic; E, environmental correlations. **, * Significant at 1 and 5 per cent levels, respectively.

between the phenotype and genotype as indicated by the relative magnitude of the phenotypic and genotypic correlations suggests the reliability of the phenotypic selection. This is in conformity with the findings of Singh and Labana (1990). Days to 50 per cent flowering was found to have a significant positive association with days to maturity and oleic acid at both phenotypic and genotypic levels. Positive association between earliness and oleic acid content, however, was reported by Fernandez-Martinez *et al.*, (1993). Negative association of days to 50 per cent flowering with oil yield at genotypic level and linoleic acid at all the three levels was observed. Days to maturity did not record significant association with any of the traits studied except days to 50 per cent flowering. The association between 100-seed weight and oil yield though positive was non-significant. Oil content had positive correlation with oil yield at genotypic, phenotypic and environmental levels and negative association with palmitic acid at genotypic level. None of the fatty acids showed any association with oil yield. The association among different fatty acids was found non-significant except between oleic and linoleic acid which was negative and of higher magnitude as also reported earlier by Seiler (1985).

The path coefficient analysis at genotypic level (Table 2) showed that most of variation in oleic acid was accounted for by the characters studied as revealed by low residual effect. It was of interest to note that positive association between days to 50 per cent flowering was mainly due to the indirect effect via linoleic acid. Days to maturity and stearic acid had also an appreciable positive effect on oleic acid through linoleic acid, whereas linoleic acid by itself had a direct strong negative effect on the oleic acid.

The present study suggests that late flowering could be used to predict the higher levels of oleic acid content. Oil yield and its component characters viz., 100-seed weight and oil content were independent of oleic acid content and thus could be combined in the same cultivar. It further suggested that there should be a reasonable compromise between oleic and linoleic acid levels as many of the characters contribute indirectly to oleic acid via linoleic acid. It is also important to strike a balance between oleic and linoleic acid contents as higher content of oleic acid is reported to have a negative association with germination and self compatibility (Fernandez-Martinez *et al.*, 1993).

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Table 2. Direct and indirect effects of various traits on oileic acid in sunflower

Character	Days to 50% flowering	Days to maturity	100-seed weight	Oil content	Oil yield	Palmitic acid	Stearic acid	Linoleic acid	Genotypic Correlation with oleic acid
Days to 50% flowering	0.0143	0.0022	-0.0008	-0.0079	-0.0126	-0.0007	0.0004	0.4248	0.4198
Days to maturity	0.0103	0.0030	-0.0013	-0.0067	-0.0045	0.0053	0.0039	0.1672	0.1772
100-Seed weight	0.0011	0.0004	-0.0103	0.0056	0.0110	-0.0024	-0.0015	0.0167	0.0205
Oil content	0.0037	0.0007	0.0019	-0.0300	0.0316	0.0241	-0.0018	-0.0752	-0.0629
Oil yield	-0.0038	-0.0003	-0.0024	0.0087	0.0469	0.0061	-0.0019	-0.1349	0.0990
Palmitic acid	0.0001	-0.0002	-0.0003	0.0099	-0.0039	-0.0729	0.0006	-0.0251	-0.0919
Stearic acid	-0.0003	-0.0006	-0.0008	-0.0028	0.0046	0.0021	-0.0195	0.2187	0.2014
Linoleic acid	-0.0061	-0.0005	-0.0002	-0.0023	0.0064	-0.0018	0.0043	-0.9935	-0.9934

values underlined show direct effects. Residual effect = 0.0822

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GENETIC DIVERSITY IN SESAME (*Sesamum indicum* L.)

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ABSTRACT

Multivariate analysis of divergence among 95 genotypes of sesame for seventeen developmental characters led to their grouping into 5 clusters. Cluster I had 74 genotypes, cluster II had 12, and clusters III, IV and V had 5, 3 and 1 genotypes, respectively. The genopypes of III, IV and V clusters were more divergent than others. Based on cluster means, the characters 1000 seed weight, seed yield, days to maturity, oil content, days to first flowering, days to 50 per cent flowering were major factors of differentiation. The inter cluster values ranged from 63.37 to 299.76 suggesting high domestication in this crop.

Key words : Cluster, genetic diversity, sesame

INTRODUCTION

Sesame is an important oilseed crop. Improvement in yield is normaly attained through exploitation of the genetically diverse parents in breeding programmes. For identifying such diverse parents for crossing, multivariate analysis by means of Mahalanobis D^2 statistic has been used in several crops. It is a powerful tool in quantifying the degree of genetic divergence among parents. Hence, the objective of the study was to know the amount of variability available for different yield components in this crop.

MATERIALS AND METHODS

The meterial for the present investigation consisted of 95 types of sesame collected from the germplasm maintained at the School of Genetics, Tamil Nadu Agricultural University, Coimbatore and were sown in RBD replicated thrice, in a row length of 3 m for each replication, with spacing 45 x 15 cm. Data were recorded on five random plants in each replication for plant height at maturity, primary branches per plant, secondary branches per plant, height to first capsule bearing node, number of capsules on main stem, capsules per plant, internode length, height to first fruiting branch, length of capsule, breadth of capsule, number of seeds per capsule, 1000 seed weight, days to first flowering, days to 50 per cent flowering, days to maturity, oil content and seed yield per plant.

The data were subjected to multivariate analysis using Mahalanobis generalised distance D^2. Test of significance of differences in character means (analysis of dispersion) was analysed (Singh and Chaudhary, 1977) and the genotypes were grouped into clusters by Tocher's method (Rao, 1952). Canonical analysis (Rao, 1952) was done to verify clustering pattern.

RESULTS AND DISCUSSION

The success of any crop breeding programme mainly depends upon the proper choice of parents (Briggs and Knowles, 1967). Knowledge of the genetic diversity of genotypes is necessary for selection of parents for crop improvement (Arunachalam *et al.*, 1984). The analysis of variance revealed highly significant differences among the types for the characters studied, indicating adequate genetic variability among the lines. Ninety five genotypes were grouped into five different clusters (Table 1) by Mahalanobis D^2 and Canonical vector analysis. The maximum number of genotypes (74 Nos.) were included in cluster I followed by cluster II (12 genotypes). Cluster III consisted of five genotypes (two exotic), Cluster

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Table 1. Composition of D^2 clusters

Cluster number	Total number of genotypes	Genotypes
I	74	Si 255, Si 768, Si 771, Si 830, Si 964, Si 983, Si 1088, Si 1248, Si 1250, Si 1260, Si 1278, Si 1490, Si 1523, Si 1545, Si 1655, Si 1661, Si 1666, Si 1714, Si 1733, Si 1754, Si 1759, Si 1765, Si 1767, Si 1744, Si 1854, Si 1869, Si 1877, Si 1884, Si 1885, Si 1970, Si 2138, Si 2205, Si 2225, Si 2226, Si 2228, Si 2237, Si 2257, Si 2281, Si 2298, Si 2320, Si 2338, Si 2339, Si 2351, Si 2365, Si 2370, Si 2438, Si 24613, Si 2510, Si 2512, Si 2533, Si 2555, Si 2563, Si 2581, Si 2664, Si 2675, Si 2755, Si 2956, Si 2969, Si 2983, Ec 279, Ec 78-831, Ec 132-832, RJS 4, RJS 29, RJS 155, RJS 157, ES 12, VS 27, B24-1, Saweon -9, TMV 3, TMV 5, TMV 6 and CO 1.
II	12	Si 1, Si 1249, Si 1782, Si 2142, Si 2500, Si 2552. Si 2571, Si 2776, Si 2802, Ec 132 - 828, VS 81 and TNAU 11.
III	5	Si 2182, Si 2377, Ec 51-276, RJS 194 and IS 79.
IV	3	Si 1525, Si 2381 and TMV 4.
V	1	Si 485.

IV had two exotic types (Sudan and U.S.A) and cluster V had single genotype from Dacca. The clustering pattern of the lines suggested that geographic diversity may not necessarily be related with genetic diversity. The selection of varieties for hybridization should be based on genetic diversity rather than geographic diversity.

Average cluster mean for different characters show that the genotypes in cluster I had shorter internodes and less number of seeds per capsule but the highest number of capsules per plant (Table 2). Cluster II showed minimum mean for number of secondary branches, height to first capsule bearing node, days to first flowering, days to 50 per cent flowering, days to maturity and oil content. Genotypes included in cluster III had maximum inter nodal length, height to first capsule bearing node and height to first fruiting branch. Cluster IV included genotypes with maximum mean for plant height, number of primaries, number of capsules on main stem, 1000 seed weight and oil content. Cluster V included only one type with multicarpellary capsules and

Table 2. Cluster means for seventeen characters in sesame

Characters	Clusters				
	I	II	III	IV	V
Plant height (cm)	76.93	70.89	74.74	**79.64**	*69.40*
Number of primaries	3.71	3.47	3.39	**4.41**	3.93
Number of secondaries	0.97	*0.59*	*0.59*	1.21	**3.30**
Height of first capsule bearing node (cm)	33.62	*30.49*	**36.58**	33.31	31.83
Number of capsules on main stem	15.76	12.91	13.52	**18.63**	*11.90*
Number of capsules per plant	**39.59**	30.36	31.49	*30.24*	33.80
Internode length (cm)	*3.99*	**4.53**	**4.53**	4.04	4.20
Height to first fruiting branch (cm)	17.23	15.76	**21.36**	18.20	*12.40*
Capsule length (m)	2.60	**2.61**	2.55	2.51	**2.46**
Capsule breadth (cm)	0.96	0.92	0.88	*0.86*	**1.21**
Seed number per capsule	*56.05*	61.05	62.44	61.45	**124.44**
1000-seed weight (g)	2.75	3.49	*2.17*	**4.21**	3.07
Days to first flowering	39.12	*38.69*	41.00	39.00	**45.33**
Days to 50 per cent flowering	44.43	*44.03*	46.60	44.22	**50.67**
Days to maturity	89.04	*86.14*	89.40	88.45	**92.33**
Oil content (%)	52.12	*51.56*	53.01	**54.33**	51.93
Seed yield (g)	3.69	3.66	*2.26*	4.22	**6.34**

Bold number indicates maximum cluster mean values. Italic numbers indicate mimimum cluster mean values

had more number of secondaries, seeds per capsule, early flowering, high seed yield, thick capsules and early maturity.

Cluster III had the lowest intra-cluster generalised distance of 25.49 (Table 3) and maximum distance was for cluster IV (61.33). The inter cluster distance ranged from 63.37 (between I and V) to 299.76 (between cluster III and IV). Based on ratings for divergence between cluster, cluster IV was highly divergent from cluster III (299.76), I (236.41) and IV (201.44). Clusters II with III and IV, and cluster III with V were moderately divergent. All other combinations were less divergent. So the types included in cluster IV may be used for crossing with the genotypes included in other clusters to exploit hybrid vigour. From Canonical vector analysis, it was found that some genotypes within cluster itself exhibited greater genetic divergence and some closely related. In cluster I, TMV 3 (T.N.) and Si 1545 (Sudan) showed no diversity. Least divergence was found between Si 2225 (Israel) and Si 1877 (Chile), Si 1248 (Greece), TMV 5 (T.N.) and Si 2370 (Turkey) and Si 1714 (Andhra Pradesh). In cluster II, Si 2571, VS 81 were closely placed while high intra-divergence was observed for Si 1 and TNAU 11 (T.N.) from the types Si 1249 (Greece) and Si 2776 (U.P.)

Table 3. Inter and intra cluster average of D^2 and D (figures in parenthesis) and the extent of diversity among clusters

Cluster No.	I	II	III	IV	V
I	**1673.73**	8945.47	5363.69	55887.79	4015.40
	(40.91)	(94.58)L	(78.27)L	(236.41)H	(63.37)L
II		**2254.62**	23564.48	22989.78	4216.44
		(4.48)	(153.51)M	(151.62)M	(64.99)L
III			**649.95**	89853.73	11549.26
			(25.49)	(299.76)H	(107.47)M
IV				**3761.77**	40576.07
				(61.33)	(201.44)H
V					**0.00**
					(0.00)

Bold figures show intra cluster average of D^2 and D values
H : Highly divergent = Above 200
M : Moderately divergent =Between 100 and 200
L : Less divergent = 99 and below

The Canonical analyses reveal that highly divergent parents for crossing programmes can also be selected within the clusters and also from different clusters. The relative distribution of types reflected a broad parallelism between grouping by D^2 and vector analysis. Similar trend was reported by several workers (Rathinaswamy, 1980, Govindarasu, 1982 and Reddy, 1986). The types Si 1525, Si 2381 and TMV 4 were distinctly separated and in D^2 group constellations also formed a separate cluster confirming wide divergence of its genotypes from the rest of the genetic stock.

The relative contribution of characters towards genetic divergence show that 1000 - seed weight recorded the highest (0.9825) followed by seed yield (0.1127) and days to maturity (0.1022) constituting the primary axis of differentiation, while days to first flowering followed by days to maturity, oil content, seed yield and days to 50 per cent flowering constituted the secondary axis of differentiation.

The choice of the character is important in multivariate analysis (Sokal, 1965) and the choice made in this study appears to be appropriate. Cyclic inbreeding and crossing may be helpful in bringing new genes into sesame population and thus, widening the range of adaptation. Phenotypic uniformity with genetic diversity within population appears to be very useful in sesame. The cluster means and divergence study indicates that in a crossing programme involving types from cluster V and I, bushy types with broader capsules, more seeds and yield could be obtained. Similarly by crossing types from cluster II and any other cluster, selection can be done for earliness and increased capsule length. Earlier sesame workers have reported high contribution to genetic diversity of certain characters such as plant height (Reddy, 1986), oil content (Thangavelu and Rajasekaran 1983), 1000 seed weight and seed yield (Alarmelu, 1992). To conclude, some of the genotypes viz., CO 1, TMV 6, Si 1490, Si 1767, EC 132-828, Si 2381, TMV 4 and Si 485 with outstanding mean performance from selected clusters may serve as potential parents for future hybridization programmes.

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GENERATION MEAN ANALYSIS IN CROSSES BETWEEN SUB SPECIES *fastigiata* AND *hypogaea* IN GROUNDNUT*

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ABSTRACT

Gene effects were estimated using five parameter model in crosses between and within sub species *fastigiata* and *hypogaea* for days to flowering, number of mature and immature pods per plant, haulm weight, harvest index and pod yield. The scaling tests were significant for most of the characters in different crosses indicting the presence of inter-allelic interaction. Additive and additive x additive type of gene effects were significant for days to flowering, number of mature pods per plant and pod yield in a cross between sub species *fastigiata* and *hypogaea* (Chico x JSP-23). For most of the traits in different crosses non-additive gene effects were significant with higher magnitude of dominance and dominance x dominance. In general pod yield was influenced by non-additive gene effects in crosses made within the subspecies, while in crosses between sub species *fastigiata* and *hypogaea* it is governed by additive gene effects (i.e. additive and additive x additive).

Key words : Gene effects, additive, dominance, epistasis, generation mean analysis.

INTRODUCTION

India is the largest producer of groundnut with an area and production of 8.35 m. ha and 8.85 m. tonnes (Anonymous, 1993). The productivity of groundnut in India is very low (1060 kgs ha^{-1}) as compared to world average of 1100 kgs ha^{-1} which indicates that there is lot of scope for improvement. For any crop improvement programme the knowledge of inheritance and gene action is important to improve the yield and yield contributing characters. The cultivated groundnuts are broadly classified into two sub-species with two varieties in each group which are as follows;

1. Sub-species *hypogaea*
   var. hypogaea (virginia type)
   var. hirsuta (peruano, not found in India)
2. Sub-species *fastigiata*
   var. fastigiata (valencia)
   var. vulgaris (spanish type)

The sub-specific groups are botanically differing in flowering habit, plant type, days required for maturity, pod characteristics etc. Wynne and Coffelt (1982) suggested that heterosis is generally observed in crosses between different sub-specific groups suggesting that gene action may differ in crosses made within and between botanical varieties.

The objective of this study was to estimate the relative importance of additive and nonadditive effects in controlling the inheritance of yield and yield contributing characters in crosses between different sub-specific groups.

MATERIALS AND METHODS

The experimental material consisted of five crosses involving parents from different sub-specific groups (viz. Somnath, JSP23, TMV10

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and GG11 (*hypogaea var hypogaeae*), Chico and J11 (*fastigiata* var *vulgaris*), JL-24 (*fastigiata var fastigiata*). Five generations viz. P_1, P_2, F_1, F_2 and F_3 in each of the five different crosses were studied in a Compact family block design in three replications at the Plant Breeding Farm, G.A.U., Anand campus, Anand during *Kharif*, 1995. The parents and F_1 s were sown in two rows each of 5m length whereas F_2,s and F_3's were sown in 10 rows each with a spacing of 45 cm between the rows, 20 cm between the plants in each row. Five random plants were taken for recording observations on days to first flowering, number of mature and immature pods per plant, haulm weight, harvest index and pod yield per plant in nonsegregating generations (viz. P_1, P_2 and F_1) and twenty plants in F_2 and F_3 generations per replication. The individual plant data for all the generations in a cross were subjected to statistical analysis as per Panse and Sukhatme (1969). The characters with significant differences among the generations were subjected to five parameter model, generation mean analysis as per Mather (1949) and Hayman and Mather (1955).

RESULTS AND DISCUSSION

Cross 1: Somnath *(var. hypogaea)* x TMV 10 *(var. hypogaea)*

The scaling tests were significant for all the characters indicating the presence of non-allelic interactions. All type of gene effects were significant for days to flowering (Table 2) i.e. additive, dominance, additive x additive and dominance x dominance with higher magnitude of dominance and dominance x dominance. The sign of dominance and dominance x dominance were in opposite direction indicating duplicate type of epistasis for this trait. This type of gene action biases the nature and magnitude of variability and hinders the pace of progress through selection. Number of mature pods per plant was regulated by additive x additive and dominance x dominance gene effects with higher magnitude of dominance x dominance type. For number of immature pods per plant and haulm weight additive, dominance and dominance x dominance type of gene effects were significant with higher magnitude of dominance x dominance. Both dominance and dominance x dominance were of same sign indicating complementary type of gene effects. Harvest index was mainly governed by additive and additive x additive type of gene effects, whereas pod yield per plant was governed by dominance and complementary epistatic interactions like additive x additive and dominance x dominance. All the characters except harvest index and number of mature pods per plant were predominantly influenced by dominance and dominance x dominance type of gene effects were significant hence, improvement in these characters is difficult. Similar results of dominance effects contributing to pod yield and other agronomic characters were also reported by Sandhu and Khehra, 1976, Isleib and Wynne, 1983 and Halward and Wynne, 1991. Selection for harvest index in early generations can bring improvement in yield as it is influenced by additive and additive x additive type of gene effects which are fixable.

Cross 2 : Somnath (var. *hypogaea*) x J 11(var. *fastigiata*)

There was no significant difference between the generations for all the characters barring days to flowering and number of immature pods per plant in the cross between sub species *hypogaea* and *fastigiata* (Table 1). The scaling tests were significant for the above two characters indicating that additive dominance model is not adequate and epistatic interactions are present (Table 2). Days to flowering was governed by dominance and dominance x dominance gene effects with complementary type of epistasis. Whereas the immature pods per plant was governed by additive, dominance and additive x additive type of gene effects with higher

Table 1 : Analysis of variance of five generations for different characters in five crosses of groundnut

Source	d.f.	I	II	III	IV	V
		Mean sum of squares				
DAYS TO FLOWERING						
Replications	2	0.16	0.15	0.12	3.19	0.25
Generations	4	44.00**	41.74**	67.51**	72.37**	65.23**
Error	8	0.63	0.38	0.44	2.32	0.34
NUMBER OF MATURE PODS						
Replications	2	32.51	15.34	58.66	80.01	4.71
Generations	4	297.58**	22.87	144.56**	168.20**	34.84
Error	8	10.96	13.52	13.46	37.98	12.20
NUMBER OF IMMATURE PODS						
Replications	2	59.50	0.58	5.91	4.02	0.14
Generations	4	631.44**	8.24*	1.63	13.82	1.20
Error	8	69.22	1.59	1.01	4.54	1.58
HAULM WEIGHT						
Replications	2	147.30	62.97	54.59	72.74	51.29
Generations	4	9592.12**	79.72	1341.99**	568.46**	71.58
Error	8	344.61	39.00	85.36	43.67	27.16
HARVEST INDEX						
Replications	2	31.89*	42.26	35.32	33.23	0.31
Generations	4	93.41**	30.62	84.86**	31.73	83.70*
Error	8	5.15	15.24	8.17	17.43	8.70
POD YIELD						
Replications	2	47.85	8.65	28.86	96.54*	7.60
Generations	4	515.96**	7.58	114.75**	109.43*	49.94
Error	8	17.89	15.39	9.69	19.25	9.36

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

Cross I - Somnath XTMV 10; Cross II - Somnath XJ11; Cross III- Chico X GG11; Cross IV- Chico X JSP23; Cross V- JL 24 X J11

magnitude of additive x additive. Number of immature pods per plant can be reduced through selection following pedigree method of breeding.

Cross 3 : Chico *(var. fastigiata)* x *GG11 (var. hypogaea)*

The scaling tests were significant for days to flowering, number of mature pods per plant, harvest index and pod yield (Table 2) suggesting that these characters are governed by interallelic interaction, whereas for number of immature pods per plant and haulm weight the scaling tests were non significant indicating that simple additive dominance model is adequate to explain the variation in these characters. All types of gene effects were significant for days to flowering with higher magnitude of dominance x dominance with complementary type of epistasis. Number of mature pods was predominantly governed by dominance type of gene effects and harvest index with dominance x dominance. Due to cancellation effect of additive and dominance type of gene effects for number of immature pods per plant, only mean was significant. Additive and dominance type of gene effects were significant for pod yield which can be improved to certain extent as it is governed by both additive and dominance gene effects.

Cross 4: Chico *(var. fastigiata)* x JSP23 *(var. hypogaea)*

There was no significant difference between the generations for number of immature pods per plant and harvest index possibly due to less variability in the parents for these characters (Table 1). The scaling tests were significant for days to flowering, number of mature pods per plant and pod yield indicating the presence of inter-allelic interactions while for the other characters like number of immature pods, haulm weight and harvest index the scaling tests were nonsignificant indicating the presence of intra allelic interaction. Days to flowering and pod yield were governed by additive, dominance and additive x additive type of gene effects, while for number of mature pods per plant dominance and dominance x dominance gene effects were significant with complementary type of gene effects. Haulm weight was governed by additive and dominance type of gene effects with predominance of dominance gene effects.

As additive and additive x additive type of gene effects were significant for days to flowering, number of mature pods and pod yield, these characters can be improved through simple selection by adopting pedigree method of breeding.

Cross 5: JL24 *(var. fastigiata)* x J11 *(var. fastigiata)*

It is a cross between two spanish varieties and there was no significant difference between the generation for number of mature pods, immature pods and haulm weight. However, for the other characters the scaling tests were significant indicating the presence of inter-allelic interaction. Days to flowering is administered by dominance and additive x additive type of gene effects. Pod yield was regulated by dominance type of gene effects while harvest index was governed by additive, dominance and additive x additive gene effects with predominance of additive and additive type.

From the above results it can be emphasized that in crosses within the sub species (*hypogaea or fastigiata*) the pod yield was governed by dominance and epistatic interactions and it would be difficult to improve the pod yield through direct selection. However, in crosses made between *hypogaea* and *fastigiata*, the heterosis for pod yield was moderate to high and was influenced by additive and additive x additive type of gene effects which are fixable. Therefore in these crosses selection should be made following pedigree method of breeding.

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Table 2 : Estimates of scaling test and gene effects for different characters in five crosses of groundnut

Characters	Scaling test		Gene effects				
	C	D	m	d	h	i	l
Cross No 1 : Somnath x TMV 10							
Days to flowering	34.15**	-1.20	28.77**	-1.07*	4.69*	4.36*	-47.11*
			±0.66	±0.31	±2.13	±2.08	±6.35
No of mature pods	-58.06**	12.77*	15.45**	-0.60	2.94	-19.39**	94.44**
			±1.18	±0.91	±4.89	±4.95	±15.03
No of immature pods	-54.01**	-4.80	10.43**	2.27*	27.13**	-1.27	65.60**
			±1.07	±0.68	±4.19	±4.83	±15.90
Haulm weight	-244.86**	35.57	62.85**	-22.67**	58.81**	-109.86	373.91**
			±5.70	±3.18	19.88	±20.67	±66.53
Harvest index	-15.96**	-6.98	18.67**	6.39**	-3.96	14.51**	12.52
			±0.99	±0.87	±3.66	±3.69	±10.61
Pod yield	-76.45**	5.50	13.32**	-0.47	10.72*	-17.34**	109.29**
			±1.15	±0.78	±4.86	±4.90	±15.19
Cross No 2: Samnath X J11							
Days to flowering	29.47**	8.60**	26.17**	-0.07	-3.49*	-0.96	-27.82**
			±0.54	±0.30	±1.76	±1.72	±5.16
No of mature pods	———	———	NS	———	———	———	
No of immature pods	-4.00	-8.60**	7.70**	1.53**	6.07**	8.13**	-6.13
			±0.54	±0.66	±1.54	±2.16	±5.37
Haulm weight	———	———	NS	———	———	———	
Harvest index	———	———	NS	———	———	———	
Pod yield	———	———	NS	———	———	———	
Cross No 3: Chico x GG11							
Days to flowering	32.54**	17.03**	30.02**	-2.10**	-6.90**	-10.13**	-20.67**
			±0.51	±0.31	±1.50	±1.57	±4.73
No of mature pods	-28.52**	-12.13*	19.97**	2.33	17.13**	8.00	21.87
			±1.41	±1.41	±4.23	±5.11	±13.91
No of immature pods	3.79	0.90	7.28**	-0.27	1.23	-0.50	-3.87
			±0.41	±0.38	±1.44	±1.49	±4.32
Haulm weight	1.74	-19.87	58.97**	10.53**	59.80**	-7.53	-28.80
			±3.98	±3.08	±12.12	±12.87	±40.17
Harvest index	-29.03**	-9.67	19.15**	-1.79	-6.42	-1.96	25.81*
			±1.19	±1.32	±4.81	±4.80	±13.15
Pod yield	-25.27**	-14.77**	12.75**	-5.73**	13.10**	-5.83	14.00
			±1.07	±1.07	±3.07	±3.55	±10.65

Contd...

Table 2 : Continued..........

Characters	Scaling test C	Scaling test D	Gene effects m	d	h	i	l
Cross No 4: Chico X JSP23							
Days to flowering	18.86**	26.13**	25.30** ±0.71	-2.70** ±0.28	19.04** ±2.59	19.67** ±2.37	9.69 ±7.17
No of mature pods	-28.65**	-0.93	21.67** ±1.43	1.73 ±1.50	13.02* ±5.81	-0.59 ±6.32	36.09* ±18.05
No of immature pods			NS				
Haulm weight	-6.40	-6.73	47.30** ±2.70	-10.67** ±2.21	31.27** ±11.72	17.80 ±11.11	-1.33 ±34.36
Harvest index			NS				
Pod yield	18.95*	-6.53	15.52** ±1.18	-5.73** ±0.91	11.07* ±4.60	10.27* ±4.72	16.53 ±14.92
Cross No 5 : JL24 X J11							
Days to flowering	24.81**	25.67**	28.17** ±0.67	0.13 ±0.25	-9.71** ±2.01	12.71** ±2.03	1.16 ±6.24
No of mature pods			NS				
No of immature pods			NS				
Haulm weight			NS				
Harvest index	-20.86**	-32.53**	-29.21** ±1.45	3.08** ±1.35	19.08** ±3.57	24.37** ±4.13	-15.59 ±11.32
Pod yield	-20.40**	-12.40*	16.40** ±0.88	1.40 ±1.39	11.47** ±3.68	7.67 ±4.21	10.67 ±11.06

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

NS - Nonsignificant; m - Mean of the Character; d - additive gene effect; h - dominance gene effect

i - additive x additive gene effect; l - dominance x dominance gene effect

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EFFECT OF SOWING METHODS AND HERBICIDAL WEED CONTROL ON OIL AND PROTEIN CONTENT IN SOYBEAN

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ABSTRACT

The effect of three methods of sowing viz., M1- sowing after receiving the monsoon without killing the weeds, M2-sowing after receiving the first shower and killing the first flush of weeds and M3-sowing after receiving the second shower and killing the second flush of weeds and five weed control treatments viz., weedy check, hand weeding at 20 DAS, fluchloralin @ 1.0 kg/ha pre plant incorporation in the soil (PPI), oxadiazon @1.0 kg/ha pre-emergence and haloxyfop-methyl @0.25 kg/ha post-emergence was studied on oil and protein percentage and yield of soybean. Oil content, oil yield, protein content and protein yield were significantly higher with M2-sowing after receiving the first shower and killing the first flush of weeds compared to M3 and M1. Among herbicide treatments hand weeding gave significantly higher oil yield and protein yield followed by oxadiazon, fluchloralin and haloxyfop-methyl, while weedy check gave lowest oil yield and protein yield. Interaction between methods of sowing and herbicidal treatments was significant.

Key words : Soybean, sowing method, herbicides, oil, protein.

INTRODUCTION

Soybean contains about 40 per cent protein and 18 to 20 per cent edible oil and fair quantity of vitamins and essential trace elements like copper, Iron and other ingredients vital for body development (Goplan *et al.*, 1971). The protein and oil content may vary due to sowing methods, weed competition stress and herbicidal treatments as reported by Johnson and Jellum (1969); Rao (1974); Pahuja *et al.*, (1985) and Sankaran *et al.*, (1988). Therefore, the present experiment was conducted to evaluate the effect of different herbicides and sowing methods on oil and protein content of soybean.

MATERIALS AND METHODS

The experiment was conducted during *Kharif* 1986 and 1987 at the Regional Agricultural Farm of Jawaharlal Nehru Krishi Vishwa vidyalaya, Sagar on clayey, medium black soil with neutral pH, low in organic carbon. Fifteen treatments were tested in split-plot design with four replications. Three methods of sowing viz., M1-sowing after receiving the monsoon without killing the weeds, M2-sowing after receiving the first shower and killing the first flush of weeds and M3-sowing after receiving the second shower and killing the second flush of weeds constituted the main plots, while five weed control treatments viz., weedy check, hand weeding at 20 DAS, fluchloralin @ 1.0 kg/ha pre plant soil incorporation (PPI), oxadiazon @1.0 Kg/ha preemergence and haloxyfop-methyl @0.25 kg/ha post emergence were assigned to sub-plot treatments.

Soybean variety Js 72-44 (Gourav) was seeded @ 100 kg/ha in rows 30 cm apart with a basal dose of 20:80:20 NPK kg/ha through diammonium phosphate, single super phosphate and muriate of potash.

The seed yield was recorded at harvest and seed samples were analysed for oil and protein content treatmentwise by Soxhlet Extraction and Microkjeldhal Methods, respectively.

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The total oil and protein yield per hectare were computed based on the seed yield (kg/ha) and percentage of oil and protein content.

RESULTS AND DISCUSSION

The sowing methods slightly affected the oil percentage of soybean. Higher oil content (19.35%) was noted in M2-method of sowing, while in M1 and M3 oil content of the seed was less (18.17). The reduction might be due to weed stress in M1-method and due to delayed sowing and moisture stress at the seed filling stage in M3-method. The effect of herbicides on oil percentage was not considerable. Similar conclusions were also drawn by Johnson and Jellum (1969) who reported that oil and protein content of soybean were not affected by herbicidal treatments.

The oil yield per hectare was more in M2-method of sowing (170.29 kg) followed by M3 (151.56 kg) and M1 (93.82 kg). The significant reduction in M1 was attributed to the lower seed production/ha due to more weed competition in this method of sowing.

The effect of different weed control treatments revealed that hand weeding gave significantly more oil yield (223.85 kg/ha) than other herbicidal treatments. However, all herbicidal treatments gave significantly higher oil production/ha as compared to weedy check (84.18 kg/ha). The interaction of sowing methods and weed control treatments was also significant. The maximum oil production was noted in plots sown by M2- method with weed free conditions obtained by hand weeding (253.58 kg) followed by M1 (215.76 kg) and M3 (202.20 kg) with hand weeding and oxadiazon @ 1.0 kg/ha in M2 (185.58). In unweeded plots the oil yield was higher with M3 (106.27), while it was the lowest with M1 (51.89).

Table 1 : Effect of sowing methods and herbicidal weed control on oil percentage and oil yield in soybean .

Methods of sowing	Weedy check	Hand weeding	Fluchloralin	Oxadiazon	Haloxyfop-methyl	Mean
			Oil percentage			
M1	19.29	17.95	17.30	18.15	18.15	18.17
M2	19.26	20.03	19.65	18.07	19.75	19.35
M3	17.45	17.15	19.45	19.23	17.55	18.17
Mean	18.67	18.38	18.80	18.48	18.48	18.56
			Oil yield (kg/ha)			
M1	51.89	215.76	66.61	62.98	71.78	93.82
M2	94.37	253.38	164.47	185.58	153.46	170.29
M3	106.27	202.20	150.35	173.65	125.31	151.56
Mean	84.18	223.85	127.14	140.74	116.88	138.56

	Methods of sowing	Herbicides	Methods of sowing x Herbicides
SEm ±	9.48	9.68	16.85
CD (0.05)	32.57	27.84	49.37

The effect of sowing methods on protein percentage of the soybean seed was negligible. Reduction in protein content was noted in weedy check (37.29 %) as compared to hand weeded (40.21%) and oxadiazon (39.80%) treated plots. The greater reduction in protein per cent in M1 and weedy check might be due to the greater weed stress and shading effects. Rao (1974) also reported that application of herbicides increase the protein content compared to weed free treatments in soybean. However, Pahuja *et al.* (1985) observed maximum protein in weed free treatments and minimum in weedy check. The total protein yield per hectare was affected significantly due to different methods of sowing and maximum protein yield (340.87 kg) was noted in M2- method of sowing where the first flush of weeds was killed followed by M3- method where the sowing was done after receiving the second shower and two flushes of weeds were killed (326.83 kg).

Among different weed control treatments significantly higher protein yield was obtained in hand weeding (488.74 kg/ha) followed by oxadiazon (300.34) and fluchloralin (251.68 kg). The lowest production was in weedy check (171.16 kg) which was due to low seed yield. The interaction of different sowing methods and weed control treatments was also significant. Hand weeding resulted in the maximum (506.40) protein in M2- method followed by M1 (480.80) and M3 (479.03) and M2 x oxadiazon (404.43) and M2 x oxadiazon (355.60). All the herbicidal treatments gave

Table 2 : Effect of sowing methods and herbicidal weed control on protien percentage and protein yield in soybean.

Methods of sowing	Weedy check	Hand weeding	Fluchloralin	Oxadiazon	Haloxyfop-methyl	Mean
			Protein percentage			
M1	36.25	40.00	38.13	40.63	38.88	38.78
M2	37.50	40.00	36.88	39.38	38.75	38.50
M3	38.13	40.63	38.75	39.38	37.50	38.88
Mean	37.29	40.21	37.92	39.80	38.38	37.92
			Protein yield (kg/ha)			
M1	97.51	480.80	146.80	140.99	153.96	204.01
M2	183.75	506.40	308.69	404.63	301.09	340.87
M3	232.21	479.03	299.54	355.60	267.75	326.83
Mean	171.16	488.74	251.68	300.34	240.93	290.57

	Methods of sowing	Herbicides	Methods of sowing x Herbicides
SEm ±	19.77	20.18	35.15
CD (0.05)	67.95	58.08	103.00

significantly lower protein yield in M1- method. In unweeded plots, higher protein yield was noted in M3 (232.21) compared to M1 (97.51). Thus, it indicated that where the weeding is not done, protein yield could be increased by manipulating the sowing methods and killing the two flushes of weeds. However, for harvesting higher protein yield, removal of weeds either by hand weeding or by herbicidal treatments integrated with manipulation of sowing methods i.e. by killing the first flush of the weeds before sowing is essential.

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ENERGY AND NUTRIENT UTILIZATION IN SOYBEAN-WEED ECOSYSTEM UNDER DIFFERENT METHODS OF SOWING AND HERBICIDAL TREATMENTS

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ABSTRACT

In a soybean-weed ecosystem the solar energy utilization by weeds was maximum under those plots where sowing was done without killing the weeds-M1 (132.97) followed by those plots where sowing was done after killing the first flush of weeds-M2 (71.99) and those plots where sowing was done after killing the two flushes of weeds-M3 (40.85 lakh k cal/ha). Among different weed control treatments the weeds utilized greater energy under weedy check (178.37) followed by oxadiazon (79.84) fluchloralin (78.85) and haloxyfop-methyl (60.97). Whereas minimum utilization was under hand weeding (11.64). The energy utilization by total crop was higher in M2 method (366.90) followed by M3 (302.29) and M1 (206.37). The utilization in seed also followed the same trend. Effect of weed control treatments revealed that maximum energy utilization by crop was in pure crop stand under hand weeding (412.62) followed by fluchloralin (301.60), Oxadiazon (262.78) and haloxyfop-methyl (257.53). The lowest utilization was in crop associated with weeds under weedy check (224.73).

Key words : Soybean, sowing method, herbicide, energy, nutrient

INTRODUCTION

Madhya Pradesh is becoming popular for soybean cultivation, but the average yield in the state is quite low (10.16 q/ha). In monsoon season weeds are the major factors which utilize the energy and nutrients and create stress for the crop and reduce the yield. The use of conventional methods of weed control is expensive, time consuming and difficult during heavy and un-timely rains. Therefore controlling the weeds by using herbicides is the only alternative to increase the yield of soybean. Hence a field experiment was conducted to find out the weed control efficiency of herbicidal treatments in relation to energy and NPK utilization by weeds and crop.

MATERIALS AND METHODS

The experiment was conducted at the Research farm of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Sagar during *kharif* 1986 and 1987 on clayey, medium black soil with neutral pH, low in available N (225.2 kg/ha), P(2.4 kg/ha) and K (166 kg/ha) and medium in organic carbon content. The experiment was laid out in a split-plot design replicated four times. The main factor consisting different methods of sowing were viz., Ml- sowing immediately after monsoon without killing the weeds, M2- sowing after receiving the first shower and killing the first flush of weeds and M3- sowing after receiving second shower and killing the two flushes of weeds. In sub-plot five herbicidal treatments were taken viz., weedy check, hand weeding at 20 DAS, fluchloralin 1.0 kg/ha as PP1, oxadiazon 1.0 kg/ha as pre-em and haloxyfop-methyl 0.25 kg/ha as post-emergence.

Soybean variety, JS 72-44 (Gaurav) was sown in rows 30 cm apart with a basal dose of 20 kg N and 80 kg P_2O_5/ha through diammonium phosphate and single super phosphate and 20 kg K_2O/ha through muriate of potash. The weed biomass specieswise, crop biomass and yield were recorded at harvest. The N, P and K contents in different weed species, crop and soil after harvest were determined as per standard methods.

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The energy utilized by weeds and crop was determined after Leisth (1965) who reported an energy content of 4.30 k cal per gram weed dry weight. Gopalan *et al.* (1971) reported the energy content of 4.52 k cal per gram of soybean. These values were utilized for converting the dry weights into energy content.

RESULTS AND DISCUSSION

Energy utilization

In a soybean-weed ecosystem, the solar energy utilization by weeds was maximum in those plots where sowing was done without killing the weeds-M1 (132.97 Lakh k Cal/ha) followed by those plots where sowing was done after killing the first flush of weeds-M2 (71.99) and those plots where sowing was done after killing two flushes of weeds - M3 (80.85) (Table 1).

