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Journal of Oilseeds Research

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SHORT COMMUNICATIONS

Dr. C. A. JAGADISH

OBITUARY

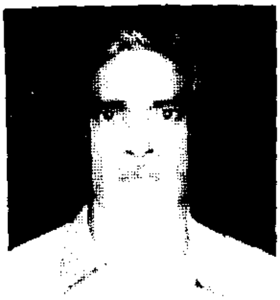
Dr. Chittoor Annamalai Jagadish, Sr. Scientist (Oilseeds), Regional Research Station, Palem, APAU passed away in a road accident on 30th May, 1992.

Sri C. A. Jagadish was born on 16th May 1941 at Madanapalle Chittoor District of Andhra Pradesh. After his early schooling in Guntur District, Dr. Jagadish obtained his B.Sc (Ag) degree in 1962 and M.Sc. (Ag) degree in Cytogenetics and Plant Breeding in 1964 from Andhra University and University of Madras respectively. He secured his Ph. D. degree in 1969 from Utkal University, Cuttack.

Starting his professsion in 1964 he worked as Asstt. Millet Specialist, Asstt. Professor, Associate Professor and later as Professor and Head of the Department of Plant Breeding, AP Agril. University. His active association with Oilseeds Research started in 1989 with his posting as Senior Scientist (Oilseeds) at Palem, a major oilseeds centre.

He has publihsed around 40 research articles and guided 25 M.Sc Ag. Students and 8 Ph. D., students. During his distinguished career, Dr. Jagadish served in many professional bodies.

Dr. Jagadish was a popular teacher and affectionate friend of student community. In his death, the agricultural scientists in general and oilseed scientists in particular have lost a worthy colleague and the Indian Society of Oilseeds Research is deprived of one of its senior member. The Indian Society of Oilseeds Research conveys deep condolences to the bereaved family members. May his soul rest in peace.



Dr. S. RAMA RAO

OBITUARY

One of our active members, Dr. Somepalle Rama Rao, Soil Physicist, Agricultural Research Institute, Andhra Pradesh Agricultural University, Hyderabad passed away on 10th May 1992 at Hyderabad in a road accident. He was forty five.

He graduated in Agriculture in 1970 from AP Agril. University, Hyderabad and subsequently obtained his M.Sc (Ag) degree in Soil Science in 1973 from the same university. He secured Ph. D., degree in 1984 from IARI, New Delhi

Starting his professional career Dr. Rama Rao worked as Associate Professor and Soil Physicist at APAU Hyderabad till his tragic demise.

Apart from being assoicated with the Indian Society of Oilseeds Research, he was also a member of Indian Society of Soil Science, Indian Society of Agronomy and Indian Society of Agro Physics.

His work on soil and water management with reference to oilseed crops like sunflower, castor and groundnut has attracted the attention of all researchers. He has earned the reputation as a dedicated Soil Physicist.

In his death, the agricultural scientists in general and oilseed scientists in particular lost a worthy colleague and the Indian Society of Oilseeds Research is deprived of one of its active members. Dr. Rama Rao is survived by his wife and two daughters. The Indian Society of Oilseeds Research conveys deep condolences to the bereaved family members. May his soul rest in peace.

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PRODUCTION TECHNOLOGY FOR AUGMENTING SOYBEAN PRODUCTIVITY IN INDIA

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ABSTRACT

Soybean occupies third place in the oilseed scenario of India covering about 20 lakh hectares. The present level of its average yield being about 9 q/ha is an under expression of its yield potential and it can be further enhanced by following the improved production technology. The salient features of 47 Indian and exotic soybean varieties are presented. Different components of production technology are comprehensively presented with reference to five agroecological zones for augmenting soybean production and productivity in India.

Key words: Soybean ; Production ; Varieties; Agroecological zones ; Production technology ; Productivity.

INTRODUCTION

Soybean ranks first among world oilseeds with an annual production of about 105 million tonnes. In oilseed and vegetable scenario of India, it has now occupied third place after groundnut and rapeseed-mustard. The crop covered an area of 16.5 lakh hectares, in 1989 of which about 84% area (13.9 lakh hectares) is in Madhya Pradesh. The area and production of soybean are rapidly increasing in India with the present estimates of area exceeding 20 lakh hectares. Of late, the standardisation and application of recent production technologies has pushed the average productivity of soybean from 7q/ha to 9q/ha. The present level of its average yield is, however, an under expression of its yield potential and it can be further enhanced by following the improved production technology.

National average yield (900 kg/ha) of soybean is only about 47 per cent of the world average (1900 kg/ha) and 69 per cent of Asian average (1300 kg/ha). To understand the factors for poor productivity in soybean, constraint analyses have been carried out by several workers (Jain, 1987; Sen 1987; Bhatnagar and Tiwari, 1989). There is a broad measure of agreement that by and large, the transfer of improved production technology to farmers' fields has been inadequate. The studies have revealed that even 30 per cent of the Indian farmers have not adopted the recommended production technology.

PRODUCTION TECHNOLOGY

Inter-disciplinary multilocational research carried out since 1967 under the aegis of the All India Coordinated Research Project on soybean (AICRFS), ICAR, gradually led to the standardisation of appropriate production technology for different agro-ecological conditions

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(Table 1). Major production technology for augmenting soybean productivity is briefly mentioned hereunder.

1.Varieties

Owing to high photosensitive nature of soybean, the need for identifying promising varieties specifically for each of the different agro-climatic zones of the country was felt. Promising soybean varieties were identified earlier by Saxena and Pandey (1971), Lal and Mehta (1972), Lal *et al* (1974) and Singh and Saxena (1975). Subsequently several varieties were indentified/released for different agro-climatic zones as given in Table 2. A detailed description of the soybean varieties of India is given by Bhatnagar and Tiwari (1990 a).

2. Selection of field and land preparation

Soybean does well in sandy loam to clay soil. However, well drained and levelled field with soil pH around 7 would be ideal for soybean cultivation (Saxena, 1975). One deep ploughing followed by two to three cross-harrowing of cultivator operation will ensure ideal seed bed for a good crop of soybean. Gentle gradient should be provided while preparing the seed bed after ploughing and harrowing.

3. Time of sowing

Timely sowing, as indicated in Table 1 for different zones, is essential for higher yields. Late planting leads to poor pod- bearing and seed-filling. In case of delayed onset of monsoon, a pre-sowing irrigation could be given to ensure optimum moisture in the soil.

4. Plant population and seed rate

For full exploitation of yield potential of soybean, plant production of about 4 to 6 lakh plants per hectare has been found to be optimum. However, it has been observed that the plant population in farmers' fields is much below the recommended optimum. Use of quality seed and germination test before sowing will help to maintain the desired plant population. Sowing should be done in rows 30 to 45 cm, apart with ideal plant to plant distance of 3 to 5 cm. In Northern plain zone, a wider spacing of 45 to 60 cm is recommended.

Studies on seed rate and depth of sowing have revealed that sowing at the rate of 75 kg per hectare planted in rows at a depth of 3 to 5 cm ensures optimum plant population. Obviously the seed rate is dependent on seed size, row-spacing and seed germinability (Table 3).

5. Fertilizer application

Judicious use of fertilizers is the most potent factor in crop production. It is also the most limiting and costliest input for small and medium farmers. Application of 20 kg N, 60 to 80 kg P and 20 to 40 kg K per hectare as basal dose is necessary. Fertilizer should be placed 5 to 7 cm below the seed, otherwise it should be evenly broadcast. Studies by Pal and Saxena

(1976), Pawar *et al* (1982) and Sekhon *et al* (1984) have shown significant increase in yield by nitrogen fertilisation.

It is reported that soils of many soybean growing regions, particularly in Madhya Pradesh are deficient in phosphorus (Motiramni, 1986). From the studies of Tomar and Dev (1973), Chandel and Saxena (1981), Shinde and Soni(1981), Kalia *et al* (1984) and Dwivedi *et al* (1985),it is clear that the phosphorus is the critical input which can help increase soybean yields (Table 4). The major soybean growing area of Madhya Pradesh has sufficient potassium (K) in soil. Application of 20kg K per hectare is enough to meet the nutritional requirement of the crop. Sulphur nutrition is very essential for oil synthesis in plants. It is also the component of methoinine, cystine and cystine amino acids (Dhillon and Dev, 1978). An application of 20 kg S per hectare is recommended for soybean.

6. Seed treatment

a) Treatment with bacterial culture

Soybean being a leguminous crop can fix atmospheric nitrogen in root nodules. Seed treatment with potent bacterial culture, hence, assumes great importance. A well inoculated crop of soybean without 'N' fertilisation gave as much yield as would be obtained with 240 to 300 kg N per hectare applied to a non- inoculated crop on silty loam soils at Pantnagar rich in organic carbon (Singh and Saxena, 1972). Peat based culture, e.g. "Nitragin" of Wisconsin, U.S.A. (being used earlier) showed good performance (Tilak and Saxena, 1974). Present day cultures are generally charcoal based and give satisfactory results. Rhizobium culture when applied at the rate of 400 to 500 g per 75 kg of seed per hectare results in effective nodulation. In the newly reclaimed soils, where soybean was not grown earlier, a double dose of culture along with a booster dose of 20 kg N per hectare is essential. For treating with bacterial culture, the seed is moistened and the culture is thoroughly mixed so that there is uniform black coloured thin layer of the culture around the seeds. The culture should be kept in cool and shady places. The treated seeds should be used on the same day.

b) Treatment with fungicide

A host of nearly 20 or even more species of fungi are known to be seed-borne in soybean under Indian conditions (Agarwal, 1981) causing several diseases. Hence, it is imperative to resort to fungicidal treatment and ensure better germination, emergence and nodulation through better protection from seed mycoflora. Treating the seed with fungicides like "Thiram" or similar fungicide, at the rate of 3 g per kg of seed, protected the seedling from fungal rots and improved plant stands (Nene *et al*. 1969 and 1972, Singh *et al*., 1973 ; Agarwal, 1981). Seed treatment with "Thiram" + "Bavistin" (1:1) at the rate of 0.3 per cent was recently found to be superior to treatment with "Thiram" alone in AICRPS trials.

7. Irrigation

Soybean being mainly a kharif crop is generally not irrigated. However, it could desirably require one preplanting irrigation and one or two more irrigations during pod-filling stage in case of early withdrawal of monsoon. The occurrence of drought should be avoided during reproductive growth phase of soybean especially early to mid-pod filling as it could lead to severe reductions in the yield (Doss *et al* 1974, Sionit and Kramer, 1977).

8. Weeding and interculture

Effective control of weeds in the first 30 days of crop growth is essential for achieving higher productivity (Bhan, 1974). In a study conducted at Sehore, the extent of loss caused by weeds in soybean ranged from 0.89% to 29.7% whereas increase in yield over weedy check was of the range of 14.83% to 42.37% (Table 5).

AICRPS experiments conducted over years in different locations indicated that application of "Lasso" (Alachlor) at the rate of 4 to 5 litres per hectare (pre-emergence spray), 'Basalin' (Fluchloralin) at the rate of 2 l /ha (pre-planting incorporation) and 'Dual' (Mutolachlor) at the rate of 1.0 kg a.i./ha (Pre-emergence) in 750-800 litres of water per hectare have been found to be efficient herbicides to control weeds in soybean. Hand weeding, hand-hoeing and 'dora' application will also help in controlling weeds. Soybean planted at narrow spacing (22.5 cm apart) with normal seed rate + one hand weeding also controlled the weeds effectively. Management of weeds is essential for not merely avoiding the competition for water, light and nutrients but also to check their harmful allelopathic effects (Tiwari *et al* 1985) on germination, emergence and proper stand of soybean as well as succeeding crop.

9. Plant protection

The expansion in area and mono-culture of soybean year after year in the same land has exposed the crop to various insect pests and diseases which were hitherto insignificant. A wide range of insect-pests attack soybean crop throughout its life cycle (Gangrade, 1974; Singh *et al* 1987). Among them, girdle beetle, blue beetle, stem fly and green semi-looper have become more important recently. Comprehensive schedules of insect-pests management have recently been presented (Singh and Singh, 1990; Bhatnagar and Tiwari, 1990 b).

A number of fungal, bacterial and viral diseases have been noticed in different soybean growing regions of the country. Diseases like bacterial pustules, rhizoctonia blight, pod blight, bud blight, seedling rot, yellow mosaic virus, leaf spots are known to reduce the yield considerably (Sarbhoy, 1987). Proper care should, hence be taken during entire period of crop growth and all recommended plant protection measures should be followed for minimising the loss in yield. If the farmers follow the major plant protection schedule, as given below, a considerable loss in yield could be avoided, Besides, use of genetic resistance by adopting varieties with resistance/tolerance to insect-pests and diseases should be resorted to essentially.

i) Furrow application of phorate 10 G @ 10 kg/ha before sowing for initial control of stem fly, white flies, thrips and jassids.

ii) Seed treatment with Thiram + Bavistin (1:1) @ 0.3% for controlling seedling diseases.

iii) Spraying of Thiodon (0.1%) and Metasystox (0.1%) 20-25 days after sowing and till pod formation for controlling defoliating insects and yellow mosaic virus.

iv) On initiation of girdle beetle and leaf feeders, spray the crop either with Monocrotophos 36 SC (0.4%) or Endosulfan 35 EC (0.07%) or Quinolphos 25 EC (0.05%) or Phosphomidon 85 EC (0.02% for leaf miner only).

10. Harvesting and seed storage

Extent of yield loss due to pod-shattering in soybean may range from negligible to significant depending upon time of harvesting, environmental conditions and genetic endowment of the variety. Besides selection of shattering resistant/tolerant varieties (Tiwari and Bhatnagar, 1988), timely harvesting of the crop after attainment of maturity in soybean is very important to avoid losses. Comprehensive measures for minimising the pod-shattering were recommended recently (Tiwari and Bhatnagar, 1988). Very early harvesting may result in shrivelled and green seeds. When all the leaves have dried and fallen, the crop is ready for harvest. The plant should be left in the field for sun-drying for 3-4 days during which the moisture content comes down to 13 to 14%. The dried produce can be threshed by threshers after adjusting the cylinder speed to 450 RPM at the seed moisture of 14% and to 300-400 RPM at 12% moisture to avoid breakage and splitting of seeds. The seed should be again sun dried by spreading them in thin layers on tarpaulin till the moisture percentage in seed comes down to at least 12 per cent. Soybean should be stored in moisture proof bags as otherwise it will absorb moisture and the quality will be deteriorated. The bags should be kept over wooden or steel racks in a manner that maximum airation is allowed for.

The adoption of improved production technology will lead to realisation of productivity potential of soybean augmenting its contribution to edible oil economy of India.

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Table 1. Soybean production technology for different agro-ecological zones

S.No	Input/Practices	Northern hill zone	Northern plain zone	Central zone	Southern zone	North eastern zone
1.	Varieities	Bragg, PK-362, PK-308, PK-327, PK-416, VL-Soya-1, VL-Soya-2, Pusa-16, Pusa-24, Pusa-20, Shivalik	Bragg, PK-262, PK-308, PK-327, PS-564, SL-4, SL-96, PK-416, Pusa-16, Pusa-24, Pusa-37, Pusa-22.	Bragg, Druga, Gaurav, Gujarat Soybean-1, &2, MACS-13, MACS-58, Monetta, PK-472, Pb-1, JS-2, JS-75-46, JS 80-21	Co-1, Hardee KHSb-2, Monetta PK-471, Pusa-40	Ankur, Birsa Soybean-1, Bragg, PK-262, PK-327.
2.	Planting time	Last week of May-June ending	Mid of June to 1st week of July.	Middle of June to middle of July	(i) Middle of June-end of July (Kharif crop) (ii) First week of October to December (Rabi crop) (iii) 2nd fortnight of January (Summer crop)	Middle of June to middle of July.
3.	Planting	45cm (row to row) x 5cm plant to plant	45-61 cm x 5 cm	30-45 cm x 5-8 cm	30-45 cm x 5 cm	30-45 cm x 5 cm
4.	Plant population	0.4 million	0.4 million	0.4 to 0.6 million plants/ha	0.4 to 0..6 million	0.4 to 0.16 million plant/ha
5.	Depth of Seedling	3 to 5 cm	3 to 5 cm	3 to 5 cm	3 to 5 cm	3 to 5 cm
6.	Fertilizers (kg/ha)	20N:80P:40K:20S	20N:60P:40K:20S	20N:60P:20K:20S	20N: 80P: 40K 20S:	20N:60P:40K:20S
7.	Bacterial Culture	About 500 g/75kg of seed	About 500 g/75 kg of seed	About 500 g/75 kg of seed	About 500 g/75 kg of seed	About 500 g/75 kg of seed
8.	Seed rate	75 kg/ha	75 kg/ha	75 kg/ha	75 kg/ha	75 kg/ha
9.	Intercropping	Maize	Maize	Sorghum, Arhar, Cotton	Cotton, Maize, Sugarcane, Ragi, Arhar	nil
10.	seed treatment	Thiram @ 3 g/kg seed or Thiram + Bavistan (1:1) @0.3%				
11.	Weed control	2 hand weeding at 25 to 30 and 45 DAS or Lasso @ 4 lit/ha or Basalin (Pre-plant incorporation) @ 2.25 lit/ha or stomp/1.0 kg a.i./ha and one hand weeding or Dual 1.0 kg a.i./ha.				
12.	Plant protection	2 - 3 sprays of 0.1% Thiodan + 0.1% Metasystox as needed.				
13.	Harvesting	When leaves turn yellow, ripe and start falling, seed has about 17% moisture.				
14.	Threshing	Operate thresher at low cylinder speed of 400 to 500 rpm at 14% seed moisture.				
15.	seed drying and storage	At seed moisture of about 10% store in moisture proof bags.				

N.B: No endorsement of product, whose trade-names are mentioned, is intended, nor is any criticism implied of similar products not mentioned but having same active ingredients

Table 2. **Soybean Varieties Of India**

Sl. No.	Name of the Variety	Area of adaptability	Duration (days)	Yield potential (q/ha)
1.	2.	3.	4.	5.
1.	Alankar (PK-71-21)	Northern plain zone	115-120	20-25
2.	Ankur (UPSM-38)	Northern plain zone	115-120	20-25
3.	Birsa Soybean-1	Bihar Plateau	106-110	25-30
4.	Bragg	Through out India esp. Northern region	112-115	15-20
6.	Co-1	Tamil Nadu	85-90	17-20
7.	Davis	Southern zone	110-115	15-20
8.	Durga(JS-72-280)	Central zone esp. M.P.	102-105	20-22
9.	Gaurav (JS-72-44)	Central zone	104-106	20-25
10.	Gujarat Soy-1	Low rainfall areas of Gujarat	90-95	15-20
11.	Gujarat Soy-2	Medium to high rainfall areas of Gujarat	105-110	22-25
12.	Hardee	Karnataka	105-110	15-20
13.	Improved Pelicon	Southern zone	112-115	15-20
14.	JS-2	Central zone esp. M.P.	90-95	18-20
15.	JS-75-46	Central zone (Narmada valley, Vindhya and Kymore Plateau, Balaghat, Bilaspur Regions of M.P.)	100-106	25-30
16.	JS-76-205	Central zone esp. M.P.	105-110	20-25
17.	JS-80-21	Central zone	105-110	25-30
18.	JS-71-05	Malwa Plateau of M.P.	90-95	20-25
19.	Kalitur	M.P. and Bundelkhand region of M.P.	120-130	18-20
20.	KHSb-2	Karnataka	115-120	20-25

Continued

1.	2.	3.	4.	5.
21.	KM-1	Tamil Nadu	95-100	12-15
22.	Lee	Northern hill zone	105-115	21-25
23.	MACS-13	Central zone	90-100	25-30
24.	MACS-58	Central zone	90-100	25-35
25.	Monetta	Central and southern zones	80-85	20-23
26.	MACS-124	Southern zone	94-98	30-35
27.	PK-262	Northern hill and Northern Plain zones	120-125	25- 30
28.	PK-308	Northern hill and Northern plain zones	110-115	20- 25
29.	PK-327	Northern hill and Northern plain zones	100-105	20-25
30.	PK-416	Northern hill and Northern plain zones	115-120	30-35
31.	PK-472	Central and Northern plain zones	100-105	30-35
32.	PK-471*	Southern zone	90-95	25-30
33.	PS -564	Northern plain zone	105-115	30-35
34.	Punjab-1	Central, Northern plain and Northern hill zones	95-100	20-22
35.	Pusa-16	Northern hill, Northern plain and North eastern zones and parts of M.P.	105-115	20-22
36.	Pusa-24	Northern plain and Northern hill zones and parts of M.P.	110-115	30-35
37.	Pusa-20	Northern hill zones	110-115	25-30
38.	Pusa-22*	Northern plain and North eastern zones and parts of central zone	110-120	25-30

Continued

1.	2.	3.	4.	5.
39.	Pusa-37*	Northen plain zone and parts of central and southern zones	110-115	25-30
40.	Pusa-40*	Southern zone	95-100	25-30
41.	Shilajeet	Northern hill and Northern plain zones	100-105	20-25
42.	Shivalik	Himachal Pradesh	120-125	25-32
43.	SL-4	Northern plain zones	100-105	16-20
44.	SL-96	Punjab	110-112	18-20
45.	Type-49	Central zone	125-130	20-25
46.	VL-Soya-1	Uttar Pradesh	110-113	20-25
47.	VL-Soya-2	Northen hill zone	104-116	25-30

*** Identified in AICRPS workshops and awaiting release.**

DESCRIPTION OF ZONES

S.No.	Zone	Area covered
1.	Northern hill zone	Himachal Pradesh and Northen hills of U.P.
2.	Northern plain zone	Punjab, Haryana, Delhi and North eastern plains of U.P. and Western Bihar
3.	Central zone	Madhya Pradesh, Bundelkhand region of Uttar Pradesh, Rajasthan, Gujarat, Northern and Western parts of Maharashtra and Orissa
4.	Southern zone	Karnataka, Tamilnadu, Andhra Pradesh, Kerala and Southern parts of Maharashtra
5.	North eastern zone	Assam, West Bengal, Bihar and Meghalaya

Table 3. Seed rate and plant stand in soybean

Spacing (row to row)	Plant population	Seed Germinability	Seed rate (kg/ha) based on 100 seed weight (g)				
			12.0	12.5	13.0	14.0	15.0
30 cm	6,66,666	100	79.9	83.3	86.6	93.3	100.0
		75	106.5	111.0	115.5	124.4	133.3
40 cm	5,00,000	100	60.0	62.5	65.0	70.0	75.0
		75	80.0	83.3	86.6	93.3	100.0
45 cm	4,44,444	100	53.3	55.5	57.7	62.2	66.6
		75	71.0	74.0	76.9	82.9	88.8

Table 4. Soybean yield as affected by phosphorus level

Phosphorus level (kg P_2O_5/ha)	Yield (kg/ha)	Benefit-cost-ratio
40	1225	0.90 : 1
56	1550	1.16 : 1
64	1653	1.39 : 1
80	2184	1.74 : 1

Table 5. Extent of loss caused by weeds in soybean

S.No.	Treatment	Grain yield (kg/ha)	Loss in yield* (%)	Increase in yield** (%)
1.	Weedy upto 20 DAS, then weed free	1542	0.89	41.10
2.	Weedy upto 40 DAS, then weed free	1352	13.10	23.73
3.	Weedy upto 60 DAS, then weed free	1296	16.67	18.64
4.	Weed free upto 20 DAS, then weedy	1269	18.45	16.10
5.	Weed free upto 40 DAS, then weedy	1463	5.95	33.90
6.	Weed free upto 60 DAS, then weedy	1500	3.57	37.29
7.	Sowing at 22.5cm row spacing and weedy	1255	19.35	14.83
8.	Sowing at 22.5cm row spacing + one hand weeding at 30 DAS	1494	3.94	36.78
9.	Weedy	1093	29.70	-
10.	Weed free	1556	-	42.37
	C.V. %		13.07	

* Yield loss as compared to weed free.

** Increase in yield over weedy check.

DAS : Days after sowing; Variety : Gaurav; Location : Sehore.

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COMBINING ABILITY STUDIES FOR SEED YIELD, ITS COMPONENT CHARACTERS AND OIL CONTENT IN INDIAN MUSTARD (*Brassica Juncea* (L). COSS.)*

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ABSTRACT

Forty five experimental F1 hybrids of Indian mustard along with 10 parents were evaluated in two environments for combining ability with respect to seed yield, its component characters and oil content. All the characters studied were governed by both additive and non-additive genetic variances. Parents Varuna, Kranti, RLC 1359 and RLC 1357 were identified as good combiners for seed yield, earliness, siliqua length, seeds per siliqua and 1000-seed weight whereas parents EC 126743, EC 126745 and EC 126746-1 emerged as good combiners for plant height, primary branches, secondary branches and oil content. Crosses namely EC 126745 x RC 781, Prakash x RLC 1357 and RLC 1359 x RLC 1357 were identified as promising for isolation of transgressive segregants in later generations.

Key words : Combining ability; Indian mustard; Brassica Juncea.

INTRODUCTION

Indian mustard (*Brassica juncea*) is most widely grown oilseed crop among the different crops in rapeseed and mustard group. It has higher yield potential and is suitable for sole cropping as well as intercropping. In planning of an efficient breeding programme in any crop, selection of parents plays a crucial role and combining ability analysis serves as a very handy tool for the selection of parents. Information on the relative importance of general and specific combining abilities is also helpful in the analysis and interpretation of the genetic basis of important traits. The present study was, therefore, undertaken to gather such an information in Indian mustard regarding seed yield and its component traits.

MATERIALS AND METHODS

The material for present study was developed by crossing 10 homozygous and genetically diverse parental lines of Indian mustard viz., Prakash, Varuna, Kranti, EC 126743, EC 126745, EC 126746-1, Domo-4, RC 781, RLC 1357 and RLC 1359 in diallel fashion (excluding reciprocals) during rabi 1986-87. The 45 F_1 hybrids developed, there of, alongwith 10 parental lines were raised in randomized block design during rabi 1987-88 in two environments (E_1 = timely sown, E_2 = late sown) each with three replications. Every genotype was grown in a single row of five metres with row to row distance of 45 cm and plant to plant distance of 15

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cm. Observations were recorded on five competitive plants in each plot per replication per environment for seed yield, its component characters and oil content. The data recorded were subjected to the analysis of Griffing(1956) method 2 model I.

RESULTS AND DISCUSSION

Analysis of variance for randomized block design indicated significant mean squares due to genotypes suggesting sufficient amount of genetic variability present in the material for all the characters. Mean squares due to general combining ability (gca) and specific combining ability (sca) were highly significant (Table 1) for all the characters under both the environments revealing importance of both additive and non-additive gene effects in the inheritance of these characters. Significant gca and sca variances were also reported by Kumar and Yadava (1986), Wang and Wang (1986), Badwal and Labana (1987) and Choudhary *et al.* (1988) in mustard for seed yield and its components.

A study of gca effects of parents (Table 2) revealed that none of the parents had desirable gca effects simultaneously for all the characters. However, the parents EC 126753, EC 126745, EC 126746-1, RC 781 and Domo-4 were found to exhibit desirable gca effects for plant height, primary branches, secondary branches and oil content in both the environments with the exception of Domo-4 in respect of oil content. On the other hand, these parental lines were poor combiners for seed yield, 1000-seed weight, seeds per siliqua and siliqua length. Parents Varuna, Kranti, RLC 1357 and RLC 1359 were found to be good combiners for seed yield, earliness, siliqua length, seeds per siliqua and 1000-seed weight in both the environments but were exhibiting undesirable gca effects for plant height, primary branches, secondary branches and oil content. Thus parental lines could be classified into two separate groups, one comprising genotypes possessing higher yield and early in maturity but having less oil content and other group of genotypes having poor yield, late in maturity and high oil content.

The evaluation of crosses for sca could be made use in two ways. Firstly,for identifying better cross combinations and secondly for obtaining transgressive segregants from the crosses with high sca effects and involving both the good combining parents. For all the cross combinations sca effects were computed with respect to each character under both the environments. However, only five best crosses selected on the basis of highly desirable sca effects and *per se* performance (pooled over two environments) with respect to all characters have been presented in Table 3. Perusal of this table revealed that the crosses having significant and highly desirable sca effects involved good, average and poor general combining parents. Among the various crosses selected for earliness Domo-4 x RC 781 was the best cross having high negative sca effects. The cross EC 126745 x RC 781 was the best for higher plant height, primary branches and secondary branches and included both good combining parents. Prakash x RLC 1357 was best combination for siliqua length involving both the parents as good combiners. Similarly Kranti x EC 126745 (good x average) was the best cross for seeds per siliqua, RLC 1359 x RLC 1357 (good x good) for 1000-seed weight, EC 126746-1 x RLC 1359 (average x good) for seed yield and Kranti x Domo-4 (poor x poor) *per cent oil content.*

From practical point of view, high sca effects of crosses alone will not lead to much improvement unless it is coupled with high *per se* performance. Therefore, selection of crosses for further breeding programmes may be based on higher values of both of these parameters. In the present investigation crosses EC 126745 x RC781, Prakash x RLC 1357 and RLC 1359 x RLC 1357 apart from having high sca effects and *per se* performance for various yield components also had both the parents as good combiners. Hence, these crosses are expected to throw transgressive segregants in the later generations.

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Table 1. Analysis of variance of 10 x 10 diallel (Griffing's *method 2, model 1*) with respect to seed yield, its attributes and oil content under two environments in Indian mustard

Source	df	Environments	Mean squares: Days to maturity	Plant height	No. of primary branches	No. of secondary bramches
1	2	3	4	5	6	7
Gca	9	E_1	107.159*	3185.440*	9.865*	36.324*
		E_2	95.965*	2709.840*	8.550*	33.284*
Sca	45	E_1	15.871*	149.281*	0.874*	16.671*
		E_2	14.984*	137.544*	0.694*	12.728*
Error	108	E_1	0.132	1.685	0.013	0.038
		E_2	0.210	2.828	0.039	0.066

Source	df	Environments	Mean squares: Siliqua length	No. of seeds per siliqua	1000-seed weight	Seed yield per plant	Oil content
1	2	3	8	9	10	11	12
Gca	9	E_1	0.790*	1.884*	2.605*	15.164*	12.324*
		E_2	0.675*	2.600*	2.064*	11.145*	11.495*
Sca	45	E_1	0.070*	1.562*	0.050*	19.835*	2.487*
		E_2	0.058*	1.197*	0.025*	14.583*	2.448*
Error	108	E_1	0.001	0.014	0.001	0.327	0.036
		E_2	0.001	0.029	0.002	0.393	0.025

* Significant at $P = 0.05$

Table 2. General combining ability (gca) effects of parents with respect to seed yield, its attributes and oil content under two environments in Indian mustard

Parents	Days to maturity		Plant height		No. of primary branches		No. of secondary branches	
	E1	E2	E1	E2	E1	E2	E1	E2
Prakash	-1.406*	-1.683*	-0.794*	-1.217*	-0.382*	-0.259*	-0.137*	-0.777*
Varuna	-3.350*	-3.156*	-11.150*	-10.514*	-0.474*	-0.601*	-1.067*	-1.171*
Kranti	-4.322*	-3.322*	-17.464*	-16.428*	-0.829*	-0.789*	-1.406*	-1.319*
EC 126743	2.650*	1.706*	15.564*	14.661*	1.315*	1.143*	1.811*	1.576*
EC 126745	3.844*	3.733*	17.025*	12.601*	0.793*	0.802*	0.305*	0.582*
EC 126746-1	1.650*	1.956*	9.806*	9.458*	0.637*	0.521*	2.474*	2.284*
Domo-4	3.067*	3.317*	15.569*	16.030*	0.709*	0.732*	1.855*	2.018*
RC 781	2.233*	2.233*	13.519*	13.411*	0.573*	0.577*	0.766*	0.904*
RLC 1359	-2.044*	-2.239*	-24.244*	-22.420*	-1.149*	-0.965*	-2.326*	-1.907*
RLC 1357	-2.322*	-2.544*	-17.831*	-15.670*	-1.193*	-1.151*	-2.276*	-2.118*
S.E. ($\hat{gi}$)	0.099	0.125	0.355	0.461	0.031	0.054	0.053	0.070
S.E. ($\hat{gi} - \hat{gj}$)	0.148	0.187	0.530	0.687	0.047	0.080	0.080	0.105

Contd..

Contd...2.

Parents	Siliqua length		Number of seeds per siliqua		1000-seed weight		Seed yield		Oil content	
	E1	E2	E1	E2	E1	E2	E1	E2	E1	E2
Prakash	0.177*	0.190*	0.206*	0.531*	-0.072*	-0.041*	0.678*	0.796*	-0.816*	-0.743*
Varuna	0.267*	0.256*	0.078*	0.048	0.636*	0.517*	1.025*	0.994*	-1.372*	-1.284*
Kranti	0.164*	0.127*	0.236*	-0.007	0.614*	0.389*	1.747*	1.224*	-0.863*	-1.045*
EC 126743	-0.231*	-0.196*	-0.913*	-1.098*	-0.328*	-0.308*	-1.438*	-1.016*	1.548*	-1.341*
EC 126745	-0.302*	-0.306*	-0.061	0.007	-0.314*	-0.330*	-1.244*	-1.053*	0.237*	0.229*
EC 126746-1	-0.150*	-0.140*	-0.426*	-0.379*	-.411*	-0.333*	0.088	0.008	1.662*	1.688*
Domo-4	-0.182*	-0.158*	0.050	-0.021	-0.644*	-0.597*	-1.666*	-1.666*	-0.111*	-0.226*
RC 781	-0.300*	-0.267*	0.222*	0.162*	-0.264*	-0.208*	-0.061	-0.061	0.570*	0.624*
RLC 1359	0.369*	0.340*	0.466*	0.460*	0.392*	0.462*	0.292	0.292	-0.294*	-0.196*
RLC 1357	0.190*	0.155*	0.142*	0.352*	0.392*	0.448*	0.483*	0.483*	-0.561*	-0.387*
S.E. ($\hat{g}_i$)	0.008	0.009	0.032	0.046	0.010	0.011	0.172	0.172	0.052	0.042
S.E. ($\hat{g}_i - \hat{g}_j$)	0.012	0.014	0.048	0.069	0.015	0.017	0.256	0.256	0.078	0.062

Table 3. Best crosses selected on the basis of specific combining ability effects and *per se* performance pooled over two environments with respect to seed yield, its component characters and oil content in Indian mustard.

Character	On the basis of	
	SCA effects	Per se performance
Days to maturity	Domo-4 x Rc 781, Domo-4 x RLC 1359, EC 126745 x RLC 1357, Varuna x EC 126745, Kranti x Domo-4	Kranti x Domo-4, Domo-4 x RLC 1359, Varuna x EC 126745, Varuna x RLC 1357, Kranti x EC 126746-1.
Plant height	EC 126745 x RC 781, Varuna x RLC 1359, Prakash x Domo-4, EC 126745 x Domo-4, EC 126743 x RLC 1357	EC 126745 x RC 781, EC 126745 x Domo-4, EC 126743 x RC 781, EC 126746-1 x RC 781, Prakash x Domo-4.
Primary branches	EC 126745 x RC 781, EC 126743 x RC 781, Prakash x EC 126746-1, Varuna x EC 126743, Kranti x EC 126743.	EC 126743 x RC 781, EC 126745 x RC 781, EC 126745 x Domo-4, EC 126746-1 x Domo-4, Prakash x EC 126746-1.
Secondary branches	EC 126745 x RC 781, EC 126743 x RC 781, EC 126747-1 x RLC 1359, EC 126746-1 x Domo-4, EC 126746-1 x RC 781.	EC 126746-1 x Domo-4, EC 126743 x RC 781, EC 126746-1 x EC 126745 x RC 781, EC 126743 x Domo-4.
Siliqua length	Prakash x RLC 1357, Domo-4 x RC 781, Varuna x RC 781, EC 126746-1 x RLC 1357, EC 126746-1 x RLC 1359	Prakash x RLC 1357, Prakash x Varuna, Kranti x RLC 1359, Vauna x RLC 1359, RLC 1359 x RLC 1357.
Seeds per siliqua	Kranti x EC 126745, Varuna x RC 781, RC 781 x RLC 1357, Varuna x EC 126746-1, RC 781 x RLC 1359	Varuna x RC 781, Kranti x EC 126745, RC 781 x RLC 1359, RC 781 x RLC 1357, Prakash x RC 781.
1000-seed weight	RLC 1359 x RLC 1357, Varuna x RC 781, EC 126743 x Domo-4, Prakash x RLC 1357, Prakash x RLC 1359	RLC 1359 x RLC 1357, Varuna x RLC 1357, Varuna x Kranti, Krnati x RLC 1359
Seed yield per plant	EC 126746-1 x RLC 1359, Prakash x Domo-4, EC 126743 x RC 781, Varuna x Domo-4, EC 126745	EC 126746-1 x RLC 1359, Prakash x Domo-4, EC 126746-1 x RLC 1357, Kranti x EC 126746-1, EC 126743 x RC 781.
Oil content	Kranti x Domo-4, EC 126745 x RLC 1357, EC 126746-1 x RLC 1359, RC 781 x RLC 1359, Domo-4, RLC 1357.	EC 126746-1 x RC 781, EC 126746-1 x RLC 1359, EC 126743 x EC 126746-1, RC 781 x RLC 1359, EC 126743 x EC 126745.

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VALIDITY LIMITS OF PLANT STAND LOSSES IN FIELD EXPERIMENTS OF SUNFLOWER (*Helianthus annuus*)

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ABSTRACT

A field experiment to study the effect of plant stand losses on seed yield of sunflower in two contrasting genotype (EC.68415 and Morden) was conducted for three years from 1984 to 1986 during *kharif* at GKVK, University of Agricultural Sciences, Bangalore on red sandy loam soils under rainfed conditions in factorial RBD with three replications. The plant stand loss treatments included were viz., 0, 10, 20, 30 and 40 per cent loss in recommended levels of plant population which were imposed 20 to 25 days after sowing by removing the plants at random. The studies indicated that loss in plant stand upto 20 per cent when the distribution is random does not reduce the seed yield significantly because of compensation by other plants and does not require analysis of covariance in these experiments.

