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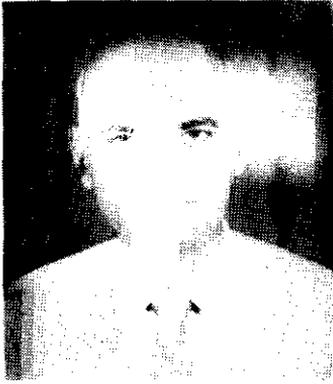
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OBITUARY



Shri RAJENDRA R. MISHRA

(November 12, 1945 - April 26, 1993)

Shri Rajendra R. Mishra a valuable member of the Indian Society of Oilseeds Research and the Director of Research, Maharashtra Hybrid Seeds Company Limited passed away on 26th April, 1993 in a plane crash at Aurangabad. After completing his post-graduation in Agriculture with specialisation in Plant Breeding and Genetics, he joined Maharashtra Hybrid Seeds Company Limited (Mahyco) in 1968, in which he worked in various capacities such as Plant Breeder, Manager of Research and Director of Research till his premature and tragic death. In recognition of his meritorious services, he was appointed as one of the Board of Directors of the company in 1981. In addition Shri Mishra was also the Director of 1) Mahyco Research Foundation and 2) India Drossabch Limited, and also the Trustee of the Barwale Agricultural Research Institute and Mahyco Trust.

Shri Mishra was liked by all the Scientists and diverse personnel engaged in agricultural development, for his spirit of cooperation and commitment to the cause of nation's seed industry.

He was one of those who believed in strong cooperation between the public and private sectors to strengthen agricultural research and development in our country.

Shri Mishra as a Plant Breeder and the active team leader of Plant Breeders of Mahyco was responsible for the development of more than 250 hybrids and varieties of different crops including cotton and sunflower.

He received the first national award in 1989 on behalf of Mahyco for R&D efforts in Agro-industry instituted by Department of Science and Technology, Government of India in 1989 and FICCI award in 1990 for Research efforts in Science and Technology by corporate sector. A gold medal was also presented to him by All India Coordinated Cotton Improvement Project during its Silver Jubilee Celebrations.

He attended several national and international symposia, conferences, workshops and group meetings in different crops and presented papers and actively participated in discussions. He was a regular participant of *kharif* and *rabi* oilseeds group workers' meeting. He always contributed his best to strengthen the Indian Society of Oilseeds Research and its activities.

OBITUARY



Prof. BISHWANATH CHATTERJEE

(October 10, 1928 - May 16, 1993)

Professor Bishwanath Chatterjee a member of the Editorial Board of the Journal of Oilseeds Research and former Professor of Agronomy, Faculty of Agriculture Bidhan Chandra Krishi Vishwavidyalaya, West Bengal passed away on 16th May, 1993. Professor Chatterjee was born on October 10, 1928. He graduated in Agriculture from Government Agricultural College, Kanpur in 1950. He was the recipient of state scholarship and Nuffield Foundation scholarship for his Ph.D., study at the University of Reading, U.K.

He worked as Agrostologist, Agronomist, Professor and Head, Department of Agronomy, Dean, Faculty of Agriculture. He was appointed as the Vice-chancellor of the Bidhan Chandra Krishi Vishwavidyalaya in 1985. His love for teaching, academic activities and agricultural research was so deep that he resigned the post of Vice-chancellor and he continued as Professor of Agronomy till his last breath. He has to his credit around 250 research papers, nine research bulletins and nine books. He guided around 40 Ph.D., and 55 M.Sc., research scholars.

His research contributions on the role of siliqua surface area of mustard in the productivity, crop competition, inter-crop-

ping, multiple cropping, moisture extraction pattern of the roots of *rabi* crops, wheat management with minimum tillage, substitution of inorganic fertilizers with organic manures for rice production etc., are not only too well known but also useful. He chaired scientific sessions of number of crop workshops and seminars dealing with crop management. He was a member of various scientific and review committees of ICAR, member of Academic Council of Assam Agricultural University and member of Board of Studies of BHU, Bhagalpur University, Ranchi University, Calcutta University, Kalyani University and BCKV.

He was actively associated with many societies dealing with Agricultural Sciences and acted as Councillor/editor for Indian Journal of Agronomy, Journal of Soil and Water Conservation Society of India, Saar Samachar, Journal of Oilseeds Research etc. He was distinguished Fellow of Indian Society of Agronomy and Fellow of Science and Technology, West Bengal.

Professor Chatterjee had visited Sweden as a member of Indian delegation under the sponsorship of Department of Science and Technology. International Rice Research Institute, Philippines invited him to participate in the symposium on rice based cropping system.

Professor Chatterjee was a reputed teacher and his unassuming simplicity and friendship with one and all not only won the hearts of the student community as a whole but left behind many admirers. By the death of Professor Chatterjee the nation has lost a dedicated exemplary Scientist and an administrator committed to the cause of Agriculture and the Indian Society of Oilseeds Research is deprived of its senior member of the Editorial Board. The Society conveys sincere condolence to the members of the bereaved family. May his soul rest in peace.

ADOPTION OF SOME IMPORTANT PRODUCTION TECHNOLOGIES AND THEIR INFLUENCE ON YIELD OF SUNFLOWER IN KARNATAKA

K. SEENAPPA¹, N. VENUGOPAL², T.N. VENKATA REDDY³,
S. RAJENDRA PRASAD⁴ and U.S. UJJINIAH⁵

ABSTRACT

A survey was conducted during 1983-84 in the districts of Bijapur, Gulbarga, Bellary, Mysore and Shimoga to study the extent of adoption of some important production technologies and their influence on seed yield of sunflower. Technologies on manures and fertilizers, hand pollination and harvesting at physiological maturity markedly increased the sunflower yields. 74% of sunflower was under rainfed situation. Only 5% to 17% of the farmers under rainfed and 16% to 25% of the farmers under irrigated conditions have followed recommended or near to the recommended levels of manures and fertilizers. 25% of the farmers followed hand pollination and 30% of the farmers harvested the crop at physiological maturity. Farmers are well aware of the marketing facilities.

Key words: Sunflower; Production technology; Adoption; Yield.

Commercial cultivation of sunflower (*Helianthus annuus* L.) started during 1972-73 in Karnataka with a modest beginning of 15,000 ha. Karnataka has been one of the leading sunflower growing states in India with a productivity of 1 tonne/ha (Virupakshappa *et al.*, 1989). Although the area under sunflower rose to 2 lakh ha with a production of 79,000 tonnes during 1982, the productivity declined to 575 kg/ha. The causes for decline in the productivity could be attributed to poor management of crop in farmers field besides, vagaries of monsoon. The research on genetic improvement and agronomic practices began with the establishment of research centres under AICORPO in 1972 and seed production centres in 1978. Consequently, a good package of practices was developed for realising higher productivity. Hence, interest arose to conduct a critical survey to know the extent of adoption of some important production technologies and their response on sunflower yield on farmers' fields. The findings of the survey are discussed in this paper.

MATERIALS AND METHODS

A proforma was designed to collect the information on a few important practices followed by the farmers and yields harvested by them. The survey was conducted during 1983-84 in the districts of Bijapur, Gulbarga, Bellary, Mysore and Shimoga. The farmers interviewed were from the taluks where sunflower cultivation was predominant. The nutrients applied both in the form of fertilizers and FYM were considered for working out the NPK applied to the crop. A tonne of FYM was considered to supply 10, 8 and 20 kg of N, P₂O₅ and K₂O per ha. The recommended/ near recommended level for (a) FYM was 6.25 t/ha or more (b) N was 50 kg or more/ha under irrigated and 40 kg N/ha or more under rainfed situation and similar amount was taken for P₂O₅. The survey data on FYM, N and P levels of Bijapur, Gulbarga and Bellary were clubbed together and similarly of Mysore and Shimoga to represent sunflower growing areas of north and south Karnataka regions, respectively.

The data on a few other important production technologies viz., sowing methods, hand pollination, harvesting time and mode of marketing the produce are represented district-wise.

RESULTS AND DISCUSSION

General information on the surveyed districts

The number of farmers interviewed who had grown irrigated and rainfed sunflower, rainfall during the cropping season, area, production and productivity figures pertaining to 1983-84 of the surveyed districts are given in Table 1. Highest area under sunflower was in Bijapur followed by Gulbarga, Bellary, Mysore and lowest in Shimoga. Highest productivity of 824 kg/ha observed in Shimoga district which also received highest rainfall of 495 mm during cropping season, while the lowest productivity (223 kg/ha) coincided with lowest rainfall (202 mm) in Gulbarga. Out of the total number of 266 farmers interviewed, 74% of farmers have grown rainfed sunflower and 26% farmers have grown the irrigated crop. So, major area of sunflower cropping was under rainfed situation.

Sowing methods

All farmers under irrigated conditions followed dibbling but under rainfed situation sowing behind the plough, drill sowing and

broadcastings were adopted (Table 2.). Sowing behind the plough was the common method adopted by 74% farmers in all the districts. However, 19% and 7% farmers followed drilling and broadcasting respectively. 40 and 30 per cent of farmers in the largest sunflower growing districts namely Bijapur and Gulbarga respectively, followed drill sowing. Only in Shimoga 33% farmers adopted broadcasting which should be discouraged.

FYM, N and P levels

The mean seed yield obtained by the farmers who followed recommended or near recommended levels of Farm Yard Manure (F), nitrogen (N), Phosphorus (P) and interactions of NP, NF and PF under irrigated and rainfed conditions as compared to yield levels obtained by farmers who followed less than recommended levels of above nutrients are presented in Table 3.

Application of recommended/near to recommended level F increased the yield by 56 and 62% ; N by 77 and 29%; P by 110 and 3% while combination of NP increased the yield by 82 and 16%, NF by 66 and 46% and PF by 65 and 34% under rainfed and irrigated conditions, respectively. In general, only 5 to 17% of the farmers under rainfed conditions and 16 to 25 per cent of the farmers under irrigated conditions have used recommended or near to

Table 1. Area, production and productivity of sunflower, rainfall during cropping season and number of farmers interviewed district-wise during 1983-84

| | Area (ha) | Production (t) | Productivity (kg/ha) | Rainfall (mm) | Number of sunflower growers | | |
|----------|-----------|----------------|----------------------|---------------|-----------------------------|---------------------|-------|
| | | | | | Rainfed condition | Irrigated condition | Total |
| Bijapur | 135700 | 92170 | 679 | 412 | 58 | 14 | 72 |
| Gulbarga | 49600 | 11070 | 223 | 202 | 51 | 10 | 61 |
| Bellary | 47800 | 30020 | 628 | 463 | 5 | 20 | 25 |
| Mysore | 10000 | 5880 | 588 | 299 | 40 | 19 | 59 |
| Shimoga | 3400 | 2800 | 824 | 495 | 43 | 6 | 49 |

Table 2. Influence of sowing methods, hand pollination and harvesting on seed yield (kg/ha) of sunflower

| Districts | Sowing methods | | | | Hand pollination | | Harvesting | |
|-----------|-------------------|------------|---------------|----------|------------------|----------|------------------------|-----------|
| | Behind the plough | Seed drill | Broad casting | Dibbling | Hand pollination | Control | Physiological maturity | Fully dry |
| Mysore | 716(40) | - | - | 1719(19) | 1328(4) | 1017(55) | 1668(19) | 738(40) |
| Shimoga | 1180(29) | - | 1000(14) | 2149(6) | 3397(2) | 1156(47) | 1368(27) | 1099(22) |
| Bijapur | 474(35) | 437(23) | - | 755(14) | 752(10) | 478(62) | 468(18) | 532(54) |
| Gulbarga | 430(36) | 496(15) | - | 844(10) | 763(6) | 489(55) | 679(10) | 480(51) |
| Bellary | 887(5) | - | - | 1281(20) | 1317(3) | 1187(22) | 1309(5) | 1180(20) |
| Mean | 685(145) | 460(38) | 1000(14) | 1307(68) | 1131(25) | 813(241) | 1144(79) | 697(187) |

Note : Dibbling is only method of sowing followed by all irrigated farmers; Figures in parenthesis indicate number of farmers.

Table 3. Influence of near to recommended versus less than recommended levels of N, P₂O₅ and FYM on seed yield (kg/ha) of sunflower in farmers' field under irrigated and rainfed conditions.

| | Mysore-Shimoga | | Bijapur-Bellary-Gulbarga | | Mean | |
|-------------------------------|-----------------------------|---------------------------|-----------------------------|---------------------------|-----------------------------|---------------------------|
| | Less than recommended level | Near to recommended level | Less than recommended level | Near to recommended level | Less than recommended level | Near to recommended level |
| A. Irrigated condition | | | | | | |
| Nitrogen (N) | 1704 (20) | 2272 (5) | 963 (35) | 1210 (9) | 1232 (55) | 1589 (14) |
| Phosphorus (P) | 1853 (21) | 1680 (4) | 988(37) | 1136 (7) | 1301 (58) | 1334 (11) |
| FYM (F) | 1606 (12) | 2025 (13) | 1013 (40) | 1334 (4) | 1150 (52) | 1862 (17) |
| NP | 1778 (41) | 2001 (9) | 988 (72)) | 1186 (16) | 1275 (113) | 1479 (25) |
| NF | 1680 (32) | 2100 (18) | 988 (75) | 1260 (13) | 1195 (107) | 1748 (31) |
| PF | 1763 (33) | 1944 (17) | 1013 (77) | 1210 (11) | 1238 (110) | 1656 (28) |
| B. Rainfed condition | | | | | | |
| Nitrogen (N) | 840 (58) | 1161 (25) | 469 (109) | 543 (5) | 598 (167) | 1058 (30) |
| Phosphorus (P) | 889 (74) | 1334 (9) | 469 (114) | - | 634 (188) | 1334 (9) |
| FYM (F) | 840 (60) | 1161 (23) | 469 (103) | 494 (11) | 606 (163) | 945 (34) |
| NP | 865 (132) | 1210 (34) | 469 (223) | 543 (5) | 616 (355) | 1124 (390) |
| NF | 840 (118) | 1161 (48) | 469 (212) | 519 (16) | 602 (330) | 1001 (64) |
| PF | 867 (134) | 1210 (32) | 469 (217) | 494 (11) | 621 (351) | 1027 (43) |

Figures in parenthesis refer to number of farmers.

recommended levels F/N/P/NP/NF/PF. Greater proportion of farmers in Mysore - Shimoga (11 to 30 and 16 to 52% under rainfed and irrigated conditions, respectively) have followed recommended/near to recommended levels of above nutrients as compared to farmers of Bijapur - Bellary - Gulbarga (0 to 10 and 9 to 21% under rainfed irrigated conditions respectively).

Hand pollination

In general, hand pollination increased the seed yield by 39% as compared to the yield of control (813 kg/ha). This practice was adopted only by 9% out of the 266 farmers interviewed (Table 2).

kg/ha harvested at full dry stage (Table 2). Harvesting at physiological maturity increased the yield by 50% and 30% under irrigated and rainfed condition, respectively. This practice was followed by 50% of the farmers in irrigated tract and 66 per cent in rainfed tract.

Mode of marketing

About 50% have sold the produce to regulated market yard (Table 4) followed by 28% to village traders, 18% to oil mills and 4% to KOF. This shows that marketing facilities for sunflower were good. However, farmers may be motivated to sell their produce to KOF/regulated market yard to get better prices.

Table 4. Mode of marketing followed by number of sunflower growing farmers of selected districts

| Districts | Regulated market yard | Village traders | Oil mills | KOF | Total |
|--------------|-----------------------|-----------------|---------------|--------------|------------|
| Mysore | 35(59) | 23(39) | 1(2) | - | 59 |
| Shimoga | 2(4) | 11(23) | 26(53) | 10(20) | 49 |
| Bijapur | 48(67) | 19(26) | 5(7) | - | 72 |
| Gulbarga | 27(44) | 21(35) | 13(21) | - | 61 |
| Bellary | 22(88) | - | 2(8) | 1(4) | 25 |
| Total | 134(50) | 74(28) | 47(18) | 11(4) | 266 |

Figures in parenthesis refers to percentage.

Time of harvest

Harvesting the crop at physiological maturity i.e., when the back of the head turn to lemon yellow in colour minimise the seed loss at harvest. In general, 30% of the farmers harvested the crop at physiological maturity and on an average this has increased the seed yield by 64 per cent as compared to the seed yield of 697

LITERATURE CITED

- Virupakshappa K., Seenappa, K., and Seetharam A., 1989. Karnataka-A leading state in sunflower production; Karnataka Agriculture on the march, 1913-1988, Diamond Jubilee Commemoration Volume, Department of Agriculture, Government of Karnataka, pp. 113-116.

YIELD COMPONENT ANALYSIS AND ITS IMPLICATION FOR SELECTION IN NIGER (*GUIZOTIA ABYSSINICA* CASS.)

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ABSTRACT

Thirty five niger strains were raised in R.B.D. thrice replicated during *kharif* 1988 to study variability, association and path analysis for yield and its component traits. Significant differences for all the traits among the strains were observed. Grain yield and harvest index had high heritability and high genetic gain, suggesting predominance of additive gene effects, while days to 50 per cent flowering, primary branches per plant, secondary branches per plant, capitula per plant and seeds per capitulum exhibited moderate to high heritability and moderate genetic gain. Other traits showed low to high heritability but very low genetic gain indicating predominance of non-additive gene effects. Grain yield exhibited positive and significant association with secondary branches per plant, capitula per plant, capitulum diameter, seeds per capitulum, 200-grain weight and harvest index. Path analysis revealed that capitula per plant and harvest index were the main yield contributing traits.

Key Words : Niger; Variability; Association; Path analysis; Yield; Selection

Oilseed production has assumed importance in the country because of acute shortage of edible oils, primarily due to their low yield potential and susceptibility to diseases. Niger is no exception to this. In spite of niger being an ancient oil crop grown in India, it remained as an unexploited crop in respect of genetic understanding and improvement. Therefore, to evolve promising genotypes, an efficient breeding strategy is desired which depends on the information available through studies on variability, character association and path analysis. The present study was carried out with this in view.

MATERIALS AND METHODS

Thirty five strains of niger, selected on the basis of their diverse geographical origin and variation in morphological traits were raised in a Randomized Block Design with three replications during *kharif* 1988 at Rajasthan College of Agriculture, Udaipur. In each replication, each entry was sown in a two row plot of 5m. length with a distance of 30 cm and 15cm between rows and plants, respectively. The plants

were randomly selected excluding the border plants per treatment per replication for recording data on thirteen traits viz., days to 50 per cent flowering, days to 75 per cent maturity, plant height (cm), number of primary branches per plant, number of secondary branches per plant, number of capitula per plant, capitulum diameter (cm), number of seeds per capitulum, 200-grain weight (g), grain yield per plant (g), harvest index (%), protein content (%) and oil content (%).

The estimates of genotypic and phenotypic coefficient of variation, heritability and genetic advance as per cent of mean were obtained following Johnson *et al.*, (1955). The correlation coefficient and path coefficient analysis were computed following the methods given by Al-Jibouri *et al.*, (1958) and Dewey and Lu (1959), respectively.

RESULTS AND DISCUSSION

Significant differences were observed among the strains for all the characters studied. The results obtained for mean, range, phenotypic

coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and genetic advance as per cent of mean are presented in Table 1. Grain yield per plant and harvest index showed high GCV and PCV values along with high estimates of heritability and genetic gain (Goyal and Kumar, 1985) suggesting selection for these traits would be effective. However, days to 50 per cent flowering, primary branches per plant, secondary branches per plant, capitula per plant and seeds per capitulum exhibited moderate to high heritability estimates but moderate genetic gain. Other traits had low genetic gain besides low to high heritability estimates indicating that selection for these traits would not be effective. The aforesaid results were in conformity with the findings of Sahu and Patnaik

(1981) and Goyal and Kumar (1985) for some of the traits.

A perusal of the Table 2 revealed a close agreement between genotypic and phenotypic correlation in most of the traits, thus indicating least environmental influence on the degree of association. Genotypic correlation coefficients were, in general, slightly higher than the corresponding phenotypic correlation coefficients. Since environment had no major influence on the degree of association, henceforth reference will be made only to genotypic correlation. Amongst various component traits, only six traits namely secondary branches per plant, capitula per plant, capitulum diameter, seeds per capitulum, 200-grain weight and harvest index exhibited significant positive association with grain yield

Table 1. Mean, range, GCV, PCV, heritability and genetic advance as per cent of mean for different characters in niger

| S. No. | Characters | Mean | Range | GCV (%) | PCV (%) | Heritability (%) | Genetic advance as per cent of mean |
|--------|--|--------|--------------|---------|---------|------------------|-------------------------------------|
| 1 | Days to 50% flowering | 72.53 | 53.00-97.00 | 16.81 | 17.46 | 92.68 | 33.34 |
| 2 | Days to 75% maturity | 102.07 | 89.00-112.33 | 5.15 | 5.59 | 84.83 | 9.79 |
| 3 | Plant height (cm) | 90.35 | 62.38-116.43 | 11.64 | 19.01 | 37.50 | 14.69 |
| 4 | Number of primary branches per plant | 14.45 | 8.90-19.25 | 16.89 | 19.35 | 76.13 | 30.38 |
| 5 | Number of secondary branches per plant | 27.29 | 16.86-39.96 | 21.31 | 25.43 | 70.20 | 36.75 |
| 6 | Number of capitula per plant | 48.19 | 25.03- | 20.50 | 26.84 | 58.34 | 32.25 |
| 7 | Capitulum diameter (cm) | 0.968 | 0.875-1.060 | 3.06 | 7.52 | 16.56 | 2.07 |
| 8 | Number of seeds per capitulum | 16.63 | 9.14-23.92 | 18.88 | 21.22 | 79.13 | 34.58 |
| 9 | 200-grain weight (g) | 0.65 | 0.49-0.76 | 6.75 | 12.73 | 28.13 | 7.69 |
| 10 | Grain yield per plant | 2.46 | 0.75-3.60 | 33.00 | 34.02 | 94.07 | 65.85 |
| 11 | Harvest index | 12.98 | 3.23-23.29 | 33.54 | 36.45 | 84.63 | 63.56 |
| 12 | Protein content (%) | 18.65 | 14.97-21.43 | 8.18 | 8.94 | 83.80 | 15.44 |
| 13 | Oil content (%) | 34.69 | 28.87-43.30 | 8.95 | 9.49 | 88.83 | 17.35 |