Among different weed control treatments the weeds utilized greater energy in weedy check (178.37) followed by oxadiazon (79.84), fluchloralin (78.85) and haloxyfop-methyl (60.97). Whereas minimum utilization was under hand weeding (11.64). The energy utilization by crop was higher in M2 method (366.90 Lakh k Cal/ha) followed by M3 (302.29) and M1 (206.37).

The effect of different weed control treatments revealed that maximum energy utilization was in pure soybean stand obtained by hand weeding (412.62) followed by fluchloralin (301.60), Oxadiazon (262.28) and haloxyfop-methyl (257.53). The lowest energy utilization was in soybean associated with weeds in weedy check (224.16 Lakh k Cal/ha). Under soybean-weed ecosystem weeds utilized energy of 178.37 Lakh k Cal/ha. The utilization in seeds also had the same trend as noted for crop biomass (Table 1).

The data in Table 2 revealed that in general higher seed yield was realised during 1986 as compared to 1987. The variations in seed yield due to different methods of sowing were significant during both the years. The highest seed yield was noted when sowing was done after destroying the first flush of weeds (1004,767 kg/ha) which was at par with those plots where sowing was done after killing the two flushes of weeds. Sowing immediately after monsoon without killing the weeds resulted in significantly lower yield (480, 560) than M2 and M3 during both the years.

All weed control treatments increased the seed yield significantly over weedy check during both the years except fluchloralin and haloxyfop-methl during second year. Significantly higher seed yield was obtained in hand weeded plots (1251, 1181 kg/ha) as compared to all other treatments.

The crop biomass (stalk + leaves + seed) at harvest differed significantly due to different methods of sowing and weed control treatments during both the years and exhibited same trend as that of seed yield.

NPK utilization by weeds

The major weed flora of the experimental field under normal and stale seed bed conditions during 1986 and 1987 is presented in Table 3. The NPK content in different weed species revealed that the maximum nitrogen content was found in *Alycicarpus longifolius* (2.40%) closely followed by *Indigofera glandulosa* (2.20%). The minimum nitrogen percentage was noted in *Cyperrus iria* (0.60%) followed by *Ceasulia axillaris* (0.70%). While the highest phosphorus and potassium percentage was noted in *Commelina benghalensis* (0.40, 0.50%) closely followed by *Euphorbia geniculata* (0.39, 3.39%).

Based on total population, the NPK uptake was greater in *Echinochloa crusgalli* in Ml method of sowing followed by M2 (4.06, 1.17, 18.26) and M3 (1.93, 0.55, 8.71). The trend was similar in *Euphorbia geniculata* and *Commelina benghalensis* in different weed control treatments,

Table 1 : Energy utilization by weeds, crop and seeds (Lakh k Cal/ha) in Soybean-weed ecosystem

Methods of sowing	Weedy check	Hand weeding	Fluchloralin	Oxadiazon	Haloxyfop methyl	Mean
			Weeds			
M1	321.91	14.80	101.56	161.10	65.46	132.97
M2	125.45	10.44	89.58	54.26	80.23	71.99
M3	87.76	9.67	45.41	24.15	37.23	80.85
Mean	178.37	11.64	78.85	79.84	60.97	-
			Crop			
M1	121.13	388.49	218.23	130.32	175.69	206.37
M2	317.58	414.21	400.36	360.43	341.91	366.90
M3	235.49	437.15	286.22	297.59	254.99	302.29
Mean	224.76	412.62	301.60	262.78	257.53	-
			Seed			
M1	11.62	51.95	16.63	14.99	17.11	22.46
M2	21.17	54.71	36.16	44.39	33.59	38.01
M3	26.33	50.93	33.42	39.01	30.87	36.11
Mean	19.71	52.53	28.74	32.80	27.19	-

Table 2 : Influence of herbicides under different methods of sowing on soybean yield and biomass (kg/ha) .

Treatment	Soybean yield (kg/ha)			Soybean biomass (kg/ha)		
	1986	1987	Mean	1986	1987	Mean
Methods of sowing						
M1	480.0	560.0	520.0	1894.0	1992.0	1973.0
M2	1004.0	767.0	885.5	4697.0	4126.0	4411.5
M3	953.0	722.0	837.0	3729.0	3094.0	3411.5
SEm±	70.2	31.9	-	280.1	207.1	-
CD (0.05)	242.0	109.0	-	968.0	714.0	-
Weed control						
Weedy check	447.0	466.0	456.0	2591.0	2458.0	2509.5
Hand weeding	1251.0	1181.0	1216.0	4358.0	4185.0	4271.5
Fluchloralin	795.0	536.0	665.0	3446.0	2923.0	3184.5
Oxadiazon	819.0	699.0	759.0	3363.0	3257.0	3310.0
Haloxyfop-methyl	750.0	534.0	642.0	3442.0	2559.0	3000.0
SEm±	53.2	51.1	-	129.1	206.4	-
CD (0.05)	153.0	147.0	-	370.0	591.0	-
Interaction						
SEm±	92.91	88.65	-	223.40	357.45	-
CD (0.05)	266.00	NS	-	641.00	NS	-

Table 3 : NPK content in different weed species present in soybean field

Weed species	Nutrient content (%)		
	N	P	K
1. Echinochloa crusgalli	0.80	0.23	3.60
2. *Cyperus iria*	0.60	0.26	1.70
3. *Commelina benghalensis*	1.80	0.40	4.50
4. *Commelina communis*	1.50	0.29	2.00
5. *Euphorbia geniculata*	1.90	0.39	3.90
6. *Euphorbia hirta*	1.10	0.20	3.80
7. *Psoralea corylifolia*	1.40	0.24	1.70
8. *Justicia diffusa*	0.92	0.32	3.20
9. *Anotis mentholoni*	0.95	0.23	2.75
10. *Digera alternifolia*	1.90	0.20	3.15
11. *Corchorus olitorious*	1.40	0.20	3.60
12. *Convolvulus arvensis*	0.80	0.35	2.30
13. *Indigofera glandulosa*	2.20	0.23	2.99
14. *Physalis minima*	0.98	0.25	3.75
15. *Acalyfa indica*	1.30	0.21	2.50
16. *Ceasulia axillaris*	0.70	0.20	2.40
17. *Alysicarpus longifolius*	2.40	0.30	2.10

Table 4 : NPK uptake (kg/ha) by the major weeds under different treatments

Treatment	*E. crusgalli*			*E. geniculata*			*C. benghalensis*		
	N	P	K	N	P	K	N	P	K
Methods of sowing									
M1	15.38	4.42	69.23	16.34	3.35	33.54	2.84	0.63	7.11
M2	4.06	1.17	18.26	16.07	3.30	32.99	2.06	0.46	5.15
M3	1.93	0.58	8.71	10.52	2.16	21.59	1.61	0.35	4.04
Weed control									
Weedy check	23.58	6.78	106.10	18.01	3.69	36.97	2.78	0.62	6.95
Hand weeding	0.67	0.19	3.02	2.41	0.50	4.95	0.36	0.08	0.92
Fluchloralin	3.85	1.10	17.30	18.59	3.82	38.15	3.06	0.68	7.65
Uxadiazon	7.04	2.02	31.69	13.45	2.76	27.59	1.43	0.32	3.57
Haloxyfopmethyl	0.49	0.14	2.23	19.30	3.92	39.2	3.23	0.72	8.08

the *Echinochloa crusgalli* utilized greater quantity of NPK in weedy check (25.58, 6.78, 106.10) followed by oxadiazon (7.04, 2.20, 31.69) while it was minimum in haloxyfop-methyl (0.49, 0.14, 2.23) followed by hand weeding (0.67, 0.19, 3.02). *Euphorbia geniculata* utilized the maximum NPK under haloxyfop-methyl (19.30, 3.92, 39.21) while it was minimum in hand weeding (2.41, 0.50, 4.95). *Commelina benghalensis* utilized greater quantity of NPK in haloxyfop-methyl (3.23, 0.72, 8.08) while it was the lowest in hand weeding (0.36, 0.08, 0.92 kg/ha). The NPK uptake by total weeds was more in M1 (33.68, 8.80, 113.12 kg/ha), while it was the lowest (14.69, 3.84, 3.84, 35,81) under M3 (Table 5).

Among different herbicidal treatments the weeds utilized the lowest NPK under oxadiazon in M3 (8.65, 1.94, 20.90) followed by the same herbicide under M2 (17.79, 4.19, 40.85). The weeds in haloxyfop-methyl treated plots utilized less NPK under all the methods of sowing as compared to fluchloralin treated plots, whereas the NPK uptake by weeds was minimum under hand weeding under all the methods of sowing. In weedy check the lowest NPK uptake by the weeds was in M3 (27.98, 6.42, 76.76).

NPK utilization by soybean

The NPK uptake by the crop was maximum in M2 method of sowing (168.19, 31.23, 154.20) followed by M3 (157.21, 28.84, 145.67 kg/ha) (Table 6).

Among different herbicidal treatments the NPK uptake was maximum under hand weeding (123.14, 20.87, 62.20) followed by oxadiazon (84.54, 14.87, 51.68) while it was the lowest under weedy check (57.54, 10.64, 42.27 NPK kg/ha). The model of NPK partitioning pattern in soybean under pure stand and in soybean-weed ecosystem reveled maximum utilization of K in stem followed by leaves, while N utilization was maximum in seed followed by leaves. The NPK utilization by crop was reduced

Table 5 : Influence of herbicides under different methods of sowing on uptake of NPK (kg/ha) by total weeds

Methods of sowing	Weedy check	Hand weeding	Fluchloralin	Oxadiazon	Haloxyfop methyl	Mean
			Nitrogen			
M1	76.07	4.95	30.72	30.72	25.93	33.68
M2	32.28	3.26	34.19	17.79	31.97	23.90
M3	27.98	3.32	17.76	8.65	15.73	14.69
Mean	45.45	3.84	27.65	19.05	24.54	-
			Phosphorus			
M1	19.58	1.08	7.15	10.66	5.54	8.80
M2	8.02	0.79	7.40	4.19	6.88	5.46
M3	6.42	0.79	6.84	1.94	3.29	3.84
Mean	11.34	0.87	7.13	5.60	5.24	-
			Potassium			
M1	237.27	12.33	84.83	127.72	57.47	113.12
M2	106.16	8.36	77.19	40.85	68.72	60.26
M3	76.76	8.44	39.12	20.90	33.84	35.81
Mean	152.07	9.71	67.05	66.49	53.34	-

Table 6 : Influence of herbicides under different methods of sowing on uptake of NPK (kg/ha) by soybean

Treatment	Nutrient uptake by soybean		
	N	P	K
Methods of sowing			
M1	103.86	20.30	93.17
M2	168.19	31.23	154.20
M3	157.21	28.84	145.67
Herbicides			
Weedy check	57.54	10.64	42.27
Hand weeding	123.14	20.87	62.20
Fluchloralin	75.35	13.39	48.48
Oxadiazon	84.54	14.87	51.68
Haloxyfop-methyl	71.03	12.79	47.06

to almost half under weed association (96, 18, 99) as compared to pure stand (218, 39, 184 kg/ha).

NPK content of soil

The NPK content in the soil after harvest (Table 7) in weedy check increased under M1 (237, 7.47, 197.33 NPK kg/ha). The increase in NPK content in weedy check was also noted under M2 and M3 as compared to initial values. The N content after harvest increased 3 to 12 kg/ha than initial value in different treatments in all methods of sowing but the increase was less under hand weeding and herbicidal treatments as compared to weedy check. The phosphorus content also increased under weed control treatments except fluchloralin in M1, hand weeding and oxadiazon under M2 method of sowing. As compared to initial values the potassium content decreased under herbicidal treatments in M2 and M3 methods of sowing except fluchloralin under M2.

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Table 7 : Influence of herbicides under different methods of sowing on NPK content of soil (kg/ha) after soybean harvest

Methods of sowing	Weedy check	Hand weeding	Fluchloralin	Oxadiazon	Haloxyfop methyl	Mean
			Nitrogen			
M1	237	228	232	232	234	232.00
M2	237	232	232	235	232	233.60
M3	237	234	235	237	237	236.00
Mean	237	232	233	235	234	-
			Phosphorus			
M1	8.00	6.40	2.40	6.40	6.40	5.92
M2	8.00	2.40	3.20	2.40	8.00	4.80
M3	6.40	8.00	4.80	8.00	6.00	6.72
Mean	7.47	5.60	3.47	5.60	6.93	-
			Potassium			
M1	185	166	166	129	185	166.20
M2	222	166	185	129	148	170.00
M3	185	166	129	148	129	151.40
Mean	197	166	160	135	154	-

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PRODUCTIVITY AND ECONOMICS OF *RABI* OILSEEDS UNDER VARYING INPUTS

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ABSTRACT

Four major rabi oilseeds were compared for their yield and profit in clay loam soils of Jabalpur (M.P.) during rabi 1992-93 and 1993-94 under double cropping system in succession to soybean. Results showed that Safflower registered the highest seed yield (20.23 q/ha) and net profit (Rs. 11,064/ha). Net profit declined by 62.3, 69.8 and 61.9% from cultivation of mustard, linseed and sunflower, respectively over safflower. Recommended dose of fertilizer resulted in higher seed yields and profits than 50% RD in all oilseeds. One irrigation applied at 35 days after sowing (DAS) alongwith a pre sowing irrigation proved equal to two irrigations applied at 35 and 70 DAS in addition to presowing irrigation with regard to seed yields and benefit-cost-ratio.

Key words : Fertilizer, irrigation, net profit, benefit-cost-ratio, mustard, linseed, safflower, sunflower.

INTRODUCTION

A variety of oilseeds like mustard, linseed and safflower are grown in Madhya Pradesh under rainfed situations. Recently, cultivation of sunflower has started in many parts of the state, particularly under irrigated conditions. The productivity of oilseeds grown under rainfed condition is very low. Generally, rainfed crops are grown without or with little use of fertilizers owing to low yields. Though conventional *rabi* oilseeds grown under rainfed condition have potential to produce good yields with the use of irrigation and fertilizers, they are not grown with these agro-inputs. When sunflower is grown with irrigation and adequate fertilizers, it is imperative to compare its productivity and profitability with other traditional oilseeds under the same level of agro-inputs. Hence, the present investigation was undertaken.

MATERIALS AND METHODS

Field experiments were conducted at Jabalpur (M.P.) during *rabi* 1992-93 and 1993-94 to compare the productivity and profitability of important *rabi* oilseeds in double cropping system after the harvest of soybean. The soil of the experimental field was clay loam in texture and neutral (pH 7.2) in reaction. It had very low available N (187 kg/ha) and P_2O_5 (13.6 kg/ha); and medium available K_2O (286 kg/ha) contents. The treatments consisted of four irrigation schedules viz., presowing irrigation (a), (a) + 35 days after sowing (DAS), (a) + 70 DAS and (a) + 35 DAS + 70 DAS and two fertility levels viz., 100% and 50% of the recommended dose (RD) as main plot treatments; and four crops viz., mustard (*Brassica juncea* L. Czern and Coss.), linseed (*Linum usitatissimum* L.) safflower (*Carthamus tinctorius* L.) and sunflower (*Helianthus annus* L.) as sub plot treatments were tested in split-plot design with three replications. Soybean was grown during *kharif* season with uniform dose (20 kg N + 60 kg P_2O_5 + 20 kg K_2O/ha) of fertilizers. Pusa bold, JL-23, No. 7 and Morden were the varieties of mustard, linseed, safflower and sunflower, respectively. Seed rates were 5, 30, 15 and 15 kg/ha for the respective crops. All crops were sown on November 30 and 15 in the two consecutive years in rows 40cm apart for mustard and safflower; 20 cm for linseed and 50 cm for sunflower. The recommended dose was 90 kg N + 40 kg P_2O_5 +30 kg K_2O/ha for mustard and linseed; and 60 kg N + 60 kg P_2O_5 + 30 K_2O/ha for safflower and sunflower. Full dose of NPK fertilizers

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as per treatments was applied as basal under the treatments receiving only pre sowing irrigation, while half N + full P and K fertilizers were given as basal and remaining half N was top dressed just after first irrigation. Seed yield was recorded and economics were computed on the basis of inputs and output under the respective treatments.

RESULTS AND DISCUSSION

Seed yield

Safflower gave highest seed yield under different irrigation schedules and fertility levels followed by (Table 1), sunflower, mustard and linseed in descending order. One irrigation applied either at 35 DAS or at 70 DAS along with a presowing irrigation gave significantly higher seed yields of all oilseeds than application of presowing irrigation alone. After a presowing irrigation, the crop irrigated at 35 DAS also proved significantly superior to the crop irrigated at 70 DAS in respect of yield. Though two irrigations given at 35 and 70 DAS besides a presowing irrigation gave maximum yield of all crops, it was at par with those obtained with irrigations at presowing and 35 DAS. Similar positive effects of irrigation applied at rosette (35 DAS) and flowering (70 DAS) stages have been reported in mustard (Shrivastava *et al.*, 1989), linseed (Tomar *et al.*, 1985), safflower (Singh and Singh, 1989; and Nimje, 1991) and sunflower (Sharma, 1994) under varying agroclimatic conditions.

Recommended dose of fertilizers gave significantly higher seed yields of all *rabi* oilseeds compared to 50% recommended dose of fertilizers. Mustard, linseed, safflower and sunflower gave seed yields of 9.37, 8.13, 21.87 and 10.77 q/ha, respectively with 100% RD which declined to 7.56, 6.45, 18.64 and 8.85 q/ha due to 50% RD, respectively. These results are in close conformity with the findings of Tomar and Namdeo (1989) in mustard; Tomar *et al.* (1985) and Tiwari *et al.* (1988) in linseed; Nimje (1991) in safflower and Sharma (1994) in sunflower.

Monetary return

Economic analysis of the treatments was made on the basis of mean yields of two years. Among the oilseeds safflower recorded the maximum gross profit (Rs. 16,164/ha) due to maximum yields (Table 2). Sunflower (Rs. 9810/ha) linseed (8740/ha) and mustard (Rs. 8470/ha) were next to it with regards to gross profit based upon the market value of the produce. Linseed though having lesser yield gave more profit than mustard because of higher market price. The cost of cultivation was almost alike for all crops, hence net profit followed the trend of gross profit for all crops. Consequently, profitability (gross profit over each rupee of investment) was 3.17, 1.99, 1.97 and 1.92 for safflower, linseed, mustard and sunflower, respectively.

Gross monetary return was significantly increased due to irrigations supplemented over a presowing irrigation in all the four oilseeds. Two irrigations applied at 35 and 70 DAS along with a presowing irrigation fetched the highest gross monetary returns in all corps, which was at par with one irrigation given at 35 DAS alongwith a presowing irrigation. Hence, these treatments were also at per with regards to net profit and benefit-cost-ratio.

Application of recommended dose of fertilizers significantly proved to be more remunerative in terms of net return and benefit cost ratio than 50% RD in all the four oilseeds.

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Table 1 : Seed yields (q/ha) of rabi oilseeds under different irrigation and fertility levels.

Treatment	Mustard			Linseed			Safflower			Sunflower		
	1993	1994	Mean	1993	1994	Mean	1993	1994	Mean	1993	1994	Mean
Irrigation												
presowing irrigation	5.93	6.63	6.228	4.14	6.90	5.52	15.13	16.85	15.99	7.85	9.53	8.69
Presowing + 35 DAS	8.96	10.42	9.69	7.31	9.03	8.17	22.67	22.86	22.27	10.36	10.61	10.49
Presowing + 70 DAS	7.38	8.09	7.74	6.00	7.76	6.88	18.00	19.27	18.64	8.87	9.43	9.15
Presowing + 35 DAS + 70 DAS	9.10	11.21	10.16	7.85	9.33	8.59	23.69	23.38	23.54	10.63	11.19	10.91
SEm±	0.44	0.63	-	0.19	0.24	-	0.43	0.56	-	0.25	0.27	-
CD (P=0.05)	1.28	1.83	-	0.55	0.70	-	1.26	1.63	-	0.74	0.79	-
Fertility level												
100% RD	8.57	10.17	9.37	7.22	9.03	8.13	21.17	22.47	21.82	9.93	11.60	10.77
50% RD	7.11	8.00	7.56	4.42	7.47	6.45	18.57	18.71	18.64	8.93	8.77	8.85
SEm±	0.31	0.47	-	0.13	0.17	-	0.31	0.43	-	0.18	0.18	-
CD (P=0.05)	0.90	1.37	-	0.38	0.49	-	0.89	1.25	-	0.52	0.52	-
Mean crop yield	7.84	9.09	8.46	6.32	8.25	7.29	19.87	20.59	20.53	9.43	10.19	9.81

RD = Recommended dose, 100% RD = 90:60:30 kg NPK/ha for mustard and linseed; and 60:60:30 kg NPK/ha for sunflower and safflower.

Table 2 : Economics of various rabi oilseed crops in relation to irrigation and fertilizer.

Treatment	Gross return (Rs/ha)				Net return (Rs/ha)				Benefit-cost-ratio			
	Mustard	Lin Seed	Safflower	Sun flower	Mustard	Lin seed	Safflower	Sun-flower	Mustard	Lin seed	Saff-lower	Sun-flower
Irrigation												
Presowing irrigation	620	6624	12797	8690	1980	2124	7592	3490	1.46	1.47	2.46	1.67
Presowing + 35 DAS	9690	9804	18216	10490	5190	5104	12816	5090	2.15	2.09	3.37	1.94
Presowing + 70 DAS	7740	8256	14912	9150	3240	3256	9512	3750	1.72	1.76	2.26	1.69
Presowing + 35 DAS + 70 DAS	10160	10308	18832	10910	5460	5408	13232	5310	2.16	2.10	3.36	1.95
SEm±	241	301	823	282	-	-	-	-	-	-	-	-
CD (P=0.05)	701	876	2395	821	-	-	-	-	-	-	-	-
Fertility Level												
100% RD	9370	9756	17456	10770	4770	5056	11956	5270	2.04	2.08	3.17	1.96
50% RD	7560	7740	14912	8850	3660	3640	10212	4150	1.94	1.89	3.17	1.88
SEm±	179	224	610	209	-	-	-	-	-	-	-	-
CD (P=0.05)	521	652	1775	608	-	-	-	-	-	-	-	-
Mean	8470	8470	16164	9810	4170	4348	11069	4210	1.97	1.99	3.17	1.92

RD = Recommended dose, 100% RD = 90:60:30 kg NPK/ha for mustard and linseed; and 60:60:30kg NPK/ha for sunflower and safflower.
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CROP COEFFICIENTS FOR PREDICTION OF IRRIGATION REQUIREMENTS OF MUSTARD

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ABSTRACT

A field experiment was conducted during 1993-94 winter season on a sandy loam soil to study the influence of evapotranspiration (Eta) deficits on crop coefficients (Kc) of mustard. The Kc values at different crop growth subperiods except establishment were significantly influenced by Eta deficits. The fully irrigated control (I-I-I) treatment recorded significantly higher Kc values at all the crop growth subperiods in comparison to other treatments. The variation of Kc values was largely a function of Eta deficit at different crop-growth subperiods and leaf area of the crop. The crop coefficient curve for I-I-I treatment showed that the Kc value was low (0.401) in the establishment period, increased linearly through vegetative period, and remained constant at 1.0 from flowering to pod filling period (30 to 85 DAS). Then the Kc value decreased precipitously to a low value of 0.410 during final 10 days of crop period. Crop coefficient curve facilitates prediction of mustard Eta in advance at a new site from estimates of reference crop evapotranspiration. For field application of this study the net (29.71 cm) and gross irrigation requirements, both at field inlet (4249 m^3/ha) and head work (7435 m^3/ha) were determined.

Keywords : Mustard, crop coefficients, evapotranspiration deficit, irrigation requirements.

INTRODUCTION

Crop evapotranspiration (Eta) estimates are extensively used for determining irrigation requirements and for scheduling irrigations to crops. Experimentally derived crop coefficients facilitate prediction of crop Eta at progressive stages of crop-growth for a given location from the estimates of reference crop (grass) evapotranspiration (Praveen Rao and Raikhelkar, 1994). Hence, the objective of the present study was to derive crop coefficients of mustard for different crop-growth subperiods under variable water supply levels. Also, methodology for determination of periodic and peak irrigation requirements was suggested.

MATERIALS AND METHODS

The field experiment was conducted during winter season of 1993-94 at College farm, College of Agriculture, Hyderabad (17.19°N, 78.23°E and 542.6m above m.s.l) on a sandy loam soil. The experimental soil had N, P and K 270, 18.17 and 508 kg/ha, respectively, with pH 7.5 and EC 0.13 dS/m. The soil moisture retentivity of different soil layers upto 60cm depth at -0.03 MPa and -1.5 MPa was 0.172 and 0.087 cm^3/cm^3, respectively. The average bulk density for 0-60 cm soil depth was 1.66 Mg/m^3. The water table was below 6 m from the ground surface.

There were eight irrigation treatments designed to allow Eta (water) deficits to develop in one or more specific crop-growth subperiods viz., vegetative (8 to 30 DAS), flowering-pod initiation and addition (30 to 70 DAS) and pod filling period (70 to 93 DAS). The irrigation treatments were administered from 8 DAS onwards. In any given growth subperiod, the crop in a given treatment was either irrigated (I) based on soil-crop-climatic data (Praveen Rao, 1993) to ensure Eta proceeded at the maximum rate (Etm) or it was not irrigated (D) at all. For instance the crop in D-I-I was not irrigated during vegetative growth subperiod i.e., from 8 to 30 DAS and was irrigated

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during the latter two crop-growth subperiods. Likewise in treatments D-I-I, I-D-I, I-I-D, D-D-I, I-D-D and D-I-D, if the crop was irrigated (I) in a given growth subperiod, the schedule duplicated that of the crop in I-I-I. If not irrigated (D) the Eta rate may have fallen below the Etm rate as that occurred in I-I-I treatments and the absolute difference for the period was expressed as an evapotranspiration deficit (Etd). Following an Etd at the end of the crop-growth subperiod in water deficit treatment, the root-zone depth of the crop was replenished to moisture content at field capacity. The designed eight irrigation treatments provide all possible combinations of growth subperiods in which Etd occurred, ranging from none (I-I-I) to all the three growth subperiods (D-D-D). The eight treatments were laid out in randomized block design with four replications.

"Seetha" mustard variety was sown on 31 October, 1993 by adopting a spacing of 30 cm x 10 cm to achieve a desired plant population of 3.3 lakhs/ha. For determination of crop Eta the soil moisture was monitored by gravimetric method at four locations and various depths in each treatment from surface to 60 cm soil depth before and after each irrigation and on intermediate dates in case of incident precipitation. The reference crop evapotranspiration (Eto) was estimated at specific crop-growth sub-periods based on FAO modified Penman method (Doorenbos and Pruitt, 1977). Thus the data obtained on Eta of mustard and Eto at specific crop-growth subperiods were used to calculate the crop coefficient (Kc) as follows :

$$Kc = Eta/Eto \quad ... (1)$$

For constructing the crop coefficient curve (Fig. 1) the crop life of mustard was divided into establishment, vegetative, flowering, pod initiation and addition, pod filling, and ripening crop-growth sub-periods. The crop in I-I-I treatment, which produced Kc values (Fig. 1), was irrigated eight times. To use the Kc values for predicting crop Eta (Eta = Kc. Eto) throughout the crop season, only Eto estimates based on modified Penman method from the new planting site are needed.

As an application of this study in irrigation water management, the estimates of Eta for mustard crop from the Kc values of irrigation treatment (I-I-I) were used to determine the actual irrigation requirements for a given design as follows :

$$In = Eta \times \text{Growth period in days} \quad ..... (2)$$

in which, In, net irrigation requirement (cm) for the growth period considered and Eta, evapotranspiration of the crop (mm/day).

$$V \text{ at field inlet} = \frac{10}{Ea} \times \frac{A.In}{1\text{-}LR} \, m^3 \quad .... (3)$$

$$V \text{ at head work} = \frac{10}{Ep} \times \frac{A.In}{1\text{-}LR} \, m^3 \quad ..... (4)$$

in which, V, gross irrigation requirement for the period considered (m^3); Ea, field application efficiency (0.7); A, area (1.0 ha); In, net irrigation requirement (cm); LR, leaching requirement (nil); and Ep, project efficiency (0.4).

RESULTS AND DISCUSSION

Effect of water deficits on Kc values

The Kc values at establishment period were not significantly different from each other (Table 1) owing to uniform water application, since the crop was subjected to water (Eta) deficits only from 8 DAS onwards. The highest value of the Kc was 1.069, and was exhibited by the crop in treatment I-I-I with irrigation at all the crop-growth subpeiods equivalent to Etm; whereas, for treatment D-D-D without irrigation for three successive crop-growth subperiods (8 to 93 DAS), the maximum value of the Kc was 0.444. The Kc value in treatment D-D-D remained significantly lower at all the crop-growth subperiods and the peak value was observed earlier i.e., vegetative period in comparison to other

Table 1: Crop coefficients of mustard as influenced by water deficits in different crop growth subperiods.

Treatment designation	Crop-growth subperiods (days)							
	Establishement (0-8)	Vegetative (8-30)	Flowering (30-50)	Pod initiation & addition (50-70)	Pod filling (70-85)	Ripening (85-93)	Crop season (0-93)	Leaf area (cm2) at 70 DAS
I-I-I	0.401	0.744	0.999	0.990	1.069	0.607	0.849	867
D-I-I	0.383	0.467	0.945	0.858	1.027	0.556	0.731	783
I-D-I	0.420	0.721	0.822	0.376	0.979	0.502	0.661	618
I-I-D	0.417	0.632	0.927	0.974	0.798	0.502	0.723	837
D-D-I	0.401	0.473	0.352	0.264	0.695	0.576	0.450	465
I-D-D	0.422	0.693	0.842	0.339	0.254	0.169	0.501	540
D-I-D	0.427	0.462	0.949	0.916	0.665	0.442	0.688	705
D-D-D	0.438	0.444	0.256	0.209	0.120	0.064	0.267	354
CD (P=0.05)	NS	0.127	0.431	0.263	0.185	0.102	-	-

treatments. This trend is expected because at the time of initiation of water deficits (8 DAS) crop root zone depth was replenished to filed capacity moisture content; this might have aided the crop in D-D-D to put forth reasonable leaf area (354 cm^2) but due to severe water deficits at later crop-growth subperiods consequent to withholding of irrigation, there was marked reduction in leaf area (59.1 per cent) as compared to I-I-I (leaf area-867 cm^2). Further it can be observed that the water deficits irrespective of the crop-growth subperiod significantly lowered the Kc value. However, the magnitude of reduction was a function of severity of water deficit. For instance in treatments D-I-I, I-D-I and I-I-D the Kc values were generally higher as compared to the treatments D-D-I and I-D-D. These trends could be traced to variation in leaf area under these treatments. The leaf area in treatment D-I-I, I-D-I and I-I-D, where water deficits were imposed only in one growth subperiod were higher and varied between 837 cm^2 to 618 cm^2 as compared to 465 cm^2 in D-D-I and 540 cm^2 in I-D-D. The Kc value in treatment I-D-I first increased with time to 0.822 owing to adequate water supply and then with further increase in time Kc value decreased to 0.376 due to withholding of irrigation at flowering-pod initiation and pod addition crop-growth subperiod. However, on irrigation at pod filling period the Kc started increasing with time to 0.999, and then decreased toward crop ripening. The variation of Kc with time in treatment D-D-I was similar to that in treatment I-D-I, except that lower Kc values were observed in D-D-I as compared to I-D-I. The second peak values in I-D-I and D-D-I were higher than the first peak values and occurred at a later crop-growth subperiod as compared to the peak values of I-I-D, I-D-D, D-I-D and D-D-D. Similarly in treatment D-I-I with no irrigation at vegetative period, the Kc value remained lower till 30 DAS in comparison to other treatments. However, on irrigation at flowering and subsequent growth subperiods, the Kc value in D-I-I started increasing at a faster rate with a further increase in time, attaining a maximum value of 1.027.

The peak value in treatment D-I-I also occurred at later crop growth subperiod as compared to other treatments.

Crop coefficient curve

The crop coefficient curve shown in Fig. 1 was drawn in such a way that the numerical deviation from the data points was minimum. The Kc values for I-I-I treatment varied between 0.401 to 1.069. The average Kc value from sowing to establishment was small in view of very little (incomplete) canopy (80 cm^2) and majority of the loss may be attributed to evaporation from the soil. The Kc value increased linearly from 0.401 to 1.0 due to increase in crop Eta as the crop grew and developed more leaf area (635 cm^2) from establishment through vegetative to flowering period. From flowering to pod filling period (30-85 DAS) the Kc almost remained constant at 1.0. This could be attributed to maximum energy intercepting leaf area i.e., transpiring surface (867 cm^2). During the final ten days of crop life the Kc value decreased precipitously reaching a low value of 0.410. This could be due to reduction in crop Eta owing to unproductive/senescence of leaves (leaf area-45 cm^2) and partly due to reduced root activity.

Irrigation requirements

Table 2 presents the irrigation requirements of mustard. The net irrigation requirement (In) was low (1.54 cm) in the establishment period, increased linearly during vegetative period to 6.86 cm, then decreased marginally at flowering (4.25 cm) owing to incident precipitation (2.74 cm). After flowering period again In increased to attain higher values of 7.72 cm and 7.04 cm in pod initiation and addition period and pod filling period, respectively. Thereafter In decreased towards maturity reaching a value of 2.33 cm. The seasonal In was 29.74 cm exclusive of effective precipitation of 2.74 cm. The gross irrigation requirements (V) showed trend similar to In with crop ontogeny (Table 2). The V varied from 220 to 1121 m^3 at field inlet and from 385 to 1930 m^3 at head work. The seasonal V

Table 2 : Irrigation requirements of mustard (var. Seeta)

Treatment designation	Crop-growth subperiods (days)						
	Establishement (0-8)	Vegetative (8-30)	Flowering (30-50)	Pod initiation & addition (50-70)	Pod filling (70-85)	Ripening (85-93)	Crop season (0-93)
ETo (cm/day)	0.48	0.42	0.35	0.39	0.44	0.48	0.41
Kc fraction	0.401	0.744	0.999	0.990	1.069	0.607	0.849
Etm (cm/day)	0.192	0.312	0.349	0.386	0.470	0.291	0.348
Pe (cm/period)	-	-	2.74	-	-	-	-
GIC (cm/period)	-	-	-	-	-	-	-
In (cm/period)	1.54	6.86	4.25	7.72	7.04	2.33	29.74
V at field inlet (m^3/period/ha)	220.00	980.00	607.40	1102.80	1005.70	332.80	4248.70
V at head work (m^3/period/ha)	385.00	1715.00	1062.00	1930.00	1760.00	582.50	7434.50
V peak (m^3/ha)							1930.00

Pe - Effictive precipitation; GIC - Groundwater contribution

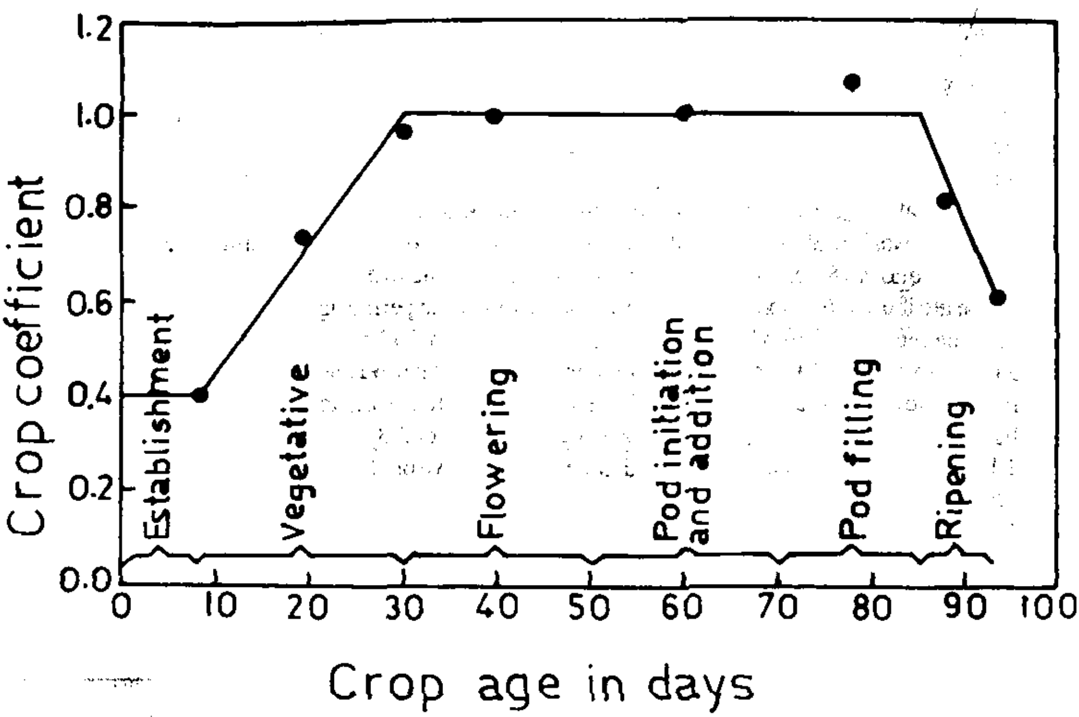

Fig - 1 : Crop coefficient curve for mustard

amounted to 4249 m^3 at field inlet and 7435 m^3 at head work. The higher V values at head work in comparison to field inlet may be attributed to low project efficiency (Ep). However, while determining irrigation requirement of mustard in advance at a new planting site, if historical rainfall and ground water data indicates any dependable (with 75% probability) contribution to crop Eta during crop growing season accordingly adjustments have to be made (as shown in Table 2) in irrigation supplies.

Thus it is concluded that the crop Kc values derived in the present study for mustard facilitate estimation of crop Eta, which in turn can be used in determining net and gross irrigation requirements for scheduling irrigation at proper time with optimum quantity.

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IRRIGATING SUNFLOWER (*Helianthus annuus* L.) WITH DEFICIENT WATER SUPPLY*

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ABSTRACT

A field study was conducted during 1992-93 winter season on a sandy loam soil to study the response of sunflower to evapotranspiration (Eta) deficits imposed at specific crop growth subperiods. The crop in fully irrigated control treatment recorded maximum yield. Eta deficits in all the growth subperiods significantly reduced the seed yield except in vegetative subperiod, relative to the yield in fully irrigated control. Yield response factors indicated that vegetative subperiod is insensitive to Eta deficits. Whereas flowering and seed filling crop-growth subperiods were 142 and 117 percent, respectively, more sensitive to Eta deficits than vegetative period, provided the crop has experienced no Eta deficits in the preceeding growth subperiods. However, the susceptibility of crop yield to Eta deficits at flowering and seed filling periods has been found to be greatly minimised if the crop is conditioned by prior Eta deficits.

Key words : Evapotranspiration, sunflower, yield response factor.

INTRODUCTION

Conventionally irrigation is given to restore the soil moisture profile in the root-zone to field capacity and fully satisfy the Eta requirements of each crop per unit area to harvest maximum yield (Ym) per unit area. But such a water management approach brings down the irrigated acreage in years of deficient water supply, so that water requirements of each hectare can be met in full. On the otherhand limited irrigation approach conserves water, improves water use efficiency and helps in increased irrigated area. Management of limited water however, results in an inevitable introduction of some ETa deficits during the crop growing season, which results in definable minimum reduction in yield below Ym assumes significance. This requires quantitative knowledge of yield response to a given level of Eta deficit in each crop-growth subperiod.

Sunflower, an important winter oilseed crop in India, is often subjected to Eta deficits, leading to severe yield reduction. Hence the study was taken up to examine the effects of Eta deficits imposed at different crop growth subperiods on growth and yield of sunflower and to suggest optimal irrigation schedules to minimise yield losses under deficient water supply.