Key words : Sunflower; Plant stand losses; Seed yield.

Even within the same progeny of variety, although the same number of seeds are sown per plot, the number of plants in each plot will not be the same at the time of harvest owing to the failure of some of the seeds to germinate or subsequent death of plants (Panse and Sukhatme, 1957). In arid and semi arid regions, soil dry up favouring crust formation, impeding germination and emergence of seedlings resulting in spotting and unsatisfactory plant stand (Arnon, 1972). The other causes for loss in plant stand could be water logging, crow or rodent damage at the time of germination, soil pathogens and other diseases resulting in seedling death. A common observation in field experiments is that plants by virtue of their ability to tiller, to produce extra branches, or to increase in size will usually make full adjustment for small deficiencies in stand and even for a large excess in stand (Salmon and Hanson, 1964). The effect of stand losses in sorghum is reported by Ramanatha Chetty and Narayana Reddy (1979) through a well designed experiment. The covariance technique recommended is effective for relatively homogenous material to improve the accuracy and sometimes permit salvaging useful results from an otherwise worthless experiment (Salmon and Hanson, 1964). They do not however, make up for large deficiencies in stand.

The covariance analysis involves extra calculation and more time for analysis than the conventional statistical analysis. In covariance analysis, yield adjustments are done for the missing plants which may not be realistic because of plasticity of neighbouring plants to adjust for small deficiencies in plant stand.

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In sunflower, often one faces the problem of uneven plant stand in experimental plots. Information is lacking on the maximum limit in respect of losses in plant stand that could be afforded to consider a field experiment as satisfactory, for normal statistical analysis and for drawing conclusions. Hence, the present study was conducted on two sunflower varieties to arrive at the minimum level of plant stand in terms of percentage of normal stand for considering the experimental data.

MATERIALS AND METHODS

A field trial was conducted for three years from 1984 to 1986 during kharif at the Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bangalore, on red sandy loam soils of average fertility under protective irrigation. The sunflower varieties included were EC-68415 and Morden. The EC-68415 is a tall long duration variety of 95 to 105 days and Morden is a dwarf early variety of 75 to 80 days (Anon., 1984 to 1987). The plant population levels maintained were 55,555 and 74, 074 plants per ha with inter-row spacings of 60 and 45 cm for varieties EC- 68415 and Morden respectively, with the intra-row spacing of 30 cm. The fertilizers dose applied were 60N, 80 P_2O_5 and 60 K_2O kg per ha. Entire dose of P and K along with 75 per cent N was applied as basal dose at sowing and the remaining 25 per cent N was top-dressed at 40 days after seeding. Five levels of plant stand losses- 0, 10, 20, 30 and 40 per cent of the recommended level were tried in randomised block design with 3 replications. The plant stand loss treatments were imposed at 20 to 25 days after sowing by removing the required number of plants at random using random number table. The plot size adopted was 5.4m x 4.2m = 22.68 m2. Biometric observations were made on ten plants selected at random and were statistically analysed. The crop was attended to routine cultural and plant protection operations.

RESULTS AND DISCUSSION

The data on monthly rainfall received during the crop growth and seed yield along with a few growth parameters in different plant stand loss treatments, year wise are presented in Tables 1 and 2 respectively.

The variety EC-68415 gave significantly higher seed yield over Morden in all the three years. The seed yields were much lower during 1986 because of high rainfall during flowering and disease incidence (Table 1).

The yield variations due to different levels of plant stand were significant in two out of three years and also in pooled analysis. The non-significant difference during 1986 was perhaps due to poor seed set on account of rains during pollination period as stated above.

The 1984 and 1985 and as well as pooled analysis data revealed that seed yields did not differ among treatments where plant stand loss was 0, 10 and 20 per cent. Though the results are not statistically significant, the loss in plant stand was compensated by the remaining plants in the form of increased leaf area, stem girth, head diameter and test weight (Table 2). The interaction effects between varieties and levels of plant stand loss was not significant. The mean seed yields averaged over three years (1984-1986) as affected by loss in plant stand is also depicted graphically in Fig.1. So, it can be said that loss in plant stand upto 20 per cent that might occur in 20-25 days of sowing is compensated by the remaining plants without significant yield loss and does not require analysis of covariance. Such type of yield adjustments of missing plants by the neighbouring plants in sunflower has also been reported by Jagannath and Venkataramu (1985) in their study on distribution of missing plants and its effect on neighbouring plants. They observed that compensation effect was more in plants of different adjoining rows, rather than in the same row. They further observed that the effect of missing plants on the community appeared to be slight, when missing plants are of the order of 8 per cent and where their distribution is random. However, when the plant losses occur in clusters due to systematic effect of pests/diseases the loss in yield has not been quantified in literature. For practical purposes the assumption of 'random misses' appear to be alright. It should also be kept in mind that the 'optimum' plant stand for the same crop varies from variety to variety and from environment to environment.

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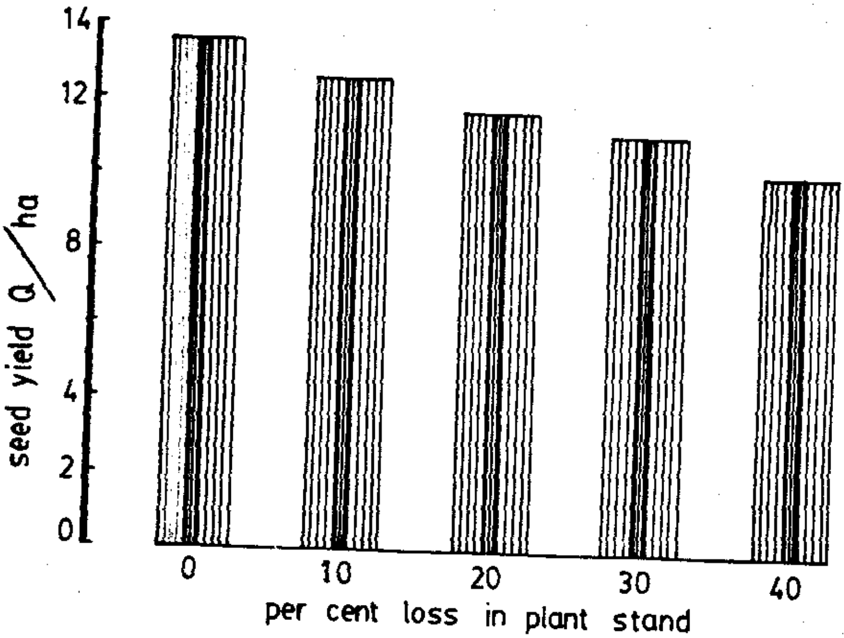

Fig.1: Effect of plant stand on seed yield of sunflower (mean of three years).

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

Month	Sowing date		
	27-07-1984	07-08-1985	06-08-1986
July	217.1	86.3	75.3
August	*65.1*	*51.0*	*70.0*
September	241.9	214.8	333.6
October	168.8	60.3	28.0
November	8.5	-	59.6
Pollination period (10 days)			
Morden (50 to 60 days)	18.0	98.6	245.2
EC-68415 (60 to 70 days)	4.7	28.1	48.6

Table 2. Effect of plant stand on seed yield, test weight and some growth parameters in sunflower genotypes

Treatments	Seed yield (kg/ha)			Mean	100 seed weight (g)			Mean	Plant height at harvest (cm)			Mean
	1984	1985	1986		1984	1985	1986		1984	1985	1986	
Varieties												
EC-68415	1512	1963	717	1398	5.01	6.48	4.60	5.36	156	179	136	157
Morden	1053	1338	472	970	4.41	6.41	5.08	5.30	72	108	79	86
C.D. (P=0.05)	82	197	98	130	0.54	NS	0.44		6	6	8	
Levels of plant stand loss (%)												
0 (No loss)	1391	1894	764	1350	4.11	5.79	4.59	4.83	111	151	111	124
10	1334	1764	673	1257	4.45	6.30	4.67	5.14	111	146	110	122
20	1279	1640	639	1186	4.49	6.40	4.84	5.24	115	143	109	122
30	1298	1564	521	1113	5.07	6.57	4.91	5.52	117	140	105	121
40	1155	1397	493	1016	5.44	7.17	5.21	5.94	118	137	103	119
C.D. (P=0.05)	130	313	NS	206	0.85	NS	NS		NS	NS	NS	
C.V.(%)	9.29	15.50	21.38	25.96	14.90	11.10	11.81		7.26	5.17	9.09	

Contd...

Table 2. contd...

Treatments	Leaf area index at full bloom stage			Mean	Stem girth (cm)			Mean	Head diameter (cm)			Mean
	1984	1985	1986		1984	1985	1986		1984	1985	1986	
Varieties												
EC-68415	2.71	3.25	2.42	2.79	2.45	2.45	1.82	2.15	16.86	20.71	12.80	16.79
Morden	1.51	3.31	1.84	2.22	2.18	2.17	1.34	2.05	15.41	17.50	11.30	14.65
C.D. (P=0.05)	0.30	NS	NS		0.13	0.20	0.13		1.19	0.83	NS	
Levels of plant stand loss (%)												
0 (No loss)	1.72	2.78	1.82	2.11	2.16	2.14	1.54	1.95	15.32	17.93	10.83	14.69
10	1.94	3.11	2.06	2.37	2.26	2.23	1.67	2.05	15.73	18.39	11.78	15.30
20	2.21	3.20	2.22	2.54	2.34	2.32	1.70	2.12	16.24	18.93	11.96	15.71
30	2.28	3.37	2.24	2.63	2.38	2.36	1.73	2.16	16.42	19.53	12.17	16.04
40	2.37	3.95	2.33	2.88	2.43	2.49	1.75	2.22	16.96	20.75	12.73	16.81
C.D. (P=0.05)	NS	0.71	0.27		NS	NS	NS		NS	1.31	0.87	
C.V.(%)	18.68	17.71	16.53		7.19	11.12	10.00		9.64	5.60	9.50	

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MUTAGENIC EFFECTIVENESS AND EFFICIENCY OF SODIUM AZIDE IN GROUNDNUT (*Arachis hypogaea* L) IN RELATION TO CANOPY DEVELOPMENT.

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ABSTRACT

The chemical mutagen Sodium azide at the concentration of 3mM was the most effective leading to the recovery of higher number of mutations per unit dose of mutagen in the two sequentially branching varieties of groundnut viz.,GAUG-1 and NC Ac 17090 representing medium compact canopy development. The mutagenic efficiency of Sodium azide was however, higher in the case of an alternate branching Virginia variety Robut 33-1. The observations indicate that the tow sequentially branching varieties are genetically more differentiated than the two Virginia varieties. In view of a wide range of novel mutations induced, as well as considering the higher mutagenic effectiveness and a reasonable degree of mutagenic efficiency, Sodium azide could be employed in groundnut mutation breeding.

Key words: Groundnut (Arachis hypogaea L.); Sodium Azide; Canopy types.

INTRODUCTION

Despite, vast literature on mutation breeding in several crop plants, our knowledge of different types and frequencies of mutants that could be induced and mutagenic effectiveness and efficiency in relation to canopy characterisation in groundnut remains fragmentary. Studies carried out by Prasad *et al.* (1984) and Prasad (1988), have indicated a differential response of sequential and alternate branching types with regard to types of mutants observed in M_2 generation. However, the mutagenic response in M_1 and M_2 generations in relation to canopy development is yet to be understood clearly. Therefore, the present investigation was under taken to study the effectiveness and efficiency of a chemical mutagen Sodium azide with reference to canopy development in groundnut.

MATERIALS AND METHODS

The experimental material consisted of four genotypes belonging to different botanical groups, which were categorized for canopy development at 60 days (Nagabhushanam, 1989). Three hundred well developed seeds of each of the four genotypes, GAUG-1, NC Ac 17090 (Canopy category 2; i.e., medium compact), Robut 33-1 (canopy category 3; i.e., medium spreading) and M13 (canopy category 4; i.e., spreading) were treated with a chemical mutagen,

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Sodium azide (Na N_3) of 3mM concentration using citric acid-sodium phosphate buffer at pH 3 for 3 hours as described by Prasad *et al.* (1985).

After mutagenic treatment the seeds of each genotype were thoroughly washed in running water and sown with the appropriate control on ridges by hand dibbling giving a spacing of 60 cm between the rows and 15 cm between the seeds with in a row in M_1 generation during the postrainy season 1986-'87 at the Agricultural College Farm, Rajendranagar.

All the seeds harvested from M_1 plants were sown in progeny rows during the rainy season of 1987 to raise the M_2 generation. All appropriate cultural operations and prophylactic measures against pests and diseases were under taken to maintain good crop growth. The seeds obtained from control material was also handled in the similar fashion.

In the present study, modified formulae of Konzak *et al.* (1965) as adopted by Prasad (1972) was used to calculate the mutagenic effectiveness and efficiency. Viable and chlorophyll mutants were recorded from each M_2 family for all the varieties in order to find out the mutagenic effectiveness and efficiency.

RESULTS AND DISCUSSION

Mutagenic effectiveness and efficiency are very important considerations to assess the genotypic response to mutagenic treatment for plant breeding purposes. Mutagenic effectiveness is the proportion of mutations isolated per unit dose of mutagen, while the mutagenic efficiency is the proportion of mutations in relation to sterility induced (Konzak *et al.* 1965). Sodium azide of the concentration of 3mM was for the mutagenic treatment based on the reports if its efficacy and efficiency (Prasad, *et al.* 1985; De Sa, 1984: and Anuradha, 1987). The results on effectiveness and efficiency (Table 1.) of these treatments in relation to four different genotypes pertaining to canopy categories 2, 3 and 4 indicate that Na N_3 at 3mM was relatively more effective in NC Ac 17090 and GAUG-1 (canopy category 2) in that order than in the case of Robut 33-1 (canopy category 3) and M13 (canopy category 4). The efficiency of mutagenic treatment in different genotypes, however, gave a different picture. The mutagenic treatment was most efficient in Robut 33-1 followed by GAUG-1 as seed sterility induced by mutagen in these varieties was of relatively lower order. In view of a higher degree of seed sterility induced in M13 and NC Ac 17090, the efficiency of the mutagen in these varieties was of the lower order. The recovery of higher number of mutations per unit dose of mutagen in the M_2 generation in the two sequentially branching varieties such as GAUG-1 and NC Ac 17090 representing canopy category 2, as compared to that of the two *Virginia* varieties confirm the interpretation that the former two varieties were genetically more differentiated than the later two *Virginia* varieties (Prasad *et al.* 1984). This also draws support from the pattern of variances observed in M_2 and M_3 generations (Nagabhushanam, 1989). In view of the wide range of novel mutations recovered in the present study, (Table 2) as well as considering the higher levels of mutagenic effectiveness and reasonable degree of mutagenic efficiency, it may be stated that Na N_3 could be used for mutation breeding purposes for canopy attributes to be employed as selection criteria (Madhavi 1988 and Nagabhushanam, 1989) and yield components leading to genetic restructuring of plant type of groundnut suggested by Prasad (1988).

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Table 1. Mutagenic effectiveness and efficiency of sodium azide in different varieties of groundnut in the M_2 generation

Varieties	Treatment	Number of M_2 families segregating for mutants (Me)	Seed sterility in M_1 (%) (S)	Mutagenic effectiveness (Me/t.c*)	Mutagenic efficiency (Me/S)
GAUG-1	control	0.00	0.00	0.00	0.00
	NaN_3 3mM (0.0195%)	31.25	5.83	534.19	5.36
NC Ac 17090	control	0.00	0.00	0.00	0.00
	NaN_3 3mM (0.0195%)	32.54	12.91	572.48	2.52
Robut 33-1	control	0.00	0.00	0.00	0.00
	NaN_3 3mM (0.0195%)	25.00	4.19	427.35	5.97
M13	control	0.00	0.00	0.00	0.00
	NaN_3 3mM (0.0195%)	24.16	22.79	422.56	1.06

*t.c = Duration of mutagenic treatment (t) x concentration of mutagen (c)

Table 2. Data on different mutant plant types of agronomic importance isolated in M_2 generation

Parent from which the mutants were developed	Description of the mutant	Canopy		Plant height (cm)	Number of			Mature			Breeding behaviour in M3 generation
		Circumferance (cm)	Diameter (cm)		Primeries	Secondaries	Mature pods	Pod weight (g)	Kernal number	Kernal weight (g)	
NC Ac 17090	Parent	116.28	37.66	27.16	3.69	0.06	8.08	9.11	17.84	5.42	BRED TRUE
	Alternate branching mutant (abm-1)	141.00	42.00	27.00	7.00	3.00	18.00	19.25	42.00	12.44	-do-
	ABM-2	138.00	41.00	26.00	6.00	2.00	21.00	21.58	45.00	15.95	-do-
GAUG 1	Parent	100.05	28.72	25.40	4.14	0.09	5.47	3.10	7.87	1.68	-do-
	ABM-3	111.00	31.00	17.00	5.00	2.00	11.00	9.19	14.00	6.12	-do-
	ABM-4	121.00	33.00	16.00	5.00	3.00	13.00	11.25	19.00	8.04	-do-
	ABM-5	116.00	35.00	22.00	6.00	2.00	16.00	13.50	24.00	9.89	-do-
	ABM-6	128.00	34.00	21.00	6.00	3.00	18.00	15.60	28.00	12.12	-do-
NC Ac 17090	Parent	116.28	37.66	27.16	3.69	0.06	8.08	9.11	17.84	5.42	-do-
	Dense canopy mutant (dcm-1)	131.00	39.00	26.00	4.00	3.00	18.00	17.44	40.00	11.69	-do-
	DCM-2	126.00	39.00	29.00	4.00	2.00	15.00	16.00	35.00	11.06	-do-
	DCM-3	121.00	40.00	17.00	5.00	5.00	15.00	14.10	27.00	10.20	-do-
	DCM-4	116.00	38.00	18.00	5.00	4.00	18.00	17.12	30.00	14.15	-do-
M 13	Parent	146.97	48.00	15.50	5.80	8.20	11.30	11.47	16.00	7.13	-do-
	Compact canopy mutant (ccm-1)	130.00	35.00	20.00	6.00	4.00	25.00	28.18	41.00	19.15	-do-
	CCM-2	123.00	33.00	16.00	7.00	7.00	35.00	36.10	64.00	27.92	-do-
Robut 33-1	Parent	114.50	37.30	18.60	5.10	3.20	8.60	5.12	8.90	3.43	-do-
	CCM-3	121.00	40.00	17.00	5.00	5.00	15.00	14.10	27.00	10.20	-do-
	CCM-4	116.00	38.00	18.00	5.00	4.00	18.00	17.12	30.00	14.15	-do-
NC Ac 17090	Small pod mutant (SPM-1)	130.67	41.50	27.00	4.00	2.15	18.00	19.02	32.00	15.16	-do-

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INFLUENCE OF SOWING DATES AND SEASONS ON GROWTH, DEVELOPMENT AND YIELD OF GROUNDNUT (*Arachis hypogaea*)

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ABSTRACT

The response of groundnut (Arachis hypogaea) cultivars viz., Gangapuri, JL 24, Kadiri 3 and M 13 to moisture stress, delayed sowing and seasons was studied during 1987-88 rainy and post-rainy seasons at Hyderabad. Though the pod yield decreased significantly under moisture stress conditions in all the cultivars the magnitude is however less in JL 24 (24 per cent). Similarly under delayed sowing both in rainy season and post-rainy season, the cultivars exhibited significant reduction in pod yield, the minimum reduction being with JL 24 (33% in both seasons). Cv. M 13 was sensitive to seasons which recorded 72 per cent more pod yield in post-rainy season compared to rainy season and Kadiri 3 recorded least variation in pod yield between seasons (3.8 and 3.9 tonnes/ha in rainy and post-rainy seasons, respectively). The contributing factors for yield performance under these conditions were discussed in detail.

Key words: Groundnut ; Sowing dates ; Planting seasons; Moisture stress ; Yield.

INTRODUCTION

Sowing time of groundnut (*Arachis hypogaea*) in both the seasons depends on the on-set of monsoon, previous crop and sufficient soil moisture. Lenka and Misra (1973) reported influence of moisture stress in decreasing the physiological efficiency. Ghosh and Das Gupta (1975) and Ghadekar (1988) reported that reduction in various morpho-physiological attributes and yield with delay in sowing was due to the depletion in soil moisture at the fag end of the crop growth and accumulated heat units.

Since enough information is lacking on causes for yield reduction with delayed sowing in the rainy season and post-rainy season and on the role of moisture stress and genotypes on such reduction, an experiment was conducted on these aspects.

MATERIALS AND METHODS

Two field trials, one in rainy (kharif) season, 1987 and the other in the post-rainy (rabi) season, 1987-88 on medium deep alfisols in Hyderabad were conducted. The seeds were sown at 0.1m interval in rows spaced 0.3 m apart on flat beds of 12 m^2 area . Cultural operations and fertilizer application were done as per recommended package of practices. During the rainy season, the experiment was laid out in a split-split plot design with three replications. The two main treatments of irrigations comprised I_0, no irrigation (rainfed only) and I_1, irrigated at an IW:CPE ratio of 0.8. When the pan evaporation reached 6 cm, irrigation of 5

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cm was given using Parshal flume. The sub-treatments consisted of 4 varieties, V_1, 'Gangapuri' (*Valencia*); V_2, 'JL 24'(*Spanish*); V_3, 'Kadiri 3' (*Virginia* bunch), and V_4, 'M 13' (*Virginia* runner). Three sub-sub-treatments of dates of sowing were D_1, 19 June 1987; D_2, 14 July 1987; D_3, 8 August 1987.

During post-rainy season the second trial was conducted in the same experiment plot, and laid out in split-plot design with 3 replications. Four varieties (V_1, 'Gangapuri'; V_2,'JL 24'; V_3, 'Kadiri 3' and V_4, 'M 13') as main treatments. Dates of sowing formed the 3 sub-treatments and were D_1, 24 October 1987; D_2, 19 November 1987 and D_3, 14 December 1987.

Growth analysis

Non-destructive sampling

Five representative plants were randomly selected in each plot and marked for recording plant height at 15-day interval starting from 20 days after sowing (DAS).

Destructive sampling

Five plants from each plot were harvested for detailed analysis. Flants from this sample were separated into leaves, stems and reproductive structures. A random sample was taken from the leaf fraction for leaf area measurement with a LI-3100 area meter (LI- COR, JNC, Lincoln, NE). Total leaf area for each sampling was calculated as the product of the leaf area/dry weight ratio of the random leaf sample and the total leaf weight (leaf weight of the sub-sample plus leaf weight of the bulk sample). The leaf area index (LAI) was calculated as the ratio of total leaf area to ground area.

Pods from the plants of one square metre marked area were harvested from each replication and pod yield was calculated in tonnes/hectare after drying in shade.

Crop (CGR) and pod (PGR) growth rates were estimated starting from the time of measurable seed growth until final harvest. Pod weights were adjusted for their higher energy content by multiplying by a factor coefficient of 1.65 as suggested by Duncan *et al*. (197Ɛ). The partitioning factor (PF)was then calculated as the rate of PGR (energy adjusted) as a percentage of the contemporary CGR during pod fill. Calculation of CGR was based on the biomass of the shoot plus the pod (energy adjusted).

$$PF = (PGR \times 1.65/CGR) \times 100$$

The data on plant height, vegetative dry matter, reproductive dry matter, total dry matter and pod yield at harvest and on leaf area index at their maximum value stage were presented (Table 1 and Table 2) for kharif and rabi seasons.

The mean data of various characters were subjected to variance and co-variance techniques (Panse and Sukhatme, 1978) for both the trials separately as per the design. Thermal time during the crop growth was computed taking 10^0C on base temperature (McCloud *et al.*, 1980).

RESULTS AND DISCUSSION

Plant height reduced (over all reduction of 12%) with the crop that did not receive irrigation (I_0) and this reduction might be due to the reduction in the rate of cell division (Bidinger, 1978).

Relative leaf expansion rate was more in irrigated conditions (0.035) as compared to unirrigated conditions (0.031) of kharif. Leaf area index showed 22 per cent reduction with moisture stress. This might be due to slow rate of leaf expansion (Pandey *et al.*, 1984 b).

The adverse effect of moisture stress on total dry matter production (a reduction of 15%) observed during kharif was in conformity with the observations of Lenka and Misra (1973)

Rainfed crop without irrigation (I_0) recorded a 30 per cent yield reduction. This confirms the finding of Pandey *et al.* (1984 a). The results suggest that though moisture stress reduces various plant parameters and yield as well, magnitude of such reduction was more pronounced on yield (30%)followed by LAI (21%). The reduction in total dry matter production was 15 per cent. Of the two components of total dry matter, reproductive dry matter was most affected (19%) compared to vegetative dry matter (12%). Partitioning factor (PF) was high under irrigated conditions compared to rainfed conditions (Table 3).

With delay in sowing, a reduction in all the parameters was observed in both the seasons in all the cultivars, however,magnitude of such reduction differed with parameters. Reduction in plant height with delay in sowing was observed in both kharif (37%) and rabi (38%) seasons. Reduction in LAI (about 31% in both seasons) observed in the present experiment was in agreement with Shelke *et al.* (1987). Dry matter production was also affected by the delay in sowings in kharif (30%) and rabi (37%) seasons. Yield reduction of 35 per cent in kharif and 55 per cent in rabi was observed with delay in sowing. In groundnut yield reduction with delay in sowing was reported in kharif (Ghosh and Das Gupta, 1975) and in rabi (Metelerkamp, 1972) seasons.

The plant performance including yield was generally much higher in rabi than kharif and also the partitioning factor is high in rabi compared to kharif season. The optimum LAI values in kharif season obtained were 2.95. 2.9. 3.04 and 3.75 for Gangapuri, JL 24 , Kadiri 3 and M 13, respectively, while the values were 3.64, 3.79, 4.61 and 6.66 during rabi season. Duncan *et al.* (1978) observed 95% interception of light at LAI of 3 while in rabi-summer, Dwivedi *et al.* (1986) made such observation at LAI of 5 - 5.5 in bunch genotypes. Plant height was not correlated with pod yield in kharif and rabi seasons. Vegetative dry matter and LAI have positive correlation in both the seasons but the correlation was significant only in rabi season. Whereas, reproductive dry matter and total dry matter have highly significant and positive correlation with pod yield in both the seasons (Table 5).

Cultivars differed significantly in their reaction to moisture stress (maximum yield reduction of 35 per cent with M 13) delay in sowing (a maximum yield reduction of 38 per cent with Gangapuri in kharif and 67 per cent with M 13 in rabi) and among seasons, though all the Cvs., recorded more yield in rabi than kharif, the pod yield variation between the seasons was more with Cv. M 13 which recorded more pod yield in rabi (49.5 q/ha) compared to kharif (29 q/ha) season.

A critical analysis of the data to identify the reasons for reduction in yield with delay in sowing showed that the yield reduction was not exclusively due to moisture stress alone during the fag end of crop growth, as even under irrigated conditions, reduction in yield was observed with delay in sowing in the present investigation.

Less number of heat units were accumulated with delay in sowing in kharif and more in rabi (Table 4). Cv. JL24 and Gangapuri accumulated less heat units during its crop growth period and gave stable yields under varied treatmental combinations during kharif, maximum yields were obtained when Gangapuri, JL 24, Kadiri 3 and M 13 accumulated 1858, 1858, 2098 2066 heat units, respectively. While accumulated heat units for maximum yields were 1392, 1392, 1646, and 1773 during rabi season for the above cultivars, respectively.

Ghadekar (1988) recorded optimum growth and yield at Nagpur, under the sowing date which could be able to accumulate 1490 heat units. Therefore, factors other than moisture stress at the fag end of the season or heat units might also be responsible for yield reductions. So multiple regression between climatic factors and pod yield was done for kharif and rabi separately and prediction formulae were arrived at as follows:

Kharif : Pod yield $= 91.51 - 7.28 x_1 + 4.93 x_2 + 0.04 x_3 - 0.04 x_4$ .... ($R^2 = 64.36$).

Rabi : Pod yield $= 89.35 - 10.23 x_1 + 9.65 x_2 - 0.1 x_3 + 0.26 x_4$ ....($R^2 = 87.37$)

Where: x_1 is mean maximum temperature
x_2 is mean minimum temperature
x_3 solar radiation
x_4 sunshine hours.

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Table 1. Influence of dates of sowing and seasons on growth, development and yield of groundnut cultivars in kharif.

Treatment		Plant height (cm)	Leaf Area Index	Optimum LAI	Vegetative dry matter (g/plant)	Reproductive dry matter (g/plant)	Total dry matter (g/plant)	Pod yield (tonnes/ha)
1		2	3	4	5	6	7	8
UNIRRIGATED								
Gangapuri	D1	34.7	3.80	2.76	14.3	9.1	23.2	2.20
	D2	29.4	3.17	2.30	11.1	7.8	18.9	1.49
	D3	19.5	2.92	2.04	9.8	6.6	16.5	1.23
JL 24	D1	30.6	3.34	3.25	11.4	9.7	22.1	2.22
	D2	24.3	3.07	2.54	9.5	8.9	18.3	1.79
	D3	19.8	2.46	2.23	8.1	8.1	16.3	1.60
Kadiri 3	D1	22.1	4.39	3.62	11.9	14.3	26.2	3.45
	D2	16.1	2.95	2.95	10.3	12.9	23.2	2.55
	D3	12.0	2.40	2.40	10.0	10.8	20.7	2.09
M 13	D1	23.0	3.39	3.95	13.0	10.7	23.6	2.34
	D2	16.3	2.74	3.30	12.0	9.9	22.5	1.99
	D3	14.6	2.55	2.07	9.7	9.5	19.2	1.33
IRRIGATED								
Gangapuri	D1	41.2	5.34	3.93	17.2	11.1	28.3	2.85
	D2	35.5	4.16	3.53	11.4	10.0	22.5	2.29
	D3	22.4	3.58	3.14	11.3	8.3	19.6	1.88
JL 24	D1	32.1	3.73	3.51	14.2	12.2	26.4	3.01
	D2	25.1	3.19	3.10	11.1	10.5	21.5	2.36
	D3	22.8	3.03	2.75	9.9	8.7	18.8	2.00

Contd...

Table 1 contd...

1		2	3	4	5	6	7	8
Kadiri 3	D1	22.3	4.62	3.89	13.3	17.4	30.7	4.74
	D2	18.5	3.63	2.91	11.0	15.0	26.1	3.69
	D3	14.3	3.03	2.45	9.3	12.0	21.2	2.97
M 13	D1	26.3	5.36	5.36	16.0	16.0	32.0	3.53
	D2	20.8	4.33	4.33	13.6	12.8	26.3	2.80
	D3	17.8	3.50	3.50	10.8	11.4	22.2	2.36
C.D. (P = 0.05)								
MT		0.90	0.11	0.06	0.47	0.42	0.37	0.013
ST		0.91	0.05	0.03	0.32	0.10	0.29	0.098
SST		0.48	0.04	0.04	0.17	0.32	0.23	0.069
MT X ST		0.92	0.08	0.04	0.46	0.35	0.41	0.139
ST X MT		0.92	0.07	0.05	0.52	0.20	0.44	0.120
MT X SST		NS	0.05	NS	0.18	0.45	0.32	NS
SST X MT		NS	0.04	NS	0.27	0.45	0.35	NS
ST X SST		0.97	0.09	0.08	0.34	0.63	0.46	0.139
SST X ST		1.14	0.08	0.07	0.40	1.0	0.45	0.143
MT X ST X SST		1.37	0.12	0.11	0.15	0.22	0.65	0.146

MT = Main treatments; ST = Sub-treatments;

SST = Sub-sub treatments; NS = Non-significant

Table 2. Influence of dates of sowing and seasons on growth, development and yield of groundnut cultivars in rabi

Treatment		Plant height (cm)	Leaf Area Index/ Optimum LAI	Vegetative dry matter (g/plant)	Reproductive dry matter (g/plant)	Total dry matter (g/plant)	Pod yield (tonnes/ha)
Gangapuri	D1	24.5	4.01	10.4	19.7	30.0	5.8
	D2	22.0	3.7	10.2	13.7	23.2	3.38
	D3	19.7	3.22	9.7	9.5	19.2	2.31
JL 24	D1	18.3	4.32	11.0	13.7	24.7	3.85
	D2	17.6	3.84	9.9	10.9	20.8	3.20
	D3	16.5	3.22	9.3	9.5	18.8	2.56
Kadiri 3	D1	17.8	5.36	11.8	18.0	29.8	5.17
	D2	16.9	4.52	11.0	14.5	25.5	4.00
	D3	13.9	3.94	10.9	10.1	21.0	2.66
M 13	D1	16.7	7.50	21.0	21.0	53.5	7.62
	D2	15.5	6.34	19.4	14.4	38.7	4.77
	D3	12.5	6.15	16.7	10.1	28.2	2.48
C.D. (p = 0.05)							
MT		1.17	0.20	0.26	0.92	0.26	0.69
ST		0.65	0.21	0.23	0.55	0.15	0.32
MT x ST		1.30	0.41	0.46	1.09	0.30	0.65
ST x MT		1.50	0.33	0.40	1.20	0.34	0.86

MT = Main treatments; ST = Sub Treatments

Table 3. Crop growth rate (CGR), pod growth rate (PGR) and partitioning factor (PF) for kharif and rabi seasons

Treatment	CGR	PGR	PF
	$g\ m^{-2}\ d^{-1}$		
Kharif (I_0)			
Gangapuri	8.96	6.42	71
JL 24	8.58	6.82	79
Kadiri 3	10.39	8.31	80
M 13	7.52	5.70	76
Kharif (I_1)			
Gangapuri	10.76	7.94	74
Jl 24	10.81	8.56	79
Kadiri 3	11.7	9.72	83
M 13	9.76	7.61	78
Rabi			
Gangapuri	14.01	11.97	85
JL 24	12.46	10.38	83
Kadiri 3	12.63	10.65	84
M 13	17.06	12.98	76

Table 4. Thermal time during crop growth period in kharif and rabi seasons

		Kharif	Rabi
Gangapuri	D_1	1858	1392
	D_2	1831	1479
	D_3	1729	1651
Jl 24	D_1	1858	1392
	D_2	1831	1479
	D_3	1729	1651
Kadiri 3	D_1	2098	1646
	D_2	2020	1763
	D_3	1898	2069
M 13	D_1	2066	1773
	D_2	1978	1937
	D_3	1838	2102

Table 5. Correlation coefficient (r) values between different attributes and pod yield

Treatment	Kharif	Rabi
Plant height	-0.11	0.26
LAI	0.47	0.69*
Vegetative dry matter	0.37	0.57*
Reproductive dry matter	0.96**	0.97**
Total dry matter	0.82**	0.87**

** , * are 1% and 5% level of significance

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COMBINING ABILITY AND HERITABILITY IN RELATION TO CANOPY DEVELOPMENT AND YIELD IN GROUNDNUT (*Arachis hypogaea* L.)**

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ABSTRACT

An analysis of fourteen diverse groundnut genotypes characterised for different degrees of canopy development in a diallel mating design revealed predominant SCA variances for canopy and yield attributes viz., number of mature pods and their weight, number of mature seeds and their weight in the F1 and F2 generations. The most spreading canopy types of category 4 and the medium spreading canopy types of category 3 exhibited significantly positive GCA effects for canopy and yield characters, while the most compact canopy genotype of category 1 showed negative GCA effects for these traits. The medium compact canopy types of category 2 showed negative and positive GCA effects for canopy and yield attributes respectively. The heritability estimates showed a decline from F1 and F2 for canopy characters and an enhancement for yield components and nodule mass, although in general the canopy and yield attributes registered low levels of heritability in both the generations. The cross combinations involving intermediate canopy types such as categories 2 and 3 appeared promising for generating transgressive segregates due to involvement of additive and complimentary epistatic effects acting in the same direction. The results of the above investigation warrant the adoption of recurrent selection with random mating in the segregating population and postponement of application of rigorous selection pressure to later generations to recover desirable recombinants.

Key words: Groundnut (Arachis hypogaea L.); GCA; SCA; Variances; Canopy types.

INTRODUCTION

The identification of promising parents is crucial for the success in breeding for higher productivity in groundnut (*Arachis hypogaea* L.). Also a proper understanding of the nature of inheritance of yield and its component characters and the relationship between canopy development and yield components, is necessary to put such breeding programmes on a sound footing (Ashley, 1984). The investigations of Duncan *et al.* (1978) and Prasad (1988) clearly brought out the relevance of canopy attributes for groundnut yield improvement. However, our knowledge regarding the nature of inheritance of canopy development in relation to the identification of better combiners still remains fragmentary. Therefore studies have been

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undertaken involving a wide range of genotypes for canopy spread in order to identify better combiners based on canopy development, which was reported to exhibit a strong positive relationship with seed yield (Nagabhushanam, 1989).

MATERIALS AND METHODS

Fourteen groundnut genotypes were categorised for canopy development at 60 days (Nagabhushanam, 1989). The categorisation revealed that the strain MH2 possessing the most compact canopy fell in category 1, while the most spreading canopy categories *viz.*, M 13 and NC Ac 2821, were of the category 4. Among the rest, the varieties *viz.*, MH2BC28 (an induced mutant of MH 2), PGN1, PGN2, TMV2 and GAUG-1 were found of category 2 representing medium compact canopy. The canopy category 3 i.e., medium spreading group included 32-2-5, Compact Mutant of M 13, TMV2NLM, Robut 33-1, ICG (C) 8 and MK374. These strains falling in different canopy categories were crossed in a diallel mating design without reciprocals during the postrainy season 1986-'87. The 91 F_1 hybrids along with the fourteen parents were grown in a randomized block design with two replications during rainy season, 1987. The plot size was 3.5m x 1.8m. The inter and intra row spacings adopted were 60cm x 15cm respectively. The F_2 generations of the above 91 crosses along with parents were grown during postrainy season 1987-'88 in a randomized block design at the Agricultural College Farm, Hyderabad. The plot size was 3.5m x 2.4m. The inter and intra row spacings adopted were the same as in the F_1 generation. A sample size of 10 plants and 20 plants of random were chosen from each cross of F_1 and F_2's respectively to record the observations on canopy *diameter at 60 days, plant height , number of primaries and secondaries, number of mature* pods and their weight, number of mature seeds and their weight, leaf area at harvest, total nodule number and nodule dry weight at harvest and total drymatter of harvest. Appropriate cultural operations and prophylactic measures were undertaken whenever necessary.