Table 2. Genotypic (r_g), phenotypic (r_{ph}) and environmental (r_{en}) correlation coefficient between different characters studied in niger

| Characters | Days to 50% maturity | Plant height | Number of primary branches per plant | Number of secondary branches per plant | Number of capitula per plant | Capitulum diameter | Number of seeds per plant | 200 grain weight | Grain yield per plant | Harvest index | Protein content | Oil content |
|--|----------------------|--------------|--------------------------------------|--|------------------------------|--------------------|---------------------------|------------------|-----------------------|---------------|-----------------|-------------|
| Days to 50% flowering | r_g | 0.94 ** | 0.72 ** | 0.09 | -0.11 | -0.80 ** | -0.48 ** | -0.90 ** | -0.24 | -0.63 ** | 0.04 | -0.00 |
| | r_{ph} | 0.84 ** | 0.60 ** | 0.61 ** | -0.10 | -0.31 | -0.41 * | -0.44 ** | -0.23 | -0.59 ** | 0.04 | 0.01 |
| | r_{en} | 0.09 | 0.18 | 0.07 | -0.02 | 0.01 | 0.02 | 0.07 | -0.04 | -0.26 | 0.10 | 0.01 |
| Days to 75% maturity | r_g | - | 1.03 ** | 0.70 ** | 0.19 | -0.80 ** | -0.31 | -0.82 ** | -0.12 | -0.47 ** | 0.13 | -0.04 |
| | r_{ph} | - | 0.65 ** | 0.58 ** | 0.15 | -0.03 | -0.30 | -0.23 | -0.38 * | -0.11 | 0.44 ** | 0.10 |
| | r_{en} | - | 0.21 | 0.06 | 0.02 | -0.00 | -0.01 | 0.15 | 0.07 | 0.00 | -0.27 | -0.01 |
| Plant height | r_g | - | 0.80 ** | 0.39 * | 0.19 | -1.07 ** | -0.13 | -0.87 ** | 0.06 | -0.40 * | -0.00 | 0.04 |
| | r_{ph} | - | 0.57 ** | 0.29 | 0.24 | -0.17 | -0.04 | -0.31 | 0.08 | -0.30 | 0.01 | 0.01 |
| | r_{en} | - | 0.38 * | 0.22 | 0.31 | 0.13 | 0.08 | -0.03 | 0.22 | -0.22 | 0.03 | -0.04 |
| Number of primary branches per plant | r_g | - | 0.54 ** | 0.38 * | 0.38 * | -0.65 ** | -0.03 | -0.69 ** | 0.22 | -0.19 | 0.21 | 0.06 |
| | r_{ph} | - | 0.62 ** | 0.49 ** | 0.49 ** | -0.30 | -0.03 | -0.39 * | 0.27 | -0.14 | 0.14 | 0.03 |
| | r_{en} | - | 0.85 ** | 0.75 ** | 0.75 ** | -0.16 | -0.00 | -0.18 | 0.68 ** | 0.09 | -0.10 | -0.17 |
| Number of secondary branches per plant | r_g | - | 0.79 ** | - | 0.79 ** | -0.05 | 0.42 * | 0.04 | 0.64 ** | 0.34 * | 0.40 * | 0.51 |
| | r_{ph} | - | 0.81 ** | - | 0.81 ** | -0.13 | 0.31 | -0.04 | 0.62 ** | 0.29 | 0.27 | 0.21 |
| | r_{en} | - | 0.86 ** | - | 0.86 ** | -0.22 | -0.01 | -0.12 | 0.76 ** | 0.13 | -0.15 | -0.19 |
| Number of capitula per plant | r_g | - | - | - | 0.02 | 0.53 ** | 0.25 | 0.82 ** | 0.82 ** | 0.51 ** | 0.27 | 0.23 |
| | r_{ph} | - | - | - | 0.36 * | 0.36 * | 0.03 | 0.74 ** | 0.40 * | 0.40 * | 0.16 | 0.13 |
| | r_{en} | - | - | - | -0.20 | -0.00 | -0.00 | -0.13 | 0.81 ** | 0.16 | -0.13 | -0.18 |
| Capitulum diameter | r_g | - | - | - | 0.88 ** | 0.52 ** | 0.51 ** | 1.04 ** | 0.30 | 0.30 | -0.14 | -0.14 |
| | r_{ph} | - | - | - | 0.41 * | 0.30 | -0.18 | 0.32 | 0.10 | 0.32 | 0.02 | 0.02 |
| | r_{en} | - | - | - | 0.22 | 0.24 | -0.11 | -0.18 | -0.11 | -0.18 | -0.02 | -0.11 |
| Number of seeds per plant | r_g | - | - | - | 0.38 * | 0.69 ** | 0.82 ** | 0.82 ** | 0.69 ** | 0.82 ** | 0.13 | 0.02 |
| | r_{ph} | - | - | - | 0.14 | 0.60 ** | 0.64 ** | 0.64 ** | 0.11 | 0.64 ** | 0.11 | 0.02 |
| | r_{en} | - | - | - | -0.09 | -0.03 | -0.17 | -0.03 | 0.02 | -0.17 | 0.03 | 0.02 |
| 200 grain weight | r_g | - | - | - | 0.61 ** | 0.81 ** | 0.81 ** | 0.81 ** | 0.61 ** | 0.81 ** | -0.26 | 0.08 |
| | r_{ph} | - | - | - | 0.30 | 0.29 | -0.10 | 0.02 | 0.30 | 0.29 | -0.10 | 0.02 |
| | r_{en} | - | - | - | - | - | - | - | -0.08 | -0.30 | 0.07 | -0.07 |
| Grain yield per plant | r_g | - | - | - | 0.78 ** | 0.14 | 0.14 | 0.20 | - | 0.78 ** | 0.14 | 0.20 |
| | r_{ph} | - | - | - | 0.72 ** | 0.12 | 0.12 | 0.16 | - | 0.72 ** | 0.12 | 0.16 |
| | r_{en} | - | - | - | 0.20 | -0.07 | -0.07 | -0.30 | - | 0.20 | -0.07 | -0.30 |
| Harvest index | r_g | - | - | - | 0.23 | 0.09 | 0.09 | 0.09 | - | 0.23 | 0.09 | 0.09 |
| | r_{ph} | - | - | - | 0.18 | 0.06 | 0.06 | 0.06 | - | 0.18 | 0.06 | 0.06 |
| | r_{en} | - | - | - | - | - | - | - | - | - | - | - |
| Protein content | r_g | - | - | - | 0.44 ** | 0.44 ** | 0.44 ** | 0.44 ** | - | 0.44 ** | 0.44 ** | 0.44 ** |
| | r_{ph} | - | - | - | 0.34 * | 0.34 * | 0.34 * | 0.34 * | - | 0.34 * | 0.34 * | 0.34 * |
| | r_{en} | - | - | - | 0.26 | 0.26 | 0.26 | 0.26 | - | 0.26 | 0.26 | 0.26 |

* Significant at 5 per cent level of significance

** Significant at 1 per cent level of significance

Table 3. Path coefficient analysis indicating direct and indirect effects of various component traits on grain yield

| Characters | Days to 50% flowering | Days to 75% maturity | Plant height | Number of primary branches per plant | Number of secondary branches per plant | Number of capitula per plant | Capitulum diameter | Number of seeds per capitulum | 200 grain weight | Harvest index | Protein content | Oil content | Genotypic correlation coefficient with grain yield per plant |
|--|-----------------------|----------------------|--------------|--------------------------------------|--|------------------------------|--------------------|-------------------------------|------------------|---------------|-----------------|-------------|--|
| Days to 50% flowering | 0.26 | -0.17 | 0.17 | -0.05 | 0.01 | -0.05 | 0.01 | 0.13 | 0.14 | -0.68 | -0.01 | -0.00 | -0.24 |
| Days to 75% maturity | 0.24 | -0.18 | 0.19 | -0.04 | 0.01 | -0.02 | 0.01 | 0.08 | 0.12 | -0.50 | -0.04 | -0.00 | -0.12 |
| Plant height | 0.25 | -0.19 | 0.18 | -0.05 | 0.03 | 0.09 | 0.02 | 0.03 | 0.13 | -0.43 | 0.00 | 0.00 | 0.06 |
| Number of primary branches per plant | 0.19 | -0.13 | 0.15 | -0.07 | 0.04 | 0.18 | 0.01 | 0.01 | 0.10 | -0.21 | -0.06 | 0.01 | 0.22 |
| Number of secondary branches per plant | 0.02 | -0.04 | 0.07 | -0.04 | 0.07 | 0.26 | 0.00 | 0.01 | -0.01 | 0.37 | -0.11 | 0.03 | 0.64** |
| Number of capitula per plant | -0.03 | 0.01 | 0.03 | -0.03 | 0.05 | 0.46 | -0.00 | -0.11 | -0.04 | 0.54 | -0.08 | 0.02 | 0.82** |
| Capitulum diameter | -0.21 | 0.15 | -0.20 | 0.04 | -0.00 | 0.01 | 0.02 | -0.23 | -0.08 | 1.12 | -0.08 | 0.01 | 0.51** |
| Number of seeds per capitulum | -0.12 | 0.06 | -0.02 | 0.00 | 0.03 | 0.28 | -0.05 | 0.26 | -0.06 | 0.87 | -0.04 | 0.00 | 0.69** |
| 200 grain weight | -0.23 | 0.15 | -0.16 | -0.04 | 0.00 | 0.12 | -0.01 | -0.10 | 0.15 | 0.87 | 0.07 | 0.01 | 0.61** |
| Harvest index | -0.16 | 0.08 | -0.08 | 0.01 | 0.02 | 0.27 | -0.02 | 0.22 | 0.12 | 1.06 | -0.07 | 0.01 | 0.78** |
| Protein content | 0.01 | -0.02 | -0.00 | -0.01 | 0.03 | 0.12 | -0.01 | -0.03 | 0.03 | 0.25 | -0.28 | 0.05 | 0.14 |
| Oil content | -0.00 | 0.01 | 0.00 | -0.01 | 0.02 | 0.11 | 0.00 | -0.01 | -0.01 | 0.10 | -0.12 | 0.11 | 0.20 |

Residual effect (R) = 0.0821; Figures underlined indicate direct effects; ** Significant at 1 per cent level of significance

indicating that grain yield and these traits have the same physiological basis for their expression. Joshi and Thombre (1984), Goyal and Kumar (1985) and Channarayappa (1987) also reported similar results in niger.

Variable results were observed with regard to association among yield components. The traits, number of secondary branches per plant, capitula per plant, capitulum diameter, seeds per plant, 200 grain weight and harvest index exhibited significant positive association with grain yield per plant. However, these traits except number of secondary branches and capitulum per plant also revealed mutual association among themselves. The protein content exhibited positive and significant association with oil content. Both these traits also showed positive but non-significant association with major yield components.

Path coefficient analysis was carried out for all the thirteen traits to work out the direct and indirect contributions of these traits on grain yield (Table 3). Direct effects of capitula per plant (Goyal and Kumar, 1985) and harvest index (Bhoop Singh, 1988) were of higher magnitude indicating their importance in grain yield. In most of the traits high magnitude of indirect effects via these two traits were also observed.

Thus, capitula per plant and harvest index are the major yield contributing traits

and selection for these traits would be effective for yield improvement.

LITERATURE CITED

- Al-Jibouri, H.A., Miller, P.A. and Robinson, H.P. 1958. Genotypic and environmental variance and covariance in upland cotton crosses of interspecific origin. *Agron. J.* 50 : 633-637.
- Bhoop Singh. 1988. Path coefficient analysis and stability parameters in niger. Unpublished M.Sc. (Ag.) Thesis, Rajasthan Agricultural University, Bikaner, Campus, Udaipur.
- Channarayappa. 1987. Response to selection, correlation and path analysis in niger (*Guizotia abyssinica* Cass.). *Mysore J. agric. Sci.*, 21(1) : 92-93.
- Dewey, D.R. and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agron. J.* 51 : 515-518.
- Goyal, S.N. and Kumar, S. 1985. Correlations and path analysis in niger. *J. Oilseeds Res.* 2(1) : 34-38.
- Johnson, H.W., Robinson H.F. and Comstock, R.E. 1955. Estimates of genetic and environmental variability in soybean. *Agron. J.* 47(7) : 314-318.
- Joshi, B.P. and Thombre, M.V. 1984. Genotypic correlation coefficients of yield and yield contributing characters in niger *J. Maharashtra agric. Univ.* 9(1) : 10-12.
- Sahu, D.P. and Patnaik, M.C. 1981. Variability, correlation and path coefficient analysis in niger. *Indian J. agric. Sci.*, 51(5) : 287-291.

RESPONSE OF MUSTARD TO SULPHUR AND NITROGEN UNDER IRRIGATED VERTISOL CONDITIONS II. EFFECT OF S AND N ON ANCILLARY CHARACTERS, YIELD AND QUALITY*

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ABSTRACT

Field experiment was conducted during *rabi* seasons of 1988-89 and 1989-90 at Zonal Agricultural Research Station, Powarkheda, Hoshangabad (M.P.) to study the effect of applied sulphur and nitrogen on the ancillary characters, seed and stalk yield and quality of mustard. Results indicated that nitrogen up to 90 kg/ha significantly increased the yield attributing characters viz., number of siliquae/plant, siliqua length, number of seeds/siliqua and test weight. Seed yield, stalk yield and protein content were significantly increased with increasing level of N up to 90 kg/ha. Nitrogen had adverse effect on oil content of mustard seed. Application of sulphur up to 30 kg/ha significantly increased the ancillary characters, seed yield and protein content, while oil content was stimulated up to 40 kg S/ha.

Key words : Mustard; Sulphur; Nitrogen; Ancillary characters; Fertilization.

INTRODUCTION

Mustard (*Brassica juncea* (L.) Czern and Coss) is one of the most important oilseed crop of the country in general. India stands second in mustard production, but the average yield is low (694 kg/ha) in comparison to that of European countries (2007 kg/ha). The productivity of mustard can be increased by proper fertilizer management and bringing more area under irrigation. Fertilizer management specially nitrogen and sulphur are the most important agronomic factors known to augment the crop yield (Singh and Saran, 1987 and Singh and Dixit, 1989). However, there is meagre information on N and S fertilization on mustard in Tawa Command Area of central Narmada valley. Therefore, the present investigation was carried out to find out the response of mustard to nitrogen and sulphur.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* seasons of 1988-89 and 1989-90 at JNKVV, Zonal Agricultural Research Station, Powarkheda on clayey-loam soils having pH 7.2. The status of available N, P, S and K content was 183.7, 13.6, 8.03 and 301.4 kg/ha respectively in 1988-89 and 202.6, 13.4, 7.95 and 333.8 kg/ha in 1989-90 respectively. The experiment was laid out in factorial Randomized Block Design with three replications during both the years. The treatment comprised the combinations of 4 nitrogen levels (0, 30, 60 and 90 kg/ha) and 6 sulphur levels (0, 10, 20, 30, 40 and 50 kg/ha). Mustard variety 'Varuna' was sown in rows 30 cm apart using 5 kg seed/ha on October 28, 1988 and November 3, 1989 and harvested 118 days after sowing. A uniform plant population was maintained by thinning the crop with an intra row spacing of 15 cm. The

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gross and net plot size was 6.0 x 5.0 m and 4.8 x 3, 8m respectively. A basal dose of 60 kg P₂O₅/ha through triple super phosphate, 40 kg K₂O/ha through muriate of potash, full dose of sulphur through gypsum and half dose of nitrogen through urea (as per treatment) were applied. The remaining nitrogen was top dressed at the stage of 35 days after first irrigation. Two irrigations were applied at 35 and 60 DAS to the crop during both the years. During the crop season, i.e., from October to February, the weather conditions were almost normal. During 1988-89 the weather was fairly dry and rainless, while in 1989-90 the crop received 42 mm rainfall at flowering and siliqua development stage. Monthly mean of daily temperatures were reached to maximum (33.9°C) in October and minimum (9.7°C) in January. The percentage of oil was determined by solvent extraction method in Soxhlet apparatus with

petroleum ether (BP 40-60 °C) as solvent. The percentage of crude protein was estimated by multiplying the total per cent of nitrogen of the seed by factor 6.25. The total N per cent was determined by micro-kjeldahl procedure as described by Jackson (1973).

RESULTS AND DISCUSSION

Ancillary Characters

Application of nitrogen up to 90 kg/ha significantly increased the number of siliqua/plant, number of seeds/siliqua and test weight of 1000-seeds in mustard during both the years. However, 60 and 90 kg N/ha did not differ significantly with regard to number of seeds/siliqua (Table 1).

The number of siliqua/plant increased significantly with successive increase in sulphur levels up to 40 kg/ha during both the years,

Table 1. Effect of nitrogen and sulphur levels on yield attributing characters

| Treatments | Number of siliquae per plant | | Number of seeds per siliqua | | Test weight (g) | |
|--|------------------------------|---------|-----------------------------|---------|-----------------|---------|
| | 1988-89 | 1989-90 | 1988-89 | 1989-90 | 1988-89 | 1989-90 |
| Nitrogen levels (kg ha ⁻¹) | | | | | | |
| 0 | 110.80 | 115.64 | 10.51 | 9.68 | 4.65 | 4.62 |
| 30 | 122.10 | 134.86 | 11.83 | 12.31 | 4.76 | 4.84 |
| 60 | 130.90 | 152.58 | 12.74 | 13.70 | 4.96 | 5.07 |
| 90 | 138.20 | 170.02 | 13.45 | 14.80 | 4.93 | 5.13 |
| SEm ± | 0.54 | 1.30 | 0.31 | 0.21 | 0.06 | 0.07 |
| CD at 5 % | 1.54 | 3.80 | 0.92 | 0.60 | 0.18 | 0.19 |
| Sulphur levels (kg ha ⁻¹) | | | | | | |
| 0 | 110.70 | 133.80 | 10.93 | 11.75 | 4.62 | 4.66 |
| 10 | 114.20 | 137.36 | 11.53 | 12.17 | 4.72 | 4.77 |
| 20 | 117.20 | 142.62 | 12.26 | 12.51 | 4.79 | 4.83 |
| 30 | 120.00 | 145.32 | 12.60 | 13.14 | 4.93 | 4.89 |
| 40 | 123.70 | 151.00 | 12.65 | 13.24 | 5.11 | 4.94 |
| 50 | 123.60 | 149.02 | 11.94 | 12.92 | 4.93 | 4.86 |
| SEm ± | 0.64 | 1.59 | 0.38 | 0.25 | 0.07 | 0.08 |
| CD at 5 % | 1.88 | 4.66 | 1.12 | 0.74 | NS | NS |

number of seeds/silique was increased significantly with the increase in levels of sulphur up to 20 kg/ha. The improved nutritional environment as a result of increased sulphur supply might have favourably influenced the carbohydrate metabolism. The favourable effect led to increased translocation of photosynthates towards, seeds resulting in formation of bold seeds (Chatterjee, *et al.*, 1985). Sulphur has no significant effect on 1000-seed weight.

Seed and stalk yield

Seed and stalk yields were significantly influenced by application of nitrogen. The seed yield increased significantly with increasing levels of nitrogen up to 90 kg/ha during both the years. The yield increase due to 90 kg N/ha over no nitrogen was of the order of 223 and 145 per

cent during 1988-89 and 1989-90 respectively. The results were in close conformity with the findings of Singh and Dixit (1989) and Saran and Giri (1990). Similarly, stalk yield was also increased significantly with the application of N up to 90 kg/ha during both the years. The stalk yield was 23.16 and 28.96 q/ha at no nitrogen level, while at highest level i.e. 90 kg N/ha, it increased 59.17 and 56.82 q/ha in 1988-89 and 1989-90 respectively.

Application of sulphur up to 30 kg/ha was found to increase seed yield significantly over control during both the years. However, 30, 40 and 50 kg S/ha were at par. The yield data indicated that the efficiency of sulphur in attaining seed yields of mustard was higher during 1989-90 as compared to that of 1988-89. The per cent increase in seed yield due to 30 kg

Table 2. Effect of nitrogen and sulphur on seed and stalk yield, oil and protein content in mustard seed

| Treatments | Seed yield (q/ha) | | Stalk yield (q/ha) | | Oil content (%) | | Protein content (%) | |
|-------------------------|-------------------|---------|--------------------|---------|-----------------|---------|---------------------|---------|
| | 1988-89 | 1989-90 | 1988-89 | 1989-90 | 1988-89 | 1989-90 | 1988-89 | 1989-90 |
| Nitrogen levels (kg/ha) | | | | | | | | |
| 0 | 4.68 | 6.22 | 23.16 | 28.96 | 37.20 | 38.19 | 17.31 | 17.43 |
| 30 | 8.20 | 9.20 | 36.05 | 38.16 | 36.61 | 37.92 | 18.06 | 18.44 |
| 60 | 12.38 | 12.80 | 51.80 | 50.41 | 35.97 | 37.44 | 19.06 | 19.18 |
| 90 | 15.12 | 15.24 | 59.17 | 56.82 | 35.67 | 37.42 | 19.63 | 19.50 |
| SEm ± | 0.50 | 0.16 | 0.70 | 0.90 | 0.11 | 0.07 | 0.09 | 0.05 |
| CD at 5 % | 1.43 | 0.46 | 2.02 | 2.56 | 0.31 | 0.20 | 0.25 | 0.14 |
| Sulphur levels (kg/ha) | | | | | | | | |
| 0 | 8.38 | 8.14 | 36.79 | 38.27 | 35.06 | 36.85 | 17.94 | 18.31 |
| 10 | 9.06 | 9.86 | 39.21 | 39.74 | 35.53 | 37.13 | 18.06 | 18.51 |
| 20 | 9.98 | 10.67 | 41.92 | 42.23 | 36.15 | 37.53 | 18.44 | 18.75 |
| 30 | 10.93 | 11.73 | 45.49 | 46.14 | 36.74 | 38.02 | 18.81 | 18.99 |
| 40 | 11.12 | 12.08 | 45.93 | 47.76 | 37.23 | 38.35 | 18.88 | 19.21 |
| 50 | 11.11 | 12.02 | 45.91 | 47.45 | 37.48 | 38.57 | 19.00 | 19.23 |
| SEm ± | 0.61 | 0.19 | 0.86 | 1.10 | 0.13 | 0.08 | 0.11 | 0.07 |
| CD at 5 % | 1.72 | 0.56 | 2.47 | 3.14 | 0.38 | 0.24 | 0.31 | 0.19 |
| N x S | NS | Sig. | NS | NS | NS | NS | NS | NS |

S/ha over an application of no sulphur was of 30.4 and 44.1 during 1988-89 and 1989-90 respectively. Such increase in seed yield was from the corresponding improvement of yield attributing characters. Singh and Bairathi, (1980) has reported increase in chlorophyll content by sulphur application. The stalk yield was also found to increase significantly with the increase in sulphur levels up to 30 kg/ha during both the years (Table 2). Increase in vegetative growth of plants by sulphur levels was ultimately responsible for such increase in stalk yield of mustard. The results are in close conformity with those of Singh (1984) and Saran and Giri (1990).

Interaction effect of N x S was significant during 1989-90 only (Table 3). At lower levels of nitrogen, the mustard responded to sulphur significantly up to 10 kg/ha, however, with increased supply of N (60-90 kg N/ha), the S need of the crop was significantly raised up to 30 kg S/ha. On the other hand, irrespective of levels of sulphur, mustard crop responded to N up to 90 kg/ha.

The response of nitrogen and sulphur was found to be linear and the regression equation is given as under

| Years | Response equation | R ² |
|----------|-----------------------|----------------|
| Nitrogen | | |
| 1988-89 | $Y = 4.77 + 0.1183 x$ | 0.943 |
| 1989-90 | $Y = 6.27 + 0.1022 x$ | 0.931 |
| pooled | $Y = 5.52 + 0.1102 x$ | 0.939 |
| Sulphur | | |
| 1988-89 | $Y = 8.61 + 0.0594 x$ | 0.952 |
| 1989-90 | $Y = 8.81 + 0.0775 x$ | 0.937 |
| Pooled | $Y = 8.72 + 0.0685 x$ | 0.946 |

Where Y = expected grain yield and
x = levels of N and S

Oil content

Nitrogen had adverse effect on oil content of mustard during both the years of experimentation. The rate of nitrogen increased from 0 to 90 kg/ha, the oil content was reduced by 1.53 and 0.77 per cent during 1988-89 and 1989-90, respectively (Table 2). At 90 kg N/ha it was 35.67 and 37.42 % where as at no nitrogen the

Table 3. Interaction effect of N x S levels on mustard seed yield (g/ha)

| N-levels(kg/ha) | 1988-89 | | | | | | |
|-----------------|------------------------|-------|-------|-------|-------|-------|-------|
| | Sulphur levels (kg/ha) | | | | | | |
| | 0 | 10 | 20 | 30 | 40 | 50 | Mean |
| 0 | 3.83 | 4.44 | 4.66 | 5.16 | 5.00 | 4.97 | 4.08 |
| 30 | 6.67 | 7.30 | 7.96 | 9.08 | 9.02 | 9.15 | 8.20 |
| 60 | 10.87 | 11.60 | 12.01 | 13.02 | 13.74 | 13.63 | 12.38 |
| 90 | 12.16 | 13.43 | 15.27 | 16.44 | 16.72 | 16.69 | 15.12 |
| SEm ± | | | 1.21 | | | | |
| CD (P = 0.05) | | | NS | | | | |
| N-levels(kg/ha) | 1989-90 | | | | | | |
| | Sulphur levels (kg/ha) | | | | | | |
| | 0 | 10 | 20 | 30 | 40 | 50 | Mean |
| 0 | 4.49 | 5.93 | 6.10 | 6.70 | 7.19 | 6.89 | 6.22 |
| 30 | 7.63 | 8.74 | 8.96 | 9.79 | 9.97 | 10.13 | 9.20 |
| 60 | 11.01 | 11.15 | 12.24 | 13.89 | 14.20 | 14.30 | 12.80 |
| 90 | 12.21 | 13.62 | 15.36 | 16.54 | 16.96 | 16.76 | 15.24 |
| SEm ± | | | 0.38 | | | | |
| CD (P = 0.05) | | | 1.11 | | | | |

seed oil was higher i.e., 37.20 and 38.19% in first and second season respectively.

Application of sulphur up to 40 kg/ha increased the oil content significantly during both the years. At this sulphur level, the oil content was 37.43 and 38.35%, in first and second season respectively. However, further incremental dose of S i.e., 50 kg/ha was at par with 40 kg S/ha. The interaction effect was not found to be significant. Pathak and Tripathi (1979) and Sawarkar *et al.*, (1987) observed similar results.