MATERIALS AND METHODS

The field experiment was conducted on a sandy loam soil during the winter season of 1992-93 at the College Farm of Acharya N.G. Ranga Agricultural University, Hyderabad (17° 19'N, 78° 23'E and 542 m above m.s.l.) having semi-arid climate.

The weekly mean maximum temperature for the crop period (19.10.1992 to 30.1.1993) varied between 26.6°C and 31.7°C, with an average of 29.4°C. Weekly mean relative humidity ranged from 50.0 to 71.9% with an average of 55.7%. There were 3.9 to 10.2 mean sunshine hours per day.

Evaporation from USWB class A Pan evaporimeter during the crop period ranged from 2.7 to 4.4 mm/day with a wind velocity of 1.7 to 6.8 km/day. A total rainfall of 9.7 cm spread over three rainy days was received during 32 to 34 days after

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sowing. Since the rainfall occurred during the transition period of vegetative to flowering, the effective rainfall (Dastane, 1974) was deducted from the net irrigation requirement while scheduling irrigation in different treatments.

The treatments consisted of eight variable water supply levels designed to allow Eta deficits to develop in one or more of the three specific crop-growth subperiods viz., vegetative (10 to 32 DAS), flowering - seed set (32 to 65 DAS) and seed filling-maturity (65 to 104 DAS) including a fully irrigated control (Eta=Etm) water regime (Table 1). In any given growth subperiod, the crop in a given treatment was either irrigated (W) based on soil crop-climatic data (Table 2) to assure Eta proceeded at potential rate or it was not irrigated at all (D). If irrigated, the schedule duplicated that of the crop in W-W-W and maximum Eta (Etm) for the following irrigation interval was assumed. If unirrigated the treatment actual Eta rate may have fallen below the Etm rate and the absolute difference for the period was expressed as an Eta deficit.

The amount of irrigation water required in stress treatments at the time of relieving the stress imposed in the preceeding crop-growth subperiods was calculated on the basis of the soil water deficit in the profile as follows. Irrigation (cm) equals soil water storage at field capacity (cm) less soil water storage just before irrigation (cm). The irrigation water supply under different treatments is given in Table - 1.

The designed eight irrigation treatments provide all possible combinations of growth subperiods in which Eta deficits occurred, ranging from none (W-W-W) to all (D-D-D). The treatments were laid in randomized block design with four replications.

The average moisture retentivity values at -0.03 MPa, -1.5 MPa and available water storage in 60 cm soil profile were 17.16, 8.68 and 8.48 cm, respectively. The average bulk density of 60 cm soil profile was 1.66 g/cm3. The pH and electrical conductivity were 7.5 and 0.13 dS/m, respectively. The experimental soil was low in available N (270 kg/ha), medium in available P (18 kg/ha) and high in available K (508 kg/ha).

Sunflower hybrid 'MSFH-8' was planted on 19 October, 1992 with a spacing of 45 cm x 30 cm in plots of 7.2 m x 4.5 m. Other recommended agronomic practices were followed. The crop was subjected to Eta deficits at different crop growth subperiods by with-holding water. The treatments were imposed from 10 DAS onwards after recharging the soil to field capacity. A 7.5 cm Parshall flume was used for measuring the water at each irrigation. The potential evapotranspiration (PET) was computed by the FAO Penman method (Doorenbos and Pruitt, 1977). The ground water table was below 6 m during the crop growing season, hence it was assumed that there was not any contribution of ground water table towards crop water needs.

The soil samples were taken at 15 cm intervals to a profile depth of 60 cm at planting and harvest, before and after each irrigation, and on intermediate dates as considered necessary for estimation of actual evapotranspiration. The crop was harvested on 30th January, 1993.

To quantify the effect of Eta deficits on crop yield the relationship between relative yield reduction and relative Eta deficit was workedout as advocated by Stewart *et al.*, (1977).

(Ym-Ya)/Ym=bo(Etm-Eta)Etm .... (1)

Where, Ym is maximum seed yield of fully-irrigated crop; ya, actual seed yield of the crop as affected by Eta deficits; Etm, seasonal evapotranspiration of fully irrigated crop and Eta, seasonal evapotranspiration of the crop as affected by soil water (Eta) deficits. The bo is yield response factor.

Table 1 : Details of irrigation treatments and amount of water applied at different crop-growth subperiods

Treatment designation	Description	Irrigation water supply (cm)			
		Vegetative	Flowering	Seed filling	Total season
W-W-W	Fully irrigated control (Eta=Etm) throughout the crop growing period	7.9	14.3	10.9	33.1
D-W-W	With holding of irrigations at vegetative period (10 to 32 DAS)	0.0	14.3	10.9	25.2
W-D-W	With holding of irrigations at flowering period (32 to 65 DAS)	7.9	0.0	20.7	28.6
W-W-D	With holding of irrigations at seed filling period (65 to 104 DAS)	7.9	14.3	0.0	22.2
D-D-W	With holding of irrigations at vegetative and flowering period (8 to 65 DAS)	0.0	0.0	19.6	19.6
W-D-D	With holding of *irrigations* at flowering and seed filling period (32 to 104 DAS)	7.9	0.0	0.0	**7.9**
D-W-D	With holding of irrigations at vegetative (10 to 32 DAS) *and seed filling period (65 to 104 DAS)*	0.0	14.3	0.0	14.3
D-D-D	With holding of irrigations at vegetative, flowering and seed filling periods (10 to 104 DAS)	0.0	0.0	0.0	**0.0**

DAS = Days after sowing

Table 2 : Calculation of irrigation requirement for sunflower in w-w-w treatment

Crop-growth subperiod	Duration in days	Eto (mm/day)	Kc	Etm (mm/day)	Crop rooting depth (m)	Sa.D. (cm)	P fraction	$i = \frac{P.Sa.D.}{Etm}$	Irrigation Water depth (mm)
Vegetative (10-32 DAS)	22	4.781	0.71	3.585	0.45	6.14	0.64	**11 days**	**39.4**
Flowering (32-65 DAS)	33	3.856	1.125	4.338	0.60	8.44	0.57	**11 days**	**47.7**
Seed filling (65-104 DAS)	39	4.532	0.75	3.999	0.60	8.44	0.66	14 days	**54.4**

Sa. D = Available soil water (Sa) in rooting depth depth (D); P = critical soil moisture depletion level; i = irrigation interval

RESULTS AND DISCUSSION

Yield as influenced by Eta deficits

Scheduling of irrigations at Eta=Etm throughout the crop growing season (W-W-W) gave significantly more yield (2.37 tonnes/ha) over other treatments but it was statistically on par with D-W-W (2.32 tonnes/ha) (Table 3). These trends could be traced to favorable soil water balance in W-W-W and D-W-W as was noticed from Eta/PET ratio (>1.34 at flowering and seed filling growth subperiods), an indicator of soil water deficit (Ritchie, 1981). Further the regression of seed yield on seasonal Eta and seasonal Eta deficit showed a significant (P = 0.01) correlation as evident from the following functions:

$$ya = 0.13714 + 0.05913\,(Eta);\ R^2 = 0.82 \quad \ldots (2)$$

$$Ya = 2.34106 - 2.20397\,\frac{(Etm-Eta)}{Etm};\ R^2 = 0.82 \quad \ldots (3)$$

Adequate soil water balance in W-W-W and D-W-W promoted the plants to produce significantly more height, which inturn put-forth more leaf area index contributing to more dry matter. Venkanna *et al.*, (1994) opined that the plant height and leaf area index were the growth characteristics which limited the dry matter accumulation of sunflower under soil water deficits. Dry matter showed a significant (P = 0.01) positive relation with plant height (r = 0.87) and leaf area index (r = 0.91). Thus the accumulated photosynthates in turn might have been responsible for higher diameter of the capitulum with higher seed filling percentage contributing to more number of filled seeds per plant (Table 3).

The higher seed test weight was associated with W-W-W and D-W-W when compared to other treatments (Table 3). These results emphasize the importance of adequate (Eta=Etm) water supply for sunflower during flowering and seed filling periods for obtaining large heads with more number of well developed seeds that contribute to higher harvest indices and inturn higher yield. The dependence of seed yield on these growth and yield components was apparent from significant (P = 0.01) association between seed yield and plant height (r = 0.86), leaf area index (r = 0.72), dry matter (r = 0.86), capitulum diameter (r = 0.99), filled seeds (r = 0.99), unfilled seeds (r = 0.86) and test weight (r = 0.96).

On the contrary, with-holding of water during flowering/seed filling growth subperiods to the crop in treatments viz., W-D-W, W-W-D, D-D-W, W-D-D, D-W-D, and D-D-D caused Eta to fall below Etm resulting in moderate to severe Eta deficits (Table 3). This condition not only reduced photosynthetically active leaf area and head size but might have also contributed to abortion of florets; which inturn limited the total number of well developed seeds per plant and possibly the non-availability of assimilates to heads resulted in reduced seed test weight and harvest index (Table 3). All of these effects finally reduced the seed yield in stress treatments except D-W-W.

Relative yield deficit vs relative Eta deficit

The relationship between relative yield deficit and relative Eta deficit is shown in Fig. 1. The slope (bo) of the regression i.e., yield response factor reflects the sensitivity of crop to Eta deficits. The higher the bo value, the more sensitive the crop to Eta deficits at a given growth subperiod.

Comparison of bo values for treatment D-W-W, W-D-W and W-W-D indicated that the crop showed less sensitivity to Eta deficits when irrigations were with held at vegetative period in comparison to either flowering or seed filling period. It follows that the sunflower crop is 1.42 (or 142 per cent) and 1.17 (or 117 per cent) times more sensitive to Eta deficits in flowering and seed filling periods, respectively, than vegetative period. Likewise the flowering period is 0.11 times (or 11 per cent) more sensitive than seed filling period. However, when there had been an Eta deficit in the preceeding growth subperiod (for instance in vegetative under D-D-W treatment) the negative effect of flowering period Eta deficit was greatly

Table 3 : Yield and yield attributes of sunflower as influenced by water (Eta) deficits

Treatment	Plant height (m)	Leaf area index	Dry matter (g/plant)	Capitulum diameter (cm)	Seeds/ plant	Filled seeds/ plant (%)	Test weight (g)	Seed yield (Mg/ha)	Harvest index	Seasonal Eta (cm)
W-W-W	1.802	2.141	105.1	15.3	808	76.8	48.7	2.37	37.9	37.27
D-W-W	1.596	2.026	98.8	15.0	806	76.0	48.6	2.32	37.3	35.03
W-D-W	1.486	1.568	76.6	11.3	678	58.0	45.1	1.70	35.8	29.57
W-W-D	1.687	2.116	98.6	14.1	743	67.2	42.7	2.01	37.3	33.17
D-D-W	1.337	1.198	54.6	11.0	549	54.3	35.4	1.84	36.7	25.14
W-D-D	1.408	1.565	64.8	10.9	407	42.6	40.3	1.58	32.9	20.08
D-W-D	1.531	1.953	83.8	13.5	743	57.4	42.0	1.91	37.0	30.35
D-D-D	1.256	1.133	47.7	10.6	409	42.0	35.0	1.01	31.9	19.74
SEm±	0.014	0.028	0.63	0.25	0.8	0.39	0.2	0.04	0.8	-
CD (P=0.05)	0.042	0.082	1.87	0.73	2.3	1.14	0.5	0.11	2.4	

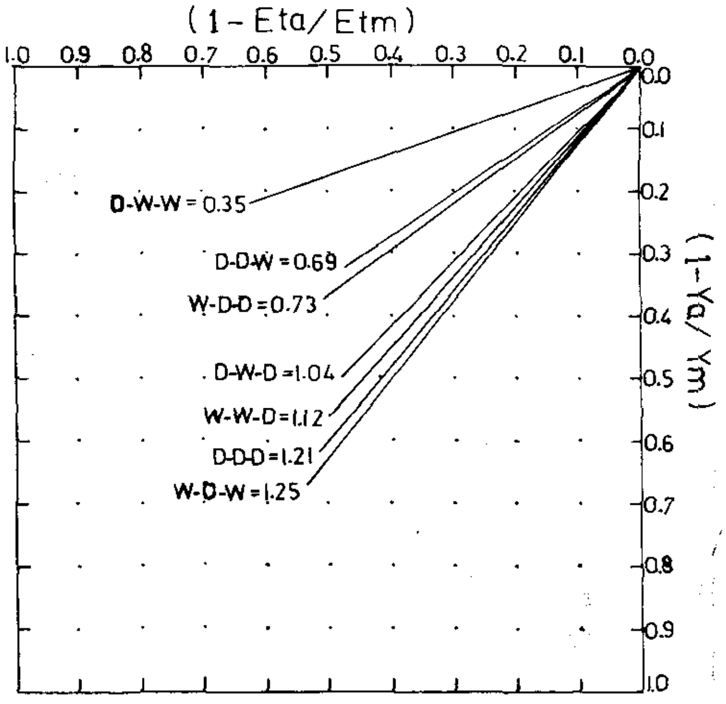

Fig -1 : Relationship between relative yield deficit and relative evapotranspiration deficit

blunted (as evident from the bo value of 0.697). This happened because the earlier water deficits reduced the plant size and "conditioned or hardened" the crop so that flowering period deficit has less negative effect on yield (Stewart et al, 1977). similar trend can also be observed in case of W-D-D and D-W-D treatments.

It can be concluded that adequate irrigation (Eta=Etm) of sunflower at all the crop-growth subperiods resulted in the maximum seed yield. Seed yield reduction due to Eta deficit at vegetative period was insignificant. Whereas Eta deficits at flowering and seed filling period caused significant reduction in seed yield relative to the fully irrigated treatment. Yield response factors indicated that seed yield of sunflower is highly sensitive to Eta deficits at flowering and seed filling period and insensitive to Eta deficits at vegetative period. Hence, under deficient water supply situation priority for water allocation be given to flowering and seed filling periods of sunflower to minimize yield losses.

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INTEGRATED WEED MANAGEMENT IN *RABI* SUNFLOWER

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ABSTRACT

An experiment was conducted at Regional Agricultural Research Station, Jagtial during rabi 1994-95 and 1995-96 in sandy clay loam soil to find out the effect of weedicides on performance of sunflower. At 60 Days after Sowing (DAS) and harvest, significantly lower weed dry matter was observed with the application of herbicides pendimethalin, fluchloralin and metolachlor @ 1.0 kg a.i./ha + one inter cultivation (push hoeing at 35 DAS) compared to these herbicides applied @ 1.0 or 1.5 kg a.i./ha. The former treatments gave similar weed control efficiency as that of hand weeding twice at 20 and 35 DAS + one inter cultivation. Pre emergence application of pendimethalin @ 1.0 kg a.i./ha + one inter cultivation has resulted in significantly higher yield over application of metolachlor or fluchloralin @ 1.0 or 1.5 kg a.i./ha, 1.0 kg a.i./ha + inter cultivation and pendimethalin @ 1.0 or 1.5 kg a.i./ha. Application of pendimethalin @ 1.0 or 1.5 kg a.i/ha has given significantly higher yield over fluchloralin applied @ 1.0 or 1.5 kg a.i./ha. Spraying of herbicides @ 1.0 kg a.i./ha coupled with one inter cultivation at 35 DAS has improved yield over that of herbicides applied @ 1.0 or 1.5 kg a.i./ha.

Keywords : Inter cultivation, Sunflower, Weedicide, Weed control efficiency, Weed dry matter.

INTRODUCTION

In Northern Telangana, sunflower is grown in large areas during winter. From a negligible area in 1991-92 the sunflower area has increased to 78000 ha in 1993-94 (Directorate of Economics and statistics, A.P, 1994). In this region, weeds pose serious problem in the cultivation of sunflower, if unchecked, they reduced seed yield to the tune of 26-50% (Kondap *et al.*, 1983). The crop is grown in *rabi* after maize, green gram and paddy. Due to non availability of labour, the farmers face problem in weeding the crop and in few cases, the crop is left un weeded. Some farmers run the country plough between rows of sunflower to avoid weed growth. Pre emergence application of fluchloralin at 0.75 kg a.i./ha followed by one manual weeding (30 DAS) recorded the highest seed yield (Sankaran, 1988) and the manual weeding (20 and 40 DAS) was the next best treatment. However, no information is available for sunflower weed management in Northern Telangana. Hence, an experiment was conducted to study the effect of weedicides on performance of sunflower.

MATERIALS AND METHODS

Field experiment was conducted during winter season of 1994-95 and 1995-96 at Regional Agricultural Research Station, Jagtial on sandy clay loam (red chalka) soil. The soil had a pH of 7.6, organic carbon 5.7 g/kg of soil, 280 kg/ha available N, 8.6 kg/ha available P_2O_5 and 399 kg/ha of available K_2O.

The treatments consisted of weedicides *Pendimethalin, Fluchloralin and Metolachlor* at two levels - 1.0 and 1.5 kg a.i./ha and 1.0 kg a.i./ha + interculture at 35 DAS along with no hand weeding and hand weeding at 20 DAS + one inter cultivation at 35 DAS (Table-1). *Fluchloralin* was applied as pre plant incorporation into soil, while pendimethalin and metolachlor were applied as pre emergence 2 days after sowing. The experiment was conducted in randomized block design with three replications. Sunflower hybrid MSFH 8 was sown at a spacing of 45 cm x 30 cm on 17 January, 1994 and 28 January, 1995. The crop was fertilized with 90 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha. Entire

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P_2O_5 and K_2O was applied at sowing and the nitrogen was applied in three splits at sowing, 30 and 45 days after sowing (DAS). The crop was irrigated at critical stages - sowing, seedling, bud initiation, flowering, seed filling and seed hardening. The weed growth in different treatments was monitored at 30 and 60 DAS and at harvest. Data on weed dry matter were recorded in 0.25 m^2 area at random in each plot and the data were analysed after subjecting the absolute values to square root transformation. The bio-metric observations i.e. plant height, capitulum diameter, number of seeds/capitulum, 1000 seed weight and seed yield per plant were recorded on five randomly selected competitive plants. Weed control efficiency (WCE) and weed index (WI) were computed as below.

$$WCE = \frac{\text{Weed dry weight in weedy check} - \text{Weed dry weight in treatment}}{\text{Weed dry weight in weedy check}} \times 100$$

$$WI = \frac{\text{Yield from minimum weed competition} - \text{Yield from treatment for which WI is to be worked out}}{\text{Yield from minimum weed competition}} \times 100$$

RESULTS AND DISCUSSION

Growth

The plant height was significantly lower in weedy check than other weed control treatments. The height was significantly higher in pendimethalin @ 1.0 kg a.i./ha and pendimethalin @ 1.0 kg a.i./ha + intercultivation over hand weeding + intercultivation, fluchloralin @ 1.0 kg a.i./ha, metolachlor @ 1.0 kg a.i./ha and metolachlor @ 1.0 kg a.i./ha + inter cultivation. However, the height in the former treatments was onpar with that in fluchloralin @ 1.5 kg a.i./ha and metolachlor @ 1.5 kg a.i./ha.

The weed flora observed in the field were *cyperus rotundus L., C. esculentus L., C. Compresus L., Cynodon dactylon (L.)* Pers., *Echinocloa colonum (L.) Link, Echinocloa crus-galli (L.)* P. Beauv., *Eclipta prostrata, Euphorbia geniculata, Panicum ripense L., Parthenium hysterophorus L., Paspalidium geminatum, Pasplum Sp., Physalis minima L., Perotis indica, Tridax procumbens L., Trichodesma indicum.*

At 30 DAS, the weed dry matter was significantly higher in un weeded treatment compared to weedicides applied and hand weeded treatments (Table 1). The differences in weed dry matter between hand weeding at 20 DAS + one inter cultivation and application of herbicides like pendimethalin, fluchloralin and metolachlor either at 1.0 or 1.5 kg a.i./ha + intercultivation were not significant. At 60 DAS and at harvest the unweeded control recorded higher weed dry matter than other treatments. However, application of herbicides pendimethalin 1.0 kg a.i./ha + inter cultivation (35 DAS), fluchloralin @ 1.0 kg a.i./ha + inter cultivation (35 DAS) and metolachlor @ 1.0 kg a.i./ha + inter cultivation has resulted in significantly lower weed dry matter than these herbicides applied at 1.0 or 1.5 kg a.i./ha without any inter cultivation. Inter cultivation coupled with herbicide application gave similar weed control as that of hand weeding + inter cultivation.

Weed control efficiency

At 30 DAS, the weed control efficiency (WCE) ranged from 82 to 85 per cent. The WCE at 60 DAS ranged between 69 to 92 per cent. The efficiency was higher in hand weeding (92%) and with herbicide application coupled with one inter culture at 35 DAS (86 to 89%). Similar trend was observed at harvest (Table 1).

Weed index

The weed index was higher in un weeded control (48%) (Table 1). On the other hand, it ranged between 8 to 21 per cent in weed control treatments. Among the herbicides, preplant incorporation of fluchloralin @ 1.0 kg a.i./ha and 1.5 kg a.i./ha and pre emergence application of metolachlor @ 1.5 kg

Table 1 : Effect of integrated weed management on mean weed dry matter, WCE and WI in rabi sunflower

Treatment	Weed dry matter (g/m^2)			Weed control efficiency(%)			Weed index, (%)
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	
Weedy check	11.2 (125)	13.3 (177.7)	13.8 (190.9)	-	-	-	48
Hand weeding (20DAS)+ Inter cultivation (35 DAS)	4.4 (19.1)	3.7 (13.8)	5.9 (35.1)	85	92	82	14
Fluchloralin (1.0 kg a.i./ha)	4.4 (19.5)	6.2 (30.7)	6.5 (42.8)	85	83	77	21
Fluchloralin (1.0 kg a.i/ha)+ Intercultivation (35 DAS)	4.6 (21.3)	4.9 (24.2)	4.2 (18.8)	84	86	90	9
Fluchloralin (1.5 kg a.i./ha)	4.3 (18.9)	6.5 (41.7)	5.7 (32.9)	85	77	83	17
Pendimethalin (1.0 kg a.i./ha)	4.6 (21.6)	7.4 (55.0)	8.2 (67.8)	85	69	64	10
Pendimethalin (1.0 kg ai/ha)+ Intercultivation (35 DAS)	4.2 (18.1)	4.4 (19.7)	5.0 (26.7)	85	89	86	-
Pendimethalin (1.5 kg a.i./ha)	4.3 (18.3)	6.8 (46.8)	6.4 (45.1)	85	74	76	11
Metolachlor (1.0 kg a.i./ha)	4.7 (22.4)	6.8 (46.0)	6.9 (48.5)	82	74	75	13
Metolachlor (1.0 kg a.i./ha)+ Inter Cultivation (35 DAS)	4.5 (20.1)	4.5 (20.6)	4.2 (18.3)	84	88	90	11
Metolachlor (1.5 kg a.i./ha)	4.3 (18.6)	6.0 (36.5)	6.2 (38.3)	85	79	80	15
S.Em±	0.17	0.21	0.18				
CD (P=0.05)	0.49	0.60	0.51				

Figures in parenthesis show absolute values (g/m^2).

a.i./ha resulted in higher values of weed index (15 to 21%). On the other hand, it varied from 9 to 13% in other herbicide applied treatments. The lower values of weed index show that the seed yield differences among herbicides metolachlor and fluchloralin applied @ 1.0 kg a.i./ha + inter cultivation are lower compared to that of the best weed control treatment (Pendimethalin @ 1.0 kg a.i./ha + inter cultivation at 35 DAS). This indicates that weedicides could be used successfully for controling weeds for realising higher seed yields.

Seed yield

Application of herbicides - fluchloralin @ 1.0 or 1.5 kg a.i./ha as pre-plant-incorporation, pendimethalin @ 1.0 or 1.5 kg a.i./ha and metolachlor @ 1.0 or 1.5 kg a.i./ha as pre-emergence application resulted in significantly higher seed yield than un weeded check. Herbicide application has recorded similar yield as that of hand weeding coupled with inter cultivation. Application of pendimethalin @ 1.0 or 1.5 kg a.i./ha gave significantly higher yield over fluchloralin applied @ 1.0 or 1.5 kg a.i./ha. However, the former treatment was on par with fluchloralin 1.0 kg a.i./ha + intercultivation. Further, application of pendimethalin and fluchloralin @ 1.0 kg a.i./ha coupled with inter cultivation improved the yield over 1.0 or 1.5 kg a.i./ha. However, the differences between the application of 1.0 or 1.5 kg a.i./ha of pendimethelin or fluchloralin and metolachlor 1.0 kg ai/ha+ intercultivation were not significant. Application of pendimethalin @ 1.0 kg a.i./ha+ intercultivation offered significantly higher yield

Table 2 : Effect of integrated weed management on mean seed and stalk yield, total dry matter and harvest index of rabi sunflower

Treatment	Seed yield (kg/ha)	Stalk yield (kg/ha)	Total dry matter (kg/ha)	Harvest index (%)
Weedy check	1149	2926	4074	28.2
Hand weeding (20 DAS) + Inter cultivation (35 DAS)	1897	4183	6080	31.2
Fluchloralin (1.0 kg a.i./ha)	1744	4233	5977	29.2
Fluchloralin (1.0 kg a.i/ha)+ IC (35 DAS)	1993	4494	6487	30.7
Fluchloralin (1.5 kg a.i./ha)	1822	4309	6131	29.7
Pendimethalin (1.0 kg a.i./ha)	1972	4340	6312	31.2
Pendimethalin (1.0 kg a.i./ha)+ IC (35 DAS)	2199	4554	6753	32.6
Pendimethalin (1.5 kg a.i./ha)	1966	4177	6143	32.0
Metolachlor (1.0 kg a.i./ha)	1908	4112	6020	31.7
Metolachlor (1.0 kg a.i./ha)+ IC (35 DAS)	1963	4460	6423	30.6
Metolachlor (1.5 kg a.i./ha)	1864	4556	6420	29.4
S.Em±	44	88	105	0.6
CD (P=0.05)	124	254	300	1.7

than all other treatments. The weed dry matter at 30, 60 and harvest had negative co-relation with seed yield. The dry matter of weeds at 30, 60 DAS and at harvest had higher r value (r = -0.9, -0.89 and -0.876 respectively). This indicates that higher weed growth in unweeded control and application of fluchloralin, pendimethalin and metolachlor alone @ 1.0 or 1.5 kg a.i./ha has resulted in lower seed yield than that obtained with application of pendimethalin or metolachlor @ 1.0 kg a.i./ha coupled with inter cultivation. The yield attributes viz., seed number per head and 1000 seed weight showed similar trend as that of seed yield (Table 3).

Stalk yield

The stalk yield was significantly lower in weedy check compared to other weed control treatments (Table 2). Significantly higher stalk yield was observed in pendimethalin @ 1.0 kg a.i./ha + inter cultivation, metolachlor @ 1.5 kg a.i./ha, fluchloralin @ 1.0 kg a.i./ha + inter cultivation, metolachlor @ 1.0 kg a.i./ha + inter cultivation over that of pendimethalin @ 1.5 kg a.i./ha, metolachlor @ 1.0 kg a.i./ha, HW + inter cultivation and fluchloralin @ 1.0 kg a.i./ha.

Harvest index

The harvest index ranged between 28.2% in weedy check to 32.6% in pendimethalin @ 1.0

Table 3 : Effect of integrated weed management on mean plant height and yield attributes of rabi sunflower.

Treatment	Plant height (cm)	Head diameter (cm)	No. of seeds/ head	1000 seed weight (g)	Seed yield/ plant (g)
Weedy check	135	10.4	596	38	22.7
Hand weeding (20 DAS) + Inter cultivation (35 DAS)	153	13.5	772	44	33.8
Fluchloralin (1.0 kg a.i./ha)	158	12.9	697	45	31.0
Fluchloralin (1.0 kg a.i/ha)+ IC (35 DAS)	163	13.8	716	46	32.6
Fluchloralin (1.5 kg a.i./ha)	172	14.3	649	46	29.9
Pendimethalin (1.0 kg a.i./ha)	169	14.0	772	44	34.1
Pendimethalin (1.0 kg a.i./ha)+ IC (35 DAS)	171	14.6	774	47	36.2
Pendimethalin (1.5 kg a.i./ha)	166	13.5	706	45	31.8
Metolachlor (1.0 kg a.i./ha)	158	13.0	696	44	30.6
Metolachlor (1.0 kg a.i./ha)+ IC (35 DAS)	158	13.4	721	44	31.5
Metolachlor (1.5 kg a.i./ha)	162	13.1	684	44	29.9
S.Em±	3	0.2	13	0.6	0.6
CD (P=0.05)	9	0.6	38	2.0	1.7

kg a.i./ha + inter cultivation. The harvest index was higher in pendimethalin applied plots than that in other treatments.

These results show that pre emergence application of pendimethalin @ 1.0 kg a.i./ha integrated with intercultivation at 35 DAS gave higher seed yield of sunflower raised during *rabi* season on sandy clay loam soils in Northern Telangana.

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INTEGRATED NUTRIENT MANAGEMENT IN RAINFED CASTOR

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ABSTRACT

A field experiment was conducted at Regional Agricultural Research Station, Palem during *kharif*, 1995 and 1996 on medium fertile alfisols. Sixteen treatment combinations of two sources each of organic (Farm yard manure @ 5t/ha and Neem cake @ 0.25 t/ha), inorganic (100 and 75% recommended dose of 60-40-30 kg N, P_2O_5 and K_2O/ha) and seed inoculation with bio-fertilizers (Azospirillum and Phosphorus solubilizing Bacteria @ 50 g kg seed) were tested in an RBD with three replications. Application of Neem cake + 100% rec.NPK + PSB or Azospirillum gave more total seed yield than other treatments and additional returns of Rs 2,849/- and 1,837 compared with no application of PSB and Azospirillum, respectively.

Key words : Castor, Farm yard manure, Neem cake, Azospirillum and Phosphorus Solubulising Bacteria.

INTRODUCTION

Integrated use of organic, inorganic and bio-fertilizers sustain productivity by improving soil physical conditions viz., reducing soil crusting in red soils, increasing water holding capacity, hydraulic conductivity and infiltration rate besides reducing environmental pollution and may reduce costly inorganic fertilizer needs (Singh *et al.*, 1990). Though a need for developing technologies for sustainable agricultural practices has been felt, no concerted efforts have been made in this direction on castor. Hence, the study on integrated nutrient management in rainfed castor was undertaken.

MATERIALS AND METHODS

The experiment was laid out in RBD during *kharif*, 1995 and 1996 at Regional Agricultural Research Station, Palem in alfisols under rainfed conditions. The treatments comprised different combinations of organic (Farm yard manure (FYM) and Neem cake (NC)), inorganic (100% and 75% of recommended dose of 60-40-30 N, P_2O_5, K_2O kg/ha) and bio-fertilizers (Azospirillum and Phosphorus solubilising Bacteria (PSB)). FYM @ 5 t/ha and Neem cake @ 0.25 t/ha were applied as band placement. Seed was inoculated with bio-fertilizers @ 50 g/kg seed. Thus, there were sixteen treatment combinations (Table 1) replicated thrice. Castor variety 'Jyoti' was sown at a spacing of 90x 60 cm in a net plot size of 3.6 x 3.6 m. The soil of the experimental field was sandy loam in texture with 7.2 pH, low in available nitrogen (181 kg/ha) and high in available P_2O_5 (67.1 kg/ha) and K_2O (257 kg/ha).

Data on nodes to primary spike, effective primary spike length, number of effective spikes and 100 seed weight were recorded. Harvesting was done at 90, 120 and 150 days after sowing. The pooled data of the yield was analysed as suggested by Steel and Torie (1980). Economics were also worked out.

RESULTS AND DISCUSSION

The data on yield attributes (Table-1) indicated that the number of nodes to primary spike did not differ during both the years. Application of Neem cake + 100% recommended NPK + Phosphorus Solubilsing Bacteria or Azospirillum resulted in more primary spike length during 1995 and more effective spikes during both the years of study.

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Table 1 : Effect of orgnaic, inorganic and biofertilizer on yield attributes, oilcontent and net returns of castor

Treatments	Nodes to primary spike		Effective primary spike length (cm)		Effective spike number		100 seed weight (g)		Oil content (%)		Total seed yield (kg/ha)			Net returns (Rs/ha)
	1995	1996	1995	1996	1995	1996	1995	1996	1995	1996	1995	1996	Pooled	
FYM + 75% rec. NPK	13.5	11.0	20.0	33.7	9.8	4.3	21.5	23.7	49.0	43.3	1266	634	950	5,680
FYM + 100% rec. NPK	13.1	10.7	21.3	35.4	11.0	4.8	21.4	23.3	50.1	45.0	1405	673	1039	6,329
FYM + AZM	12.8	10.7	16.8	29.7	8.8	4.0	19.3	23.0	48.4	45.0	818	449	633	2,963
FYM + PSB	12.3	11.1	15.6	29.8	9.5	4.1	20.0	24.3	49.3	44.6	787	516	652	3,172
NC + 75% rec. NPK	11.7	10.7	21.1	30.9	10.9	4.3	21.4	23.0	49.5	44.8	1210	697	954	4,974
NC + 100% rec. NPK	13.0	10.1	21.8	32.3	11.9	5.2	21.6	24.3	50.2	44.8	1510	776	1143	6,723
NC + AZM	12.8	10.1	16.9	31.5	9.3	4.3	19.9	23.5	49.7	44.9	706	526	616	2,026
NC + PSB	12.6	9.7	18.5	31.1	8.7	4.2	19.9	24.0	48.6	44.9	746	571	658	2,488
FYM + 75% rec.NPK+AZM	12.5	10.5	20.4	31.2	10.1	4.7	21.7	23.3	50.4	42.2	1423	626	1025	6,505
FYM + 75% rec.NPK+PSB	13.5	10.1	20.1	32.5	10.1	4.5	21.1	23.0	50.4	43.2	1432	717	1075	7,055
FYM + 100% NPK+AZM	11.9	10.3	22.0	33.2	11.6	5.3	21.9	23.0	51.4	44.3	1589	795	1192	8,012
FYM + 100% NPK+PSB	12.5	10.2	21.5	33.7	11.5	4.5	21.3	22.7	50.4	43.1	1608	869	1239	8,529
NC + 75% rec.NPK+AZM	13.0	10.0	21.3	32.0	10.5	4.5	20.1	23.7	50.7	44.4	1447	707	1077	6,327
NC + 75% rec.NPK+PSB	12.5	9.9	20.4	33.5	10.5	4.7	20.4	23.0	49.0	44.9	1540	743	1141	7,031
NC + 100% rec.NPK+AZM	13.3	10.4	23.3	36.5	11.5	5.3	21.9	24.0	49.7	45.0	1741	879	1310	8,560
NC + 100% rec.NPK+PSB	12.2	10.3	26.3	41.9	12.5	6.9	21.7	24.0	50.5	45.1	1874	930	1402	9,572
SEm±	0.6	0.5	1.4	2.4	0.6	0.4	0.5	0.8	0.8	1.01	101	50	52	
CD 5%	NS	NS	4.0	NS	1.7	1.7	1.4	NS	NS	NS	294	194	147	

AZM - Azospirillum; PSB - Phosphorus Solubilising Bacteria.

Similarly, under irrigated conditions of Gujarat castor cake + recommended NPK + PSB was reported to result in more primary spike length (Anonymous, 1995a). Primary spike length and effective spikes were less in organic and bio-fertilizers applied plots without inorganic fertilizers. Seed test weight and oil content was not influenced during both the years contrary, to the reports from Junagadh (Anonymous, 1995a).

Use of PSB along with neem cake + 100% recommended NPK gave higher yield followed by Azosprillum at the same level of other fertilizers, as compared to the rest of the treatments during both the years. Similar trend was observed in pooled yield. Application of FYM + 100% recommended NPK together with PSB or Azospirillum was on par with Neem cake + 100% recommended NPK + Azospirillum. The increase in yield can be attributed to more primary spike length and more effective spikes (Anonymous, 1994). At Mandore also application of FYM or castor cake in conjunction with recommended dose of NPK with PSB gave substantially higher yield (Anonymous, 1995a). The conjunctive use of organic, inorganic and bio-fertilizers might have improved soil physical conditions and increased nutrient uptake. Reports from Palem also indicated that application of tank silt + FYM and recommended NPK increased total nitrogen, phosphorus and potassium uptake besides having high moisture content during different sampling periods (Anonymous, 1995 b)

Lowest yield was noticed in the treatments with application of organic (FYM or Neem cake) or biofertilizer (Azosprillum or PSB) alone, without inorganic fertilizers. Thus it can be inferred that organic and bio-fertailizers can not completely substitute inorganic fertilizers. However, conjunctive use of these fertilizers can sustain productivity.

Seed yield and oil content in all the treatments was low during 1996 as compared to 1995. This was due to incidence of Botrytis grey rot during October because of incessant rains (124 m m in eight rainy days) coupled with cloudy weather and high relative humidity (95.3%)

Economic analysis showed that additional net return obtained with application of 0.25 t/ha Neem cake + 100% recommended NPK + PSB or Azospirillum was Rs. 2,849 and 1,837/ha more than no PSB or Azospirillum, respectively. Kumar *et al.* (1993) also reported more gross and net returns in Pearl millet + castor inter cropping system with Azospirillum seed inoculation besides application of nitrogen and phosphorus.

Thus it can be highlighted that conjunctive use of 0.25 t/ha Neem cake + 100% rec. NPK + seed inoculation with PSB or Azospirillum @ 50 g/kg seed increased castor yield under rainfed conditions.

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FERTILIZER MANAGEMENT IN SOYBEAN - CHICKPEA CROP SEQUENCE

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ABSTRACT

The study with two cycles of soybean-chickpea crop sequence under variable fertilizer levels indicated that application of 100% recommended NPK (S free) and 100% recommended NPK + Farm yard manure was superior to other fertilizer treatments for seed yield of soybean as well as chickpea. Increasing fertilizer levels beyond 100% did not have favourable effect on yield of both the crops. The economic evaluation and energy balance also favoured the high yield treatments stated above.

Key Words : Chickpea-soybean, fertilizer, energy

INTRODUCTION

High cost of fertilizers coupled with low purchasing power of peasents calls for judicious use of fertilizer inputs. The crop grown in a particular sequence may require differential supplementation of NPK than growing it individually. Adoption of a crop sequence necessitates making adjustments in scheduling NPK. Considering above, an attempt has been made to study the effect of fertilizer application in soybean (*Glycine max* L. Merrill)-chickpea (*Cicer areitinum* L.) crop sequence in Malwa plateau of Madhya Pradesh.

MATERIALS AND METHODS

The experiment was initiated involving soybean (JS 335) - chickpea (Pusa 244) crop sequence at the Research Farm, National Research Centre for Soybean, Indore in 1993 *Kharif* and two cycles of the said system were completed in fixed plots, each measuring 10m x 3.6 m. The soil of the experimental site belonged to fine, montmorillonitic, hyperthermic family of typic chromusterts and is very deep, dark greyish brown to very dark greyish brown clay and slightly alkaline. The analysis revealed pH 7.86, EC 0.14 m Mohs/cm, organic carbon 0.35%, available phosphorus 11 kg/ha and available potassium > 120 kg/ha.

The experiment consisting 10 treatments was laidout in RBD with 4 replications. The treatments comprised of control, 50% of recommended NPK, 100% recommended NPK, 150% recommended NPK, 100% recommended NPK plus hand weeding, 100% recommended NPK plus Zn @ 10 kg/ha as $ZnSo_4$ (to chickpea only), 100% recommended NPK + FYM 10t/ha, 100% recommended N, 100% recommended NP and 100% recommended NPK (S free). The carriers used for last treatment were DAP and muriate of potash. The recommended dose of NPK was 20:26:17 kg/ha for soybean and 20:18:0 kg/ha for chickpea. Soybean was sown on 26 and 23 June in 1993 and 1994, whereas the successive chickpea was sown on 8 and 15 November 1993 and 1994, respectively. Three irrigations were imparted to chickpea as presowing, at branching and at flowering. The observations on yield and growth parameters of both the crops were recorded and economics of each treatment was worked out using prevailing market rates.