The data were analysed for general combining ability (GCA) and specific combining ability (SCA) following Griffing's (1956), method-2, model-I. Heritability in narrow sense (n) was estimated according to Gardner (1963) in both the generations.

RESULTS AND DISCUSSION

Significant genotypic differences (mean squares) for all the characters were observed among parents and F_1 hybrids (not shown). Significant mean squares due to GCA and SCA were observed for all the characters, predominant SCA variance was also observed for all the characters studied (Table 1). Similar trend of genotypic differences (mean squares) were also found in F_2 (not shown). Significant mean squares due to GCA and SCA were observed for all the traits, predominant SCA variance was also observed for all the characters studied in F_2 generation (Table 2) also. The significant mean squares for all the attributes, indicated the presence of considerable genetic variability among the parents justifying their classification for their canopy development at 60 days.

The results on GCA effects of the parents (Table 3) followed an interesting trend indicating that the genotypes *viz.*, M 13 and NC Ac 2821 pertaining to the most spreading canopy type (canopy category 4) exhibited positive GCA for canopy and yield component characters, while the most compact canopy type MH2 (canopy category 1), exhibited negative GCA effects for all the traits.

The genotypes classified under canopy category 3, showed preponderance of GCA effects for canopy diameter at 60 days, pod number and their weight, while Compact Mutant of M13 and 32-2-5 (mutants derived from M13 and MK374 respectively) pertaining to canopy category 3, appeared to be the best general combiners for most of the attributes. High GCA effects are mostly due to additive gene effects or additive x additive interaction effects (Griffing's, 1956). In view of this, the genotypes such as Compact Mutant of M13 and 32-2-5 could be considered for inclusion in breeding programmes for yield and associated agronomic attributes. However, the genotype TMV2 NLM (which is a narrow leaf *Virginia* mutant of *Spanish* bunch variety TMV2), while exhibiting high positive GCA for canopy attributes, revealed negative GCA for most of the yield components.

The genotypes pertaining to canopy category 2, representing predominantly *Spanish* and *Valencia* varieties except MH2BC28, indicated negative GCA effects for canopy attributes and positive GCA for yield and yield component characters. The genotype PGN1 (canopy category 2) was found to be good general combiner especially for yield and its components.

The above trend in both the generations, could also form a basis for explaining the preponderance of SCA effects due to the involvement of high x low, high x medium general combiners indicating the presence of epistatic interaction i.e., additive x dominance (Isleib *et al.* 1978) in most of the cross combinations involving 2x3, 3x2 and 3x3 canopy types. The cross combinations of intermediate canopy categories appeared very promising for generating progenies with agronomically superior transgressive segregants that could occur in the later generations. In general, SCA effects can not be readily exploited for the improvement of self pollinated crops. However, when SCA effects are observed in the crosses having at least one good general combiner, the possibility of their exploitation in practical breeding increases (Hammons, 1973). In the present study also, most of the intermediate canopy cross combinations *viz.*, 2x3, 3x2 and 3x3 exhibited the involvement of one good general combiner, and as such are likely to throw some transgressive segregates as a result of the complementary epistatic and additive effects acting in the same direction as observed by Hammons (1973).

In the present study, heritability estimates were arrived at for the above attributes in the F_1 and F_2 generations (Tables 1 and 2). While heritability for canopy diameter was 25% in the F_1 and it was only 15% in the F_2. The heritability estimates for the primaries and the secondaries decreased from 33% and 34% in the F_1 to 16% and 28% in the F_2 respectively. In the case of yield components on the other hand, the heritability estimates got enhanced in the F_2. The nodule number also showed similar pattern in the heritability both in the F_1 and

F_2. By and large all the above characters registered low levels of heritability ranging from 9% to 34% in the F_1 and 11% to 28% in the F_2 generations.

Low heritability estimates were observed for the above traits, as was reported by Mohammed *et al.* (1978), Norden (1982) and Monteverde-Penso and Wynne (1988). However, Wynne and Rawlings (1978) and Sandhu and Khehra (1977) observed high heritability for several characters. The low heritability estimates in the present study are at variance with the above investigations. However, the present trends of heritability for all the traits are in line with the higher levels of specific combining ability effects in the F_1 and F_2 generations, thereby warranting, adoption of comprehensive and non-traditional strategies and breeding procedures designed to exploit such genetic effects.

In view of the higher levels of SCA effects and variances and low heritability for various characters especially in the crosses involving intermediate canopy types 2 and 3, it would be desirable to practice selection in F_4 and later generations (Baker 1968 and Arunachalam *et al.* 1980). In order to ensure, the maintenance of adequate degrees of genetic buffering in the population, the selection pressure up to F_3 may have to be modified by the way of rejection of the least productive individuals from the population (Norden 1982). Random intermating among the individuals in such a population will ensure the conservation of genetic buffering. Since the intermating through hand pollination would be laborious and practically not feasible, it would be necessary to employ low doses of radiation treatment to induce some degree of pollen sterility leading to natural out crossing (Dutta *et al.* 1986). It has already been reported (Brock, 1971) that the low doses of radiation while on one hand could induce some pollen sterility with out any accompanying deleterious effects. Where hybridization is difficult, recurrent selection with minimal crossing followed by single seed descent method may be practised (Monteverde-Penso and Wynne 1988), leading to better results.

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Table 1. Analysis of variance (mean squares) for combining ability of 14 parents and 91 F_1 hybrids

Source	df	Canopy diameter	Plant height (cm)	Number of primaries	Number of secondaries	Number of mature pods	Mature pod weight (g)
1	2	3	4	5	6	7	8
GCA	13	111.26*	23.40**	8.19**	210.28**	38.15**	24.28**
SCA	91	20.09**	8.68**	1.01**	25.21**	21.17**	13.69**
Error	104	2.50	2.29	0.27	3.42	3.48	2.70
Var GCA		6.80	1.32	0.49	12.93	2.17	1.35
Var SCA		17.59	6.39	0.74	21.79	17.69	10.99
h2 (narrow sense)		0.25	0.13	0.33	0.34	0.09	0.09

Source	df	Number of mature seeds	Mature seed weight (g)	Leaf area at harvest (cm^2)	Total nodule number at harvest	Nodule mass at harvest (g)	Total dry matter at harvest (g)
1	2	9	10	11	12	13	14
GCA	13	78.26**	11.54**	609641.88**	7158.00**	0.011**	232.77**
SCA	91	50.89**	6.75**	89772.27**	2308.64**	0.003**	46.64**
Error	104	7.21	1.09	27900.35	738.21	0.001	16.84
Var GCA		4.44	0.65	36358.84	401.24	0.001	13.49
Var SCA		43.68	5.66	61871.92	1570.43	0.002	29.80
h2 (narrow sense)		0.08	0.09	0.29	0.15	0.250	0.22

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

Var - variance

Table 2. Analysis of variance (mean squares) for combining ability of 14 parents and 91 F_2 progenies (Diallel experiment)

Source	df	Canopy diameter (cm)	Plant height (cm)	Number of primaries	Number of secondaries	Number of mature pods	Mature pod weight (g)
1	2	3	4	5	6	7	8
GCA	13	130.44**	69.15**	7.45**	373.71**	286.40**	464.04*
SCA	91	46.22**	19.38**	2.31**	58.60**	108.09**	99.51*
Error	104	1.63	1.15	0.37	0.95	3.86	4.33
Var GCA		8.05	4.25	0.44	23.30	17.66	28.73
Var SCA		44.59	18.23	1.94	57.66	104.23	95.19
h2 (narrow sense)		0.15	0.18	0.16	0.28	0.14	0.22

Source	df	Number of mature seeds	Mature seed weight (g)	Leaf area at harvest (cm^2)	Total nodule number at harvest	Nodule dry weight (g)	Total dry matter at harvest (g)
1	2	9	10	11	12	13	14
GCA	13	554.67**	258.84**	8582124.00**	23022.23**	0.011**	1142.25**
SCA	91	271.99**	46.64**	3034716.75**	5703.67**	0.004**	480.62**
Error	104	22.93	2.96	27533.54	117.89	0.000	19.67
Var GCA		33.23	15.99	534661.88	1431.52	0.001	70.16
Var SCA		249.07	43.68	3007183.25	5585.78	0.004	460.96
h2 (narrow sense)		0.11	0.26	0.15	0.20	0.200	0.13

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

Var - variance

Table 3. Estimates of general combining ability effects for some characters in 14 parents (F_2 - Diallel experiment)

Parents	Canopy diameter (cm)	Plant height (cm)	Number of primaries	Number of secon-daries	Number of mature pods	Mature pod weight (g)	Number of mature seeds	Mature seed weight (g)	Leaf area at harvest (cm^2)	Total nodule no. at har-vest	Nodule dry wt. at harvest (g)	Total dry matter at harvest (g)
32-2-5	1.74**	0.12	0.96**	4.40**	-2.56**	0.88	-1.91	1.70**	1262.02**	52.84**	0.04**	5.89**
Com.Mut. M13	3.62**	-0.85**	0.88**	5.51**	1.13*	2.93**	2.16	3.11**	955.05**	66.53**	0.05**	10.24**
TMV2NLM	1.21**	-2.97**	0.93**	9.29**	0.84	-0.44	-1.78	-1.37**	-215.50**	3.98	0.00	10.47**
MH2BC28	-5.30**	0.62*	-0.24	-6.38**	-8.87**	-9.83**	-7.19**	-7.44**	-778.76**	-47.71**	-0.03**	-9.40**
PGN1	-0.91*	-1.45**	-0.50**	-2.83**	6.30**	6.52**	7.69**	4.20**	-372.61**	-9.01**	0.01	-3.36**
PGN2	-1.22**	3.34**	-1.02**	-6.14**	1.79**	-3.71**	1.52	-1.91**	-863.35**	-48.29**	-0.02**	-8.24**
TMV2	-0.64	2.62**	-0.86**	-3.25**	3.01**	-1.94**	0.58	-2.37**	-358.36**	-48.09**	-0.04**	0.61
MH2	-5.47**	-2.53**	-0.57**	-4.09**	-7.16**	-10.92**	-14.14**	-8.15**	-917.93**	-5.70*	-0.02**	-12.51**
M13	3.70**	-0.60*	0.39*	4.56**	-1.26*	5.25**	-2.77*	3.54**	371.49**	49.60**	0.01	5.68**
Robut 33-1	0.03	-1.50**	-0.51**	-2.69**	1.55**	1.52**	3.71**	2.06**	-419.68**	-12.28**	-0.00	-11.40**
GAUG-1	-1.89**	1.27**	-0.44*	-3.77**	-3.41**	-2.71**	-2.06	-1.55**	-440.32**	-27.29**	-0.03**	-7.75**
ICG(C)8	1.30**	3.73**	0.01	0.73**	2.11**	3.41**	2.50*	2.25**	970.31**	25.72**	0.02**	7.64**
NCAc2821	2.75**	-0.79**	0.49**	2.08**	3.94**	5.53**	9.45**	4.59**	100.27*	14.31**	0.02**	5.67**
MK374	1.07**	-1.01**	0.48**	2.59**	2.58**	3.49**	2.17	1.35**	707.39**	-14.60**	-0.01	6.46**
SE of G(I)	0.31	0.26	0.15	0.23	0.47	0.50	1.15	0.41	39.97	2.62	0.004	1.07
SE of G(I)-G(J)	0.45	0.38	0.21	0.34	0.69	0.73	1.69	0.61	58.67	3.84	0.005	1.57

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

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POD YIELD, TOTAL WATER USE, CONSUMPTIVE USE, WATER USE EFFICIENCY AND MOISTURE EXTRACTION PATTERN OF SUMMER GROUNDNUT AS INFLUENCED BY IRRIGATION SCHEDULES*

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ABSTRACT

The results of the two years study on effect of scheduling irrigation at different stages of summer groundnut at the Main Research Station, Hebbal, Bangalore-24, India revealed that irrigation at 0.5 IW/CPE ratio during 10 to 40 DAS and later at 0.75 IW/CPE ratio resulted in higher pod yield and water use efficiency with a saving of 40 mm of water compared to uniform irrigation at 0.75 IW/CPE ratio throughout the crop growth. Total water use and seasonal consumptive use of water increased with increase in number of irrigations. The per cent moisture depletion in 0-30 cm soil layer was more when irrigations were scheduled at 0.75 IW/CPE ratio in the beginning of crop growth while in the lower layers (30-60 and 60-90 cm) more moisture was depleted when irrigations were scheduled at 0.5 IW/CPE ratio.

Key words : *Groundnut*; Total water use; Consumptive use; Water use efficiency; Moisture extractions pattern.

INTRODUCTION

Productivity of irrigated summer groundnut is more since it is not subjected to the vagaries of monsoon. In the early stages of its growth evapotranspiration is low and root and canopy growth is less. Irrigations may be given at longer interval. As the plant growth advances daily consumptive use increases and when it attains maturity stage evapotranspiration decreases(Sabale and Khuspe, 1986). Crop water use varied with irrigation schedules. Pahalwan and Tripathi (1984) recorded 674 mm with the irrigation at 0.9 IW/CPE ratio and it ranged from 455 to 600 mm at 0.6 and 0.8 IW/CPE ratio respectively (Ramachandra Reddy, 1988). Efficient management of irrigation water not only helps to augment production but also improves the water use efficiency. Irrigation at 0.9 IW/CPE ratio at later stages and at 0.6 IW/CPE ratio during early growth increased the water use efficiency (Subramanian *et al.*, 1974). While, Shinde and Pawar (1984) recorded higher water use efficiency due to uniform irrigation at 0.6 IW/CPE ratio throughout the crop growth. The information about the effect of scheduling irrigation at different stages of summer groundnut on total water use, consumptive water use, water efficiency and moisture extraction pattern is inadequate for the purpose of developing management strategies aimed at more efficient use of water, hence , the present study was under taken.

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MATERIALS AND METHODS

Field experiment was conducted for two seasons (Summer 1989 and 1990) at the Agronomy field unit, Main Research Station, Hebbal, Bangalore-24. TMV-2 variety of groundnut was sown in 4.8 m x 3.5 m plots on 9th and 11 th January 1989 and 1990 respectively on sandy loam soil (coarse sand 53.10%; fine sand 27.15%; silt 8.25% and clay 11.50%) of pH 6.60. The available water holding capacity was 0.78, 1.29, 2.04 and 3.48 cm in 0-15, 15-30, 30-60 and 60-90 cm soil layers respectively. N, P_2O_5 and K_2O at the rate of 25:75:37.5 kg per ha were applied at the time of sowing. Study consisted of five irrigation schedules comprising two IW/CPE ratios (0.5 and 0.75) varied at three stages (10 to 40 DAS, 40 to 70 DAS and 70 DAS to harvest).

	10 to 40 days	40 to 70 days	70 days to harvest
		(IW/CPE ratio)	
I_1	0.5	0.75	0.75
I_2	0.5	0.75	0.75
I_3	0.5	0.75	0.5
I_4	0.5	.05	0.5
I_5	0.75	0.75	0.75

The experiment was laid out in randomised complete block design with four replications. At each irrigation 40 mm of water was applied by Parshall Flume. Vertical polythene barriers were laid to a depth of 60 cm between two plots to avoid lateral movement of water and water was taken to the plots in polythene lined irrigation canals to avoid seepage losses. One pre-sowing irrigation (50 mm) and one post-sowing irrigation (20 mm) on 9th day after sowing was given. Irrigation treatments were imposed from 10th day after sowing. During the crop growth period effective rainfall of 47.9 mm and 79.0 mm was received in 1989 and 1990 seasons respectively. Stored soil moisture at sowing before and after every irrigation and at harvest was estimated in 0-15, 15-30, 30-60 and 60-90 cm soil layers gravimetrically.

Total water use (mm) = Quantity of irrigation water applied (including common irrigation before sowing and post-sowing) + Effective rainfall + contribution of crop water use from the stored soil moisture at sowing and harvest.

Seasonal consumptive use (Cu) has been worked out using the formula suggested by Dastane(1972). Water use efficiency was calculated by dividing the pod yield (kg/ha) by hectare^{-cm} of total water used. The total moisture depleted form 0-30, 30-60 and 60- 90 cm depths was calculated by adding all the short period depletions at respective depths till the harvest and the percentage contribution from various depths to the total depletion was worked out. The crop was harvested on 25th and 28th May 1989 and 1990 respectively. Pod yield was recorded after complete drying. Results were discussed based on the pooled data of 1989 and 1990.

RESULTS AND DISCUSSION

Pod yield and water use efficiency

Data in Table 1 revealed that irrigation scheduled at 0.5 IW/CPE ratio from 10 to 40 DAS and later at 0.75 IW/CPE ratio (I_1) produced maximum water use efficiency (83.91 kg/ha^{-cm}) closely followed by I_2 (83.08 kg/ha^{-cm}) irrigation schedule. These two irrigation treatments were significantly superior to other irrigation schedules (74.38 to 77.30 kg/ha^{-cm}). Higher pod yield (59.02 q/ha) coupled with lower water use (703.93 mm) were responsible for high water use efficiency in I_1 irrigation schedule. In I_2 irrigation treatment higher water use efficiency was mainly because of less reduction in pod yield (6.81%) and greater reduction in total water use (663.94 mm). This has a significant manageriable option in that the delayed irrigations from 10 days to 70 days at 0.5 IW/CPE ratio could be allowed for considerable yield of 55.0 q per ha with a saving of irrigation water (79.99 mm) in I_2 irrigation schedule compared to uniform irrigation at 0.75 IW/CPE ratio throughout (I_5). Similar results were recorded by Ravikumar *et al.* (1985).

Irrigation at 0.5 IW/CPE ratio throughout (I_4) registered lowest water use efficiency (74.38 kg/ha^{-cm}) followed by I_3 (76.08 kg/ha^{-cm}) irrigation schedule. Such reduction in water use efficiency in I_3 and I_4 irrigation treatments was due to stress at pod filling and maturity stage in (I_3) and at gynophore penetration and pod development stage in I_4 causing greater reduction in pod yield (21.19 to 28.07%) and also due to less reduction in total water use (13.23 to 18.91%) over I_1 irrigation treatment.

Consumptive use

Scheduling irrigation at 0.75 IW/CPE ratio (I_5) recorded maximum consumptive use of water (624.1 mm) (Table 1) followed by I_1 (598.35 mm) irrigation treatment. Irrigation at 0.5 IW/CPE ratio throughout (I_4) registered lowest consumptive use of water (544.75 mm) closely followed by I_3 (567.65 mm) irrigation treatment. Consumptive use of water increased with increase in number of irrigations given in different treatments. Irrigations at 0.75 IW/CPE ratio throughout the crop growth (I_5) received 14 irrigations at an interval of 9 to 10 days from 10 to 40 days and 8 to 9 days form 40 to 70 days later at 7 to 8 days interval. While, in I_4 which received nine irrigations at 0.5 IW/CPE ratio at an interval of 13 to 14, 12 to 13 and 11 to 12 days from 10 to 40, 40 to 70 days and 70 days to harvest respectively. Thorat *et al.*(1984) reported 550 mm of water through 11 irrigations at 0.8 IW/CPE ratio and 300 mm at 0.4

IW/CPE ratio through six irrigations. Thus, the results in the present study bear testimony to the earlier evidences. The higher consumptive use of water with more number of irrigations was probably due to greater ease with which the moisture was available in the soil due to regular and frequent irrigations.

Moisture extraction pattern

The results on moisture extraction pattern furnished in Table 2 and depicted in Fig. 1 showed 60.02, 23.13 and 16.85 per cent moisture extraction from 0-30, 30-60 and 60-90 cm soil layers respectively. Moisture depletion was more from the surface layer (0-30 cm) in I_5 and I_1 irrigation schedules which received more number of irrigations. Delayed irrigations at 0.5 IW/CPE ratio either from 10 DAS to harvest (I_4) or from 70 DAS to harvest (I_3) caused less depletion of moisture in 0-30 cm layer while, more moisture was extracted from below layers. The greater percentage of moisture depletion from 0-30 cm soil layer in I_5 and I_1 irrigation schedules was due to more number of irrigations which probably restricted root proliferation in surface layer. On the contrary, less number of irrigations in I_4 an I_3 irrigations treatment perhaps enforced better root growth in deeper layers causing more depletion from deeper layers. Robertson *et al.* (1980) also observed variation in moisture extraction and root length in irrigated and dry season groundnut.

Thus, it can be concluded from the results that groundnut can withstand delayed irrigation at 0.5 IW/CPE ratio during 10 to 40 DAS with higher yield and water use efficiency compared to uniform irrigation at 0.75 IW/CPE ratio throughout the crop growth.

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Table 1. Pod yield (q/ha), total water use (mm), seasonal consumptive use (mm) and water use efficiency (kg/ha^{-cm}) as influenced by irrigation schedules in summer groundnut

Treatments	Irrigation schedules (IW/CPE ratio) 10-40 days	40-70 days	70 days to harvest	Pod yield 1989	Pod yield 1990	Pod yield Pooled	Total water use (mm) 1989	Total water use (mm) 1990	Total water use (mm) Pooled
I1	0.5	0.75	0.75	58.14	59.90	59.02	676.84 (13)	731.02 (13)	703.93 (13)
I2	0.5	0.5	0.75	56.68	53.33	55.00	636.84 (12)	691.05 (12)	663.94 (12)
I3	0.5	0.75	0.5	42.52	50.50	46.51	605.99 (10)	615.99 (10)	610.79 (10)
I4	0.5	0.5	0.5	41.76	43.15	42.45	565.99 (9)	575.59 (9)	570.79 (9)
I5	0.75	0.75	0.75	56.83	58.08	57.45	716.84 (14)	771.02 (14)	743.93 (14)
S.Em ±				1.24	1.87	1.12			
C.D. at 5%				3.62	5.43	3.11			

Treatments	Irrigation schedules (IW/CPE ratio) 10-40 days	40-70 days	70 days to harvest	Seasonal consumptive use (mm) 1989	Seasonal consumptive use (mm) 1990	Seasonal consumptive use (mm) Pooled	Water use efficiency (kg/ha^{-cm}) 1989	Water use efficiency (kg/ha^{-cm}) 1990	Water use efficiency (kg/ha^{-cm}) Pooled
I1	0.5	0.75	0.75	598.1	598.6	598.35	85.89	81.93	83.91
I2	0.5	0.5	0.75	568.3	582.5	575.40	89.00	77.16	83.08
I3	0.5	0.75	0.5	591.9	543.4	567.65	70.17	82.00	76.08
I4	0.5	0.5	0.5	562.2	527.3	544.75	73.79	74.98	74.38
I5	0.75	0.75	0.75	625.7	622.5	624.10	79.28	75.33	77.30
S.Em ±							1.99	2.80	1.71
C.D. at 5%							5.77	NS	4.76

Figures in the parenthesis indicate the total number of irrigations excluding two common irrigations (one before sowing and other on 9th day)

NS : Not significant

Table 2. Soil moisture extraction (% of total) from different depths as influenced by irrigation schedules in summer griundnut (pooled data of 1989 and 1990)

Treatments				Soil moisture extraction (% of the total) Depth of soil (cm)			
				0-30	30-60	60-90	Total
Irrigation schedules (IW/CPE ratio)							
	10-40 days	40-70 days	70 days to harvest				
I_1	0.5	0.75	0.75	60.23	23.18	16.59	100
I_2	0.5	0.5	0.75	61.21	21.74	17.05	100
I_3	0.5	0.75	0.5	58.52	24.91	16.57	100
I_4	0.5	0.5	0.5	59.53	23.42	17.05	100
I_5	0.75	0.75	0.75	60.59	22.38	17.03	100
		Mean		60.02	23.13	16.85	100

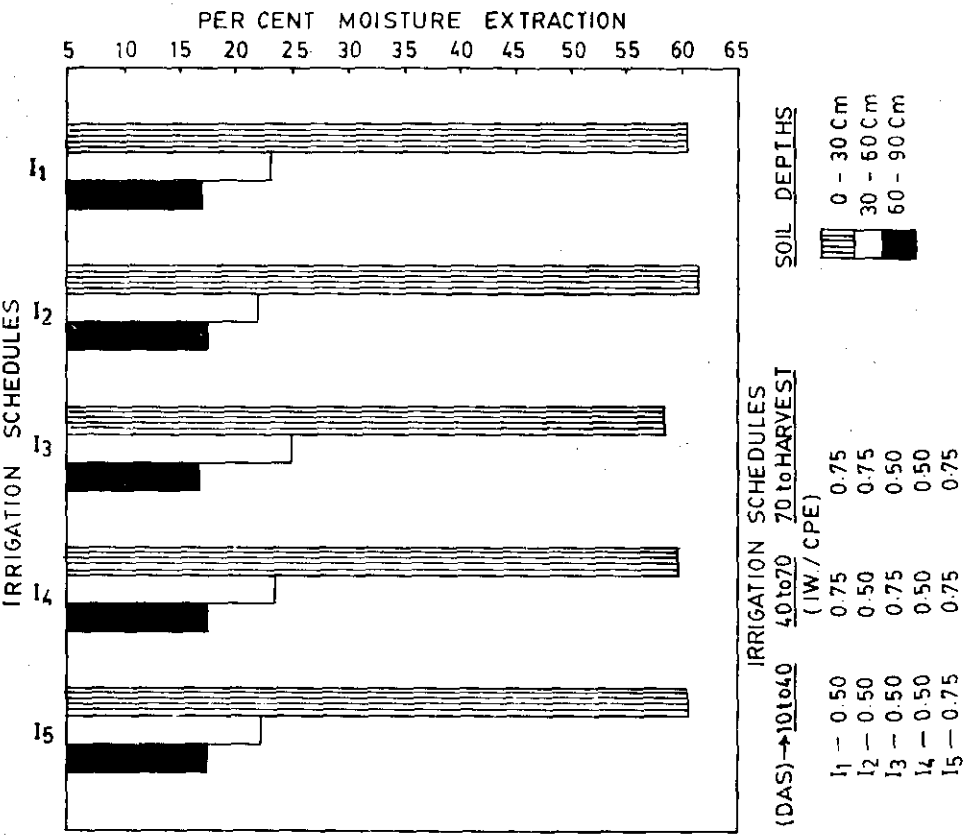

FIG. 1. SOIL MOISTURE EXTRACTION (%) OF THE TOTAL FROM DIFFERENT DEPTHS AS INFLUENCED BY IRRIGATION SCHEDULES IN SUMMER GROUNDNUT (MEAN)

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NUTRITIONAL QUALITY OF OIL BLENDS BASED ON MAHUA (*Madhuca latifolia*) AND GROUNDNUT (*Arachis hypogaea* L.) OILS.

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ABSTRACT

The effect of feeding 10% oil from oil blends based on mahua oil and groundnut oil in ratios of (1) 25:75, (2) 50:50 and (3) 75:25 was studied on growth performance, feed efficiency, digestibility and lipid profiles of serum and liver tissue in weanling rats. Animals showed normal growth and normal digestibility with oil blends. Lipid levels in serum and liver were comparable to edible oils in common use. Histopathological examination of tissue did not reveal any gross abnormalities.

Key words: Lipid profiles; Feed efficiency ratio;Triglycerides; Cholesterol; HDL, LDL, VLDL -Cholesterol.

INTRODUCTION

Mahua kernels (two species of the genus *Madhuca latifolia* and *Madhuca longifolia*) belonging to the family sapotaceae, yield 45- 50% oil. The oil is semi-solid in consistency with yellow colour. This fat is also known as 'illipe butter'. Tribals are consuming this oil from times immemorial. It is permitted in vanaspati manufacture as a component oil(CSIR, 1962). Government is in favour of blending one major oil with another non-conventional oil (like groundnut oil with cotton seed oil, sesame oil with cotton seed oil, and rice bran oil with mustard oil) to promote the marketability of non-conventional oils for direct human consumption and to improve the edible oil supply in the country (Lewis, 1986). Very little research has been done on the implications of oil blends on physiological systems. This idea has prompted us to take up this study on oil blends to understand the nutritional effects and later to suggest for human use.

MATERIALS AND METHODS

The physico-chemical characteristics and fatty acid composition of Mahua oil (MO), Groundnut oil (GNO) and three oil blends based on the above two oils *viz.*, blend 1 (25:75 MO:GNO), blend 2 (50:50 MO:GNO) and blend 3 (75:25 MO:GNO) were analysed (AOAC, 1973).

A biological study was carried out for 12 weeks on five groups of (8 animals in each) male weanling rats of Wistar strain. Five diets were formulated keeping in view the nutritional requirements of growing rats. Mahua oil and groundnut oil and three oil blends under study

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were incorporated the semi-synthetic diets at 10% level and fed to the five groups of animals as follows:

Diet 1 - Contained 10% mahua oil

Diet 2 - Contained 10% groundnut oil

Diet 3 - Contained 10% of the oil blend 1 (25:75 MO:GNO)

Diet 4 - Contained 10% of the oil blend 2 (50:50 MO:GNO)

Diet 5 - Contained 10% of the oil blend 3 (75:25 MO:GNO)

During the feeding trial the body weight and food intake of all the animals were recorded at weekly intervals to assess growth and feed efficiency. The rats were also closely observed for the appearance of any abnormal pathological signs and symptoms. At the end of 12 weeks feeding the true digestibility of oil blends was assessed after making corrections for metabolic fat (Henry, 1964).

The rats were sacrificed soon after termination of feeding after an overnight fast. The blood was collected and serum separated. The liver, spleen, heart, kidney, brain, testes and visceral fat were collected from each rat and their weights recorded. A section of each organ was stored in 10% neutral buffered formaline, later processed and examined for histopathological changes (Clayden, 1971). The serum and liver homogenates were analysed for total lipids (Folch *et al.* 1957) total cholesterol (Frings *et al.* 1972), HDL cholesterol (Varley, 1980) and triglycerides (Vanhandel and Zilversmit, 1957).

RESULTS AND DISCUSSION

The findings of the study are presented in Tables 1-3. The physico-chemical characteristics of mahua oil and its blends were very close to the oil reference and other commonly used edible oils (Table 1). Only the IV of the mahua oil is some what lower than groundnut oil and the blends. The fatty acid composition of the oils and oil blends showed that the mahua oil contained higher percentage of palmitic and stearic acids and lower levels of oleic and linoleic acids compared to groundnut oil (Table 1).

The mean food intake of the mahua oil fed rats was less than those fed groundnut oil and this perhaps could be due to the strong flavour of mahua oil. However the food intake of the animals having blend 3 oil were found to have maximum food intake throughout the 12 weeks period of feeding (Table 2).

The mean gain in body weight of rats fed diets containing mahua oil, blends 1, 2 and groundnut oil were close upto first 4 weeks of feeding. But the animals fed on diet having blend 3 oil showed superior growth rates over others. The FER and true digestibility in rats fed mahua oil was slightly lower than groundnut oil. On the other hand diets containing blend

1 and 2 showed better digestibility than blend 3, where the proportion of mahua oil was more (Table 2).

The total lipid levels in the serum of rats fed mahua oil, blends 2 and 3 were significantly lower than those fed groundnut oil. Rats fed on oil blend 1 containing diet showed a higher level of total lipid content in serum compared to mahua oil. A somewhat similar trend too was followed in the triglyceride levels and total cholesterol levels in serum on feeding mahua oil and groundnut oil and the three oil blends.

Among the cholesterol fractions the HDL cholesterol level in rats fed mahua oil was slightly lower than the three blends, which may be attributed to the higher levels of saturated fatty acids especially of palmitic and stearic acids. Though the differences were marked among groups of animals they were not significant. Also the LDL and VLDL cholesterol, levels show significant differences between mahua and groundnut, a similar trend as HDL cholesterol need not necessarily be followed viewed from biological aspects (Table 3).

Regarding the liver weight the rats fed mahua oil diet and three blends have indicated low values compared to groundnut oil. The total lipids too have shown similar trend. The triglyceride levels in the livers of mahua oil and blend 3 fed rats were slightly high compared to blends 1, 2 and groundnut oil, but these values were not significant. The differences due to feeding of mahua oil and its blends were not marked and significant with regard to total cholesterol.

The rats fed mahua oil diet and blend 3 diet had slightly higher HDL cholesterol level than those fed blends 1, 2 and groundnut oil. In all the groups the LDL + VLDL cholesterol levels in livers were almost similar.

Only the rats fed mahua oil showed hepatocyte degeneration. The organs in all other groups were normal without any pathological changes in parenchyma. Further the testes of mahua oil fed rats showed near normal tubules and germinal cells.

To conclude that this short term study on rats indicated that the blending of mahua oil with groundnut oil proved to be beneficial nutritionally and can be expected for human consumption.

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Table 1. Fatty acid profiles and physico-chemical characteristics of mahua oil and the oil blends

	Mahua oil (MO)	Groundnut oil (GNO)	Blend 1	Blend 2	Blend 3
Fatty acid Composition					
C 16 : 0	21.4	13.7	15.7	17.7	20.9
C 18 : 0	19.2	4.3	9.5	12.9	17.1
C 18 : 1	36.4	48.0	44.6	41.2	38.5
C 18 : 2	20.0	28.5	26.0	25.0	20.2
C 20 : 0			Traces		
C 24 : 0	2.0	4.1	3.1	3.0	2.0
Physico-chemical characteristics					
SPgr	0.9024	0.9100	0.9088	0.9053	0.9030
RI	1.4544	1.4557	1.4556	1.4553	1.4545
IV	*63.0000*	*89.5000*	*83.0000*	*75.8000*	*69.3000*
SV	193.7000	191.7000	192.1000	192.7000	193.1000
FFA	3.9000	1.3000	2.4000	3.4000	3.7000

Table 2. Feed efficiency and true digestibility of mahua oil and the oil blends

Parameters	Mahua oil (MO)	Groundnut oil (GNO)	Blend 1	Blend 2	Blend 3
Food intake (g)	304	278	303	290	290
Gain in body wt. (g)	63	64	67	66	71
Feed Efficiency Ratio	0.21	0.22	0.22	0.23	0.24
True Digestibilty (%)	98[a]	91[b]	97[b]	97[b]	94

Table 3. Lipid profiles in serum and livers of rats

Parameters	Mahua oil	Groundnut oil	Blend 1	Blend 2	Blend 3
Serum (mg/100)					
Total lipids	242.3 ± 44.7^a	432.5 ± 17.5^b	334.6 ± 38.3^b	282.7 ± 30.6^a	265.4 ± 15.8^a
Triglycerides	106.5 ± 19.1^a	200.9 ± 35.6^b	126.2 ± 14.1^a	123.9 ± 3.9^a	119.8 ± 6.5^a
Total cholesterol	119.0 ± 8.0^a	152.9 ± 15.2^b	110.3 ± 6.9^a	112.6 ± 7.8^a	118.9 ± 7.7^a
HDL - Cholesterol	48.2 ± 4.9^a	69.6 ± 2.8^a	59.1 ± 8.7^a	53.0 ± 10.7^a	59.1 ± 3.4^a
VLDL + LDL	71.7 ± 8.8^a	83.2 ± 16.0^a	51.2 ± 5.5^b	59.6 ± 8.1^b	59.8 ± 5.9^b
Liver					
Liver weight (g)	8.5 ± 8.4	10.3 ± 1.8	7.7 ± 1.1	8.3 ± 1.6	7.6 ± 0.9
Total lipids	31.4 ± 4.3^a	50.6 ± 8.9^b	49.9 ± 7.1^b	35.2 ± 7.7^a	34.8 ± 4.6^a
Triglycerides	29.5 ± 4.0^a	21.5 ± 9.1^a	22.7 ± 2.6^a	23.6 ± 5.8^a	26.7 ± 3.9^a
Total cholesterol	2.1 ± 0.3^a	2.2 ± 0.2^a	2.2 ± 0.2^a	2.0 ± 0.2^a	2.2 ± 0.2^a
HDL - Cholesterol	1.6 ± 0.2^a	1.4 ± 0.1^b	1.3 ± 0.1^b	1.4 ± 0.1^b	1.7 ± 0.1^b
VLDL + LDL	0.5 ± 0.3^a	0.8 ± 0.3^a	0.9 ± 0.2^a	0.6 ± 0.2^a	0.5 ± 0.2^a

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GENETIC VARIABILITY, CORRELATION AND PATH COEFFICIENT ANALYSIS IN SOYBEAN (*Glycine max.* (L.) MERRILL)

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ABSTRACT

Genetic parameters of variability, correlations and path coefficients were studied in F_2s of 7 x 7 half diallel in soybean for 12 components. A wide range of variability was observed for days to 50% flowering and maturity, plant height, nodes and pods/plants, 100-seed weight and seed yield/plant. The characters plant height, branches/plant, pods/plant, 100-seed weight and seed yield/plant showed higher GCV with high heritability estimates and genetic advance. Significant and positive and phenotypic correlations were noticed between seed yield and days to 50% flowering and maturity, branches and pods/plant and the highest association was between pods/plant and seed yield. Nodes/plant followed by mean internodal length and branches/plant exhibited highest direct effect on seed yield. The study revealed that it would be rewarding to lay emphasis on more number of nodes, pods and branches per plant, 100-seed weight and longer duration in selection programme in soybean.

Key words : Soybean; Genetic variability; Correlation analysis

INTRODUCTION

Genetic variability in a crop is the basic requirement for its further genetic improvement. Release of variability in segregating generations and its assessment is an important aspect in any crop improvement programme. Similarly, the correlation and path analysis studies are of great help in formulating efficient scheme of multiple trait selection, as they provide means for direct and indirect selection of component characters. Hybridization followed by selection is the main breeding procedure for improvement in crops like soybean. However, in most of the cases quantum of variability correlation and path analysis are studied by evaluating the homozygous cultivars. But inferences derived will be meaningful only when study is based on individual plant observations in a segregating generation like F_2 (Biradar *et al.* 1991). The present study was therefore, undertaken with the objective to obtain estimates of genetic parameters, correlations and path coefficients in F_2s of soybean.