Protein content

Seed protein increased significantly with the increasing levels of nitrogen from 0 to 90 kg/ha in both the years. The highest seed protein was 19.63 and 19.50% at 90 kg N/ha, whereas it was only 17.31 and 17.43% at without nitrogen in 1988-89 and 1989-90 respectively.

Application of sulphur enhanced the protein content significantly during both the years. In 1988-89, sulphur application up to 30 kg/ha was found significant over lower levels. At no sulphur level the protein content was 17.94% which increased up to 18.81% at 30 kg S/ha. In 1989-90, increasing levels of S up to 40 kg/ha increased significantly over lower levels and was comparable with 50 kg S/ha. However, maximum protein content i.e., 19.00 and 19.23% was recorded at 50 kg S/ha in 1988-89 and 1989-90 respectively. The interaction effect was not significant. Similar results were also reported by Chatterjee *et al.*, (1985) and Singh and Saran (1987).

It is concluded that 90 kg N and 30 kg S per hectare would be the optimum dose for realising the best growth of plant, seed yield and oil and protein content of mustard crop under irrigated conditions with deep Vertisol

in Tawa Command Area of Central Narmada valley.

LITERATURE CITED

- Chatterjee, B.N., Ghosh, R.K. and Chakraborty, P.K. 1985. Response of mustard to sulphur and micronutrients. *Indian J. Agron.* 30 (1) : 75-78.
- Jackson, M.L. 1970. Soil chemical analysis. Prentice Hall of India, New Delhi.
- Pathak, R.K. and Tripathi, R.D. 1979. Effect of nitrogen and sulphur on yield and quality of rai. *Indian J. agric. Chem.* 12 (2) : 151-157.
- Saran, G. and Giri, G. 1990. Influence of nitrogen, phosphorus and sulphur on mustard under semi-arid rainfed conditions of North-West India. *Indian J. Agron.* 35 (1&2) : 131-136.
- Sawarkar, N.J., Shukla, S.S. and Tomar, P.S. 1987. Effect of sulphur fertilization on yield and quality of mustard. *J. Oilseed Res.* 4 : 227-229.
- Singh, B.P. 1984. Seed yield and quality of mustard as affected by soil profile moisture and rates of sulphur on aridsols. *Madras agric J.* 71 (3) : 163-170.
- Singh, K.S. and Bairathi, R.C. 1980. A study on the sulphur fertilization of mustard (*B.juncea*) in the semi-arid tract of Rajasthan. *Ann. Arid. Zone* 19 (3) : 197-202.
- Singh, R.P., Bhola, A.L. and Yadava, T.P. 1980. Effect of nitrogen levels and row spacings on yield and oil content of Indian mustard. *Oilseeds J.* 10 (1) : 56-57.
- Singh, S.S. and Dixit, R.S. 1989. Response of mustard to various levels of irrigations and nitrogen. *Indian J. Agron.* 34 (3) : 307-311.
- Singh, Sahdev and Saran, G. 1987. Effect of sulphur and nitrogen on growth, yield, quality and nutrient uptake of Indian rapeseed. *Indian J. Agron.* 32 (4) : 474-475.
- Tandon, H.L.S. 1990. Fertilizer recommendations for oilseed crops- A guide Book. Fertilizer Development and Consultation Organisation, New Delhi.

EFFECT OF WATER STRESS AND IRRIGATION SCHEDULE ON PERFORMANCE OF SUMMER SOYBEAN (*GLYCINE MAX* Merrill)

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ABSTRACT

A field experiment was conducted during summer seasons of 1989 and 1991 at the Research Farm of Indira Gandhi Krishi Vishwa Vidyalaya, Raipur to find out the suitable irrigation schedule and critical stages for moisture stress. Irrigation scheduled at 0.9 IW/CPE ratio throughout the crop period produced the maximum number of pods and seeds/plant, seed and straw yield as well as protein content. Water requirement and water use efficiency were also maximum under 0.9 IW/CPE ratio. Moisture stress for 15 days at podding or seed filling stage was found to be more detrimental to crop yield than stress at blooming stage.

Key words: Water stress; Irrigation; IW/CPE ratio; Water use efficiency; Water requirement; Soybean.

INTRODUCTION

Madhya Pradesh is the leading state in the country in respect of area and production of soybean during *kharif*. However, little work has been done to explore the possibilities of growing soybean in *rabi* and summer season. The soil moisture becomes a limiting factor in these seasons. In the absence of rains, the effect of water deficit and scheduling of irrigation at specific or different growth stages of soybean has not been well documented, specially for summer season. The research work done elsewhere revealed that flowering (Singh and Tripathi, 1972), pod filling (Healthery, 1983) and mid flowering and/or rapid pod filling stage (Pahalwan and Tripathi, 1984) were the critical stages for moisture stress, and moisture stress at these stages adversely affected seed yield and yield components. In the light of the above, a field experiment was conducted to identify the critical growth stage, and also the yield components which are most sensitive to water deficit during summer season.

MATERIALS AND METHODS

The experiment was carried out during summer seasons of 1989 and 1991 at Research farm of Indira Gandhi Krishi Vishwa Vidyalaya, Raipur. The soil of experimental site was clayey having pH 6.9 low in available nitrogen (169 kg N/ha), high in available phosphorus (23 kg P/ha) and available potash (336 kg K/ha). The moisture contents at field capacity and permanent wilting point were 27.7 and 18.3 percent, respectively at 0-90 cm soil depth. The bulk density was 1.36 g/cc. Out of different possible combinations of four IW/CPE ratio viz., 0.3, 0.5, 0.7 and 0.9 IW/CPE ratio and three growth stages viz., vegetative (germination to flower initiation), flowering (flower initiation to pod initiation) and podding (pod initiation to maturity). Only seven treatment combinations were selected. The notation used for different irrigation schedules consisted of three ratios of IW/CPE adopted during three growth stages of soybean for instance R 579 represent as irrigation schedules at 0.5 IW/CPE during the vegetative growth, 0.7 IW/CPE during the

flowering and 0.9 IW/CPE during the podding stage.

Three treatments of moisture stress were also studied where irrigation was applied at 0.9 IW/CPE and was maintained throughout the growth period except withholding of irrigation for 15 days at bloom (R.9sb), podding (R.9sp), or seed filling stage (R.9ssf). In all, ten treatments were laid out in Randomized Block Design with three replications. Medium duration dwarf soybean variety Gaurav (JS 72-44) was sown on January 29, 1989 and February 1, 1991. The crop was fertilized with uniform basal dose of 30 kg N, 60 kg P₂O₅ and 20 kg K₂O/ha. Cumulative pan evaporation under different treatments was computed using evaporation data obtained from standard US Weather Bureau class 'A' open pan. The depth of water for each irrigation was 6cm in all the treatments. The water requirement was calculated based on irrigation requirement and rainfall as the stored soil moisture before sowing and after the harvest of the crop was below the permanent wilting point. In general the irrigation were stopped 10 days before harvest.

RESULTS AND DISCUSSION

Yield and yield attributes

Irrigation scheduled at R.999 resulted in substantially higher number of pods and seeds/plant, grain and straw yield over rest of the treatments (Table 1). This is done due to high frequency of irrigation which maintained proper nutrient and moisture supply and helped in better partitioning of photosynthates into different yield components. However, besides saving two or three irrigations a comparable yield was obtained with irrigation schedule of R.777, R.579 and R. 597 during both the years but it was significantly lower than R. 999. The irrigation scheduled at 0.9 IW/CPE ratio throughout the crop period except stress for 15 days at bloom (R.9sb) stage significantly reduced the number of pods and seeds/plant as compared with R. 999. Soybean being an indeterminate type of crop, the stress given at bloom affects seeds/plant due to moisture stress (Laing, 1966). Pahalwan and Tripathi (1984) also observed that seed yield and yield components of field grown soybean were most adversely affected by soil moisture

Table 2. Water requirement, water use efficiency and protein content of soybean as influenced by different irrigation schedules in summer

| Treatments | | | Water requirement (cm) | | Water use efficiency (kg/ha/cm) | | protein content of grain (%) | |
|-------------------|----|----|------------------------|-------|---------------------------------|-------|------------------------------|-------|
| Crop growth stage | | | 1989 | 1991 | 1989 | 1991 | 1989 | 1991 |
| V | F | P | | | | | | |
| R.5 | .5 | .5 | 44.46 | 32.08 | 18.80 | 26.49 | 41.50 | 40.73 |
| R.5 | .7 | .9 | 62.46 | 44.08 | 22.03 | 29.58 | 41.52 | 40.92 |
| R.5 | .9 | .3 | 50.46 | 38.08 | 20.41 | 25.44 | 40.32 | 40.47 |
| R.5 | .9 | .7 | 62.46 | 44.08 | 22.19 | 30.53 | 41.76 | 41.45 |
| R.7 | .3 | .9 | 62.46 | 38.08 | 17.03 | 25.94 | 40.44 | 40.18 |
| R.7 | .7 | .7 | 62.46 | 44.08 | 22.86 | 30.62 | 42.07 | 41.49 |
| R.9 | .9 | .9 | 80.46 | 56.08 | 23.20 | 31.56 | 44.60 | 44.00 |
| R.9sb (15 days) | | | 68.46 | 44.08 | 20.68 | 29.71 | 41.72 | 41.47 |
| R.9sp (15 days) | | | 62.46 | 44.08 | 17.43 | 24.54 | 41.52 | 41.68 |
| R.9ssf (15 days) | | | 62.46 | 38.08 | 17.03 | 24.21 | 39.53 | 40.16 |

Table 1. Yield and yield components of soybean as influenced by different irrigation schedules in summer

| Crop | Treatments | | Pods/plant (number) | | Seeds/plant (number) | | 100 grain weight (g) | | Grain yield (q/ha) | | Straw yield (q/ha) | |
|----------------------------------|------------|-------|---------------------|-------|----------------------|--------|----------------------|-------|--------------------|-------|--------------------|-------|
| | Growth | Stage | 1989 | 1991 | 1989 | 1991 | 1989 | 1991 | 1989 | 1991 | 1989 | 1991 |
| R.5 | .5 | .5 | 37.53 | 38.63 | 88.2 | 88.2 | 11.28 | 12.46 | 8.36 | 8.50 | 15.36 | 16.01 |
| R.5 | .7 | .9 | 50.66 | 45.60 | 137.0 | 120.4 | 11.93 | 12.69 | 13.76 | 13.03 | 23.52 | 22.90 |
| R.5 | .9 | .3 | 38.87 | 41.23 | 90.63 | 95.2 | 11.52 | 12.28 | 10.30 | 9.69 | 17.61 | 15.02 |
| R.5 | .9 | .7 | 48.93 | 46.60 | 125.8 | 122.66 | 12.30 | 12.89 | 13.86 | 13.46 | 22.91 | 23.91 |
| R.7 | .3 | .9 | 44.60 | 40.26 | 101.8 | 98.6 | 12.28 | 12.48 | 10.64 | 9.88 | 17.91 | 16.25 |
| R.7 | .7 | .7 | 58.20 | 47.76 | 151.7 | 123.6 | 12.35 | 12.87 | 14.28 | 13.50 | 22.32 | 23.39 |
| R.9 | .9 | .9 | 63.33 | 61.66 | 172.7 | 163.8 | 13.09 | 12.89 | 18.67 | 17.70 | 29.19 | 28.43 |
| * R.9 ^{sb} (15 days) | | | 50.87 | 47.46 | 140.9 | 123.8 | 12.0 | 12.64 | 14.16 | 13.10 | 21.05 | 22.10 |
| ** R.9 ^{sp} (15 days) | | | 45.60 | 39.00 | 110.1 | 97.4 | 12.10 | 12.39 | 10.89 | 10.82 | 18.16 | 17.76 |
| *** R.9 ^{ssf} (15 days) | | | 45.73 | 42.46 | 109.5 | 89.6 | 11.13 | 12.32 | 10.64 | 9.22 | 17.61 | 16.63 |
| SEm ± | | | 2.48 | 1.64 | 5.55 | 1.41 | 0.55 | 0.45 | 1.57 | 0.76 | 1.78 | 0.94 |
| CD (P = 0.05) | | | 5.21 | 3.44 | 11.67 | 2.96 | NS | NS | 3.31 | 1.63 | 3.75 | 1.97 |

*R.9^{sb} - .9 maintained at all the growth stages and stress at bloom for 15 days** R.9^{sp} - .9 maintained at all the growth stages and stress at podding for 15 days*** R.9^{ssf} - .9 maintained at all the growth stages and stress at seed filling for 15 days

(V = vegetative; F = flowering; P = podding stage)

.3 = 200 ± 2; .5 = 120 ± 2; .7 = 85.5 ± 2; .9 = 66.6 ± 2

stress imposed at mid flowering stage and/or pod filling stage. Irrigation scheduled at R. 739 also reduced the grain yield, indicating that moisture stress at flowering reduced the yield significantly by reducing the number of pods and seeds/plant. Significant reduction in grain and straw yield was recorded when stress was given at podding (R. 9sp) and seed filling stage (R.9ssf). Moisture stress during seed filling stage might have reduced the supply of carbohydrate and other metabolites to the developing sink and resulted in poor or no development of pods and/or seeds/plant and thus resulted in poor yield. This is also confirmed with the treatment of R. 593 where stress was given at seed filling stage which reduced the grain yield.

Water requirement and water use efficiency

The maximum water requirement and water use efficiency was obtained with the irrigation schedule of R. 999 under the agroclimatic conditions of Raipur during summer which was closely followed by the irrigation schedule of R. 777, R. 579 and R. 597. In the present experi-

ment, both water requirement and water use efficiency was maximum under frequent irrigation scheduling mainly because of high evaporation demand in the region where temperature is very high and humidity is very low. The increased water use efficiency was mainly due to increase in seed yield in proportion to the quantity of water used.

LITERATURE CITED

- Heatherly, Larry G. 1983. Stress day index to characterize effects of water stress on crop yields. *Trans. ASAE*, 14: 757-761.
- Laing, D.R. 1966. The water environment of soybean. Ph.D., Thesis, Iowa State University of Science and Technology, Ames, Iowa.
- Pahalwan, D.K. and Tripathi, R.S. 1984. Effect of soil moisture stress during different growth stages of field grown soybean (*Glycine max* Merrill.) *Indian J. Agron.* 29 (9) 559-560.
- Singh, Ambika and Tripathi, N.C. 1972. Effect of moisture stress on soybean (*Glycine max* (L.) Merr.) *Indian J. agric. Sci.* 42 (7) : 582-585.

EFFECT OF INTERCROPPING ON YIELD AND ECONOMICS OF SESAME AND MUNG

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ABSTRACT

A field experiment involving different combinations of sesame with mung was conducted at the BCKV farm from 1987 to 1989 to find out suitable combination of sesame and mung in sandy loam soil of West Bengal in pre-kharif sesame. Intercropping system significantly influenced the yield and yield attributes of sesame and mung. Yield attributes like number of capsules/plant was significantly higher in intercrops over sole crop whereas the number of seeds/capsule was higher in sole crop. In mung also there was beneficial affect of intercropping on yield attributes. sole crop of sesame and mung significantly out yielded intercrops both in seed and stalk yield. There was definite intercropping advantage in intercrops over sole crops. Higher intercropping advantage in respect to seed yield (LER 1.66) and stalk yield (LER 1.11) was recorded in sesame + mung (2:1) and sesame + mung (1:3) treatments respectively. There was 50%, 48%, 47% and 39% yield advantages in sesame + mung 3:4, sesame + mung (1:1), sesame + mung (2:2) and sesame + mung (3:3) treatments, respectively. Highest net profit of Rs. 2401/ha was found in sesame + mung (2:1).

Key words : Intercropping; Sesame; Mung; LER

INTRODUCTION

Intercropping involves growing two or more crops having different growth habits on the same piece of land with the objective that they could utilize the natural resources in a better way resulting in higher production per unit area. This system of cropping also gave better insurance against total crop failure during aberrant weather conditions. In West Bengal, the farmers usually grow mung and sesame as a mixed crop. In this experiment, an attempt has been made to study whether there is any beneficial effect of growing sesame and mung in definite row arrangement and to select the best row combination. Advantages of intercropping in potato with oilseeds and groundnut with other oilseeds has been reported by Singh *et al.*, 1989 and Samui and Roy 1990 respectively.

MATERIALS AND METHODS

A field experiment on intercropping of sesame with mung was conducted at the University farm, Kalyani, West Bengal during pre-kharif seasons of 1987-88 and 1988-89. The soil of the experimental field was sandy loam having total N 90 kg/ha, available P₂O₅ 48 kg/ha, available K₂O 109 kg/ha and pH 7.1. The experiment was laid out in Factorial Randomized Block Design with three replications and there were 12 crop combinations including sole crops (Table 1). The crops were sown on 20th and 28th February during 1987-88 and 1988-89. Mung was harvested on 25th April and 2nd May and sesame on 23rd May and 30th May respectively during 1987-88 and 1988-89 seasons.

The variety used was B 67 (Tilottoma) and B 105 (Panna) in sesame and mung respectively. A fixed spacing of 25 cm between rows of sesame and mung adopted in all treatments.

Table 1. Effect of intercropping on growth and yield attributes of sesame and mung (Pooled value of 1987-88 and 1988-89)

| Treatment | sesame | | | | Mung | | | |
|-------------------|------------------------------|---------------------------|--------------------------|----------------------|------------------------------|---------------------------|--------------------------|----------------------|
| | Plant height at harvest (cm) | No. of capsules per plant | No. of seeds per capsule | 1000 seed weight (g) | Plant height at harvest (cm) | No. of capsules per plant | No. of seeds per capsule | 1000 seed weight (g) |
| Sole sesame | 58.3 | 17.9 | 58.7 | 1.24 | - | - | - | - |
| Sole mung | - | - | - | - | 43.5 | 16.23 | 9.75 | 36.81 |
| Sesame + mung 1:1 | 58.7 | 21.2 | 52.7 | 1.27 | 35.7 | 20.56 | 9.98 | 33.21 |
| Sesame + mung 1:2 | 60.3 | 22.6 | 53.7 | 1.31 | 37.5 | 21.70 | 10.00 | 38.56 |
| Sesame + mung 1:3 | 67.7 | 22.9 | 49.1 | 1.27 | 38.9 | 23.03 | 8.18 | 34.82 |
| Sesame + mung 1:4 | 64.6 | 26.7 | 56.0 | 1.18 | 41.0 | 25.68 | 10.55 | 35.98 |
| Sesame + mung 2:1 | 69.8 | 24.3 | 48.8 | 1.18 | 38.2 | 29.00 | 11.68 | 36.30 |
| Sesame + mung 2:2 | 61.5 | 27.0 | 51.8 | 1.37 | 42.5 | 20.93 | 9.65 | 39.86 |
| Sesame + mung 2:3 | 66.0 | 22.6 | 50.1 | 1.22 | 36.2 | 28.43 | 10.85 | 36.71 |
| Sesame + mung 2:4 | 62.9 | 29.8 | 48.1 | 1.18 | 37.9 | 32.16 | 10.65 | 33.72 |
| Sesame + mung 3:3 | 69.3 | 25.9 | 56.2 | 1.22 | 41.1 | 25.13 | 12.05 | 35.75 |
| Sesame + mung 3:4 | 64.3 | 24.1 | 56.8 | 1.26 | 38.1 | 27.90 | 11.36 | 35.07 |
| SEm ± | 2.8 | 1.4 | 2.2 | 0.1 | 2.0 | 1.8 | 0.98 | 1.46 |
| CD at 5 % | 8.1 | 4.0 | 6.3 | NS | 5.8 | 5.2 | 2.82 | 4.21 |

The crops received 20 kg, 40 kg P₂O₅ and 20 kg K₂O/ha in the form of urea, single super phosphate and muriate of potash respectively. A dose of 20 kg N/ha was top dressed at 21 days after sowing in sesame rows. Irrigation, inter-culture and plant protection measures were undertaken as and when needed.

RESULTS AND DISCUSSION

Growth and yield attributes of sesame

Effect of intercropping system on growth and yield attributes of sesame and mung has been presented in Table 1. Plant height of sesame at harvest was significantly higher in sesame + mung (2:1), sesame + mung (3:1) and sesame + mung (1:3) over sole sesame and sesame + mung (1:1). Number of capsules per plant in sesame was significantly higher in sesame + mung (2:4, 2:2, 1:4 and 3:3) over sole and 1:1. Highest number of seeds/capsule was recorded

in sole sesame followed by sesame + mung (3:4, 3:3 and 1:4). There was no significant difference in 1000 seed weight among treatments.

Yield of sesame

Seed and stalk yields of sesame were significantly influenced by different crop combinations (Table 2). Sole crop of sesame gave higher seed and stalk yields as compared to intercrops in both years. The result is in conformity with the findings of Desai and Goyal (1980). Higher seed yield in intercrops was recorded when two rows of sesame was alternated with one row of mung (2:1) in both years. This might be attributed to improvement of yield components like number of capsules/plant, in intercrop over sole crop. Seed yield was comparatively less in sesame + mung (1:3). Stalk yield was higher when two rows of

sesame was alternated with one row of mung in both years. This might be due to higher plant height which led to higher dry matter production.

Growth and yield attributes of mung

Intercropping system significantly influenced the plant height at harvest (Table 1). Sole mung crop had highest plant height whereas height was lower in sesame + mung (1:1). Sesame + mung (2:2) gave higher plant height among intercrops. Number of pods/plant in mung was significantly higher in sesame + mung (2:4, 2:1 and 2:3) as compared to sole mung and sesame + mung (2:2, 1:1, 1:2, 1:3). Significantly higher number of seeds/pod was observed in sesame + mung (3:3) over sesame + mung (1:3). Thousand seed weight in sesame + mung (2:2) was significantly higher over sesame + mung (1:1, 2:4, 1:3 and 3:4).

Yield of mung

Intercropping had significant influence on seed and stalk yield of mung (Table 2). Sole mung gave significantly higher yield over inter-

crops except sesame + mung (1:1 and 3:4). Higher seed yield of mung was found in sesame + mung (1:1, 3:4, 1:4) among intercrops. The higher seed yield might be due to improvement of yield components like number of pods and number of seeds. Seed yield was lower in sesame + mung (1:2). Stalk yield of mung was higher when one row of sesame was alternated with 3-4 rows of mung. This might be due to more plant population of mung.

Land equivalent ratio (LER)

There was definite advantage of intercropping of sesame with mung in respect to seed yield (Table 3). Highest yield advantage was recorded when two rows of sesame was alternated with one row of mung (2:1). The results corroborate the findings of De (1980), Thorat *et al.*, (1986) and Samui and Roy (1990). The yield advantage was higher in intercrop treatments because the yield attributing characters were found better in intercrops than in sole crops. In case of stalk yield, there was also definite intercropping advantages though of lower magnitude (Table 4). The stalk yield ad-

Table 3. Land equivalent ratio (LER) of seed and stalk yield (Mean value of 1987-88 & 1988-89)

| Treatments | Seed yield | | | Stalk yield | | |
|-------------------|----------------|------|-------|----------------|------|-------|
| | Partial LER of | | Total | Partial LER of | | Total |
| | Sesame | Mung | | Sesame | Mung | |
| Sole Sesame | 1.00 | - | 1.00 | 1.00 | - | 1.00 |
| Sole Mung | - | 1.00 | 1.00 | - | 1.00 | 1.00 |
| Sesame + mung 1:1 | 0.53 | 0.95 | 1.48 | 0.56 | 0.50 | 0.06 |
| Sesame + mung 1:2 | 0.47 | 0.77 | 1.24 | 0.36 | 0.72 | 1.08 |
| Sesame + mung 1:3 | 0.43 | 0.85 | 1.28 | 0.31 | 0.80 | 1.11 |
| Sesame + mung 1:4 | 0.51 | 0.87 | 1.38 | 0.21 | 0.77 | 0.98 |
| Sesame + mung 2:1 | 0.82 | 0.84 | 1.66 | 0.66 | 0.29 | 0.95 |
| Sesame + mung 2:2 | 0.68 | 0.79 | 1.47 | 0.46 | 0.47 | 0.93 |
| Sesame + mung 2:3 | 0.57 | 0.83 | 1.34 | 0.47 | 0.62 | 1.09 |
| Sesame + mung 2:4 | 0.47 | 0.79 | 1.26 | 0.39 | 0.64 | 1.03 |
| Sesame + mung 3:3 | 0.59 | 0.80 | 1.39 | 0.51 | 0.45 | 0.96 |
| Sesame + mung 3:4 | 0.54 | 0.96 | 1.50 | 0.36 | 0.54 | 0.90 |

vantage was highest (LER 1.11) when one row of sesame was alternated with three rows of mung. Similar results were reported by Samui *et al.*, (1986). Therefore, it may be concluded that intercropping of sesame with mung in the ratio of 2S:1M, 3S:4M, 1S:1M or 2S:2M may be

Table 4. Economics of intercropping systems

| Treatments | Net return (Rs.) | Net profit over sole cropping (Rs.) |
|-------------------|------------------|-------------------------------------|
| Sole sesame | 4458 | - |
| Sole mung | 3400 | - |
| Sesame + mung 1:1 | 5474 | 1545 |
| Sesame + mung 1:2 | 4565 | 636 |
| Sesame + mung 1:3 | 4876 | 947 |
| Sesame + mung 1:4 | 5084 | 1155 |
| Sesame + mung 2:1 | 6330 | 2401 |
| Sesame + mung 2:2 | 5597 | 1668 |
| Sesame + mung 2:3 | 4757 | 828 |
| Sesame + mung 2:4 | 4639 | 710 |
| Sesame + mung 3:3 | 5222 | 1293 |
| Sesame + mung 3:4 | 5518 | 1589 |

practised for higher production of mung and sesame.