The total energy consumed in different operations for cultivation under each treatment was computed. The energy gained from the product was estimated. For calculation of energy input and output, the equivalent coefficients were used (Mittal and Dhawan, 1988). Energy intensiveness was computed (Burnett, 1982).

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RESULTS AND DISCUSSION

Growth and yield attributes

There was no significant impact of differential application of fertilizer on growth parameters of soybean. However, in case of succeeding chickpea, the plants acquired maximum height when 100% recommended NPK (S free) was applied. The maximum number of branches was associated with 100% recommended NPK, while pods/plant with 100% NPK + hand weeding. The lowest plant height, branches and pods per plant were recorded in control treatment (Table 1).

Yield

Soybean yield as well as that of succeeding chickpea was significantly influenced by fertilizer treatments. The maximum soybean yield associated with 100% NPK+FYM was significantly superior to control. The remaining treatments were at par except 100% NPK + Zn which yielded lowest. While comparing the chickpea yield, the highest yield was noted in 100% NPK (S free) which remained at par with 100% NPK + FYM and 100% NPK. The increase in chick pea yield with addition of N, NP and NPK was 4.8, 4.9 and 6.8% over control.

Thus integration of NPK with FYM could further better the yield (9.5%) over control. The above results bring out the impact of balanced supply of major nutrients and integrating inorganic fertilizer supplementation with organic manures. The non-significant results may be accounted for higher content (56 %) and dominance of montmorillonitic type of clay minerals which could have paved way for increased sorption of N,P and K. This in turn has caused low nutrient concentration in soil solution thereby affecting the uptake of nutrients and concomitant non-significant response (Jonson and Sahrawat, 1991 and Tomar *et al.*, 1995).

The maximum soybean equivalent yield was recorded with 100% recommended NPK minus S and remained at par with 100% NPK+FYM and 100% NPK. The lowest soybean equivalent yield was associated with 100% NPK + ZN. The effect of control, 100% N, 50% NPK, 100 % NPK + hand weeding and 150% NPK was similar for soybean equivalent yield. The highest soybean equivalent yield in 100% NPK (S free) and 100% NPK + FYM may be because of the balanced fertilizer application which was conducive for better growth and nutrient uptake. The site of experimentation has been regularly receiving the recommended levels of S in earlier years (available sulphur level 8.6 ppm) and hence no adverse effect of deleting S from schedule was observed. Similar results were also observed by Raghuwanshi *et al.*, (1988), Patel *et al.*, (1991) and Rathore *et al.*, (1995) in cereal-cereal cropping sequence. The lowest yield associated with 100% NPK + Zn may be due to the sufficiency of Zn in experimental soil and additional level was not needed by the crop.

The oil content in soybean seed has invariably increased significantly by fertilizer treatments except in case of 50% NPK. No specific trend in protein content could be seen (Table 1).

Economics

The economic parameters like net returns and benefit-cost ratio differed significantly. The maximum net returns were associated with 100% NPK (S free) which was superior to control. Comparison of the benefit - cost ratio revealed the maximum value with control. Among the fertilizer treatments, 100% NPK (S free) and 100% N showed identical values and proved superior to other treatments. The lowest B:C ratio was noted in 150% NPK. These differences may be due to the differences in yield and cost of cultivation in respective treatments (Table 2).

Energy balance

The exercise on energy balance revealed that maximum energy use efficiency and energy productivity was associated with control and was

Table 1 : Yield, Yield attributes and quality of soybean and chickpea as influenced by fertilizer treatments (Pooled)

Treatment	Soybean							Chickpea				
	Branches/ plant	Pods/ plant	Seed index	Seed yield (kg/ha)	Harvest index (%)	Oil (%)	Protein (%)	Plant height (cm)	Branches/ plant	Pods/ plant	Seed yield (Kg/ha)	HI (%)
Control	3.50	27.0	11.66	2612	49.30	15.81	39.17	37.02	3.10	32.22	1578	46.50
50% NPK	2.85	26.1	11.46	2648	48.20	15.87	39.10	38.50	3.79	30.70	1624	52.91
100% NPK	3.15	28.7	11.71	2737	48.40	16.00	38.96	39.70	4.14	37.57	1685	51.22
150% NPK	3.30	31.2	11.54	2733	47.20	15.96	39.05	38.43	4.02	35.22	1585	56.87
100% NPK+HW	3.25	28.5	11.75	2663	48.80	16.01	39.00	38.86	4.00	41.55	1612	47.85
100% NPK+Zn	2.90	26.2	11.60	2540	48.40	16.11	38.53	37.30	4.04	35.82	1501	47.97
100% NPK+FYM	3.15	28.2	11.18	2807	48.60	15.91	38.80	39.92	3.47	36.65	1735	50.99
100% N	3.40	25.6	11.88	2616	48.90	16.09	39.00	38.99	3.36	35.90	1655	52.55
100% NP	3.35	27.1	11.91	2703	48.30	16.07	38.70	39.70	3.98	39.53	1656	50.98
100% NPK-Sfree	3.40	29.6	11.44	2770	48.40	16.05	39.12	41.30	3.94	47.95	1801	54.16
CD(P=0.05)	NS	NS	NS	167	0.45	0.08	0.17	0.96	0.13	4.30	129	2.58

significantly superior to the rest of fertilizer treatments. The lowest values for these parameters were recorded with 150% NPK. Invariably more energy has been conserved in fertilizer treatments compared to control. The highest net energy output was with 100% NPK + FYM. In general, increasing the levels of nutrients decreased the energy use efficiency and productivity, while regarding energy intensiveness the results were contrary to energy use efficiency. The results confirm the findings of Baishya and Sharma (1990) in rice-wheat and Billore *et al.*, (1994) in sorghum-wheat crop sequence.

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Table 2 : Economics and energy parameters as influenced by fertilizer application in soybean-chickpea crop sequence (pooled)

Treatment	Soybean Equivalent yield (Kg/ha)	Net returns (Rs/ha)	B:C ratio	Energy input (MJ/ha)	Energy output (MJ/ha)	Net energy (MJ/ha)	Energy use efficiency (%)	Energy productivity (Kg/ha)	Energy intensiveness (MJ/ha)
Control	4015	28435	4.69	8926	118285	109329	13.25	0.47	0.22
50% NPK	4092	28102	4.22	10771	117148	106377	10.87	0.40	0.26
100% NPK	4235	28363	3.91	12805	121866	109061	9.52	0.34	0.30
150% NPK	4142	26500	3.46	14639	116587	101948	7.96	0.29	0.36
100% NPK+HW	4131	26627	3.52	13261	121155	107894	9.14	0.32	0.32
100% NPK+Zn	3874	25082	3.56	13850	111353	97503	8.04	0.29	0.36
100% NPK+FYM	4349	29189	3.93	12835	125592	112757	9.78	0.35	0.30
100% N	4087	28788	4.60	11361	116396	105035	10.24	0.38	0.28
100% NP	4175	27955	3.90	12471	120590	108119	9.67	0.35	0.30
100% NPK-Sfree	4371	30774	4.60	13049	123656	110607	9.48	0.35	0.30
CD (P=0.05)	140	1299	0.38	1476	3717	3980	0.64	0.04	0.03

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PERFORMANCE OF GROUNDNUT-BASED INTERCROPPING SYSTEMS UNDER VARYING LEVELS OF IRRIGATION

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ABSTRACT

Field experiments were conducted at College of Agriculture, Rajendranagar, Hyderabad for two rabi seasons (1991-93) to evaluate the performance of groundnut-based intercropping systems under variable water supply. The results indicated that groundnut pod equivalents were significantly more when irrigations were scheduled at 1.0 IW/CPE ratio in comparison to 0.8 IW/CPE ratio, but it was on par with 1.2 IW/CPE ratio. Among different cropping systems, intercropping of either sunflower or mustard in groundnut was equally effective and recorded significantly higher groundnut pod equivalents, net returns and yield per unit amount of water in comparison to other combinations. The yield advantage with groundnut/sunflower and groundnut/mustard intercropping systems varied between 32 to 36 *per cent* and 34 to 35 *per cent*, *respectively*.

Key Words : Irrigation, intercropping, groundnut, mustard, sunflower, pigeonpea.

INTRODUCTION

Probably the most common cause of higher yields from intercropping over sole cropping is the improved use of growth resources. For example, Fisher (1997) suggested that intercropping was advantageous when the moisture supply was adequate but not when it was limited. On the otherhand Willey et al. (1985) reported that in millet/greengram intercropping system the yield advantage improved from 14% in well-watered (298mm) treatment to 93% in stressed (11 mm) treatment. They also observed that in millet/groundnut intercropping system the increased yields in the intercrop were partly because of a greater total water use, and partly because of reduced evaporation losses.

However, the research work on intercropping systems in relation to moisture supply till now was limited to replacement series, wherein the population of each component crop was only a portion of its sole crop. Very meagre information is available on the additive series where total plant populations are greater in intercropping than in sole cropping. Hence an experiment was conducted to study the performance of groundnut based intercropping system under variable moisture supply in rabi season.

MATERIALS AND METHODS

Field experiments were conducted in 1991-92 and 1992-93 *rabi* seasons at Agriculture College Farm, Andhra Pradesh Agricultural University, Hyderabad, on a sandy loam soil. The treatments consisted of three irrigation levels (0.8, 1.0 and 1.2 IW/CPE ratio) as main plot treatments and seven cropping systems (sole groundnut, sole sunflower, sole mustard, sole pigeonpea, groundnut + sunflower, groundnut + mustard, and groundnut + pigeonpea) as sub-plot treatments. The experiment was laidout in split-plot design with four replications. The experimental soil had N, P_2O_5 and K_2O @ 215, 20.75 and 305 kg/ha, respectively. Whereas the pH and EC were 7.46 and 0.28 dS/m, respectively. The average soil moisture retentivity of 60 cm soil depth was 0.17 cm^3/cm^3 at -0.033 MPa and 0.077 cm^3/cm^3 at -1.5 MPa. The average bulk density of 0-60 cm soil depth was 1.6 g/cm^3. The ground water table was below 8 m from the ground surface.

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The varieties of different crops under test were ICGS-11, APSH-11, Seetha, and MRG-66 for groundnut, sunflower, mustard, and pigeonpea, respectively. The base crop (groundnut) population was maintained at 100 per cent, while the component crops in intercropping system were sown at 50 per cent of sole crop population in 3:1 row arrangement. Thus the recommended fertilizer dose (20:60:40 kg NPK/ha) was given for both, sole groundnut and groundnut in intercropping system treatments. Likewise for sole sunflower (75:90:30 kg NPK/ha), sole mustard (80:60:60 kg NPK/ha) and sole pigeonpea (20:50:40 kg NPK/ha) recommended fertilizer schedule was adopted. Whereas for component crops fifty per cent of the recommended fertilizer dose of sole crop was applied.

An irrigation water depth (IW) of 5.0 cm was maintained in IW/CPE ratios. The CPE was measured in U.S class A pan evaporimeter. The water was measured by installing a parshall flume (7.5 cm throat width) in the field channel. Irrigation treatments were administered after giving two common irrigations (50 mm each) for germination and establishment of the crop. The soil moisture in different depths viz., 0-20, 20-40, and 40-60 cm before and after each irrigation was monitored by following gravimetric methods, which facilitated the estimation of crop evapotranspiration (Eta).

For the purpose of comparison of different intercropping systems with sole base crop (groundnut) the yields of component crops (Table 1) were converted into pod equivalents to get the total productivity as follows :

$$\text{Groundnut pod equivalent} = \text{Yield of groundnut in intercropping system} + \frac{\text{Yield of intercrop} \times \text{Unit price of intercrop}}{\text{Unit price of groundnut yield}}$$

Further to assess the efficiency of an intercropping system the land equivalent ratio (LER) was worked out as suggested by Mead and Willey (1980) and the net returns were calculated.

RESULTS AND DISCUSSION

Leaf area and dry matter accumulation

Application of water equivalent to that lost in pan evaporation (1.0 IW/CPE ratio) recorded significantly higher leaf area and dry matter per plant in case of groundnut and sunflower (Table 2 and 3) when compared to 0.8 IW/CPE ratio. Scheduling irrigations beyond 1.0 IW/CPE ratio did not prove to be advantageous (Cox and Jolliff, 1986; Patel *et al.*, 1988). Conversely for mustard and pigeonpea, leaf area and dry matter were significantly more at 0.8 IW/CPE ratio in comparison to either 1.0 or 1.2 IW/CPE ratio (Singh *et al.*, 1994; Singh and Ressell, 1980). But the latter two treatments (1.0 and 1.2 IW/CPE ratio) were on par in both the crops and seasons except that the dry matter recorded at 1.2 IW/CPE ratio in mustard was inferior to 1.0 IW/CPE ratio.

As expected the sole crops of groundnut, sunflower, mustard and pigeonpea recorded significantly more leaf area and dry matter per plant in both the seasons when compared to intercropping situation probably owing to competition between component crops in intercropping for growth resources. However, it was also observed that under intercropping situation all the intercrops exhibited statistically similar effect on groundnut leaf area and dry matter per plant except that the leaf area under sole groundnut and groundnut intercropped with pigeonpea were on par. Likewise the difference between dry matter accumulated by sole groundnut and groundnut intercropped with sunflower was not significant.

Yield, net returns and LER

Crop yields obtained in different cropping systems were translated into groundnut pod equivalents for valid statistical comparison and

Table 1 : Yield of sole and intercrops as influenced by IW/CPE ratio and cropping systems

Treatment	Grain yield, kg ha⁻¹ 1991-92 0.8 IW/CPE	1991-92 1.0 IW/CPE	1991-92 1.2 IW/CPE	1992-93 0.8 IW/CPE	1992-93 1.0 IW/CPE	1992-93 1.2 IW/CPE
Cropping system						
C_1 - Sole groundnut	2015	2648	2714	2156	2869	29'1
C_2 - Sole sunflower	1361	2100	1805	1396	2225	1855
C_3 - Sole mustard	1212	1159	1021	1320	1138	1057
C_4 - Sole pigeonpea	1247	977	783	1340	1078	961
C_5 - Groundnut + sunflower	1752 (497*)	2333 (778)	2482 (941)	1919 (557)	2577 (795)	2649 (1002)
C_6 - Groundnut + Mustard	1823 (590)	2277 (465)	2319 (337)	2035 (566)	2537 (576)	2509 (433)
C_7 - Groundnut + pigeonpea	1528 (469)	1996 (349)	2242 (399)	1719 (607)	2255 (423)	2468 (399)

* Figures in parentheses are intercrop yields

Table 2 : Effect of irrigation and cropping systems on leaf area per plant (cm^2) and dry matter production per plant (g) of groundnut

	Leaf area/plant at 90 DAS (cm^2)		Dry matter production at harvest (g/plant)	
	1991-92	1992-93	1991-92	1992-93
IW/CPE ratio				
0.8	1116.5	1182.6	17.24	18.51
1.0	1250.6	1389.5	19.49	20.87
1.2	1269.2	1425.2	19.91	21.37
C.D. (P=0.05)	58.4	74.6	1.84	2.28
Cropping system				
Sole groundnut	1309.8	1402.9	20.78	22.09
Groundnut + sunflower	1174.7	1299.2	18.85	20.19
Groundnut + mustard	1159.3	1284.4	18.64	19.82
Groundnut + pigeonpea	1204.6	1343.3	17.25	18.90
C.D. (P=0.05)	52.3	65.8	1.88	2.11

Table 3 : Leaf area per plant (cm^2) and dry matter production per plant (g) of intercrops as influenced by irrigation and cropping systems

Treatment	Sunflower				Mustard				Pigeonpea			
	Leaf area		Dry matter		Leaf area		Dry matter		Leaf area		Dry matter	
	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93
IW/CPE ratio												
0.8	2710	2885	70.15	74.65	845.7	891.1	12.37	12.85	522.2	547.4	12.8	13.6
1.0	3429	3579	85.73	90.43	781.7	829.1	11.89	12.00	480.6	500.8	11.0	11.6
1.2	3272	3326	82.18	86.29	765.2	813.6	10.31	10.82	465.6	488.1	10.5	11.1
C.D. (P=0.05)	289	436	9.23	9.50	22.7	23.9	0.62	0.66	19.9	24.2	1.1	1.2
Cropping system												
Sole	3317	3468	85.89	91.10	811.9	862.5	12.07	12.48	502.7	522.6	12.7	13.3
Intercrop	2957	3059	72.82	76.18	783.2	826.7	10.99	11.30	476.3	501.6	10.2	10.9
C.D. (P=0.05)	256	357	10.89	11.03	19.9	19.6	0.73	0.68	19.4	19.4	1.1	1.4

presented in Table 4.

Irrigations scheduled at 1.0 IW/CPE ratio gave significantly higher pod equivalent yields in comparison to 0.8 IW/CPE ratio, but the difference between 1.0 and 1.2 IW/CPE ratio was not significant in both the seasons. On an average, irrigations at 1.0 and 1.2 IW/CPE ratio recorded 18.3 and 15.1 per cent more pod equivalents respectively than irrigations at 0.8 IW/CPE ratio. Higher pod yield equipments under 1.0 IW/CPE ratio could be attributed to favourable soil water balance as indicated by evapotranspiration: potential evapotranspiration ratio (an index of soil water deficit), which was more than 1.0 at mid season stage (Ritchie, 1981). This might have aided the plants to putforth more photosynthetic surface (leaf area) thus contributing to more dry matter (Table 1 and 2) and finally the crop yield. The yield was positively related to leaf area (r=0.912) and dry matter (r=0.942) Likewise pod yield showed a significant relation with seasonal crop evapotranspiration (r=0.965)

Among the sole and intercropping combinations the yield in terms of pod equivalents was significantly more when groundnut was intercropped either with sunflower or mustard in comparison to other combinations. This advantage may be due to temporal complementarity. It occurs when component crops make their major demands on resources at different times during the season (Willey *et al.*, 1985). Significantly lower pod equivalents were recorded in sole pigeonpea system. Similar trends were noticed with net returns in relation to irrigation.

Further the LER values indicated that the yield advantage with groundnut/sunflower and groundnut/mustard intercropping system was more and varied between 32 to 36 per cent and 34 to 35 per cent, respectively. Whereas the yield advantage amounted to 22 to 27 per cent in groundnut/pigeonpea intercropping system. Similar observations with different intercropping systems involving annual crops were made by Natrajan and Willey (1981) and Willey *et al.*, (1983).

Crop evapotranspiration and WUE

Each higher level of IW/CPE ratio appreciably increased the seasonal Eta in both the seasons (Table 5). This could be attributed to adequate soil water balance in the crop root zone with high frequency irrigation schedule (1.2 IW/CPE ratio) contributing to enhanced water loss in the form of Eta from the cropped field (Singh and Singh, 1991).

With regard to cropping systems, water use in intercropping systems was more than sole corps. Whereas in intercropping systems seasonal crop Eta was more in groundnut/pigeonpea combination owing to longer crop duration and probably due to better root proliferation and also earlier plant coverage of interrow space due to differences in crop growth habits (Singh and Russell, 1980). Expectedly lower crop Eta was noticed in mustard and sunflower sole crops due to their short duration.

Crop water use efficiency showed an inverse relationship with IW/CPE ratios in both the seasons (Table 5) (Bhan, 1981). Among cropping systems, groundnut/mustard intercropping system used water more efficiently, followed by groundnut/sunflower combination. Higher water use efficiency under intercropping systems could be attributed to higher pod equivalents with out proportionate increase in crop Eta.

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Table 4 : Groundnut pod equivalents, LER and net returns as influenced by IW/CPE ratios and cropping systems.

	Groundnut pod equivalent (kg/ha^{-1})		Land equivalent ratio (LER)		Net returns (Rs/ha^{-1})	
	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93
IW/CPE ratio						
0.8	1985	2254	1.00	1.00	12726	11833
1.0	2373	2645	1.00	1.00	15853	14738
1.2	2303	2578	1.00	1.00	15515	14170
C.D. (P=0.05)	187	199			1835	855
Cropping system						
Sole groundnut	2459	2646	1.00	1.00	16486	14388
Sole sunflower	1798	1989	1.00	1.00	12237	10979
Sole mustard	1923	2235	1.00	1.00	13173	12625
Sole pigeonpea	1056	1288	1.00	1.00	6205	6369
Groundnut + sunflower	2946	3237	1.36	1.32	20008	17894
Groundnut + mustard	3013	3360	1.34	1.35	19846	18769
Groundnut + pigeonpea	2349	2693	1.27	1.22	14928	14087
C.D. (P=0.05)	255	273	0.08	0.10	2395	2018
I x C interaction	NS	NS	NS	NS	NS	NS

Table 5 : Influence of irrigation and cropping systems on seasonal evapotranspiration and crop water use efficiency

	Evaportranspiration (mm)		Crop water use efficiency (kg.ha mm)	
	1991-92	1992-93	1991-92	1992-93
IW/CPE ratio				
0.8	312.9	310.8	6.36	7.24
1.0	383.2	380.4	6.19	6.96
1.2	415.1	410.0	5.49	6.22
Cropping system				
Sole groundnut	371.4	363.2	6.59	7.26
Sole sunflower	314.3	312.2	5.71	6.36
Sole mustard	310.9	303.3	6.27	7.51
Sole pigeonpea	369.2	365.5	2.96	3.64
Groundnut + sunflower	406.4	403.4	7.21	7.99
Groundnut + mustard	402.6	406.2	7.60	8.37
Groundnut + pigeonpea	417.9	415.8	5.64	6.53

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INTEGRATED NUTRIENT MANAGEMENT IN RAINFED CASTOR ALLEY CROPPED WITH SUBABUL (*Leucaena leucocephala*)

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ABSTRACT

The study on economics of castor alleycropped with *Leucaena leucocephala* under integrated use of organic and inorganic sources of nitrogen revealed that the yields of castor were significantly superior under alley cropping of castor to over the yields obtained under sole cropping. Green leaf manuring with Leuceana leaves resulted in higher yield in alley cropping and in sole cropping than without green leaf manuring. During both the years application of 80 kg N ha^{-1} gave superior seed yields to other levels. Integrated use of 40 kg N ha^{-1} with green leaf manuring under alley cropping produced significantly higher seed yields than 80 kg N ha^{-1} without green leaf manuring under sole cropping. The net returns obtained were significantly higher in alley cropping during both the years of study than sole cropping. Similarly the net returns were maximum with green leaf manuring in alley cropping during 1995 and 1996. Nitrogen at lower levels resulted in lower net returns in both the years. However conjunctive use of 40 kg N ha^{-1} with green leaf manuring gave higher net returns of Rs. 3659 ha^{-1} (1995) and 2257 ha^{-1} (1996) than 80 kg N ha^{-1} without green leaf manuring under sole cropping. Benefit : cost ratio was significantly higher in alley cropping. Green leaf manuring in alley cropping resulted in better benefit cost ratio than 80 kg N ha^{-1} without green leaf manuring under sole cropping. Both leaf area and leaf area index of castor recorded during first year was found significantly high in alley cropping with integrated use of 40 kg N ha^{-1} and green leaf manuring.

Key Words : Integrated nutrient management, alley cropping, greenleaf manuring, Leucaena, Castor.

INTRODUCTION

India, one of the most populous country in the world needs vertical growth as the horizontal growth is no more possible. Increased productivity through use of improved cultivars, biological pest control, efficient management of land and water resources and integrated nutrient management are some of the means of achieving vertical growth. The integrated nutrient management is of particular interest, because the approach has immense potential to maximise the productivity as it encourages use of organic manures, minimizes the use of inorganic fertilizers and maximises the efficiency of applied fertilizers. Alley cropping, a version of agro-forestry, specially promotes the use of tree leaves as organic manures and augments the yields of associated crops by maximizing efficiency of applied fertilizers in the system (Kang *et al.*, 1981). The returns obtained were higher in alley cropping with *Leucaena* than sole cropping of arable crops (Singh *et al.*, 1987). Hence the present investigation was initiated.

MATERIALS AND METHODS

A field study on the effect of integrated nutrient management on yield and economics of castor alley cropped with subabul (*Leucaena leucocephala*) was carried out during *Kharif* 1995 and 1996 at students Farm, College of agriculture, Rajendranagar, Hyderabad. The experimental site was under five year old subabul plantations, spaced at 4x3m which was medium in available N, high in available P and K with high organic carbon content. The entire tree planted area was with 7 alleys and 8 trees of *Leucaena* in each alley were pollarded at 2-3m height and the lopped green

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foliage was collected and applied at 5 t/ha to half of the area in tree and open area. The green foliage of *leucaena* was incorporated 10 days before sowing. Thus the treatments comprised two cropping systems *viz*. Green leaf manuring (t/ha^{-1}) and no green leaf manuring and three levels of nitrogen - 0, 40, 80 kg N/ha replicated thrice in factorial RBD.

The plot size was 6 x 4m. Castor variety *'Aruna' was sown at a spacing of 60 x 30cm both in* pollarded trees and open area which was fertilized with 60 kg ha^{-1} each of P and K at the time of sowing, while nitrogen was applied as per the treatments in two splits. Gross and net returns and benefit; cost ratio was computed adopting standard formulae. Leaf area was measured using LICOR leaf area meter during first year.

RESULTS AND DISCUSSION

Leaf area and Leaf area index

Both leaf area and leaf area index of castor were significantly influenced by the cropping system (Table 1) where alley cropped castor had more leaf area and LAI with values of 2572.1 cm^2 and 1.417 respectively over sole cropping of castor (178.7 cm^2 and 0.991). Less competition for light with improved site conditions could be the reason for better growth of castor under alley cropping.

Incorporation of green leaves of *leucaena* resulted in significantly higher area and LAI of *2809.2 cm^2 and 1.537, respectively in alley cropping* as against 2396.3 cm^2 and 1.331 respectively in sole cropping as compared to no green leaf manuring which could be due to increased organic matter content leading to higher leaf area and LAI of castor (Subba Reddy *et al.*, 1991).

Though 80 kg N/ha^{-1} produced higher leaf area and LAI of castor (2791.4 cm^2 and 1.204), combined use of 40 kg N/ha^{-1} with 5 t/ha of green leaf manuring under alley cropping recorded significantly higher leaf area and LAI than 80 kg N/ha^{-1} without green leaf manuring under sole cropping.

Table 1: Leaf area (cm^2) index of castor at 120 DAS as influenced by cropping systems, greenleaf manuring and nitrogen levels during 1995.

Treatments	Leaf area (cm^2)				Leaf area index			
	N_0	N_{40}	N_{80}	Mean	N_0	N_{40}	N_{80}	Mean
Alley cropping								
Green leaf manuring	1808.7	2888.0	3730.9	2809.2	0.936	1.604	2.072	1.537
No green leaf manuring	1677.9	2506.9	2820.1	2334.9	0.932	1.392	1.566	1.297
Mean	1743.3	2697.4	3275.5	2572.1	0.934	1.498	1.819	1.417
Sole cropping								
Green leaf manuring	1790.4	2560.7	2837.8	2396.3	0.991	1.424	1.576	1.331
No green leaf manuring	212.9	1529.4	1777.1	1173.2	0.118	0.849	0.987	0.651
Mean	1001.7	2045.1	2307.4	1784.7	0.554	1.137	1.281	0.991
Total mean	1372.5	2371.2	2791.4	2178.4	0.744	1.317	1.550	1.304
CD = (0.05)								
Cropping systems (F1)	22.9							
Green leaf manuring (F2)	22.9							
Nitrogen levels (F3)	28.1							
Between F1 x F2	32.4							
Between F1 x F3	39.7							
Between F1 x F2 x F3	56.1							

Seed yield

Alley cropped castor offered a seed yield of 598.9 and 474.5 kg/ha during 1995 and 1996, respectively which was superior to that of sole cropping. Higher yields in alley cropping were also reported by Singh *et al.*, (1987).

Application of green leaf manuring resulted in higher yields as compared to without green leaf manuring both under alley cropping and under sole cropping. Better growth of castor with more leaf area, leaf area index and yield components through enhanced availability of nutrients and moisture with more organic matter could be the reasons for increased yield with green leaf manuring. The results of present study are in conformity with the findings of Kang *et al.*, (1991) (Table 2).

Application of nitrogen at 80 kg/ha though individually resulted in significantly higher yields of castor, integrated use of 5 t/ha of green leaf of *leucaena* along with 40 kg N/ha under alley cropping produced maximum seed yields of 708.3 kg ha^{-1} (1995) and 559.3 kg ha^{-1} (1996) than 80 kg N/ha without green leaf manuring under sole cropping (584.0 and 218.7 kg ha^{-1}, respectively). Timely and increased release of nutrients through efficient mineralization of organic matter might be the reason for higher yields of castor. Reports of Kang *et al.*, (1981) and Subba Reddy *et al.*, (1991) corraborate the findings of our study.

Economics

Net returns differed significantly due to cropping systems (Table 3) where higher returns of Rs. 2874/ha^{-1} (1995) and Rs. 1593/ha^{-1} (1996) were obtained under alley cropping than sole cropping (1761 and 463 Rs/ha^{-1}). Similar results were reported with alley cropping (Singh *et al.*, 1987).

Green leaf manuring of *Leucaena* in alley cropping resulted in higher returns of Rs. 3295/ha (1995) and Rs. 1813 ha^{-1} (1996). Similarly in sole cropping green leaf manuring produced more

Table 2: Seed yields (kg/ha) of castor as influenced by cropping systems, green leaf manuring and nitrogen application.

Treatments	1995				1996			
	N_0	N_{40}	N_{80}	Mean	N_0	N_{40}	N_{80}	Mean
Alley cropping								
Green leaf manuring	423.2	708.3	877.7	669.4	449.1	559.3	529.1	512.5
No green leaf manuring	355.5	542.3	687.4	528.4	406.8	443.4	460.7	436.9
Mean	388.8	625.3	782.6	598.9	427.9	501.4	494.9	474.5
Sole cropping								
Green leaf manuring	324.7	575.6	693.1	531.1	296.5	318.6	331.2	315.4
No green leaf manuring	247.9	416.6	584.0	416.2	212.8	215.3	218.7	215.6
Mean	286.3	496.2	638.5	473.6	254.6	266.9	274.9	265.5
Total mean	337.5	560.7	710.5	536.3	341.3	384.2	384.9	370.1
CD = (0.05)								
Cropping systems (F1)	21.6		7.68					
Green leaf manuring (F2)	21.6		7.68					
Nitrogen levels (F3)	26.4		9.41					
Between F1 x F2	30.5		18.8					
Between F1 x F3	37.4		10.8					
Between F1 x F2 x F3	82.9		13.3					

Table 3: Net returns (Rs/ha^{-1}) as influenced by cropping systems, green leaf manuring and nitrogen.

Treatments	1995 N_0	1995 N_{40}	1995 N_{80}	1995 Mean	1996 N_0	1996 N_{40}	1996 N_{80}	1996 Mean
Alley cropping								
Green leaf manuring	1373	3659	4853	3295	1608	2257	1573	1813
No green leaf manuring	749	2511	4102	2454	1224	1567	1330	1374
Mean	1061	3085	4477	2874	1416	1952	1452	1593
Sole cropping								
Green leaf manuring	439	2811	3514	2255	355	324	873	517
No green leaf manuring	0	1316	2489	1268	113	395	596	368
Mean	219	2063	3002	1761	234	359	734	443
Total mean	640	2574	3740	2318	843	1136	1075	1018
CD = (0.05)								
Cropping systems (F1)	198.6		208.9					
Green leaf manuring (F2)	198.6		208.9					
Nitrogen levels (F3)	243.3		255.8					
Between F1 x F2	280.0		295.4					
Between F1 x F3	344.1		361.8					
Between F1 x F2 x F3	486.6		511.7					

returns during 1995 (2255 Rs ha^{-1}) and 1996 (517 Rs. ha^{-1}) than without green leaf manuring because of higher seed yields. The results of present study are in conformity with the findings of Kang *et al.*, (1981).

Though, higher dose of 80 kg N/ha gave significantly higher net returns, combined use of 40 kg N/ha and green leaf manuring with *Leucaena* resulted in significantly higher returns over 80 kg N/ha without green leaf manuring under sole cropping. Integrated use of organic and inorganic sources of nitrogen resulted in higher seed yields and thereby higher net returns. Bheemaiah *et al.*, (1995) obtained similar results with *insitu* green leaf manuring of *F. albida* tree leaves in conjunction with 40 kg N/ha.

Benefit : Cost Ratio

The benefit cost ratio was found significantly higher in alley cropped castor (Table 4) with values of 0.994 and 0.568 during 1995 and 1996, respectively than sole cropping.

Both in alley cropping and sole cropping green leaf manuring with *leucaena* resulted in increased benefit : cost ratio with values of 1.087 (1995) and 0.612 (1996) and 0.807 (1995) and 0.228 (1996) respectively as compared to no green leaf manuring. Higher seed yields compensating the cost of green leaf manuring could be the reason for higher benefit cost ratio both in alley cropping and green leaf manuring.

Lower dose of nitrogen application was less beneficial in rainfed castor as compared to higher dose of 80 kg N/ha. However integrated use of nitrogen with 40 kg N/ha along with 5 t/ha^{-1} green leaf incorporation was found to increase the yield and returns of the castor leading to higher benefit cost ratio of 1.306 (1995) and 0.753 (1996) *over 80 kg N without green leaf manuring under* sole cropping (0.829 and 0.210) (Singh *et al.*, 1981).

The results of the present study indicated

Table 4: Benefit Cost Ratio of castor as influenced by cropping systems, green leaf manuring and nitrogen.

Treatments	1995				1996			
	N_0	N_{40}	N_{80}	Mean	N_0	N_{40}	N_{80}	Mean
Alley cropping								
Green leaf manuring	0.528	1.306	1.579	1.087	0.463	0.753	0.620	0.612
No green leaf manuring	0.288	0.837	1.427	0.901	0.440	0.470	0.603	0.504
Mean	*0.816*	*1.072*	*1.502*	*0.994*	*0.451*	*0.611*	*0.611*	*0.568*
Sole cropping								
Green leaf manuring	0.168	1.081	1.172	0.807	0.176	0.240	0.270	0.228
No green leaf manuring	0	0.506	0.829	0.445	0.040	0.190	0.210	0.146
Mean	0.083	0.793	1.007	0.626	0.108	0.215	0.240	0.187
Total mean	0.449	0.932	1.254	0.810	0.279	0.413	0.425	0.372
CD = (0.05)								
Cropping systems (F1)	0.071		0.039					
Green leaf manuring (F2)	0.071		0.039					
Nitrogen levels (F3)	0.087		0.048					
Between F1 x F2	0.101		0.055					
Between F1 x F3	*0.123*		*0.068*					
Between F1 x F2 x F3	0.174		0.096					

that the yields and returns of rainfed castor can be enhanced by growing it under pollarded *leucaena* trees (Alley cropping) than growing alone. The returns can further be increased due to incorporation of 5 t/ha *Leucaena* leaves.

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EFFECT OF INTRA - ROW SPACINGS ON SPANISH BUNCH GROUNDNUT VARIETIES UNDER RAINFED CONDITIONS

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ABSTRACT

To assess the possibility of reducing the seed rates in groundnut without any appreciable decrease in the pod yield, a trial was conducted on four varieties of Spanish bunch groundnut with three intra row spacings of 15, 10 and 7.5 cm, with a common 30 cm inter row spacing. The results of two year data indicated maximum pod yield with K-134 (831 kg/ha) followed by ICGS-E-27 (761 kg/ha). Though closer spacing of 30 x 7.5 cm recorded highest pod and haulm yields, the differences among the spacings were not significant with regards to pod yield. The recommended spacing of 30 x 10 cm was found to he better for rainfed groundnut.

Key Words : Intra row spacing, groundnut varieties.

INTRODUCTION

Seed is one of the costly inputs in groundnut cultivation. The recommended seed rate is 100 kg/ ha under rainfed conditions. The crop is generally sown with the help of seed drill with 30 cm inter row spacing and 10 cm intra row spacing. There is necessity to reduce the seed rate to lower the cost of cultivation without any appreciable reduction in the pod yields. Nandania *et al.*, (1992) reported decreased pod and haulm yield with decrease in the inter row spacing and increased pod yields with increase in the seed rates from 80 to 120 kg/ ha. though Sandhu and Hundal (1993) reported that row spacings did not affect the pod yields but stalk yields were higher at closer spacing. Higher pod yields were reported with narrow spacing by El-seesy and Ashoub (1994). To findout the effect of three different plant populations on four Spanish bunch varieties of groundnut, an experiment was conducted in alfisols under rainfed conditions.

MATERIALS AND METHODS

Four Spanish bunch varieties of groundnut (TPT-1, K-134, ICGS-E-27 and TMV2) were tested at three intra row spacings (15, 10, 7.5 cm) with a common inter row spacing of 30cm. The experiment was laid out in factorial randomised block design replicated thrice. The soils are red sandy loam in texture with medium depth (45 cm) and moderate water holding capacity (160 mm per meter depth). They are poor in available nitrogen and phosphorus and medium in available potash. Sowing was done in the first week of July and the crop was harvested in second week of October after 105 days. The rainfall received during crop growth period was 208.6 and 203.6 mm in 1991 and 1992, respectively. The data on final plant stand, number of filled pods per plant, pod and haulm yield were presented in Table - 1.

RESULTS AND DISCUSSION

Rainfall and available soil Moisture

The total amount of rainfall received during the crop growing period was same in both the years. However the distribution of rainfall varied from year to year. Groundnut is moderately deep rooted crop with the effective root zone depth of 90 cm. The crop absorbs moisture mostly from the top

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Table 1 : Yield components and yield of groundnut as influenced by varieties and intra row spacings

	Final Plant Stand/m2			No. of filled pods per plant			Pod yield (kg/ha)			Haulm yield (kg/ha)		
Treatments	1991	1992	Mean	1991	1992	Mean	1991	1992	Mean	1991	1992	Mean
Varieties												
TPT-1	24.1	31.7	27.9	8.3	5.7	7.0	881	626	754	1870	1676	1773
K-134	30.2	32.4	31.3	6.2	7.4	6.8	937	724	831	3189	1585	2387
ICGS-E-27	29.7	36.4	33.1	6.7	5.0	5.9	844	678	761	2448	1588	2018
TMV 2	28.5	32.1	30.3	5.3	5.7	5.5	600	650	625	2715	1720	2118
S.Em±	0.68	1.50		0.39	0.60		71	54		35	77	
C.D. at 5%	1.99	NS		1.14	NS		NS	NS		NS	NS	
Intra row spacing (cm)												
15	21.1	25.9	32.5	7.0	6.2	6.6	763	654	709	2192	1323	1758
10	28.9	33.7	31.3	7.1	5.8	6.5	818	653	736	2658	1737	2198
7.5	32.4	39.9	36.2	5.8	5.8	5.8	870	702	786	2822	1869	2346
Mean	27.5	33.2		6.6	5.9		817	670		2557	1643	
S.Em±	0.59	1.29		0.2	0.5		60	47		30	66	
C.D. at 5%	1.72	3.81		NS	NS		NS	NS		89	NS	

half of rhizosphere. The available moisture holding capacity of the soil is 40 mm for 50 cm depth of soil. The rainfall and available soil moisture (ASM) data for both the years indicated moisture stress conditions for most of the cropping season. More than 50% of moisture was available only during 30-32 standard weeks in both the years.

Final Plant Stand

The variety K-134 recorded significantly higher plant population at harvest in 1991 but was at par with ICGS-G-27. However the differences in the final plant stand among varieties were not significant in 1992. The differences among the intra row spacings were significant in both the years. Closer spacing of 7.5 cm recorded significantly more plant stand compared to normal and wider spacing. It was due to higher seed rate used in the treatment. The crop was subjected to moisture stress conditions for three weeks immediately after sowing in 1991 leading to reduced plant stand compared to 1992 (Table 1).