MATERIALS AND METHODS

The F_2s of a 7 x 7 half diallel cross were grown in a randomised block design with three replications during kharif 1988. It consisted of 4 rows of 3 m length, with a spacing of 45 cm between and 10 cm within row. Randomly selected 50 plants from each block were used for recording the data on days to 50% flowering and maturity, plant height (cm), number of branches/plant, number of nodes/plant, mean internodal length, number of pods/plant, num-

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ber of seeds/pod, 100-seed weight (g), oil and protein content (%) and seed yield (g/plant). The estimates of genotypic and phenotypic coefficients of variation, broadsense heritability and expected genetic gain were worked out following the methods of Singh and Chaudhary (1985), and the path analysis by method given by Dewey and Lu (1959).

RESULTS AND DISCUSSION

The genetic parameters of variability, heritability and genetic advance are given in Table 1. A wide range of variability was observed for days to 50% flowering and maturity, plant height, nodes/plant, pods/plant, 100-seed weight and seed yield/plant. Branches/plant and seeds/pod had intermediate range of variation. Bhatia *et al.*(1983) and Sarma and Abraham (1988) also reported similar results for these characters. The highest values of genotypic (GCV) and phenotypic (PCV) coefficients are generally in agreement with the reports of Sarma and Abraham (1988). Protein content followed by oil content had lowest GCV and PCV. In the present study, the characters plant height, branches/plant, pods/plant, 100-seed weight and seed yield/plant have shown high genotypic coefficient of variation along with high heritability estimates and genetic advance. As suggested by Burton (1951) and Johnson *et al.* (1955), selection for these characters would bring an improvement in soybean. Characters with low GCV such as days to 50% flowering and maturity showed high heritability estimates, indicating higher heritable portion of the variability. These results are in agreement with the findings of Lal and Harve (1972), Konwar and Talukdar (1984) and Sarma and Abraham (1988). Low genetic coefficient of variation coupled with low genetic advance were noticed for protein content, as obtained by Dai *et al.* (1986).

The genotypic and phenotypic correlation coefficients between 12 characters are given in Table 2. It shows that days to 50% flowering and maturity, branches/plant and pods/plant exhibited significant and positive correlation with seed yield both at genotypic and phenotypic level. The degree of association was highest between pods/plant and seed yield. It was followed by days to 50% flowering and maturity. This clearly indicated that number of pods/plant is a highly reliable component of yield and can be utilized as an yield indicator in soybean. Myakushko and Dudka (1984) and Surlan-Momirovic (1987) observed similar strong correlations for pods/plant. Diaz Carrasco *et al.* (1985) also suggested that yield could be raised by selecting for lateness, tallness, and more pods/plants, which is evident in the present study. Seed/pod exhibited highly significant negative correlation at genotypic level. This could be expected as accommodation of more number of seeds/pods will reduce the seed size thereby reducing test weight resulting in lower yield. This is also evident from its significant negative association with 100-seed weight in the present study.

The traits, days to 50% flowering, days to maturity, plant height, branches/plant, nodes/plant and pods/plant had highly significant and positive correlations both at genotypic and phenotypic levels among themselves. All these traits also had positive relationship with seed yield indicating certain inherent relationship with seed yield. Selection for these characters simultaneously would bring improvement in soybean yield. These results are in conformity with the findings of Konwar and Talukdar (1984), Myakushko and Dudka (1984), Diaz Carrasco *et al.* (1985). Both the quality characters, oil and protein content, were negatively correlated with each other and showed no association with seed yield. Similar results were also noticed by Hrustic *et al.* (1985).

Path analysis (Table 3) revealed that nodes/plant showed highest direct effect on seed yield, followed by mean internodal length and branches/plant. Highest direct effect on nodes on main stem were also recorded by Yao (1988). He also observed highest direct effect of 100-seed weight. Other characters in this study *viz.*, days to 50% flowering, seeds/pod and 100-seed weight also showed high positive direct effects on yield. Selection for these characters would bring improvement in soybean as also reported by earlier workers Myakushko and Dudka (1984), Liu *et al.* (1985). The direct effects of plant height and pods/plant were negative but their positive correlation with seed yield could be due to high indirect effects through nodes/plant. Days to maturity, though had significant positive correlation with seed yield, had low direct effect. It exerted its effect via nodes/plant. It would be logical to expect that a genotype which has a longer vegetative period will have a greater ability to produce more seed yield. This sort of relationship is evident from the present study.

This investigation thus revealed that it would be rewarding to lay emphasis on more number of nodes, pods and branches per plant, higher seed weight and lateness in selection programme of soybean.

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Table 1. Range, mean, genotypic and phenotypic coefficient of variation, heritability and genetic advance in soybean

	Character	Range	General mean	GCV	PCV	Heritability (%)	Genetic advance	G.A. as % of mean
1.	Days to 50% flowering	41.67-56.42	49.06	8.84	9.70	83.19	8.15	16.61
2.	Days to maturity	85.33-108.83	97.05	7.24	7.77	86.93	13.50	13.91
3.	Plant height	18.93-60.30	29.78	36.42	37.52	94.24	21.69	72.83
4.	Branches/plant	2.07-6.33	3.86	25.37	29.83	72.32	1.71	44.30
5.	Nodes/plant	6.67-16.87	11.49	20.86	23.79	76.92	4.33	37.68
6.	Mean internodal length	1.86-3.57	2.58	19.19	22.52	72.66	0.87	33.72
7.	Pods/plant	30.50-99.67	61.57	30.74	34.61	78.85	34.62	56.22
8.	Seeds/pod	1.63-2.57	1.99	11.60	14.94	60.26	0.37	18.59
9.	100-Seed weight	5.14-17.30	10.14	26.06	28.50	83.63	4.98	49.11
10.	Oil content (%)	17.00-24.33	20.99	6.90	12.63	29.68	4.33	20.63
11.	Protein content (%)	38.20-44.69	41.71	3.30	5.16	40.92	1.81	4.33
12.	Seed yield/plant	6.75-21.42	12.51	26.16	32.30	65.57	5.45	43.56

Table 2. Estimates of genotypic (above diagonal) phenotypic (below diagonal) correlations between 12 characters in soybean

Charecter	Days for 50% flowering	Days for maturity	Plant height	Branches/ plant	Nodes/ plant	Mean internodal length	Pods/ plant	Seeds/ pod	100-Seed weight	Oil content (%)	Protein content (%)	Seed yield/ plant
	1	2	3	4	5	6	7	8	9	10	11	12
1	-	0.8697**	0.5875**	0.6487**	0.5107**	0.4404**	0.7495**	-0.4788**	0.1338	0.0138	-0.1879	0.7908**
2	0.8083**	-	0.6324**	0.6336**	0.7408**	0.2682	0.7595**	-0.5208**	0.0496	0.0869	0.0952	0.7104**
3	0.5052**	0.5470**	-	0.8779**	0.8639**	0.6745**	0.6038**	0.1049	-0.4253	0.2402	-0.3985*	0.2851
4	0.5228**	0.5637**	0.7406**	-	0.8721**	0.5633**	0.8395**	-0.0051	-0.4705	-0.0030	-0.2423	0.5344**
5	0.4068*	0.5779**	0.7657**	0.6479**	-	0.3506	0.6651**	-0.0483	-0.5158**	0.1433	-0.1752	0.2580
6	0.3212	0.2137	0.6853**	0.4430*	0.0775	-	0.3682	0.2424	-0.1474	0.3535	-0.4381*	0.3079
7	0.6174**	0.6014**	0.5944**	0.7102**	0.5785**	0.3221	-	-0.2336	-0.2585	0.0268	0.0809	0.8350**
8	-0.3701	-0.4264*	0.1295	0.0597	0.0197	0.1975	-0.0859	-	-0.8053**	-0.2946	-0.2164	-0.5718**
9	0.0911	0.0429	-0.3857*	-0.4308*	-0.4529*	-0.0790	-0.2705	-0.5897**	-	0.1625	0.2048	0.2421
10	0.0214	0.0165	0.1359	0.0042	0.0129	0.2220	0.0691	-0.1433	0.0112	-	-0.0234	0.0144
11	-0.1208	0.0271	-0.2613	0.1477	-0.0255	-0.3260	-0.0044	-0.0869	-0.0709	-0.1558	-	0.2083
12	0.5781**	0.4784*	0.3056	0.4388*	0.2197	0.2891	0.8001**	-0.1596	0.1708	0.0463	0.0232	-

** P = 0.01 ; * P = 0.05

Table 3. Path coefficient analysis of yield components on grain yield at genotypic level in soybean

Charecter	Days for 50% flowering	Days for maturity	Plant height	Branches/ plant	Nodes/ plant	Mean internodal length	Pods/ plant	Seeds/ pod	100-seed weight	Oil content (%)	Protein content (%)	Correlation with yield
	1	2	3	4	5	6	7	8	9	10	11	
1	0.780	0.115	-3.014	0.606	1.508	1.027	-0.094	-0.200	0.073	0.000	-0.010	0.790**
2	0.679	0.133	-3.244	0.610	2.187	0.625	-0.095	-0.218	0.027	0.002	0.005	0.710**
3	0.458	0.084	-5.130	0.820	2.551	1.782	-0.076	0.044	-0.232	0.005	-0.021	0.285
4	0.506	0.087	-4.503	0.934	2.575	1.313	-1.105	-0.002	-0.256	-0.000	-0.013	0.534**
5	0.398	0.098	-4.432	0.814	2.953	0.817	-0.083	-0.020	-0.281	0.003	-0.009	0.258
6	0.344	0.036	-3.922	0.526	1.035	2.331	-0.046	0.101	-0.080	0.007	-0.023	0.308
7	0.585	0.101	-3.097	0.784	1.964	0.858	-0.125	-0.098	-0.141	0.001	0.004	0.835**
8	-0.374	-0.069	-0.538	-0.005	-0.143	0.565	0.029	0.418	-0.439	-0.006	-0.001	-0.572**
9	0.104	0.007	2.182	-0.439	-1.523	-0.343	0.032	-0.337	0.545	0.003	0.011	0.242
10	0.011	0.012	-1.232	-0.003	0.423	0.824	-0.003	-0.123	0.089	0.019	-0.001	0.014
11	-0.147	0.013	2.044	-0.226	-0.517	-1.517	-0.010	-0.090	0.112	-0.000	0.052	0.208

Underlined figures indicate direct effects

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SOCIOECONOMIC COMPONENT IN SESAME RESEARCH AND PRODUCTION

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ABSTRACT

Area under sesame had undergone only marginal changes while the productivity had increased substantially. Despite such developments, the production of oilseed is not catching upto the expectations. A few key socioeconomic components like localization, farmer's preference, economics of production, production constraint, technology viability and comparative advantages need to be considered by the scientists for achieving any breakthrough in this crop. In developing technologies for farmers, the socioeconomic components also must be included in the research.

Key words : Sesame; Socioeconomic factors ; Research; Production.

INTRODUCTION

Oils and fats constitute an essential part of human diet. The per capita consumption of oils and fats in the world was estimated (1988) at 11.7 kg per year.

Sesame is cultivated throughout the world and the crop on an average occupies 6.5 million hectares. The total production of sesame is estimated at 2.3 million tonnes, with an average productivity of 357 kg per hectare. The developing nations are the major allocators of the area under this crop and they contribute 99.95 per cent of the total area in the world. Hence sesame is predominantly a crop of the developing nations.

In India, next to food grains, the oilseeds occupy a larger area (18.6 million hectares) and of this, the sesame is cultivated in 2.1 million hectares with 0.4 million tonnes of production. The crop ranks third among the various oilseed crops. The average production in India is 273 kg per hactare, as compared to world productivity of 357 kg/ha during 1989.

The growth indices of area, production and productivity for sesame crop (1949 to 1987) would reveal the performance of the crop over the years. The index numbers were constructed by taking a three year period (Triennium) ending 1969-70 as the base year. The indices of the years '49-50, '59-60, '69-70, '79-80 and '86-87 are presented in Table 1.

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Table 1. Index Numbers of area, *production* and *productivity of sesame in India.*

(Base : Triennium ending 1696-70 = 100)

Year	Area	Production	Productivity
1949-50	84.1	94.5	112.4
1959-60	88.4	85.2	96.4
1969-70	93.8	102.2	108.6
1979-80	96.5	79.1	82.0
1986-87	88.6	100.7	143.7
Percentage change (1949-50 to 1986-87	5.35	6.56	27.85

(Source : Indian Agriculture in Brief, 22nd Edition, 1989, pp. 154-155).

The table reveals that the area, production and productivity indices have shown a sharp fluctuating trend over the years. The area under the crop has increased by 5.35 per cent and the productivity by 27.85 per cent resulting in an over all increase in production by 6.56 per cent during the span of 37 years. Thus, the area under sesame had undergone only marginal changes while substantial increase in productivity of the crop was noticed. However, Rath(1985) pointed out that inspite of the favourable price, the production of oilseeds is not catching upto the expectations. Some of the key socioeconomic components that need the attention of scientists are discussed below :

1. Production constraint-localization

Sesame has been cultivated as an invaluable oilseed crop and the productivity increase is far from satisfactory level compared to cereal crops. The very psychology of farmers in the choice of sesame in cropmix on the farm is largely affected by the production environment in which the crop is cultivated. In India, the crop is cultivated mostly in rainfed situation and only 0.15 million hectare (7.14 per cent) is under irrigated conditions, out of the total area. Since the crop is highly subjected to vagaries of monsoon, the area under this crop fluctuates widely.

In Tamil Nadu, the sesame cultivation is localized predominantly in North Eastern zone (Chengai Anna, North Arcot Amberkar and South Arcot districts), North Western zone (Salem and Dharampuri districts) and Western zone (Coimbatore and Periyar districts) of the State. The mean annual rainfall in these zones ranges from 718 to 1106 mm distributed in 47 to 53 rainy days.

2. Farmer's Preference

In the North Western zone, groundnut is the major oilseed crop followed by Sesame. In drylands, groundnut, pearlmillet or redgram is sown during the South West monsoon rains as a first crop. A second crop of sesame or horsegram is cultivated in the years of favourable rainfall. In the North Western Zone, under rainfed fertile lands, finger millet/groundnut is sown in June- July months. In less fertile soils, sesame or castor is raised in July followed by horsegram. Castor and redgram are usually grown as intercrops with groundnut.

In Western Zone, sesame is cultivated after sorghum or maize and raised during April to June. Sesame is also grown as a catch crop under rice fallow condition especially in Cauvery delta zone mainly to utilize the residual moisture.

Thus, the cropping pattern and crop rotation practised in the above zones would indicate that the sesame cultivation is taken up mainly as sequence /relay or catch crop before and/or after the main crops. This has implication on the sesame research and production and the area allocation is constrained by the environmental factor.

3. Economics for Production

Being grown predominantly under rainfed condition, little work has been done to compare the economics of production of sesame with that of other crops.

Through a quick survey method, a sample of 100 farmers spread over the entire state of Tamil Nadu was selected. The sample farms were selected in districts where the sesame crop dominated. The cost of cultivation (C2), cost per quintal of production, and net return per hectare for various crops were estimated. The details are presented in Table 2.

Among the various costs, cost of seed, human labour, manures and fertilizers and bullock power are the major components in the variable costs, besides , plant protection, irrigation and interest that are included under the cost. The rental value of owned land and depreciation of the farm assets constitute a major cost component in fixed cost estimation. The total cost (C2) will be the variable cost plus fixed cost.

Such detailed estimation of cost structure is essential for working out alternative crop plans and to advise the farmers on rationalising the resource use to contain the cost.

It could be seen from Table 2 paddy, maize, groundnut are capital intensive crops compared to low capital intensive crops like sesame, horsegram and bajra.

The cost/q of production of sesame is higher (Rs. 428) since the cost is worked out based on the total output (460 kg/ha), which, is relatively low as compared to crop output from paddy (4.6 tonnes/ha). However, the prospects of earning more returns through sesame cultivation is clearly evinced by the net return calculation, provided the rainfall is normally distributed during the crop cultivation.

4. Constraints

Shifting the whole area from other crops to sesame may not be a right option based on the criteria of net return alone. An optimal resource allocation based on the constraints at farm level may be a realistic approach.

Kandaswamy *et al.* (1989) conducted a study in Western zone to find an optimal crop and livestock mix on a marginal farm cultivating sesame under rainfed situation. The results of the optimal plan were encouraging since the reallocation of the existing resources could improve the net return of the farm by 27 per cent over the existing plan. The various constraints identified were land, labour, capital, seasonality, availability and requirement of fodder for the animals. The changes suggested are given hereunder.

Existing plan	Optimal plan
	First season
1. Sorghum - I season	1. Sorghum - 0.17 ha - Aug. to Dec.
2. Greengram - II season	2. Sorghum + Greengram - 0.23 ha - Aug. to Jan.
	3. Greengram (pure) - 0.24 ha - Aug. to Nov.
	4. Groundnut + Redgram - 0.20 ha - Aug. to Jan.
	Second season
	1. Sesame - 0.84 ha - April to July.

Such exercises are essential for many localities to find out how best the low capital intensive and relatively higher profitable crop (sesame) could fit in the existing farming system of dryland.

5. Technology Viability

The socioeconomic factors have a stake on the viability of any technology developed. It is equally important to add some economic interpretations also to the research results.

Rao *et al.* (1990) conducted a study to see the response of sesame yield to different levels of nitrogen in different years. The results obtained through the study are presented below.

Table 3. Sesame yield at different levels of nitrogen

Treatment	Seed Yield (kg/ha)		
	1982	1983	Mean
Nitrogen			
0	233	419	326
20	248	497	373
40	258	512	385
C.D. at 5%	N.S	50.1	

Source : Rao *et al.* 'Response of sesamum to nitrogen and phosphorus under rainfed conditions'. Journal of oilseeds Research 7(2) 1990 pp. 117-120.

The study concluded that the yield levels were higher in the year 1983 compared to 1982.

The nitrogen had significant influence on yield at different levels of application.

In the above study from '0' level to 20 kg of nitrogen, the additional yield in 1982 and 1983 were 15 kg and 78 kg respectively. The returns from these additional yields would be Rs.90 (1982) and Rs468 (1983) at the rate of Rs.6 per kg of seed. So, when such additional return is compared with additional cost Rs.100 (from 0 to 20 N), the additional yield level in 1982 did not compensate the additional cost and it will be uneconomical to go for higher fertilizer dosage. In the year, 1983, the additional returns were greater than additional cost. Therefore, only when the return is higher, the farmers will be interested to go for additional dosage of fertilizer application and such a simple budgeting exercise would enhance the interpretation of the technology results.

Similarly Bhaskaran (1986) made an attempt to work out economics of mixed cropping of sesame crop with pulses. The results of the study showed that maximum return was obtained at 15 kg/ha of nitrogen and the return was higher than the return obtained at 5 kg/ha nitrogen application. The additional cost of fertilizer would be Rs. 45/- resulting in an increased return of Rs. 258.

Such budgeting exercises are essential to assess the economic viability of the technology and spreading of the recommendations.

6. Comparative advantage

The economic principle of 'Comparative advantage' plays an important role in deciding the resources that give a comparative advantage over others.

In Cauvery delta zone, three crops viz., sesame, blackgram and soybean are usually recommended as a catch crop.

The crop sequence and fertilizer recommendations are :

Sequence I:	Rice	Rice	**Sesame**
Fertilizer Recommendation kg/ha (NPK)	120-40-40	150-50-50	**23-13-13**
Sequence II:	Rice	Rice	Balckgram
Fertilizer	120-40-40	150-50-50	12.5-25-0
Sequence III:	Rice	Rice	Soybean
Fertilizer	120-40-40	150-50-50	12.5-25-0

Source : *NARP - Cauvery Delta Zone Report, Vol.1, 1991. Tamil Nadu Rice Research Institute, Aduthurai,* TNAU pp.44-45

Empirically the economics were worked out in terms of returns, cost of fertilizer and oil yield. The results are presented below :

Table 4. Return, fertilizer cost and oil yield in three crop sequences

(Per hectare)

Particulars	Sequence		
	I	II	III
Return (Rs.) (Main Product)	25, 950	26, 725	26, 640
Cost of Fertilizer (Rs.)	2, 332	2, 322	2, 322
Oil yield (kg)	147	-	114

Source : *The yield, price and nutrient costs were collected from various published reports like Season and Crop Reports, Fertilizer News etc.*

Note : Yield levels : Paddy - 6 tonnes/ha in first season, 4 tonnes/ha in second season, blackgram - 500 kg/ha, soybean 600 kg/ha and sesame 300 kg/ha.

Nutrient prices (Rs) : N- 5.11/kg: P-5.94/kg; K-2.17/kg

Output prices : Paddy Rs. 240/qtl ; Blackgram Rs.545/qtl. Soybean Rs.440/qtl. and Sesame Rs. 650/qtl.

The above results would lead to three alternative choices viz., (i) in terms of return, the second sequence yields higher, (ii) in terms of fertilizer cost and nutrient replenishment, the second and third sequences will be less costlier and finally (iii) in terms of oil yield per unit area, the first sequence is more advantageous.

Thus, the principle of comparative advantage in terms of returns and oil yield plays a major role in adopting a particular crop sequence besides a few social issues like preference of farmer, know-how etc.

Conclusions

In India, sesame cultivation is constrained by many socioeconomic factors and these factors need to be considered for achieving a breakthrough in increasing the productivity and area coverage under the crop. In developing technologies for farmers, the social and economic interpretations must be added in the research. The comparative advantage of the crop with other oilseed and competing crops, the price and potential usage in industrial use are some of the major thrust areas of research for the scientists to probe into.

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Table 2. Economics of production of selected crops (Per hectare)

	Crops							
Particulars	Paddy	Sorghum	Bajra	Maize	Horsegram	Groundnut	Sesame	Castor
	(I)	(R)	(R)	(I)	(R)	(I)	(I)	(R)
a). Variable costs Rs.								
i. Labour	3250.5	765	628	1957.0	623	1617	636	1003
ii. Manures & Fertiliser	1481.0	164	144	940.5	-	530	304	406
iii. Seed	337.0	50	86	154.0	52	1246	79	127
iv. Bullock	495.0	337	436	516.0	346	304	149	630
v. Others	1258.0	257	188	370.5	26	642	41	94
Total V.C	6821.3	1573	1482	3938.0	1047	4339	1209	2260
b) Fixed Costs Rs.								
i. Rental value of owned land	1454.0	1004	967	2177.0	364	1086	483	870
ii. Deprecciation	250.0	241	153	634.0	82	428	161	143
iii. Others	2109.5	204	130	317.0	48	309	118	68
Total F.C	3813.5	1449	1250	3128.0	494	1823	762	1081
c) Cost B1	6278.0	1667	1553	3967.0	920	4552	1203	1960
d) Cost B2	9617.0	2671	2515	6144.0	1284	5683	1686	2830
e) Cost C1	7296.0	2018	1770	4889.0	1177	5076	1488	2471
f) Cost C2	10635.0	3022	2732	7066.0	1541	6162	1971	3341
Cost/qtl	192.51	244.39	174.66	200.78	200.88	419	428	354.79
Net Return	583.61	76.51	272.64	66.69	176.31	638.73	978.69	44.49

Note: I - Irrigated, R - Rainfed. Cost B1: cost A1 + interest on value of owned capitala assets. Cost B2: Cost B1 + rental valueof owned land & rent for leased in land. Cost C1: cost B1 + imputed value of family labour.

Cost C2: Total cost including fixed cost, variable cost and imputed value of owned inputs. The above estimates are based on quick survey method and hence it should be interpreted with caution.

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RESPONSE OF GROUNDNUT (*Arachis hypogaea* L.) TO CALCIUM SOURCES AND SATURATION LEVELS IN TWO SOILS*

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ABSTRACT

Greenhouse study on the response of groundnut to calcium sources and calcium saturation levels in two soil types conducted during kharif 1989 and summer 1990 at the Main Research Station, Hebbal of the University of Agricultural Sciences, Bangalore, India revealed that calcium oxide was more effective in increasing the pod yield (15.06 g/plant), kernel yield (11.27 g/plant) and shelling per cent (74.6%) than calcium sulphate. There was a significant increase in pod yield with increase in calcium saturation upto 75 per cent in red sandy loam soil but in sandy clay loam soil the increase was significant only upto 25 per cent calcium saturation. Similar trend was observed with respect to kernel yield.

Key words: Groundnut; Calcium sources; Calcium oxide; Calcium sulphate; Calcium saturation.

INTRODUCTION

Calcium nutrition is often considered a yield limiting factor for groundnut production. Calcium absorbed by the roots is not translocated to the developing pod. Whereas, calcium required for pod formation is absorbed directly from the soil solution. During the stages of initial pegging to full seed development, adequate supply of available calcium in the fruiting zone is extremely important to facilitate diffusion of calcium from soil solution to developing pods. Presently the recommendation of gypsum application to groundnut is being made without considering the calcium saturation of the soil. Mehlich and Reed (1947) observed an increase in percentage of well filled pods with an increasing degree of calcium saturation. There is a need to develop a standardized technique of application of suitable source of calcium based on calcium saturation percentage. Hence, the present investigation on the effect of calcium sources and saturation levels on the yield response of groundnut in the two soils was undertaken.

MATERIALS AND METHODS

A greenhouse experiment was conducted at the agronomy field unit, Main Research Station, University of Agricultural Sciences, Hebbal, Bangalore-24 during kharif 1989 and summer 1990. There were 16 treatment combinations consisting of two soils, two sources of calcium and four levels of calcium saturation (Table 1) tested in completely randomized design with three replications. Burnt clay pots of 706 cm^2 area were used for the study and in

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each pot 15.5 kg soil free from stones and stubbles was filled. The red sandy loam soil of ARS Chintamani was characterised by 40.9% sand, 25.7% silt and 23.4% clay; while the corresponding fractions of the sandy clay loam soil of GKVK farm soil were 33.23, 33.62 and 33.13% respectively. The red sandy loam soil of the Agricultural Research Station, Chintamani has pH 5.8, CEC 9.6 c.mol/kg, exchangeable calcium 1.38 c.mol/kg, available sulphur 32 ppm, available nitrogen 571.2 kg/ha, available phosphorus 45.02 kg/ha and available potassium 99.68 kg/ha. The sandy clay loam soil of the Gandhi Krishi Vignana Kendra, Bangalore possessed pH 5.3, CEC 9.8 c.mol/kg, Ex. Ca 1.3 c.mol/kg, available sulphur 16.0 ppm, available nitrogen 280 kg/ha, available phosphorus 21.88 kg/ha and available potassium 55.63 kg/ha.

The quantity of both calcium oxide and calcium sulphate required per pot (15.5 kg soil) was calculated by the formula:

Required calcium (meq/100g) to attain saturation level = CEC (Calcium saturation required -Calcium saturation present)/100

The soil was saturated as per the treatments ten days prior to sowing. During this equilibration period soil was stirred and water added. Diammonium phosphate and muriate of potash were used at sowing to supply 25 :75 : 37.5 kg N, P_2O_5 and K_2O per ha. Two plants were maintained per pot and different yield parameters were recorded at harvest and mean worked out.

RESULTS AND DISCUSSION

Effect of soil type

The red sandy loam soil registered significantly more pod and kernel yield as compared to sandy clay loam soil in 1989. Though similar trend in pod and kernel yield was observed during 1990 the differences were not significant. York and Colwell (1951) described ideal soil for groundnut as a " well drained, light coloured, loose, friable, sandy loam soil well supplied with calcium and a moderate amount of organic matter". A well drained soil facilitates adequate exchange of air to meet nitrogen, carbondioxide and oxygen requirements of the crop. Higher pod yield in red sandy loam soil was due to higher fertility status in terms of higher nitrogen, phosphorus, potassium and sulphur and better physical conditions like texture as compared to sandy clay loam. Similar observations were also made by Ramanathan and Ramanathan (1982) in Aliyarnagar and Tindivanam soils of Tamil Nadu.

Superiority of Red sandy loam soil in producing higher pod yield was due to significantly more number of mature pods comprising higher number of more than one kernelled pods as compared to sandy clay loam soil (Table 1).

Effect of calcium sources

Of the two sources of calcium tried, calcium oxide produced significantly more pod and kernel yield than calcium sulphate (Table 2). Kanwar *et al.* (1983) observed better response to liming material than gypsum additions on very acid soils of pH below 5.0. The soil pH in the present study was 5.8 in red sandy loam soil and 5.3 in sandy clay loam soil resulting in greater response to calcium oxide application. Beneficial effect of calcium was due to neutralization of soil pH and increase in base saturation with concomitant increase in nutrient availability (Sudhir *et al.*, 1987). Although there was no significant difference in the yield components between the two sources of calcium, the values were higher with calcium oxide compared to calcium sulphate in respect of characters like number of mature pods (1989) number of more than one kernelled pods (1989). There was significant and positive correlation between pod yield per plant and yield components such as number of mature pods (r = 0.848 and 0.764 during 1989 and 1990 respectively) number of more than one kernelled pods (r = 0.843 and 0.792 during 1989 and 1990 respectively) and shelling per cent (r = 0.636 during 1990).

Interaction effect of calcium sources and soil types indicated that, calcium sulphate application in sandy clay loam soil significantly increased the oil per cent than calcium oxide. While in red sandy loam soil both the sources of calcium were on par (Table 4). The native sulphur is being low in sandy clay loam soil (16 ppm), the increased response to calcium sulphate application was observed thus, calling for a need to redefine the critical limit of sulphur. The increase in oil per cent was due to the involvement of sulphur in sulfhydral (-SH) linkage in the biosynthesis of oil.

Effect of calcium saturation levels

The calcium saturation level exhibited a discernible influence on pod yield of groundnut during both the years (Table 2). Twenty five per cent calcium saturation caused significant increase in pod yield by 34.19 per cent in 1989 and 41.17 per cent in 1990 over control. The difference in pod yield per plant due to calcium saturation was attributed to the variation in yield components. Calcium saturation at 25 per cent produced significantly more number of mature pods and number of more than one seeded pods per plant over control during both the years (Table 1). This has resulted in significantly more ratio of mature pods to total pegs at 25 per cent calcium saturation over control during both the years. There was reduction in the number of immature pods with increase in calcium saturation levels over control but the differences beyond 25 per cent saturation were not significant. There was significant increase in kernel yield with 75 per cent calcium saturation as compared to control and 25 per cent saturation in 1989. This can be related to higher shelling per cent at 25 per cent saturation (75%) over control (70.82%) during 1989. During 1990, though there was increase in kernel yield with increase in calcium saturation the increase was significant only upto 25 per cent saturation. Further, there was significant improvement in the oil per cent due to 25 per cent saturation over control during both years.

The interaction of calcium saturation levels and soils during 1989 revealed that there was a significant increase in pod yield with increase in calcium saturation upto 75 per cent in red sandy loam soil while in sandy clay loam soil the increase was discernible only upto 25 per cent saturation (Table 3). Similar trend was observed with respect to kernel yield. The increased response to calcium saturation in red sandy loam soil may be attributed to the high level of soil fertility as indicated by nitrogen, phosphorus, potassium and sulphur status, as compared to sandy clay loam soil which has low fertility.

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Table 1. Effect of soil type, calcium source and calcium saturation level on the yield components of groundnut

Treatments	Number of mature pods		Number of more than one kernelled pods		Number of immature pods		Ratio of pegs with mature pods to total pegs		Ratio of pegs with more than one kernelled pods to total mature pods	
	1989	1990	1989	1990	1989	1990	1989	1990	1989	1990
Soils										
Red sandy loam soil	25.56	25.12	24.16	23.12	25.10	8.14	0.48	0.63	0.93	0.88
Sandy clay loam soil	22.75	27.35	21.16	24.85	18.89	10.25	0.51	0.56	0.92	0.87
S.Em.±	0.73	1.48	0.73	1.69	0.70	0.55	0.01	0.02	0.07	0.01
C.D. at 5%	2.04	NS	2.03	NS	1.96	1.52	NS	0.05	NS	NS
Calcium sources										
Calcium oxide	24.73	25.66	23.02	23.27	20.91	8.99	0.51	0.59	0.92	0.87
Calcium sulphate	23.58	26.81	22.31	24.70	23.08	9.43	0.48	0.59	0.93	0.89
S.Em.±	0.73	1.48	0.73	1.69	0.70	0.55	0.01	0.02	0.01	0.01
C.D. at 5%	NS	NS	NS	NS	1.96	NS	NS	NS	NS	NS
Calcium saturation levels										
Control	18.16	19.58	16.25	16.30	27.75	11.62	0.35	0.46	0.88	0.82
25 % saturation	24.91	27.87	23.79	25.91	21.15	8.37	0.52	0.63	0.95	0.89
50 % saturation	26.75	29.66	25.16	27.95	18.70	8.50	0.57	0.64	0.93	0.89
75 % saturation	26.79	27.83	25.45	25.87	20.41	8.29	0.54	0.63	0.94	0.92
S.Em.±	1.04	2.09	1.03	2.39	1.00	0.78	0.01	0.03	0.01	0.02
C.D. at 5%	2.89	5.81	2.87	6.62	2.77	2.16	0.05	0.08	0.03	0.05

Table 2. Effect of soil type, calcium source and calcium saturation level on pod yield (g/pl), kernal yield (g/pl), shelling per cent and oil per cent of groundnut

Treatments	Pod yield (g/pl)		Kernal yield (g/pl)		Shelling (%)		Oil (%)	
	1989	1990	1989	1990	1989	1990	1989	1990
Soils								
Red sandy loam soil	17.08	14.40	12.56	10.38	73.20	73.54	45.17	42.80
Sandy clay loam soil	11.64	14.05	8.73	10.19	74.80	71.47	44.81	42.92
S.Em.±	0.43	0.68	0.34	0.53	0.31	0.89	0.24	0.27
C.D. at 5%	1.20	NS	0.95	NS	0.87	NS	NS	NS
Calcium sources								
Calcium oxide	15.06	14.20	11.27	10.17	74.60	72.32	45.25	42.54
Calcium sulphate	13.66	14.24	10.03	10.39	73.40	72.69	44.73	43.17
S.Em.±	0.43	0.68	0.34	0.53	0.31	0.89	0.24	0.27
C.D. at 5%	1.20	NS	0.94	NS	0.87	NS	NS	NS
Calcium saturation levels								
Control	10.82	10.54	7.62	7.42	70.82	70.11	44.10	41.64
25 % saturation	14.52	14.88	10.90	10.58	75.00	72.73	45.51	42.78
50 % saturation	15.28	15.54	11.55	11.43	75.68	73.74	45.17	43.75
75 % sdaturation	16.80	15.92	12.52	11.69	74.50	73.43	45.17	43.26
S.Em.±	0.61	0.96	0.48	0.76	0.44	1.27	0.34	0.38
C.D. at 5%	1.70	2.67	1.34	2.10	1.23	NS	0.96	1.05

Table 3. Interaction effect of soil type and calcium saturation level on pod yield and kernal yield of groundnut in 1989

	Pod yield (g/pl)			Kernal yield (g/pl)		
	Red sandy loam soil	Sandy clay loam soil	Mean	Red sandy loam soil	Sandy clay loam soil	Mean
Saturation levels						
Control	13.22	8.43	10.82	9.15	6.08	7.62
25% saturation	15.91	13.14	14.52	11.94	9.85	10.90
50% saturation	18.20	12.37	15.28	13.57	9.53	11.55
75% saturation	20.99	12.62	16.80	15.59	9.46	12.52
Mean	17.08	11.64		12.56	8.73	
S.Em.±	0.87	0.87		0.68	0.68	
C.D. at 5%	2.41	2.41		1.90	1.90	

Table 4. Interaction effect of soil type and calcium sources on oil content of groundnut in 1990

	Soil type		Mean
	Red sandy loam soil	Sandy clay loam soil	
Sources of calcium			
Calcium oxide	42.87	42.21	42.54
Calcium sulphate	42.72	43.62	43.17
Mean	42.80	42.92	
S.Em. ±	0.38	0.38	
C.D. at 5%	1.05	1.05	

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INDIAN OILMEALS/CAKES SCENARIO, 1961-90

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ABSTRACT

NCA (1976) has estimated that 5.75 million tonnes of concentrates are needed to bridge the gap between availability and requirement. On the other hand the demand for milk is increasing year after year due to population growth and rise in per capita income. Hence demand for livestock feeds for economic milk production will increase. This paper is an attempt to review consumption, production and trade related aspects of oilmeals in India. Cotton, groundnut and rapeseed are major cakes in terms of consumption and production, though there are wide fluctuations in their relative shares. In recent years soybean meal has started entering into the oilmeals market. Positive and significant coefficient on adult bovine stock indicated the need to either increase production substantially or to reduce the stock. The supply of oilmeals has been increasing from 1981 onwards resulting in significant increase in the availability of these feed stuffs. India is a major exporter of oilmeals in the world and on an average 20% production is being exported to developed economies of the world.

Key words: Oilmeals; Oilcakes; Consumption; Production; Foreign trade.

INTRODUCTION

Oilseeds hold a key position in the Indian economy and contributed 4% of India's GDP and also accounts 10% of value of all agricultural commodities during the period 1981-85 (Chandhok and The Policy Group, 1990). India is one of the largest oilseed producing countries with 7% share in the global production, on an average, during the period 1986-90 (Oil World, 1991). Oilseeds considered in the study are: soybean, cottonseed, groundnut, sunflower, rapeseed and mustard, sesamum, copra and linseed. These seeds have long been crushed for their oil and meal/cake. Cake is that portion of oilseed after oil has been expelled mechanically , whereas meal is the portion of oilseed after solvent extraction of Oil (UNO. 1984) . However, these two terms are used interchangeably in this study. As cattle feed, oilmeals are more nutritive and readily digestible. As such, they have no substitutes. Milch animals with high performance can only be maintained at peak production by feeding high quality oilmeals, over and above the green fodder. These feeds provide metabolic energy (in calories), proteins, and other nutrients and the nutrient composition vary from feed to feed (Sarma, 1986). Given the importance of oilmeals in the livestock industry, an attempt is made here to review the trends in consumption, production and trade aspects of oilmeals in India during 1961-90.

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CONSUMPTION

Feed is of paramount importance for economic milk production. However, overall feed deficiency is estimated to be 30% in respect of total digestible nutrients. It is as high as 70% in respect of digestible crude protein. Apart from green fodder and dry fodder, by-products obtained from grain processing (brans), oilseed processing (meals and cakes), and pulses processing (chunni) are the major feed ingredients fed to Indian livestock. According to one estimate, brans are the main source accounting for 47% in 1970 and 38% in 1988 of the total concentrates produced in the country. As of oilmeals, it was 31 and 28% respectively for the same period (Reddy, 1988).