It is seen from Table 4 that highest net profit (Rs. 2401) was observed in Sesame + mung (2:1), followed by 2:2 (Rs. 1668).

LITERATURE CITED

- De, G.C. 1980. Effect of row orientation and different proportion of sesame and blackgram under intercrop situation. *Madras agric. J.* 67: 695-697.
- Desai, N.D. and Goyal, S. N. 1980. Intercropping of sesame with other oilseed crops. *Indian J. Agric. Sci.* 50: 603 - 605.
- Singh, V. P., Hooda, R.S., Faroda, A.S. and Sharma, H.C. 1980. Effect of different intercrops and fertility levels on the yield and economics of potato. *Crop Res.* 2: 180-184.
- Samui, R.C. and Roy, A. 1990. Possibilities of increasing production oilseeds through intercropping system. *J. Oilseeds Res.* 7: 14- 21.
- Thorat, S. T., Sanune, S. P. and Chavan, S. A. 1986. Intercropping of some pulses and oilseeds in Kharif. *J. Maharashtra agric Univ.* 11: 286-271.

EFFECT OF CO₂ FERTILIZATION, LIGHT ENRICHMENT AND TRIACONTANOL SPRAYS IN SUNFLOWER-SOYBEAN INTERCROPPING*

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ABSTRACT

A field experiment was conducted during *kharif* seasons of 1988 and '89 at Main Research Station, University of Agricultural Sciences, Bangalore to study the effect of CO₂, light enrichment and triacontanol sprays in and intercropping system of sunflower and soybean. The leaf area index and dry matter of sunflower improved, whereas the seed filling per cent and harvest index decreased due to reduced duration of sunflower by about 5 days by CO₂ fertilization which consequently brought no changes in seed yields compared with controls. Light enrichment increased the seed yield by 1.3 q/ha due to increased dry matter and seed filling per cent. Triacontanol sprays also improved the seed yield by about 0.66 q/ha over no sprays due to increased chlorophyll content, dry matter and seed filling per cent. The seed yield of soybean enhanced due to CO₂ fertilization by about 2.25 q per ha. Higher leaf area index and total dry matter resulted in increased number of pods and hence the harvest index and seed yield. Neither light enrichment nor triacontanol influenced the seed yield of soybean. However, triacontanol significantly enhanced the chlorophyll content of leaves and crude protein content of seed in sunflower and soybean. The gross income from intercropping increased by individual effects of CO₂ fertilization (by Rs. 1026 / ha), light enrichment (by Rs.681 / ha) and triacontanol application (by Rs.450 / ha), over the two years study due to enhanced total leaf area index, total biomass production, seed yield of intercrops and the total oil yield.

Key Words : CO₂; Light; Triacontanol; Sunflower; Soybean; Intercropping

INTRODUCTION

Intercropping of sunflower and soybean was found promising in terms of higher seed and oil yield and greater stability in its performance over different seasons (Shivaramu, 1990). However in sunflower, one of the major problems is seed filling although nutrition, hand pollination and growth regulators spray were found marginally effective (Krishnegowda, 1983). In addition, in high density cropping such as intercropping systems, inadequate light at the middle and lower strata of the canopy greatly affects the productivity of soybean and it is further aggravated during *kharif* season which is characterized by several cloudy rainy days. As there is a dearth of information on the effects of light intensity, CO₂ concentration and Triacontanol on the seed filling of sunflower and the yield of soybean, the present

investigation was taken up in the sunflower-soybean intercropping system.

MATERIALS AND METHODS

A field experiment was conducted at main research station of the University of Agricultural Sciences, Hebbal, Bangalore on a red sandy loam soil during *kharif* 1988 and 1989. Eight treatment combinations from out of three factors of two levels each viz., CO₂ (ambient CO₂ and approximately 800 ppm CO₂), light (normal sunlight and light enrichment with 25% more than normal) and Triacontanol (no Tria and 3 sprays of Tria) were compared in Randomised Block Design with three replications. Sunflower was grown in uniform rows of 75 cm x 16 cm with 0.83 lakh plants per ha and two rows of soybean having 2.67 lakh plants per ha at 10 cm between the plants were introduced in between the sunflower rows.

For CO₂ enrichment, the technique as followed by Shivashankar and Vlassak (1978) was adopted in the present study. About 800 ppm of CO₂ was maintained in the chambers during sunshine hours from 8.30 a.m. to 5.00 p.m. for 60 days from 30th day after sowing (DAS). The CO₂ concentration was measured by using CO₂ analyser (ADC, LCA2-10009). Light enrichment to respective plots was made through reflection of sunlight by aluminium sheets measuring 3 m length and 1.25 m width, inclined at 30° to the vertical plane or around 53° to the sun rays at 12 noon. The sheets were kept parallel to the crop rows (i.e., in East-West direction). The light enrichment was done during the same period as of CO₂ fertilization. The light intensity was measured using tube solarimeter and it was around 25 per cent higher in light enriched plots than control.

Triacontanol is the trade name of 'GRINIT' was sprayed to the respective treatments three times viz., button stage (40 DAS), at mid flowering (55 DAS) and at mid seed filling (75 DAS) stages of sunflower at 0.05 ppm using 500 litres of spray mixture per ha.

Leaf area index (LAI) of individual intercrops, and dry matter (DM) per plant at maturity were estimated. The combined LAI and total biomass yield of the intercropping system was also estimated. The chlorophyll content of leaves was estimated by the method of Hiscox and Israelstam (1979). The seed yield and its parameters viz., seed filling per cent in sunflower, the number of pods per plant in soybean and harvest index were recorded. Crude protein content of soybean seeds was obtained by multiplying nitrogen content with a factor of 6.25. Oil content in seeds was determined by Nuclear Magnetic Resonance Spectrometer and oil yield was calculated using oil per cent in seed and seed yield obtained per ha.

RESULTS AND DISCUSSION

1. Response of sunflower and soybean to CO₂ fertilization

The LAI of sunflower (Table 1) at 68 DAS was significantly improved by CO₂ fertilization and consequently the total dry matter production at maturity also improved, while the seed filling was significantly lower resulting in no increase in seed yield. Further, the duration of sunflower was shortened by 5 days and the maturity was abruptly hastened when CO₂ was provided. Reduction in duration of sole sunflower by 10 days due to CO₂ fertilization was observed by Mauney *et al.*, (1978) who opined that this phenomenon was common in determinate types where the entire stem apex is ended with an inflorescence unlike indeterminate types like soybean. Yet another cause of a low response of sunflower to CO₂ enrichment might be because of the nature of CO₂ trying to sink to the ground level, being heavier than air. Thus it is the component crop of soybean which made use of this additional CO₂ better for its growth and development.

In contrast to improved growth and no yield response to CO₂ in the base crop of sunflower, soybean responded well in terms of growth and yield attributes to CO₂ enrichment at around 800 ± 75 ppm in the intercropping system (Table 2). There was an improvement in LAI, DM production, number of pods per plant and harvest index as compared to no CO₂ fertilization. All these finally resulted in increased seed yield of soybean which, being a legume, is known to respond to CO₂ by improvements in growth, nodulation and yield (Shivashankar and Vlassak, 1978).

With regard to intercropping system as a whole, the combined LAI of sunflower and soybean was improved besides total biomass yield. The oil yield was also improved (Table 4). The gross income realised from intercropping was thus substantial with a rise of Rs. 703 per

Table 2. Leaf area index, total dry matter, number of pods, seed yield, harvest index of soybean as influenced by CO₂ fertilization, light enrichment and Triacontanol sprays in sunflower-soybean intercropping system

| Treatments | LAI at 68 DAS | | TDM at maturity (g/plant) | | No. of pods/plant | | Seed yield (q/ha) | | Harvest Index | |
|--------------------|---------------|------|---------------------------|------|-------------------|------|-------------------|-------|---------------|-------|
| | 1988 | 1989 | 1988 | 1989 | 1988 | 1989 | 1988 | 1989 | 1988 | 1989 |
| 1. CO ₂ | | | | | | | | | | |
| Control | 2.18 | 1.54 | 11.22 | 8.09 | 16.3 | 15.0 | 9.42 | 7.54 | 0.475 | 0.518 |
| + CO ₂ | 2.61 | 1.85 | 13.54 | 9.86 | 19.9 | 18.2 | 11.46 | 10.00 | 0.502 | 0.545 |
| 'F' test | ** | ** | ** | ** | ** | ** | ** | ** | ** | NS |
| 2. Light | | | | | | | | | | |
| Control | 2.31 | 1.65 | 12.12 | 8.60 | 17.6 | 16.0 | 10.18 | 8.50 | 0.484 | 0.531 |
| + light | 2.43 | 1.75 | 12.63 | 9.35 | 18.6 | 17.3 | 10.75 | 9.04 | 0.494 | 0.532 |
| 'F' test | NS | NS | ** | * | * | NS | NS | NS | NS | NS |
| 3. Triacontanol | | | | | | | | | | |
| Control | 2.30 | 1.63 | 12.16 | 8.80 | 17.7 | 16.3 | 10.09 | 8.58 | 0.492 | 0.532 |
| + Tria | 2.49 | 1.76 | 12.59 | 9.35 | 18.6 | 17.0 | 10.84 | 8.96 | 0.486 | 0.531 |
| 'F' test | ** | * | NS | ** | ** | NS | NS | NS | NS | NS |
| SEm ± | 0.03 | 0.04 | 0.19 | 0.10 | 0.2 | 0.2 | 0.25 | 0.20 | 0.006 | 0.10 |
| CD at 5% | 0.09 | 0.12 | 0.57 | 0.29 | 0.6 | 0.8 | 0.74 | 0.61 | 0.016 | - |
| CV (%) | 4.4 | 8.3 | 5.3 | 3.7 | 3.9 | 5.3 | 8.1 | 7.9 | 3.7 | 6.1 |

* Significant at 5%; ** Significant at 1%

ha in first year and Rs. 950 per ha in the second year.

2. Response of sunflower and soybean to light enrichment

In *khurif* season under the prevailing low light intensities and duration, the effect of enhanced light through reflections offered by aluminium foils at the borders of the plots have been considerable as is seen from the growth and yield of sunflower component (Table 1). The dry matter per plant was enhanced besides seed filling during both the years due to light enrichment. These results are in agreement with the findings of Rawson *et al.*, (1984). The seed yield was ultimately increased. Rawson and Hindmarsh (1983) also reported similar results. The effect of light enrichment was not significant on seed yield of soybean although it had significant effect on the number of pods

per plant (Table 2). The growth parameters also showed no response to light enrichment except in the second year, where the dry matter per plant was enhanced significantly. Supplemental light was equally beneficial as that of CO₂ in improving the combined LAI, total biomass, total oil yield and finally the gross income (Table 4).

3. Response of sunflower and soybean to Triacontanol applications

Triacontanol sprays at three crop growth stages of sunflower brought significant improvement in the seed yields (Table 4). Improvement in chlorophyll content of leaves (Table 3), total DM and seed filling per cent (Table 1) were responsible for increased seed yield of sunflower. These results corroborate the findings of Prasanna (1987).

Table 4. Total leaf area index, total biomass and oil yield and gross income from sunflower-soybean intercropping system as influenced by CO₂ fertilization, light enrichment and Triacantanol application

| Treatments | Total LAI | | Total biomass yield (q/ha) | | Total oil yield (q/ha) | | Gross income (Rs. /ha) | |
|--------------------------|-----------|------|----------------------------|------|------------------------|------|------------------------|------|
| | 1988 | 1989 | 1988 | 1989 | 1988 | 1989 | 1988 | 1989 |
| 1. CO₂ | | | | | | | | |
| Control | 3.25 | 3.30 | 42.7 | 52.0 | 6.67 | 5.02 | 6631 | 8126 |
| + CO ₂ | 3.79 | 3.84 | 48.2 | 59.6 | 7.19 | 5.41 | 7334 | 9076 |
| 'F' test | ** | * | ** | ** | ** | ** | ** | ** |
| 2. Light | | | | | | | | |
| Control | 3.45 | 3.44 | 43.4 | 54.1 | 6.63 | 4.89 | 6640 | 8287 |
| + Light | 3.60 | 3.71 | 47.5 | 57.6 | 7.24 | 5.53 | 7325 | 8915 |
| 'F' test | * | * | ** | ** | ** | ** | ** | ** |
| 3. Triacantanol | | | | | | | | |
| Control | 3.40 | 3.30 | 44.0 | 54.8 | 6.75 | 5.04 | 6757 | 8427 |
| + Tria | 3.65 | 3.84 | 46.9 | 56.8 | 7.12 | 5.39 | 7208 | 8775 |
| 'F' test | ** | ** | ** | * | ** | ** | * | * |
| SEm ± | 0.04 | 0.08 | 0.5 | 0.6 | 0.06 | 0.06 | 135 | 118 |
| CD at 5% | 0.13 | 0.25 | 1.7 | 1.9 | 0.20 | 0.17 | 410 | 358 |
| CV (%) | 4.3 | 8.0 | 4.2 | 3.9 | 3.2 | 3.6 | 6.7 | 4.7 |

* Significant at 5%; ** Significant at 1%

Table 3. Effect of Triaccontanol on leaf chlorophyll content of sunflower and soybean (in 1989) and crude protein content of soybean seeds

| Treatments | Chlorophyll in sunflower (mg/g fresh leaf) | | Chlorophyll in soybean (mg/g fresh leaf) | | Crude protein in soybean (%) | |
|------------|---|-------|---|-------|---------------------------------|-------|
| | Total | Chl.b | Total | Chl.b | 1988 | 1989 |
| Control | 2.18 | 0.59 | 4.07 | 1.64 | 44.62 | 44.90 |
| + Tria | 2.29 | 0.63 | 4.34 | 1.71 | 45.70 | 45.95 |
| 'F' test | ** | NS | ** | ** | ** | ** |
| SEm ± | 0.01 | 0.01 | 0.04 | 0.03 | 0.19 | 0.18 |
| CD at 5% | 0.04 | | 0.11 | 0.01 | 0.57 | 0.53 |
| CV (%) | 1.8 | 6.3 | 3.0 | 2.2 | 1.4 | 1.3 |

* Significant at 5%; ** Significant at 1%

Spraying Triaccontanol to soybean intercrop at three stages significantly enhanced the LAI, DM production (Table 2), chlorophyll content (Table 3) and the number of pods per plant (Table 1). However, the effect of Triaccontanol on the above parameters was marginal and inconsistent over two years resulting in non-significant seed yield (Table 2). In studies by Jourdan and Oplinger (1983), no response of soybean has been reported. It is probably that Triaccontanol would fare better in pure soybean with no limitation of light. The effect of Triaccontanol was significant in producing total LAI and total biomass yield (Table 4) but to a slightly lesser extent than the other two factors. The oil yield and gross income were improved.

Thus, these results lend support to the practical considerations of augmenting the overall productivity of sunflower-soybean intercropping through CO₂ and light enrichments and use of Triaccontanol sprays.

LITERATURE CITED

- Mauney, J.R., Fry, K.E. and Gruinn, G. 1978. Relationship of photosynthetic rate to growth and fruiting of cotton, soybean, sorghum and sunflower. *Crop Sci.* 18(2): 259-263.
- Shivashankar, K and Vlassak, K. 1978. Influence of straw and CO₂ on N₂ fixation and yield of field grown soybeans. *Pl. and Soil* 49: 259-266.
- Hiscox, J.D. and Isrealstam, G.F. 1979. A method of extraction of chlorophyll from leaf tissue without maceration. *Canadian J. Bot.* 57: 1332.
- Jourdan, S.W. and Oplinger, E.S. 1983. Evaluation of Triaccontanol as a potential soybean growth regulant. *Pl. Growth Regulator Bull.* 11(4): 6-8.
- Krishnegowda, K.T. 1983. Agronomic investigations on problem of poor seed set and yield of sunflower (*Helianthus annuus* L.) Ph.D. Thesis, University of Agricultural Sciences, Bangalore, Karnataka.
- Rawson, H.M. and Hindmarsh, J.H. 1983. Light, leaf expansion and seed yield in sunflower. *Aust. J. Pl. Physiol.* 10: 25-30.
- Rawson, H.M., Dustone, R.L., Long, M.S. and Begg, J.E. 1984. Canopy development, light interception and seed production in sunflower as influenced by temperature and radiation. *Aust. J. Pl. Physiol.* 14(4): 255-265.
- Prasanna, K.T. 1987. Influence of Triaccontanol on carbon exchange rate, growth and productivity in a few crop plants. Ph.D., Thesis, University of Agricultural Sciences, Bangalore, Karnataka.
- Shivaramu, H.S. 1990. Productivity of sunflower-soybean intercropping system as influenced by canopy architecture, CO₂ fertilization, Triaccontanol, light enrichment, lime and organic amendments. Ph.D., Thesis, University of Agricultural Sciences, Bangalore, Karnataka.

EFFECT OF IRRIGATION AND FERTILIZATION ON GROWTH AND YIELD IN SESAME

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ABSTRACT

Field experiments were conducted during summer 1988 and 1989 to analyse the growth and yield of sesame (var. Rajeshwari) in relation to irrigation (0.6, 0.9 and 1.2 irrigation water depth/ cumulative pan evaporation ratio), N (0, 40 and 80 kg/ha) and P (0,13 and 26 kg/ha) fertilization. Scheduling of irrigations at 0.9 ID/CPE ratio showed significantly positive effects on dry matter production, leaf area index, leaf area duration, crop growth rate, capsules and seeds/plant and test weight, which in turn contributed to more seed yield/plant. On the other hand irrigation either at 0.6 or 1.2 ID/CPE showed significant adverse effects on growth and yield when compared to 0.9 ID/CPE ratio. Increasing N and P levels significantly increased the seed yield. This improvement was primarily due to increase in capsules/ plant, seeds/ plant and test weight. However, the response to increasing levels of N was more pronounced when compared to P application owing to variations in inherent fertility.

Key words: Sesame; Growth analysis; Irrigation; Nitrogen; Phosphorus.

Sesamum indicum L. popularly known as sesame is widely grown in the irrigation districts of peninsular India during summer because it is commercially viable, matures within 80-85 days, fits well in the existing turmeric, rice and groundnut based cropping systems and also ensures timely sowing of succeeding monsoon crop. Although some studies have shown that limited water supply to sesame imposes restriction on canopy development through various physiological process (Vyas *et al.*, 1987), no field studies have been reported on the detailed growth analysis in relation to irrigation, N and P. The present paper deals with the effect of irrigation, N and P fertilization on dry matter production and seed yield of sesame.

MATERIALS AND METHODS

Field experiments were conducted during summer 1988 and 1989 at Agricultural College Farm, Marathwada Agricultural University, Parbhani, India (19° 16' N-latitude, 76° 47' E-longitude and 409 m altitude). The experimental soil was vertisol, slightly alkaline in reaction (pH 8.1) and low in N and P and high

in K. The soil moisture retentivity at -0.033 and -1.5 MPa were 0.456cm³/cm³ and 0.206cm³/cm³, respectively; its bulk density was 1.3 g/cm³.

The treatments three levels of irrigation viz., 0.6, 0.9 and 1.2 ID/CPE ratio, in combination with 0,40 and 80 kg N/ha and 0,13 and 26 kg P/ha were tested in 3³ (3 x3 x3) partially confounded design in two replications with block size of nine plots each. Second order interaction was confounded with the block. The measured quantity of irrigation water was delivered in each plot with a 50mm water meter attached to the main water source. The irrigation water depth was 6.0cm and CPE was measured from USWB pan evaporimeter. The crop was sown on 26 and 29 January in 1988 and 1989, respectively at 45cm x 15cm spacing using 1.0 kg seed rate/ha to achieve a desired plant population of 1.48 lakh/ha. The crop in all the experimental units received 24.9 kg K/ha as basal application. Other recommended agronomic and plant protection measures were adhered to. Relative leaf water content was measured in each treatment prior to and one

day after each irrigation (Delvin and Witham, 1986).

Five plants in each plot were randomly selected and uprooted at 30, 45, 60 and 75 DAS for determining dry matter and leaf area/plant. From these data leaf area index (LAI), net assimilation rate (NAR, $\text{g/m}^2/\text{day}$), crop growth rate (CGR, g/day), leaf area duration (LAD, dm^2/day) were computed according to the procedure described by Hunt (1978). The effect of various treatments on capsules/plant, seeds/plant, test weight (g), harvest index and seed yield/plant was also recorded.

RESULTS AND DISCUSSION

Dry matter/plant, LAI and LAD followed a sigmoid pattern with crop ontogeny (Table 1 and 2). Irrigations scheduled at 0.9 ID/CPE ratio produced significantly higher dry matter/plant, LAI and LAD when compared to either 0.6 or 1.2 ID/CPE ratio in both the seasons. Likewise the rate of dry matter accumulation (CGR) was also significantly higher with 0.9 ID/CPE ratio. The higher LAI and LAD in the 0.9 ID/CPE ratio were due to favourable plant water balance as reflected by the RWC, which were 81.4, 81.0 and 81.7 per cent at vegetative, flowering and seed filling stages, respectively contributing to more CGR and dry matter/plant. The corresponding values of RWC under 0.6 ID/CPE ratio were 76.1, 75.6 and 75.4 per cent (Vyas *et al.*, 1987). On the other hand lower values for LAI, LAD and CGR in 1.2 ID/CPE ratio might have been due to reduced aeration in the crop root zone because of high frequency irrigation, interfering with the plant water uptake ($\text{RWC} < 75$ per cent at all the crop growth phases) since root activity requires energy. These results are in conformity with the findings of Hack (1980). Each higher level of N significantly enhanced the LAI, LAD, CGR and dry matter/plant over its preceding level at all the crop growth phases and in both the seasons. Similarly each successive dose of P significantly improved the LAI

and dry matter/plant except that the difference between dry matter recorded at no P and 13 kg P/ha at 30 DAS in 1988 and 1989 was not significant. With regard to LAD, application of 13 and 16 kg P/ha were equally effective and significant over no P at all the stages in both the seasons. Although there was a clear trend of significant increase in the CGR with increase in the level of P from 0 to 26 kg P/ha, the difference between no P and 13 kg P/ha at 0-30 DAS (1988) and 45-60 and 60-75 DAS (1989) and that between 13 and 26 kg P/ha at all the stages except 30-45 DAS were not significant. The beneficial effect of N and P application on LAI, LAD and CGR and dry matter/plant were also reported by Chakraborty *et al.*, (1984) and Deshmukh (1988).

Similar values for NAR in all the treatments (irrigation, N and P) during both the seasons suggested that the LAI limited the CGR and dry matter accumulation in 0.6 and 1.2 ID/CPE ratio. Thus it can be concluded that the leaf development (LAI and LAD) and not the photosynthetic efficiency limits sesame dry matter production under soil water and nutrient stresses. Similarly, the irrigation, N and P treatments did not exhibit any significant effect on CGR at all the stages and in both the seasons.