Number of filled pods per plant

The varieties TPT-1 in 1991 and K-134 in 1992 recorded more number of filled pods per plant. The varietal differences were found to be significant in 1991 only. On the two year average, TPT-1 recorded more number of filled pods per plant followed by K-134. However the number of filled pods per plant were lower than normal (about 15) because of moisture stress conditions prevailed during pod development stage (33 - 37th standard weeks). However there was sufficient soil moisture at the time of flowering in both the years (30-32 standard weeks). The treatment differences due to intra row spacings were not significant.

Pod and haulm yields

Pod yield differences among the varieties were not significant in both years. K-134 recorded higher numaric pod yield of 831 kg/ha. The differences among the intra row spacings were not significant in both the years. It was mainly due to lower number of filled pods per plant. The crop was subjected to moisture stress for most part of the crop growing season except at flowering (30-32 standard weeks). A low rainfall of about 200 mm during entire crop growing period was found insufficient to meet the evapotranspirational demand of the crop.

In 1991, K-134 recorded significantly higher haulm yield followed by TMV2. However the differences in haulm yield were not significant in 1992. On the two year average, K-134 recorded higher haulm yield (2387 kg/ha) followed by TMV2 (2118 kg/ha). Closer spacing recorded more haulm yield but differences were significant only in 1991. The trend in haulm yield followed that of pod yield. Sandhu and Hundal (1993) reported higher haulm yield with closer spacings.

The groundnut variety K-134 was found to be more suitable for alfisols of Rayalaseema region in Andhra Pradesh under rainfed conditions. The normal spacing of 30 x 10 cm can he followed (Basak *et al.*, 1995). There was no significant yield advantage by increasing the seed rate or following closer spacing. Reducing the seed rate was also not advantageous.

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PRODUCTIVITY AND ECONOMICS OF DIFFERENT SOYBEAN-BASED CROPPING SEQUENCES ON THE BLACK SOILS OF KRISHNA-GODAVARI ZONE OF ANDHRA PRADESH

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ABSTRACT

An experiment was conducted during the rainy and post-rainy seasons of 1992-93, 1993-94 and 1994-95 to evaluate the productivity and economic returns of different soybean based cropping sequences in the black soils of Krishna - Godavari zone of Andhra Pradesh. Out of the 7 crop sequences soybean-mustard recorded the maximum soybean equivalent yield, followed by soybean chickpea. Soybean - sorghum offered the least soybean equivalent yield. On the basis of net returns (Rs. 6,114/-) and cost benefit ratio (1.83) soybean - mustard was found to be highly profitable system.

INTRODUCTION

The traditional practice of growing long duration monocrops had landed the farmers into a plethora of problems in the Krishna-Godavari zone of Andhra Pradesh. Consequently, a need for developing alternative cropping systems for efficiently utilising the available limited resources is being felt. Soybean (*Glycine max* L. Merr), a new introduction to Krishna-Godavari zone has made in roads into the traditional cotton belt as a monsoon season crop. This provided a scope for raising a second crop making double cropping feasible under rainfed conditions. Under such situations it calls for a need to identify an appropriate crop sequence for achieving maximum net returns (Tomar and Tiwari, 1990; Jodhao *et al.*, 1994; Thakur and Khan, 1994). Hence, an experiment was conducted to study the production potential and economics of different cropping sequences on the black soils of Krishna - Godavari zone.

MATERIALS AND METHODS

The field experiment was conducted during *kharif* and *rabi* seasons of 1992-93, 1993-94 and 1994-95 at Regional Agricultural Research Station, Lam. The soil was black-clay in texture with a pH of 8.0; 185.00 kg/ha available nitrogen, 12.6 kg/ha available phosphorus and 557.0 kg/ha of available potassium. The total annual rainfall received was 622.5, 578.8 and 1279.4 mm respectively during 1992-93, 1993-94 and 1994-95. The experiment was laid out in a Randomised block design involving 7 crop sequences (Soybean-mustard, soybean-chickpea, soybean-blackgram, soybean-safflower, soybean-sorghum, greengram-soybean and blackgram-soybean) and replicated thrice. The gross plot size was 3.6 m x 6.0 m.

The *kharif* crops were sown in the first week of July and *rabi* crops were seeded in the first week of November during all the three years. Soybean was fertilized with 30, 60 and 40 kg/ha of N, P_2O_5, K_2O and inoculated with *Rhizobium japonicum* in both the seasons. The fertilizer doses in kg/ha of N, P_2O_5, K_20 applied to other crops were as follows : 20-50-0 for greengram, blackgram and chickpea; 60-30-20 for mustard; 40-20-0 for safflower and 75-40-30 for sorghum. The mode of fertilizer application was basal.

The crop varieties used for the experiment were-MACS 201 (*kharif* soybean), Hardee (*rabi* soybean), PDM 54 (greengram), LBG 20

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(blackgram), ICCV 2 (chickpea), Sita (mustard) CSH9 (Jowar), and J2218 (Safflower). All the crops in both the seasons were grown as rainfed. The cost of cultivation was calculated based on the mean cost of inputs and field operations over the three years.

RESULTS AND DISCUSSION

Effect of Seasons

During 1992-93, good yields of *Kharif* crops were recorded which can be attributed to well distributed rainfall during the season, while during 1993-94, there was an early drought and the *kharif* crops suffered due to moisture stress. Blackgram and greengram crops were effected more than soybean. During 1994-95, the total rainfall was very high (1279.4 mm) and crops were damaged due to heavy and continuous cyclonic rains at harvesting stage. Nearly 60% of the rainfall was received at maturity period resulting in seed damage in green gram, blackgram and soybean. During *rabi* season of 1992-93, due to failure of N-E monsoon, crops experienced moisture stress and had to survive on residual moisture alone, where as an amount of 30mm and 50mm rainfall was received during the *rabi* 1993-94 and 1994-95, respectively, at 30-50 days stage of the crops which helped in obtaining better *rabi* yields during both the years.

Crop productivity

Yields of the crops during *Kharif* 1992-93 were good and on par, while during 1993-94 when there was an early drought soybean yielded significantly more than blackgram and greengram. Similarly during 1994-95 when there were excess rains at maturity, soybean yielded significantly higher than greengram and blackgram (Table 1). During *rabi* seasons, the productivity of soybean, mustard and chickpea was higher than blackgram, safflower and sorghum particularly in the years of moisture stress. The total productivity of different sequences expressed as soybean equivalent yield was significantly higher with soybean - mustard during the three years with a mean productivity of 1992 kg/ha, followed by soybean-chickpea (1669 kg/ha).

Economics

The gross monetary return was significantly influenced by crop sequences (Table 2). Soybean-mustard sequence consistently gave the maximum gross returns during all the three

Table 1 : Seed yield of different soybean based crop sequences (kg/ha)

Cropping Sequence	Seed yield kg/ha						Soybean equivalent yield (Kg/ha)			
	1992-93		1993-94		1994-95		92-93	93-94	94-95	Mean
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi				
Greengram-Soyben	1198	484	489	811	674	926	1768	1335	1648	1584
Blackgram-Soybean	1077	487	260	817	821	772	1641	1096	1652	1463
Soybean-Mustard	1222	494	778	593	1126	648	2034	1752	2191	1992
Soybean-Chickpea	1222	466	845	444	1096	509	1828	1422	1758	1669
Soybean-Blackgram	1184	232	911	176	1111	540	1433	1100	1690	1408
Soybean-Safflower	1209	447	967	467	1080	463	1688	1456	1576	1573
Soybean-Sorghum	1198	235	922	309	1126	231	1289	1041	1215	1182
C.D. (0.05)	NS	20.37	149.22	87.89	40.20	188.56	151.8	180.2	238.3	68.8

Table 2 : Monetary returns (Rs./ha) as influenced by different soybean based crop sequences

Cropping Sequence	Gross returns (Rs/ha) 1992-93			1993-94			1994-95			Mean			Mean		
	Kharif	Rabi	Total	Kharif	Rabi	Total	Kharif	Rabi	Total	Kharif	Rabi	Total	cost of Cultiv-ation (Rs/ha)	Net returns (Rs/ha)	Benefit cost ratio
Greengram-Soyben	8,983	3,383	12,371	3,665	5,677	9,342	5,056	6,482	11,537	5,901	5,182	11,083	7,500	3,583	1.48
Blackgram-Soybean	8,075	3,407	11,482	1,950	5,717	7,667	6,155	5,402	11,557	5,394	4,841	10,235	7,500	2,735	1.37
Soybean-Mustard	8,556	5,681	14,237	5,444	6,824	12,267	7,824	6,214	14,038	7,275	6,239	13,514	7,400	6,114	1.83
Soybean-Chickpea	8,556	4,241	12,797	5,913	4,044	9,956	7,670	6213	11,883	7,380	4,166	11,545	8,400	3,146	1.38
Soybean-Blackgram	8,290	1,738	10,028	6,377	1,318	7,695	7,959	4,863	12,822	7,542	2,639	10,182	7,900	2,281	1.29
Soybean-Safflower	8,463	3,355	11,818	6,787	3,520	10,307	7,562	3,470	11,032	7,604	3,448	11,052	9,000	2,052	1.23
Soybean-Sorghum	8,383	634	9,017	6,445	834	7,289	7,975	636	8,614	7,604	702	8,307	6,900	2,057	1.30
C.D. (0.05)	N.S.	155	1,063	1,044	749	1,257	286	1,467	1,573	364	488	660		584	0.09

Market rates (Rs/q) : Soybean 700; Blackgram 750; Greengram 750, chickpea 910; Mustard 1150; Safflower 750; Sorghum 270.

years. The highest mean net returns (Rs. 6,114) were recorded from soybean-mustard followed by greengram-soybean (Rs. 3,583) and soybean-chickpea (Rs. 3,146) sequences. The profitability of soybean-chickpea and soybean-mustard was also reported by Tomar *et al.*, (1996). The lowest net returns were recorded with soybean-safflower and soybean-sorghum. Similarly, the benefit cost ratio of soybean-mustard (1.83) was more than the other sequences.

It can be concluded that the crop sequence soybean-mustard followed by soybean-chickpea or greengram-soybean was found remunerative and may be adopted for black soils of Krishna-Godavari zone of Andhra Pradesh for productive, effective and economic use of available resources.

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EFFICACY OF CONTROLLED RELEASE FORMULATIONS OF GRANULAR INSECTICIDES AGAINST GROUNDNUT LEAFMINER *Aproaerema modicella* DEVENTER (LEPIDOPTERA; GELECHIIDATE)

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ABSTRACT

Certain granular insecticides including controlled release formulations (CR) were evaluated for their efficacy against groundnut leafminer *Aproaerema modicella* Deventer, under rainfed conditions by applying them to the soil in furrows along with fertilizers at the time of sowing. Isofenphos 5G (2kg and 5kg a.i./ha), Carbosulfon 10G (CR) (4kg a.i./ha) and phorate 10G (CR) (4kg a.i./ha) were found significantly more effective and maintained the leafminer population below the economic injury level for 65 to 85 d.a.s. These treatments have also recorded increased pod yields which varied from 17 to 122%. Chlorpyrifos 10G in any formulation was not effective on leafminer. The activity of the natural enemies of groundnut leafminer was not affected by any of these insecticides.

Key words : Groundnut leafminer, granular insecticides, controlled release formulation, natural enemies.

INTRODUCTION

Groundnut, being the major source of edible oil in India, occupies first place in both the area and production, accounting for more than one third of the world area (7 million ha) and a little less than one third (30.8%) of the world production (5.7 million tons). Larger area is covered under rainfed conditions, though it is being cultivated under irrigation also.

The major constraints in the production of groundnut are the insect pests such as leaf miner (*Aproaerema modicella*), white grubs (*Holotrichia* spp.), red headed hairy caterpillar (*Amsacta albistriga* Moore) and cut worm (*Spodoptera litura* (Fb.). Amoung these, the leafminer has been found to cause appreciable yield loss in South India ranging from 15 to 76% (Vittal *et al.*, 1964; Yang and Liu, 1966; Prasad *et al.*, 1971; Lal *et al.*, 1975; Tejkumar, 1979; Anonymous 1985, 1986; Veeresh *et al.*, 1989), in both irrigated and rainfed groundnut. The rainfed groundnut suffers the maximum damage in July-August and the irrigated groundnut is damaged severely in February-March in South India. Nair (1975), Cherian & Basheer (1942) and Kothai (1974) have recorded severe infestations of this pest in Tamil Nadu and Karnataka.

A wide range of insecticides have been used against this pest in spray and dust formulations. Most organophosphates with systemic and strong contact action were quite effective against this pest (Nair, 1975). Monocrotophos, dimethoate, carbaryl and chlorfenvinfos, were found more effective in reducing leafminer damage and for obtaining higher yields (Sangappa and Ali, 1977; Sangappa, 1979). Four sprays of monocrotophos (0.075%) or endosulfan (0.1%) were recommended to protect rainfed groundnut against leafminer damage in Malaysia (Geh and Lim, 1975). Groundnut seeds when treated with carbofuran 50 WP @ 3,5 and 7 g a.i./100 g registered 46 to 71% increased pod yield

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by suppressing the leafminer population for 4 to 6 weeks (Lal *et al.*, 1974).

Application of insecticides either in spray or dust formulations, is the popular method of pest control in groundnut although attempts have been made here and there by applying insecticides as seed dressing or to the soil (Srivastava *et al.*, 1986).

In this study some of the newer granular insecticides including controlled release (CR) formulations were evaluated for their efficacy against groundnut leafminer under rainfed conditions.

MATERIALS AND METHODS

The field trials were conducted during *kharif* 1987 and 1988 at Agricultural Research Station, Chinthamani and Regional Research Station, Gandhi Krishi Vignana Kendra campus of the University of Agricultural Sciences, Bangalore, with Dh 3-30, a bunch type groundnut variety. The experiment was laid out in a randomized block design and the treatments (Table 1) were replicated four times. The plot size and spacing were maintained at 4.0 x 3.0m and 30 cm x 15 cm, respectively. The insecticides were applied in furrows along with the fertilizers at the time of sowing. All the recommended agronomic practices for groundnut cultivation were followed.

Observations on per cent leafminer infestation and number of leafminer larvae/plant were recorded at 45, 65 and 85 d.a.s. The per cent infestation was worked out by counting all the healthy and affected groundnut plants in randomly selected rows in each plot. The larval population was recorded in ten infested plants selected randomly in each plot and average population per plant was worked out. Observations were also made on the occurrence of natural enemies on the pest by collecting known number of larvae and observing them in the laboratory for occurrence of the disease or emergence of parasitoids. Finally the pod yields in an unit area (150 plants/plot) were recorded. The data were statistically analyzed and presented.

RESULTS

The maximum infestation of leafminer during different growth periods varied between 87.11 and 93.44% at ARS, Chinthamani (1987) and between 58.61 and 86.82% at GKVK campus (1988).

During *kharif* 1987 at ARS, Chintamani, significantly more effective insecticides recording lower infestation of leafminer (Table 1 & Fig 1a) were-isofenphos 5G (2kg a.i./ha) (2.14%), carbosulfan 10G (4 kg a.i./ha) (3.2%), isofenphos 5G (5 kg a.i./ha) (6.74%) and phorate 10G (29.10%). The different treatments with chlorphyrifos were found ineffective in suppressing the leafminer infestation and they were on par with untreated check, where the plants presented a typical burnt appearance due to heavy infestation of leafminer.

The trend was similar both at 65 and 85 d.a.s. indicating that these insecticides were effective even at 85 d.a.s. Observations at 45 d.a.s. were not recorded since the level of infestation was negligible.

Experiments at GKVK also showed almost similar results (Table 2). When observed at 45 d.a.s., carbosulfon 10G (5.45%), phorate 10G (2.55%) and isofenphos 5G at both the doses (5.84 and 16.63%) have proved significantly more effective in suppressing the leafminer infestation (Fig 1b). The plots treated with chlorpyrifos have recorded higher infestation of leafminer and were on par with untreated check (47.64 to 67.8%). These four effective treatments have also recorded the lowest larval population per plant (0.04 to 0.64) which varied from 2.22 to 3.24/plant in other treatments including untreated check (Fig 1c).

At 65 d.a.s. similar trend was noticed with respect to the leafminer infestation but the larval population was very less in all the treatments

Table 1 : Efficacy of controlled release (CR) formulations of granular insecticides against A. modicella (ARS, Chinthamani, Kharif 1987).

Treatments	Dosage (Kg.ai/ha)	Mean Percentage infestation		Increase in pod yield (%)
		65 d.a.s.	85 d.a.s.	
Chlorpyrifos 10G	4.00	75.2b	63.41b	31.03
Chlorpyrifos 10G (CR)	4.00	82.56b	79.37b	15.79
Chlorpyrifos 10G (CR)	2.00	62.98b	66.88b	11.59
Chlorpyrifos 10G (CR)	1.00	64.12b	66.88b	1.06
Carbosulfan 10G (CR)	4.00	3.20a	7.37a	112.47
Phorate 10G (CR)	4.00	29.10a	23.50a	90.90
Isofenphos 5G	5.00	2.14a	2.85a	122.60
Isofenphos 5G	2.00	6.74a	10.87a	95.04
Untreated Check	-	93.44b	87.11b	—

In each column values followed by same letter are not significantly different from each other.

including the check, which was mainly due to the higher incidence of the parasitoid and pathogens (Table 3). At 85 d.a.s. the infestation (51.47 to 86.82%) and larval population (3.18 to 7.85 larvae per plant) were high in all the treatments including untreated check indicating that the insecticides have lost their effect at 85 d.a.s.

The plots treated with carbosulfan 10G (4kg a.i./ha) phorate 10G (4 kg a.i./ha) and isofenphos 5G (2 kg and 5 kg a.i./ha) gave significantly higher pod yields. (Fig. 1d) and the per cent increase in the pod yield over untreated check varied between 17.4 and 122.6 in both the places (Table 1 & 2). Isofenphos 5G (5 kg a.i./ha) occupied first place during different years.

The weather data recorded during the crop period indicated that the mean minimum and maximum temperatures at ARS Chinthamani during 1987 were higher (21.9°C & 29.08°C) and relative humidity was lower (61.2%) when compared to GKVK (1988), which were 18.5°C, 27.45°C and 73.35% respectively (Table 4).

The rainfall at ARS, Chanthamani during 1987 was also scanty (about 500 mm) and unevenly distributed. Most of the crop growth period coincided with dry weather conditions. But at GKVK during 1988 the rainfall, right from sowing of the corp, was very frequent and some times heavy. More than 800 mm rainfall was received which was well distributed throughout the crop period (Table 4).

DISCUSSION

In general, the leafminer infestation and its damage was more at ARS, Chaintamani during 1987 as it manifested in the typical burnt appearance of the plants. As stated by Yang and Liu (1966) several factors like size of previous population, rainfall, temperature, relative humidity, extent of activities of hymenopterous parasitoids and pathogens etc., may influence the leafminer population. Lewin et al. (1979) reported that temperature and rainfall play major role, which were positively and negatively

Table 2 : Efficacy of controlled release (CR) formulations of granular insecticides against A. modicella (GKVK, Bangalore, *Kharif* 1988)

Treatments	Dosage (kg.ai/ha)	Mean Percentage infestation			Mean no.of larvae per plant			Increase in pod yield (%)
		45 d.a.s	65 d.a.s.	85 d.a.s.	45 d.a.s	65 d.a.s.	85 d.a.s.	
Chlorpyrifos 10G	4.00	67.12c	50.40df	78.66a	2.95b	0.76bc	7.85a	-
Chlorpyrifos 10G (CR)	4.00	67.80c	56.97df	51.47a	2.22b	0.45ab	5.54a	-
Chlorpyrifos 10G (CR)	2.00	47.64c	64.88df	84.96a	2.35b	0.42ab	7.08a	-
Chlorpyrifos 10G (CR)	1.00	55.29c	56.32df	62.18a	3.24b	1.06bc	4.29a	-
Carbosulfan 10G (CR)	4.00	05.45ab	27.62cd	73.94a	0.08a	0.37ab	3.95a	17.44
Phorate 10G (CR)	4.00	02.55a	07.02ab	72.77a	0.04a	0.02a	6.14a	20.43
Isofenphos 5G	5.00	05.84ab	05.23a	63.67a	0.08a	0.06a	3.18a	22.07
Isofenphos 5G	2.00	16.63b	21.79bc	72.49a	0.64a	0.33ab	4.16a	18.98
Untreated Check	-	58.61c	66.52df	86.82a	2.79b	0.31ab	5.95a	-

In each column values followed by same letter are not significantly different from each other.

Table 3 : Percent mortality of groundnut leafminer larvae due to various natural enemies (GKVK, Bangalore, Kharif 1988)

Period (Fortnight)	Bacillus thuringiensis	Beauveria bassiana	Bracon gelechiae	Virus	Total mortality(%)
Aug. 88					
I F. N.	0.0	0.0	0.0	0.0	0.0
II. F.N.	36.4	27.2	5.2	1.2	70.0
Sep. 88					
I F.N.	18.0	30.8	33.2	1.2	83.2
II F.N.	7.2	27.6	21.2	5.2	61.2
Oct. 88					
I. F.N.	6.0	11.6	10.1	2.8	30.8

correlated with leafminer population. The higher mean maximum and minimum temperature and continuous dry weather conditions prevailed during the crop period during 1987 at ARS Chinthamani might have built up the leafminer population.

During 1988 at GKVK campus the weather conditions were totally different from those of ARS Chintamani. The mean maximum and minimum temperatures were lower and relative humidity was higher which has encouraged the activity of the larval parasitoid and pathogens. When observed

Table 4 : Weather conditions at ARS, Chinthamani (1987) and GKVK, Bangalore (1988) during groundnut crop period (Fortnightly average)

Period (Fortnight)	ARS, Chinthamani (1987)				GKVK, Bangalore (1988)			
	Temperature°C		Relative Humidity (%)	Total Rainfall (mm)	Temperature °C		Relative Humidity (%)	Total Rainfall (mm)
	min.	max.			min.	max.		
Aug.								
I F. N.	22.10	30.85	41.00	37.60	18.98	28.10	73.55	127.00
II. F.N.	22.40	29.10	63.60	17.00	19.40	27.48	75.70	47.40
Sep.								
I F.N.	23.65	31.35	64.00	21.40	18.74	26.64	77.35	158.80
II F.N.	23.50	30.15	48.50	202.80	19.05	27.36	74.38	314.20
Oct.								
I. F.N.	23.10	28.15	69.00	186.30	18.48	26.72	73.87	125.70
II. FN.	20.10	27.46	71.33	24.80	16.43	28.71	65.30	4.00
Nov.								
I. F.N.	18.15	26.50	71.00	15.00	-	-	-	-
Average	21.90	29.08	61.20	-	18.50	27.45	73.35	-

at 65 d.a.s. the larval population was less than one per plant though the incidence was quite high (66.52%). This was mainly due to the heavy mortality of the leafminer larvae (61.2 to 83.2%) by various natural enemies, importantly the larval parasitoid, *Bracon gelechiae* Ashm., (5.2 to 33.2%), the fungus, *Beauveria bassiana* (Balsmo) (27.2 to 30.8%), and the bacterium, *Bacillus thuringiensis* Berliner, (7.2 to 36.4%). The period has coincided with moderate teperature of 18.74°C minimum and 27.36°C maximum with relative humidity 75 to 77% and intermittent rainfall.

The insecticides have also lost their effectiveness faster during 1988 at GKVK. None of the chemicals were found effective at 85 d.a.s. during 1988 where as carbosulfan, phorate and isofenphos were found effective at 85 d.a.s. during 1988, where as they were found effective even at 85 d.a.s. during 1987 at ARS Chinthamani. This may be due to more soil moisture prevailed during the early crop period at GKVK as a result of more frequent rains. The soil moisture play an important role in the persistence of a chemical in the soil and degradation is faster when the moisture content of the soil is high (Harris and Lichtenstein, 1961; Dixit *et al.*, 1974; Siddaramappa and Sethunathan, 1975; Agnihotri *et al.*, 1975).

Arunin (1978) from Thailand and Khan and Raodeo (1979) from India have obtained effective control of leafminer by applying carbofuran, disulfaton and phorate granules to the soil in soybean and groundnut crops respectively. In the present study, carbosulfan 10G (CR), phorate 10G (CR) and isofenphos 5G were able to keep the leafminer population at a minimum level, less than one larva per plant. The economic injury level for groundnut leafminer has been worked out to be 2 larvae per plant (Tej Kumar, 1979) and 1.4 larve per plant or 14 larvae per meter row (Anonymous, 1985). The above insecticides were able to check the leafminer population and kept far below the economic injury level for about 65 to 85 d.a.s. depending on the weather conditions, resulting inincreased pod yields.

It is advantageous to use these granules since there is no additional cost of application involved as they are applied to the soil with fertilizers at the time of sowing. Besides they do not have any adverse effect on the non target organisms particularly the natural enemies and are comparatively less toxic to the soil microorthropods in the groundnut fields (Rajagopal *et al.*, 1990).

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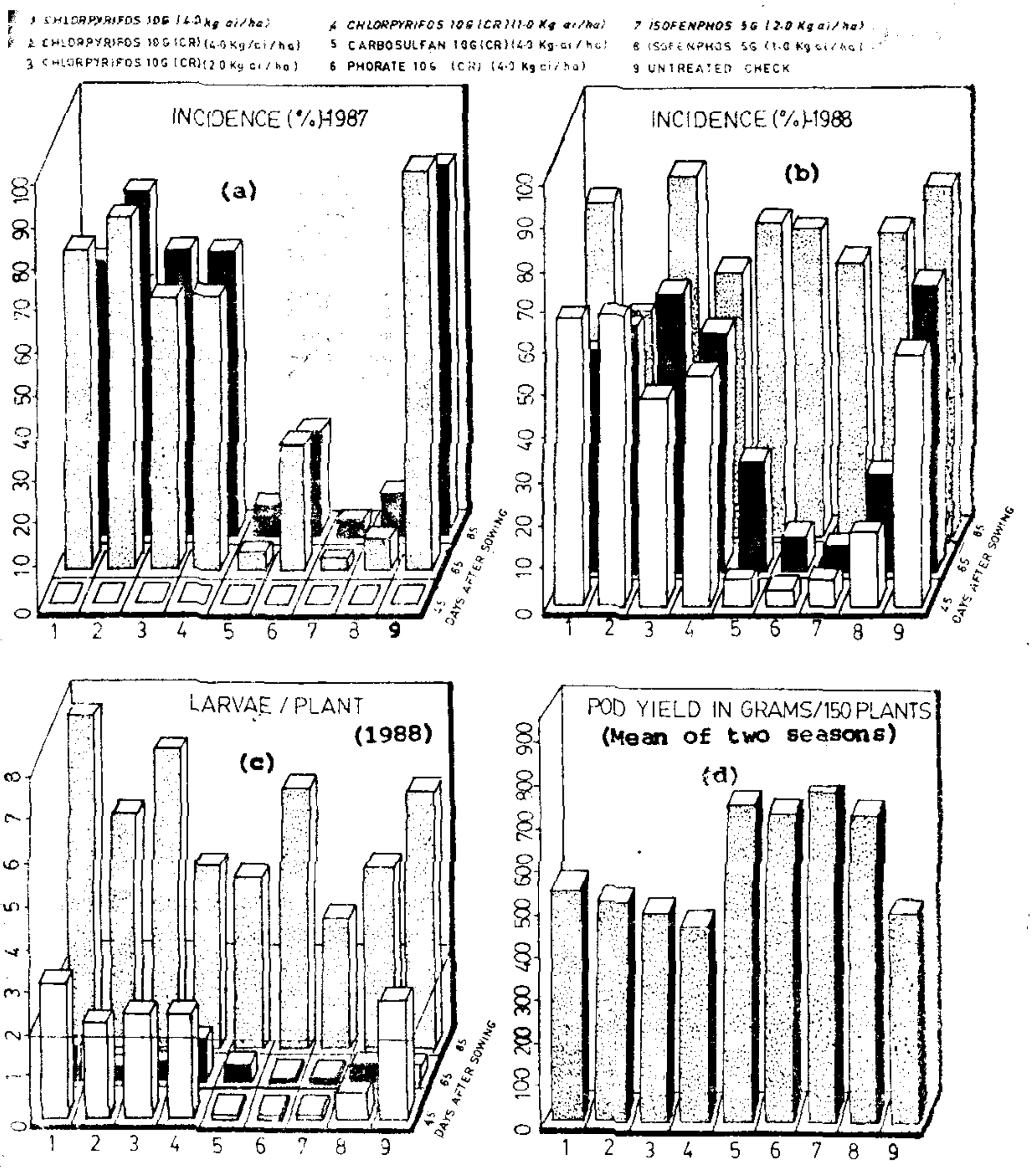

Fig. 1 : Efficacy of granular insecticides against *A. modicella.*

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COMPATIBILITY OF INSECTICIDES AND FUNGICIDE FOR THE MANAGEMENT OF BUD FLY AND ALTERNARIA BLIGHT ON LINSEED

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ABSTRACT

Field experiments for the management of bud fly and Alternaria blight infestation on linseed using different combinations of pesticides viz., phosphamidon 85 SL (0.03%), chlorpyrifos 20 EC (0.05%), endosulfan 35 EC (0.07%), deltamethrin 2.8 EC (0.002%) and mancozeb (0.2%) were carried out at Kanpur during 1994-95 and 1995-96. Significantly low infestation of bud fly (8.92%) and Alternaria blight (8.75%) were recorded in deltamethrin and mancozeb sprayed plots, respectively. The crop treated with endosulfan + mancozeb harboured a total of 36.72 grubs and adults of *Coccinella septempunctata* and *Menochilus sexmaculatus* per metre row length. Two fortnightly applications of phosphamidon + deltamethrin with mancozeb provided lowest total infestation of 19.65 per cent due to bud fly and Alternaria blight with significantly highest seed production of 2231 kg/ha and net monetary return of Rs. 18192/ha with benefit : cost ratio of 12.33, which has total population of predatory coccinelids of 31.13 grubs and adults per metre row length.

Key Words : Linseed, Bud fly, Alternaria blight, coccinellids.

INTRODUCTION

Linseed, *(Linum usitatissimum* Linn.) is an important rabi oilseed crop with an average national productivity of about 350 kg/ha against 600 kg/ha of world level. Among the biotic constraints responsible for its low productivity, the insect-pests are of prime significance. Bud fly, *(Dasyneura lini* Barnes), is the key pest infesting floral buds upto 88 per cent (Pal *et al.*, 1978), whereas Alternaria blight disease (c.o. *Alternaria lini*) tolls upto 57.27 per cent during reproductive phase of the crop (Anon., 1994a). These biotic constraints are more prevalent in Indo-Gangetic plains of the country. However, two fortnightly applications of phosphamidon 85 SL (0.03%), endosulfan 35 EC (0.07%), deltamethrin 2.8 EC (0.002%) or chlorpyrifos 20 EC (90.05%) have been reported economical against bud fly infestation (Jakhmola, 1973; Singh and Mathur, 1986; Singh *et al.*, 1991 and Malik, 1993), While two sprays of mancozeb (0.2%) are recommended for Alternaria blight (Anon., 1994a). Separate application of these pesticides is not only expensive but also deleterious to the fauna and flora. Thus, the present investigations were carried out for the integrated management of bud fly and Alternaria blight infesting linseed with some promising insecticides alone and their combinations with fungicide mancozeb.

MATERIALS AND METHODS

Field trials were conducted at Oilseeds Research Farm, Kalyanpur of C.S.A. Univ. of Agri & Technology, Kanpur on linseed cv. Neelum during rabi 1994-95 and 1995-96. The crop was sown during the end of November in randomised block design replicated thrice in 3x3 m plot size during each year. Sixteen combinations of pesticides schedule (Table 1) were applied at fortnightly interval starting from bud initiation stage of the crop. All recommended agronomical practices were provided to the crop except plant protection measures. Bud fly infestation was recorded as per the standard method of AICORP on linseed

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(Anon., 1994b) and Alternaria blight infection by counting healthy as well as infected buds on three tagged plants replication wise at dough stage. Population of predatory coccinellids was recorded per metre row length one week after second application of the pesticides. The data obtained on infestation of bud fly and Alternaria blight, population of coccinellids and seed yield were recorded during both years and computed on pooled basis for critical differences. Economic analysis of the treatments was done.

RESULTS AND DISCUSSION

Bud Fly Infestation

The bud fly infestation after first spray varied from 3.38 to 18.61 per cent and minimum bud damage was noticed in deltamethrin 2.8 EC (D) treated crop, which was at per with the infestation observed in other treatments (Table 2). After second application, deltamethrin maintained its superiority over the other treatments with significantly minimum (6.80 per cent) bud infestation. At dough stage of the crop too spraying deltamethrin exhibited its superiority over the other treatments having significantly minimum (8.92 per cent) infestation. This was at par with 9.00, 10.16, 10.43, 11.01, 12.00 and 12.15 per cent bud fly infestation noticed in phosphamidon + deltamethrin + mancozeb (PDM), phosphamidon + endosulfan + mancozeb (PEM), deltamethrin + mancozeb (DM), phosphamidon + deltamethrin (PD), chlorpyrifos + mancozeb (CM) and endosulfan (E) treated plots, respectively. Significantly higher bud infestation (44.84%) was recorded in untreated crop, which did not differ significantly from moncozeb (M) sprayed crop. The application of phosphamidon, endosulfan, chlorpyrifos and deltamethrin has also been found very promising by Jakhmola (1973), Singh and Mathur (1986), Singh *et al.*, (1991), Malik (1993) and Singh *et al.*, (1995).

Alternaria blight infection

Alternaria blight infection on floral buds

Table 1 : Shedule of different pesticidal treatments made in the experiment.

Treatments No.	Symbol	First spray	Second spray
T-1	P	Phosphamidon 85 SL (0.03%)	Phosphamidon 85 SL
T-2	C	Chlorpyrifos 20 EC (0.05%)	Chlorpyrifos 20 EC
T-3	E	Endosulfan 35 EC (0.07%)	Endosulfan 35 EC
T-4	D	Deltamethrin 2.8 EC (0.002%)	Deltamethrin 2.8 EC
T-5	PC	Phosphamidon 85 SL	Chlorpyrifos 20 EC
T-6	PE	Phosphamidon 85 SL	Endosulfan 35 EC
T-7	PD	Phosphamidon 85 SL	Deltamethrin 2.8EC
T-8	PM	Phosphamidon 85 SL + Mancozeb	Phosphamidon 85 SL + Mancozeb
T-9	CM	Chlorpyrifos 20 EC + Moncozeb	Chlorpyrifos 20 EC + Moncozeb
T-10	EM	Endosulfan 35 EC + Mancozeb	Endosulfan 35 EC + Mancozeb
T-11	DM	Deltamethrin 2.8 EC + Mancozeb	Deltamethrin 2.8 EC + Mancozeb
T-12	PCM	Phosphamidon 85 SL + Mancozeb	Chlorpyrifos 20 EC + Mancozeb
T-13	PEM	Phosphamidon 85 SL + Mancozeb	Endosulfan 35 EC + Mancozeb
T-14	PDM	Phosphamidon 85 SL + mancozeb	Deltamethrin 2.8 EC + Mancozeb
T-15	M	Mancozeb (0.2%)	Mancozeb
T-16	UT	Untreated	Untreated

varied from 8.75 to 26.54 per cent at dough stage of the crop (Table 2). Crop treated with mancozeb had the lowest bud infestation (8.75%), which did not significantly differ from endosulfan + mancozeb (EM), phosphamidon + deltamethrin + mancozeb (PDM), chlorpyrifos + mancozeb (CM), phosphamidon + mancozeb (PM), deltamethrin + mancozeb (DM), phosphamidon + chlorpyrifos + mancozeb (PCM) and phosphamidon + endosulfan + mancozeb (PEM) having 9.53, 10.62, 10.86, 11.83, 11.91, 15.02 and 15.34 per cent infestation, respectively. Maximum disease incidence (26.54%) was observed in untreated crop. These results are in accordance with Anonymous (1994a).

Total bud infestation due to bud fly and Alternaria blight was minimum (19.65 per cent) in phosphamidon + deltamethrin with mancozeb (PDM) treated crop, which was at par with deltamethrin with mancozeb (DM), chlorpyrifos with mancozeb (CM) and phosphamidon + endosulfan with mancozeb (PEM) treatments having 22.45, 23.09 and 25.83 per cent bud infestation, respectively, against 71.49 per cent in untreated crop. This particular combination reduced 72.51 per cent bud infestation due to bud fly and Alternaria blight. Compatibility of these insecticides with mancozeb may be responsible for minimum bud infestation, as reported by Mathur *et al.*, (1988).

Population of Coccinellids

Grubs as well as adults of *C. septempunctata* and *M. sexmaculatus* were found predating upon the maggots of bud fly and their total number varied upto 26.62 and 15.21 per metre row length in untreated crop, respectively (Table 3). As regards the impact of pesticidal application, maximum population of *C. septempunctata* was observed in deltamethrin (D), whereas endosulfan + mancozeb (EM) sprayed plots harboured 14.36 grubs and adults of *M. sexmaculatus*. Total counts of both coccinellids were to the tune of 36.72, 35.40, 32.83 and 32.60 grubs and adults per metre row length with application of endosulfan + mancozeb (EM), deltamethrin (D), deltamethrin with mancozeb (DM) and endosulfan (E), respectively, against 41.60 in untreated plot. The selectivity of endosulfan and deltamethrin has been noticed against coccinellids feeding upon mustard aphid during flowering stage by Mathur *et al.*, (1988).

Economics

Significantly higher seed yield of 2231 kg/ha with lowest total bud infestation (19.65%) due to bud fly and Alternaria blight was recorded in phosphamidon + deltamethrin with mancozeb (PDM) sprayed crop (Table 4), which provided maximum net return of Rs. 18192 with 12.33 benefit cost ratio. Application of deltamethrin (D), deltamethrin + mancozeb (DM) and phosphamidon + endosulfan with mancozeb (PEM) also provided net monetary return of Rs. 17232, 16651 and 15637 per ha, respectively. However, application of phosphamidon proved to be more economical, as it had highest BCR of 17.42, but gave moderate net monetary return of Rs. 12719 per ha. These results are in accordance to Malik *et al.*, (1995), who reported maximum net monetary return from deltamethrin sprayed crop.

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Table 2 : Efficacy of some pesticidal schedules against bud fly and Alternaria blight infestation in linseed.