In the light of the above facts an attempt is made to review the trends in composition of oilmeals in consumption/domestic disappearance. Disappearance was calculated as the residual of balance from opening stocks plus production minus exports and ending stocks. Practically there have been no imports of oilmeals into India. Disappearance of different oilmeals for selected periods are presented in Table 1.

Total domestic disappearance of oilmeals stood at 3252 thousand tonnes during 1961-65 and it went upto 5878 thousand tonnes during 1986-90 an increase of 81%. In terms of compound growth rate, it grew at 2.1% per annum during 1961-90. Of the total consumption, cotton, groundnut, and rapeseed, together accounted for about 84% and 86% during 1961-65 and 1986-90 respectively. While the relative share of rapeseed meal has been increasing that of groundnut declined. Another interesting point that emerges from Table 1 is that soybean and sunflower meals are entering into cattle feed basket from mid eighties. However, over time, relative shares of sesamum, copra and linseed have declined. Though the domestic disappearance of groundnut meal in absolute terms has increased, its relative share has declined mainly due to increase in the relative share of soybean. During 1986-90 relative percentage shares of cotton, rapeseed, groundnut, soybean, sesamum, linseed, copra, and sunflower oilmeals are 32, 27.5, 26.3, 3.9, 3.4, 3.2, 2.2 and 1.5 respectively. Soybean with its low oil, high cake content compared with most other oilseeds, is becoming an important source of oilmeal in recent years.

DEMAND FOR OILMEALS

Demand function analysis was carried out using the time series data, 1961-87, to directly assess the relationship between demand for oilmeals and relevant factors. Domestic disappearance demand is considered to be a function of weighted price of oilmeals (WPO), adult bovine stock, (ABS) and wholesale price index of milk (WPIM). The demand function is specified as follows:

$$D_t = a_0 + a_1 (WPO) + a_2 (ABS) + a_3 (WPIM)$$

where D_t = Total demand for oilmeals in year t (000 tonnes), WPO = Weighted price of oilmeals (US $/tonnes),

ABS = Adult bovine stock (millions),

WPIM = Wholesale price index of milk (1970/71 = 100) and a_1, a_2 and a_3 are the respective coefficients.

Linear, semilog, and double-log functions are tried and double-log form turned out to be best fit in terms of signs, levels of significance, coefficient multiple determination (R_2), and F-value. Though double-log form has more acceptable assumptions, we are aware of the problems associated with it. Double-log assumes constant elasticities and allows little flexibility to the shape of the demand functions. The selected function is reported here:

$$\text{Log}(D_t) = -8.97(2.96) - 0.2635^{**}(4.76)\,\text{Log}(WPO) + 3.5745^{**}(5.55)\,\text{Log}(ABS) + 0.0119\,(0.15)\,\text{Log}(WPIM)$$

Figures in parentheses are respective t-values.

** Significant at 1% level of significance.

$R^2 = 0.88$ F-value = 64.3 D-W = 1.8680 N = 1961-87

The estimated elasticity of price of oilmeals and adult bovine stock are of the expected sign and statistically different from zero at 99% level. Elasticity of adult bovine stock appeared with expected sign and is also statistically different from zero at 99% level. Thus, a million increase in stock would require an additional 3.57 thousand tonnes of oilmeals. Hence, it is advisable to have a less number of improved/crossbred stock which would give higher milk yields. However, one is to be cautious in promoting cross breeding in rural areas as some farmers are still not in favour of it. Though price elasticity of milk, cross price elasticity, is appearing with right sign it is not significant. Thus price of cakes and stock are the influential factors in explaining the variation in demand for oilmeals in India.

PRODUCTION

On the supply side, oilmeals production is a function of cropping pattern and productivity. It is said that oilseeds cultivation is mostly restricted to drylands with no little application of fertilizers and other improved agronomic practices. Further, there is no appreciable breakthrough in oilseeds breeding programmes, except in castor seed. As of cropping pattern, it is highly rigid in the country because of habit formation and other cultural practices. With this background, changes in production of different oilseeds are analysed. Table 2 presents changes in production of oilmeals during 1961-90. Three points are emerging: (a) the share of groundnut is declining and that of rapeseed is increasing; (b) soybean is fast emerging as one of the major oilmeals; and (c) the relative share of cotton is more or less constant.

Oilmeals production has increased from 4046 thousand tonnes during 1961-65 to 7308 thousand tonnes during 1986-90 an increase of 81%. Thus production and consumption are increasing simultaneously with similar growth rate. Again, groundnut, cotton, and rapeseed accounted for about 86% of the total oilmeals production during 1961-65 and 77% during 1986-90. Groundnut meals production has increased from 1683 thousand tonnes to 1877 thousand tonnes during 1961-65 to 1986- 90. However, its relative share has declined from 41.6 to 25.7% during the same period. It is mainly due to the emergence of soybean crop. Soybean production started in the mid seventies and its relative share rose to as much as 13% during 1986-90. Similarly, rapeseed meals production accounted for 17% of the total Oilmeals during 1961-65 and went up to 26% during 1986-90 period. There is constant decline in the relative shares of sesamum, copra and linseed.

EXPORTS

Oilmeals are actively traded in both domestic and international markets. During 1961-90, about 20% of oilmeals produced in India are exported, the range being 11 to 33%. These oilmeals are being exported to developed countries of the world, especially to the European Economic Community (Surendra Singh and Kamaljit Singh, 1985). Adequate literature is available for and against the exports of oilmeals, and we are no more interested in confusing the readers on this aspect (Surendra Singh and Kamaljit Singh, 1985; Niar, 1985; Vinod and Achaya, 1980; Achaya and Vinod 1986; and Shanti George, 1987). Changes in the exports of different oilmeals from India are presented in Table 3.

During the period 1961-65, Indian exports of major oilmeals, amounted to 793 thousand tonnes, of which groundnut meal alone accounted for 88%. By 1986-90 exports of oilmeals and cakes have increased to 1429 thousand tonnes. For various reasons, exports dipped down to 809 thousand tonnes during 1981-85. Further, there is an appreciable change in the relative shares of different oilmeals. Soybean cake entered the international trade during the mid-eighties, and its relative share went up to as much as 48% during 1986-90 period.

Groundnut meal, a major oilmeal exported during 1961-65, has lost her share by as much as 65% a remarkable decline indeed. The decline in the exports of groundnut meal could be due to the following reasons. Firstly, lower production, particularly in Gujarat. Secondly, incidence of protein in Indian groundnut is sometimes so low that it is difficult to produce and tender meals on the basis of 50% O + A warranty. Thirdly, high aflatoxin content continues to pose a problem. Infact, this has affected the image of Indian groundnut meal in the world market. Further world trade in groundnut meals is shrinking mainly on account of stiff competition from soybean meal (Oil World, 1990). East European countries do not seem to be in a position to continue buying from India, whereas free currency area countries are hesitant to turn to India for meeting their protein requirement (The Economic Times, 1991). Of late, rapeseed meal also being exported and its share went upto 19% during 1986-90 period. In terms of current prices, value of these exports increased from US$0.84 lakh during 1961-65 to US $ 2.4 lakh during 1986-90. The United Kingdom, the Netherlands, France, Italy and West Germany (now united Germany) are the major importers of Indian oilmeals.

An analysis of production of oilmeals and its exports during 1961-89 period reveals the following facts : (a) exports as a percentage of production is the highest, 33% in 1976; (b) there is a sharp decline in the proportion of exports during the period 1978-88 and (c) exports again picked up in 1989.

BOVINE ECONOMY

So far, with the help of available data, Indian oilmeals system, which consists of consumption, production and trade sub-systems are analysed. For want of data, policy and processing sub-systems are not analysed here. Instead, per adult bovine availability of oilmeals are worked out (Table 4) as these feeds account for about 20-30% of the total cost of milk production. To this end, two assumptions are made: (a) of the available oilmeals 12% is fed to pigs, poultry, sheep and goats (Amble, 1965), and (b) no oilmeals were fed to young stock. It is to be mentioned here that there are wide variations in feeding patterns across different categories of animals and hence one has to be cautious in using these estimates. Availability of oilmeals, per adult bovine, worked out to be 153 kg in 1961 and 239 kg per annum in 1987. However, in 1977, it dipped to a low of 164 kg. As of milk production, it increased from 19.4 million tonnes in 1961 to 43.9 million tonnes in 1987 an increase of 115% of 4.25% per annum during 1961-87. Thus the growth in milk production is twice that of availability of oilmeals. The credit goes to operation flood programme under which both forward and backward linkages with respect to milk are made.

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Table 1. Domestic disappearance of oilseeds in India

'000 tonnes

Period	Soybean	Cotton	Groundnut	Sunflower	Rapeseed	Sesame	Copra	Linseed	Total
1961-65	0.0(0.0)	1041.0(32.0)	985.0(30.3)	0.0(0.0)	699.8(21.5)	189.2(5.8)	103.6(3.2)	233.8(7.2)	3252.4(100)
1966-70	0.0(0.0)	972.8(30.8)	917.0(29.0)	0.0(0.0)	787.8(24.9)	187.8(5.9)	106.6(3.4)	188.8(6.0)	3160.8(100)
1971-75	20.6(0.6)	960.6(27.5)	938.8(26.9)	0.2(0.0)	1038.2(29.7)	182.8(5.3)	127.4(3.6)	222.4(6.4)	3491.0(100)
1976-80	97.8(2.7)	1011.4(27.9)	1063.2(29.3)	4.0(0.1)	955.0(26.4)	172.8(4.8)	126.4(3.5)	191.8(5.3)	3623.4(100)
1981-85	182.0(3.7)	1343.8(27.3)	1492.6(30.4)	65.6(1.3)	1268.2(25.8)	221.0(4.5)	128.4(2.6)	214.6(4.4)	4916.2(100)
1986-90	227.8(3.9)	1878.6(32.0)	1545.8(26.3)	87.8(1.5)	1618.4(27.5)	201.0(3.4)	129.0(2.2)	189.6(3.2)	5876.0(100)

Figures in parentheses are percentages of total
Source: oil World

Table 2. Production of major oilmeals in India, 1961-90

'000 tonnes

Period	Soybean	Cotton	Groundnut	Sunflower	Rapeseed	Sesame	Copra	Linseed	Total
1961-65	0.0(0.0)	1103.6(27.3)	1683.0(41.6)	0.0(0.0)	699.8(17.3)	189.8(4.7)	121.8(3.0)	247.8(6.1)	4045.8(100)
1966-70	0.0(0.0)	1089.8(27.3)	1591.4(39.9)	0.0(0.0)	787.8(19.8)	194.6(4.9)	116.6(2.9)	204.8(5.2)	3985.0(100)
1971-75	20.6(0.5)	1114.4(25.0)	1703.0(38.1)	0.2(0.0)	1038.2(23.2)	190.0(4.3)	129.2(2.9)	270.4(6.0)	4466.0(100)
1976-80	134.0(2.9)	1190.6(25.6)	1779.6(38.1)	7.2(0.2)	974.8(20.9)	184.8(4.0)	130.2(2.8)	252.6(5.4)	4654.2(100)
1981-85	405.4(7.1)	1491.4(26.0)	1781.8(31.1)	93.8(1.6)	1373.0(24.0)	228.4(4.0)	131.0(2.3)	224.8(3.9)	5729.6(100)
1986-90	926.4(12.7)	1912.6(26.2)	1876.6(25.7)	160.8(2.2)	1884.0(25.8)	219.2(3.0)	129.6(1.7)	198.8(2.7)	7307.6(100)

Figures in parentheses are percentages of total
source: Oil World

Table 3. Exports of major oilmeals from India, 1961-90

'000 tonnes

Period	Soybean	Cotton	Groundnut	Sunflower	Rapeseed	Sesame	Copra	Linseed	Total
1961-65	0.0(0.0)	62.6(7.9)	698.0(88.0)	0.0(0.0)	0.0(0.0)	0.6(0.0)	18.2(2.3)	14.0(1.8)	793.4(100)
1966-70	0.0(0.0)	100.8(12.5)	674.4(83.5)	0.0(0.0)	0.0(0.0)	6.8(0.8)	10.0(1.2)	16.0(2.0)	808.0(100)
1971-75	0.0(0.0)	153.8(15.8)	764.2(78.3)	0.0(0.0)	0.0(0.0)	7.2(0.7)	2.4(0.2)	48.8(5.0)	976.4(100)
1976-80	37.4(3.6)	179.4(17.4)	716.6(69.3)	2.6(0.2)	20.0(1.9)	12.0(1.2)	5.0(0.5)	60.8(5.9)	1033.8(100)
1981-85	216.2(26.8)	147.8(18.3)	289.2(35.9)	28.2(3.5)	105.0(13.0)	7.4(0.9)	2.6(0.3)	10.2(1.3)	806.6(100)
1986-90	692.2(48.4)	34.2(2.4)	331.0(23.2)	72.8(5.1)	270.8(18.9)	18.4(1.3)	1.2(0.1)	9.0(0.6)	1429.0(100)

Figures in parentheses are percentages of total
Source: Oil World

Table 4. Trends in availability of oilmeals in India for selected periods

Year	Disappearance of oilmeals ('000 tonnes)	Adult bovines (millions)	Availability per animal (kgs/annum)	Milk production (million tonnes)
1961	2445.52	159.50	153.32	20.4
1966	2511.52	163.35	154.70	19.4
1972	3119.60	168.16	185.51	22.5
1977	2829.20	172.75	163.77	28.3
1982	4057.68	188.55	215.20	32.9
1987	4629.68	193.77	238.93	43.9

Source: Dairy India and oil World

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MANIPULATION OF OIL QUANTITY AND QUALITY IN ANNUAL OILSEED CROPS *

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ABSTRACT

This review paper highlights the importance of oil quantity and quality in terms of Indian economy and the strategy which could be used in increasing oil content and improve oil quality of annual oilseed crop in general. Vast amount of work done so far gives clear insight about the way fatty acids are synthesized in developing oilseeds. However, information in respect of molecular biology of enzymes leading to oil synthesis is scanty. Recent developments in biotechnology allow us modification of genes not only for hyper expression of genes but also in modifying enzymes for changing plant metabolities. The newer developments like site-directed mutagenesis, antisense RNA technology, ribozyme technology permits elimination of toxin from crop plants. This could be invaluable in removing toxic constituents and thus making oil cake edible. The review confines only to groundnut, rapeseed, mustard, sunflower, sesame and niger.

Key words : Oilseed crops; Oil Content; Oil quality; Oil synthesis; Biotechnology.

INTRODUCTION

Oilseed crops occupy a place of prime importance in Indian economy. The oilseeds not only provide oil for human consumption but also provide oils for various industries like soap, varnishes, aviation fuel etc. The demand for oil is ever increasing in view of the increase in population. Plant breeding efforts have been directed towards increasing yield of each of the oilseed crop and also productivity. During 1990-91 despite drought in several parts of the country, the total oilseed production was 18.46 million tonnes (Economic Survey, 1991-92) and edible oil production was nearly 3.8 million tonnes (The Hindu Agriculture Survey, 1990). Although impressive gains have been made in respect of increase in productivity, it still does not match the requirements and the country had to import 525.8 thousand tonnes of edible oils costing Rs. 330 crores (Hindu Agriculture Survey, 1990; Economic Survey, 1991-92). This necessitated all out efforts by Government of India for increasing oilseed production. In this paper we have reviewed the information in respect of oil composition, oil synthesis and effects of various cultural practices on oil content and quality and biotechnological approaches that can be fruitfully used for improving oil content and quality. The oil quality is important from the view point of nutritional properties, physiological effects of fatty acids and storage etc. Linoleic acid (C 18:2) in addition to being an essential fatty acid is also hypocholesteremic

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while oleic acid (C 18:1) and stearic acid (C 18:0) have little **effect on** cholesterol levels (Mathur and Sharma, 1989).

Groundnut and rapeseed mustard are the major oilseed crops and contribute more than 70% of the edible oil. Each oil has its own characteristics, fatty acid and triacylglycerol composition. Most of the edible oils derived from seeds contain palmitic, stearic, oleic, linoleic acids as major components. The quality of oils is determined, apart from other factors, by the quantity and quality of different fatty acids. A high proportion of long chain of polyunsaturated fatty acids (PUFAs) is desirable from human nutrition point of view. Linoleic acid plays an important role in the synthesis of prostaglandins, which regulates various body functions. The PUFAs are known to lower the abnormally high cholesterol level in blood and are recommended for patients with risk of coronary diseases due to their hypocholesteremic nature. Linolenic acid (18:3) is highly unsaturated and oil rich in it find use in paint and varnish industry. Oils with very high unsaturation develop rancidity on storage which can be prevented by the addition of anti-oxidants. Free fatty acids should be present in smaller amounts to avoid early deterioration of seed oils.

Groundnut, brassica, castor, sesame, soybean, sunflower, safflower and niger are the main oilseed crops. The annual production of oilseed crops in the country is shown in Table 1 and 2. The oil content is shown in Table 3 and fatty acid composition of oil in Table 4 & 5.

GROUNDNUT

The groundnut (*Arachis hypogaea* L.), also known as peanut is a member of Papilionaceae, the largest and important of three divisions of Leguminosae. There is a wide variation in the types and strains being cultivated (Weiss, 1983). But in general the two main types, the Virginia and Spanish, grown commercially are distinct in appearance.

The oil content in groundnut ranges from 44-65% (Table 3). The oil is characterized by having iodine value of 82-106, refractive index of 1.4550 and saponification value of 189 and small amount of free fatty acids (Weiss, 1983; Mathur and Sharma, 1989). It contains fairly large amount of polyunsaturated fatty acids, the oleic and linoleic acids (Table 4). Fatty acids variation in cultivars observed is given in Table 5.

For edible purpose, bold seeded and relatively low oil content nut with high protein and sugar is favoured. On the other hand, for industrial purpose nuts are required to have a high oil content, high shelling percentage, long dormancy and good storage quality. A great deal of success has been achieved in development of cultivars which partition more of their daily assimilate to fruit, and this has largely been responsible for yield gains. Other factors affecting yield and oil content are early maturity, flower fertility and seed dormancy. Quick growth is important where available moisture limits groundnut growing. Synchronous flowering is an ideal attribute in groundnut.

There is a great deal of genetic variability in cultivars and wild species with respect to oil content and quality which still remains unexploited. Collection and maintenance of wild and cultivated species of *Arachis* is provide breeders with a broadly based gene pool is , therefore, of great importance. In recent years the value of widening the groundnut gene pool through interspecific crosses has been recognized. The recombinant breeding programmes involve intercrossing of various kinds of varieties including Virginia, Spanish and Valencia. In India under irrigated and assured rainfall conditions, the varieties most commonly cultivated are the Spanish bunch types characterized by early maturity and resistance to major pests and diseases. But the late maturing Virginia spreading forms are cultivated under rainfed conditions of a less stable environment. The crosses between Spanish and Virginia bunch are runner types hold considerable potential both for the kernel yield and oil content.

The groundnut meal is generally used as animal feed. There is tremendous potential for not only export of oilseed cake but also in extracting its protein to supplement protein in diet. However, one of the major problem faced by industry is the production of aflatoxins by the mould *Aspergillus flavus* which not only gives bitter taste to groundnut kernal but also consumption of such infested nut leads to certain disorders characterized by childhood liver cirrhosis and severe type of corcinogenicity leading to the development of cancer (ICRISAT, 1989). It is for this reason, most of the Governments have made regulations regarding allowable maximum aflatoxin content. Many of the Indian varieties are prone to *Aspergillus flavus* growth and as a result kernels and oilseed meal have high levels of aflatoxins. This is particularly severe under conditions where humidity is high on farms. Therefore, plant breeding efforts have been directed towards transferring genes for resistance to *Aspergillus flavus*. Already some genotypes having resistance have been identified at ICRISAT. The alternate strategies include innovations in drying methods, heat treatments and rejection of nuts with discoloured skins or cotyledons by special machines (Mixon, 1979).

RAPESEED MUSTARD

Rapeseed is an important crop after groundnut in our country. *Brassica campestris* L. and *Brassica napus* L. are the two important oilseed crops in rapeseed and mustard group. There are three distinct types of *B.campestris* in India, brown and yellow sarsons and toria and another species *B. juncea*, rai is also an important minor oilseed.

The oil content in rapeseed mustard varies from 29-54% (Table 3). The oil is characterized by iodine value of 90-125; refractive index of 1.4582 and saponification value of 175 (Weiss, 1983; Mathur and Sharma, 1989). The fatty acid profile is unique due to the presence of an unusual fatty acid, erucic (22:1) in high amounts. As a result the content of oleic and linoleic acids are comparatively low in this oil (Table 4). Fatty acid variability in cultivars studied is given in Table 5.

Besides increase in seed yield and seed oil content, reduction in erucic acid (C 22:1) has been a major goal of breeding (Loaf & Appelqvist, 1972). Injurious effects of erucic acid on heart muscle have been demonstrated in animals (Engstrom, 1978). It is also reported to be responsible for poor digestibility of traditional rapeseed oil (Rogers, 1978) and enlargment of adrenal gland (Petersen 1978). In Britain, traditional varieties contain about 40 per cent erucic acid but this has been progressively reduced to level below 5 per cent in the oil. Low erucic acid varieties are hybrids produced from low and high erucic acid types. The F_1 generation often containing less than 0.5 per cent erucic acid in the oil.

The selection of very low or erucic acid free strains has made the oil more attractive, commercially, and reduction in the linoleic acid content resulted in an improved oil storage quality. However, low erucic acid content cultivars tend to early initiation of the inflorescences, which is a distinct disadvantage in winter sown crops. The introduction of the first low erucic acid varieties, such as Oro, Span, Sinus and Lesira resulted in a reduction of seed and oil yield potential (Downey, 1978). It has been however, possible through continued breeding work to raise the oil yield of low erucic acid varieties in Sweden (Weiss, 1983).

The oil of zero erucic rapeseeds is characterized by high content of oleic acid (60%), linoleic acid (20%) and linolenic acid (10%). Recognition of the principles of inheritance of these characters is considered essential for further improvement of winter rapeseed breeding (Broda, 1978). A highly significant combining ability for oleic and linoleic acid and fat content has been reported .

As increase in the linoleic acid (C 18:2) is desirable, combined if possible with a decrease in linolenic acid (C 18:3) content, since the latter can cause rancidity in stored products. However, changing the content of these polyunsaturated fatty acids is genetically more difficult than altering the erucic acid level. Recent studies have shown that single selection for oil content could possibly result in significant increase in other attributes, since Indian rapes have not been subjected to any intensive selection for this characteristic (Asthana *et al.,* 1979). Studies on cultivars showed that despite significant differences between them, heritability for yield components was generally low.

It has been reported that a reduction in seed coat fibre content would add to meal palatability, and yellow seeded varieties under development have significantly lower crude fibre, higher protein and oil content, thus producing a more attractive, high energy meal (Weiss, 1983).

A strong positive association was noted between biological yield and seed yield in yellow and brown seeded populations and oil content with all the seed characters in yellow seeded population (Katiyar *et al.*, 1985). Specific gravity showed strong positive association with all the seed characters including oil content and majority of yield characters in yellow seeded population. The largest determiner of oil content variability was the 1000 seed volume followed by specific gravity of seeds. To raise oil content emphasis should be given on the seed characters in yellow seeded population. The data indicated that oil content varied from 41.1 - 54.5% in yellow seeded and 42.4 - 53.5% in brown seeded populations (Table 3). The genotypes containing 49.1 - 51 per cent oil were observed in maximum frequency in yellow seeded population while in the other population, majority of plants were found in the 47.1 - 49.0 per cent oil range. The frequency of genotypes possessing maximum oil content (53.0 - 54.5%) was five times greater in yellow seeded population than in brown seeded population (Katiyar *et al.*, 1985).

Katiyar (1988) observed richness in oil content in the light colour over the dark colour seed in *B. campestris*, This indicated that light colour seed was positively associated with high oil content. Since selection for highest oil content is not detrimental to seed yield (Loof and Appelqvist, 1972 and Stringham *et al.*, 1975), the yield can also be upgraded by simultaneous selection for the two characters.

One of the major problem associated with rapeseed mustard is the presence of allyl-isothiocynates varying from 0.6% in Bronowski to 16.2 per cent in Target cultivars (Weiss 1983). Although most of the glucosinolates remain in the rapeseed meal, the oil also contains a small proportion of allyl-isothiocynate and glucosinolates which imparts characteristic pungency and odour to oil. The high content of glucosinolates in meal make it unfit as animal feed stock. Feeding trials conducted have shown convincingly the deleterious effects (Bijster *et a*l., 1978; Vermorel *et al.*, 1988; Buchmann and Wenk, 1989).

Although several attempts have been made to develop processes that could eliminate thioglucosinolates, as yet no economic process has been developed. There is a vast scope for isolating proteins from meals since it is extremely rich in protein. It has been suggested that heat treatment of meal could inactivate myrosinase and prevent production of nitrile. However, even after heat process, the meal is not suitable even as animal feed. The alternate approach has been the extraction of proteins by use of alkali. But the process is not economical as yet. Differences in the thioglucosinolates content in different cultivars offers scope for breeding rapeseed mustard for low thioglucosinolate content.

SUNFLOWER

The sunflower, *Helianthus annuus* L. is a member of the compositae. Many sunflower varieties are open pollinated with honeybees being the main agents.

Considerable variation for oil content and quality characteristics exists in known sunflower species. The oil content in this oilseed ranges form 25-65% (Table 3). Sunflower oil is characterized by a slightly higher iodine value (115-145) in comparison to groundnut and rapeseed mustard oils. It's refractive index is 1.4597 while saponification value is around 191 (Weiss *et al.*, 1983; Mathur and Sharma, 1989). As regards fatty acid profile, the oil contains lesser amount of saturated fatty acids and appreciably high amount of essential fatty acid, linoleic (Table 4). In contrast to other oil seeds, a wide variability with regard to linoleic acid has been reported in sunflower cultivars (Table 5).

Oil constituents vary with linoleic acid upto 89 per cent and oleic acid upto 85 per cent (Weiss, 1983; Dorrell & Whelan, 1978). Simple recurrent selection procedures are effective in increasing both oil content and desirable constituents (Miller, *et al.*, 1977). Breeding or selection of varieties whose seed has a space between the hull and kernel without loss of oil content would materially exist seed processors.

Hybrids of inbred lines have given the biggest increase in yield and oil content and are in commercial use. Synthetic varieties are also available with high seed and oil yields.

SESAME

Sesame, *Sesamum indicum* L. is a member of family Pedaliaceae which comprise sixteen genera and nearly sixty species, of which several can be crossed with *S.indicum* and a few also cultivated for their seeds. It's seeds and oil have been widely noted in Indian literature from as early as vedic period (BC 800-600) for the quality and medicinal use.

The oil content in sesame varies from 44-63% (Table 3). The oil is characterized by having an iodine value between 100-115; refractive index of 1.4582 and saponification value of 192 (Weiss *et al.*, 1983; Mathur and Sharma, 1989). The oil is rich in unsaturated fatty acids. Oleic and linoleic together account for 88%. The saturated fatty acid (C16 - C20) account for only 20% (Table 4).

The great diversity of sesame types, their wide environmental adaption and considerable range of seed oil content and characteristics make an exceptional gene pool of material available to plant breeders.

NIGER

Niger is a short, erect, moderately branched annual herb, with attractive yellow flowers whose seed produce edible oil. It is adapted to semi-tropical environment, can grow under poor cultural and soil conditions but requires adequate rainfall over the main growing periods to produce a commercially acceptable yield. Crambe and niger have been neglected and both are particularly suitable for specific regions or agricultural systems. It is the main oil seed crop of tribal areas.

The oil content in niger ranges widely (35-45%) (Table 3). The niger seed oil also possess fairly good characteristics like other common edible oils reported earlier. The oil has iodine value of 132-139; refractive index of 1.471 and saponification value of 280-295. The oil has substantially high amount of linoleic acid and at par with sunflower oil (Table 4).

Niger, ($2n = 30$) is considered to have no distinct varieties in the accepted sense, neither there are recognizable cultivars except some selections which have local names or line numbers. Niger is basically cross-pollinated, but self fertilized seed is viable. Since a large number of seeds is produced per plant, selection for required characters can be rapid. The most important objective of breeding programme todate has been to increase seed yield, since this being the major factor limiting niger's profitability. This has been substantially achieved in India where selected strains can now produce 1 tonne/ha compared with earlier yields of 300-400 kg/ha. Seed oil content was negatively correlated with yield, but the degree of depression was small compared to the increase in potential yield, and therefore yield of oil per hectare is high. Work on quality of oil of niger is neglected so far. It is however, quite possible to develop cultivars with high quality oil using breeding techniques and selections.

MUTATION BREEDING

It is now well recognized that induced mutagenesis basically helps the crop improvement efforts through enlarging variability. In situations where naturally occurring variability is sufficient and has not been exploited fully, mutagenesis should not be the tool for seeking improvement (Chopra & Sharma, 1985). It is to be realised that the contribution of induced mutations in the development of commercially released varieties is sufficiently significant (IAEA, 1972). Sigurbjornsson (1983) has recorded 213 seed propagated cultivars that have been developed by induced mutations. The useful genetic materials generated through this approach include a number of mutants evolved from Spanish Improved by the scientists of Bhabha Atomic Research Centre. 'TG-8', 'TG-9' and 'TG-10' had maximum oil content (54%) as well as superior yielding ability (Patil, 1973). 'TG-14' to 'TG-19' were developed after intercrossing the induced mutations. Oil seed varieties developed by mutation are given in Table 6.

CULTURAL PRACTICES AND ENVIRONMENTAL CONDITIONS

Cultural practices and environmental conditions have been shown to affect not only oil quantity but also fatty acid composition of oil.

(a) Effect of season

The effect of environment has been studied in several oilseed crops. The oil content has been shown to vary even for the same genotype over years at the same location. The variation has largely been influenced by the temperature during seed development period. In addition, in sunflower major change in fatty acid composition of oil has been observed when grown during different cropping season during the year (Sen *et al.*, 1976). Seeds of 28 sunflower strains when analyzed for their fatty acid composition showed the linoleic acid content to be 60-70% in rabi grown crop as compared to 20-23% in kharif grown corp. The proportion of stearic acid and linoleic acid decreased considerably while that of oleic increased in kharif crop as compared to rabi (Table 10). Oleic/linoleic acid ratio was found higher in kharif grown crop.

Similarly in a study of the effect of season on fatty acids in three groundnut strains, has been shown in Table 11. More linoleic acid synthesis was observed during kharif grown crop in comparison to spring grown crop. This resulted in a higher oleic/linoleic acid ratio during the spring season. A higher ratio is indicative of better storage quality of the oil.

Studies on the biosynthetic pathways for fatty acids in oilseeds have indicated that unsaturation is brought about by desaturases which require oxygen and the supply of NADH. The desaturases have higher activity at 25°C as compared to the activity at elevated temperatures. In addition higher temperature tends to reduce the oxygen solubility in the cell sap. Therefore, increased temperature would result not only in lower activity of desaturases but also lower oxygen solubility in cell sap, and thus retard conversion of oleic acid to linoleic acid. The effect of growing season is related to the effect of temperature on fatty acid synthesis. In crops such as groundnut and sunflower the variations in growing temperature are very significant and may affect fatty acid composition. Changes in fatty acid composition in groundnut have already been observed in response to growing season as well as location (Sharma *et al.*, 1981, 1985; Mathur and Sharma, 1989).

(b) Effect of location

Fatty acid composition of seed oil also gets affected by location. Fatty acid profile of three groundnut mutants (TG-8 and TG-14) grown in Bombay and at Gauribidanur showed appreciable differences in the content of each fatty acid (Mathur and Sharma, 1989). Palmitic, stearic and linoleic were generally higher at Gauribidanur than in Bombay (Mathur and Sharma, 1989).

(c) Effect of fertilization

It has been reported that in sesame oil content increased with N application; oleic acid being maximum at the highest NPK application and linoleic acid content being maximum at the intermediate fertilization (Seo *et al.*, 1986). Studies on effect of nitrogen fertilization on oil content in Brassica showed that oil content decreased with an increase in N-application. Oil content was the lowest in groundnut when no fertilizer was given. Maximum oil was synthesized under the influence of calcium sulphate + sulphur treatment (Pathak and Pathak, 1972).

STUDIES ON BIOSYNTHESIS OF OILS

The data with regard to change in oil content and quality characteristics of mustard oil during seed maturation are given in Table 7, 8. In the beginning, oil synthesis was minimum and with very high acid value. Changes in fatty acid profile of the oil from different ripening stages is given in Table 8. Despite a little more synthesis of saturated fatty acids (palmitic & stearic) during first stage, the oil is comparatively rich in linoleic acid (18:2) and had the lowest content of erucic acid. Erucic acid content increased with maturity.

Similarly changes in the fatty acids of sunflower oil are summarized in Table 9. Maximum linoleic acid (18:2) accumulated only at maturity viz., 51 days after pollination. oleic acid (18:1), however, did not change much.

BIOTECHNOLOGICAL APPROACHES

Improvement of oilseed crops in terms of higher oil content and better oil quality is quite possible by following the newer techniques of plant biotechnology . The methods for gene transfer to some of the oilseed crops like Brassica and groundnut have been developed and this would permit cloning of gene like the ACP (acyl carrier protein) for higher oil synthesis. Techniques such as Ribozymes and antisense nucleic acid technology could be fruitfully used in eliminating toxin from oilseeds. The pathway for oil synthesis has been well worked out and the role of desaturases in bringing about unsaturation of fatty acid is known but the characterization of the desaturases has not been done to an extent that oil quality could be altered. It is therefore necessary to understand the molecular biology of this enzyme and isolate the enzyme so that ultimately the enzyme could be cloned for getting higher linoleic acid in oils such as groundnut as that it could be used by people having the problem of atherosclerosis. Major gains in next few years are expected from exploitation of somaclonal variation and development of inter-specific hybrids. Understanding of mitochondrial genome would permit development of male sterile lines for eventual development of low cost hybrids from diverse species.

TISSUE CULTURE

Genetic changes occur in plant tissue culture and these changes are transmitted to regenerated plants and their progenies (Shepard, 1981). A new genetic variability is induced either spontaneously or artificially during the culture process in tissue culture. Cell culture methods have opened new possibilities for mutation breeding by making it possible to select mutants among large population of cells. The variability generated by the use of tissue culture cycle is referred to as "somaclonal variation" (Bhaskaran, 1985).

The widespread occurrence of somaclonal variation in wide variety of plants has been extensively documented. Many a times the variability generated during tissue culture cycle is of agronomic value and can provide a valuable adjunct to plant improvement. Recent reports on a wide range of genetic variation among regenerated plants from protoplasts, cell and callus cultures have created a lot of interest in this variation from plant breeding point of view (Thomas *et al.*, 1982).

By screening and selection among plants regenerated from cell culture and their progeny substantial improvement in cultivars can be achieved which may be difficult to achieve otherwise. Among Brassica species, using explants of anthers, embryos and meristems variant characters for flowering time, growth habit, waxiness, low glucosinoles etc. were observed to show sexual transmission (Scowcroft, 1984).

Plant regeneration through somatic embryogenesis has been reported from leaf callus cultures of *B.oleracea var. botrytis* (Pareekh, 1978) and *B.campestris* (Bhattacharya and Sen, 1980) and from somatic embryogenesis has also been reported in protoplast cultures of

B.napus (Li and Kohlenbach, 1982), *B. oleracea* (Jourdan and Earle, 1985), and *B.nigra* (Klimaszewka and Keller, 1986). In *B.juncea*, plantlet regeneration by adventitious shoot bud formation has been obtained in cultures initiated from the hypocotyl (Hui and Zee, 1978) and cotyledons (George and Rao, 1980, Narasimhulu and Chopra, 1988). Chatterjee *et al.* (1985) have reported plantlet regeneration from cultured mesophyll protoplasts.

In *Brassica*, shoot regeneration from callus cultures has been reported for explants like cotyledons, stem segments, leaf, root and anthers (George and Rao, 1980; Hui and Zee, 1978; Dunwell, 1981, Lazzeri and Dunwell, 1984; keller and Armstrong, 1977; Klimaseewska and Keller, 1986). Also, plant regeneration has been achieved in *B. oleracea* and *B.napus* from cultured protoplasts (Kartha *et al.*, 1974; Xu *et al.*, 1982). *B. napus*, produced from fusion of *B. campestris* and *B.oleracea* protoplasts, has been used for increasing variability, for selecting resistance to pathogens (*Phoma imgam* and *Alternaria brsssicicola*) and for producing hybrids from incompatible interspecific cross combinations (Sacristan 1982, Schenck and Robbelen 1982, McDonald and Ingram 1985, Inomata, 1985).

Plant regeneration protocols from *Brassica juncea* with a high frequency of shoot regime have been reported (Kirti & Chopra, 1985) and this offers potential for somatic hybridization between *Brassica juncea* and related wild species for developing mutants resistant to viruses and biotic stresses.

Plant regeneration from callus of *Brassica carinata* has been developed (Narasimhulu & Chopra, 1987). This would permit utilization of tolerance to aphids, resistance to blight, white rust and downy mildew present in *carinata* species. So far, there are no well documented reports of variability in oil content and oil quality.

With the development of in vitro regeneration protocols in respect of majority of the oilseed crops (Moyne *et al.*, 1988; McCann *et al.*, 1988; Witrzens *et al.*, 1988; Zhang-Dawei *et al.*, 1988; DeBlock *et al.*, 1989; Mckently *et al.*, 1990) it is now possible to address the problem of not only removal of toxic constituents but also improvement in oil content and quality. However, so far there are no well documented reports of variability in oil content and oil quality as a result of tissue culture work in rapeseed mustard.

A significant achievement has been the development of ELISA method of screening for sinigrin and gluconapin, based on polyclonal antibodies raised in rabbits against a sinigrin protein conjugate, and allows rapid screening for glucosinolates during tissue culture work.