The capsules/plant, seeds/plant, test weight and harvest index (HI) were significantly more when irrigations were scheduled at 0.9 ID/CPE ratio as compared to either 0.6 or 1.2 ID/CPE (Vyas *et al.*, 1987). On the other hand there was significant increase in capsules/plant, seeds/plant and test weight with successive dose of N and P in both the seasons (Table 3). However, the differences between test weight recorded at 40 and 80 kg N/ha in 1988 and that between capsules/plant (1989) and test weight (1988) recorded at 13-26 kg P/ha were not significant. The linear increase in yield attributes with N fertilization was due to adequate supply of photosynthates and part-

Table 1. Dry matter accumulation and leaf area index in relation to irrigation and fertilization

| Treatments | Days after sowing | | | | | | | |
|------------------------------------|-------------------|-------|-------|-------|-------|-------|-------|-------|
| | 30 | | 45 | | 60 | | 75 | |
| | 1988 | 1989 | 1988 | 1989 | 1988 | 1989 | 1988 | 1989 |
| Dry matter accumulation (g) | | | | | | | | |
| ID/CPE ratio (I) | | | | | | | | |
| 0.6 | 0.25 | 0.23 | 6.95 | 8.97 | 15.24 | 17.16 | 18.43 | 20.78 |
| 0.9 | 0.30 | 0.38 | 9.21 | 12.17 | 18.30 | 21.96 | 22.59 | 24.45 |
| 1.2 | 0.22 | 0.18 | 4.43 | 6.39 | 8.57 | 13.23 | 12.03 | 17.78 |
| N (kg/ha) | | | | | | | | |
| 0 | 0.21 | 0.21 | 4.32 | 6.51 | 8.93 | 12.47 | 11.83 | 15.26 |
| 40 | 0.26 | 0.26 | 6.94 | 9.27 | 14.45 | 17.93 | 18.50 | 21.19 |
| 80 | 0.31 | 0.31 | 9.33 | 11.71 | 08.72 | 21.95 | 22.99 | 26.57 |
| P (kg/ha) | | | | | | | | |
| 0 | 0.24 | 0.25 | 5.77 | 8.43 | 12.14 | 16.41 | 15.62 | 19.87 |
| 13 | 0.26 | 0.26 | 6.89 | 9.21 | 13.93 | 17.47 | 17.99 | 21.00 |
| 26 | 0.27 | 0.27 | 7.92 | 9.89 | 16.02 | 18.46 | 19.99 | 22.15 |
| CD (P = 0.05) for I or N or P | 0.037 | 0.017 | 0.39 | 0.55 | 1.30 | 0.75 | 1.00 | 0.89 |
| Leaf area index | | | | | | | | |
| ID/CPE ratio | | | | | | | | |
| 0.6 | 0.071 | 0.087 | 0.886 | 0.764 | 1.543 | 1.849 | 1.930 | 2.333 |
| 0.9 | 0.092 | 0.102 | 1.209 | 1.083 | 1.894 | 2.068 | 2.893 | 2.603 |
| 1.2 | 0.059 | 0.061 | 0.697 | 0.626 | 1.350 | 1.606 | 1.812 | 2.044 |
| N (kg/ha) | | | | | | | | |
| 0 | 0.060 | 0.068 | 0.688 | 0.587 | 1.321 | 1.464 | 1.754 | 1.863 |
| 40 | 0.077 | 0.083 | 0.969 | 0.821 | 1.642 | 1.882 | 2.078 | 2.370 |
| 80 | 0.085 | 0.098 | 1.136 | 1.065 | 1.824 | 2.077 | 2.270 | 2.747 |
| P (kg/ha) | | | | | | | | |
| 0 | 0.069 | 0.079 | 0.811 | 0.758 | 1.467 | 0.765 | 1.914 | 2.245 |
| 13 | 0.073 | 0.084 | 0.950 | 0.833 | 1.600 | 1.848 | 2.040 | 2.333 |
| 26 | 0.080 | 0.086 | 1.032 | 0.882 | 0.719 | 1.911 | 2.148 | 2.402 |
| CD (P = 0.05) for I or N or P | 0.003 | 0.000 | 0.044 | 0.019 | 0.063 | 0.050 | 0.045 | 0.050 |

Table 2. Leaf area duration and crop growth rates in relation to irrigation and fertilization

| Treatments | Days after sowing | | | | | | | |
|---|-------------------|--------|-------|-------|-------|-------|-------|-------|
| | 0-30 | | 30-45 | | 45-60 | | 60-75 | |
| | 1988 | 1989 | 1988 | 1989 | 1988 | 1989 | 1988 | 1989 |
| Leaf area duration (dm²d) | | | | | | | | |
| ID/CPE ratio (I) | | | | | | | | |
| 0.6 | 7.2 | 8.8 | 48.5 | 43.0 | 123.1 | 132.2 | 175.8 | 211.7 |
| 0.9 | 9.4 | 10.3 | 65.9 | 60.0 | 157.1 | 159.5 | 215.3 | 236.5 |
| 1.2 | 6.0 | 6.2 | 38.3 | 34.8 | 103.6 | 113.1 | 160.1 | 184.8 |
| N (kg/ha) | | | | | | | | |
| 0 | 6.1 | 7.0 | 37.8 | 33.2 | 101.7 | 103.9 | 155.7 | 168.4 |
| 40 | 7.8 | 8.4 | 52.9 | 45.8 | 132.1 | 136.9 | 188.2 | 215.3 |
| 80 | 8.6 | 10.0 | 61.8 | 58.9 | 149.8 | 164.1 | 207.3 | 249.3 |
| P (kg/ha) | | | | | | | | |
| 0 | 7.0 | 8.0 | 44.5 | 42.4 | 115.3 | 127.7 | 171.2 | 203.0 |
| 13 | 7.4 | 8.5 | 51.8 | 46.4 | 129.1 | 135.8 | 184.3 | 211.7 |
| 26 | 8.1 | 8.7 | 56.3 | 49.0 | 139.3 | 141.4 | 195.7 | 218.4 |
| CD (P = 0.05) for I or N or P | 0.7 | 0.6 | 5.2 | 3.7 | 11.1 | 7.7 | 12.5 | 11.0 |
| Crop growth rate (g/day) | | | | | | | | |
| ID/CPE ratio | | | | | | | | |
| 0.6 | 0.008 | 0.007 | 0.446 | 0.583 | 0.552 | 0.545 | 0.212 | 0.241 |
| 0.9 | 0.010 | 0.012 | 0.593 | 0.786 | 0.605 | 0.652 | 0.304 | 0.165 |
| 1.2 | 0.007 | 0.006 | 0.280 | 0.410 | 0.276 | 0.459 | 0.231 | 0.303 |
| N (kg/ha) | | | | | | | | |
| 0 | 0.007 | 0.007 | 0.273 | 0.419 | 0.307 | 0.397 | 0.193 | 0.185 |
| 40 | 0.008 | 0.009 | 0.445 | 0.599 | 0.500 | 0.577 | 0.270 | 0.217 |
| 80 | 0.010 | 0.010 | 0.601 | 0.760 | 0.625 | 0.682 | 0.284 | 0.308 |
| P (kg/ha) | | | | | | | | |
| 0 | 0.008 | 0.008 | 0.368 | 0.544 | 0.425 | 0.532 | 0.231 | 0.229 |
| 13 | 0.008 | 0.009 | 0.442 | 0.596 | 0.469 | 0.550 | 0.251 | 0.234 |
| 26 | 0.009 | 0.009 | 0.510 | 0.638 | 0.539 | 0.574 | 0.264 | 0.245 |
| CD (P = 0.05) for I or N or P | 0.0009 | 0.0009 | 0.060 | 0.031 | 0.036 | 0.025 | 0.011 | 0.012 |

Table 3. Yield and yield components of sesame as influenced by irrigation and fertilization

| Treatments | Capsules/plant | | Seeds/plant | | Test weight (g) | | Harvest index | | Seed yield/plant | |
|--|----------------|------|-------------|------|-----------------|-------|---------------|-------|------------------|-------|
| | 1988 | 1989 | 1988 | 1989 | 1988 | 1989 | 1988 | 1989 | 1988 | 1989 |
| ID/CPE ratio (I) | | | | | | | | | | |
| 0.6 | 40 | 51 | 2546 | 2949 | 3.325 | 3.274 | 0.454 | 0.502 | 8.24 | 9.64 |
| 0.9 | 57 | 64 | 3282 | 3841 | 3.540 | 3.530 | 0.479 | 0.540 | 1.46 | 12.24 |
| 1.2 | 37 | 42 | 1839 | 2374 | 8.715 | 2.835 | 0.462 | 0.438 | 5.48 | 6.73 |
| N (kg/ha) | | | | | | | | | | |
| 0 | 39 | 41 | 2070 | 2318 | 2.900 | 2.874 | 0.501 | 0.507 | 5.88 | 6.61 |
| 40 | 47 | 55 | 2619 | 3181 | 3.278 | 3.299 | 0.462 | 0.506 | 8.50 | 10.14 |
| 80 | 52 | 62 | 2977 | 3666 | 3.397 | 3.466 | 0.432 | 0.468 | 9.81 | 11.85 |
| P (kg/ha) | | | | | | | | | | |
| 0 | 43 | 50 | 2319 | 2881 | 3.057 | 0.134 | 0.470 | 0.493 | 7.20 | 8.84 |
| 13 | 46 | 53 | 2576 | 3061 | 3.211 | 3.211 | 0.475 | 0.498 | 8.17 | 9.55 |
| 26 | 49 | 55 | 2773 | 3223 | 3.312 | 3.294 | 0.450 | 0.489 | 8.82 | 10.21 |
| CD (P = 0.05) for I or N or P | 2.6 | 2.6 | 1131 | 72 | 0.120 | 0.052 | 0.014 | 0.034 | 0.64 | 0.33 |

ly due to poor N status of experimental soil. While the variable response to P application could be traced to similar variation in LAI, LAD, CGR and medium P status of experimental soil. As expected, each higher level of N and P significantly reduced the HI except with P in 1989.

All these yield attributes reflected on seed yield and the effect of irrigation, N and P was well marked (Table 3). Average seed yield was significantly highest with 0.9 ID/CPE as compared to 0.6 and 1.2 ID/CPE. The 0.9 ID/CPE facilitated favourable plant water balance (RWC) resulting in optimum photosynthetic surface with high CGR. These in conjunction with prevailing high temperature and long photoperiods (Narayanan and Narayan, 1987) were responsible for more capsule set with heavier seeds in greater number contributing to more partitioning coefficient (HI), consequently more yield with 0.9 ID/CPE treatment. The significantly more seed yield/plant with successive dose of N and P was a direct consequence of better growth and yield components such as LAI, LAD, CGR, capsules and seed/plant, and test weight.

LITERATURE CITED

- Chakraborty, P.K., Maiti, S. and Chatterjee, B.N. 1984. Growth analysis and agronomic appraisal of sesame. *Indian J. agric. Sci.* 54: 291 - 295.
- Deshmukh, V.A. 1988. Effect of different nitrogen and phosphorus levels on growth, yield and quality of sesame varieties. M.Sc (Ag) Thesis, Marathwada Agricultural University, Parbhani, India. (unpublished).
- Hack, H.R.B. 1980. Effects of pre-sowing flooding, rainfall, irrigation and surface drainage on sesame in the central Sudan rainlands. *Expl Agric.*, 16:137-148.
- Hunt, R. Plant growth analysis. Studies in biology No.96. Edward Arnold, London.
- Narayanan, A. and Narayan, V. 1987. Yield response of sesame cultivars to growing seasons and population density. *J. Oilseeds Res.* 4:193-201.
- Vyas, S.P., Garg, B.K., Kathju, S. and Lahiri, A.N. 1987. Influence of soil fertility on sesame (*Sesamum indicum* L.) under repeated water stress *Ann. Arid Zone*, 26:259-266.
- Delwin, R.M. and Witham, F.H. 1986. *Plant Physiology*. CBS Publishers.

Table 3. Yield and yield components of sesame as influenced by irrigation and fertilization

| Treatments | Capsules/plant | | Seeds/plant | | Test weight (g) | | Harvest index | | Seed yield/plant | |
|--|----------------|------|-------------|------|-----------------|-------|---------------|-------|------------------|-------|
| | 1988 | 1989 | 1988 | 1989 | 1988 | 1989 | 1988 | 1989 | 1988 | 1989 |
| ID/CPE ratio (I) | | | | | | | | | | |
| 0.6 | 40 | 51 | 2546 | 2949 | 3.325 | 3.274 | 0.454 | 0.502 | 8.24 | 9.64 |
| 0.9 | 57 | 64 | 3282 | 3841 | 3.540 | 3.530 | 0.479 | 0.540 | 1.46 | 12.24 |
| 1.2 | 37 | 42 | 1839 | 2374 | 8.715 | 2.835 | 0.462 | 0.438 | 5.48 | 6.73 |
| N (kg/ha) | | | | | | | | | | |
| 0 | 39 | 41 | 2070 | 2318 | 2.900 | 2.874 | 0.501 | 0.507 | 5.88 | 6.61 |
| 40 | 47 | 55 | 2619 | 3181 | 3.278 | 3.299 | 0.462 | 0.506 | 8.50 | 10.14 |
| 80 | 52 | 62 | 2977 | 3666 | 3.397 | 3.466 | 0.432 | 0.468 | 9.81 | 11.85 |
| P (kg/ha) | | | | | | | | | | |
| 0 | 43 | 50 | 2319 | 2881 | 3.057 | 0.134 | 0.470 | 0.493 | 7.20 | 8.84 |
| 13 | 46 | 53 | 2576 | 3061 | 3.211 | 3.211 | 0.475 | 0.498 | 8.17 | 9.55 |
| 26 | 49 | 55 | 2773 | 3223 | 3.312 | 3.294 | 0.450 | 0.489 | 8.82 | 10.21 |
| CD (P = 0.05) for I or N or P | 2.6 | 2.6 | 1131 | 72 | 0.120 | 0.052 | 0.014 | 0.034 | 0.64 | 0.33 |

toria in order to save time and to see that the sowing of wheat is not delayed.

In the first year rice crop was taken as the base crop and after its harvesting toria crop was sown using split plot design with three replications and the gross plot size was 4.5 x 4 m. The treatments for toria involved combinations of three fertilizer levels (60:45:45, 40:30:30 and 20:15:15 kg N + P₂O₅ + K₂O/ha) and the two levels of irrigation (no irrigation and one irrigation at flowering) in main plots and combinations of two toria varieties (T.9 and TL-15) and two levels of insecticide (B.H.C and B.H.C + Oxydemeton methyl) in sub plots. The same lay-out plan was adopted for the succeeding wheat and rice crops to complete the sequence and to see the treatment effects on succeeding crops. In toria, fertilizer was applied according to the treatment, whereas rice and wheat crops were fertilized with 120 kg N + 60 Kg P₂O₅ + 60 Kg K₂O/ha. Irrigation to toria crop was applied according to irrigation schedule of the treatment. In plot receiving irrigation, 70 mm of water was applied to bring the effective root zone to field capacity. The consumptive use of water was worked out according to the method advocated by Dastane (1967).

In toria, according to treatment B.H.C. 5% dust @ 25 kg/ha was applied at 20 days crop stage to control mustard sawfly. However, in plots receiving precautionary treatment against mustard aphid, Oxydemeton methyl 25 E.C. (@ 0.1%) was sprayed at mass flowering and seed formation stages. Observations on mustard sawfly larvae, before and after B.H.C application, and yield attributing characters were recorded on five randomly selected plants from net plot area of each plot.

RESULTS AND DISCUSSION

In general, the performance of all the three crops in the sequence was better during the first year of the present investigation. In the

second year the rice crop during the initial stages of its growth suffered a severe drought condition (Table 2); wheat crop also received very little precipitation (11.2 mm). On the other hand, an unexpected rainfall of 48 mm in early November (1982) coincided with the mass flowering stage of toria causing shedding of flowers and young fruits. Consequently the overall performance was poor in case of all the three crops during the second year.

Among the various treatments, the two levels of insecticide did not differ significantly in respect of yield, moisture use and moisture use efficiency. Therefore, the data on the effect of insecticides on these characters are not presented. Mustard sawfly attacked the toria crop at seedling stage in both the years and the application of B.H.C. 5% dust @ 25 kg/ha was found highly effective (data not reported). However, the use of Oxydemeton methyl proved superfluous because aphids, did not appear on toria crop during both the years and hence the observed trend.

Yield attributing characters and yield.

The data presented in Table 1 indicate that all the yield attributing characters studied viz. siliquae/plant, siliquae on main shoot, seeds/siliqua and test weight were favourably influenced by increasing levels of fertilizer application in both the years. Similarly the increasing levels of fertilizer application significantly increased the seed and stover yield of toria (Table 2). Mudholkar and Ahlawat, 1981 and Saini *et al.*, 1989 have reported similar results.

As compared to control, one irrigation at flowering increased the siliquae/plant and siliquae on main shoot (Table 1). Seed and stover yield were also improved with irrigation (Table 2). However, the differences were significant only during 1981 as the treatment effect was vitiated by winter rains of November during the year 1982. The beneficial effect of

Table 1. Effect of various treatments on yield attributing characters of toria

| Treatments | Siliquae/plant | | Siliquae on main shoot | | Seeds/siliqua | | Thousand seed weight | |
|--|----------------|------|------------------------|------|---------------|------|----------------------|------|
| | 1981 | 1982 | 1981 | 1982 | 1981 | 1982 | 1981 | 1982 |
| Fertilizer levels (N : P ₂ O ₅ : K ₂ O kg/ha) | | | | | | | | |
| 60 : 45 : 45 | 174 | 153 | 51 | 47 | 15.5 | 15.3 | 3.4 | 3.3 |
| 40 : 30 : 30 | 150 | 136 | 47 | 43 | 15.2 | 15.3 | 3.2 | 3.2 |
| 20 : 15 : 15 | 120 | 109 | 37 | 38 | 14.0 | 14.0 | 3.0 | 3.0 |
| CD 5% | 8.3 | 5.3 | 2.9 | 1.7 | 0.77 | 0.39 | 0.08 | 0.04 |
| Irrigation levels | | | | | | | | |
| No irrigation | 139 | 131 | 43 | 42 | 14.7 | 14.8 | 3.1 | 3.1 |
| One irrigation | 156 | 135 | 47 | 43 | 15.1 | 15.0 | 3.2 | 3.2 |
| CD 5% | 6.8 | NS | 2.3 | NS | NS | NS | NS | NS |
| Varieties | | | | | | | | |
| T.9 | 149 | 122 | 42 | 40 | 14.4 | 14.4 | 3.1 | 3.0 |
| TL.15 | 146 | 137 | 48 | 46 | 15.4 | 15.4 | 3.3 | 3.3 |
| CD 5% | NS | 6.1 | 1.9 | 1.8 | 0.78 | 0.31 | 0.06 | 0.10 |

NS : Not significant

Table 2. Effect of various treatments on yield (q/ha), consumptive water use and water use efficiency of toria

| Treatments | Seed yield (q/ha) | | Straw yield (q/ha) | | Consumptive water use (mm) | | Water use efficiency (kg/mm/ha) | |
|--|-------------------|------|--------------------|------|----------------------------|------|---------------------------------|------|
| | 1981 | 1982 | 1981 | 1982 | 1981 | 1982 | 1981 | 1982 |
| Fertilizer levels (N : P ₂ O ₅ : K ₂ O kg/ha) | | | | | | | | |
| 60 : 45 : 45 | 11.4 | 10.4 | 37.4 | 34.6 | 163 | 175 | 7.0 | 5.9 |
| 40 : 30 : 30 | 9.2 | 8.5 | 31.6 | 29.6 | 157 | 167 | 5.9 | 5.1 |
| 20 : 15 : 15 | 6.6 | 6.2 | 24.0 | 23.0 | 148 | 160 | 4.4 | 3.0 |
| CD 5% | 0.45 | 0.55 | 1.75 | 1.20 | - | - | - | - |
| Irrigation levels | | | | | | | | |
| No irrigation | 8.3 | 8.2 | 29.1 | 28.8 | 141 | 158 | 5.9 | 5.2 |
| One irrigation | 9.9 | 8.5 | 32.8 | 29.4 | 171 | 176 | 5.8 | 4.8 |
| CD 5% | 0.36 | NS | 1.43 | NS | - | - | - | - |
| Varieties | | | | | | | | |
| T.9 | 8.4 | 7.5 | 28.7 | 26.7 | 155 | 165 | 5.4 | 4.6 |
| TL.15 | 9.8 | 9.2 | 33.3 | 31.4 | 157 | 169 | 6.2 | 5.4 |
| CD 5% | 0.33 | 0.33 | 1.51 | 0.77 | - | - | - | - |

NS : Not significant

irrigation on toria yield has also been reported by Wankhede *et al.*, 1970.

Toria variety TL-15 recorded significantly higher test weight and because of its long central axis, bore significantly more siliquae on main shoot than T.9 in both the years (Table 1). Consequently, TL.15 excelled T.9 by margins of 17% and 22% in 1981 and 1982, respectively. Barthakur *et al.*, (1983) also reported similar results.

Fertilizer and irrigation treatments interacted significantly in influencing the number of siliquae/plant and seed yield during 1981 (Table 3). Without irrigation, the response to fertilizer application was very low but when the fertilizer application was supplemented with one irrigation the response became distinctly high. The toria plants under irrigated conditions might have utilized the applied nutrients more efficiently than under unirrigated conditions (Bhan, 1974).

Moisture use and moisture use efficiency

The seasonal value of consumptive use of water by toria crop was slightly higher during 1982 than in 1981 (Table 2). This could be attributed to the higher amount of rainfall received during 1982.

The consumptive water use increased with increasing fertilizer levels. The highest fertilizer level resulted in increased moisture use to the extent of 7.2 and 15.4 mm more of water use as compared to the other treatments receiving medium and lowest fertilizer levels, respectively. Similarly, the moisture use efficiency of toria was improved with increasing levels of fertilizer application during both the years, thereby indicating that at higher fertilizer level, the plants have utilized moisture more efficiently for seed production.

Application of irrigation to toria increased the consumptive use of water. However, the moisture use efficiency decreased

under irrigated conditions to that of unirrigated. It means that plant used water more economically under moisture stress by closing their stomata for longer periods, and dispel a greater proportion of absorbed radiant energy through convection (Kramer, 1972).

As regards varietal differences, toria var : TL-15 owing to its better growth characteristics utilized slightly more moisture than the other variety T.9 during both the years. Moreover, the high yielding ability of TL-15 also enabled it to utilize water more efficiently than T.9.

Rice and Wheat

It may be noted from Table 4 that various treatments applied to toria crop did not exert any significant effect on the grain yield of succeeding wheat and rice crops. This could be ascribed to the high dose of fertilizer (120 kg N + 60 kg P₂O₅ + 60 kg K₂O/ha) applied to these crops, which might have maintained optimum fertility in all the plots.

Benefit cost ratio

In general the rice-toria-wheat sequence proved profitable during both the years. However, the favourable weather conditions during 1981-82 resulted in better yield levels, of all the three crops in the sequence and recorded higher benefit cost ratio, than during 1982-83.

The benefit cost ratio increased with increasing levels of fertilizer application in both the years. However, the differences were significant only between the highest and lowest fertilizer levels, thereby suggesting that the middle level of 40:30:30 kg/ha of NPK, would be sufficient for raising a successful crop of toria in the rice fallows.

Application of one irrigation to toria improved the benefit cost ratio of rice-toria-wheat sequence in both the years. However, the difference was significant during first year only.