Treatment		Bud fly infestation (%)			Alternaria blight infestation (%)	Total bud infestation (%)	Decreased infestation over control (%)	Linseed yield (kg/ha)
No.	Symbol	I spray	II spray	Dough stage				
T-1	P	9.43 (17.89)	14.72 (22.56)	18.75 (25.66)	19.96 (26.54)	38.85 (38.56)	45.65	1712.9
T-2	C	8.03 (16.46)	12.82 (20.98)	16.14 (23.69)	19.94 (26.52)	36.12 (36.94)	49.47	170".8
T-3	E	4.88 (12.77)	8.48 (16.93)	12.15 (20.40)	16.23 (23.76)	28.54 (32.29)	60.08	1921.1
T-4	D	3.38 (10.59)	6.80 (15.12)	8.92 (17.38)	21.25 (27.45)	30.46 (33.50)	57.39	2124.4
T-5	PC	12.89 (20.87)	17.97 (25.08)	27.05 (31.34)	23.05 (28.69)	50.10 (45.06)	29.92	1291.5
T-6	PE	7.75 (16.16)	13.62 (21.66)	16.34 (23.84)	19.35 (26.10)	35.80 (36.75)	49.92	1823.7
T-7	PD	5.42 (13.46)	9.08 (17.54)	11.01 (19.38)	22.47 (28.30)	33.88 (35.60)	52.61	1856.3
T-8	PM	8.37 (16.82)	13.36 (21.44)	16.22 (23.75)	11.83 (20.12)	28.27 (32.12)	60.45	1981.1
T-9	CM	5.53 (13.60)	9.75 (18.20)	12.00 (20.60)	10.86 (19.24)	23.09 (28.72)	67.70	2064.4
T-10	EM	9.35 (17.81)	15.32 (23.04)	18.63 (25.57)	9.53 (17.98)	28.24 (32.10)	60.50	2022.9
T-11	DM	5.18 (13.16)	7.95 (16.38)	10.43 (18.84)	11.91 (20.19)	22.45 (28.28)	68.60	2120.4
T-12	PCM	10.17 (18.60)	18.02 (25.12)	22.27 (28.16)	15.02 (22.80)	37.35 (37.67)	47.75	1504.1
T-13	PEM	4.35 (12.04)	7.34 (15.72)	10.16 (18.59)	15.34 (23.06)	25.83 (30.55)	63.87	2027.4
T-14	PDM	4.85 (12.72)	6.85 (15.17)	9.00 (17.45)	10.62 (19.02)	19.65 (26.31)	72.51	2231.1
T-15	M	16.19 (23.73)	24.17 (29.45)	41.06 (39.85)	8.75 (17.21)	50.05 (45.03)	30.00	930.4
T-16	UT	18.61 (25.56)	32.52 (34.77)	44.84 (42.04)	26.54 (31.01)	71.49 (57.73)	-	592.2
SE (M)		1.71	1.65	1.56	1.54	1.21		89.3
CD 1%		6.67	6.42	6.07	5.99	4.70		347.3

Figures in parentheses are angular transformed values.

Table 3 : Population of coccinellids (No./m row length) in different pesticidal schedules

Treatment No.	Symbol	*C. septempunctata* Grub	*C. septempunctata* Adult	*C. septempunctata* Total	*M. sexmaculatus* Grub	*M. sexmaculatus* Adult	*M. sexmaculatus* Total	Grand Total
T-1	P	3.65 (1.91)	5.47 (2.34)	8.64 (2.94)	3.42 (1.85)	3.31 (1.82)	6.25 (2.50)	14.29 (3.78)
T-2	C	8.58 (2.93)	4.33 (2.08)	12.60 (3.55)	3.61 (1.90)	2.59 (1.61)	5.81 (2.41)	17.47 (4.18)
T-3	E	8.70 (2.95)	12.89 (3.59)	20.98 (4.58)	5.34 (2.31)	7.24 (2.69)	12.11 (3.48)	32.60 (5.71)
T-4	D	10.05 (3.17)	12.62 (3.69)	22.85 (4.78)	4.12 (2.03)	9.36 (3.06)	13.48 (3.60)	35.40 (5.95)
T-5	PC	2.16 (1.47)	2.50 (1.58)	4.16 (2.04)	2.16 (1.47)	1.74 (1.32)	3.46 (1.86)	7.13 (2.67)
T-6	PE	6.05 (2.46)	8.35 (2.89)	13.69 (3.70)	3.61 (1.90)	4.62 (2.15)	7.73 (2.78)	20.70 (4.55)
T-7	PD	8.47 (2.91)	9.36 (3.06)	16.97 (4.12)	5.20 (2.28)	6.97 (2.64)	11.83 (3.44)	28.30 (5.32)
T-8	PM	4.53 (2.13)	4.24 (2.06)	8.35 (2.89)	3.10 (1.76)	4.80 (2.19)	7.45 (2.73)	15.29 (3.91)
T-9	CM	9.86 (3.14)	4.53 (2.13)	13.76 (3.71)	4.08 (2.02)	3.38 (1.84)	7.07 (2.66)	20.16 (4.49)
T-10	EM	11.29 (3.36)	12.18 (3.49)	22.65 (4.76)	4.93 (2.22)	10.11 (3.18)	14.36 (3.79)	36.72 (6.06)
T-11	DM	9.36 (3.06)	13.76 (3.71)	22.47 (4.74)	4.37 (2.09)	6.65 (2.58)	10.43 (3.23)	32.83 (5.73)
T-12	PCM	4.41 (2.10)	3.92 (1.98)	7.95 (2.82)	2.00 (1.41)	2.59 (1.61)	4.12 (2.03)	11.63 (3.41)
T-13	PEM	9.86 (3.14)	10.89 (3.30)	20.07 (4.48)	4.28 (2.07)	8.29 (2.88)	12.25 (3.50)	31.81 (5.64)
T-14	PDM	7.78 (2.78)	11.42 (3.38)	18.40 (4.29)	6.71 (2.59)	6.81 (2.61)	13.10 (3.62)	31.13 (5.58)
T-15	M	7.13 (2.67)	8.06 (2.84)	14.67 (3.83)	3.53 (1.88)	5.95 (2.44)	9.12 (3.02)	22.94 (4.79)
T-16	UT	11.63 (3.41)	15.13 (3.89)	26.62 (5.16)	6.81 (2.61)	9.06 (3.01)	15.21 (3.90)	41.60 (6.45)
SE (M)		0.26	0.22	0.22	0.21	0.22	0.21	0.26
CD 1%		1.01	0.87	0.84	0.80	0.86	0.81	1.01

Figures in parentheses are transformed x values.

Table 4 : Economic analysis of various pesticidal schedules in linseed.

Treatment		Cost of treatment (Rs/ha)			Economic return			Net monetary return (Rs/ha)	Benefit cost ratio (BCR)
No.	Symbol	Cost of insect-cide	Labour + sprayer charge	Total cost	Yield (kg/ha)	Yield increase over control (kg/ha)	Cost of increased yield (Rs/ha)		
T-1	P	250	480	730	1712.9	1120.7	13449	12719	17.42
T-2	C	1330	480	1810	1707.8	1115.6	13387	11577	6.40
T-3	E	896	480	1376	1921.1	1328.9	15947	14571	10.59
T-4	D	675	480	1155	2124.4	1532.2	18387	17232	14.92
T-5	PC	790	480	1270	1291.4	699.3	8391	7121	5.61
T-6	PE	573	480	1053	1823.7	1231.5	14778	13725	13.03
T-7	PD	463	480	943	1856.3	1264.1	151.69	14226	15.08
T-8	PM	782	480	1262	1981.1	1388.9	16667	15405	12.21
T-9	CM	1862	480	2342	2064.4	1472.2	17667	15325	6.54
T-10	EM	1428	480	1908	2022.9	1430.7	17169	15261	8.00
T-11	DM	1207	480	1687	2120.4	1528.1	18338	16651	9.87
T-12	PCM	1322	480	1802	1504.1	911.9	10942	9140	5.07
T-13	PEM	1105	480	1585	2027.4	1435.2	17222	15637	9.86
T-14	PDM	995	480	1475	2231.1	1638.9	19667	18192	12.33
T-15	M	532	480	1012	930.4	338.1	4058	3046	3.01
T-16	UT	-	-	-	592.2	-	-	-	-

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POPULATION BUILD UP OF GROUNDNUT LEAFHOPPER IN RELATION TO WEATHER PARAMETERS

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ABSTRACT

Groundnut leafhopper, *Empoasca kerri* Pruthi (Cicadellidae : Hemiptera) is one of the major pests, attacking groundnut during both *Kharif* and summer seasons. Among the various weather factors maximum temperature and sunshine hours showed significant positive influence on population, whereas rainy days and wind speed showed a significantly negative influence during *Kharif* season. During summer, leafhopper population showed significant negative correlation with mean relative humidity. Multiple regression studies indicated that increase in windspeed by one km/hr resulted in decrease of 0.964 leafhopper per plant in *Kharif* season, while in summer season, an increase in 1°C of minimum temperature resulted in an increase of population by 0.759 per plant and increase in 1 per cent relative humidity resulted in decrease of 0.281 per plant.

Key words : Groundnut leafhopper, population build up, weather parameters, multiple regression.

INTRODUCTION

Groundnut is one of the important oilseed crops of semiarid tropics in general and Saurashtra region of Gujarat in particular. It is attacked by a number of pests from germination to harvest. Among the various pests, groundnut leafhopper, *Empoasca kerri* Pruthi (Hemiptera : cicadellidae) is one of the major pests. The climatic factors play substantial role in the biology of any pest. It is rather difficult to find a direct cause and effect relationship between any single factor and pest activity, because the impact of weather elements on pest is usually confounded (Parker, 1946; Benerjee, 1972). However, temperature, rainfall, relative humidity, sunshine and wind speed are the chief weather parameters that largely direct the activity of a given species of insect. The present study deals with the population build up of *E. kerri* in relation to these abiotic factors.

MATERIALS AND METHODS

Field experiments were conducted at Sagdividi Farm, Gujarat Agricultural University, Janagadh to determine the influence of abiotic factors on the population building up of *E. kerri* in GG 4 variety of groundnut during *Kharif* 1995 and summer 1996. The crop was grown in an isolated plot of size 10 x 4.5 m^2 with 45 cm spacing in both the seasons. All the recommended agronomic practices suitable to South Saurashtra Agroclimatic Zone were followed. The plots of this experiment were kept unsprayed throughout the season. Ten quadrates each consisting of 10 plants were observed at weekly interval to record incidence of *E. kerri*, starting from first week after sowing (WAS) till harvest of the crop. To determine the *E. kerri* population, nymphs were counted and mean incidence was worked out. Meteorological data for the growth period on weekly basis corresponding to population are presented in Table 1. In order to study the influence of different meteorological parameters on *E. kerri* incidence, correlation and regression analyses were carried out.

RESULTS AND DISCUSSION

The results (Table 1) revealed that the incidence

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Table 1. Weekly meteorological data and population buildup of *E. kerri* during kharif and summer seasons at Junagadh

Kharif 1995

Week after sowing	Standard week No.	and	Date	Temperature°C Max.	Min.	R.H. (%)	Sun-shine (hours)	Wind speed (km/hr)	Rain fall (mm)	Rainy days	Nymphs per plant
1	2			3	4	5	6	7	8	9	10
1	29	July	16-22	28.6	23.9	83.0	0.3	10.5	412.0	7	0.0
2.	30		23-29	38.4	24.6	87.0	0.8	11.4	78.2	4	0.5
3.	31		30-05	29.6	24.5	90.0	0.9	6.5	75.2	4	1.2
4.	32	Aug	06-12	30-5	25.0	85.0	1.2	7.2	19.3	4	2.3
5.	33		13-19	31.3	25.0	82.5	2.4	10.8	2.4	1	3.5
6.	34		20-26	31.1	24.3	84.5	3.3	4.0	22.2	5	4.7
7.	35		27-02	31.5	24.2	85.5	2.2	2.8	74.5	7	5.4
8.	36	Sept.	03-09	31.5	23.7	80.5	4.2	4.1	37.2	1	7.6
9.	37		10-16	33.9	23.5	68.5	7.9	1.8	0.0	0	11.3
10.	38		17-23	34.1	22.8	73.0	8.8	3.3	16.7	1	13.5
11.	39		24-30	33.5	24.5	73.0	5.6	2.2	1.7	1	15.2
12.	*40*	*Oct.*	*01-07*	*34.3*	*24.4*	*75.5*	*8.1*	*2.0*	*32.5*	*1*	*10.3*
13.	41		08-14	36.4	23.7	55.0	7.0	3.9	0.8	0	8.5
14.	42		15-21	34.2	23.9	71.0	6.2	5.6	12.2	1	6.6
15.	43		22-28	36.0	18.6	47.5	9.3	4.9	0.0	0	2.3

Table 1. Contd...

Summer 1996

Week after sowing	Standard week No.	and	Date	Temperature oC Max.	Min.	R.H (%)	Sun-shine (hours)	Wind speed (km/hr)	Rain fall (mm)	Rainy days	Nymphs per plant
1	2			3	4	5	6	7	8	9	10
1	5	Jan.	29-04	31.3	8.7	42.0	9.5	6.2	-	-	0.5
2.	6	Feb.	05-11	32.6	13.3	41.5	9.3	5.6	-	-	1.3
3.	7		12-18	31.8	12.9	44.5	9.5	6.6	-	-	2.4
4.	8		19-25	33.9	17.9	53.0	8.9	6.7	-	-	3.6
5.	9		26-04	33.5	15.5	39.5	9.9	7.4	-	-	5.2
6.	10	March	05-11	38.2	19.1	42.5	10.2	6.1	-	-	6.2
7.	11		12-18	38.9	22.5	40.0	8.3	8.8	-	-	7.0
8.	12		19-25	36.8	21.4	40.0	10-5	8.9	-	-	6.9
9.	13		06.01	38.1	19.4	41.0	10.6	8.9	-	-	5.1
10.	14	Apr.	02-08	39.1	20.2	41.5	10.8	7.8	-	-	4.8
11.	15		09-15	39.3	20.6	47.5	10.1	7.8	-	-	4.1
12.	16		16-22	38.9	22.7	56.5	10.0	8.5	-	-	3.2
13.	17		23-29	38.7	24.1	60.0	10.7	9.8	-	-	2.0
14.	18		30-06	39.8	23.6	52.0	10.6	9.7	-	-	1.0
15.	19	May	07-13	39.5	24.6	63.5	10.4	10.6	-	-	0.3

of *E. kerri* started on groundnut from second week after sowing (WAS) i.e. 4th week of July in *Kharif* and continued throughout the crop season. Its population ranged from 0.5 to 15.2 nymphs per plant. The incidence increased gradually reaching a peak of 15.2 nymphs per plant on 11th WAS (last week of September). Later on, population decreased gradually. During summer, the incidence commenced from 1st WAS i.e. last week of January and attained the maximum population of 7.0 nymphs per plant on 7th WAS (Second week of March). The pest incidence remained high during March. *E. kerri* population decreased gradually from 8th WAS (3rd week of March). However, population was comparatively low during summer than rainy season.

According to Singh *et al.* (1990 a) the leafhopper remained active on groundnut throughout the crop period during *Kharif* and summer seasons and remained at higher levels in the month of September and March, respectively under Delhi conditions.

Correlation between E. kerri and weather parameters

It is evident from the data (Table 2) that *E. kerri* population exhibited significant positive correlation with maximum temperature and sunshine hours, whereas significant negative correlation with rainy days and wind speed during *Kharif* season. These findings support the reports of Singh *et al.* (1990a). During summer, *E. kerri* population showed significant negative correlation only with mean relative humidity.

Multiple regression studies of E. kerri with weather parameters

The regression coeffecient for *E. kerri* population with wind speed showed significant negative effect during *Kharif* season, while other parameters were non-significant. It was noted that increase in one km/hr of wind speed resulted in decrease of 0.964 per plant keeping other parameters constant in *Kharif.* The R^2 value (0.873) indicated that seven weather parameters jointly contributed 87.3 per cent of the total variation in density of *E. kerri* population in groundnut.

During summer, minimum temperature showed significant positive effect, whereas relative humidity was significantly negative with *E. kerri* population. The data further indicated that an increase in 1°C of minimum temperature resulted in an increase of 0.759 *E. kerri* population per plant, whereas increase in one per cent relative humidity resulted in decrease of 0.281 per plant keeping other parameters constant. The R^2 value (0.800) also indicated that five weather parameters (Table 3) jointly contributed 80.0 per cent of the total variation in *E. kerri* population per plant in summer. Similar findings were observed by Upadhyay (1984) and Singh et al., (1990b) from the experiments conducted at junagadh and Delhi, respectively.

Table 2. Correlation coefficient between *E. kerri* and weather parameters

Season	Year	Temparature°C		Relative Humidity (%)	Sunshine (hours)	Wind speed (Km/hr)	Rainfall (mm)	Rainy days
		Max.	Min					
Kharif	1995	0.602*	-0.034	-0.336	0.691*	-0.786*	-0.464	-0.531*
Summer	1996	0.237	0.200	-0.577*	-0.092	-0.066	-	-

* Significant at 0.05 level

Table 3. Multiple regression coefficient between *E. kerri* population on weather parameters

Season	Year	A-Value	Temparature°C		Relative Humidity (%)	Sunshine (hours)	Wind speed (Km/hr)	Rainfall (mm)	Rainy days	R^2
			Max.	Min						
Kharif	1995	-85.568	1.031	0.374	0.396	0.141	-0.964**	0.025	-1.342	0.873
Summer	1996	21.486	-0.344	0.759	-0.781*	-0.139	-0.656	-	-	0.800

* Significant at 0.05 level; ** Significant at 0.01 level

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SCREENING OF GROUNDNUT GERMPLASM FOR RESISTANCE TO PEANUT BUD NECROSIS

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ABSTRACT

Peanut bud necrosis disease (PBND) of groundnut, caused by Peanut Bud Necrosis Virus (PBNV) has been serious problem in kharif groundnut at the Crop Research Station, Mainpuri. The disease incidence was observed to be over 50% in some cultivars. A regular field screening of 447 available groundnut lines during rainy season of 1987 to 1993, resulted in the identification of ten highly resistant and sixty five resistant lines.

Key words : Peanut Bud-necrosis, groundnut, Germplasm.

INTRODUCTION

Groundnut (*Arachis hypogea* L.) is an important oilseed crop, occupying nearly 46 per cent of area under oilseeds in the country. It has an average productivity of 900 kg/ha as against the Asian average of 1190 kg/ha (Anonymous, 1993). Several reasons including damage caused by diseases have been ascribed to its low productivity (Ghewande, *et al.*, 1987). The Peanut Bud-necrosis disease (PBND) is one of the serious disease problems of groundnut causing as much as 80% losses (Ghanekar *et al.*, 1979). The disease was present in patches causing frequent epidemics after 1975 (Amin, 1983). Now the disease has spread to all groundnut growing areas in the country with an incidence ranging from 5 to 80% (Mayee, 1987a). In Uttar Pradesh, its incidence is reported to be 10 to 30 per cent in several commercial cultivars (Singh and Gupta, 1989).

The regular occurrence of disease and sometimes in severe from at AICORPO (Groundnut) centre , Mainpuri, necessitated the screening of germplasm collection at the centre. A regular screening of available germplasm against disease was done during *kharif* seasons of 1987 to 1993 for search of appropriate sources of resistance.

MATERIALS AND METHODS

The groundnut gremplasms/cultures were planted in 2m rows (30 x 10 cm) in three replications. A susceptible line (JL-24) was flanked after a set of ten entries as infector row. The sowing dates ranged between mid June to middle July in different years. The screening was done under natural field conditions. The final observations on the incidence of the disease were recorded during October each year. The entries have been grouped in to different categories following a standard disease rating scale (0-5).

RESULTS AND DISCUSSION

The disease reaction of 447 groundnut germplasm at Crop Research Station, Mainpuri is presented in Table-1. The data revealed that out of the total cultures tested, 10 were highly resistant (incidence 0-1%); 65 resistant (1.1-5%); 110 moderately resistant (5.1-10%); 147 moderately susceptible (10.1-25%); 106 susceptible (25.1-50%) and 9 highly susceptible lines (50.1 and above). The ten highly resistant lines were CSMG-12, EC-21070, ICG-98, ICGS-11, ICGS-44, GBFDS-92, GBPRS 4, GBPRS-15, Robot-33-1 and U-4-7-7.

Among these, ICGS-11 and Robot-33-1 were reported tolerant to this disease by Amin (1985).

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Table-1 : Reaction of groundnut germplasms to BND at Crop Research Station, Mainpuri, U.P (1987 - 1993).

Sl. No.	Disease score/ grades (% incidence)	Germplasms/cultures
1.	Highly resistant (0-1%)	CSMG-12, EC-21070, ICG-98, ICGS-11, ICGS-44, GBFDS-92, GBPRS-4, GBPRS-15, Robot-33-1, U-4-7-7 (Total 10)
2.	Resistant (1.1 to 5.0%)	28/207, Ah-7215, Ah-7286, Ah-7913, BPG-511, Chaudra, CSMG-5, CSMG-5-1, CSMG-9, CSMG-15, CSMG-17, EC Nos. 1246, 20957, 21161. GBFDS-273, GBPRS-66, GBPRS-92, ICG Nos. 18, 42, 98, 100, 275, 516, 538, 541, 552, 568, 645, 809, 813, 869, 1093, 1117, 1977, 2527, 3802, 4143, 4170, 4743, 6155, 6317, 6588, 7067, 7623, 8318, 8339, 9978, ICGV 86031, ICGV 89249, ICGV-89257, LG-46, LG-49, M-13, MA-8, MA-10, MC-62, M-65-75, NCAC-343, NCAC-737, NCAC-945, NCAC-2242, S-901, Spanish local, T-60, U-4429 (Total 65).
3.	**Moderately resistant(5.1 to 10%)**	7-1 28-206, 213-72082, 408, 5082, 5401, 5512, 5809, 5903, Ah-7983, Ah-8180, BP-2, BPG-512, Chitra, C-55-431, C-19-1, C-19-2, C-187, C-421, CSMG-82-2, CSMG-913, CSMG-916, EC Nos. 1667, 1667-1, 1682-1, 2105, 16665, 16667, 16668, 16669, 16676, 20806, 20886, 20967, 20979, 21022, 21042, 21063, 21071, 21135, 21137-1, 21309, 21665, 21678, 21688, 21787, 21791, 21885, 22424, 36892, G-201, GBFDS-272, GBPRS-312, H-56, H560, ICG Nos.65, 168, 200, 327, 363, 648, 1105, 1677, 2271, 2324, 3973, 4209, 5160, 5983, 7984, 8703, 10712. ICGS-18, ICGV-86430, ICGV-87807, ICGV-89287, ICGV-89259, ICGV-89415, j-8, J-14, k-3, Kanpur local, Kaushal, KG-61-240, Kopargon, Krinkle leaf, LG-30, LG-42, LG-52, LG-57, LG-100, LG-120, M-145, MC-1, MC-61, MC-158, MH-4, Mutant-33-1, P.G. No. 1, Pi-268689, Pol-1, RS-1, Rs-124, Spanish Improved, Spanish No. 5, Starr-1, Tifspan, TG-14, TG-16 (Total 110).
4.	Moderately susceptible (10.1 to 25%)	3-38, 59-127, 13-10, 9/136-2187, 10/45-2208, 99-5, 5902, 5908, 5910, 91136-2187, AH-2105, Ah-8194, BAC-325, C-10-13, C-10-19/7, C-10-23/1, C-85, C-180, CS-9, CS-39, CSMG-2, CSMG-84-1, EC Nos. 1616, 1662, 1691-1, 1700, 1735, 1736, 1777, 1778, 2092, 2099, 2213, 2215, 4085, 6119, 16662, 16663, 16672, 20916, 20925, 20950, 20951, 20958, 20962, 20963, 20969, 20973, 20974, 20986, 20991, 20995, 20999, 21014, 21020, 21023, 21027, 21031, 21132, 21134, 21137, 21144, 21149, 21156, 21165, 21189, 28866, GBFDS-31, G0-969, grindal-221-13, H-14, H-560, IARI-48, ICG Nos. 8-18, 23, 404, 799, 852, 869, 885, 899, 1041, 1602, 1607, 1656, 1697, 2248, 2271, 2288, 23071, 2323, 2599, 2741, 3806, 3873, 4497, 4970, 5030, 5042, 5043, 5044, 5240, 5299, 5401, 5678, 5679, 5697, 5804, 5908, 5910, 6317, 7237, 7404, 7652, 7827, 7884, 8010, 8184, 8284, 9116, 9512, ICGS-50, J-28, L-10-23/2, MC-3-2, MC-14, MC-61, MC-92, MS, MS-4, MS-5, MPi-2, P.G. No. 1, Pi-268971, PYTF-9-32, R-7, RG-15, Rs-11, Rs-67, Rs-211, Southern cross, Spanish C-7-5, T-1, T-17, TG-8, Totani-76, U-4-47-20 (Total 147).

Table-1 : Contd.....

Sl. No.	Disease score/ grades (% incidence)	Germplasms/cultures
5.	Susceptible (25.1 to 50%)	3-5, 4-8-115A, 13-46, 41-28, 4081, 4093, 5804, Ah-1192, Ah-7279, Ah-7887, Ah-7983, Ah-8180, Ah-8992, B-10, B-46, BPG-511, BPG-514, C-10-13/2, C-10-23/3, Chibchurya, China groundnut., CSMG-84-3, CSMG-88-4, Culture No. 941, Dh-3-30, Dh-120, Dharwar-2, EC Nos. 40, 408, 1689, 1963, 1704, 2112, 2114, 8180, 16666, 21024, 21025, 21026, 21041, 21044, 21048, 21060, 21166, EL-5, Exi-1, G-64-838, GAC-325, Gangapuri, GO-969, Georgia-1271, H2-14, Hotakuchchi, Hyderabad local, IW-5, ICG Nos. 14, 80, 221, 862, 1440, 2307, 5809, 6749, 7016, 7437, 7754, 7881, 7894, 8896, 9385, IGS (PRS)-8, J-6, J-11, K-61-240, Kadiri-104, Kadiri-106, MC-2-6/1, MC-14-29, MC-8, MC-15, MC-43, MC-50, MC-67, MC-73, MGS-9, MS-6, MS-7, MS-20, R-7-24-5, RG-141, RS-15, RS-60, RS-124, RS-271, RSHY-9, S-196, Sp Imp-1, T-2, T-17, T-31, TG-3, TG-17, TMV-7, TMV-9, V-2-24-6, VG-55 (Total 106).
6.	Highly susceptible (50.1 and above)	EC-1692, EC-5809, EC-21035, JL-24, RS-116, Small Japan, T-28, TMV-2, TMV-7 (Total 9).

Sixty five resistant cultures included NCAC-343 and NCAC-2242, which were found resistant by Ghanekar (1980).

It was observed during this study that peanut bud necrosis disease was a serious problem at Mainpuri with a severity above 50 per cent in certain lines. Singh and Gupta (1989) have reported 10-30 per cent disease incidence from Uttar Pradesh. In another study Singh *et al.*, (1994) have reported infection above 50 per cent. Highly resistant lines identified in this study can be used as donors in the breeding programme after confirming under artificially inoculated condition.

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PERFORMANCE EVALUATION OF A SCUTCHING MACHINE FOR LINSEED STALKS

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ABSTRACT

Linseed stalk is a high value by-product which contains quality fibre. The major problem has been the scutching of the stalk to obtain usable fibre. A scutching machine developed at the Central Research Institute for Jute and Allied Fibres (formerly Jute Agricultural Research Institute, JARI), Barrackpore was evaluated to assess its suitability for linseed stalk. The linseed stalk, retted for an optimized period of 96 hours and dried to a moisture content of 6.4% (dry basis), was used for optimum performance of the machine. At these conditions, the machine was found to have a scutching capacity of 2.5 kg of the stalk per hour. The extraction efficiency and cleanliness percentage obtained were 83.3% and 64.9% respectively. The scutching cost worked out to Rs. 12.42 per hour which provided the clean fibre worth Rs. 23.49.

Key words : Linseed stalk, scutching, fibre extraction, extraction efficiency, fibre quality.

INTRODUCTION

Linseed (*Linum usitatissimum* L) is an important oilseed crop of India cultivated in about 2 million hectares, which is 25% of the global area under linseed. The national production of deseeded straw is about 1.3 MT, which contains 0.3 MT of useful fibre. This flax fibre has a number of applications in pure form as well as when blended with jute, cotton and wool. The fibres are lustrous, stronger, less stretchy, more durable and better resistant to environmental fluctuations than cotton and jute. They can also be used in textiles, cordage, artificial silk, plastic and nitro-cellulose products in agro-industries. The hard woody matter can be converted into useful pulp, straw boards, corks and match-sticks. Despite so many useful applications, the linseed straw is either thrown away as a waste material or burnt as fuel and the linseed/flax fibre worth about Rs. 300 million is imported annually for defence purposes (Rai, 1985).

The utilization of linseed stalk is, therefore an important economic proposition for India, especially to save foreign exchange (Datta, 1980). The main problem in exploring this potential fibre for its applications has been absence of a simple, suitable and low-cost machinery which an extract dry and clean fibre from the deseeded straw of flax plant at farmer's level. The traditional manual extraction method by beating them on hard surface produces rough and broken fibre with high percentage of woody matter.

Although in the past, a number of studies (Richharia, 1950; Bhatia *et al.*, 1972; Dhar, 1973; Mandal and Ghosh, 1974; Gite *et al.*, 1977; Datta, 1980) have been undertaken with a view to optimize the various process variables involved with mechanical flax scutching process and to develop an efficient scutching machine for this purpose, no workable model could yet be developed and popularized. This was mainly due to the fact that the resulting fibre contained large quantity of unseparated pith and quality of fibres was also not as expected by the fibre industry.

A manually operated flax scutching machine (Ghosh and Mandal, 1979) developed by Central Research Institute for Jute and Allied fibres

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(formerly known as Jute Agricultural Research Institute, JARI), Barrockpore was sent to Central Institute of Agricultural engineering, Bhopal for evaluating its performance, quality of the extracted fibres and economics of operation. The results obtained have been presented in this paper.

Flax fibre extraction process

The bast or phloem fibres are about 22-26% (on dry weight basis) of the linseed stalk. The fibres are beneath the epidermis and cortical layers which constitute the outer layers in the bark. These layers are to be removed before reaching the bast fibre or phloem fibre of the flax stem. The fibres in flax are so peculiar in nature that they are not separated in to the individual filament. They occur in bundles in pericycle and each bundle contains about 10-140 individual fibres (Fig. 1). This is because of the presence of some pectineous material which needs to be disintegrated/ decomposed to enable separation of the flax fibre. To accomplish this, a biochemical treatment such as retting is necessary. During this treatment, the pectineous material is decomposed and fibres are separated. Hence, retting is an integral part of any manual/mechanical fibre extraction system. The retting is followed by drying, mechanical extraction and cleaning of the scutched fibres.

Retting

For retting, linseed stalk is usually submerged in retting tank filled with soft water preferably for 4-6 days depending on water temperature, biological activity of bacteria, age of the crop and initial quantum of microorganism present in the retting tank. Duration of retting is very important because if retting is incomplete, it is difficult to separate fibre from woody part. On the contrary, if retting process is allowed to go too far, the cementing material binding the fibre together in bundles will also be broken down and the strength of fibre will be adversely affected. An optimized duration of retting at a temperature range of 29-34°C has been reported to be 96 hours (Richharia, 1950; Bargale, 1989). The fibres obtained from such retted plants are clean, lustrous and generally strong. The basic difference between the jute and flax fibre is that in case of jute the reed containing the fibre when in wet condition can be taken out by hand, the flax fibre does not come out from the entire length even at the end of retting period. To accomplish this objective, an efficient flax scutching machine is required.

Drying/dewatering of retted stalk

The retted stalk contains 60-70% moisture. This needs to be removed up to 4 to 6% moisture level to facilitate efficient machanical extraction of fibre. This is normally accomplished by uniform spreading of retted stalk in an open shed. Direct sunlight and higher temperature may adversely affect the ultimate fibre quality. However, to eliminate weather dependence and expedite drying process, a mechanical dryer may also be used with drying air temperature in the range 50 to 60°C. Uniform drying is essential for efficient fibre extraction.

Mechanical extraction

In mechanical extraction the stalk undergoes crushing, the pith fails laterally and the fibres get separated from the woody matter. For this to happen, the stress applied by the breaker tooth must be higher than the ultimate bending stress of straw. Thus, when pith is broken laterally and closely at a number of points, fibres around the pith get separated from the main body.

Cleaning of extracted fibres

Despite optimum retting and drying to an appropriate moisture level, the extracted flax fibres consists of foreign matter in the form of unseparated wooden pith and straw pieces. Hence, cleaning of fibres is an integral part of flax scutching process. Besides retting period and the moisture content of the scutched stems, the cleanliness percentage is influenced by the applied pressure the revolutions of the scutching rollers. For better cleanliness percentage, the applied load may be increased but this adversely affects the strength of the finally obtained fibres. Hence, depending on the priority the operating parameters need to be set in an scutching process operation (Bargale, 1989). A manual and another wide toothed comb method is normally used for cleaning of fibres (Datta, 1980).

MATERIALS AND METHODS

The JARI hand operated flax scutching machine (Fig 2) for linseed stalk was procured from Chandra Sekhar Azad University of Agriculture and Technology (C.S.A.U.A.T), Kanpur. The machine consists of three pairs of galvanized M.S. fluted rollers for scutching of flax fibre. Each roller has 20 teeth, a diameter of 38 mm and a length of 300 mm. The machine also has a spreading roller (grooved) on the feeding conveyor and the cleaner roller (plain) on the delivery conveyor. Both the feeding as well as the delivery conveyor are made of 3 mm rubberized canvas.

The machine with two fly wheels fitted on its two sides is hand driven. Power from the flywheels is transmitted to the rollers by proper arrangement of gears as shown in Fig. 2. Each set of fluted rollers is arranged one above the other. The lower roller is fixed while the upper roller is pressed by compression springs provided at the two ends of the roller. The gap between the two rollers could be adjusted with the help of these springs.

When the machine is in operation, each pair of rollers revolves opposite to each other around their respective axes. Thus, straw gets crushed as it advances and there is also some brushing action which cleans the crushed fibre and roller teeth. At the end of the fluted rollers, there is a conveyor with cleaning rollers where loose crushed stalk is eliminated. Cleaned fibre is obtained at the end of delivery conveyor.

The machine was evaluated for the linseed stalk (double purpose variety LCK-152) obtained from C.S.A.U.A.T. Kanpur. The stalk was retted in a G.I. sheet tank (1.7 x 0.8 x 0.8 m), filled with tap water for an optimized duration of 96 hours (Bargale, 1989). The retted stalk was allowed to drain for several hours before it was spread uniformly on the floor for natural air drying under the shed. The stalk was shuffled at regular intervals for uniform removal of moisture. Samples were dried to a moisture content (MC, expressed herein on % dry basis) of 6.4-0.5% and was scutched with the machine. The moisture content of the stalk was determined by the standard hot air oven method, placing the sample at 105°C for 24 hours (Anon., 1982). The time required for scutching, including rest periods, was recorded. For optimum scutching, the normal load was varied for three rollers and was measured by determining the spring constant. Each experiment was replicated thrice and the samples with best Extraction Efficiency (EE) and the cleanliness Percentage (CP) were used to determine the capacity of the machine. Following formula proposed by Datta (1980) was used to determine the EE and the CP:

$$EE = \frac{W1}{W2} \times 100 \quad \text{and} \quad CP = \frac{W1}{W3} \times 100$$

Where:

EE is the extraction efficiency in %.

W1 is the weight of the clean fibre obtained from the scutching machine, g,

W2 is the weight of the fibre present in the straw, g,

W3 is the total weight of the fibre and pith obtained from the machine, %

CP is the cleanliness percentage, %.

For determining the capacity, the machine was operated for eight hours with one hour break for lunch after four hours. In all three operators were involved, two for rotating the flywheels and one to feed the stalk to the feeding conveyor. These operators interchanged their jobs as per their suitability. They operated the machine at normal and uniform speed as far as possible. The revolutions of the flywheel, duration of each run, the time for rest, quantity of pith and the fibre obtained were recorded.

The quality characters like tenacity (strength), fineness, bulk density and lustre were measured respectively using the fibre bundle strength tester, fineness tester, bulk density tester and colour and lustre meter. These instruments were procured from Jute Technology Research Laboratory (JTRL), Calcutta. The standard procedure for measurement of these properties was followed on 10 to 15 number of sample for each quality parameter to be determined. The average values and standard deviation of these measurements were calcuated.

The bundle strength of the fibres, also referred to as tenacity, is expressed in g/tex. The fineness, expressed in tex, is the weight of one kilometer long single fibre strand. The smaller its value, the higher is the fineness and vice versa. The colour and lustre of the fibre measured as the ratio light reflected at 90° and 45° from fibres to that reflected from standard What man filter paper at the same two angles.

RESULTS AND DISCUSSION

Capacity of the machine

The average capacity of the machine was found to be 2.50 kg of stalk/h with a variation in the range of 2.20 to 2.90 kg/h (Table 1). This variation was mainly because the machine was manually operated and, therefore, it was difficult to maintain uniform feeding and operating speed. The capacity of the machine generally decreased with time of operation as operator of the machine developed fatigue. The capacity of the machine, excluding the rest period, was 3.92 kg of stalk/h. The cleaned fibre obtained from operation of the machine was 0.522 kg/h while quantity of uncleaned mix (fibre + unseparated pith) was 0.780 kg/h.

The effective machine operation time for three days varied between 59.37 and 71.31% of total time with an average of 64.35%. The average Revolutions Per Minute (RPM) of flywheel for each day varied in the range of 35 to 36 with scutching rollers rotating at 68 RPM.

Quality evaluation of the extracted fibre

Results on the quality analysis of fibres obtained from the mechanical scutching of linseed stalk at optimized retting condition of 96 h and drying upto moisture content 64±0.5% (dry basis) are summarized in Table 1. A value of 24.21 g/tex for fibre tenacity was relatively lower considering a value of as high as 35 g/tex is obtainable from flax fibre. One of the reasons for such a lower strength was probably the lower moisture content of the fibre at which fibre underwent higher impact and shear due to reduced cushioning effect.

No information is available in literature to compare the other measured values of quality parameters of the extracted fibres including fineness (3.81 tex), bulk density (4.11 g/cm^3) and colour (48.9%) and lustre (0.98).