In groundnut protocols for plant regeneration from immature embryos and other plant parts have also been standardized which would permit exploitation of somaclonal variation as well as production of intraspecific hybrid plants form immature *Arachis* embryos. Clone propagation, mutagenesis, *in vitro*. selection, somatic hybridization and transformation offer scope for improvement for most of the oilseed crops. Palmer *et al*, (1988) were successful in selection of seeds from an apparent somaclonal variant with significantly lower seed glucosinolate levels.

Globally considerable emphasis is being put on biotechnological approaches for improvement of yield of different oilseed crops specially in developing hybrids with in-built resistance to insect pests and diseases. However the work relating to improvement in oil content and more specifically oil quality is still in infancy. With the availability of rapid non-destructive methods of oil estimation using NMR, continuous effort is put on upgrading oil content. The stage is now ready for an all out effort in improving the oil quality of different oilseed crops taking advantage of the developments in plant genetic engineering.

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Table 1. Area and production of principal oilseed crops in India (1990-91)

Crop	Area (m.ha)	Yield (kg/ha)	Production (m.tonnes)
Oilseeds (Kharif)	13.8	703	9.7
Oilseeds (Rabi)	10.2	859	8.7
Oilseeds (total)*	24.0	769	18.4
Groundnut (Kharif)	6.8	778	5.2
Groundnut (Rabi)	1.5	1536	2.4
Groundnut (total)	8.5	919	7.6
Rapeseed and mustard	5.7	900	5.2

Source : Economic Survey 1991-92

* includes groundnut, rapeseed, mustard, sesamum, linseed, niger seed, safflower and soybean.

Table 2. Production of different oilseed crops in India (million tonnes)

Oilseed	1989-90	1990-91
Groundnut		
Kharif	6.10	5.25
Rabi	2.00	2.37
Rapeseed and mustard	4.12	5.15
Cotton seed	0/52	0.72
Sesamum	0.74	0.81
Linseed	0.33	0.34
Niger seed	0.19	0.19
Safflower	0.49	0.32
Sunflower		
Kharif	0.27	0.34
Rabi	0.36	0.55
Soybean	1.80	1.42
Total	16.92	18.46

Source : Economic survey, 1991-92, Part II, Govt. of India.

Table 3. Oil content variation in principal oil seed crops

Oilseed	Oil Per cent
Groundnut	44-65
Rapeseed	29-54
Sunflower	25-65
Sesame	44-63
Niger	35-45

Table 4. Fatty acid composition (%) of oil from principal oilseed crops

	Palmitic 16:0	Stearic 18:0	Arachidic 20:0	Oleic 18:1	Linoleic 18:2	Linolenic 18:3	Erucic 22:1
Groundnut	8	4	3	55	25	0	-
Rapeseed	1	1	-	22	22	3	41
Sunflower	5	2	1	35	57	0	-
Sesame	8	3	1	47	41	0	-
Niger	8	5	1	30	52	0	-

Niger contains 3% myristic acid (14:0) also.

Table 5. Fatty acids variation in principal oil seed crops (% by weight)

Oil/fatty acid	Palmatic	Stearic	Arachidic	Behenic	Lignoceric	Oleic	Linoleic	Linolenic	Ecosenoic	Erucic
	16:0	18:0	20:0	22:0	24:0	18:1	18:2	18:3	20:1	22:1
Groundnut	6-14	2-7	1-2	2-4	1-2	40-72	13-38	-	0-2	-
Rapeseed	1-3	1-3	0-2	0-3	0-2	8-40	10-29	4-18	4-15	0-60
Sunflower	3-10	1-10	-	-	-	14-72	20-75	-	-	
sesame	7-12	3-6	-	-	-	32-54	35-59	-	-	-
Niger	5-12	3-12	1-3	-	-	5-39	51-73	1-3	-	-

Myristic acid in Niger is 1.1 - 3.3 %
* FC less than 1% have been omitted

Table 6. List of mutant varieties of oilseeds released or approved for cultivation in India

Name of variety	Year of release and Institution	Kind of mutagenic treatment or muant crosses	Main attributes of variety
Groundnut			
Vikram(TGI)	1973- BARC, Bombay	X-Rays 75 kR (Sapnish Improved)	Large kernels suitable for expert yield upto 4t/ha
TG-3	1984-BARC, Bombay	15 kR-X-rays (Spanish Improved)	More pods/plant high yield
TG-14	1984-BARC, Bombay	Intermutant cross	Uniform maturity high yield
TG-17	1984-BARC, Bombay	Intermutant cross	High yield, suitable for summer cultivation
Castor			
Aruna	1969, IARI, N.Delhi	1400 rad thermal neutrons, 1965	Very early, high yield
Sowbhagya (147-B)	1969, IARI, N.Delhi	Aruna x dwarf mutant of HC-6	Long duration suitable for intercropping
RC-8			
Mustard			
RLM-198	1975, PAU, Ludhiana	Irradiation (RL-18)	Increase oil content and yield
RLM-514	1980, PAU, Ludhiana	200 kR gamma rays	higher gain yield over check var. varuna
Sesame			
Kalika	1980, Orrisa Agric. & Tech., Bhubaneshwar.	1% EMS presoaked 6 hr., 1974.	Dwarf, Higher yield

Soruce : Chopra & Sharma (1985)

Table 7. Characteristics of rapeseed oil during seed maturation

Characteristics	Ripening Stages		
	I	II	III (Ripe)
Oil per cent	21	40	47
Oil level per cent	45	86	100
Acid value	14	6	2
Iodine value	100	106	101
Saponification value	192	189	187
Saturated acids	9	7	6
Unsaturated acids	76	82	87

Source : Singh (1975)

Table 8. Fatty acids changes in rapeseed oil during seed maturation

Fatty acid (%)	Ripening stages		
	I	II	III
Palmitic (16:0)	6.1	4.7	3.9
Stearic (18:0)	3.0	2.2	1.0
Oleic (18:1)	11.6	10.4	9.3
Linoleic (18:20)	18.8	14.1	11.9
Linolenic (18:30)	6.1	8.9	6.4
Eicospenoic (20:1)	8.6	8.0	11.6
Erucic (22:1)	44.2	48.4	50.0
Arachidonic (24:1)	1.1	1.4	1.9

Soruce : Singh (1975)

Table 9. Fatty acids changes in sunflower oil during seed maturation

Days after pollination	Fatty acids per cent			
	Palmitic 16:0	Stearic 18:0	Oleic 18:1	Linoleic 18:2
9	19.4	3.5	18.1	46.3
21	8.2	7.0	28.4	64.4
38	6.2	5.3	17.9	69.2
45	6.0	4.9	16.2	71.6
51	6.2	5.4	14.7	72.4

Source : Harris *et al.* (1978).

Table 10. Effect of season on fatty acid composition in sunflower

Fatty acid (%) strain	EC - 68413		EC - 66002	
	Rabi	Kharif	Rabi	Kharif
Palmitic	5.8	5.8	6.7	7.3
Stearic	6.9	3.8	10.6	< 1
Oleic	18.1	63.7	18.3	68.8
Linoleic	69.2	26.7	64.4	23.9
Oleic/Linoleic	0.26	2.39	0.28	2.80

Source : Mathur and Sharma (1989)

Table 11. Effect of season on fatty acid composition in groundnut

Fatty acid (%) strain	M-145		T-28		BP-1	
	Spring	Kharif	Spring	Kharif	Spring	Kharif
Palmitic	9.9	10.7	9.5	9.9	14.2	13.2
Stearic	2.0	2.2	2.0	2.1	2.6	2.5
Oleic	66.2	53.3	67.5	60.9	54.1	49.6
Linoleic	16.7	26.4	16.6	20.9	26.3	31.8
Oleic/Linoleic	4.0	2.0	4.1	2.9	2.1	1.6

Source : Mathur and Sharma (1989)

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NEW APPROACHES TO DISEASE MANAGEMENT IN KHARIF OIL-SEED CROPS*

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ABSTRACT

Management of diseases of groundnut, sesamum, sunflower is rarely adopted by farmers mainly because the current strategies are assorted and no definite returns are expected. A large array of management strategies such as seed treatment, timely sowing, optimum plant populations, preparatory tillage, soil polarization, rotation, proper irrigation are available which not only reduces losses due to diseases but are useful for better crop growth and production. It is only when epidemic situation is expected that fungicidal chemical control are advocated particularly for foliar disease management. Host resistance is prefered but cultivars resistant to large number of diseases cannot easily be developed. The concept of integrated disease management can be easily applied to oilseed crops. The paper describes the case examples.

Key words : Oilseed crops; Integrated disease management.

INTRODUCTION

Groundnut, sesamum and sunflower together occupy around 60% of the total area under all annual oilseed crops in India. They are the major oilseeds grown in kharif (rainy season). Castor and niger cover around 7.0% area together but are neglected from disease management point of view. Soybean is yet another oilseed becoming popular and is raised mainly in rainy season but dealt separately. It is only recently when the oil imports became feature of vegetable oil economy that the oilseed cultivation got some respectability from planners, administrators, researchers and farmers. However, excepting groundnut to some extent disease management is fairly neglected subject in the cultivation of these crops during rainy season. A survey in Parbhani district of Maharashtra revealed some disturbing trends. *A practice like seed treatment is followed by only 10% groundnut growers and that too these* are the elite farmers who are adopting the intensive cultivation practices such as, bed sowing, micronutrient and gypsum application, high yielding cultivars etc. This figure is also on higher side (Table 1) because the sample cut across the seasons. Farmers used certified sunflower seed and hence seeds were hardly treated. The situation in sesamum is still bad as none of the grower treated seeds prior to planting. Disease management component in the cultivation of oilseed crops, thus, is by far neglected. However, it is realized by now that stability in oilseeds production cannot be achieved until all the cultivation practices including disease management are kept mandatory and deletion of any one can drastically reduce the yields.

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2. MANAGEMENT STRATEGIES

2.1 Seed treatment

A wide array of routine and unconventional management strategies are available for control of diseases of oilseed crops. The very first problem in all oilseeds is gappy field. Not all gaps occur due to seed physiological problems but on an average 5 to 12% seed is killed before or immediately after emergence by pathoflora available either on the seed, in the seed or in the seed zone of soil where the seed imbibes moisture. The non-pathologists refer to it as poor plant stand (Reddy, 1991). The performance of thiram, carbendazim or carboxin singly or jointly has been successfully demonstrated in number of cultivars throughout the country in groundnut, sunflower and sesamum. Seed treatment alone can be beneficial not only in reducing the seed and soil-borne diseases but also yield by optimising plant stand (Table 2).

2.2 Cultural practices

Timely sowing particularly in rainy season (early) has been demonstrated to be of great value in minimized incidence of bud necrosis disease (BND) of groundnut and phyllody of sesame. For management of groundnut BND, there can be no better substitute to early planting (Table 3) and optimum plant population (Amin, 1987). The same has been proved effective for phyllody control in sesamum in AICORPO trials (Sharma. 1991). Soil borne diseases such as, collor rot, root rot, charcoal rot, wilts, damping off and even downy mildew of sunflower can be efficiently reduced by proper preparatory tillage, soil solarization and rotation. The monoculture of sunflower can reduce yield by 100% and increase downy mildew and other diseases by manifolds (Giriraj, 1991). The practice of growing groundnut on bed furrow system where faulty irrigation is avoided has been shown to reduce the damage by *Sclerotium rolfisii* drastically.

2.3 Chemical control

Rust and leaf spots are known to reduce yield of groundnut by 50% (Mayee, 1987 a, Mayee and Datar, 1988). Similarly, rust, *Alternaria* blight and downy mildew of sunflower and leaf spots due to *Cercospora* and *Alternaria* in sesamum are devastating diseases. These pathogens have capacity to multiply at fast rate in short time and bring about secondary infection in entire plant population are responsible for major epidemics in oilseed crops. Recent epidemics of *Alternaria* blight of sunflower and foliar diseases of groundnuts are a testimony to these situations (Mayee, 1987 b, 1989, 1990, 1991). For such compound interest diseases timely application of proper fungi toxicants has great utility. Rust and leaf spots of groundnut can be efficiently managed by combined spray of carbendazim (0.05%) plus triemorph (0.07%) or mancozeb (0.20%). Mancozeb alone or coupled with carboxin at 0.1% can reduce foliar diseases of sunflower and sesamum (Maiti, 1987; Mayee, 1987 a, 1991). Mayee and co-workers (Mayee, 1991 b) worked out the foliar disease management schedule based on forewarning system. The summary of efficiency of chemical management of foliar diseases has been provided in Table 4 and 5, which depicts assured yield increases by chemical control of diseases. Low adoption of fungicidal management is due to unawareness of damage, difficulty in early diagnosis, timely application, lack of forewarning systems and economic constraints. Some of these reasons can be answered precisely.

2.4 Host resistance

By far the most effective and cheap management strategy is to make available cultivars with disease resistance or tolerance. A range of groundnut cultivars, Girnar 1, ICGS (FDRS) 10, ICGS (FDRS)4, are released for commercial cultivation during kharif. These have proven tolerance to foliar diseases and thus yield better (Table 6). Similarly, LSH-1 and LSH-3 sunflower hybrids bred for downy mildew resistance have comparable yield levels with high yielding hybrids (Table 7). Making the seed available to farmers is a major task before extension agencies. Sunflower hybrids are generally tolerant to rust but none possesses any resistant to Alternaria blight. This is one area where AICORPO programme must concentrate. Similarly, no worthwhile contribution towards phyllody resistant Sesamum has been in the sight. Even the epidemiology of phyllody is less investigated. It is time now that such specific target oriented research is done in breeding for disease resistance so that the programme can provide disease resistant cultivars of oilseed crops to farmers which have generally larger acceptance than other management components.

2.5 Biological control

Laboratory experimentation in biological control of diseases have been fairly successful in India. However, none of them has reached adoption stage. mass multiplication, supply system in the bio-control agent; *Trichoderma* spp. normally should not pose a problem. The utility of *Trichoderma* has been shown recently for control of stem and pod rots of groundnuts (Table 8) by Asghari and Mayee (1991). It was revealing that onion and garlic rotations with groundnut enhance biocontrol activity of *Trichoderma* by augmenting native population. Studies are warranted in this section particularly in sunflower and sesamum where the stem and collar rots posing threat endeimically in certain pockets.

3. INTEGRATED DISEASE MANAGEMENT (IDM)

IDM as practiced in the developed countries is a sophisticated technology achieving a computerized on-line service. Practical IDM methods have been suggested for less developed countries or traditional agro-ecosystem. It is based on efficacy, ecology and economics employing routine and supervisory practices with minimum use of agrochemicals being backed by epidemiology and management science without using computers. Recent efforts by some groundnut growers under the non-profit organization 'Theodore Schultz krishi Vigyan Mandal' is worth quoting here. The members of this organisation have achieved record yields of 62 q/ha with an average productivity of 25 q/ha across three seasons in five years. The high yielding cultivars, ICGS-11 , 21, 44, 76 etc. are raised on broad or narrow beds (BBF) using a locally developed BBF markers. Required dosages of fertilizers, micronutrient and gypsum are applied. In protecting groundnuts against rust, leaf spots, BND, sucking pests, leaf minor, the members are trained in early diagnosis of diseases, egg laying etc. In Parbhani, the author had opportunity to monitor the diseases through weather based forecasting system. Timely sprays are given and efficient pest and disease management have regularly obtained. The IDM concept must merge in the Integrated Crop Management as raising healthy crop is dependent on several factors. It has been observed that total package instead of bits is essential for successful production of oilseed crops.

EPILOGUE

Farm constitutes a dynamic production environment and naturally research conducted on experimental farm may not be exactly applicable in farmers' field strategy. Researchers develop strategies that can be practiced by farmers. Hence it is logical that the proven disease control strategies need to be reproven in conditions similar to farmer's fields and in large plots and within the framework of farming systems. At present disease control strategies are fairly rigid. They must consider the strata of farmers and suggest suitable disease management strategy in a country like, India where there are several non- users of disease management inspite of it's knowledge. Prioritization of disease control approach based primarily on tolerance, resistance, secondarily on crop rotation, nutrient, water management and allied cultural practices and tertiarily on chemical control shall go a long way in stabilizing oilseed production during the disease-pest favourable kharif season.

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Table 1. Adoption of management strategies by farmers in Parbhani District for oilseed crops

Practice	% adoption by farmers out of a sample of 78 to 120 farmers		
	Groundnut	Sunflower	Sesamum
Pre-sowing tillage	82	80	85
BBF	2	-	-
Rotation	95	73	90
Timely planting	15	10	19
Seed treatment	10	30	0
One spray	10	2	0
Morethan one	6	0	0
Improved cultivars	3	35	40
Fertilizer (NPK)	59	65	55
Micronutrients	3	0	0

Table 2. Seed treatment in sunflower in relation to management of diseases and yield

Treatment	Max. emergence (%)	DM*(%)	Blight severity (%)	Leaves per plant	Yield (kg/ha)	Oil (%)
Control	72	4.5	46	24	1580	36.1
Carbendazim	87	1.9	25	29	2180	37.8
Carboxin	84	3.5	24	27	1972	37.9
Thiram	85	3.1	29	28	2067	36.2

* *Under natural conditions . All treatments were significantly different than control.*

Table 3. Varietal impact and planting time in relation to disease and yield of K. groundnut

Cultivar	Reaction to BND	Early planting (12 June)		Late planting (10 July)	
		BND %	Yield(kg/ha)	BND %	Yield(kg/ha)
Kadiri 3	Tolerant	14.9	1102	31.8	752
TMV - 2	Susceptible	25.6	835	66.3	366
JL - 24	Susceptible	29.1	848	79.6	214

Table 4. Effect of chemical management of foliar diseases during kharif

Crop	Yield (kg/ha)		BC Ratio
	Protected	Unprotected	
Groundnut	2200	1150	11.3
Sunflower	1312	860	10.5

Table 5. Influence of management practices in disease and yield of sunflower

Treatment	Cultivar	DM %	Blight %	Yield(kg/ha)	Oil %
Control	Morden	20	28	626	38.7
	LSH - 12	6	25	908	36.8
Seed treat	Morden	3	24	760	38.7
	LSH - 12	3	23	1059	37.0
Three sprays	Morden	17	16	725	40.0
	LSH - 12	8	11	972	38.0

Table 6. Varietal impact on groundnut production in kharif (TOT, Jagtial, 1987)

Variety	Disease reaction to foliar diseases	Yield (kg/ha)
ICGS(FRDS) 10	MR diseases	1605
ICGS(FRDS) 4	MR	1705
TMV - 2	Susceptible	1100

Table 7. Varietal impact on sunflower production (DM- resistant)

Cultivar	Mean 1986	Yield (kg/ha) 1987	Oil %
LSH - 1 (R)	1954	1316	35.3
LSH - 3 (R)	2760	1962	34.2
BSH - 1 (S)	1716	1200	37.5
MSFH - 1 (S)	1783	1643	34.3

Table 8. Stem and pod rot reduction and yield of groundnut as influenced by management practices

Treatment	Reduction % in			pod yield increase %
	Stem rot	Pod rot (SR +)	Pod rot (SR -)	
Control	-10.5	-12.6	-89.4	-22.8
Onion	51.7	55.4	37.2	34.0
Garlic	43.9	41.2	27.0	17.4
Tricoderma	59.8	60.3	44.7	46.7
Carbendazim	49.8	56.3	37.2	32.1

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OILSEEDS IN INDIA - SOME RESEARCH IMPERATIVES *

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ABSTRACT

This paper takes an over view of the research work done in India on oilseed crops more from the conceptual than from the procedural or methodological aspects.

It begins by posing some questions on the real state of our vegetable fat economy to highlight some paradoxical situations. Some estimates are given to show that there is a sufficiency of vegetable oil production, but deficiency in utilization.

In most of the oilseeds productivity gains due to research and developmental efforts have been marginal and are plateauing.

In groundnut crop, one that has been researched upon most intensively in the country, improvement has been highly constrained by the narrow genetic base, and by the lack of understanding of the basic physiological aspects of production.

As a strategy, the heavy dominance of groundnut in research and developmental efforts should yield place to a wider and diversified oil crops base.

Conceptually, research programming has lacked location-specific relevance. The hardy nature of the oilseed crops and their relative low water requirement have not been exploited in research. The significant role that these crops could play in sustainable production systems is emphasised. A greater understanding of the seed yield in physiological terms would lead to a greater emphasis on ideotype breeding than hitherto. Research activities should, at least in terminal stages, be of the on-farm type. Field experiments should be so designed to estimate the treatment-by-environment interaction effects more precisely to derive maximum benefit from on-farm research. Research planning and programming should be totally decentralised. Data collected should be subjected to in-depth analyses.

A situation is envisaged where with the existing trends of production, particularly in rapeseed-mustard, when vegetable oil surpluses could become a reality. Emphasis should then be on value added products for export or for import substitution. Fatty acids, pisticizers, lecithin, erucic acid and its cleavage products, detergent additives, rubber additives, use of vegetable oils as a diesel fuel replacement etc., are some such products. Research efforts should be initiated immediately with these value added products as end points in view.

Keywords: Oilseeds; Research; Development

* Based on a talk given at the annual kharif Oilseeds Research Workers' Group Meeting on Groundnut, Sunflower, Sesame and Niger held at the UAS, Dharwad, 21-24 April, 1992

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1. INTRODUCTION

1.1 Economic development firmly rests on the tripod whose legs are the packages of technological improvements, of supporting services, and of public policies. It is rather unfortunate that the vegetable fat economy of the country is very poorly served in this regard, with the three legs weak, unequal in structure and diffuse in effectiveness. As a group charged with the responsibility of developing the technology packages, we should not only feel concerned about this but should be prepared to mount an aggressive research programme, if only to reduce the impact of deficiencies in the other two legs on the effectiveness of the technology packages evolved. With this in the back of my mind I propose to share with you some of my thoughts which I feel are relevant to the situation.

1.2 I feel I cannot begin better than posing some questions, more with the intention of initiating some debates than guiding you to the answers, which is distinctly beyond my competence.

2. SOME VITAL QUESTIONS

2.1 In the agricultural sub-sector is there a well enunciated national policy on the vegetable fat economy of the country?

2.2 How real is the deficit of edible vegetable oils in the country ? Will it be correct to say that we are deficient in utilisation but sufficient in production ? (*vide* Table 1)

2.3 Why is it in all attempts at a critical appraisal of the edible oil situation in the country by planners, administrators and oilseeds experts alike, the primary cause for the low levels of production of oilseeds is given as the relatively small area under irrigation thereby implying the ameliorative step to be the bringing more area under oilseeds under irrigation. This disregards the fact that most of the oil crops are of low water requirement and are also endowed with drought tolerant traits. We can ill afford not to exploit this. In crops like groundnut limited water stress seems to have even beneficial effects, (Rao and Williams, 1985 quoted in Bailey and Boisvert, 1991). If not oilseeds (along with millets and pulses) what other crops do these analysts have in mind for the major part of the 60% of the cultivated area in the country which can never hope to be brought under irrigation. Even though characterised by high risk uncertainities of production the cultivation of oilseeds in such areas is not only an important economic measure, but also an important equity measure (Shenoi, 1988).

2.4 Why is it that inspite of the phenomenal increase in soybean production in the country from 3.5 lakh tonnes a decade ago to 23 lakh tonnes last year, the soya processing industry is making out a case for the import of soybean seeds ?

2.5 What flexibility in operations do the research apparatuses have to adjust and modify research programmes to the fast changing oilseed production systems, regionally as for instance, the fast disappearance of the groundnut crop in Punjab, or the reemergence of sunflower as a major component of the cropping systems in the North, or nationally, the reduced dominance of groundnut from 66% in 1979-80 to 42% in 1990-91, of oilseeds produced ?

2.6 What technology was responsible to bring about a spectacular rise in the production of rapeseed-mustard from 2.61 million tonnes in 1983-84 to 6.6 million tonnes in 1991-92 with nealry a 30% per annum growth rate ?

2.7 In 1986-87 when the Technology Mission on Oilseeds was launched, the production of oilseeds was at 11.3 million tonnes. In 1990-91 the production was 19.2 million tonnes. What new technology was introduced by the Mission that brought about this increase ? Why is this gain in production so transient that in 1991-92 we are anticipating a production of only 16.8 million tonnes ?

2.8 How is it that in a high oil content crop like sunflower (some of the varieties/hybrids touching 50%) the commercial recovery of oil is reported to have fallen below 30% ?

2.9 Why is it that even after the technical feasibility has been demonstrated beyond doubt, crops like safflower in Rajasthan, or soybean in Gujarat and Bihar have failed to establish ?

2.10 Why is it in the oil crops the degree of adoption of well field-tested and proven technological recommendations, including high yielding varieties is very low (17% ?) ?

2.11 Why is it so difficult to find an export market (other than Russia) for the exportable surplus of castor oil, which under the meager input conditions it is raised in this country, should be the cheapest castor oil in the world ?

3. RESEARCH IMPERATIVES

3.1 Research work on oilseeds can be said to have commenced in 1905 when the groundnut variety 'Spanish Improved' was introduced, for cultivation in the Bombay-Karnataka region. Since then, for the past nine decades, oilseeds research has been mainly sponsored by public sector institutions like the Departments of Agriculture of the different States, the Indian Central Oilseeds Committee, adhoc schemes under the ICAR, the PIR-RCOM, All India Coordinated Project (s), and the State Agricultural Universities. Institutions in the private sector and seed companies have also been involved in a marginal way. The main thrust has been on varietal improvement with a secondary emphasis on production management research. It is difficult to precisely assess the impact of the results from these endeavours on oilseeds production which is generally pronouncedly influenced by market forces.

3.2 In groundnut, the crop most intensely researched upon among oilseeds, there has been no fundamental breakthrough of yield barrier. The variety Girnar released in 1988 did not differ in yield appreciably from AK 12-24 of TMV-2 released 40 years earlier, or from J

11 released in 1964, but marginally superior in shelling % and oil content. Likewise T.C.26 with 2846 kg/ha was only 6.8 % better than the check, or DRG 12 only 10.8% with 2772 kg/ha. This is not surprising since the groundnut crop in India, which traces its origin to a few plants introduced 300 years ago, is notoriously invariable nor is this situation unique to India. Concern has been expressed regarding the narrowness of the germplasm base of the groundnut cultivars in the USA (Hammons, 1976). Recently the situation seems to have showed signs of improvement (Knauft and Gorbet, 1989). A comparative study of the variety NC 4 released in 1944 in the USA, with NC 18423, yet to be released, after three breeding cycles spanning 50 years, indicated yield increment of 18 kg/ha/year, (Wells *et al.*, 1991). Similar comparisons have not been made with Indian materials, but if we go by reported performances, comparing the groundnut variety Spanish Improved with 2400 kg/ha of pod yield, with one released 70 years later, Dh 3-30 with 400 kg/ha of increased yield, represents an annual increment of 5.67 kg/ha. With reference to other oil crops, *the exploitations of heterosis in castor and sunflower* are worth mentioning. Understandably, researches on the formulation of management optima with high input levels of water, fertiliser and plant protection chemicals have been on the low key. On the other hand, resistance breeding programmes have been followed with considerable success. If incorporating genetic resistance to rust and wilt diseases in linseed represents the early phase, the evolution of groundnut variety Girnar with multiple resistance to diseases, the latest one. With reference to mixed, multiple and relay cropping systems, for which the oilseeds are most eminently suited, and studies have been on going for more than 50 years, we are still gropingly engaged in finding out the optimum ratios and planting times. The approach of identifying plant types with the required root systems (that compete for water and nutrients) and canopy coverage (competing for light) is yet to be adopted for research on mixed cropping. Except in crops in which hybrids have been commercialised (castor and sunflower) seed production in others is undertaken by the primary producer himself and constitute no more than the retention of the required part from the commercial harvest. The research group has not felt obliged to formulate some simple guidelines for the farmer, for this operation, which is very essential for maintaining the purity of varieties.

The above brief and sketchy account is intended more to serve as a background for what follows than to present a comprehensive account of achievements and failures of oilseeds research in this country.

3.3 Dichotomy of objectives

I am sure, research workers on oil crops, at some time or the other, have wondered whether to fix the small pockets of high production potential, or the vast areas of low and uncertain production, as the target beneficiaries of research programmes. Ideally, if resources would have permitted we would have catered for both. Such is not being the case we have ignored the distinction between the two, and have piously hoped that our research results would be applicable to both the situations. I think that the time has come to specifically plan for the two situations since the characteristics and requirements are so distinctly different. As a first step, we should recognise the dichotomy involved in planning for the two situations (Parthasarathy and Rajan, 1972). In the first case, the pockets of high production potential (which can be identified for each oil crop in the major cropping zones) can said to be charaterised by assured rainfall or adequate irrigation, capacity for the producer for investment or availability of credit, monocropped but with land utilisation of 100% or more, adequate supporting services including marketing. We can visualise the plant type that would be appropriate for this: relatively photosensitive, early maturing, compact branching or single stemmed to facilitate close or solid planting, high degree of water use efficiency and of response to fertilisers, not necessarily resistant to diseases or pests, but with a high degree of withstanding weed competition, high harvest index, a C_4 or a mix C_3 and C_4 photosynthetic pathways. The breeding end points for this would be homogenous populations of homozygotes (pure lines) or heterozygotes (hybrids). We shall call this situation an 'area of advanced agronomy' with input intensive production system.

On the other hand, we have the 'stress intensive' production system. In this the main target is not massive or even high yields, but stability of seed yields, even at average levels over a period avoiding violent fluctuations due to crop failures. The breeding end point could be a composite, synthetic or improved populations, or even mechanical varietal blends. The required plant type would be drought tolerant or resistant one, with a deep root system, open branching habit (these two traits being compatible with those of the companion crop used in the mixed cropping system), elongated flowering period to avoid early, mid- season or late season drought. High levels of disease and/or pest resistance would be required. In some situations tolerance to salinity soil conditions may be required.

It will be seen from the above that when once the dichotomous divide between the two situations is recognised as a major guiding factor in our approach, then the breeding end points, and the appropriate methodologies leading to them are logically derived. It will be obvious from the above that what I am making out is case for greater emphasis for 'ideotype breeding' in our oilseed crops. This is not, however, to suggest that breeding for 'high seed yield *per se* should be abandoned. But close to a century of this method with only a modicum of success, should alert us to the need for trying out other methods. But ideotype breeding demands a greater understanding of the physiology of the plant, in its form as well function. This aspect of research on the oil crops has been badly neglected, inspite of the AICORPO being one of the earliest of the All India Coordinated Research Projects to be provided with full fledged centres on plant physiology.

3.4 Decentralisation of research planning and programming

Even a cursory review of the technical programme of work for the AICORPO (by itself not an easy task since there exists no single document enlisting the programme), indicates the dominance of centrally planned research programme with relatively less emphasis on location-specific problems. At experimental stations that have their own on-going parallel programme, it is not unusual to find field experiments on the same theme (for example, on fertiliser requirement) side by side, one a 'Project trial' and the other a 'State trial' with similar, overlapping or different experimental variables. Stations without their own programme just accept the all India one without any adjustments or modifications to suit local requirements where necessary. This type of 'straight-jacketing' of research has already been warned against by Rao (1988) as a consequence of imposed uniformity in the name of All-India Coordination. Consequently, the results lacking in local relevance, have reduced efficiency and acceptability. For instance, one of the most important causes for low seed yield in oil crops is the 'patchy stand' of the crop at the harvest time. This could be as high as 40% of the planted area no matter how well the field is served in the matter of improved varieties, and other inputs, there can be no yield from these bald patches. The reasons for the patches could be varied, in different instances, like poor seed viability, moisture deficiency, diseases or pests, water logging etc. In each case the ameliorative step could be different and to ascertained by appropriate experimentation. The process of problem identification has, therefore, to be decentralised. For this purpose, it is suggested that a first step that the entire activity of the AICORPO be suspended for the next two kharif, rabi and summer seasons. Multi-disciplinary diagnostic teams be formed for each unit of oil cropped area of 50,000 or 100,000 hectares. These teams should visit oilseed fields as frequently as possible, and identify the problems affecting production. For the third season the teams should sit together and formulate the technical programme with appropriate emphasis on regional or local problems without enforcing uniformity for its own sake.

3.5 Oilseed crops and sustainable agricultural systems

In monocultural, input-intensive production systems of oil crops productivities tend to plateau, and cost-benefit ratios tend to taper out. Consequently, with no immediate prospect of breakthrough in seed yield ceilings, we should look for future gains in outputs to be realised mostly from rainfed production systems. Productivity gains are likely to be based more on mixed, multiple or relay cropping systems for which oil crops are eminently suitable. Breeding researches will have to be conducted, if not in its entirety, at least in the final stages, under real farm conditions. One should anticipate higher levels of genotype-environment interactions and should design appropriate experiments in the farmers' fields to quantify them. In the building up of productive populations phenomena like genetic homeostasis, populational buffering, inter genotype competition, or gene conditioning as noticed by Durrant (1962) in linseed, will become relevant. Programmes should aim at the most efficient yields (MEY), rather than maximum yield (MYR). This system also known as sustainable agricultural system, or low input sustainable (LISA) is not a return to the subsistance farming of the 30s. High yields are possible with appropriate combinations of organic farming, integrated pest/disease control and soil moisture conservation methods. All biological phenomena are under genetic control. Hence any type of production problem must have a gentic solution. But it need not be the most efficient, quickest and most economical solution. Hence a systems approach to production problems will have to be adopted. The oilseed worker should consider himself and his work as an important component, but only a component of an area-based improvement programme.

3.6 In-depth analyses of data collected

We are all now accustomed to being presented with voluminous tonnes of collected data, at the workshop meetings. It is a matter of great satisfaction that improved gadgetry and instrumentation available at the project centres has made the collection of data possible. But it is rather unfortunate that the data are not subjected to in-depth analyses. Pooled analyses of data collected over locations and seasons are not reported upon. Multilocation testing is essentially wasted if not assessed for genotype environmental interaction effects. Character associations with seed yield under various experimental conditions are not estimated through correlation analyses. Weather data collected at the experimental stations are not correlated to production parameters. Enormous amount of valuable information lies submerged in these data waiting to be ladled out by suitable statistical techniques. It is indeed a tragedy that the time and effort spent on the collection of the data, are not taken to the rewarding and logical conclusion of in-depth analyses. This should be quite feasible since all the experimental stations of the AICORPO have access to some form of electronic data processing facility.

4. THE FUTURE

4.1 I feel that the AICORPO should prepare itself with suitable research programmes to deal with situations of oilseed surpluses, in the not too distant a future. In the context of present day shortages this might sound too unrealistically optimistic. But I am fully convinced that there are no technological reasons why India should not be self sufficient, but also become a net exporter of vegetable fats and its products, not to mention the oilseed of cake export which we have already established. We have already a surplus of castor oil. In rapeseed-mustard with 6.6 million tonnes of production (equivalent to 1.98 million tonnes of mustard oil) adequate for the needs of a population of 423 million (347 m adult equivalent) of the mustard oil consuming tract at the present levels of consumption of 5.5 per person per year or 1.91 million tonnes of mustard oil, the signs of surpluses are already discernable. Since the rate of growth of production of rapeseed-mustard is much higher than the population growth rate, sizeable surpluses can be anticipated. With the reduced dominance of groundnut in the vegetable fat economy, the instability can also be expected to be reduced. In such a scenario the research group should think interms of possible exports of value added items like, fatty acids, platicizers, lecithin, erucic acids and its cleavage products, rubber additives, detergents additives, use of oils as diesel fuel replacements. Let us hope that this is not an empty dream

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Table 1. Estimated supply (realised as well as potentials) and demand of vegetable oils for the year 1991-92

production (provisional estimates for 1991-92)	
crop	Production in million tonnes
Groundnut	7.00
Rapeseed-mustard	6.00
Soybean	2.35
Sesame	0.50
Sunflower	0.60
Niger	0.22
Toria	0.45
Safflower	0.55
Total edible	17.67
Oil equivalent at 20% recovery	3.534
Castor	0.65
Linseed	0.45
Total non edible	1.10
Oil equivalent	0.275

Population (estimated for mid 1992)	
population in mid 92	863 million
64 % adult	552.32 m
adult equivalent of 36% under the age of 15 years	155.34 m
Total adult	707.66 or 708

	Oil availability (m tonnes)		*Potential*	
Source	Edible	Non edible	Edible	Non edible
Annual oilseeds	3.534	0.275		
Coconut	0.2	0.1		
Rice bran	0.3	0.1	0.4	
Solvent extracted cakes		0.25	-	0.4
Cotton seed	0.4		0.1	
Corn oil			0.1	
Total	4.434	0.725	0.6	0.4

Demands

For 708 m pop. at 5.5 kg/yr	3.894	For the soap industry	0.5 mt
Vanaspathi	1.00	paints	0.1
		lubricants	0.05
		hair oil	0.1
		exports	0.1
Total	4.894		0.85 mt

Please note that 0.1 mt of oil from tree sources not taken into account

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STUDIES ON SEED YIELD, CONTRIBUTION OF DIFFERENT BRANCHES AND OIL DEVELOPMENT PATTERN OF INDIAN MUSTARD VARIETIES AT VARYING RATES OF NITROGEN FERTILIZATION*

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ABSTRACT

Six varieties of Indian mustard (Brassica juncea, L. Czern and Coss) namely Krishna, Varuna, Vardan, Kranti, Rohini and Pusa Bold were tested at 4 N rates (0, 40, 80 and 120 kg N/ha) to assess the effect of nitrogen fertilization on yield attributes, seed yield, oil content, contribution of different branches in seed and oil yield and oil development pattern during the winter seasons of 1987-88 and 1988-89. 1000-seed weight was recorded higher in Pusa Bold during both the years, but the varieties did not differ significantly in respect of seed yield per plant. Krishna gave higher seed and oil yield in 1987-88 and Vardan during 1988-89. The oil synthesis, in general, decreased with advancement of the crop age. Vardan synthesized maximum amount of oil (40.2 per cent in 1987-88 and 40.3 per cent in 1988-89).