Table 3. Siliquae/plant and seed yield as influenced by interaction between fertilizer and irrigation levels during 1981

| Treatments | Siliquae/plant | | | Seed yield(q/ha) | | |
|--------------|----------------|----------------|------|------------------|----------------|-------|
| | No irrigation | One irrigation | Mean | No irrigation | One irrigation | Mean |
| 60 : 45 : 45 | 161 | 186 | 174 | 10.24 | 12.62 | 11.43 |
| 40 : 30 : 30 | 139 | 160 | 149 | 8.58 | 9.89 | 9.24 |
| 20 : 15 : 15 | 117 | 123 | 120 | 6.05 | 7.08 | 6.57 |
| Mean | 139 | 156 | - | 8.29 | 9.86 | - |
| CD 5% | | 11.8 | | | 0.64 | |

Table 4. Effect of various treatments on grain yield of rice and wheat and on benefit cost ratio of rice-foria-wheat sequence

| Treatments | Rice grain yield (q/ha) | | Wheat grain yield (q/ha) | | B : C ratio* | |
|---|-------------------------|-------|--------------------------|---------|--------------|---------|
| | 1981 | 1982 | 1981-82 | 1982-83 | 1981-82 | 1982-83 |
| Fertility levels (N : P ₂ O ₅ : K ₂ O kg/ha) | | | | | | |
| 60 : 45 : 45 | 41.18 | 38.39 | 32.45 | 31.14 | 2.53 | 2.35 |
| 40 : 30 : 30 | 41.18 | 38.52 | 32.36 | 30.87 | 2.42 | 2.28 |
| 20 : 15 : 15 | 41.18 | 38.43 | 32.13 | 30.50 | 2.29 | 2.14 |
| CD 5% | - | NS | NS | NS | 0.18 | 0.14 |
| Irrigation levels | | | | | | |
| No irrigation | 41.18 | 38.56 | 32.43 | 30.90 | 2.34 | 2.25 |
| One irrigation | 41.18 | 38.56 | 32.21 | 30.77 | 2.51 | 2.27 |
| CD 5% | - | NS | NS | NS | 0.14 | NS |
| Varieties | | | | | | |
| T.9 | 41.18 | 38.86 | 32.59 | 30.94 | 2.34 | 2.16 |
| TL.15 | 41.18 | 38.05 | 32.04 | 30.74 | 2.52 | 2.35 |
| CD 5% | - | NS | NS | NS | 0.12 | 0.11 |

* Benefit Cost ratio = $\frac{\text{Gross return}}{\text{Cost of cultivation}}$; NS : Not significant

Among the two toria varieties TL-15, owing to its higher seed yield, significantly enhanced the benefit-cost ratio of rice-toria-wheat sequence during both the years.

Thus the present study shows that in rice-toria-wheat sequence both the toria varieties responded well to fertilizer application and recorded economic responses at 40 kg N + 30 kg P₂O₅ + 30 kg K₂O/ha and to one irrigation at flowering. B.H.C. 5% dust applied at 25 kg/ha effectively controlled the mustard sawfly. Toria variety TL-15 performed better than T.9.

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LITERATURE CITED

- Barthakur, A.K., Doloi, P.C., Sarmah, S. and Hussain, M. 1983. Performance of toria variety M 27 in Assam. *Indian. Fmg.* 33 : 17-19.
- Bhan, S. 1974. Water use and yield of mustard (*Brassica juncea* L.) Czern. and Coss) in relation to soil moisture and fertility under Gangetic Alluvium of Uttar Pradesh. UXIPD Seminar on Soil Management, Hisar. 1974.
- Bohra, J.S. and Singh K. 1982. Toria and multiple cropping. *Intensive Agr.*, 20 : 19-20.
- Dastane, N.G. 1967. *A practical Manual of Water Use Research*. Navbharat Prakashan, Poona.
- Kramer, P.J. 1972. Plant and soil water relationships a Modern Synthesis. Mc-Graw Hill, Inc. New York, 484 pp.
- Mudholkar, N.J. and Ahlawat, I.P.S., 1981. Response of rapeseed to plant density and fertilization. *Ind. J. Agron.* 26 : 184-188.
- Saini, J.S., Sahoia, T.S. and Dhillon, A.A. 1989. Agronomy of rapeseed and mustard and their place in new emerging cropping systems. *J. Oilseeds Res.* 6 : 220-227.
- Wankhede, N.P., Ahlawat, I.P.S. and Sahani, U.M. 1970. Effect of varying levels of irrigation, plant population and fertilizer on yield and quality of Indian rape (*B. Campestris* L.Var.Toria). *Ind. J. agric. Sci.* 40: 873-877.

ESTIMATES OF ASSOCIATION BETWEEN YIELD AND QUALITY CHARACTERS OVER ENVIRONMENTS IN LINSEED

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ABSTRACT

The pooled data generated over four environments were used and estimates of genotypic and phenotypic correlation coefficients were made for 10 parents and their 45 F₁s for seed yield and quality characters in linseed. Seed index was found to have high positive correlation with seed length and seed breadth. Iodine value had high positive correlation with linolenic acid. Significant and negative association was observed between seed index and linolenic acid; palmitic, stearic and oleic acid with iodine value; stearic acid with linoleic acid and linoleic acid with linolenic acid. Negative association of linolenic acid with seed yield, seed length, seed breadth and seed index was apparent. Oil and protein content did not show significant association with any of the fatty acids.

Key words : Correlation coefficient; Seed yield; Quality characters; Linseed.

INTRODUCTION

Fatty acid composition has been observed to be greatly affected by environmental factors (Marquard *et al.*, 1978). Dybing (1964) noticed that oil content and iodine value were significantly reduced by application of nitrogen in field as well as under controlled environments. Alessi and Power (1970) reported the influence of irrigation on oil content and iodine value in linseed. Considering reported sensitivity of quality components of linseed to environmental factors, it was felt necessary to study correlation of traits based on data pooled over environments, so as to obtain a realistic base for understanding the likely implication of selection in its improvement programme.

MATERIALS AND METHODS

Ten diverse varieties of linseed were crossed in all possible combinations excluding reciprocals. Parents and their 45 F₁s were sown during *rabi* 1987-88 under irrigated as well as rainfed conditions at two locations each i.e., Ajitmal and Kanpur in a Randomized Block Design with three replications, keeping single row of genotypes with inter and intra row distance

maintained at 25 cm and 5 cm respectively. In the first instance randomly selected five competitive plants were tagged. The data were recorded for seed yield/ plant, seed length, seed breadth, seed index, protein content, oil content, iodine value, palmitic acid, stearic acid, oleic acid, linoleic acid and linolenic acid.

Biochemical analysis was done using Soxhlet procedure for oil content, micro-kjeldahl method for protein content and transesterification and gas liquid chromatography for fatty acids. Correlations were worked out according to the formula given by Robinson *et al.*, (1951).

RESULTS AND DISCUSSIONS

In the present investigation genotypic, phenotypic and environmental correlation coefficient were estimated to assess the degree of association among 12 characters (Table 1).

As could be seen in this table, the genotypic correlation coefficient, in general, were greater than the corresponding phenotypic ones. Out of 66 combinations, 11 were significant. Seed yield/plant could not ex-

press significant association with any of the character at phenotypic level, pointing the major role of environment in expression of the character. Correlation coefficient between seed yield and oil content was positive but magnitude at genotypic level was quite low, thus indicating that these characters are not correlated to each other. Seed length and seed breadth showed strong positive and significant correlation with seed index. It was further interesting to note that seed yield, seed length, seed breadth and seed index showed negative correlation with linolenic acid which is a predominant fatty acid in linseed oil. Out of these, only the negative correlation of seed index with linolenic acid was significant. Thus, it could be concluded that smaller seed size as determined by seed length and seed breadth could be an important factor in considering the selection strategy for the improvement of linseed oil for breeding varieties for edible purposes. Nevertheless, the fact remains that no variety as yet is commercially released for cultivation for edible purposes any where in the world, it would be desirable to obtain and study the experimental lines to provide a concrete base for the improvement of the crop from quality point of view.

The coefficient of correlation between oil content and protein content was observed to be negative at all the levels. As such, it would be desirable to look for an optimum balance of these two traits or to devise selection strategy depending on the economic importance of traits under consideration. The seed components viz., oil and protein were not significantly correlated with any of the quality components of oil, i.e., iodine value and fatty acids.

Iodine value showed negative and significant correlation with palmitic, stearic and oleic acids but its association was positive and significant with linolenic acid. Iodine value which indirectly indicates the degree of unsaturation of the oil determines the quality of the oil for technical purposes. A positive as-

sociation between iodine value and linolenic acid was also observed by Sekhon *et al.*, (1973) and Naqvi *et al.*, (1987). None of the fatty acids showed positive and significant correlation among themselves. Negative and significant correlation appeared between stearic and linoleic acid, oleic and linolenic acid and linoleic acid and linolenic acid. The present findings are in agreement with those reported by Yarosh and Ermakov (1986) and Naqvi *et al.*, (1987).

On the basis of the present study, it can be concluded that there is a good scope to develop varieties high in linolenic acid for technical purposes and considering probable use of linseed oil for human diet, developing varieties low (i.e. less than 3%) in linolenic acid by means of biparental mating in the segregating population involving suitable parents.

LITERATURE CITED

- Alessi, J. and Power, J.F. 1970. Influence of row spacing, irrigation and weed on dryland and flax yield, quality and water use. *Agron. J.* 62 : 635-37.
- Dybing, C.D. 1964. Influence of nitrogen level on flax growth and oil production in varied environments. *Crop Sci.* 4 : 491-94.
- Marquard, R., Schuster, W. and Iran-Neyad, H. 1978. Changes in fatty acids pattern of linseed caused by regional factors, specific climatic conditions and mutagenic treatment, *Fette Seifen. Anstr. Mitt.* 80 : 213-18.
- Naqvi, P.A., Rao, M. and Vasistha, A.K. 1987. Association of different components of seed and oil in linseed. *Indian. J. Agric. Sci.* 57 : 231-36.
- Robinson, H.F. Comstock, R.E, and Harvey, P.H. 1951. Genotypic and phenotypic correlation in corn and their implications in selection. *Agron. J.* 43 : 282-87.
- Sekhon, K.S., Gill, K.S., Ahuja, K.L., and Sinjhu, R.S. 1973. Fatty acid composition and correlation studies in linseed. *Oleagineux* 28 : 525.
- Yarosh, N.P. and Ermakov, A.I. 1986., Genotypic variation in content of fatty acid in the seed oil of fibre flax plants. *Sbornik Nauchnykh Trudov po Prikladnoi Botanike Genetikei Seleksii.* 107 : 3-10.

Table 1. Estimates of correlation coefficients pooled over four environments among 12 characters at genotypic (r_g), phenotypic (r_p) and environmental (r_e) levels in 55 genotypes of linseed

| | Seed yield per plant | Seed length | Seed breadth | Seed index | Protein content | Oil content | Iodine value | Palmitic acid content | Stearic acid content | Oleic acid content | Linoleic acid content | Linolenic acid content |
|-----------------------|----------------------|-------------|--------------|------------|-----------------|-------------|--------------|-----------------------|----------------------|--------------------|-----------------------|------------------------|
| Seed yield per plant | r_g 0.441 | 0.877 | 0.485 | -0.054 | 0.009 | -0.304 | -0.389 | 0.319 | 0.637 | -0.444 | -0.259 | |
| | r_p 0.151 | 0.121 | 0.229 | -0.019 | 0.019 | -0.071 | -0.135 | 0.021 | 0.143 | 0.026 | -0.009 | |
| | r_e 0.037 | 0.043 | 0.102 | -0.011 | 0.021 | -0.004 | -0.108 | -0.010 | 0.005 | 0.114 | -0.064 | |
| Seed length | r_g 0.906 | 0.963 | 0.135 | 0.043 | -0.083 | 0.288 | 0.465 | -0.352 | 0.689 | -0.252 | | |
| | r_p 0.325* | 0.588** | 0.118 | -0.025 | 0.004 | 0.003 | 0.025 | -0.106 | 0.143 | -0.048 | | |
| | r_e 0.266 | 0.229 | 0.117 | -0.043 | 0.044 | -0.053 | -0.046 | 0.001 | -0.011 | 0.023 | | |
| Seed breadth | r_g 0.999 | 0.228 | 0.439 | -0.963 | 0.701 | 0.461 | 0.842 | -0.329 | | | | |
| | r_p 0.318* | 0.058 | -0.034 | -0.122 | -0.003 | 0.056 | 0.033 | 0.154 | | | | |
| | r_e 0.253 | 0.042 | -0.061 | -0.026 | -0.041 | 0.026 | -0.016 | 0.100 | | | | |
| Seed index | r_g 0.191 | 0.492 | 0.234 | 0.712 | 0.087 | 0.691 | -0.706 | | | | | |
| | r_p 0.012 | -0.232 | 0.071 | 0.077 | 0.074 | 0.215 | -0.276* | | | | | |
| | r_e -0.035 | -0.075 | 0.045 | -0.065 | 0.076 | 0.045 | -0.088 | | | | | |
| Protein content | r_g -0.379 | 0.398 | 0.079 | 0.281 | 0.245 | -0.623 | | | | | | |
| | r_p -0.115 | 0.049 | 0.047 | 0.064 | -0.029 | -0.076 | | | | | | |
| | r_e -0.084 | 0.008 | 0.009 | 0.048 | 0.099 | -0.076 | | | | | | |
| Oil content | r_g -0.096 | -0.213 | 0.871 | 0.441 | 0.441 | 0.533 | | | | | | |
| | r_p 0.045 | -0.039 | -0.028 | -0.002 | -0.006 | 0.008 | | | | | | |
| | r_e 0.068 | 0.038 | 0.020 | -0.069 | -0.059 | 0.068 | | | | | | |
| Iodine Value | r_g -0.446 | -0.347 | -0.947 | 0.193 | 0.956 | | | | | | | |
| | r_p -0.394** | -0.375** | -0.654** | -0.044 | 0.823** | | | | | | | |
| | r_e -0.405 | -0.397 | -0.531 | -0.095 | 0.794 | | | | | | | |
| Palmitic acid content | r_g -0.357 | 0.847 | -0.789 | -0.159 | | | | | | | | |
| | r_p 0.218 | 0.016 | -0.184 | -0.184 | | | | | | | | |
| | r_e 0.248 | -0.095 | -0.131 | -0.190 | | | | | | | | |
| Stearic acid | r_g 0.306 | -0.517 | -0.032 | | | | | | | | | |
| | r_p -0.005 | -0.363** | -0.048 | | | | | | | | | |
| | r_e -0.042 | -0.356 | -0.050 | | | | | | | | | |
| Oleic acid | r_g -0.255 | -0.986 | | | | | | | | | | |
| | r_p -0.082 | -0.585** | | | | | | | | | | |
| | r_e -0.048 | -0.489 | | | | | | | | | | |
| Linoleic acid | r_g -0.117 | | | | | | | | | | | |
| | r_p -0.506** | | | | | | | | | | | |
| | r_e -0.571 | | | | | | | | | | | |

* Significant at $P = 0.05$; ** Significant at $P = 0.01$

COMBINING ABILITY AND HETEROSIS FOR YIELD AND ITS COMPONENTS IN SESAME

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ABSTRACT

Line x tester analysis using 4 females x 6 males, was carried out to study the heterosis and combining ability for yield and its attributes. The estimated components of general and specific combining ability (gca and sca) variance showed major contribution of additive gene action for plant height, number of capsule/plant and days to maturity and a dominance gene action for rest of the characters. The female JLSC-1 was the best general combiner for earliness. JLT-26 was good general combiner for plant height, number of capsule/plant and days to maturity. Highest magnitude of standard heterosis (usable heterosis) was recorded in the cross JLT-26 x TC-326. Other promising crosses for high yield were JLT-26 x AT-18, Tapi x B-14, Tapi x RT-46 and JLT-26 x RT-46. The practical implications of heterosis and combining ability study in sesamum breeding have been discussed.

Key words : Sesamum; Combining ability; Heterosis; Standard heterosis.

INTRODUCTION

The usual breeding procedure involves direct selection or hybridization followed by selection. The combining ability study is an aid in selecting parents which in combination would provide more desirable segregants. The present investigation was undertaken to know the genetic architecture of lines having high *per se* performance and to make use of these lines to generate new recombinants for selecting high yielding lines.

MATERIAL AND METHODS

Four female (JLT-26, Tapi, PDP-1-2 and JLSC-1) and six males (RT-46, OMT-11-6-5, TC-326, B-14, AT-18 and HT-24) were used. The resulting 24 hybrids were grown in Randomized Block Design and the parents were grown in a Randomized Block Design in a contiguous plot with three replications at the Oilseeds Research Station, Jalgaon during 1988. All recommended practices were followed to raise a healthy crop. Observations were recorded on five randomly selected plants for days to first flower, days to 50% flowering, plant height, number of branches/plant, num-

ber of capsule/plant, days to maturity and yield. Line x tester analysis for combining ability was carried out, following Kempthorne (1969) and Arunachalam (1974).

Heterosis over mid parental value and better parental value was calculated as the deviation of F_1 over check variety Tapi (JLT-7) and expressed as a percentage increase over it.

RESULTS AND DISCUSSION

Analysis of variance for combining ability is given in Table 1. Crosses, males, females, male x female differed significantly for all the characters except female for days to 50% flowering and male x female for plant height, number of capsule/plant and days to maturity indicating thereby crosses differed genetically. Significance of male and female variances indicated presence of additive gene action whereas, dominance was also involved to play role for controlling the inheritance of these characters. Similar results in sesamum have been reported by Chaudhari *et al.*, (1984). Non-significance variance male x female in case of plant height, number of capsule/plant and days to maturity observed in the study gave

Table 1. Analysis of variance for combining ability

| Source | D.F | Mean sum of squares | | | | | | |
|-------------------------|-----|---------------------|-----------------------|---------------------|---------------------------|---------------------------|--------------------|---------------------------|
| | | Days to flowering | Days to 50% flowering | Plant height cm | No. of branches per plant | No. of capsules per plant | Days to maturity | Grain yield per plant (g) |
| Crosses | 23 | 14.75** | 23.14** | 621.32** | 0.683** | 272.53** | 53.00** | 8.905** |
| Males | 5 | 18.73** | 96.54** | 810.92** | 1.572** | 210.80 ^{NS} | 16.52** | 3.068 ^{NS} |
| Females | 3 | 54.92** | 108.33 | 2937.39** | 0.229 ^{NS} | 936.65** | 356.33** | 25.06** |
| Males X Females | 15 | 53.92** | 10.61** | 94.90 ^{NS} | 0.478** | 160.24 ^{NS} | 4.50 ^{NS} | 7.618* |
| Error | 46 | 2.128 | 1.722 | 105.81 | 0.167 | 113.95 | 3.74 | 3.59 |
| $\sigma^2 (sca)$ | - | 17.264 | 3.20 | - | 0.103 | - | - | 1.34 |
| $\sigma^2 gca$ (male) | - | 1.385 | 7.901 | 58.759 | 0.117 | - | 1.065 | - |
| $\sigma^2 gca$ (female) | - | 2.932 | - | 157.31 | - | 45.70 | 19.58 | 1.192 |

*, ** Significant at 0.05 and 0.01 levels respectively. NS = Non-significant.

an indication of additive variance to be very important for these characters. Similar conclusions have also been reported by Fattah *et al.*, (1982). Shinde *et al.*, (1991) reported additive gene action for plant height and non-additive gene action for seed yield/plant and number of capsule/plant.

General combining ability (*gca*) effects are given in Table 2. JLSC-1 was found to be best general combiner for maximum number of characters. However, for earliness and dwarfness, negative significant *gca* for number of capsule/plant is better, but for yield/plant it is not desirable. It was the parent maturing most early (66 days) and was less yielder. However, it is a very good source of earliness for use in hybridization. Positive and higher *gca* was observed for yield/plant in JLT-26 and Tapi (JLT-7) which are released varieties and known for their performance. JLT-26 was good general combiner for plant height, number of capsules/plant and days to maturity where Tapi noted its good general combining ability for days to 50% flowering, plant height and maturity. All these above characters are very important. B-14 was good general combiner for as many as five characters but is black

seeded and therefore, is not desirable for the sesamum growing areas of Maharashtra. Other parents were poor general combiners for many characters.

Table 3 depicted the specific combining ability (*sca*) effects. Significant *sca* for days to flowering was noted for crosses JLT-26 x B-14, JLT-26 x AT-18 (negative), Tapi x TC-326 (negative), Tapi x HT-24, JLSC-1 x RT-46 and JLSC-1 x B-14 (negative). In none of the combinations significant *sca* effect was observed for plant height. Only five crosses exhibited significant *sca* effects for number of branches/plant and positive significant *sca* effect was observed in combinations JLT-26 x RT-46 and JLSC-1 x OMT-11-6-5. JLT-26 x OMT-11-6-5 combination only had negative significant *sca* effects for number of capsule/plant. None of combinations was significant in case of days to maturity. Out of the twenty four crosses, only 10 combinations showed positive *sca* effects for grain yield/plant. Positively significant and maximum *sca* effect was observed in the cross JLSC-1 x OMT-11-6-5. Interestingly, significantly negative *sca* effect was observed in JLT-26 x OMT-11-6-5. In both the cases OMT-11-6-5 was the

Table 2. General combining ability effects of parents

| Parents | Days to flowering | Days to 50% flowering | Plant height (cm) | No. of branches per plant | No. of capsules per plant | Days to maturity | Grain yield per plant (g) |
|---------------|----------------------|-----------------------|-----------------------|---------------------------|---------------------------|----------------------|---------------------------|
| Males | | | | | | | |
| RT-46 | 1.083 [*] | -0.972 [*] | 0.487 | -0.106 | -2.646 | -1.11 [*] | 0.075 |
| OMT-11-6-5 | -0.750 | -0.639 | -8.979 ^{**} | 0.527 ^{**} | 5.846 | -0.194 | -0.725 |
| TC-326 | -0.833 [*] | -0.556 | -5.912 [*] | -0.181 | -4.571 | -1.028 | 0.642 |
| B-14 | -1.417 ^{**} | 1.444 ^{**} | 14.854 ^{**} | 0.373 ^{**} | 4.129 | 1.889 ^{**} | 0.325 |
| AT-18 | 1.833 ^{**} | 0.278 | -1.037 | -0.365 ^{**} | 0.196 | 0.889 | -0.142 |
| HT-24 | 0.083 | 0.444 | 0.587 | -0.248 [*] | -2.950 | -0.444 | -0.458 |
| SE(gj) | 0.421 | 0.378 | 2.969 | 0.118 | 3.081 | 0.558 | 0.547 |
| Female | | | | | | | |
| JLT-26 | 0.500 | 0.100 | 6.143 [*] | 0.152 | 7.174 ^{**} | 2.278 ^{**} | 0.864 |
| Tapi | 0.667 | 0.833 ^{**} | 6.973 ^{**} | 0.116 | 1.124 | 2.444 ^{**} | 0.719 |
| PDP-1-2 | 1.389 ^{**} | 2.500 ^{**} | 6.036 [*] | -0.103 | 1.724 | 1.944 ^{**} | 0.119 |
| JLSC-1 | -2.556 ^{**} | -3.333 ^{**} | -19.151 ^{**} | -0.065 | -10.021 ^{**} | -6.667 ^{**} | -1.703 ^{**} |
| SE(gj) | 0.343 | 0.309 | 2.424 | 0.965 | 2.516 | 0.456 | 0.447 |

Table 3. Specific combining ability effects of the crosses

| Crosses | Days to flowering | Days to 50% flowering | Plant height (cm) | No. of branches per plant | No. of capsule per plant | Days to maturity | Grain yield per plant (g) |
|----------------------|-------------------|-----------------------|-------------------|---------------------------|--------------------------|------------------|---------------------------|
| JLT-26 x RT-46 | -0.250 | -0.417 | 1.090 | 0.523* | 7.918 | 0.556 | 0.369 |
| JLT-26 x OMT-11-6-5 | -0.417 | -0.750 | -6.443 | 0.223 | -14.407* | -0.028 | -2.690* |
| JLT-26 x TC-326 | 0.333 | -0.167 | 1.824 | -0.135 | -1.524 | 1.138 | 1.869 |
| JLT-26 x B-14 | 1.250* | -2.500** | -1.876 | -0.623** | 9.576 | -1.778 | -0.614 |
| JLT-26 x AT-18 | -1.667* | 4.000** | 5.815 | 0.048 | 5.510 | -0.444 | 1.769 |
| JLT-26 x HT-24 | 0.750 | -0.167 | -0.410 | -0.035 | -7.074 | 0.556 | -0.697 |
| Tapi x RT-46 | -0.750 | 0.750 | 2.590 | -0.041 | -0.732 | 1.056 | 1.514 |
| Tapi x OMT-11-6-5 | 0.417 | -1.917* | -10.076 | -0.541* | 3.043 | -1.194 | -0.753 |
| Tapi x TC-326 | -2.167* | -1.333 | 2.590 | 0.134 | -6.140 | -1.694 | -1.386 |
| Tapi x B-14 | 0.083 | 1.667* | 6.357 | 0.397 | 1.626 | 1.722 | 1.264 |
| Tapi x AT-18 | 0.833 | -0.500 | -1.151 | 0.051 | -3.507 | 0.389 | -1.353 |
| Tapi x HT-24 | 1.583* | 1.333 | -0.310 | 0.001 | 5.710 | -0.278 | 0.714 |
| PDP-1-2 x RT-46 | -0.806 | 0.750 | -0.999 | 0.178 | -0.199 | -0.444 | -1.219 |
| PDP-1-2 x OMT-11-6-5 | -0.639 | 0.750 | 2.201 | -0.255 | 2.643 | -0.029 | 0.514 |
| PDP-1-2 x TC-326 | 1.111 | 1.000 | 7.201 | 0.253 | 6.593 | 0.806 | -0.186 |
| PDP-1-2 x B-14 | 0.361 | 0.667 | -4.999 | 0.033 | -5.040 | -0.111 | -0.603 |
| PDP-1-2 x AT-18 | 0.779 | -3.167** | -1.835 | 0.037 | -1.707 | -1.111 | 0.847 |
| PDP-1-2 x HT-24 | -0.806 | 0.000 | -4.140 | -0.247 | -2.290 | 0.889 | 0.647 |
| JLSC-1 x RT-46 | 1.806* | -1.083 | -2.682 | -0.660** | -6.987 | -1.167 | 0.664 |
| JLSC-1 x OMT-11-6-5 | 0.639 | 1.917* | 9.318 | 0.573* | 8.721 | 1.250 | 2.936** |
| JLSC-1 x TC-326 | 0.722 | 0.500 | 0.585 | -0.252 | 1.071 | -0.250 | -0.297 |
| JLSC-1 x B-14 | -1.694* | 0.167 | -6.315 | 0.194 | -6.162 | 0.167 | -0.047 |
| JLSC-1 x AT-18 | 0.056 | -0.333 | 0.524 | -0.135 | -0.296 | 1.167 | -1.264 |
| JLSC-1 x HT-24 | -1.528 | -1.167 | -0.382 | 0.281 | 3.654 | -1.167 | -0.664 |
| SE (sij) ± | 0.8423 | 0.757 | 5.939 | 0.2364 | 6.1631 | 1.1179 | 1.0953 |

common parent. It had positive *gca* effects for yield/plant but significantly negative *gca* effects for plant height. JLT-26 however, had significantly positive *gca* effects for plant height. Therefore, consideration of only *gca* or *sca* effects may not give exact picture of genetic architecture of genotype and further study in heterobeltiosis, standard heterosis (useful heterosis) is described below.