Economics of machine operation

The economics of operation (Table 1) of this machine was worked out considering that the initial cost of the machine was Rs. 3000, it had a life of ten years, is operated for 8 h/day for a period of 100 days in an year (possible duration for which the linseed stalk is normally available after harvest in an year). On this basis, machine could scutch about 20 quintals of linseed stalk per year. The total cost of scutching worked out to be Rs. 1242 per hour with a fixed cost of Rs. 1.17 and the variable cost of Rs. 12.42 per hour for producing 522 g of fibre worth Rs. 23.48, thus providing a net profit of Rs. 11.07 per hour. It is interesting to note

Table 1 : Performance of the evaluated flax scutching machine, quality of extracted fibres and economics of machine operation for linseed stalk

	Values
I. Machine Parameters	
Scutching capacity,kg of stalk/h	2.50
Quantity of fibre produced, kg/h	0.52
Extraction efficiency, %	83.3
Cleanliness percentage, %	64.9
Number of operators required	3
Optimized moisture content for scutching, % dry basis	6.4±0.5
Optimum retting period, hours	96
Average number of revolutions per minute	36
Percentage ratio of actual operating hours to total working hours, %	64.2
II. Quality Parameters	
Tenacity (strength), g/tex	24.21±1.80
Fineness, tex	3.81±0.19
Bulk density, g/cm³	4.11±.36
Colour, %	48.95±4.04
Lustre, dimensionless	0.98±0.11
III. Economics	
Intial cost of the machine, Rs.	3000
Fixed cost per hour, Rs.	1.17
Variable cost per hour, Rs.	11.25
Total cost of operation per hour, Rs.	12.42
Total cost of fibre produced per hour @ Rs. 45.00 per kg.Rs.	23.49
Net profit per hour of operation, Rs.	11.07

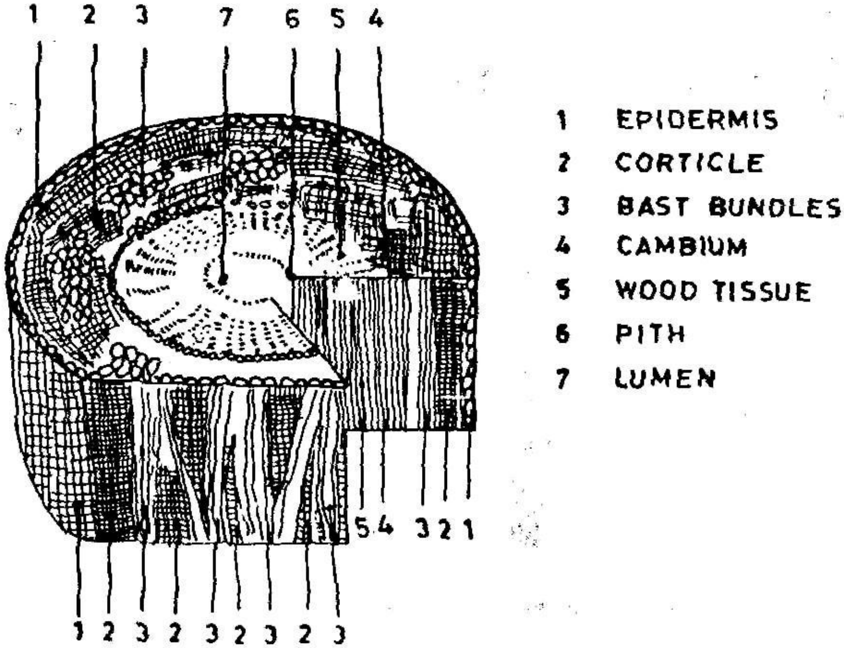

Fig 1 : Cross section of flax stem

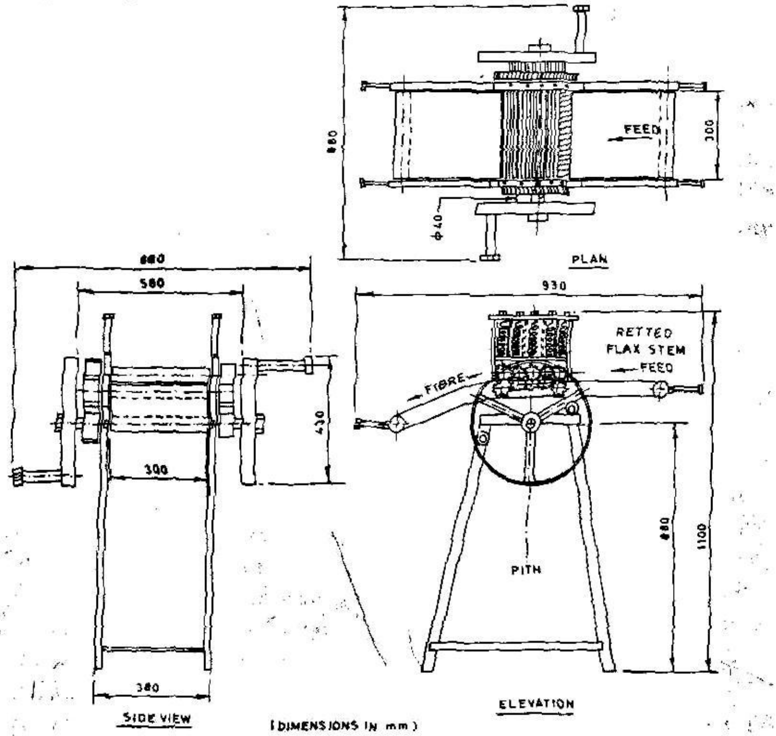

Fig 2 : Different views of evaluated flax scutching machine that 90.6% of the total cost is due to labour charges. The total cost of operation, therefore, depended on labour rates which change frequently.

It can be concluded that the JARI scutching machine evaluated for its performance for extraction of fibre from linseed stalk has a capacity of 2.50 kg of stalk per hour. The extraction efficiency (EE) was 83.31% while the Cleanliness Percentage (CP) was 64.92. The extracted fibre had a tenacity (strength) of 24.21 g/tex, fineness of 3.81 tex, bulk density of 4.11 g/cm3, colour of 48.95% and lustre of 0.98 (Dimensionless). The cost of scutching per hour was Rs. 12.42 producing 522 g of fibre worth Rs. 23.48. Thus, the machine may be used profitably at farmers level.

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ANALYSIS OF YIELD GAPS AND CONSTRAINTS FOR LOW YIELD IN RAINFED GROUNDNUT IN KARIMNAGAR DISTRICT OF ANDHRA PRADESH

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ABSTRACT

Study conducted at the RRS, Karimnagar with a view to identify the gaps and constraints for low yields in rainfed groundnut revealed that wide gap existed between potential farm yield and two groups of farmers (1268 kg/ha and 983 kg/ha) indicating that the second group of farmers had more adoption of improved technology. Gap I, the difference between experimental yield and demonstration yield was only 200 kg/ha showing that environmental influence was less on the productivity of groundnut.

Keywords : Yieldgap, Constraints, groundnut, productivity.

INTRODUCTION

Among the various oilseed crops grown in Andhra Pradesh, groundnut accounts for about three fourths of the area (21.76 lakh ha.) under oilseeds with a total production of 16.71 lakh tonnes. Karimnagar district though adjudged as the most agriculturally potential district in the state, the statistics revealed that the area had been decreasing from 26000 ha. in 1990-91 to 8000 ha. during 1994-95 and was being replaced by commercial crops like cotton, chillies, maize etc. It is distressing to observe that the yields of *kharif* groundnut in the district (501 kg/ha) were far less than the state average yield (623 kg/ha).

However, the research results revealed that wide yield gaps prevailed between yields at farmers fields and demonstration plots and that between demonstration plots and experimental yields. It indicates that technology is playing a major role in the district. Under these circumstances, there is every need to study the gaps in yields and also identify the constraints for low yields in *kharif* groundnut in Karimnagar district. It was envisaged i) to identify the various gaps existing in rainfed groundnut at different levels of technology. ii) to identify the constraints in adoption of yield increasing technology and (iii) to offer suggestions to overcome the low yields in rainfed groundnut.

MATERIALS AND METHODS

The study was carried out in Karimnagar district of Andhra Pradesh where the annual total rainfall ranges between 1000-1100mm. For selection of the farmers two stage sampling technique was adopted. In the first stage, two mandals based on the highest and lowest average area under *Kharif* groundnut were selected randomly for the present study. The selected mandals were Manakondur, with the highest *Kharif* area of 5420 ha. and Dharmapuri with the lowest *Kharif* area of 25 ha. under groundnut. In the second stage a total of 40 farmers were selected randomly from both the mandals for data collection and analysis. Further, based on the yield data the selected farmers' were again classified into two groups considering the district average yield (504 kg/ha) as a base. Accordingly the first group (less than average yield) included 23 farmers and the second (more than average yield) 17 farmers (Table 1).

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Table 1 : Groupwise distribution of respondents growing *Kharif* groundnut.

S.No	Mandal	Group-I	Group-II	Sub-total
1.	Dharmapuri	6	6	12
2.	Manakondur	17	11	28
	Sub-total	23	17	40

The primary data for the present study was obtained for *Kharif* 1995-96 through personal interviews and pre-tested schedules from the sample farmers. Apart from this, the Asst. Agronomist (Oilseeds) has taken up Front Line demonstrations (FLDs) in different locations of the district for which data on costs and returns were analysed and tabulated. The experimental yield (i.e., potential yield) was obtained from Regional Agricultural Research Station, Jagtial.

Based on the yields at Research Station, FLDs and farmers' fields, the following gaps have been identified and the nomenclature is as defined below.

a) Yield gap : Yield gap refers to the gap between potential and actual yields.

b) Potential yield : Potential yield is that yield obtained on research farms. This yield is considered as the absolute maximum production potential of the crop in the given environment.

c) Actual yield : Actual yield refers to the yield realised by the farmers on their farms under their own management practices.

d) Yield gap I : Yield gap I refers to the gap between the yield obtained in the RARS and the yield obtained in demonstration plots.

e) Yield gap II : Yield gap II refers to the gap between the farm yield obtained in the demonstration plots and the actual average yield realised in the group I farmers field.

f) Yield gap III : Yield gap III is the gap realised between the farm yield obtained in the demonstration plots and the average yield realised in the group II farms fields.

Further, to justify that the two groups of farmers belong to the same population, the yields were tested by the Mann - Whitney 'U' test, a non-parametric one.

$$Ua = n_1 + n_2 + \frac{n_1(n_1+1)}{2} - R1$$

Where

n_1 = no. of observations in first group

n_2 = no. of observations in second group

R1 = sum of ranks in the first group

apart from this various constraints viz; agronomic/managerial practices which include land preparation, bunding, levelling, seed sowing, fertilizers, intercultivation, plant protection, harvesting, drying, marketing, etc., that led to the reduction in yields of *Kharif* groundnut have been identified through opinion survey. These constraints were further divided into different practices and the farmer's perceptions pertaining to a problem for the particular cause of low yields were collected from both the groups of farmers. After confirming through non-parametric Mann-whitney 'U' test, that the sample farmers belong to a homogeneous group, these constrains were analysed through rank correlation as indicated below :

$$P = 1 - \frac{6 \sum di^2}{N(N^2 - 1)}$$

Where,

P = rank correlation coeffecient

di = difference between ranking

N = no. of categories

The correlation coefficient was further tested for its significance through the following formula.

$$t = P \sqrt{\frac{n-2}{1-P^2}} \quad \text{with n - 2 d.f.}$$

RESULTS AND DISCUSSION

Yield gaps

It was evident from Table 2 that yield gap 1, the difference between experimental yield and demonstration yield was 200 kg/ha., which was 10.25% less than the maximum attainable yield. Yield group II, refers to the difference between potential farm yield and Group I farmers, (1268 kg/ha) recorded higher gap than the yield gap III, which is the difference between potential farm yield and Group II farmers (983 kg/ha). These gaps indicated that the second group of farmers were used to the practice of yield increasing technology to some extent when compared to group I.

Identification of constraints for low yields in *Kharif* groundnut

Various constraints that were identified through opinion survey are presented in Table 3. After summing up the ranks obtained for different constraints under each sub-group they are presented in Table 4, which are further tested through rank correlation.

Before proceeding to rank correlation, the two groups of farmers were tested with a non-parametric Mann-whitney 'U' test to confirm that both the groups of farmers belong to the same population of groundnut farmers in the selected district.

Mann-Whitney 'U' Test ---------- Ua=39.50
Ub=37.50

The values of the 'U' test were statistically significant and hence there was no difference in identifying the problems for low yields in *Kharif* groundnut between the groups and thus they belong to the same population. As the two groups are homogeneous the constraints were further analysed to examine the difference of ranking of the constraints between them.

As per the opinion survey, 93 per cent of farmers in Group I and 84 per cent in Group II felt that marketing is the major problem followed by the constraints in seed, fertilizers and plant protection, chemicals. Both the groups of farmers opined that agronomic practices, post harvest operations and sowing methods were influencing less in rainfed groundnut productivity. Further, the relationship between two groups of farmers was tested by rank correlation which revealed that constraints for low yields in rainfed groundnut as expressed by both the groups of farmers were the same and there was no difference among both the groups in ranking the constraints.

Suggestions and policy implications

After identifying the constraints for low yields in rainfed groundnut in the district, the following suggestion could be considered while formulating the policies and making decisions to bridge the existing yields gaps.

i) Improved production technology must reach the farmers through different extension programmes like verification trials, on-farm trials, etc., at various locations in the district.

Table 2. Computation of different yield gaps in kharif groundnut

S.No	Particulars	Yield	Yield gap	Percentage gap	Remarks
1.	Experimental yield at RARS., Jagtial. (Potential yield)	1950	-	-	-
2.	Domonstration yield (FLDs) (Potential farm yield)	1750	200	10.25	Yield gap I
3.	Farmer's method				
	a) Group I	482	1268	72.45	Yield gap II
	b) Group II	767	983	56.17	Yield gap III

Table 3 : Perceptions on constraints for low yields in rainfed groundnut.

S.No.	Particulars	Group I (23)		Group II (17)	
		No.	Percentage	No.	Percentage
1.	Agronomic/Managerial	15	65.22	4	23.53
2.	Seed				
	i) Non-availability of HYVs	20	86.96	8	47.06
	ii) Non-availability of dormant varieties.	23	100.00	10	58.82
	iii) Non-availability of disease resistant varieties	18	78.26	15	88.23
	iv) Non-adoption of seed treatment.	21	91.30	5	29.41
3.	Sowing				
	i) Criss cross sowing	20	86.96	7	41.17
	ii) Depth of sowing	3	13.04	1	5.88
4.	Fertilizers				
	i) No use of micronutrients	23	100.00	17	100.00
	ii) Non-availability of gypsum	23	100.00	15	88.23
	iii) No use of recommended dose of fertilizers	18	78.26	7	41.17
	iv) Method of application of fertilizer	18	78.26	9	52.93
5.	Intercultivation				
	i) No use of weedicide	23	100.00	15	88.23
	ii) No weeding and intercultivation	5	21.74	1	5.88
	iii) Lack of implements	20	86.96	10	58.82
6.	Plant protection				
	i) No use of insecticides	18	78.26	2	11.76
	ii) Rodent & other pests	20	86.96	12	70.59
7.	Harvesting				
	i) Hard soil surface	12	52.17	2	11.76
	ii) Improper uprooting of plants	15	65.22	5	29.41
	iii) No mechanical harvesters/strippers	21	91.30	15	88.23
	iv) Actual time of stripping	15	65.22	8	47.06
8.	Drying				
	Shade dryig	13	56.52	4	23.53
9.	Marketing				
	i) Price fluctuations	21	91.30	15	88.23
	ii) Grading/Storage	23	100.00	13	76.47
	iii) Optimum price	20	86.96	15	88.23

Table 4 : Ranking of major category of constraints for low yields in kharif groundnut.

S.No.	Particulars	Group I (23)			Group II (17)		
		No.	%	Rank	No.	%	Rank
1.	Agronomic/managerial	15	65.22	7	4	23.53	7.5
2.	Seed	21	89.13	2.5	9	55.88	3
3.	Sowing	11	50.00	9	4	23.50	9
4.	Fertilizers	21	89.13	2.5	12	70.58	2
5.	Intercultivation	16	69.57	5	8	50.97	4
6.	Plant protection	19	82.61	4	7	41.17	6
7.	Harvesting	16	68.48	6	8	44.11	5
8.	Drying	13	56.52	8	4	23.53	7.5
9.	Marketing	21	92.75	1	14	84.31	1

Rank correlation (P) - 7.4273 with 7 d.f.

ii) Care should be taken to see that the fertilizers including gypsum be available in time to the farmers.

iii) More research is needed for developing high yielding, disease resistant, dormant varieties of *Kharif* groundnut.

From the foregoing analyses it could be inferred that wide yield gaps (Gap II) existed between potential farm yield and two groups of farmers (1268 kg/ha and 983 kg/ha) indicating that second group of farmers had comparatively more rate of adoption of improved technology for getting higher yields. Gap I, which is the difference between experimental yield and demonstration yield was only 200 kg/ha indicating that the environmental influence was negligible on the productivity of groundnut at both locations.

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PATH COEFFICIENT ANALYSIS OF SEED YIELD IN SUNFLOWER (*Helianthus annuus* L.) HYBRIDS

Sunflower is the third most important edible crop in the world after soyabean and groundnut. The area under sunflower expanded in India after introduction of open pollinated variety. In recent years hybrids are replacing open pollinated varieties due to wider adaptability, high autogamy, resistance to disease, uniformity in crop stand and maturity. In order to increase the yield potential of sunflower hybrids, an understanding of the relationships among different plant traits is important. Therefore, the present study on path analysis of seed yield in different hybrids was undertaken.

Twentyfour hybrids of sunflower including one composite check "Peredovik" collected from Oilseeds Improvement project, Dholi centre, were grown in *rabi* 1995-96 in randomized block design with three replications. Each entry was sown in 3 m long rows spaced at 60 cm between rows and 30 cm between plants. The data were recorded on 10 random plants in each replication for seed yield, oil content and other ten economic traits. Single plant data averaged from two plants over replications were used for statistical analysis. Genotypic correlations were used to perform the path coefficient analysis (Deway and Lu, 1959).

Seed yield per plant exhibited highly significant and positive correlation with stem girth, head diameter, number of leaves per plant, leaf area index, number of seeds per head and 100 seed weight (Table 1). Positive and significant correlation of seed yield with stem girth and 100-seed weight was observed by Pathak and Dixit (1990), with plant height, number of leaves, head diameter and 100-seed weight by Pallikondaperumal and Rajasekaram (1993).

High positive direct effect on seed yield per plant was given by 100-seed weight and number of seeds per head (Table 1). This was also supported by the fact that indirect effect of other economic traits through 100-seed weight was positive and high. Pallikondaperumal and Rajasekaram (1993) reported maximum direct contribution of 100-seed weight to seed yield. Head diameter also influenced the seed yield directly. Pathak and Dixit (1990), and Singh and Labana (1990) also reported that head diameter had the maximum effect on seed yield. Stem girth, head diameter, number of leaves per plant and leaf area index contributed indirectly to seed yield via number of seeds per head and 100-seed weight. Mogali and Virupakshappa (1994) also observed indirect effects of plant height, stem girth, number of leaves per plant, 100-seed weight on seed yield through number of seeds per plant. The residual effect of seed yield revealed that number of characters considered for path analysis was appropriate.

It may be concluded from this study that number of seeds per head, 100-seed weight, head diameter and number of leaves per plant are the most important components determining seed yield in sunflower. Hence, these traits should be given high priority for developing hybrids of sunflower with high yield and oil concent.

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Table 1 : Direct (in bold) and indirect effect of yield components on seed yield per plant at genotypic level.

Character	Plant height	Stem girth	Head diameter	Leaves per plant	Leaf area index	Seeds per head	100-seed weight	Genotypic correlation with yield per plant
Plant height	***-0.085***	-0.010	0.042	0.068	0.009	0.131	0.143	0.296
Stem girth	-0.017	***-0.051***	0.081	0.038	0.016	0.433	0.202	0.673**
Head diameter	-0.033	0.039	***0.207***	0.094	0.022	0.601	0.301	1.101**
Leaves per plant	-0.044	-0.015	0.076	***0.132***	0.011	0.107	0.258	0.474**
Leaf area index	-0.030	-0.034	0.098	0.063	***0.024***	0.330	0.256	0.701**
Seeds per head	-0.021	-0.041	0.014	0.027	0.015	***0.533***	0.132	0.762**
100-seed weight	-0.022	-0.019	0.058	0.061	0.011	0.127	***0.557***	0.802**

Residual factor = 0.093

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SWETHA THIL - A HIGH YIELDING AND HIGH OIL WHITE SEEDED NEW SESAME VARIETY

Sesame (*Sesamum indicum* L) is one of the important, multi-season and multi purpose oilseed crop in Andhra Pradesh. In the Telangana region of the state the trade and consumers prefer white seed varieties. A high yielding sesame variety "Swetha-Thil" was developed through simple pedigree method using variety E-8 as ovule parent and culture IS-13 as donor parent. The crossing of the parents was done in the year 1978. The culture under the name JCS 96 (Jagtial Centre Sesame) was tested in the station trials. All India Coordinated trials and in farmers' fields in both *kharif* and *rabi*/summer seasons. It is a high yielding, medium duration variety with high oil content having field tolerance to phyllody, bacterial blight, leaf curl and powdery mildew diseases. The variety resists the capsule borer attack. Swetha-Thil was superior to the existing variety 'Rajeshwari' which was released in the year 1988 (Ganga Kishan, *et al.*, 1989) for cultivation in the region. The new sesame variety 'Swetha-Thil' exhibited 32-46 per cent yield increase over the existing local check 'Rajeshwari'. Similarly the increase in seed yield was over 60 per cent when compared with national check TC-25.

Morphological characters of Swetha-Thil : The main character of the variety is that it bears capsules from the middle of the stem, leaf surface glabrous, herbaceous in texture. Stem is quadrangular, smooth and light green. Flower colour is white with purple tinge and hairs. Calyx is slightly pubescent and capsules are tetralocular and slightly hairy. Seed testa is white in colour.

Agronomical characters : Swetha-thil is early in maturity being 84.5 days in *kharif* and 80 days in rabi being 3-7 days earlier as compared to local check Rajeshwari. This variety exhibited its superiority in yield components over the check varieties (Table 1).

Yield performance : Yield potential of Swetha-Thil was confirmed in both *kharif* and *rabi/summer* seasons at the Research Station and in farmers' fields. In kharif the variety showed increased seed yield potential over Rajeshwari (Local check) and TC-25 (National check) In *rabi/summer* also the variety proved its superiority in seed yield over 'Rajeshwari'. The oil percent was also higher in Swetha-Thil (Table 2).

Reaction to pests and diseases : Swetha-Thil is tolerant to major pests viz., gallfly and capsule borer and major diseases such as phyllody, root rot and bacterial blight over the four check varieties (Table 3).

Swetha-Thil is superior in yield, has high oil content and matures earler than the local check 'Rajeshwari'. It is suited for both *kharif* and *rabi*/summer seasons and is recommended for Telangana region of Andhra Pradesh. The variety is released by the XXVI State Seed - sub committee for the Release of Crop Varieties in the year 1996 for general cultivation.

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Table 1 : Gomparative agronomical triats of Swetha-Thil and the check varieties (Kg/ha).

Agronomic trait	Varieties		
	SWETHA-THIL	RAJESHWARI(L.C.)	TC-25(N.C.)
Plant height (cm)	86.2 (k) 95.5 (r/s)	99.5 (k) 91.2 (r/s)	63.5 (k)
Primary branches/plant	3.6 (k) 3.2 (r/s)	3.3 (k) 2.9 (r/s)	3.0 (k)
Capsules/plant	46.6 (k) 61.1 (r/s)	38.6 (k) 53.8 (r/s)	25.5 (k)
Days to maturity	84.5 (k) 80.0 (r/s)	87.6 (k) 87.5 (r/s)	75.6 (k)
1000 Seed weight	3.1 (k)	2.5 (k)	2.4 (k)

k = kharif, r/s = rabi/summer, L.C. = Local Check, N.C. = National Check

Table 2 : Seed yield and oil yield of SWETHA-THIL and the check varieties in different seasons

Year (season)	Varieties		
	SWETHA-THIL	RAJESHWARI(L.C.)	TC-25(N.C.)
Seed yield (kg/ha)			
1984 (k)	330.0	146.0	166.0
1985 (k)	631.0	451.0	389.0
1986 (k)	725.0	510.0	436.0
1987 (k)	880.0	665.0	480.0
(r/s)	725.0	510.0	-
1988 (k)	-	-	-
(r/s)	1290.0	1195.0	-
1989 (k)	-	-	-
(r/s)	1379.0	1245.0	-
1990 (k)	-	-	-
(r/s)	762.0	660.0	-
1993 (k)	650.0	495.0	-
1994 (k)	480.0	264.0	-
(r/s)	1259.0	496.0	-
Mean: (k)	616.0	422.0	367.8
(r/s)	1083.0	821.0	
Percent increase (k)		45.9	67.5
(r/s)		31.8	
Oil yield (kg/ha) (k)			
1994 (k)	239.04	131.70	
(R/S)	672.30	248.90	
Increase(%) over L.C	139.50		

k = kharif, r/s = rabi/summer, L.C. = Local Check, N.C. = National Check

Table 3 : Reaction of 'SWETHA-THIL' to pests and diseases

	Reaction to major pests (Percent damage)		Reaction to major diseases (percent disease intensity)		
	Gallfly	Capsule borer	Phyllody	Root rot	bacterial blight (0.5 Scale)
Swetha-Thil *(JCS 96)*	*0.0*	*0.0*	*1.4*	1.2	2.3
TC 25 (NC)	3.6	1.8	4.0	6.0	9.0
RT 54 (ZC)	5.2	2.2	1.7	3.3	4.0
Rama (SC)	0.0	2.1	2.0	1.0	1.0
Rajeshwari (L.C.)	0.7	2.8	2.2	1.0	1.5

NC : National check; ZC : Zonal check; SC : Standard Check; LC : Local Check.

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EFFECT OF VARIETIES AND PLANT DENSITY ON PRODUCTIVITY OF GROUNDNUT

Groundnut is an important oil seed crop of India. It is a non traditional crop of the tribal belt of Surguja region of Madhya Pradesh, which is prominently rainfed and monocropped with rice under uplands, medium and low land situations. Mostly the uplands with sandyloam soils are well drained, porous and ideally suited for groundnut cultivation. Traditional crops like upland rice, ragi and miner millets give poor yields and low profits. Groundnut, on the other hand is much more profitable under upland situation (Anonymous, 1988). The agronomy of groundnut crop has not been standardised so far. As the variety and crop geometry play a prime role for obtaining high yield of crop (Kalra, 1984), the present experiment was undertaken to findout suitable variety and optimum spacing for obtaining good yield of crop.

An experiment was conducted during *kharif* 1989-90 and 1990-91 at IGKVV, Zonal Agricultural Research Station, Ambikapur (MP). The soil of the experimental field was sandy loam having pH 5.6, low in organic matter (0.33%), nitrogen (186.00 kg/ha), phosphorous (9.1 kg/ha) and medium in exchangeable potassium (286 kg/ha). The experiment was conducted in split-plot design keeping three groundnut improved varieties (J11, JL24 and DS29) in main plot and four spacings (30 x 15 cm, 30 x 20 cm, 45 x 15 cm and 45 x 20 cm) in sub plots with three replications. The plot size was 5 x 4 m. The crop was sown on 28th June and 4th July in 1989-90 and 1990-91, respectively. An uniform application of 20kg N, 60kg P_2O_5 and 30 kg K_2O per ha was applied before sowing. The seasonal rainfall received during the crop period in 1989-90 and 1990-91 were 987 mm (63 rainy days) and 1292 mm(86 rainy days), respectively.

Data on pod yield showed that groundnut variety DS29 gave significantly higher pod yield than J11 and JL24 in both the years. On an average DS-29 registered 65 and 84% increase in yield over JL24 and J11, respectively. The significantly higher yield of DS29 was due to favorable yield attributes i.e. number of branches/plant, number of pods/plant, pod weight/plant and 100 kernel weight. Thus the variety DS29 maintained its superiority giving 7.98 and 9.19 q/ha higher yield over JL24 and J11, respectively. The higher yielding ability of DS 29 variety may be attributed to larger kernel size and bold pods which are mainly responsible for higher yields (Ahmed *et al.*, 1986).

The closer plant spacing of 30 x 15 cm gave significantly higher pod yield and yield attributes than wider spacings. These findings are in conformity with those of Kalra *et al.*, 1984 and Agasimani *et al.*, 1984 who found that closer row spacing produced more yield than wider spacings. The variety J11 and JL24 gave higher pod yield (Table 2) at 30 x 15 cm spacing where as variety DS 29 gave significantly higher yield at 30 x 20 cm plant spacing because of its higher number of branches, number of pods and other yield attributes. Thus, interaction effect was also found significant. In variety J 11 andJL 24 the pod yield decreased correspondingly with increase in plant spacing. Where as the decrease in pod yield of variety DS29 was observed with wider spacing (i.e. 45 x 15 cm and 45 x 20 cm) than 30 x 20 cm spacing.

Hence, the groundnut variety DS29 is recommended for sowing at 30 x 20 cm spacing, while the variety JL24 and J11 should be sown at 30 x 15 cm to obtain the higher pod yield.

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Table 1 : Yield and yield atributes as influenced by spacings in groundnut varieties.

Treatments	Pod yield (q/ha)			Branches/plant		No. of pods/plant		100 Kernel wt.(g)		Pod wt./plant (g)	
	89-90	90-91	pooled	89-90	90-91	89-90	90-91	89-90	90-91	89-90	90-91
Variety											
J11	11.68	10.29	10.95	5.13	4.94	10.30	9.80	28.27	28.76	7.38	6.43
JL 24	12.76	11.84	12.16	5.23	5.16	11.59	10.89	29.16	29.20	8.08	7.33
DS29	19.55	20.75	20.14	5.83	5.64	12.53	12.71	33.20	33.70	12.36	13.17
CD at 5%	1.24	1.56	1.37	0.28	0.37	0.83	0.69	4.83	2.14	1.36	2.18
Spacing (cm)											
30x15	17.26	16.41	16.83	4.97	4.52	9.84	9.30	30.63	30.86	7.93	7.82
30x20	16.11	15.34	15.73	5.32	4.85	11.74	11.50	30.23	30.29	9.27	9.12
45x15	13.21	13.30	13.25	5.87	5.36	11.83	11.55	30.20	30.30	9.80	9.86
45x20	12.08	11.62	11.85	6.10	5.61	12.49	12.17	30.20	30.30	10.98	10.56
CD at 5%	1.09	0.81	0.75	0.23	0.19	1.13	0.94	NS	NS	0.93	0.72

Table 2 : Interaction between variety and plant spacing in respect of pod yield (q/ha) of groundnut.

Spacing (cm)	Variety							
	J11		JL24		DS29		Mean	
	89-90	90-91	89-90	90-91	89-90	90-91	89-90	90-91
30x15	15.53	12.61	15.70	14.28	21.56	22.34	17.26	16.41
30x20	11.66	10.33	12.80	11.57	23.83	24.29	16.11	15.34
45x15	10.72	9.53	11.62	10.54	17.30	19.80	13.21	13.30
45x20	9.84	8.37	10.87	9.93	15.53	16.58	12.08	11.62
Mean	11.68	10.29	12.76	11.84	19.55	20.75		
CD at 5% V x S		1989-90	1990-91					
		1.59	1.39					

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EFFECT OF DIFFERENT LEVELS OF NITROGEN AND SULPHUR ON THE GROWTH AND YIELD OF MUSTARD.

Improved varieties of mustard are capable of giving higher yields when grown under optimum levels of fertility, especially nitrogen and sulphur. Fertilizer schedules developed for mustard under the north Indian conditions may not be suitable for adoption under the non-traditional agroecological zone of Southern Telangana. Therefore, a comprehensive study was made to asses the effects of different levels of nitrogen and sulphur on yield and yield attributes of mustard crop in southern Telangana zone of A.P.

A field experiment was conducted on sandy loam soil of college farm, Rajendranagar, Hyderabad, deficient in nitrogen and sulphur (195.9 kg /ha and 19.8 kg/ha) respectively, medium in phosphorus and high in potassium during *rabi* 1995-96. The experiment was laid out in split-plot design with four nitrogen levels (40, 80, 120 and 160 kg/ha) constituting main plots and four sulphur levels (0,20,40 and 60 kg/ha)assigned to sub plots and replicated thrice. Mustard Cv. TM-4 was sown on 6th November, 1995 at a row spacing of 30 cm and thinned to 10cm plant spacing 10 days after sowing. Half of the dose of nitrogen and full dose of P (60 kg P_2O_3/ha), K (40 kg K_2O/ha) and S were applied as basal and the remaining half of nitrogen was applied 30 days after sowing. Nitrogen and phosphorus were supplied through diammonium phosphate (18:46:0) while the balance of nitrogen was made up with urea (46% N). Potassium was supplied through muriate of potash (60% K_2O) while the source of sulphur was elemental sulphur (85.0% S).

Data were recorded on growth characters, yield attributes and yield. Oil content was estimated by nuclear magnetic resonance spectrophotometer and oil yield was calculated by multiplying oil content with the seed yield of respective treatments.

Results revealed that application of 160 Kg N/ha resulted in the maximum plant height, dry matter production, number of branches per plant and leaf area index, while the minimum values were observed with the lowest nitrogen of 40 kg/ha. Among the sulphur levels, 40 kg S/ha resulted in significantly higher plant height, dry matter production and number of branches per plant over lower levels, but remained comparable with 60 kg S/ha. Peak values of leaf area index were recorded with the higher sulphur levels (40 and 60 kg/ha). Better availability of nitrogen and sulphur in deficient soils at active growth of the crop increases cell division and cell elongation which probably led to more plant stature combined with better spread of plants and increased leaf area index. Similar results were reported by Sarkar and Ghatak (1988). Flowering was hastened with increase in the nitrogen and sulphur levels. Similar results were also reported by Deekshitulu (1995).

The number of siliquae per plant and number of seeds per siliqua increased with the increase in the nitrogen level. Maximum number of siliquae/plant, seeds/siliqua and seed yield were produced at 160 kg N/ha. All the yield attributes viz, number of siliquae/plant, number of seeds/ siliqua, test weight and seed yield were significantly higher at higher levels of sulphur application (40 and 60 kg/ha). Significant increase in seed yield with nitrogen and sulphur application might be due to better availability of these nutrients for production of more siliquae/plant and seeds/ siliqua. However, test weight was not significantly influenced by nitrogen application. Similar results were also reported by Parihar (1991).

Nitrogen application at 160 kg /ha resulted in significantly higher stalk (45.18 q/ha) and oil (384.54 kg/ha) yields while significantly higher stalk and oil yields were obtained at 40 kg S/ha which

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Table 1 : Growth parameters, yield attributes and yield of mustard as influenced by nitrogen and sulphur levels.

	Plant height (cm)	Dry matter production (gm^{-2})	Leaf area index	Number of branches per plant	Days to 50% flowering	No. of siliquae per plant	No. of seeds per siliqua ($q\ ha^{-1}$)	Test weight (g)	Oil content (%)	Yield(q/ha)			Harvest index (percent)
										Seed	Stalk	Oil	
Nitrogen (kg/ha)													
40	146.0	238.0	1.1	10.0	32.6	88.8	12.0	2.6	37.7	8.3	29.8	3.12	21.8
80	153.1	297.3	1.5	12.5	31.8	128.4	12.6	2.6	36.9	9.3	36.6	3.37	20.3
120	168.5	342.0	1.8	14.5	31.3	155.1	13.1	2.8	36.2	9.9	39.2	3.57	20.1
160	175.8	377.9	2.4	15.7	31.0	292.2	13.9	2.9	35.1	10.8	45.2	3.84	19.3
CD (P=0.05)	10.7	31.5	0.1	1.8	1.0	14.9	0.2	NS	1.2	0.5	2.6	0.21	1.7
Sulphur (kg/ha)													
0	151.0	234.2	1.5	11.2	33.1	130.8	12.6	2.6	35.9	9.0	34.6	3.27	20.8
20	156.8	291.7	1.6	12.0	32.6	150.6	12.7	2.7	36.2	9.3	36.5	3.39	20.5
40	167.3	359.9	1.8	15.3	30.4	181.5	13.1	2.8	36.6	10.0	39.8	3.61	20.2
60	168.3	369.9	1.9	14.3	30.5	201.5	13.2	2.8	37.2	9.9	39.8	3.63	20.1
CD (P=0.05)	10.0	18.1	0.1	1.5	1.5	12.9	0.1	0.1	NS	0.5	2.1	0.19	NS

was comparable with 60 kg S/ha. Harvest index and oil content showed a reverse trend with nitrogen application. Highest (21.8 per cent) and lowest (19.27 per cent) harvest index and maximum (37.69 percent) and minimum (35.10 per cent) oil content were recorded with the lowest and highest nitrogen levels respectively. However, the differences in harvest index and oil content among sulphur levels were not significant.

Nitrogen and sulphur interaction had marked effect on number of siliquae/plant and number of seeds/siliqua. The maximum number of siliquae/plant and seeds/siliqua were recorded with 160 kg N/ha and 40 kg S/ha. However, none of the other growth parameters, yield attributes or yield were influenced by this interaction. Based on the present study, it can be concluded that combination of 160 kg N/ha and 40 kg S/ha is beneficial in improving the growth, yield attributes and yield of mustard on alfisols of Southern Telangana zone of Andhra Pradesh.

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EFFECT OF MOISTURE STRESS AMELIORANTS ON YIELD ATTRIBUTES AND YIELD OF RAINFED GROUNDNUT (*Arachis hypogaea.* L)

The characteristic feature of groundnut production in rainfed areas of Rayalaseema region of Andhra Pradesh is poor and unstable yields which are due to low and erratic rainfall occuring in a few rainy days resulting in prolonged dry spells. This situation has resulted in low and disastrous yields in most of the dry land areas. Dry spells during *kharif* season has very adverse and dismal effect on the growth and development of groundnut. Therefore, it is essential to minimise the yield losses due to excessive evapotranspiration and ensure improved moisture supply to the crop. In order to reduce these losses to a considerable extent, an investigation was carried out on dry land block of S.V. Agricultural College, Tirupati during *kharif* 1996 with different stress mitigant techniques.

The experiment consisted of 3 main plot treatments i.e., M1 = rainfed, M2 = irrigated (An amount of 5 cm of irrigation was given at IW/CPE ratio of 0.85 so as not to allow stress), M3 = Moisture stress treatment (from 30 to 75 DAS). The crop in this last treatment was protected from rain. Five agro techniques consisting of water spray (S2), Groundnut shell mulching (S3) @ 4 t ha^{-1}, 4%, kaoline spray twice (S4) at 45 and 60 days after sowing, mulching + Kaoline (S5), mulching + Kaoline + urea 2% spray (S6) twice were tested to study the ameliorating effect of these on drought affected rainfed groundnut with no treatment as a control (S1). The experiment was laid out in split-plot design replicated thrice.

The experimental field was sandy loam in texture, low in water holding capacity, available N, and medium in phosphorus and potassium. The pH of the soil was 6.8. The total amount of rainfall received during the crop growth period was 619.9 mm

The groundnut variety used was TPT-1, a drought resistant bunch type with a duration of about 100 days. A basal dose of 20N + 40 P_2O_5 + 50 kg K_2O ha^{-1} was applied to the crop. The yield attributing characters studied were total number of pods, filled pods per plant, 100 pod weight, shelling percentage, pod and haulm yield.

All the yield attributing characters were reduced significantly due to moisture stress as observed in M3 (Moisture stress treatment) and increased due to irrigated treatment (M2) followed by rainfed treatment (M1) (Table 1). Total and filled pods were highest in Mulch + koaline (S5) which was on par with mulch alone (S3). Highest 100 pod weight and shelling percentage was recorded with Mulch + Kaoline (S5) and least with control (S1).

Mulch + Kaoline treatment recorded highest pod yield of 21.8 q/ha which was on par with mulch alone and mulch + kaoline + urea spray but was superior to kaoline alone. The least yield was obtained where no ameliorant was applied, whereas even water spray twice resulted in significant increase in yield (19.14 q/ha) over the check (17.99 q/ha).

There was significant increase in yield due to amelioration treatments over the check. The pod yield obtained with mulching alone gave an extra yield of 2.72 q/ha compared to no treatment, which was higher by 15.1%. The yield obtained in mulching alone was significantly higher than water spray or Kaoline alone. However the pod yield in mulch + kaoline or Mulch + Kaoline + Urea was at par. Haulm yield also followed the trend as in pod yield.

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Table 1 : Yield and yield attributes of groundnut as influenced by different ameliorants

Treatment	Total pods per plant	Filled pods per plant	100 pods weight (g)	Shelling (%)	Pod yield (q/ha)	Haulm yield (q/ha)
Moisture situation:						
M1	18.9	17.2	66.21	75.9	21.37	38.87
M2	19.5	17.9	68.19	77.4	22.35	39.63
M3	16.3	14.4	64.32	71.9	15.94	35.57
Sem ±	0.35	0.35	0.22	0.28	0.359	1.36
CD (P=0.05)	1.41	1.40	0.88	1.13	1.410	5.16
Agrotechniques:						
S1	15.3	12.6	63.00	72.4	17.99	36.05
S2	15.9	13.3	64.06	73.0	19.14	37.24
S3	20.4	19.0	68.28	76.6	20.71	39.01
S4	17.0	15.3	65.61	74.2	19.75	37.88
S5	21.3	20.2	68.44	77.9	21.18	39.60
S6	19.6	18.3	68.04	76.5	20.56	38.36
Sem ±	0.51	0.49	0.33	0.36	0.266	3.42
CD (P=0.05)	1.49	1.41	0.96	1.05	0.769	9.89
Interaction	NS	NS	Sig.	Sig.	NS	NS

The increased number of pods, filled pods, 100 pod weight and shelling percentage in turn resulted in highest yield with mulch + kaoline. The increased pod weight was due to better soil moisture since the losses were checked which in turn exercised favourable effects on growth and yield attributes. The better filling of pods naturally resulted in higher shelling out turn. The favourable effects of higher moisture content on increased shelling percentage was reported by Reddy (1978), Ramana Rao *et al.* (1994). the increased pod and haulm yields due to favourable effect of improved moisture relations has been reported by several researchers (Ramesh Babu *et al.*, 1984; Patel and Golakiya 1988 and Trivedi *et al.*, 1994).