INTRODUCTION

Inadequate supply of nutrients, particularly nitrogen, often leads to low productivity of mustard. Application of fertilizer nitrogen in the right amount enhances the yield of mustard remarkably, as this crop is exhaustive and requires more energy (Kumar and Singh, 1989). With the development of new varieties, it also becomes imperative to study their performance at varying rates of nitrogen fertilization. Therefore, field experiments were conducted to find out the effect of nitrogen fertilization on 1000-seed weight, seed and oil yields, contribution of different branches and oil development pattern of recently developed mustard varieties.

MATERIALS AND METHODS

Field experiments were conducted at Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar, during the winter seasons of 1987-88 and 1988-89 on silty clay-loam soil. The soil in profile (0-15 cm) had a pH of 7.1, organic carbon 1.02 per cent, total nitrogen 0.087 per cent, available phosphorous 61 kg/ha, available potassium 295 kg/ha, E.C. 0.30 d s m $^{-1}$ at 25 ^{0} C and C.E.C 18 m.e./100 g of soil. Split-plot design, taking six varieties (Krishna, Varuna, Vardan, Kranti, Rohini and Pusa Bold) as main-plot treatments, and four nitrogen rates (0, 40, 80 and 120 kg N/ha) as sub-plot treatments, was followed with three replications. A uniform basal application of 20 kg P_2O_5 alongwith 20 kg K_2O/ha and 50 per cent of the N as per the treatment was made the remaining 50 per cent N was top-dressed

* Part of Ph.D. thesis by senior author

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after first irrigation. Planting was done in 45 cm rows with plant spacing maintained at 15 cm by thinning at 15 days after sowing. Seed samples for studying 1000-seed weight, seed yield per plant and oil development pattern were taken from marked rows in every plot. Oil analysis was performed using Soxhlet's extraction method. Oil yield per hectare was calculated by multiplying the seed yield with oil content.

RESULTS AND DISCUSSION

1000-seed weight

Pusa Bold recorded significantly higher 1000-seed weight during both the years, except Kranti, which was at par with Pusa Bold during 1987-88 (Table 1). With successive increase in nitrogen application 1000-seed weight increased, significantly higher value being recorded in 120 kg N/ha treatment.

Seed yield per plant

The difference among the varieties were non-significant with respect to seed yield per plant during both the years (Table 1). However, Krishna and Vardan recorded higher seed yield per plant during respective years. With successive increase in N rates seed yield per plant increased significantly, the maximum value being obtained at 120 kg N/ha.

Seed and oil yield

During 1987-88, the varieties did not differ significantly with respect to seed and oil yield but Krishna had higher yield over other varieties (Table 1). Vardan had maximum seed and oil yield during 1988-89 but remained at par with Kranti, Krishna and Varuna. The yield significantly increased with the application of 120 kg N/ha and the maximum values were obtained at 120 kg N/ha. Sharma and Kumar (1988) also reported increase in seed and oil yield of Krishna variety upto 120 kg N/ha.

Oil content

Maximum amount of oil was recorded in the seeds obtained from main shoot followed by primary branches (Table 2). Vardan had higher oil content among the different varieties tested with successive increase in the rate of nitrogen fertilization significantly lower oil content was recorded in seeds obtained from different branches and minimum values was recorded at 120 kg N/ha, during both the years. Similar trend was recorded by Gupta and Das (1973) and Khan (1980).

Protein content

Protein content was higher in Vardan during both the years (Table 1). However, it remained at par with other varieties except Rohini during 1988-89. Nitrogen application significantly increased protein content in seeds.

Contribution of different branches in oil and seed yield per plant

Variety Vardan had maximum contribution from secondary branches in oil yield among all the varieties during both the years (Table 2). Rohini had maximum contribution from main shoot and minimum from secondary branches. The contribution of main shoot in oil yield per plant decreased with the application of nitrogen, whereas the contribution of secondary branches increased primarily due to the fact that fertilization enhanced the vegetative growth.

Maximum amount of seed yield per plant was contributed by primary branches followed by secondary branches in different varieties. The contribution of main shoot in total seed yield per plant was more in Rohini and contribution of primary branches was more in Pusa Bold during 1987-88 and Krishna followed by Pusa Bold during 1988-89. The contribution of secondary branches in total seed yield per plant were highest in Vardan amongst all other varieties during both the years (Fig. 1). With the increase in nitrogen rates, contribution of main shoot declined and secondary branches increased during both the years (Fig. 2), which may be due to enhanced formation of secondary branches.

Oil development pattern

The oil development pattern, presented in Fig. 3 showed that with the advancement of the crop age, the oil content increased in the seeds. Vardan followed by Krishna, synthesized maximum amount of oil at different stages and at harvest. Kranti was superior at 95 days after sowing but at later stages Pusa Bold had higher oil content.

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Table 1. Yield and quality parameters of mustard as influenced by varieties and nitrogen rates

Treatments	1000-seed weight(g)		Seed yield/plant (g)		Seed yield (kg/ha)		Oil content (%)		oil yield (kg/ha)		protein content (%)	
	a	b	a	b	a	b	a	b	a	b	a	b
Varieties												
Krishna	4.64	4.67	11.24	10.47	1722	1218	39.8	39.7	684.2	481.0	21.0	20.7
Varuna	4.58	4.56	8.35	9.64	1528	2109	38.8	38.9	592.2	469.1	20.8	20.5
Vardan	5.63	4.63	10.25	11.11	1656	2189	40.2	40.3	664.8	515.8	21.1	21.0
Kranti	4.66	4.66	10.66	10.82	1652	1256	39.4	39.6	650.4	494.9	21.0	20.8
Rohini	4.50	4.56	7.99	9.31	1521	968	38.6	38.8	590.5	373.1	20.4	20.1
Pusa Bold	4.70	4.76	10.51	10.70	1691	1010	39.6	39.8	670.1	400.0	20.9	20.8
SEm	0.02	0.02	1.00	0.58	66	48	0.1	0.2	26.7	19.0	0.3	0.2
C.D. at 5%	0.06	0.08	N.S.	N.S.	N.S.	150	0.4	0.6	N.S.	59.8	N.S.	0.5
N rates (kg/ha)												
0	4.43	4.45	6.33	7.71	1399	687	40.2	40.5	563.2	278.4	19.6	19.5
40	4.55	4.57	8.45	9.31	1574	1069	39.7	39.8	625.2	425.7	20.6	20.2
80	4.70	4.70	10.70	11.16	1709	1320	39.1	39.2	669.5	517.2	21.5	21.1
120	4.82	4.84	13.87	13.19	1838	1557	38.6	38.6	710.3	601.9	21.9	21.7
SEm	0.01	0.005	0.26	0.11	30	21	0.02	0.03	12.1	8.6	0.05	0.06
C.D. at 5%	0.03	0.01	0.75	0.31	86	61	0.06	0.08	34.7	24.6	0.1	0.2

a = 1987-88

b = 1988-89

Table 2. Branch wise oil content (%) in seeds and per cent contribution of different branches in oil yield per plant of mustard as influenced by varieties and nitrogen rates

Treatments	Main shoot		primary branches		Secondary branches	
	a	b	a	b	a	b
Varieties						
Krishna	40.4(14.8)*	40.5(14.5)	39.7(42.5)	39.6(48.4)	39.2(42.3)	39.0(37.0)
Varuna	39.6(17.6)	39.6(14.7)	38.6(46.5)	38.7(45.3)	38.3(35.8)	38.5(39.9)
Vardan	40.8(14.1)	40.8(13.5)	40.1(46.6)	40.3(45.8)	39.6(38.8)	39.7(40.7)
Kranti	39.8(15.2)	39.9(14.5)	39.3(48.8)	39.5(46.3)	39.3(36.2)	39.4(39.3)
Rohini	39.0(18.5)	39.1(14.2)	38.5(49.3)	38.7(47.9)	38.4(32.1)	38.5(36.6)
Pusa Bold	40.1(16.3)	40.4(14.2)	39.6(49.7)	39.6(47.9)	39.1(33.7)	39.4(38.0)
SEm	0.3	0.2	0.3	0.4	0.1	0.1
C.D. at 5%	1.1	0.8	0.8	NS	0.4	0.5
N rates (kg/ha)						
0	40.7(20.5)	41.0(17.0)	40.1(51.2)	40.4(45.8)	39.7(28.3)	40.0(36.9)
40	40.2(16.7)	40.4(15.4)	39.6(48.7)	39.7(46.6)	39.2(34.3)	39.4(37.9)
80	39.7(15.8)	39.7(13.8)	39.0(47.6)	39.0(47.5)	38.7(36.8)	38.7(38.7)
120	39.1(13.6)	39.2(12.85)	38.5(44.1)	38.5(47.1)	38.2(42.2)	38.2(40.0)
SEm	0.03	0.04	0.03	0.074	0.04	0.03
C.D. at 5%	0.09	0.01	0.1	0.2	0.1	0.1

Figures in parenthesis give the per cent contribution (%) of different branches in oil yield/plant.
a - 1987-88
b - 1988-89.

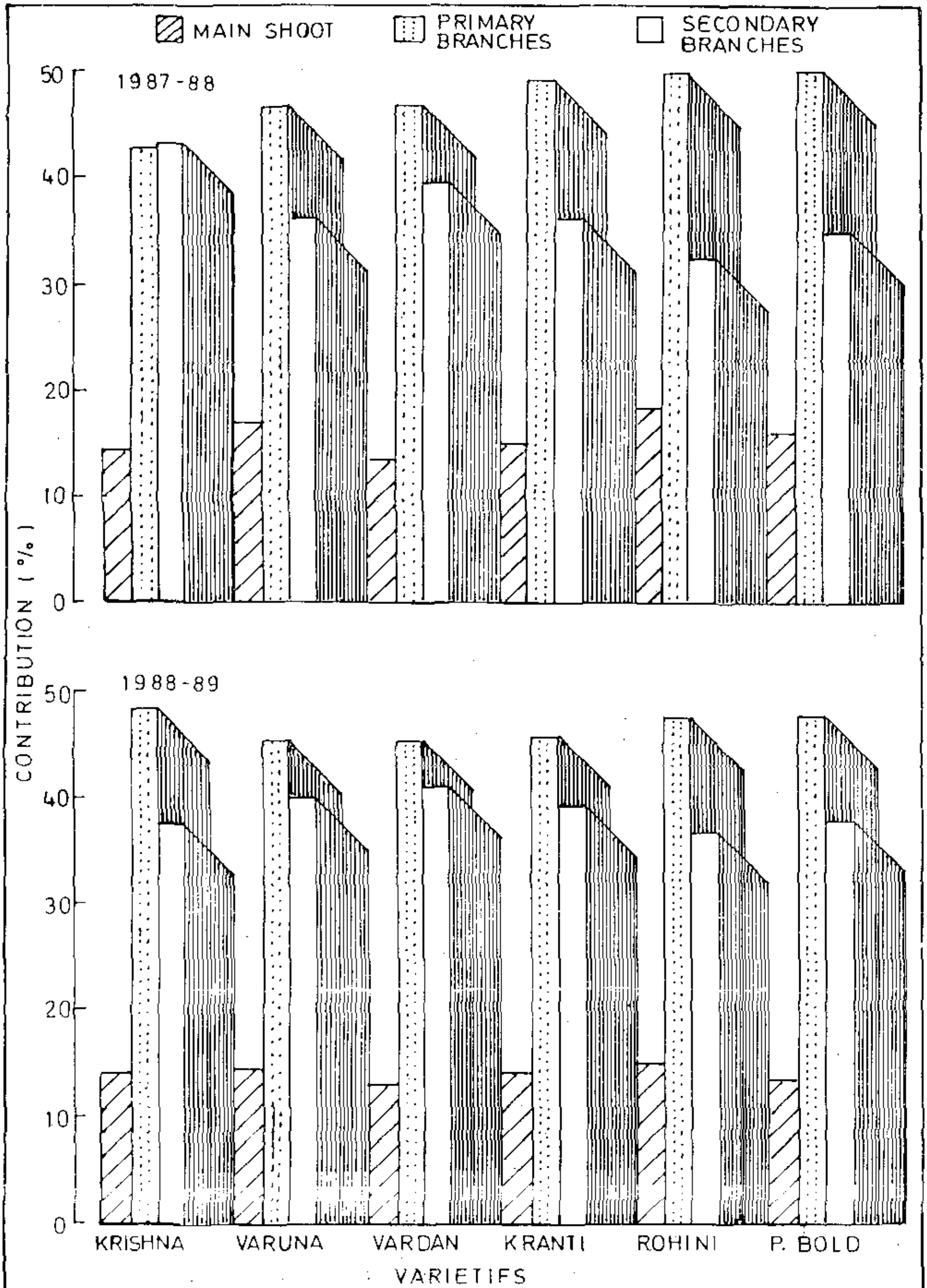

Fig. 1 CONTRIBUTION (%) OF DIFFERENT BRANCHES IN SEED YIELD PER PLANT AS INFLUENCED BY VARIETIES DURING 1987-88 AND 1988-89.

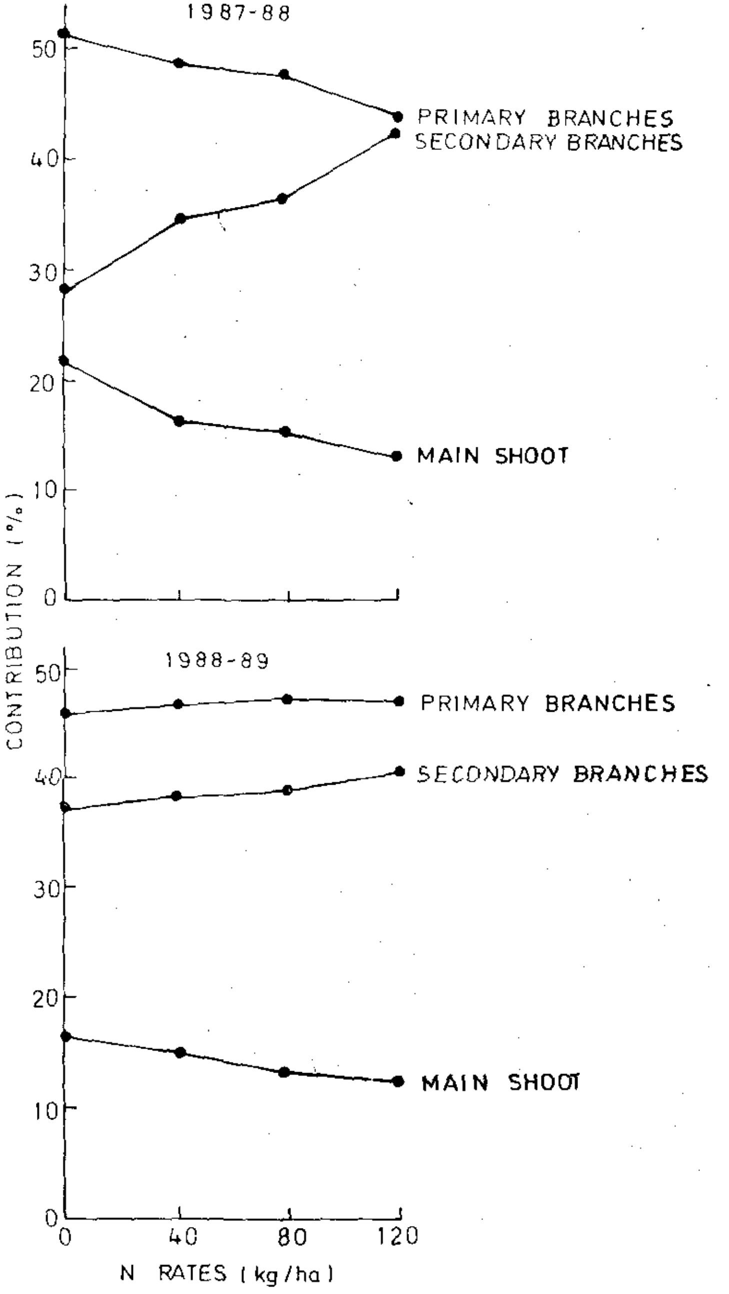

Fig-2. CONTRIBUTION (%) OF DIFFERENT BRANCHES IN SEED YIELD PER PLANT AS INFLUENCED BY NITROGEN RATES DURING 1987-88 AND 1988-89

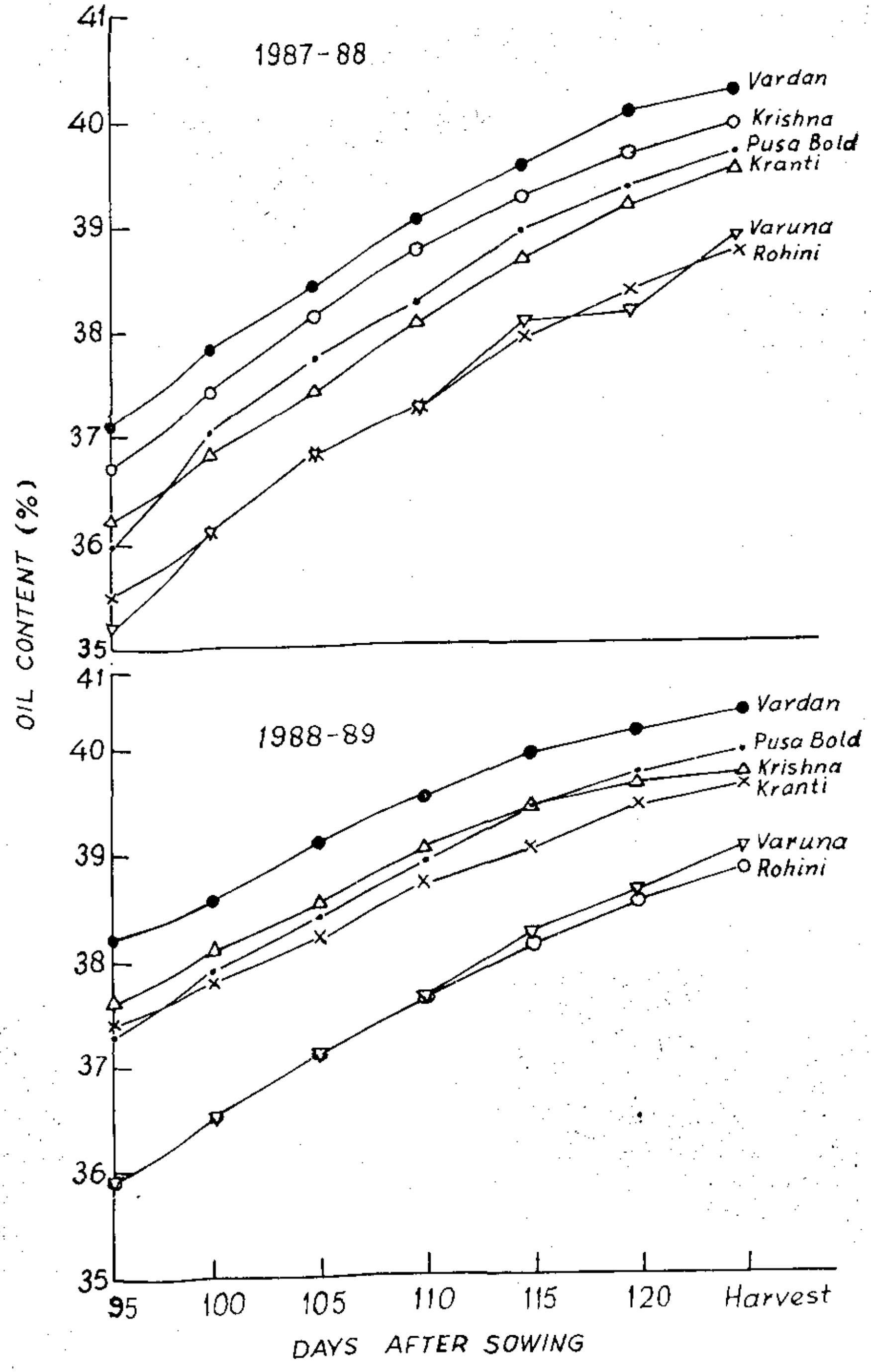

Fig. 3. OIL DEVELOPMENT PATTERN IN DIFFERENT VARIETIES DURING 1987-88 AND 1988-89.

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STUDIES ON SEQUENCE CROPPING AFTER SESAMUM AND GROUNDNUT

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ABSTRACT

Studies were undertaken during 1987, 1988 and after 1989 to find out most remunerative sequence cropping sesamum, taking safflower, sorghum, gram, sunflower, coriander and linseed as rabi crops after sesamum and groundnut. The maximum gross monetary returns (Rs.16120/ha) were obtained by groundnut - safflower sequence. However, the highest benefit cost ratio was realised by sesamum - safflower sequence. Sesamum - safflower sequence was found most remunerative than any other crop sequences studied.

Key words : Sequence cropping ; Groundnut ; Sesamum ; Gross returns; Benefit cost ratio.

INTRODUCTION

Sesamum (*Sesamum indicum* L.) and groundnut (*Arachis hypogaea* L.) are important oilseed crops grown in kharif season in Maharashtra. In Khandesh tract of the state double cropping is possible after growing early maturing varieties of these crops with rabi crops like safflower, sunflower, coriander, linseed, sorghum and gram (chick pea). Therefore, the study was undertaken, with a view to find out the most remunerative sequence cropping after sesamum and groundnut.

MATERIALS AND METHODS

A field experiment was carried out at the Oilseeds Research Station, Jalgaon (M.S.) during kharif and rabi for three years from 1987 to 1989. The soil was black having pH 7.5 which is near neutral. The experiment was conducted in a randomised block design with three replications having gross plot size 5.00 x 3.60 m net plot size 4.40 x 2.70 m. Tapi (JLT-7) and Phule Pragati (JL-24), high yielding and early maturing varieties of sesamum and groundnut respectively, were sown in the kharif seasons. The rabi crops were sorghum (M-35-1), gram (Vikas), safflower (Bhima), sunflower (Morden), coriander (Local) and linseed (S-36) sown as a succeeding crops. Twelve sequence cropping (i.e., combinations of 2 kharif and six rabi crops mentioned) were tested. Sowing was undertaken after receiving sufficient rains in kharif and after harvest of kharif crops in rabi. The dates were 26th June and 15th October during 1987, 30th June and 13th October during 1988 and 1st July and 29th September during 1989 for kharif and rabi crops respectively. All the recommended packages of practices (including recommended spacings and fertilizer doses) were followed for each kharif and rabi crops.

The rainfall received for crop growth period is presented in Table 1. Rainfall was more during 1988 (937.2 mm) as compared to rainfall of 1987 (683.4 mm) and of 1989 (673.5 mm).

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Of the total rainfall, maximum was received during August in 1987 and 1989 and in July 1988. Gross monetary returns were computed based on previous market rates of different produces.

RESULTS AND DISCUSSION

Data on seed yields of kharif and rabi crops, gross monetary returns and benefit cost ratio as influenced by different sequence croppings are presented in Table 2 and 3.

Grain yield

The yield levels of all rabi crops were more in 1988 as compared to 1987 and 1989 (Table 2). This might be due to more rainfall (937.2 mm) received during 1988, than other two seasons, and therefore sufficient residual moisture was available for rabi crop growth and stand.

Among the rabi crops tried, safflower gave more yield (928, 1894 and 923 kg/ha) in all the three seasons when sown after sesamum. The next best rabi crop was sorghum (789 and 693 kg/ha) after sesamum crop during 1987 and 1989 and by safflower (1572 kg/ha) taken after groundnut during 1988 season.

All rabi crops produced more yields when sown after sesamum than sown after groundnut. Increased yield of rabi crops were also noticed after kharif sesamum by Warsi *et al.* (1980) and Agasimani *et al.*(1984). This indicated that there is a scope for second crop after sesamum which might be perhaps due to more availability of residual moisture after sesamum. This is because sesamum is harvested within 80 to 85 days whereas Groundnut takes 90 to 95 days. Therefore, more residual moisture is available to rabi crops after sesamum than that after groundnut.

Pooled results for three years were found significant for yield. The safflower gave significantly more yield (1246 kg/ha) when sown after sesamum where as it gave an yield of 832 kg/ha when sown after groundnut than other rabi crops.

Monetary returns

The gross returns showed significant differences due to various sequence cropping in all three seasons. The benefit cost ratio of each sequence cropping varied due to yield of kharif and rabi crops and their market prices (Table 3).

The highest gross returns of Rs.19907/ha were recorded by sesamum - safflower sequence cropping followed by sesamum - sorghum (Rs.17256/ha) during 1987. However, during 1988 the sequence copping of groundnut - sorgham gave the highest gross returns of 18628/ha and groundnut - safflower was the second (Rs.17483/ha). During 1989, groundnut - safflower sequence cropping recorded the highest gross returns of Rs16801/ha and groundnut - sorghum was the second (Rs.15581/ha).

On pooling the results for three years, the differences in gross monetary returns of sequence croppings were found to be highly significant. The highest gross returns of Rs.16120/ha was recorded by groundnut - safflower sequence cropping followed by that of groundnut - sorghum (Rs.15143/ha) and sesamum - safflower (Rs.14133/ha) which were at par. However, the highest B.C. ratio (Rs. 1.68) was recorded by sesamum - safflower sequence cropping followed by the groundnut - safflower sequence cropping (Rs. 1.59). The maximum gross return (Rs.16120/ha) was obtained by groundnut - safflower sequence but has lower B.C.ratio (1.59). Similar results were also reported by Agasimani *et al.* (1984). The reason for higher gross returns obtained from groundnut - safflower sequence cropping may be due to more yield potentiality of improved groundnut variety Phule Pragati (JL-24). However, the highest B.C. ratio was seen from sesamum - safflower sequence cropping due to less cost of cultivation of sesamum crop than groundnut. The data of gross monetary returns revealed that the money values increased more substantially due to sequence cropping of safflower when sown after sesamum.

In general all rabi crops produced more yield when sown after sesamum than those sown after groundnut. The sesamum - safflower sequence cropping observed to be the most remunerative than the other sequences tested. Therefore, for getting more assured benefit by less expenditure, sesamum - safflower sequence cropping was found to be most beneficial for assured rainfall condition of Maharashtra. The sequence cropping sesamum - safflower could therefore be practised from the angle of low input sustainable agriculture.

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Table 1. Monthwise rainfall during 1987 to 1989 at Jalgaon

Month	Rainfall (mm)		
	1987	1988	1989
June	158.0 (7)*	136.7 (12)	153.4 (14)
July	73.4 (9)	374.5 (26)	155.8 (16)
August	290.2 (16)	82.6 (19)	268.1 (24)
September	06.6 (2)	298.4 (16)	89.0 (9)
October	96.0 (5)	45.0 (5)	0.8 (1)
November	46.2 (3)	-	-
December	13.0 (3)	-	6.4 (1)
Total	683.4 (45)	937.2 (78)	673.5 (65)

Figures in parenthesis indicate number of rainy days.

Table 2. Yield of sesamum and groundnut and rabi crops as influenced by various sequence cropping systems

Sr. No.	Crop sequence	Yield of kharif crops(kg/ha)				Yield of rabi crops(kg/ha)			
		1987-88	1988-89	1989-90	pooled mean	'87-88	'88-89	'89-90	pooled mean
1.	Sesamum-sorghum	1332	244	265	614	789 (1543)*	791 (4892)	693 (3025)	758 (3153)
2.	Sesamum-gram	1360	287	292	646	242	518	309	413
3.	Sesamum-safflower	1315	279	400	665	928	1894	923	1246
4	Sesamum-sunfower	1304	270	301	625	342	243	265	311
5	Sesamum-Coriander	1247	295	301	614	98	120	101	120
6	Sesamum-Linseed	1189	230	309	576	79	111	86	93
7	Groundnut-Sorghum	1220 (5174)	1240 (6240)	1544 (4657)	1332 (5357)	345 (1132)	417 (4657))	540 (3137)	434 (2975)
8	Groundnut-Gram	1566 (5780)	1234 (6369)	1389 (5600)	1396 (5916)	98	415	256	302
9	Groundnut-Safflower	1487 (5617)	1120 (7267)	1540 (4223)	1387 (5702)	301	1572	622	832
10	Groundnut-Sunflower	1533 (5473)	1164 (6060)	1598 (4820)	1431 (5451)	271	221	206	231
11	Groundnut-Coriander	1454 (5743)	1215 (7043)	1241 (4349)	1303 (5712)	78	110	88	91
12	Groundnut-Linseed	1454 (5717)	1178 (6257)	1201 (4910)	1278 (5628)	61	97	78	75
S.E ±		107	70	76	33	48	16	15	134
C.D. at 5%		314	205	222	98	141	48	43	393
C.V. %		13	17	15	-	29	5	7	-

* Figures in parenthesis are fodder/creeper yields.

Table 3. Monetary returns as influenced by various sequence cropping systems during three seasons

Sr. No.	Crop sequence	Gross monetary returns (Rs/ha)				Benefit cost ratio (Rs/ha)
		1987-88	1988-89	1989-90	Pooled mean	
1.	Sesamum - Sorghum	17256	5707	6019	9660	1..23
2	Sesamum - Gram	16397	6153	4453	8998	0.93
3	Sesamum - Saffloweer	19907	12374	10109	14133	1.68
4	Sesamum - Sunflower	16650	3763	5126	8510	0.88
5	Sesamum - Coriander	15985	4130	4992	8426	0.97
6	Sesamum - Linseed	13577	1894	3460	6318	0.83
7	Groundnut - Sorghum	11229	18628	15581	15743	1.36
8	Groundnut - Gram	13140	12643	13300	13027	1.24
9	Groudnut - Safflower	13822	17483	16801	16120	1.59
10	Groundnut - Sunflower	13931	10497	14983	13140	1.26
11	Groundnut - Coriander	13460	10455	10892	11602	1.26
12	Groundnut - Linseed	12045	7508	9203	9585	1.08
	S E±	964	809	691	2210	-
	C.D. at 5%	2827	2371	2071	6482	-
	C.V. %	11	15	12	-	-

Market rates(Rs./kg)		1987-88	1988-89	1989-90
1.	Sesamum	11.25	7.00	10.50
2	Groundnut pods-Creepers	7.00 , 0.30	6.00, 0.50	7.50, 0.30
3	Sorghum Grains-Fodder	2.30, 0.30	3.20, 0.30	3.16, 0.30
4	Gram	4.50	6.00	4.50
5	Safflower	5.50	4.30	6.40
6	Sunflower	5.75	5.75	7.40
7	Coriander	20.0	7.15	18.0
8	Linseed	2.50	2.50	2.50

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SHORT COMMUNICATIONS

CHANGES IN SEED WEIGHT, OIL AND MOISTURE CONTENT DURING DEVELOPMENT AND MATURATION OF SEEDS IN SUNFLOWER.

Maturation of seeds progress over several weeks after pollination and fertilization and get reflected in the increased weight of seeds. In oilseeds, much of the weight increase is due to accumulation of oil in the endosperm. Nevertheless, the rate of oil accumulation is not constant throughout the period of seeds maturation. Since the post anthesis assimilates primarily support the seed development and oil build up (Connor and Cawood, 1978; Saugier, 1975), it is important to understand the critical phases of seed development. Such information would be useful in optimising crop management in the post flowering phase in order to prevent losses in oil and seed yield. In the present investigation development of kernel as well as oil build up during seed development has been studied in five varieties of sunflower which included two open pollinated varieties, one hybrid and its two parental lines.

Two open pollinated varieties (EC. 68415 and Morden), one hybrid (BSH - 1) and its parents (234 B and RHA 274) were involved in this study. Large population of the above five lines were grown during kharif 1990 under irrigated conditions with uniform fertility adopting recommended cultivation package. In order to have uniformity for the climatic factors particularly temperature and humidity, the plant which flowered on the same day were tagged and sampled. The day of anthesis was taken as zeroeth day and at every five days interval the developing seeds were sampled from the two outermost peripheral rows of the capitulum. Ten heads were included for sampling for each treatment. In all, eight samples were drawn at five day intervals upto 40th day after anthesis (DAA). In the seeds sampled, the fresh weight was recorded and subsequently oven dried for three days at 55^0c to record the dry weight. The moisture percentage in freshly harvested seeds was determined on weight basis and oil content was determined in the oven dried seeds using Minispec 20 pi NMR. For each sample, moisture content, test weight of 100 seeds and oil content was determined progressively till seed maturation was completed.

The test weight increased from the day of pollination and reached its maximum around 30th day (Table 1). On the other hand moisture content progressively decreased as the maturation progressed reaching its lowest value on 40th day. It is interesting to note that process of oil accumulation started soon after pollination and fertilization. However, the peak oil build up was from 15th day onwards reaching its maximum around 30th DAA. In fact, during 15th and 30th day of seed maturation , more than 50 per cent of the oil was synthesised and after 30th day there was very little oil build up in the seeds. The trend was more or less same in all the five cultivars.

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From the data it is clear that the kernel development and oil build up in sunflower seed is more or less completed in 30 DAA which coincides with physiological maturity (Fig. 1). After seed maturation (physiological maturation) there could be reduction in test weight and oil content if the harvest of the crop is delayed.

It may be seen from the table that the mean test weight reduced from 4.16 g on 30th day to 3.68 g on 40th day. Similarly for oil content also there was a marginal reduction from 35th day to 40th day. Reduction in test weight and oil percentage could be attributed to *drawing of energy by the plant during its senescence stage from the sink as current photosynthesis* will be at low level. The high carbon and energy requirements of oil seed crops in general demand fairly high level of current photosynthesis during post anthesis stage. As current photosynthesis is mainly dependent on active leaf area available (Whitefield *et al.* 1989) ; preservation of leaf tissue in the form of healthy leaves will be a critical factor in promoting kernel weight and oil build up in developing seeds.

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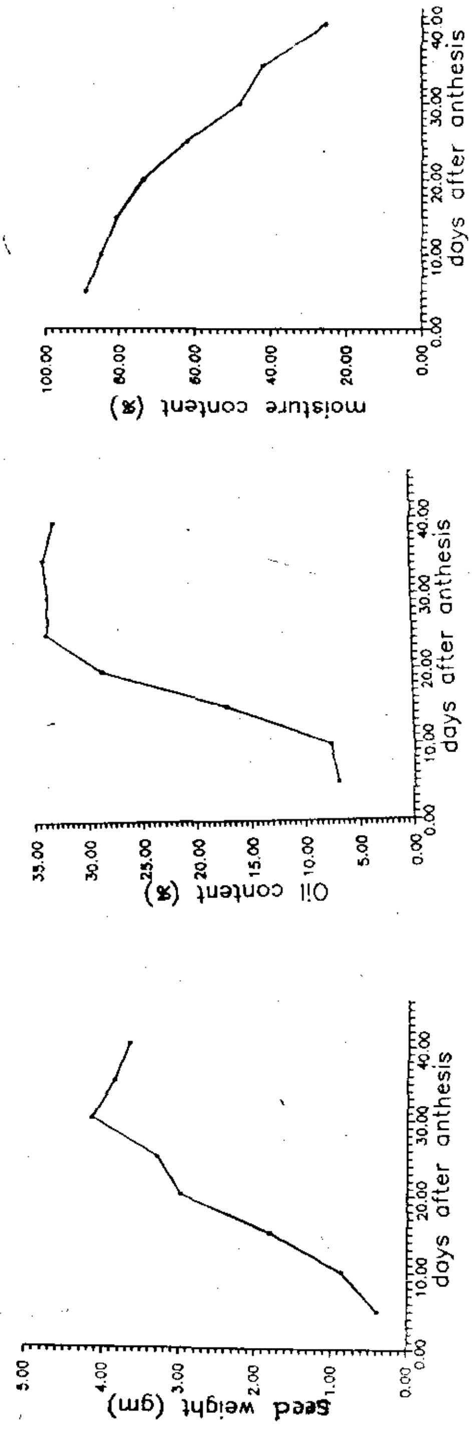

Fig 1. Mean seed weight, oil and moisture content at different days after anthesis.

Table 1. Seed weight, oil content and moisture content in different varieties at different intervals after pollination and fertilization

Days after pollination and fertilization	RHA 274	234 B	BSH 1	Morden	EC 68415	Mean
Grain weight						
5 days	0.17 (8.59)	0.48 (11.59)	0.36(8.70)	0.40(8.77)	0.58(9.67)	0.40(9.60)
10 days	0.56 (28.28)	0.88 (21.26)	1.18(28.50)	1.72(37.72)	1.38(23.00)	0.87(20.91)
15 days	0.82 (41.41)	1.96 (47.34)	2.06(49.76)	2.20(48.25)	2.00(16.67)	1.81(43.51)
20 days	1.35 (68.18)	3.36 (81.12)	2.96(71.59)	3.56(78.07)	3.70(61.67)	2.99(71.88)
25 days	1.50 (75.75)	3.44 (83.09)	3.46(83.57)	3.92(85.96)	4.20(70.00)	3.30(79.32)
30 days	1.98 (100.00)	4.14 (100.00)	4.24(100.00)	4.46(97.80)	6.00(100.00)	4.16(100.00)
35 days	1.46 (73.73)	4.14 (100.00)	3.64(87.92)	4.56(100.00)	5.50(91.67)	3.86(92.78)
40 days	1.46 (73.73)	3.86 (92.51)	3.66(88.41)	4.18(91.67)	5.22(87.00)	3.68(88.46)
Oil content						
5 days	7.00 (21.53)	7.00 (20.23)	7.50(20.68)	6.15(18.87)	7.57(21.16)	7.04(20.67)
10 days	7.30 (22.45)	7.78 (22.48)	7.50(20.68)	7.60(23.21)	8.60(23.99)	7.76(22.78)
15 days	16.75 (51.51)	12.52 (36.18)	16.70(46.04)	18.32(56.20)	21.73(60.61)	17.20(50.50)
20 days	30.12 (92.62)	25.85 (74.71)	30.92(85.25)	24.21(73.99)	32.35(90.24)	28.67(84.42)
25 days	32.52 (100.00)	34.60 (100.00)	34.40(95.40)	32.60(100.00)	35.35(98.61)	33.89(99.50)
30 days	31.78 (97.72)	34.40 (99.42)	36.13(99.61)	30.40(93.25)	35.85(100.00)	33.71(98.97)
35 days	31.80 (97.79)	34.18 (98.79)	36.27(100.00)	32.52(99.75)	35.52(99.08)	34.06(100.00)
40 days	32.50 (99.94)	32.70 (94.51)	36.06(99.42)	30.55(93.71)	-	32.95(96.74)
Moisture content						
5 days	89.00 (100.00)	89.10 (100.00)	87.40(100.00)	88.70(100.00)	90.09(100.00)	88.86(100.00)
10 days	84.00 (94.38)	85.35 (95.79)	85.30(97.60)	84.80(95.60)	84.14(93.40)	84.72(95.34)
15 days	80.60 (90.56)	85.03 (95.43)	73.38(83.96)	84.10(94.81)	80.50(89.36)	80.72(90.83)
20 days	69.00 (77.53)	70.70 (79.35)	82.10(93.39)	76.20(85.91)	69.75(77.42)	73.55(82.77)
25 days	65.86 (74.00)	54.30 (60.94)	63.04(72.13)	63.90(72.04)	62.27(69.19)	61.87(69.63)
30 days	32.38 (36.38)	51.29 (57.56)	54.50(62.35)	57.40(64.71)	54.26(60.23)	47.97(53.98)
35 days	19.90 (22.34)	52.60 (59.03)	35.27(40.35)	54.50(61.44)	47.54(52.73)	41.96(47.22)
40 days	17.10 (19.21)	25.90 (29.07)	24.78(28.35)	27.40(30.89)	32.19(35.73)	25.47(28.66)

Values in parenthesis are relative percentages

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RESPONSE OF SOYBEAN CULTIVARS TO ROW SPACINGS DURING RABI SEASON

Soybean is gaining importance due to its high oil and protein contents. Production practices have already been developed and recommended both for irrigated and rainfed conditions for kharif cultivation. However, much information on cultivation aspects of the crop during rabi season is not available. Halwankar *et al.* (1989) has reported that soybean could be grown profitably during rabi season. Therefore, the present investigation was carried out to evaluate the performance of soybean cultivars during rabi season (1989-90) under rainfed situation at College of Agriculture, Dharwad.