Heterosis, however, has already been reported by various workers, Murthy (1975), Chaudhari *et al.*, (1984), Krishnaswami and Appadurai (1984), Bhagwandora and Kamala (1986) and Osman (1986).

The heterosis (H_1), heterobeltiosis (H_2) and useful heterosis (H_3) are given in Table 4. The range of heterosis for days to flowering was -18.66 to 12.50 over mid-parent (H_1), -19.34 to 8.33 over better parent (H_2) and useful heterosis was -19.33 to 5.83 over best parent (H_3). It appears that H_1 was more than H_2 and H_3 . H_3 heterosis was least suggesting thereby that days to flowering will not fluctuate much in the material under study. Earliness could be brought using JLSC-1 as one of the parents as the maximum negative values were observed whenever JLSC-1 was used as one of the parents. More or less similar trend was observed for days to 50% flowering. Least amount of heterosis was noted for days to maturity. It indicated that the maturity period neither could be brought towards very earliness nor towards late maturity in the materials under study.

There was no considerable heterotic effect in respect of plant height. The maximum was 45.27 over mid parent and only 16.321 over the best parent. This means that the heterotic effect was not manifested in vegetative phase but would have got diverted to reproductive phase which finally connected to yield.

The heterotic effect for yield/plant over mid-parent ranged between 5.61 to 232.14, the minimum was in cross JLT-26 x OMT-11- 6-5 and the maximum was recorded in cross JLSC-1 x OMT -11-6-5. The range of heterosis over better parent was -6.500 to 189.30 recorded in crosses JLSC-1 x AT-18 and JLT-26 x TC-326 respectively. Heterosis up to 102.80 per cent over best check was observed in cross JLT-26 x TC-326. Considerable amount of significant heterosis (189.362) was recorded in the same cross (JLT-26 x TC-326). JLT-26 was good general combiner for number of capsule/plant, days to maturity and yield/plant where positive *gca* effect was noted in TC-326. It was poor combiner for capsule/plant. So it is not necessary that both parents must have high *gca* effect for high heterosis effect. On the contrary, contrasting diverse parent many a times may exhibit good heterosis effect.

First five good crosses are depicted in Table 5 where it is indicated that if *gca* effects are considered average x average combination should throw good heterotic effect or average x poor may be a good combination. Useful heterosis ranged from 56.59 to 102.90 per cent giving hopes for use of heterosis in this crop.

Table 5. Selected crosses and their performance in some selected parameters for yield

| Crosses | Yield per plant (g) | Heterosis (%) | Useful Heterosis (%) | Gca effect of parent | | Sca effect |
|-----------------|---------------------|---------------|----------------------|----------------------|----|------------|
| | | | | P1 | P2 | |
| JLT-26 x TC-326 | 9.07 | 189.36** | 102.90** | A | A | 1.86 |
| JLT-26 x AT-18 | 8.47 | 173.00** | 89.48** | A | P | 1.76 |
| Tapi x B-14 | 8.00 | 110.52** | 78.97** | A | A | 1.26 |
| Tapi x RT-46 | 8.00 | 96.72** | 78.97** | A | A | 1.51 |
| JLT-26 x RT-46 | 7.00 | 105.88** | 56.59** | A | A | 0.369 |

** = Significant at 1%; A = Average; P = Poor

Table 4. Heterosis (H₁), Heterobeltiosis (H₂) and useful heterosis (H₃) for different characters

| Crosses | | Days to flowering | Days to 50% flowering | Plant height (cm) | No. of branches per plant | No. of capsules per plant | Days to maturity | Grain yield per plant (g) |
|---------------------|----------------|-------------------|-----------------------|-------------------|---------------------------|---------------------------|------------------|---------------------------|
| JLT-26 X RT-46 | H ₁ | 12.500** | -6.464** | 32.891** | 49.254** | 72.903** | 2.725* | 105.882** |
| | H ₂ | 8.333** | -8.899** | 28.273** | 47.059** | 50.419** | 1.660 | 90.909** |
| | H ₃ | -6.77** | -6.818** | -1.27 | 42.91** | 27.03** | -2.77 | 56.59** |
| JLT-26 x OMT-11-6-5 | H ₁ | -1.333 | -5.385** | 20.017** | 57.143** | 42.355** | 1.863 | 5.618** |
| | H ₂ | -5.128** | -6.818** | 16.774** | 48.649** | 30.740** | -0.405 | 0.00 |
| | H ₃ | -4.200 | -6.818 | -16.06** | 57.51 | - | -2.38 | - |
| JLT-26 x TC-326 | H ₁ | 1.802 | -1.186 | 36.829** | 20.000** | 59.311** | 3.564** | 189.362** |
| | H ₂ | -0.877 | -2.344* | 30.484** | 18.182** | 54.140** | 2.490 | 189.362** |
| | H ₃ | -4.200** | -4.54** | -6.2 | 11.58** | 2.69 | -1.98 | 102.90** |
| JLT-26 x B-14 | H ₁ | 1.333 | -6.061** | 45.271* | 9.589** | 99.415** | 3.132* | 100.00** |
| | H ₂ | -2.564* | -8.824** | 39.851** | 0.10 | 74.872** | 1.646 | 100.00** |
| | H ₃ | -4.200** | -6.818** | 8.63 | 14.59** | 44.70** | -1.98 | 40.26** |
| JLT-26 x AT-18 | H ₁ | 3.139** | 11.554** | 44.830* | 32.203** | 83.164** | 3.333* | 173.00** |
| | H ₂ | 0.000 | 9.375** | 41.210** | 18.182** | 65.688** | 1.639 | 170.213** |
| | H ₃ | -1.68 | 6.818** | 1.504 | 11.58** | 27.73** | -1.58 | 89.48** |
| JLT-26 x HT-24 | H ₁ | 4.464** | -1.158 | 29.834* | 41.071** | 43.595** | 2.277* | 95.181** |
| | H ₂ | 0.862 | -2.290** | 24.500** | 19.697** | 36.680** | 0.000 | 72.340** |
| | H ₃ | -1.68 | -2.27* | -2.49 | 12.87** | -5.64 | -1.98 | 20.80** |

Contd..

Table 4. Contd..

| Crosses | | Days to flowering | Days to 50% flowering | Plant height (cm) | No. of branches per plant | No. of capsules per plant | Days to maturity | Grain yield per plant (g) |
|----------------------|----------------|----------------------|-----------------------------|----------------------|---------------------------------|---------------------------------|---------------------|---------------------------------|
| Tapi x RT-46 | H ₁ | 8.920** | -3.371* | 14.042 | 14.493** | 3.761 | 0.203 | 96.721** |
| | H ₂ | 2.655* | -4.444** | 0.754 | 12.857** | -4.385 | -1.984 | 79.104** |
| | H ₃ | -4.20** | -2.27* | 0.756 | 12.87** | -4.37 | -1.98 | 78.97** |
| Tapi x OMT-11-6-5 | H ₁ | -0.870 | -7.576** | -2.968 | 15.278** | 39.384** | -2.605 | 35.780** |
| | H ₂ | -2.564 | -7.576** | -18.493** | 12.162** | 21.641* | -3.571* | 10.448** |
| | H ₃ | -11.77 | -6.818** | -18.49** | 18.45** | -16.54 | -3.571* | 10.29** |
| Tapi x TC-326 | H ₁ | -6.608** | -3.502* | 15.228* | 22.388** | -3.905 | -3.043* | 49.123** |
| | H ₂ | -7.018** | -6.061** | -4.912 | 17.143** | -19.943* | -5.159** | 26.866** |
| | H ₃ | -6.77** | -6.818** | -4.809 | 15.87** | -19.94* | -5.15* | 26.84** |
| Tapi x B-14 | H ₁ | -3.478** | 3.731** | 31.158** | 42.000** | 25.851* | 4.242** | 110.526** |
| | H ₂ | -5.128** | 2.206* | 16.522** | 33.125** | 14.993 | 2.381 | 79.104** |
| | H ₃ | 3.35** | 4.54** | 16.521** | 54.50** | 15.00 | 2.380 | 78.97** |
| Tapi x A-18 | H ₁ | 7.895** | 1.176 | 14.296* | 21.311** | 8.147 | 1.210 | 38.053** |
| | H ₂ | 6.957** | -2.273** | -3.826 | 5.714** | -4.243 | -0.397 | 16.418** |
| | H ₃ | 0.83 | -2.27* | -4.34 | 7.29** | -4.24 | -0.39 | 16.33** |
| Tapi x HT-24 | H ₁ | 4.803** | 2.662* | 10.273 | 31.034** | 28.536** | -1.804 | 94.175** |
| | H ₂ | 3.448** | 2.273* | -1.681 | 8.571** | 8.628 | -2.778 | 49.254** |
| | H ₃ | -1.68 | 2.27* | -16.78 | 8.58** | 8.63 | -2.77 | 49.21** |

Contd..

Table 4. Contd..

| Crosses | Days to flowering | Days to 50% flowering | Plant height (cm) | No. of branches per plant | No. of capsules per plant | Days to maturity | Grain yield per plant (g) | |
|----------------------------|-------------------|-----------------------|-------------------|---------------------------|---------------------------|------------------|---------------------------|-----------|
| PDP-1-2xRT-46 | H ₁ | 7.763 | -0.372 | 8.231 | 22.388** | 11.415 | -1.833 | 33.333** |
| | H ₂ | -0.840 | -0.741 | -5.275 | 20.588** | 6.994 | -3.600* | 27.273** |
| | H ₃ | -4.20** | 2.27* | -3.191 | 15.87** | -1.973 | -4.36** | 4.47** |
| PDP-1-2x OMT-11-6-5 | H ₁ | -4.237** | 1.504 | 12.466 | 25.714** | 46.894** | -1.408 | 82.609** |
| | H ₂ | -5.042** | 0.746 | -6.353 | 18.919** | 33.179** | -2.000 | 68.000** |
| | H ₃ | -1.68 | 2.27* | -4.28 | 24.46** | 22.06* | -2.77 | 25.27** |
| PDP-1-2x TC-326 | H ₁ | 1.288 | 5.019** | 4.848 | 26.154** | 36.908** | -0.204 | 93.814** |
| | H ₂ | -0.840 | 1.493 | -14.124* | 24.242** | 18.210 | -2.000 | 88.000** |
| | H ₃ | -4.20** | 2.27* | -12.23* | 15.87** | 8.35 | -2.77 | 40.26** |
| PDP-1-2x B-14 | H ₁ | -3.390** | 4.444** | 24.267** | 26.027** | 17.113 | 1.826 | 71.134** |
| | H ₂ | -4.202** | 3.676** | 9.359 | 15.000** | 11.42 | 0.400 | 66.000** |
| | H ₃ | 5.87** | 6.818** | 11.76* | 33.04** | 2.12 | -0.39 | 23.71** |
| PDP-1-2xAT-18 | H ₁ | 6.838** | -1.946 | 8.807 | 18.644** | 19.531* | -0.810 | 112.500** |
| | H ₂ | 5.042** | -5.970** | -9.246 | 6.061* | 10.031 | -2.000 | 104.000** |
| | H ₃ | -4.20** | -4.54** | -7.24 | -1.28** | 0.848 | -2.77 | 52.12** |
| PDP-1-2x HT-24 | H ₁ | -2.128* | 2.642* | 9.377 | 16.071** | 15.669 | -0.604 | 109.302** |
| | H ₂ | -3.361** | 1.493 | -3.403 | -1.515** | 1.389 | -1.200 | 80.000** |
| | H ₃ | -1.68 | 2.27* | -1.27 | -5.57** | -7.06 | -1.98 | 34.22** |

Contd..

Table 4. Contd..

| Crosses | | Days to flowering | Days to 50% flowering | Plant height (cm) | No. of branches per plant | No. of capsules per plant | Days to maturity | Grain yield per plant (g) |
|--|----------------|----------------------|-----------------------------|----------------------|---------------------------------|---------------------------------|---------------------|---------------------------------|
| JLSC-1 x RT-46 | H ₁ | 4.110** | -10.843** | 12.233 | -21.622** | -10.657 | -2.961* | 47.826** |
| | H ₂ | -4.202** | -17.778** | -4.233 | -27.500** | -30.369** | -11.618 | -7.273* |
| | H ₃ | -11.7** | -15.90** | -26.54** | -18.45** | -41.29** | -15.47** | - |
| JLSC-1 x OMT-11-6-5 | H ₁ | -11.017** | -1.626 | 23.814** | 48.052** | 80.930** | 0.225 | 232.143** |
| | H ₂ | -11.765** | -8.333** | 11.253* | 42.500** | 42.628** | -9.717** | 121.429** |
| | H ₃ | -11.77** | -9.090** | -24.34** | 63.09** | 10.05 | -11.51** | 38.70** |
| JLSC-1 x TC-326 | H ₁ | -9.871** | -2.092 | 18.447* | -5.556** | 26.119* | -1.595 | 113.115** |
| | H ₂ | -11.765** | -6.400** | 8.444 | -15.000** | 7.643 | -10.373** | 38.298* |
| | H ₃ | -19.33** | -11.36** | -29.27** | -1.28* | -28.28 | -14.28** | - |
| JLSC-1 x B-14 | H ₁ | -18.644** | -2.400* | 25.538** | 22.500** | 15.251 | 2.494* | 108.836** |
| | H ₂ | -19.328** | -10.294** | 6.667 | 22.800** | -9.573 | -6.996** | 36.170** |
| | H ₃ | -6.73** | -6.118** | -16.93** | 41.63** | -25.16* | -10.32** | - |
| JLSC-1 x AT-18 | H ₁ | -5.128** | -1.266 | 20.823** | 0.00 | 27.107* | 2.262* | 43.333** |
| | H ₂ | -6.793** | -4.878** | 8.362 | -17.800** | 2.238 | -7.377** | -6.522* |
| | H ₃ | -14.29** | -11.36** | -26.08** | -5.57** | -21.06* | -10.32** | - |
| JLSC-1 x HT-24 | H ₁ | -14.043** | -6.122** | 13.998 | 30.159** | 38.855** | -3.371* | 72.000** |
| | H ₂ | -15.126** | -12.214** | -3.553 | 2.500** | 16.803 | -12.955** | 19.444** |
| | H ₃ | -11.77** | -13.63** | -24.46** | 15.87** | 19.37 | -14.67** | - |
| SE (H ₁) ± | | 1.031 | 0.927 | 7.27 | 0.288 | 10.67 | 1.36 | 1.33 |
| SE (H ₂) and (H ₃) ± | | 1.19 | 1.07 | 5.93 | 0.333 | 8.715 | 1.57 | 1.54 |

The supporting plus points of this crop like (1) many seeds in single pollination and (2) an ease in pollination are very important to exploit heterosis in sesamum.

LITERATURE CITED

- Arunachalam, V. 1974. The fallacy behind the use of a modified line x Tester design. *Indian J. Genet.* 34 : 280-87.
- Bhagwandora, K. and Kamala, T. 1986. Heterosis and gene action in sesame. *Indian J. agric. Sci.* 56 (10) : 690-694.
- Chaudhari, F.P., Shah, R.M. and Patel, I.D. 1984. Heterosis and combining ability in sesamum. *Indian J. agric. Sci.* 54(11) : 962-966.
- Fatteh, U.G., Shah, R.M. and Bodur, D.G. 1982. Studies on combining ability in sesamum (*Sesamum indicum* L.). *Madras agric. J.* 69 (3) : 145-150.
- Kemphorne, O., 1969. An Introduction to genetic statistics. 2nd Ed. John Wiley, New York. : 468-470.
- Krishnaswami, S. and Appadurai, R. 1984. A preliminary study of heterotic potential in sesamum (*Sesamum indicum* L.). *Madras agric. J.* 71(2) : 81-84.
- Murthy, D.S. 1975. Heterosis, combining ability and reciprocal effects for agronomic and chemical characters in sesamum. *Theor. Appl. Genet.* 45(7) : 294-299.
- Osamn, H.E. 1986. Studies in sesamum : II Heterosis (Abst.) *In Tropical Oilseeds Abst.* 11(8) : 88.
- Shinde, Y.M., Badhe, P.L., Patel, D.M. and Deokar, A.B. 1991. Genetic evaluation of some lines in sesamum. *J. Maharashtra agric. Univ.* 16(1) : 22-24.

ESTIMATION OF CROP EVAPOTRANSPIRATION AND CROP COEFFICIENTS (Kc values) IN SUMMER GROUNDNUT

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ABSTRACT

The results of the two years study on summer groundnut revealed that the crop evapotranspiration predicted based on the modified Penman method (603.2 to 614.78 mm) were nearer to the actual values determined by field method (597.3 to 695.7 mm) in different irrigation schedules. In the absence of actual crop evapotranspiration based on the field experimentation, computed ET crop based on modified Penman method could be used for crop water planning to make efficient use of available irrigation water. Pan evaporation method predicted 22 per cent less ET crop than modified Penman method. Actual crop coefficients vary depending on the irrigation schedule (0.37 to 0.96) and interfering rains. Pod development stages (70 days to harvest) followed by flowering and pegging stages (40 to 70 days) are moisture sensitive stages requiring more irrigation.

Key words : Groundnut; Crop evapotranspiration; Crop coefficients; Prediction methods.

INTRODUCTION

Crop water requirements depends mostly on evapotranspirational demands. Estimation of evapotranspiration or consumptive use of a crop is of immense use for efficient use of available water. Several methods, direct and indirect have been used to estimate evapotranspiration. Use of empirical formulae for predicting the crop evapotranspiration is considered to be easier and quicker compared to field experimental methods. Among the different methods, Blaney-Cridde, Radiation, Pan evaporation and modified Penman methods were found to give closer estimates to actual crop evapotranspiration based on field experiments. An attempt was made to compute evapotranspiration of groundnut for Bangalore region based on two prediction methods viz., modified Penman method and Pan evaporation methods recommended by FAO group of scientists (Doorenbos and Pruitt, 1977). Crop evapotranspiration was also estimated by field method and the values were compared with the prediction methods.

MATERIALS AND METHODS

A field experiment involving five irrigation schedules (Table 1) was conducted at Main Research, Station, Hebbal, Bangalore, on sandy loam soils for two season (summer 1989 and 1990). The experiment was laid out in 16.8 m² plots replicated four times in Randomized Block Design. Each plot was separated by a polythene barrier burried to a depth of 60 cm to prevent the lateral movement of water from one plot to another plot. Two common irrigations; one before sowing (50 mm) and other on 9th day after sowing (20 mm) were given. This was accounted for computing total evapotranspiration. At each irrigation 40 mm depth of water measured through Parshall flume was given. Soil samples were taken from three replicates before each irrigation and 24 hours after irrigation and soil moisture content was determined gravimetrically. Short period consumptive use was worked as per the formula suggested by Dastane (1972). The actual Kc values were estimated as follows :

$$Kc = \frac{ET}{ET_0}$$

Table 1. Predicted and actual crop evapotranspiration (mm) at different stages of summer groundnut during 1989 and 1990

| Stages | Methods of estimation | | 1989 | | | | 1990 | | | | | | | |
|-------------------------------------|-----------------------|------------|--------------------|---------------|---------------|----------------|---------------|---------------|---------------|----------------|--------|--------|-------|-------|
| | Establishment | | Establishment | | Total (mm) | | Establishment | | Total (mm) | | | | | |
| | 10-40 days | 40-70 days | 10 to 40 days | 41 to 65 days | 66 to 96 days | 97 to 137 days | 10 to 41 days | 42 to 68 days | 69 to 97 days | 98 to 136 days | | | | |
| Modified Penman method | 70 | 46.81 | 94.75 | 226.92 | 176.3 | 614.78 | 70 | 51.2 | 104.22 | 218.66 | 159.12 | 603.2 | | |
| Pan evaporation method | 70 | 43.71 | 75.25 | 172.05 | 116.03 | 477.04 | 70 | 48.96 | 83.43 | 162.98 | 103.35 | 468.72 | | |
| Field Method | | | | | | | | | | | | | | |
| Irrigation schedules (IW/CPE ratio) | | | | | | | | | | | | | | |
| | 10-40 days | 40-70 days | 70 days to harvest | | | | | | | | | | | |
| I ₁ | 0.5 | 0.75 | 0.75 | 62.2 | 114.6 | 192.4 | 228.9 | 668.1 | 70 | 40.2 | 111.9 | 194.0 | 252.5 | 668.6 |
| I ₂ | 0.5 | 0.5 | 0.75 | 62.2 | 84.8 | 192.4 | 228.9 | 638.3 | 70 | 40.2 | 95.8 | 194.0 | 252.5 | 652.5 |
| I ₃ | 0.5 | 0.75 | 0.5 | 62.2 | 114.6 | 183.6 | 231.5 | 661.9 | 70 | 40.2 | 111.9 | 181.9 | 209.4 | 613.4 |
| I ₄ | 0.5 | 0.5 | 0.5 | 62.2 | 84.8 | 183.6 | 231.5 | 632.1 | 70 | 40.2 | 95.8 | 181.9 | 209.4 | 597.3 |
| I ₅ | 0.75 | 0.75 | 0.75 | 89.8 | 114.6 | 192.4 | 228.9 | 695.7 | 70 | 64.1 | 111.9 | 194.0 | 252.4 | 692.5 |

During the crop growth 47.9 and 79.0 mm of effective rainfall was received and this was accounted in computation process.

Predicted ET crop and selected crop coefficients (Kc values) were as per the guidelines given by Doorenbos and Pruitt (1977). The two prediction methods followed were modified Penman method and Pan evaporation method as indicated below.

The prediction equation of the modified Penman method is :

$$ET_0 = C [W, R_n + (1-W) f(u) (e_a - e_d)]$$

| | |
|-------------------|---------------------|
| Radiation term | Aerodynamic term |
|-------------------|---------------------|

$$ET_{crop} = ET_0 \times K_c$$

The data on different weather parameters were collected for the corresponding period and predictions were done.

Predicted and actual evapotranspiration of groundnut and also crop efficient values were compared at different stage to identify the peak period of water use and to know the validity of prediction methods.