The economic analysis has shown that the highest net return was obtained with mulching followed by water spray whereas additional return was favourable in Mulch + Kaoline spray application (Table 2). However groundnut shell mulching was the most economic and feasible technique to mitigate the moisture stress effects in rainfed groundnut. Thus mulching has potential to be an important agrotechnique to stabilise rainfed groundnut yield.

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Table 2 : Economics of moisture stress ameliorants on rainfed groundnut

Treatment	Yield (kg/ha)		Additional yield (kg/ha)		Additional returns (Rs/ha)	Additional cost of cultivation (Rs/ha)	Net returns (Rs/ha)
	Pod	Haulm	Pod	Haulm			
Control	1799	3605	-	-	-	-	-
Water spray	1914	3724	115	119	1469	210	1259
Mulch	2071	3901	272	296	3486	1260	2226
Kaoline	1975	3788	176	183	2249	2010	239
Mulch + Kaoline	2118	3960	319	355	4094	3270	824
Mulch + Kaoline + urea spray	2056	3836	257	231	3257	3375	117

Cost of Pods Rs. 10.00 per Kg.; Cost of Haulm Rs. 1.00 per Kg.

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INFLUENCE OF NITROGEN AND PHOSPHORUS ON FATTY ACID COMPOSITION OF SOYBEAN SEED OIL

Soybean (*Glyçine max (L.) Merril*) has diverse uses. Its seeds contained 19-21 per cent oil, 38-42 per cent high quality protein and high level of essential amino acids. Recently cultivation of soybean has increased several folds as an oil seed crop. Soybean oil consists of predominantly 5 fatty acids viz., palmitic, stearic, oleic, linoleic and linolenic. Palmitic and steric acids are saturated fatty acids, while oleic, linoleic and linolenic acids are unsaturated fatty acids with one, two and three double bonds, respectively in their structure. It is generally accepted that linoleic acid is responsible for the problems associated with flavour of soyabean oil, which limits the acceptance of the oil as cooking medium (Evans *et al.*, 1981). Experiments were therefore carried out to study the effect of nitrogen and phosphorus on fatty acid composition of soybean oil.

A field experiment was conducted in *rabi* 1992-93, at College of Agriculture, Rajendranagar, Hyderabad. The soil of the experimental field was a sandy loam (sand 60.3 per cent, silt 21.3 per cent and clay 18.4 per cent), slightly alkaline (pH 7.4), low in available nitrogen (147.4 kg ha^{-1}) and available phosphorus (11.8 kg ha^{-1}) and high in available potassium (298 kg ha^{-1}). Organic carbon content of the soil was 0.38 per cent. Four levels of nitrogen (0, 30, 60 and 90 kg N ha^{-1}) and four levels of phosphorus (0, 25, 50 and 75 kg P_2O_5 ha^{-1}) were applied and the experiment was laid out in Randomised block design with factorial concept and replicated thrice. Nitrogen and phosphorus were applied in the form of urea and single superphosphate, respectively. A uniform dose of potassium at the rate of 40 kg K_2O ha^{-1} was applied at the time of sowing in the form of muriate of potash. Soybean variety Hardee was sown at a spacing of 30 cm x 10cm in 3.3 x 4 m^2 plots. The recommended cultural practices were followed to raise the crop. The seed yield was recorded. The oil content in seeds was determined by using nuclear magnetic resonance (NMR) method (Tiwary *et al.*, 1974). Methyl esters of the fatty acids in the oil samples were prepared by using sodium methoxide in dry methonol (Christie, 1982). Methyl esters of fatty acids were resolved using gas liquid chromatography (GLC) using a Hewlett Packard gas liquid chromatograph model 5.840. The column temperature was maintained at 210°C. Injection port and detector block were kept at 250°C and 300°C respectively. The flow rate of nitrogen was 30 ml min^{-1}. Different fatty acid per cents were quantified by peak area integration.

Saturated fatty acids

Palmitic acid : There were significant differences in mean palmitic acid content due to different levels of nitrogen and phosphorus. The mean palmitic acid content decreased significantly with increase in N level from N_0 (15.9 per cent) to N_{90} (10.9 per cent) level. Among the phosphorus levels, the mean palmitic acid content increased with increase in phosphorus levels from P_0 (13.5 per cent) to P_{50} (14.5 per cent) but a decreasing trend was observed with increase in phosphorus level from P_{50} to P_{75}. The interaction between the levels of nitrogen and phosphorus was significant. Among the interactions, the combinations of NoP50 recorded the highest plamitic acid content (18.1 per cent) followed by N_0P_{25} (16.9 per cent), while the lowest palmitic acid content was recorded with N_{90} P_{75} (10.0 per cent).

Stearic acid : There was significant influence of nitrogen levels on mean stearic acid content. As the nitrogen level increased from N_o to N_{90}, the mean stearic acid content decreased from 3.9 to

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Table 1 : Effect of nitrogen and phosphorus fertilization on saturated fatty acids of soybean oil (%)

	Palmitic acid					Stearic acid				
	P0	P25	P50	P75	Mean	P0	P25	P50	P75	Mean
N0	16.55	16.85	18.06	11.95	15.85	2.55	4.61	5.95	2.50	3.90
N30	14.25	15.25	15.95	11.00	14.11	2.96	2.93	4.50	2.50	3.22
N60	10.90	13.20	13.99	12.74	12.70	2.85	3.12	4.20	2.44	3.15
N90	10.70	11.10	11.70	10.00	10.87	2.80	3.16	3.95	2.30	3.05
Mean	13.10	14.10	14.92	11.42		2.79	3.45	4.65	2.43	
			S.Em±	CD (0.05)					S.Em±	CD (0.05)
N			0.111	0.32					0.031	0.09
P			0.111	0.32					0.031	0.09
NXP			0.228	0.66					0.065	0.19

3.1 per cent. Regarding the levels of phosphorus, the mean stearic acid content increased from P_0 (2.8 per cent) to P_{50} (4.7 per cent). Beyond P_{50} level the trend reversed. The interaction between the levels of nitrogen and phosphorus was also significant. The values ranged from 2.3 per cent to 6.0 per cent. The highest stearic acid content was recorded with N_0P_{50}, while the lowest was recorded with N_{90} P_{75}. These results are in agreement with those of Aulakh *et al.*, (1987) for linseed crop (Table1).

Unsaturated fatty acids

Oleic acid : Increase in the levels of nitrogen from N_0 to N_{90} significantly decreased the mean oleic acid from 18.1 to 17.0 per cent. Whereas increase in levels of phosphorus from P_0 to P_{50} increased the mean oleic acid content significantly from 15.6 to 20.8 per cent. Further increase in level of phosphorus, lowered oleicacid. The interaction between the levels of nitrogen and phosphorus on oleic acid content was also significant. The highest oleic acid content of 21.1 per cent was recorded with N_{90} P_{50}, while the lowest (13.1 per cent) was recorded in control (N_0 P_0).

Linoleic acid : The differences in mean linoleic acid due to different levels of nitrogen, phosphorus and their interaction were significant. An increase in level of N from N_0 to N_{90} resulted in anincrease of linoleic acid content from 32.5 per cent to 39.4 per cent. In respect of phosphorus, with an increase in level from P_0 to P_{50}, the linoleic acid content decreased from 37.5 to 30.7 per cent. Further increase in the level of phosphorus, however, caused an increase. The treatment P_{75} gave the highest linoleic acid content (41.5 per cent). The combination of N_{90} P_{75} gave the highest linoleic acid content (44.5 per cent) while the lowest (30.2 per cent) was obtained with N_0P_{25} (Table 2).

Linolenic acid : The content of linolenic acid increased from 2.6 to 3.8 per cent with increase in nitrogen level from No to N_{90}, whereas the linolenic acid content decreased from P_0 to P_{50}. Among the phosphorus levels, P75 recorded the highest linolenic acid content (4.0 per cent). The interaction between nitrogen and phosphorus was found to be significant and the combination of N_{90} P_{75} gave the highest linolenic acid content (4.2 per cent), while the lowest (2.0 per cent) was recorded with N_0P_{50}.

These results were in agreement with the

Table 2 : Effect of nitrogen and phosphorus fertilization on unsaturated fatty acids of soybean oil (%)

	Oleic acid (%)					Linoleic acid (%)					Linolenic acid (%)				
	P0	P25	P50	P75	Mean	P0	P25	P50	P75	Mean	P0	P25	P50	P75	Mean
N0	13.10	20.25	20.45	18.75	18.13	30.30	30.16	30.25	38.91	32.40	2.55	2.05	2.00	3.88	2.62
N30	17.58	16.25	20.70	16.15	17.65	39.61	34.25	30.25	40.50	36.15	2.60	3.30	2.15	4.00	3.01
N60	16.10	17.15	20.95	15.35	17.38	39.32	40.55	30.28	42.06	38.20	4.15	3.55	2.30	4.05	3.51
N90	15.80	17.50	21.05	13.75	17.02	40.25	40.80	32.18	44.45	39.42	4.40	4.05	2.40	4.15	3.75
Mean	15.64	17.78	20.78	16.00		37.52	36.44	30.74	41.48		3.42	3.23	2.21	4.02	
			S.Em±	CD (0.05)				S.Em±	CD (0.05)				S.Em±	CD (0.05)	
N			0.055	0.16				0.186	0.54				0.041	**0.12**	
P			0.055	0.16				0.186	0.54				0.041	**0.12**	
NXP			0.110	0.32				0.377	1.09				0.090	**0.26**	

findings of Gaydon and Arrivets (1983) who reported that application of phosphorus to soybean results in significant increase in oleic acid content from 22.1 to 27.3 per cent. They also obtained positive correlation between linoleic and linolenic acids and negative correlation between linolenic and oleic acids.

Our results showed that the nitrogen and plosphorus can influence the fatty acid composition of soybean oil. The problem with utilization of soybean oil as cooking medium is due to its flavour instability (Evans *et al.*, 1981). It has been reported that the flavour problems are associated with the presence of linolenic acid content in soybean oil and is a genetic character and can be controlled by 5 different genes (Howell *et al.*, 1972). The results obtained in the present investigation show that the linolenic acid content varied from 2.0 to 4.4 per cent. And to some extent the levels of linolenic acid can be kept low by selecting a right combination of fertilizer.

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WATER MANAGEMENT IN *RABI* SUNFLOWER

Of late sunflower is gaining importance in the Rayalaseema region of Andhra Pradesh because of its many desirable characters like drought tolerance, photoinsensitivity and good quality oil content. The crop is mostly confined to black soils where it is grown under residual soil moisture conditions. Due to its popularity, it is also grown in red sandy loam soils under irrigated conditions during *rabi*. Information on the water requirements of the crop is meagre. A scientific method of scheduling irrigations, which can be easily followed by the farming community is very essential for utilizing limited irrigation water.

To study the water requirements of *rabi* sunflower grown on the alfisols of Rayalaseema region an experiment was conducted during 1993-94 and 1994-95 at Agricultural Research Station, Utukur, Cuddapah (A.P.). The treatments included six irrigation schedules with irrigations at 10 days (T_1) and 15 days (T_2) intervals and at IW/CPE ratio of 1.0 (T_3) and 0.75 (T_4) and at cumulative can *evaporation (CCE) rates of 4 cm (T_5) and 6 cm (T_6).* The experiment was laid out in a randomised block design with four replications. The depth of irrigation water was 5 cm for all the treatments. A parshall flume was used to measure irrigation water. Evaporation data from one liter can evaporimeter (10 cm diameter and 14.3 cm height) was utilized for scheduling irrigations in T_5 and T_6 (Sharma and Dastane, 1970). The soil was sandy clay loam with low available nitrogen and phosphorus and medium available potash. The field capacity, permanent wilting point, bulk density and water holding capacity of the soil in the 0-30 cm depth of soil layer were 27%, 13%, 1.4 g/cc and 18 cm/m. Morden variety was sown in the first week of November at a spacing of 45 x 20 cm. The crop was fertilized with a uniform dose of 80 kg N, 50 kg P_2O_5 and 30 kg K_2O/ha. Nitrogen was applied in two splits, half at sowing and the rest 30 days after sowing. Entire dose of P_2O_5 and K_2O were applied at sowing alone. The gross and net plot sizes were 27.0 and 18.0 m^2. Buffer channels were formed to avoid seepage losses. The rainfall recorded during the crop growth period was 250 mm in 1993-94 and 58 mm in 1994-95. The effective rainfall was 164 and 50 mm, respectively for the two years (Doorenbos and Pruitt, 1975).

Scheduling of irrigations at 4 cm CCE resulted in taller plants (Table 1). The differences were found to be not significant in 1993-94 as the crop was not subjected to moisture stress in any treatment due to the rains received in the month of November, 1993. However, the differences in the plant height were significant in 1994-95 recording maximum height when irrigations were scheduled at IW/CPE ratio of 0.75 (137.3 cm). Similarly seed yield differences were found to be significant during 1994-95 alone with the maximum seed yield (1735 kg/ha) when irrigations were scheduled at 4 cm CCE (T5). Provision of irrigations at a shorter interval was mainly responsible for higher seed yield as the crop was not subjected to moisture stress. On the average scheduling of irrigations at 4cm CCE recorded maximum seed yield (1669 kg/ha) followed by 6cm CCE (1611 kg/ha).

The water requirements ranged from 357 mm to 632 mm in different treatments. Scheduling of irrigations at 4 cm CCE resulted in the highest water requirement in both the years due to more number of irrigations received. Scheduling of irrigations once in 15 days recorded the lowest water requirement because of longer irrigation interval (Somasundaram and Irythaya raj, 1981). However water use efficiency was highest (3.79 kg/mm) when irrigations were scheduled at 15 days interval followed by IW/CPE ratio of 0.75 (3.50 kg/mm). It was mainly due to lesser water requirement compared to the other treatments. Scheduling of irrigations based on the cumulative evaporation from one liter can evaporimeter was found to be the best method of irrigation from the farmers point of view.

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Table 1 : Plant height at maturity, seed yield and water use efficiency of *rabi* sunflower

Treatments	Plant height at maturity (cm)			Seed yield (kg/ha)			Total water used (mm/ha)			Water use efficiency (kg/mm)		
	93-94	94-95	Mean	93-94	94-95	Mean	93-94	94-95	Mean	93-94	94-95	Mean
Irrigation at												
T 1 Once in 10 days	201.6	123.9	162.8	1478	1407	1443	514	449	482	2.88	3.13	3.01
T 2 Once in 15 days	185.1	99.6	142.4	1253	1364	1309	414	299	357	3.02	4.56	3.79
T 3 IW/CPE ratio of of 1.0	193.5	132.0	162.8	1436	1611	1524	514	499	507	2.79	3.23	3.01
T 4 IW/CPE ratio 0.75	185.6	137.3	161.5	1314	1660	1487	464	399	432	2.83	4.16	3.50
T 5 CCE of 4 cm	194.5	134.0	164.3	1603	1735	1669	714	549	632	2.24	3.16	2.70
T 6 CCE of 6 cm	186.1	136.4	161.3	1555	1667	1611	614	307	507	2.53	4.18	3.36
SEm±	7.6	3.89		236	78							
CD (P=0.05)	NS	11.72		NS	234							

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BIO-ENERGETICS AND ECONOMIC EVALUATION OF CERTAIN SESAMUM BASED INTERCROPPING SYSTEMS IN ALFISOLS

In India, to feed the ever growing population there is an imminent need to concommitantly enhance the food production. As the available arable land resource is limited, it is imperative to intensify the food production over time and space. Agricultural production has increased more than three fold during last 50 years, while the fossil fuel energy consumption has showed an exponential increase from 33.22 to 741.33 million Gj (Joshi, 1989). This consumption pattern may accelerate with time but the energy use efficiency has shown an alarmingly declining trend, since crop production continues to depend largely on fast depleting non-renewable sources of energy. Hence the present investigation was undertaken to develop an energy efficient and economically-viable intensive cropping system.

An experiment was conducted at the Research farm of the Directorate of Oilseeds Research, Hyderabad during *kharif*, 1994. The soil of the experimental site was sandy loam which was low in available nitrogen, phosphorus and medium in potash. Ten treatments comprising different sesamum-based intercrops in three row ratios were evaluated in a RBD with three replications (Table 2). The crop received 20 kg each of N, P_2O_5 and K_2O as basal dose, and an additional dose of 20 kg N/ha was top dressed to sesame 21 days after sowing. The crop was raised completely under rainfed situations. The crop was sown during second week of June, 1994. The cultivars used in greengram, sorghum, groundnut and sesame crops in order were ML-267, CSH-6, DRG-17 and T-85.

Energy input and out put were calculated using the equivalents (Table 1). The energy intensiveness was worked out as proposed by Burnett (1982). No allowance was made for energy removed from the soil in the form of plant nutrients, nor the energy captured from the sun by the plants. The energy efficiency indices were calculated as follows:

Cultural energy (CE) - K.EC
Energy output (ED) = Y.Ec
Energy returns (ER) = Eo/CE
Specific energy requirement = CE/Y

Where K is physical unit viz., cultural inputs like oxenhours, fertilizer nutrients etc. The total gross and net returns (Rs./ha) were calculated on the basis of prevailing market prices of the produce.

Intercropping of sesamum with groundnut in 4:2 (1072 kg/ha); 6:2 (931 kg/ha) and 3:1 (926 kg/ha) resulted in higher sesamum equivalent yields followed by sesamum + sorghum 3 : 1 ratio (906 kg/ha). There was a distinct advantage of intercropping groundnut and sorghum with sesamum over sole cropping of sesamum.

Energy analysis (Table 2) elucidated that in general sesamum + groundnut system consumed more energy though there was no significant difference between various treatments. The slight variation in energy input is due to the difference in their seed rates. The energy output was substantially greater in intercropping sesamum + sorghum in 3 : 1, 4:2 and 6:2 ratios than the other treatments.

Significantly higher energy returns in respect of seed, straw and total returns were obtained when sesamum was intercropped with sorghum in 3:1, 4:2 and 6:2 row proportions than the rest. This was followed by sesamum + groundnut 4:2. The highest energy returns in these treatments could be due to higher energy output in terms of higher yields. Sesamum + greengram intercropping system offered the least energy output.

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Table 1 : Energy coefficients for selected cultural inputs

Sl.No.	Particulars	Energy coefficient	Unit of measurement	Source
A.	Input			
1.	Human labour			
	Adultman	1.96	Mjh^{-1}	Maheswari et al (1983)
	Woman	0.98	Mjh^{-1}	Maheswari et al (1983)
2.	Pair of oxen	10.10	Mjh^{-1}	Maheswari et al (1983)
3.	Wooden implements	10.50	Mjkg	Maheswari et al(1983)
4.	Chemical fertilizers			
	Nitrogen	60.00	Mjkg	Lockeretz (1980)
	Phosphorus	12.00	Mj kg	Lockeretz (1980)
	Potassium	6.70	MJ kg	Lockeretz (1980)
B.	Output			
	1. Sorghum/pulses	14.7	kg	Joshi (1989)
	2. Groundnut / sesamum	25.0	kg	Joshi (1989)
	3. Straw/crop residues	12.5	kg	Pandya (1979)

Table 2 : Bioenergetics of sesame-based intercropping systems in Alfisols of SAT region

Treatment	Energy input (Gj/ha)	Specific energy requirements (MJ/kg)	Energy prodn. ratio	Energyoutput		Energy returns		Biomass energy output	Energy returns	Energy intensiveness (Mj/kg)
				Seed	Straw	Seed	Straw			
Ses+Greengram (3:1)	3.98	9.33	0.11	10.28	21.84	2.63	5.58	32.12	8.17	0.16
Ses+Groundnut (3:1)	4.02	4.34	0.23	15.20	22.00	3.78	5.47	37.19	9.25	0.38
Ses+Sorghum (3:1)	3.90	4.35	0.23	38.80	32.92	9.95	8.42	71.81	18.37	0.41
Ses+Greengram (4:2)	3.91	9.15	0.11	10.30	23.17	2.63	4.84	33.47	8.56	0.80
Ses+Groundnut (4:2)	4.05	3.79	0.27	18.41	18.93	4.54	4.67	37.34	9.22	0.33
Ses+Sorghum (4:2)	3.98	5.82	0.15	35.15	29.58	8.99	7.57	64.73	16.56	0.53
Ses+Greengram (6:2)	3.90	7.26	0.14	10.97	22.36	2.81	5.72	33.34	8.53	0.83
Ses+Groundnut (6:2)	4.02	7.03	0.23	14.51	19.28	3.61	4.79	33.80	8.40	0.38
Ses+Sorghum (6.2)	3.90	5.30	0.19	24.03	18.11	6.15	4.63	42.14	10.78	0.48
Sole sesame	3.50	7.85	0.12	12.30	12.47	3.15	3.20	24.77	6.35	0.70
SEm±	-	0.63	0.01	1.11	0.05	0.35	0.01	1.59	0.35	1.06
CD (0.05)	NS	1.87	0.029	3.30	0.148	1.039	0.029	3.59	1.039	NS

Specific energy requirement is a measure of energy efficiency analogous to transpirations or evapo - transpiration (ET) ratio and reflects the amount of cultural energy required to provide a kilogram of output. If this specific energy *requirement is low (Closer to unity) higher is the efficiency. Lower specific energy requirement was* observed in sesamum + groundnut (4:2 ratio) followed by intercropping of groundnut and sorghum with sesame in 3:1 ratio. The greater efficiency in these treatments could be attributed to favourable crop environment, which inturn contributed to realise higher yields in these treatments. The above intercropping systems also proved to be highly productive. Substantially lower energy productivities were obtained in intercropping of sesame with greengram in 3:1, 4:2 and 6:2 row ratios and sole sesame, as evidenced by greater specific energy requirements (Table 2).

When the energy intensiveness was compared, just the reverse trend of the energy use efficiency was observed, indicating lower values of energy intensiveness in sesamum + groundnut/ sorghum intercropping systems at all row ratios.

Economic analysis revealed that *sesamum* + groundnut system offered higher net returns followed by sesamum + sorghum system. When the benefit cost ratio was compared, sesame + groundnut 3:1 followed by sesamum + sorghum 3 : 1 ratio registered higher B:C ratios than the rest. In general, greengram intercropping with sesamum in all row ratios offered lower monetary returns (Table 3).

Thus, it can be inferred that sesamum + groundnut 4 : 2 followed by sesamum + sorghum 3 : 1 row ratio were more energy efficient and economically viable systems than sesamum + greengram system.

Table 3 : Economic analysis of sesamum-based intercropping system

Treatment	Sesame seed equivalent yield (q/ha)	Net returns (Rs/ha)	Benefit : Cost ratio
Ses+Greengram (3:1)	4.25	2582.81	1.20
Ses+Groundnut (3:1)	9.26	8014.25	3.15
Ses+Sorghum (3:1)	9.06	7253.00	3.38
Ses+Greengram (4:2)	4.30	2766.67	1.29
Ses+Groundnut (4:2)	10.72	9684.65	3.80
Ses+Sorghum (4:2)	6.80	5353.99	2.50
Ses+Greengram (6:2)	5.73	3046.54	1.41
Ses+Groundnut (6:2)	9.31	7662.90	2.59
Ses+Sorghum (6.2)	7.38	5974.56	2.76
Sole sesame	4.92	3554.04	1.72
SEm±	0.48	321.53	0.14
CD (0.05)	1.42	954.60	0.42

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EVALUATION OF SOME PLANT EXTRACTS AGAINST *Alternaria brassicae* (BERK.) SACC.

Blight caused by *Alternaria brassicae* (berk.) Sacc. is the most common among the destructive diseases of Brassica oilseed crops around the world. Fungicidal sprays are generally recommended for the control of this disease because of lack of any resistant varieties against this pathogen. Several workers in the past have established the antifungal properties of a large number of plant species (Mishra and Tewari, 1992, Gourinath and Manoharachary, 1991, Sarvamangala *et al.*, 1993, Bisht and Khulbe, 1995). The action of the various plant products is pathogen specific and very little information is available on this aspect of *Alternaria brassicae*. In the present study, leaf extracts of 25 locally available plant species including some medicinal plants and obnoxious weeds were screened against *A. brassicae* for their antifungal properties.

Fifty grams of fresh crushed leaves of each test plant were boiled in 500 ml of water for half an hour. The plant extract thus obtained was filtered through double layered cheese cloth followed by whatman No 1 filter paper. Antifungal properties of leaf extracts (leaf decoctions) were evaluated for their ability to inhibit spore germination. Germination was considered as the extension of germ tube to a length equal to one half of the diameter of the spore (Medwid and Grant, 1984) from any cell. The spore suspension was prepared in the sterilized distilled water from ten days old cultures of *A. brassicae* isolated from the infected leaves of mustard variety Varuna on V-8 juice agar supplemented with Rose Bengal and Streptomycin (Degenhardt, 1973). One drop of spore suspension (2×10^5 conidia /ml) was placed in separate cavity slides alongwith a drop of the test extract and incubated at 25°C. After 24 hours of incubation spore germination was examined under microscope. Appropriate control was maintained with sterilized distilled water. Experiment was replicated twice. The percentage inhibition of spore germination was calculated as per the following formula (Vincent, 1947).

$$I = \frac{C - T}{C} \times 100$$

Where I = inhibition Percentage.
C = spore germination in control and
T = spore germination in treatment

The data in Table 1 revealed that spore germination was significantly reduced in case of *Aegale marmelos, Ricinus communis, Adhatoda vasica, Callistemon viminalis, Thuja orientalis* and *Pinus roxburghii*. Spores did not show any germination in extracts of *Solanum xanthocarpum* and *Datura innoxia*. Spore germination was significantly higher in rest of the treatments as compared to control. This maybe because of presence of some nutrients in extracts of these plants. *Solanum xanthocarpum* and *Datura innoxia* completely inhibited the spore germination whereas germination was substantially inhibited in *Pinus roxburghii* (82.1%) followed by *Thuja orientalis* (74.9%). This observation shows that these plants possess some fungitoxic properties against *A. brassicae*. The characterization of active substances involved needs further studies. Fungitoxic nature of roots of radish, leaves of *Lawsonia alba*, roots of *Datura stramonium* and inflorescence of *Mentha piperata* against *A. brassicae* have been reported earlier (Nehrash, 1961, Ahmed and Agnihotri, 1977). In the present study additional plants have been explored for their antifungal properties against *A. brassicae*.

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Table 1 : Evaluation of some plant extracts against *Alternaria brassicae*

S.No.	Plant species	Spore germination (%)	Inhibition of germination (%)
1.	*Ipomea carnea Jacq.*	98.5	-
2.	Aeqale marmelos (L.) Corr.	86.0	3.9
3.	Ageratum conzoides L.	100.0	-
4.	Lantana camara L.	100.0	-
5.	Eucalyptus citriodora Hook.	99.0	-
6.	Vitex negundo L.	96.5	-
7.	Murraya Koenighi (L) Spreng.	93.0	-
8.	Bougainvillea glabra Choisy	97.5	-
9.	Mentha spicata L.	100.0	-
10.	*Ocimum sanctum L.*	99.0	-
11.	Cannabis sativa L.	95.5	-
12.	Ricinus communis L.	83.0	7.3
13.	Azadirachta indica A. Juss.	91.0	-
14.	Berberis sp.	99.0	-
15.	Adhatoda vasica Nees	85.5	4.5
16.	Callistemon viminalis Cheell	86.0	3.9
17.	Solanum xanthocarpum Shrad & Wendl.	0	100.0
18.	*Opuntia dillenii Haw.*	98.5	-
19.	Sapindus mukorossi Gaertn.	98.0	-
20.	Euphorbia royleana Boiss	100.0	-
21.	Parthenium hysterophorus L.	100.0	-
22.	Thuja orientalis L.	22.5	74.9
23.	Datura innoxia Mill.	0	100
24.	Pinus roxburghii Sarg.	16.0	82.1
25.	Bambusa sp.	100.0	-
26.	Control (water)	89.5	-
	CD at 5%	3.5	-

(-) indicate no inhibition

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LEAF BLIGHT OF SESAME

An unreported blight of sesame (*Sesamum indicum* L.) caused by *Rhizoctonia bataticola* (Taub.) Butler was noticed every year at this University farm. It was first mistaken for bacterial blight caused by *Xanthomonas campestris* pv. *sesami* (Phookan *et al.*, 1991). When isolation was done aiming bacterial culture, *R. bataticola* was growing. This was due to mixed infection of same leaf by the above two pathogens. Symptoms were most distinct when seen early in the morning, 0600h. Large water soaked patches appeared on leaf blade (Fig. 2a, 2b, 4). Pods were also blighted (Fig. 3). Infected leaves were sticking to each other due to the creeping mycelium. The most reliable symptom was the presence of numerous, tiny, brown sclerotia on the undersurface of leaf, midrib, petiole, pods and stem (Fig 1, 2a, 3). The advancing mycelium on stem, pod and vein transformed into sclerotia. They resembled the excreta of timber borer or powder-post beetle. The above two symptoms distinguished this disease from bacterial blight. Its incidence was about 3% of the leaf area damaged. The fungus was cultured on PDA and Koch's postulates were proved. Only the aerial blight symptom was produced. The sclerotia measured 198-405 µm in diameter. The stem rot caused by *Macrophomina phaseolina* (Tassi) Goid is the second most severe disease of sesamum in Karbi Anglong (Hills) district of Assam (Rathaiah, 1984). Maiti *et al.*, (1985) stated that charcoal rot of sesamum caused by *M. phaseolina* (pycnidial stage of *R. bataticola*) was common throughout India. The aerial blight phase of this pathogen was not described on sesame from anywhere till now. Gupta and Kolte (1982) described two isolates of *M. phaseolina*, respectively from leaf and root of groundnut. The leaf isolate on sesame is different from that of root or stem isolate of *M. phaseolina*.

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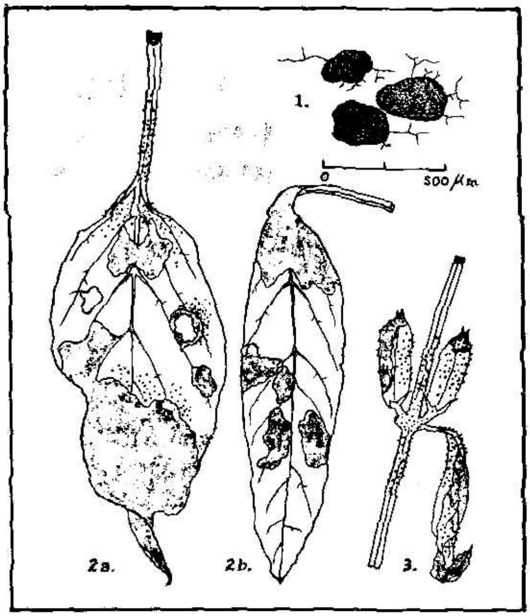

Fig : 1, 2a, 2b and 3. Symptoms of aerial blight of sesame caused by *Rhizoctonia* ***bataticola***. 1. Sclerotia 2a. Aerial blight on leaf. Note the sclerotia on petiole. 2b. Islands of blighted **areas on leaf**. 3. Infected pods with sclerotia.

Fig : 4. **Symptoms of** aerial blight on sesame leaf caused by *Rhizoctonia bataticola*

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PROXIMATE COMPOSITION, MINERAL CONTENTS AND LEVELS OF ANTINUTRITIONAL FACTORS OF SOME HIGH YIELDING OILSEED CULTIVARS

Recently, much attention has been focused on utilising oilseeds and their meals for human consumption. Oilseeds possess high nutritive value and contribute sizeable amount of not only fats but also proteins (Deosthale and Longvah, 1988) and the role of oils in the human diet as source of proteins and calories is enplorable (parpia, 1988). Besides nutrients, there are numerous factors present in the oilseeds which bear adverse effects on nutrition. In order to assess their possible nutrient contribution and antinutritional effect, the high yielding varieties of oilseeds were investigated for proximate composition, mineral contents and levels of antinutritional factors.

Two cultivars of groundnut, three of raya and one each of *toria*, sesame and linseed were evaluated in five replicates. Raya ('RH-30') contained the lowest quantity (38.00%) of fat and the highest amount (26.02%) of digestible carbohydrates (Table 1). Sesame ('HT-1') had the maximum percentage of fat (46.49%) and the minimum of digestible carbohydrate (13.36%). Groundnut ('MH-1') was found to be the richest (26.25%) and Toria ('Sangam') the poorest (18.31%) in crude protein contents. Percentages of crude fibre and ash varied from 2.95 (groundnut 'MH-2') to 8.40 (linseed 'LH-1'), and from 2.30 (groundnut 'MH-1') to 5.11 (Sesame 'HT-1'), respectively. Recently, Gabriel *et al.*, (1996) reported 56.30% fat in sesame seed flour.

Calcium and phosphorus contents varied from 92.5 (groundnut 'MH-1') to 1595 mg (Sesame 'HT-1'), and from 373 (groundnut 'MH-1') to 863 mg (Raya 'Varuna'), respectively (Table 2). when compared with other oilseeds groundnut seemed to be a poor source of both calcium and phosphorus. As regards zinc, there was not much variation (4.28 to 6.14 mg) in its concentration among theoilseed cuetivars. Linseed (LH - 1) and

Table 1 : Proximate composition (% DM basis) of oilseeds varieties.

Oilseed	Variety	Moisture	Protein	Fat	Crude fibre	Ash	Digestible carbohydrates
Groundnut	'MH-1'	5.74±0.14	26.25±0.10	40.96±0.17	3.62±0.17	2.30±0.04	21.13±0.41
	'MH-2'	5.64±0.46	25.37±0.14	38.77±0.27	2.95±0.04	2.54±0.06	24.73±0.31
Raya	'Parkash'	5.14±0.12	21.43±0.12	39.21±0.19	5.95±0.09	3.75±0.08	24.52±0.25
	'RH-30'	4.41±0.38	22.30±0.08	38.00±0.34	5.10±0.11	4.17±0.09	26.02±0.18
	'Varuna'	4.92±0.51	19.25±0.12	41.19±0.23	5.85±0.06	4.24±0.08	24.55±0.20
Toria	'Sangam'	4.96±0.36	18.81±0.31	40.10±0.23	7.80±0.06	3.84±0.08	24.50±0.20
Sesame	'HT-1'	4.71±0.48	24.06±0.25	46.49±0.19	6.00±0.08	5.11±0.10	13.63±0.12
Linseed	'LH-1'	5.12±0.26	20.56±0.16	39.23±0.37	8.40±0.10	3.51±0.07	23.18±0.28

Values are means ± SE of five independent determinations

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Table 2 : Mineral composition (mg/100 g, DM basis) of oilseeds varieties

Oilseed	Variety	Minerals					
		Calcium	Phosphorus	Zinc	Copper	Manganese	Iron
Groundnut	'MH-1'	92.5±2.30	373±4.54	5.71±0.42	3.21±0.07	3.43±0.10	8.75±0.15
	'MH-2'	98.4±1.56	395±5.02	4.97±0.38	2.85±0.04	3.12±0.09	4.75±0.09
Raya	'Parkash'	535±6.54	802±6.93	4.57±0.10	2.04±0.03	4.37±0.12	16.50±2.46
	'RH-30'	562±6.30	828±8.46	4.28±0.09	2.24±0.08	5.00±0.17	13.00±1.99
	'Varuna'	598±4.71	863±9.20	5.28±0.21	2.19±0.08	4.37±0.08	14.75±1.86
Toria	'Sangam'	496±7.42	772±8.90	4.71±0.18	1.42±0.10	5.20±0.09	11.00±2.00
Sesame	'HT-1'	1595±12.46	626±6.58	5.85±0.31	2.85±0.09	2.50±0.04	11.00±2.00
Linseed	'LH-1'	185±6.40	442±5.67	6.14±0.32	2.50±0.07	4.06±0.16	10.75±1.47

Values are means ± SE of five independent determinations

Raya ('Parkash') had the highest and the lowest quantities of zinc, respectively. Levels of iron, manganese and copper ranged from 4.75 to 16.5 mg%, 2.50 to 5.20 mg% and 1.42 to 3.21 mg%, respectively. Toria ('Sangam') had the maximum amount of manganese and the minimum of copper. The highest quantity of iron and copper was found in Raya ('Parkash') and groundnut ('MH-1'), respectively. Reddy and Hotwani (1993) reported iron content to range from 6.5 (linseed seeds) to 23.0 mg% (mustard seeds) (Table 2).

Many plants have the capacity to synthesize a wide variety of chemical compounds which are known to cause deleterious effects when ingested by man and animals. Oilseeds are no exception. The present study also reports the phytate, tannin, oxalate, haemagglutinin and trypsin inhibitor activity of oilseeds cultivars. Phytate contents ranged from 780 mg% (groundnut, 'MH-2') to 2060 mg% (Sesame, 'HT-1'); tannins from 406 mg% (Sesame HT-1), to 3800 mg% (Toria, 'Sangam'); and oxalate from 407 mg% (Toria, 'Sangam') to 2400 mg% (Sesame, 'HT-1'). Haemagglutinins (lectins) were present only in groundnut varieties (MH-1 and MH-2) whereas trypsin inhibitor activity was found in both groundnut ('MH-1', 'MH-2') and sesame ('HT-1'). Toria ('Sangam') appeared to have a little higher quantity of glucosinolates, the characteristic toxic constituents of cruciferrae seeds, than Raya (Table 3).

The main objection to the use of cruciferae oilseed meal for man and animals has been its content of deleterious glucosinolates. By the action of myrosinases the glucosinolates are split into toxic constituents; isothicocyanates or oxazolidinethiones; and glucose and bisulphate (Becker and Tiernan, 1976). Rapeseed products contained 35.41 umol/g glucosinolates (Mansour *et al.*, 1993).

Apart from being rich in fat, the oilseeds are potential sources of protein as well as minerals essential for human and animal nutrition. Protein contents seem to be comparable and even better than legumes, the only protein rich component of a common Indian diet. For better utlization of protein and minerals, in which the oilseeds are comparatively rich, it is desirable that quantity of tannins and glucosinolates in Raya and Toria; phytate and oxalates in sesame; is reduced to minimum. This can be achieved either by selection of improved varieties containing less of these attributes or introduction of suitable processing techniques.

Table 3 : Contents of antinutritional factors (DM basis) in oilseed varieties

Oilseed	Variety	Phytic acid (mg/100g)	Tannins (mg/100g)	Trypsin inhibitor activity (Units/g)	Lectins	Oxalate (mg/100g)	Glucosinolates (g/100g)
Groundnut	'MH-1'	800±9.6	800±8.4	816±6.4	+ ve	675±7.6	NIL
	'MH-2'	780±10.4	800±8.2	900±8.7	+ ve	506±9.5	NIL
Raya	'Parkash'	940±8.7	3200±11.4	ND	- ve	421±6.4	5.89±0.54
	'RH-30'	1720±15.5	3600±10.8	ND	- ve	5.20±8.6	5.44±0.62
	'Varuna'	1480±13.8	3700±14.5	ND	- ve	478±5.6	5.98±0.51
Toria	'Sangam'	1720±11.6	3800±21.2	ND	- ve	407±6.8	6.69±0.09
Sesame	'HT-1'	2060±12.8	406±4.5	160±5.4	- ve	2400±10.7	NIL
Linseed	'LH-1'	1520±15.6	900±6.8	ND	- ve	900±7.9	NIL

Values are means ± SE of five independent determinations, ND = Not detected

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