Three soybean cultivars *viz.*, Hardy, KHSB-2 and Monetta were tested at three row spacings (45, 30, and 22.5 cm with 10 cm intra-row spacing) in a factorial randomized block design with four replications. The gross plot size was 3.6 x 3.0 m and the net plot size were 2.70 x 2.80 m, 3.00 x 2.80 m and 3.15 x 2.80 m, respectively for 45, 30 and 22.5 cm row spacings. The soil of the experimental site was medium black (52.5 % clay) with pH 7.5. The total nitrogen, available phosphorus and available potassium were 0.052, 0.004 and 0.025 per cent, , respectively. A basal dose of 37.5:50:37.5 kg/ha N, P_2O_5 and K_2O were applied at the time of sowing. Soybean was sown on 30.9.1989. A rainfall of 142.2 mm was received during the cropping season in nine rainy days. The rainfall was not well spread over but good rains were received during September (82.9 mm) and November (44.4 mm) coinciding with sowing and flowering stages, respectively. Cultivars varied in their maturity period. Monetta was the earliest to mature which was harvested after 67 days of sowing. Other cultivars took more time for physiological maturity and were harvested after 104 days of sowing.

The soybean cultivars differed significantly in their yielding ability (Table 1). Among the three cultivars KHSB-2 produced significantly highest seed yield of 869 kg/ha. This was followed by Hardy with 745 kg/ha. The higher yield in these cultivars could be attributed to the duration, prolonged vegetative phase *viz.*, plant height, and total dry matter production/plant, number of pods/plant, seed weight/plant and test weight. Monetta, which recorded reduced plant height, dry matter, number of pods, seed weight/plant and test weight produced the lowest grain yield (293 kg/ha) may be attributed to shorter duration with smaller seeds (8.75 g/100 seeds) than that of either KHSB-2 cf Hardy. Hardy produced the boldest grains (14.21 g/100 seeds) of all.

The row spacings also showed significant influence on the seed yield, closest row spacing (22.5 cm rows) has recorded higher grain yield than widest row spacing (45 cm). The increased yield in close row spacing could be attributed solely to increased population level as the yield components did not show significant variation due to variation in row spacings except in seed yield/plant which was predictably and significantly highest in wider row spacings.

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Thus it is clear from the study that the soybean cultivars that normally take more time for maturity perform better than those maturing early. Further, the reduced plant growth provides an opportunity for increasing plant density by reducing row spacing to increase seed yield.

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Table 1. Yield and yield components of soybean as influenced by cultivars and row spacing during rabi season

Treatment	Duration (days)	Plant height at maturity (cm)	Total dry matter/plant (g)	Number of pods/plant	Seed weight/plant (g)	100 seed weight (g)	Seed yield (kg/ha)	Seed yield (kg/day0	Harvest Index
Cultivars									
Hardy	104	22.00	9.27 a	20.66	4.00 a	14.21	745	7.16	0.45
KHSB-2	104	27.70	9.11 a	23.21	4.23 a	11.40	869	8.36	0.45
Monetta	67	13.85	3.01	8.28	1.40 b	8.75	293	4.37	0.47
S Em ±		0.92	0.28	0.81	0.15	0.22	29		0.02
C.D. at 5%		2.82	0.86	2.50	0.45	0.67	89		NS
Row spacing									
45		20.76	7.23	17.88	3.70 a	11.67	574 b		0.44
30		21.18	7.45	17.60	2.98 b	11.51	648 ab		0.50
22.50		21.62	6.72	16.66	2.95 b	11.18	685 a		0.43
S Em ±		0.92	0.28	0.81	0.15	0.22	29		0.02
C.D. at 5%		NS	NS	NS	0.45	NS	89		NS

Note : Interaction effects were non-significant

NS = Not significant

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EFFECT OF DIFFERENT STAGES OF SEED ON DRY POD YIELD IN GROUNDNUT Cv. PHULE PRAGATI (JL-24)

Low yields of groundnut (*Arachis hypogaea* L.) could be partly attributed to lack of good quality seeds of the recommended varieties. Considering its self-pollinated nature, doubts were expressed often with regards to the existence of clear cut difference in the quality of seeds of different stages produced in the seed production chain (AICORPO, 1989) and suggestions were made for the reduction of the numbers of steps and stages in the groundnut seed production. In view of the paucity of literature on impact of groundnut seed of different stages on yield of dry pod, an attempt was made to find out the differences in pod yield among the seeds of different stages, considering the questions often raised as to the superiority of the certified seed over the farmer's seed/truthfully labelled seed.

An experiment with four treatments viz. breeder's, certified, truthful and farmer's seed of Phule Pragati (JL-24) of groundnut, was laid out in kharif season for three successive year i.e.1987 to 1989, in a randomized block design replicated six times. The kernels were hand dibbled at a spacing of 30 x 15 cm. A basal dose of 20 kgN and 40 kg P_2O_5/ha was applied to soil in the form of diammonium phosphate. The gross and net plot size were 3.00 x 5.00 m and 2.40 x 4.40 m respectively. The soil of the experimental field was medium black with pH 7.8, 20025 kg/ha available nitrogen 12.76 kg/ha P_2O_5 and 666.24 kg/ha K_2O. The recommended schedule of pest and disease management were followed regularly. The yield data on dry pod were recorded from the net plot. The data were pooled over seasons as per the procedure laid down by the Sukhatme and Amble (1985) and Snedecor and Cochran (1967).

The data pertaining to dry pod yield as influenced by different treatments are presented in Table 1. The differences due to breeder's, certified, truthful and farmer's seed were statistically not significant for dry pod yields. The breeder's seed gave the highest pod yield (20.86 per cent over farmer's seed) in all the three years followed by certified, truthful and farmer's seed except during the year 1987 where the farmer's seed gave more dry pod yield than the truthful seed; one reason could be that in a drought year charcaterised by moisture stress, the variability/heterogenosity available in the farmer's seed could have been of advantage, unlike in the case of more uniform, homogenous population of the other categories of seed. Thus, it is indicated that there were differences in yields due to seed of different stages although, they were not significant as reported in the other crops like safflower tested at Indore, Phalthan and Solapur only for one year (AICORPO, 1988). However, the results obtained at Jalgaon was non-significant for seed yield (AICORPO, 1988). The similar trend of dry pod yield of groundnut was also noticed at Dharwad (TMV-2) and Ludhiana (M-37), but the differences were not significant. Similar studies were also carried out at Vridhachalam (0.1) and Junagadh (JL-24) and it was found that the breeder's seed produced significantly higher dry pod yield (AICORPO, 1989). Contrary to this, Kher *et al.* (1983) reported higher seed yield of foundation stage than breeder's seed in alfalfa.

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Table 1. Pooled data of dry pod yield (kg/ha) as influenced by various categories of seed

S. No.	Year	Breeder seed	Certified seed	Truthful seed	Farmers' seed	S E ± kg/ha	C.D. at 5%	C V %
1.	1987	1282	1132	1176	1190	48.84	N.S	29.69
2.	1988	2300	2185	2184	2080	90.61	N.S	54
3.	1989	1127	1113	1104	1103	80.11	N.S	17.72
WTD Pooled Mean		2190	2050	1881	1812	311	N.S	-
Per cent increase over farmers' seeds		20.86	13.14	3.81	-	-	-	-

From the above it could be concluded that use of breeder seed gave higher dry pod yield.

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INFLUENCE OF IRRIGATION ON THE COMPOSITION AND QUALITY OF GROUNDNUT GENOTYPES

Groundnut (*Arachis hypogaea* L.) is an important source of vegetable oil of high quality and utilised for edible purposes. The four botanical groups of groundnut viz., *Virginia* runner, *Virginia* bunch, *Valencia* and *Spanish* bunch differ with respect to their chemical composition and oil quality (Nagaraj, 1988) and *Virginia* runner have been considered to be better with respect to their oil quality (Nagaraj, 1990). The present investigation was carried out to know the biochemical components of groundnut seeds of different cultivars belonging to various genotypes under delayed sowings and moisture stress conditions.

An experiment was conducted during the kharif season of 1987 on red sandy loams of College of Agriculture, Hyderabad. The experiment was laid out in a split-split plot design with plot size of 12 m^2 and the treatments were replicated thrice. The two main treatments of irrigation comprised I_0 (no irrigation) and I_1 (irrigated at IW/CPE ratio of 0.8), when the pan evaporation reached 6 cm an irrigation of 5 cm was given using parshall flume. The sub-treatments consisted of four cultivars, V1 : Gangapuri (*Valencia* 0, V2: JL 24 *(Spanish)*, V3: Kadiri 3 (*Virginia* bunch) and V4: M 13 (*Virginia* runner). Sub-sub treatments were dates of sowing (D_1: 19-6-87, D_2 : 14-7-87 and D_3 : 8-8-1987).

Oil content was estimated by nuclear magnetic resonance spectrometry (Jambunatham *et al.*, 1988). Protein content was estimated by multiplying nitrogen content (obtained by Technicon Auto Analyser) with factor 6.25. Fatty acid composition was determined by Gas chromatography. Iodine value was estimated as per A.O.A.C. official method ed. 1.25.

The effects of irrigation and dates of sowing on 100-kernel weight, oil, protein contents, fatty acid composition and Iodine value are presented in Tables 1 and 2.

The kernel-100 weight is more in irrigated crop over rainfed crop in kharif season. Mehrotra *et al.,* (1968) stated that irrigation increased 100-kernel weight and extra large kernels significantly. However, with delay in sowing the 100-kernel weight was reduced in rainfed as well irrigated conditions. Among the cultivars 100-kernel weight was highest with cultivar Kadiri- 3 followed by M 13, JL 24, and least in Gangapuri.

Protein and oil contents were more with irrigated crop than rainfed crop in kharif season. Significantly higher protein yields were obtained by scheduling irrigation at 0.8 IW/CPE ratio (Birajdar *et al.*, 1979). Adverse effects of moisture stress during flowering to last pod set were highlighted by Sarma (1983) on seed filling protein and oil content. With delay in sowing, there was increase in protein content and decrease in oil content. In groundnut, there was a negative correlation between protein and oil contents (Hung, 1975 and Rao and Rao, 1981). Soluble sugars were more with rainfed crop than irrigated crop. Among the genotypes Gangapuri recorded the highest oil content and JL 24 the highest protein content in rainfed conditions. While in irrigated conditions, M 13 recorded the

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highest oil content and Gangapuri the highest protein content. In both the conditions M 13 recorded highest soluble sugars and JL 24 the least. Nagaraj (1990) also observed more soluble sugars with Virginia runners and more protein content with Valencia.

Oleic acid is more in seed oil of irrigated crop and Linoleic acid in seed oil of unirrigated crop. There is a negative correlation between the percentage of Oleic acid and linoleic acids, since linoleic acid is produced from the conversion of oleic acid. Of all the fatty acids, oleic and linoleic acids together make up 75 -80% of total ranging from 36 - 80% and from 2 - 43% respectively. Since seed of most peanut cultivars are composed of approximately 50 per cent, oil quality of peanut product can be greatly effected by oil stability (Worthington and Hammons, 1971). Oil stability Index and the Nutritional quality Index were high in respect of the irrigated crop indicating that the keeping quality of groundnut seeds produced under irrigated conditions is good. With the delay in sowing, there was decrease in oleic acid and increase in linoleic acid in rainfed as well as irrigated conditions of kharif season and so the O/L ratio decreased with delay in sowing indicating that the seed oil of June sowing is more stable than seed oil of July and August sowings. Among the cultivars the linoleic acid was more with Kadiri 3 and oleic acid with M 13 in all the treatmental combinations. So the seed oil of cv. M 13 is more stable compared with other cultivars.

The Iodine values which provide measure of the degree of oil unsaturation, has been commonly used as a means of predicting shelf-life. Iodine value increased with delay in sowing and was highest for cv. Kadiri 3 and lowest for cv. M 13, indicating more shelf-life of M 13. The Iodine value of Kadiri 3 was high in both rainfed as well as irrigated conditions.

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Table 1. Composition and oil quality of groundnut genotypes in irrigated (I_1) and rainfed (I_0) of kharif

Character	Cultivars							
	M 13		Kadiri 3		JL 24		Gangapuri	
	I0	I1	I0	I1	I0	I1	I0	I1
Pod yield (q/ha)	18.9	29.0	26.9	38.0	18.7	24.5	16.4	23.4
100-kernel weight	13.3	22.9	16.8	21.9	14.1	20.3	12.1	17.9
Whole seed (Per cent)								
Oil	42.3	46.1	42.5	44.7	45.0	45.8	44.1	45.2
Protien	29.1	27.5	29.8	32.0	33.6	32.6	31.7	33.2
Soluble sugars	10.2	9.8	9.1	8.5	7.2	6.8	7.3	6.9
Oil quality (Per cent)								
Palmitic (16.0)	11.9	11.2	13.0	12.7	13.5	13.0	11.9	11.9
Stearic (18.0)	2.7	2.6	2.1	2.1	3.3	3.1	3.4	3.3
Arachidic (20:0)	1.5	1.4	1.4	1.4	1.6	1.6	1.8	1.8
Behenic (22:0))	3.4	3.4	3.8	3.6	4.0	3.5	3.8	3.8
Lignoceric (24:0)	1.8	1.7	2.3	2.2	1.9	1.8	1.8	1.9
Oleic (18:1)	44.6	48.7	36.3	37.7	34.8	37.6	38.8	36.9
Linoleic (18:2)	32.6	29.1	39.0	38.2	35.7	37.5	36.5	38.7
Eicosenisc (20:1)	1.5	1.4	1.6	1.5	1.7	1.1	1.5	1.2
Iodine value	100.2	96.3	106.5	104.0	98.8	103.5	100.3	104.2
Oil stability Index (18:1/18:2)	1.37	1.67	0.93	0.99	0.97	1.0	1.06	0.95
Nutritional quality Index 18:2/Sat.fatty acids	1.53	1.43	1.73	1.74	1.47	1.63	1.61	1.70

Table 2. Composition and quality of groundnut oil under different dates of sowing in irrigated and rainfed conditions of kharif

Character	Rainfed			Irrigated		
	D_1	D_2	D_3	D_1	D_2	D_3
Pod yield (q/ha)	25.5	19.5	15.6	35.3	27.9	23.0
100-kernel weight	15.9	13.8	12.6	24.6	19.9	17.8
Whole seed (Per cent)						
Oil	45.1	43.4	42.0	47.1	45.4	43.8
Protien	29.3	31.0	32.8	28.3	31.2	34.4
Oil quality (Per cent)						
Palmitic (16.0)	13.5	11.7	12.8	12.4	12.3	13.0
Stearic (18.0)	2.5	2.3	3.0	2.4	2.8	3.1
Arachidic (20:0)	1.5	1.4	1.6	1.5	1.6	1.6
Behenic (22:0))	3.9	3.8	3.6	3.6	3.6	3.5
Lignoceric (24:0)	2.1	2.1	1.9	2.0	1.9	1.9
Oleic (18:1)	37.2	33.4	33.4	41.4	40.4	40.2
Linoleic (18:2)	37.3	38.6	42.6	35.0	35.2	36.0
Eicosenisc (20:1)	1.4	1.6	1.4	1.4	1.3	1.6
Iodine value	98.9	101.8	103.2	98.9	103.3	104.1
Oil stability Index (18:1/18:2)	1.0	0.87	0.78	1.18	1.15	1.12
Nutritional quality Index 18:2/Sat.fatty acids	1.59	1.81	1.86	1.60	1.59	1.55

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EFFECT OF SEASONS AND DATES OF SOWING ON THE COMPOSITION AND QUALITY OF GROUNDNUT GENOTYPES

Groundnut is an important edible oilseed of semi-arid tropics. The four botanical groups of groundnut viz., *Virginia* runner, *Virginia* bunch, *Valencia* and *Spanish* bunch are under cultivation. They differ with respect to their chemical composition and oil quality (Nagaraj, 1990). Further it was reported that *Virginia* bunch is rich in oil and energy content followed by *Spanish* bunch (Nagaraj, 1988). Whereas protein content was high among *Valencias*. With respect to oil keeping quality (Oleic/linoleic ratio) runner type was better while *Valencias* possessed a higher nutritional quality index (linoleic/saturated fatty acids). Hence, Virginia runners have been considered to be better with respect to their old quality (Nagaraj, 1990). However, documented information on the effect of delay in sowing and seasons on biochemical composition of various groundnut genotypes is scanty. In view of this, the pattern of biochemical components of groundnut seeds in different cultivars belonging to various genotypes under different treatmental conditions subjected, was aimed at and carried out during the present investigation.

Two field experiments, one kharif, 1987 and the other in rabi, 1987-88 were conducted on red sandy loams of College of Agriculture, Hyderabad. The experiment was laid out in split plot design with three replications. The size of the plot was 12 m^2. The main treatments were four cultivars viz., V_1: Gangapuri (*Valencia*), V_2 : JL 24 *(Spanish)*, V_3 : Kadiri-3 (*Virginia* bunch), and V_4 : M 13 (*Virginia* runner). Sub-treatments were three dates of sowing (D_1 : 19-6-87, D_2 : 14-7-87 and D_3 : 8-8-1987 in kharif and D_1 : 25-10-87, D_2 : 19-11-87 and D_3 : 14-12-1987 in rabi).

Oil content was estimated by nuclear magnetic resonance spectrometry (Jambunathan *et al*., 1985). Protein content was estimated by multiplying nitrogen content (obtained by Technicon Auto Analyser) with factor 6.25. Fatty acid composition was determined by Gas Chromatography. Iodine value was estimated as per A.O.A.C, official method cd 1.25.

The effects of dates of sowing and season on various characters were presented in Table, 1 and 2.

Among the genotypes M 13 (*Virginia* runner) recorded the highest oil content and soluble sugars and Gangapuri, a *Valencia* cultivar recorded the highest protein content in both the seasons. Nagaraj (1990) also observed more soluble sugars with Virginia runner and more protein content with *Valencia*. Oleic acid is more in seed oil of M 13 for the both kharif and rabi crops. Whereas, the linoleic acid is more in the seed oil of Kadiri-3. In general, Palmitic, Behenic and Linoleic acids were more in kharif season and stearic Arachidic and Oleic acids were more in rabi season. While other acids were more or less same in both the seasons. In both the seasons, Iodine value was lowest and oil stability index was highest in M 13 compared to other cultivars, which indicates the keeping quality of groundnut cultivars.

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In both the seasons with delay in sowing, the 100-kernel weight was reduced. 100-kernel weight was the highest for the crop sown in the fourth week of October and the lowest for the crop sown in first week of August. It is not surprising since the cloudy weather in kharif season does not contribute to the high rate of photosynthesis as in rabi season. The crop duration was also longer for rabi crop than kharif crop which could be another contributing factor. The reason for decrease in 100-kernel weight in rabi, with the delay in sowing might be due to higher temperatures that the late sown crop faced during pod filling.

In kharif season with delay in sowing there was increase in protein content and decrease in oil content and vice versa in rabi. Such inverse trends between the protein content and oil content was also observed by several workers (Hung, 1975 and Rao and Rao, 1981). Protein content is more in the crop sown in October and oil content for the crop sown in first fortnight of December. Bhattacharya *et al.*, (1982) observed the highest oil content in sunflower with the crop sown in November fourth week. Oleic acid was more with the late sown crop and linoleic acid with early sown crop in rabi season. Such trend was not seen in kharif season. Oil stability index decreased with delay in sowing in kharif, whereas, oil stability index increased and nutritional quality index decreased with delay in sowing in rabi season. Iodine value decreased with delay in sowing in both the seasons. Gupta *et al.*, (1983) observed decrease in Iodine value with delay in sowing.

From the present studies, it can be concluded that, for oleic acid-rich groundnut seed oil, groundnut crop should be sown in rabi season and for linoleic acid rich oil in kharif season. Within the kharif season , August sowing resulted in seed with more linoleic acid and June sowing resulted in seed with more oleic acid. While in rabi season December and October sowings exhibited high linoleic acid and oleic acid in seeds respectively. The oil stability index is significantly more when sown in December (1.39) compared to other dates of sowing, which may be attributed to high temperatures prevailing during its seed maturation period.

Among the varieties *Virginia* runner has 10.7 and 12.7 per cent more oleic acid than the other varieties, whereas, the bunch varieties contained 8.4 and 10.2 per cent more linoleic acid in kharif and rabi seasons, respectively. Oil stability index (O/L ratio) was highest and Iodine value was lowest for M 13 indicating more stability and keeping quality of the oil. While oil stability of Kadiri 3 is low and Iodine value is high indicating poor quality of the oil.

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Character	M 13		Kadiri 3		JL 24		Gangapuri	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
Whole seed (Per cent)								
Oil	46.1	47.6	44.7	46.4	45.8	**45.0**	45.2	44.6
Protien	27.5	32.6	32.0	31.9	32.6	**35.2**	33.2	36.9
Soluble sugars	9.8	7.7	**8.5**	6.5	6.8	**5.0**	6.9	5.1
Oil quality (Per cent)								
Palmitic (16:0)	11.2	10.2	12.7	11.9	13.0	12.4	11.9	11.0
Stearic (18:0)	2.6	2.9	**2.1**	2.5	3.1	**3.6**	3.3	3.4
Arachidic (20:0)	1.4	1.5	**1.4**	1.5	1.6	**1.8**	1.8	1.7
Behenic (22:0))	3.4	3.1	**3.6**	3.3	3.5	**3.4**	3.8	3.5
Lignoceric (24:0)	1.7	1.7	**2.2**	1.9	1.8	**1.8**	1.9	1.8
Oleic (18:1)	48.7	51.6	37.7	38.1	37.6	**38.3**	38.7	40.1
Linoleic (18:2)	29.1	27.0	38.2	38.8	37.5	36.1	36.8	36.5
Eicosensic (20:1)	1.4	1.5	**1.5**	1.5	1.1	**1.1**	1.2	1.3
Iodine value	96.3	96.3	104.0	104.0	103.5	103.5	104.2	104.0
Oil stability Index (18:1/18:2)	1.7	1.9	**1.0**	1.0	1.0	**1.0**	1.0	1.1
Nutritional quality Index 18:2/Sat.fatty acids	1.4		**1.7**		1.6		**1.6**	

Table 2. Composition and oil quality of groundnut under different dates of sowing in kharif and rabi seasons

Character	Kharif			Rabi		
	D1	D2	D3	D1	D2	D3
Pod yield (q/ha)	35.3	27.9	23.0	56.1	38.4	25.0
Oil yield (q/ha)	11.2	7.8	5.8	19.9	12.3	7.3
100-kernel weight (%))	66.8	61.4	57.2	79.4	70.2	62.1
Protein per cent in kernel	28.3	31.2	34.4	35.8	34.5	32.2
Oil per cent in kernel	47.1	45.4	43.8	44.8	45.6	47.2
Oil quality (Per cent)						
Palmitic (16:0)	12.3	12.2	12.0	11.0	11.7	11.6
Stearic (18:0)	2.4	2.8	3.1	2.9	3.3	3.1
Arachidic (20:0)	1.5	1.6	1.6	1.6	1.7	1.6
Behenic (22:0))	3.6	3.6	3.5	3.5	3.2	3.2
Lignoceric (24:0)	2.0	1.9	1.9	1.9	1.6	1.8
Oleic (18:1)	41.3	40.4	42.6	40.0	41.9	44.2
Linoleic (18:2)	35.0	35.2	36.0	37.2	35.0	31.7
Eicosensic (20:1)	1.3	1.6	1.3	1.5	1.3	1.2
Iodine value	104.1	103.3	98.9	102.9	101.2	97.6
Oil stability Index (18:1/18:2)	1.18	1.15	1.12	1.08	1.20	1.39
Nutritional quality Index 18:2/Sat.fatty acids	1.6	1.59	1.63	1.77	1.65	1.48

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HETEROSIS IN RELATION TO GENETIC DIVERGENCE IN RAPESEED AND MUSTARD

In heterosis breeding programme the choice of parents on the basis of their genetic divergence has been proved useful by many workers (Murty and Tiwari, 1967; Singh and Gupta, 1968; Moll and Stuber, 1974). But, there are many cases where higher magnitude of heterosis is not always directly relate to extreme parental diversity (Arunachalam and Bandopadhya, 1986; Arunachalam *et al.*, 1984; Thakur and Zarger, 1989). The present study was therefore undertaken to know the relationship of heterosis and genetic diversity among five genotypes of rapeseed (*Brassica campestris* L.) and six for mustard (*B. juncea* L. Czern & Coss).

Genotypes of each species along with their F_1s (excluding reciprocals) were grown seperately in RBD plots with three replications. Observations were recorded on 12 characters (Table 1). The genetic divergence was computed in terms of euclidean distance coefficient (djk) using hierarchical cluster analysis (Arkley, 1976; Sokal and Sneath, 1963).

Cross combinations in genotypes having medium djk values (ranging from 2.521 to 7.794) exhibited positive and significant heterosis for most of the characters in rapeseed but, in mustard heterosis for seed yield was observed positive and significant in all the cross combinations with no matter which genotypes in combinations are related with high or low djk values (Table 1). Interestingly, in mustard, cross combinations having low degree of divergence (white glossy mut. x pusabold; RW29-6 x pusabold) exhibited more heterosis for seed yield/plant and 1000-seed weight. However, combinations with medium range of djk values showed positive and significant heterosis for seed yield and some of its components. Falconer (1960) mentioned that heterosis is a function of genomic diversity but it depends on the availability of optimum environment and the extent to internal cancellation of various components responsible for the expression of heterosis. In the present study, high heterosis in cross combinations of genotypes of low djk value may be due to the fact of cancellation effect of the mean of one character by the mean of other character(s), as djk is calculated on the basis of mean of a particular character. Therefore, dissimilarity/diversity between genotypes is not always positively associated with the heterosis. The same result was also obtained by Singh and Ramanujam (1981) in chickpea, however, Ramanujam *et al.*, (1974) observed a good agreement between the amount of heterosis and genetic distance in mungbean. Although hybrid vigour has been utilized for over five decades, but its basis is not completely understood. Notani (1989) mentioned that heterosis is due to the contribution of some heterotic loci in the dominant form by one parent and the rest are provided by the other parent.

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Table 1. Relationship between genetic diversity and heterosis (MP)

(Rapeseed)

Parent	Parent	djk value	No. of pri. branches/plant	No. of Sec. branches/plant	Plant height	Days to flower initiation	Days to 50% flowering	No of siliquas per plant
1	2	3	4	5	6	7	8	9
YSB -11	YSB 19-7-C	0.171	4.918**	-4.000**	5.524	0.345	-0.498	-18.943
YSB -11	Tori-TSC-3	4.337	8.695**	29.515**	-3.815	4.382**	4.058**	-37.086*
YSB -11	YSB-9	2.521	6.527**	17.212**	-1.428	2.719*	3.113**	-25.483
YSB -11	NC-1	7.623	52.844**	95.019**	-2.904	3.952**	4.287**	5.115
YSB 19-7-C	Tori-TSC-3	4.503	38.407**	162.335**	12.404*	-1.219	-0.839	-37.361*
YSB 19-7-C	YSB-9	2.350	14.797**	-38.545**	9.311	1.698	2.284*	-8.914
YSB 19-7-C	NC-1	7.794	13.905**	50.243**	20.397**	0.169	0.817	70.898**
Tori-TSC-3	YSB-9	6.858	34.726**	12.571**	7.341	0.171	0.831	5.044
Tori-TSC-3	NC-1	3.286	2.022**	58.858**	-1.213	-0.684	-0.675	-29.380
YSB-9	NC-1	10.144	44.129**	3.166**	6.142	0.513	0.809	-9.407

(Rapeseed contd...)

(Rapeseed contd...)

Parent	Parent	djk value	Siliqua length	No. of seeds/siliqua	Seed yield/plant	Harvest index	Biological yield/plant	1000-seed weight
1	2	3	10	11	12	13	14	15
YSB -11	YSB 19-7-C	0.171	-7.706**	33.559**	3.154**	-33.697**	50.236**	-1.886**
YSB -11	Tori-TSC-3	4.337	-35.596**	-61.731**	35.454**	-12.189**	54.360**	0.000
YSB -11	YSB-9	2.521	12.347**	28.931**	17.647**	-1.600**	19.074**	0.000
YSB -11	NC-1	7.623	-8.824**	37.673**	2.290**	-51.109**	91.388*	4.166**
YSB 19-7-C	Tori-TSC-3	4.503	5.768**	26.459**	-10.092**	-29.075**	24.401**	-5.660**
YSB 19-7-C	YSB-9	2.350	-13.968**	26.596**	34.752**	16.545**	13.738**	13.207**
YSB 19-7-C	NC-1	7.794	-1.987**	31.625**	-1.205*	-27.822**	10.169**	-1.961**
Tori-TSC-3	YSB-9	6.858	-28.911**	-2.411*	-10.968**	-18.310*	9.358**	-4.000**
Tori-TSC-3	NC-1	3.266	13.359**	56.509**	25.815**	-40.279**	92.148	0.000
YSB-9	NC-1	10.144	-36.751**	-11.407**	25.358**	-31.111**	60.419**	-4.166**

(Table 1 contd...)

(Mustard)

Parent	Parent	djk value	No.of pri.branches/ plants	No. of Sec. branches/plant	*Plant height*	Days to flower initiation	Days to 50% flowering	No. of siliquas per plant
1	2	3	4	5	6	7	8	9
RW-85-59	RW-29-6	14.601	18.577**	-10.326*	5.724	-6.885**	-11.111**	158.070
RW-85-59	RW 351	15.988	-1.433**	-28.065**	8.992*	7.227**	7.689**	80.477
RW-85-59	White Glossy	14.334	13.086**	-43.686**	12.016	-6.141**	-7.351**	0.899
RW 85-59	Pusa Bold	13.600	-4.921**	-18.541**	12.258**	7.531**	7.080**	86.555
RW 85-59	B-85	21.989	-26.315**	-38.369**	8.273	9.530**	7.013**	-4.614
RW 29-6	RW-351	1.387	17.068**	10.536**	16.488**	27.096**	17.955**	200.522*
RW 29-6	White Glossy	0.267	1.010**	-24.988**	-4.119	-3.646	-6.829**	47.162
RW 29-6	Pusa Bold	1.001	45.089**	101.740**	9.067*	1.733	-4.787**	361.161**
RW 29-6	B-85	7.388	0.001	3.866**	10.861*	14.191**	-16.403**	97.947
RW 351	White Glossy	1.654	3.718**	-19.102**	31.834**	12.300**	4.054**	117.907
RW 351	Pusa Bold	2.388	10.000**	3.295**	16.748**	15.644**	16.228**	147.675
RW 351	B-85	6.001	14.255**	-2.860**	13.545**	5.256**	5.727**	35.932
White Glossy	Pusa Bold	0.734	37.653**	60.860**	18.824**	8.804**	1.115	222.373*
White Glossy	B-85	7.655	32.850**	-12.540**	9.784*	0.809	-1.042	83.190
Pusa Bold	B-85	8.389	35.894**	45.687**	10.312*	5.618**	-7.061**	220.691*

(Mustard contd...)

(Mustard contd..)

Parent	Parent	djk value	Siliqua length	No. of seeds/siliqua	Seed yield/plant	Harvest index	Biological yield/plant	1000-seed weight
1	2	3	10	11	12	13	14	15
RW-85-59	RW-29-6	14.601	8.343**	-13.136**	85.973**	-57.262**	161.579**	0.030**
RW-85-59	RW 351	15.988	-9.477**	209.939**	41.612**	-34.583**	98.851**	1.538**
RW-85-59	White Glossy	14.334	-21.420**	-3.931*	4.550**	24.835**	-22.441**	-2.941**
RW 85-59	Pusa Bold	13.600	-4.157**	-1.989**	61.649**	-49.693**	183.273**	9.090**
RW 85-59	B-85	21.989	25.659**	-26.556**	20.189**	-32.811**	-5.821	-7.692**
RW 29-6	RW-351	1.387	17.195**	5.151**	100.239**	-53.649**	328.175**	14.754**
RW 29-6	White Glossy	0.267	-8.521**	-1.768*	38.123**	-54.455**	203.171**	3.125**
RW 29-6	Pusa Bold	1.001	32.996**	8.594**	262.699**	-47.968**	589.642**	29.032**
RW 29-6	B-85	7.388	-13.947**	-11.409**	70.719**	-53.055**	250.567**	8.196**
RW 351	White Glossy	1.654	-4.358**	24.744**	72.575**	-57.219**	303.207**	11.111**
RW 351	Pusa Bold	2.388	-2.075**	21.629**	87.044**	-56.525**	324.617**	14.754**
RW 351	B-85	6.001	-1.143*	8.741**	35.669**	-68.383**	304.686**	10.000**
White Glossy	Pusa Bold	0.734	8.014**	11.758**	139.041**	-39.034**	288.476**	21.875**
White Glossy	B-85	7.655	-21.592**	-8.508**	57.627**	-63.177**	228.918**	4.762**
Pusa Bold	B-85	8.389	12.165**	-9.042**	115.938**	-46.745**	418.166**	18.033**

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REPORT ON THE INCIDENCE OF HITHERTO UNKNOWN LEAF MINER *Liriomyza trifolii* BURGESS (DIPTERA:AGROMYZIDAE) ON CASTOR

An unusual incidence of leaf miner was noticed on the cotyledonary leaves of castor in second fortnight of June 1991 at the Research Farms of Directorate of Oilseeds Research. Characteristic mines confined to the cotyledonary leaves to start with spread to true leaves. Field surveys revealed the widespread occurrence of the pest in all castor growing areas of the country. The mines covered 20 to 60 per cent leaf area in older leaves and the severity was either low or negligible as the crop growth progressed. The infestation of the pest showed declining trend from mid September on the farmers' fields. The leaf miner was later identified as *Liriomyza trifolii* belonging to the family Agromyzidae of order Diptera.

In accordance with the available reports (Parrella, 1982) *Liriomyza trifolii* among all the leaf miners assumed economic importance in California. It infact posed enormous damage to various vegetable, ornamental and field crops. Castor is a known host of *L. trifolii* in Everglades agricultural area of South Florida (Parkman, 1987). Poe and Montz (1982) considered *L. trifolii* the most serious threat to agriculture.

The biology of *L. trifolii* was studied during kharif 1991, on 35 days old VP.1 castor plants grown in glasshouse after 24 hours exposure to freshly emerged adult flies. The hyaline eggs inserted singly in to the leaf tissues were observed. The egg period found to last for 2-3 (mean 2.5) days. Within 3 days of oviposition newly hatched maggots entered in between the epidermal layers there by making characteristic serpentine mines. Yellow maggots after 6-9 (mean 7.25) days growth came out of the mines and dropped on to the soil for pupation. A small proportion of the maggots pupated on the leaf surface. Adult flies emerged from brown puparia in 6-7 days. The longevity of adult lasted for 3-6 (mean 4.75) days.

The leaf miner was also found feeding on cotton, tomato, leafy vegetables , gourds, marygold and various weeds. Water melon had severe infestation of leaf miner damaging 70% foliage in Dharwad region of karnataka. Early reports confined the incidence of *L. trifolii* on water melon in Hawai (Johonson *et al.* 1989) and on cotton seedlings in Israel (Yathom, 1989). The revisionary study of Spencer (1981) on leaf miners indicated wide host range of *L. trifolii*.

All the castor breeding materials and germplasm accessions grown at the Research Farm, Directorate of Oilseeds Research showed variable degrees of leaf miner infestation. Some accessions with broad leaves got heavily damaged and hundreds of leaf miner maggots were found crawling on leaf surface and congregating in case of cup shaped leaves, before falling on to the ground for pupation. The leaf miner continued to infest the castor fields sown during late kharif, rabi and summer in different experiments. Satisfactory control of the leaf miner could not be achieved with common insecticides like monocrotophos and phos-

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phamidon. Parrella *et al.*, (1984) found *L. trifolii* to have high potential for development of resistance to commonly used pesticides.

These observations indicate that it is likely to assume economic importance on castor in years to come because of the wide host range, ability to survive and multiply over wide range of seasonal conditions and low sensitivity to common insecticides. It is therefore, of utmost importance to make an indepth study on the biology, behaviour, preference and management strategies of castor leaf miner, *Liriomyza trifolii.*

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CORRIGENDUM

As per the request from the Senior Author of the article entitled "Nitrogen harvest index in relation to productivity in Groundnut" published in Volume 8(2) of Journal of Oilseeds Research on Page Nos. 186 to 194, the name of Sri A. Bandyopadhyay is included as the third author of the above paper.

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