RESULTS AND DISCUSSION

Crop evapotranspiration

Results on predicted evapotranspiration (Table 1) indicated 22 per cent higher ET_{crop} with modified Penman method than Pan evaporation method during both the years. High ET_{crop} with modified Penman method compared to Pan evapotranspiration method can be attributed to the fact that it takes into account almost all the weather parameters influencing the ET_{crop} (Ramachandra Reddy *et al.*, 1984 and Seshagiri Rao *et al.*, 1983). The actual crop evapotranspiration varied in different irrigation schedules. Scheduling irrigation uniformly at 0.75 IW/CPE ratio throughout (I₅) caused maximum crop

evapotranspiration during both the years, followed by I₁, I₃ and I₂ irrigation schedules during 1989 and I₁, I₂ and I₃ irrigation schedules during 1990. Irrigation schedule at 0.5 IW/CPE ratio throughout caused minimum crop evapotranspiration. However, the actual crop evapotranspiration based on field method was higher in all the five irrigation schedules except in I₄ during 1990 compared to both the prediction methods, but the estimated values by modified Penman method were nearer to the actual values.

The methods presented on ET crop assume soil water in ample supply. After irrigation, the soil water content will be reduced primarily by evapotranspiration. As the soil dries the rate of water transmitted through the soil will reduce. When the rate of flow falls below the rate needed to meet ET crop, ET crop will fall below its predicted level (Doorenbos and Pruitt, 1977). This phenomenon was noticed in I₄ irrigation schedule during 1990. While in the other irrigation schedules due to 47.9 and 79.0 mm of effective rainfall received during the crop growth increased the crop ET more than the predicted ET crop by modified PENMAN method.

In all the three methods crop evapotranspiration was less in the flowering stage (10 to 40 days) and it increased with advancement in growth attaining peak at pod development stage (70 days to harvest). This clearly indicates that pod development stage followed by flowering and pegging stages were moisture sensitive stages requiring more irrigation. These results also confirm the findings of Ramachandra Reddy (1988). Hence in the absence of actual crop evapotranspiration based on field experimentation, computed ET crop based on modified Penman method can be used for predicting the crop evapotranspiration for efficient use of available irrigation water.

Table 2. Selected and actual crop coefficients (Kc values) at different stages of summer groundnut during 1989 and 1990

| Stages Methods | 1989 | | | | 1990 | | | | | | |
|--|------------------|------------------|--------------------------|-------------------|------------------|------------------|------------------|-------------------|------|------|------|
| | 10 to 40 days | 41 to 65 days | 66 to 96 days | 97 to 137 days | 10 to 41 days | 42 to 68 days | 69 to 97 days | 98 to 136 days | | | |
| Modified Penman method | 0.3 | 0.62 | 1.05 | 0.6 | 0.31 | 0.63 | 1.05 | 0.6 | | | |
| Pan evaporation method | 0.37 | 0.64 | 1.05 | 0.6 | 0.38 | 0.67 | 1.05 | 0.6 | | | |
| Field Method Irrigation schedules (IW/CPE ratio) | | | | | | | | | | | |
| | 10-40 days | 40-70 days | 70 days to harvest | | | | | | | | |
| I ₁ | 0.5 | 0.75 | 0.75 | 0.7 | 0.7 | 0.84 | 0.78 | 0.23 | 0.64 | 0.9 | 0.96 |
| I ₂ | 0.5 | 0.5 | 0.75 | 0.51 | 0.51 | 0.84 | 0.78 | 0.23 | 0.55 | 0.9 | 0.96 |
| I ₃ | 0.5 | 0.75 | 0.5 | 0.7 | 0.7 | 0.75 | 0.83 | 0.23 | 0.64 | 0.74 | 0.90 |
| I ₄ | 0.5 | 0.5 | 0.5 | 0.51 | 0.51 | 0.75 | 0.83 | 0.23 | 0.55 | 0.74 | 0.90 |
| I ₅ | 0.75 | 0.75 | 0.75 | 0.70 | 0.70 | 0.84 | 0.78 | 0.37 | 0.64 | 0.90 | 0.96 |

Crop coefficients (Kc values)

Selected crop coefficients were almost same in both the prediction methods except the first and second stages where it varied slightly due to variation in the estimated ET_0 in both the methods. Kc values were less in the beginning and increased with advancement in crop growth and tended to decrease later revealing a bell shaped crop coefficient curve (Table 2).

Actual Kc values in the early stages of crop growth (10-40 days) ranged from 0.37 to 0.54 in 1989 and 0.23 to 0.37 in 1990 in different irrigation schedules (Table 2). With the advancement in crop growth in maximum canopy and root system around 100 days the crop coefficients attained the maximum. Later ratios tended to decrease in 1989 except in I_3 and I_4 but the increasing trend was noticed in 1990 consequent to the occurrence of rains before harvest which caused increase in the ratio (Fig. 1). The value of Kc largely depended on the frequency with which the soil is wetted by irrigation and/or rain (Doorenbos and Pruitt, 1977). In general, scheduling irrigation at 0.75 IW/CPE ratio at one stage or the other resulted in higher crop coefficient values while the Kc values were lower when irrigations were scheduled at 0.5 IW/CPE ratio at any stage. Sharp increase in Kc values just following irrigation with a less sharp but marked decline afterwards until the next irrigation was probably the cause for the variation in Kc values in different irrigation schedules.

Thus, it can be concluded that in the absence of actual crop evapotranspiration based on the field experimentation, computing ET crop based on modified Penman method could be used for crop water planning.

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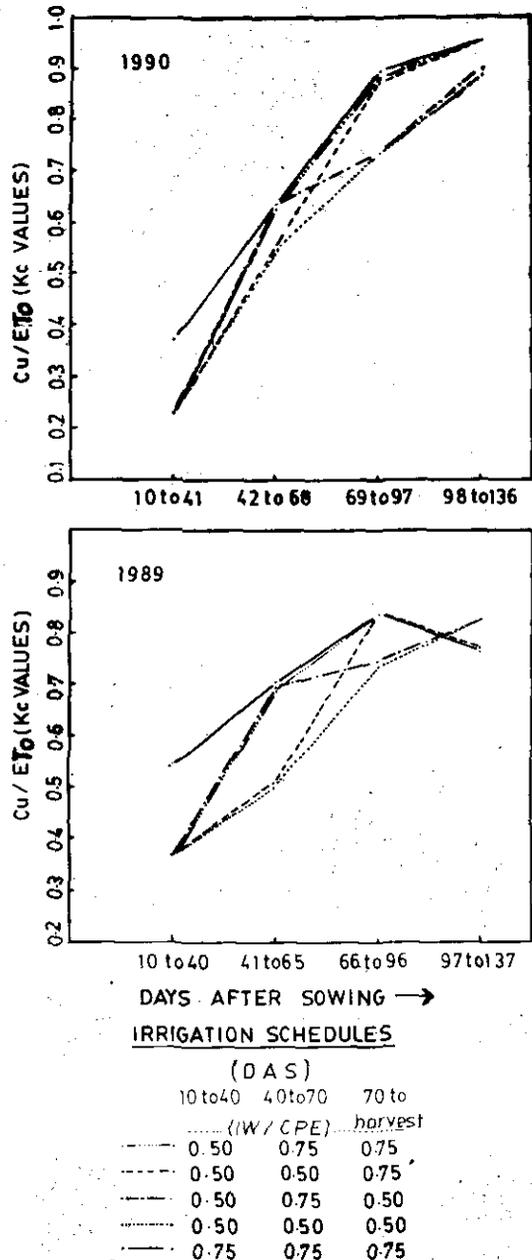


Fig. 1. Cu/ET_0 (Kc values) as influenced by irrigation schedules in summer groundnut

LITERATURE CITED

- Dastane, N.G. 1972. A Practical manual for water use research in agriculture. Navabharat Prakashan, Poone-2 pp.120.
- Doorenbos, J. and Pruitt, W.O. 1977. Guidelines for predicting crop water requirements. *FAO Irrigation and Drainage paper* -24.
- Ramachandra Reddy, P., Rami Reddy, S., Ramakrishna Reddy, M.G., Subramanyam, M.V.R., Gopala Rao, P. and Ananda Rao, 1981. Computing water requirement of field crops using prediction methods for Bapatla region. *The Andhra agric. J.* 31 (2) : 106-112.
- Ramachandra Reddy, P., 1988, Computing water requirement of groundnut. *Annals of Arid zone.* 27(3 and 4) : 247-251.
- Seshagiri Rao, M., Rami Reddy, S. and Reddy, Y.M. 1983. Reliability of empirical formulae for the determination of crop water requirements. *The Andhra agric. J.* 30 : 160-163.

EFFECT OF TILLAGE ON CLOD SIZE DISTRIBUTION, PENETRATION RESISTANCE AND YIELD OF GROUNDNUT IN RICE BASED CROPPING SYSTEM AFTER PUDDLED RICE

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ABSTRACT

Field experiments were conducted on a sandy loam soil to study the effect of tillage on irrigated groundnut crop after wet season puddled rice during 1988 - 89 and 1989 - 90. Tillage methods tried were: ploughing twice with bullock drawn country plough; country ploughing twice followed by bullock drawn disc harrow twice; country ploughing twice followed by bullock drawn disc harrow 4 times; country ploughing twice followed by power tiller operate rotavator twice and disc plough once plus disc harrow once, both tractor drawn. Higher proportion of finer clods were obtained with rotavator and soil penetration resistance was significantly reduced. Tillage had no significant effect on bulk density. Germination of groundnut was highest in rotavator treatment. Yields in rotavator and tractor drawn treatments were higher compared to bullock drawn treatments.

Key Words: Tillage; Clod size distribution; Penetration resistance; Germination; Yield.

INTRODUCTION

Oilseeds and pulses are grown after wet season puddled rice in Andhra Pradesh, and one of the factors responsible for their low yields is the entirely different soil physical environmental requirements of these crops compared to rice crop. Puddling is done for sowing rice crop which results in destruction of soil structure, thereby reducing percolation losses of irrigation water and also reduce weed growth. After harvest of rice crop the puddled soils become hard on drying thus making seed bed preparation difficult for upland crops following rice. For growing a successful crop of groundnut after puddled rice the limitations are poor germination resulting in low crop stand, restricted root growth, poor nodulation, resistance to peg penetration and pod development. In view of these limitations potential yields are not achieved even with assured irrigation and fertilizer application in Andhra Pradesh. It is essential to develop economically viable and

easily adoptable tillage practices to increase the yields of groundnut crop in rice - based cropping system after puddled rice.

MATERIALS AND METHODS

A field experiment was conducted at the Agricultural College Farm, Rajendranagar, A.P. Agricultural University, Hyderabad, during *rabi* 1988-89 and 1989-90. During *kharif* season puddled rice was taken up in both the years, and after the harvest of *kharif* rice the study was taken up with groundnut crop. The soil was sandy loam (Alfisol). Land was prepared for groundnut crop by imposing five tillage treatments at optimum soil moisture conditions. The tillage treatments were :

- T₁ : Ploughing twice with the bullock drawn country plough.
- T₂ : T₁ + Bullock drawn disc harrow twice.
- T₃ : T₁ + Bullock drawn disc harrow four times.

* Since diseased

T4: T1 + power tiller operated rotavator twice.

T5: Disc plough once + disc harrow once, both tractor drawn.

The treatments were replicated four times in Randomized Block Design. After the tillage treatments were imposed, groundnut seed (TMV-2) was hand-dibbled at a spacing of 30x10 cm. Recommended fertilizer doses were given. Irrigation was given immediately after sowing and whenever required during crop growth period.

Depth of tillage was measured and soil samples were collected from the tilled layer from 0.5 m² area before sowing. Clod size distribution was measured by dry sieving method and mean weight diameter (M.W.D.) was calculated (Black, 1965). Penetration resistance of soil at peg penetration stage was measured using cone penetrometer. Soil moisture was estimated gravimetrically. Bulk density was measured on core samples. Data on per cent germination and yield were collected.

RESULTS AND DISCUSSION

Clod size distribution

Tillage had significantly influenced the clod size distribution (Fig.). Big clods of >10cm diameter were found only in country ploughing treatment (T1). Clods of >5cm diameter were highest (43.3%) in T1 and lowest (7.7%) in rotavator treatment. Medium size aggregates (≥ 0.5 cm and <2cm diameter) were more in rotavator, followed by bullock drawn disc harrowing, tractor drawn and country ploughing treatments. Aggregates of 5-10 cm diameter were lowest (9.7%) in tractor drawn treatment (T5). Relatively uniform size distribution and highest proportion of finer aggregates were obtained with rotavator (T4) which might be due to the pulverising effect of rotavator.

Mean weight diameter

The mean weight diameter (M.W.D) of dry aggregates was highest in T1 (4.37 and 4.57 cm respectively, during the two years). It was almost the same in tractor drawn and two times disc harrowing treatments, followed by four

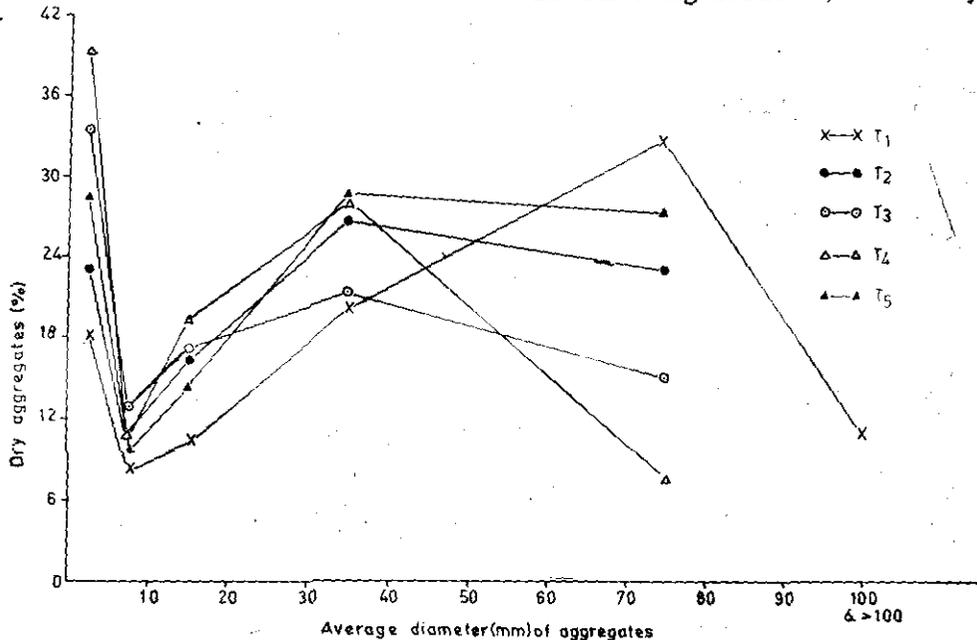


Fig. Dry aggregate size distribution of soil after puddled Rice as influenced by tillage

Table Effect of tillage on soil physical properties, germination and yield of groundnut

| Tillage treatments Parameter | 1988-89 | | | | | 1989-90 | | | | | | | | |
|--|----------------|----------------|----------------|----------------|----------------|----------|-------|----------------|----------------|----------------|----------------|----------------|----------|-------|
| | T ₁ | T ₂ | T ₃ | T ₄ | T ₅ | CD at 5% | SEm ± | T ₁ | T ₂ | T ₃ | T ₄ | T ₅ | CD at 5% | SEm ± |
| Depth of ploughing (cm) | - | - | - | - | - | - | - | 7.0 | 7.1 | 7.8 | 7.6 | 12.9 | - | - |
| Bulk density (g/cc) | - | - | - | - | - | - | - | 1.52 | 1.53 | 1.53 | 1.53 | 1.57 | NS | - |
| Mean weight diameter (cm) | 4.37 | 3.76 | 2.90 | 1.90 | 3.8 | - | - | 4.57 | 2.30 | 1.70 | 1.30 | 2.10 | - | - |
| Germination (%) | 53.7 | 61.7 | 61.0 | 66.8 | 66.4 | - | - | 40.5 | 40.8 | 43.3 | 47.3 | 43.9 | - | - |
| Penetration resistance (kg/cm ²) | | | | | | | | | | | | | | |
| a) At flowering stage | 21.8 | 25.8 | 29.0 | 28.6 | 28.2 | - | - | 18.8 | 21.1 | 23.2 | 11.3 | 19.8 | 2.90 | 0.94 |
| b) At pegging stage | 39.6 | 33.8 | 34.3 | 28.6 | 28.2 | 2.69 | 0.83 | 31.1 | 31.9 | 35.8 | 30.1 | 34.0 | 2.80 | 0.86 |
| Soil moisture content (%w/w) | | | | | | | | | | | | | | |
| At pegging stage | 13.6 | 14.4 | 13.7 | 13.0 | 10.9 | - | - | 8.7 | 8.6 | 9.0 | 9.2 | 9.1 | 0.33 | 0.10 |
| Yield (q/ha) | | | | | | | | | | | | | | |
| a) Haulms | 24.8 | 25.9 | 24.7 | 32.9 | 36.2 | 5.30 | 1.62 | 22.9 | 24.4 | 26.1 | 29.6 | 27.8 | 4.04 | 1.24 |
| b) Pods | 10.88 | 10.99 | 14.56 | 16.32 | 19.56 | 4.03 | 1.24 | 17.82 | 17.99 | 19.52 | 21.64 | 19.66 | 2.38 | 0.73 |

times disc harrowing, and was the lowest (1.90 and 1.30 cm in two years, respectively) in rotavator treatment. The lowest M.W.D. was due to the presence of more small sized clods obtained with rotavator.

Bulk density

Bulk density in different tillage treatments ranged between 1.52 and 1.57 g/cc (Table). However, there were no significant differences in bulk density due to tillage.

Germination

Data on per cent germination (Table) revealed that tillage affects germination. Rotavator treatment (T₄) resulted in highest germination (66.8 and 47.3% in two years respectively), followed by tractor drawn treatment (66.4 and 43.9%), bullock drawn disc harrowing treatment, and was lowest in country ploughing treatment (53.7 and 40.5% in two years, respectively). Germination per cent showed a more or less inverse relation with M.W.D. Good germination in rotavator treatment might be due to higher proportion of finer aggregates, relatively uniform clod size distribution resulting in closer seed - soil contact. Padmaraju, reported that poor germination of groundnut, after puddled rice is due to lack of proper seed - soil contact, (unpublished data).

Penetration resistance

Penetration resistance of soil was measured at flowering and pegging stages. Penetration resistance in rotavator was on par with tractor drawn treatment in first year and was lowest (30.1 kg/cm²) in second year at pegging stage. This has significance from the point of view of peg penetration.

Soil moisture

There was significant effect of tillage on soil moisture content during the second year, particularly at early stages of crop growth. It was higher in rotavator treatment throughout the crop growth.

Yield

The haulm and pod yields were significantly influenced by tillage in both the years (Table 1). In the year 1988-89, haulm and pod yields were highest in tractor drawn treatment (36.20 and 19.56 q/ha respectively) closely followed by rotavator treatment. During 1989-90, highest yields of haulm and pods were recorded in rotavator treatment (29.60 and 21.64 q/ha, respectively) closely followed by tractor drawn treatment. However, in both the years, the difference between the two treatments was not statistically significant.

Higher yields in rotavator treatment could be due to uniform clod size distribution with more of finer clods, higher germination (crop stand), higher moisture content and also less soil resistance to peg penetration. Higher yields in tractor drawn treatment could be due to higher depth of ploughing resulting in breaking of sub-soil hard layer which might have helped in better development of crop and pods.

CONCLUSION

Based on the above results, it is suggested that power tiller operated rotavator tillage is beneficial for growing groundnut after puddled rice in light textured soils of Andhra Pradesh, because of relative ease of operation, low cost and higher yields.

It may be concluded that the tillage, which results in smaller clod size and relatively deep ploughing to break the sub-soil hard layer are essential for groundnut when taken up in puddled rice soils for obtaining higher yields.

LITERATURE CITED

- Black, C.A. 1965. Methods of soil analysis. Part I. Monograph No.9, Agronomy series, American Society of Agronomy Madison, Wisconsin.
- Prihar, S.S., Ghildyal, B.P., Painuli, D.K. and Sur, H.S. 1985. Physical properties of mineral soils affecting rice-based cropping system. In Soil physics and rice, IRRI. pp. 57-70.

CHEMODIAGNOSIS OF PHYLLODY MLO INFECTION IN SESAME (*SESAMUM INDICUM* L.)

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ABSTRACT

Phyllody MLO (SPD MLO) infection in sesame could be detected using Dienes' stain at 0.5 per cent concentration and staining period of 15 min. Apical stem tissue was found to be the most suitable tissue for detecting SPD MLO infection. Infection could be detected in 6-10 days prior to the expression of visible symptoms.

Key words : Mollicutes; Chemodiagnosis; Phyllody.

INTRODUCTION

The application of diagnostic tests for identifying the virus/MLO- infected plants has been found to be useful either in eliminating sources of inoculum in the field or obtaining virus/MLO- free seed material. Such tests are based on differential colour reactions of infected tissues (Linder, 1961) or serological tests. Sesame phyllody disease (SPD) is the most destructive disease of sesame and can cause losses as high as 99 per cent in yield (Marimuthu *et al.*, 1973). Several methods have been tested by researchers. If the method is simple, it is likely to be adopted in large scale provided the detection of MLO infection can be done with reasonable accuracy. With this aim in view, many chemicals have been tested for their usefulness in detecting phyllody MLO infection in sesame.

MATERIALS AND METHODS

Sesame (*Sesamum indicum* L.) plants showing symptoms of phyllody infection were marked in the fields of oilseeds breeding station, Tamilnadu Agricultural University, Coimbatore. Transmission of SPD MLO was made by using

insect vector, *Crosius albicinctus*. Distant to healthy sesame (TMV 3) plants. Plants showing typical phyllody symptoms were used in the study.

Diagnostic tests

Plant tissues from sixty days old TMV 3 sesame plants inoculated at 15 DAS were used for all the studies, unless until specified.

Effect of different concentrations of Dienes' stain on sesame phyllody disease detection

Dienes' stain was used to detect the sesame phyllody disease infection in the plants as per the procedure described by Deelay *et al.*, 1979.

Free hand cross sections of healthy and diseased stem were taken and transferred to stain solutions at different concentrations for different staining periods viz., 15, 30, 45 and 60 min. Then the sections were placed in distilled water for 30 min. After washing in distilled water, the sections were mounted in water on a microscope slide and examined. For each concentration 25 sections from five plants were examined.

Reaction of various plant parts of sesame with Dienes' stain

Free hand cross sections of healthy and diseased stems, leaf petiols and flower pedicle were subjected to Dienes' stain. Sections were observed under microscope for their reaction to stain.

Early detection of sesame phyllody infection with Dienes' stain

Fifteen days old TMV 3 seedlings were inoculated. They were used to detect sesame phyllody infection by Dienes' stain (0.5 per cent concentration) at different intervals viz., 5, 8, 11, 14, 17, 20, 23, 26, 29, 32 and 35 days after inoculations. Stem sections of five plants at each interval of testing (10 sections) were examined. Number of plants showing positive reaction with stain was recorded. Sections of comparable tissues from uninoculated TMV 3 plants served as control.

Detection of sesame phyllody disease with 2, 3, 5-triphenyl tetrazolium chloride and phloroglucinol

2, 3, 5-Triphenyl tetrazolium chloride (SISCO Research Lab. Maharaj Bhavan, Bombay) was used to detect sesame phyllody disease as per the procedure described by Sharma (1988). Phloroglucinol (SISCO Research Lab, Maharaj Bhavan, Bombay) was used in these studies and the method of Narayanasamy and Natarajan (1974) was followed.

Flourescence test

Ten gram leaf samples each from healthy and phyllody infected sesame plants were taken in test tube and 20 ml of distilled water was added. Samples were autoclaved at 15 lb pressure for 15 min. To the supernatant, equal volume on *n*-butanol was added and the mixture was shaken well. A drop of one percent ammonium hydroxide was added to the mixture and observed for omission of flourescence.

Detection of sesame phyllody disease with DAPI

A DNA specific flouochrome, 4,6-diamidno-2-phenyl indole 2HCl (DAPI, Fluka chemie, Switzerland) was used to detect sesame phyllody disease following the method of Hiruki (1986). Transverse sections were hand cut with razor blade from stem, leaf petiole and flower pedicle of healthy and diseased plants. These sections were fixed in five per cent gluteraldehyde in 0.1 M phosphate buffer (pH 7.0) at 4°C for 2h. The sections were washed in same buffer and stained in DAPI (1 µg/ml) for 30 min and mounted in a drop of DAPI and observed under Nikon Microphot FX-35 microscope with flourescence attachment using exciter filter U and barrier filter BA 420. Twenty five sections for five plants were examined for each set of treatment.

RESULTS AND DISCUSSION

In the present investigations using Dienes' stain at 0.5 per cent concentration with a staining period for 15 min, it was possible to distinguish the SPD MLO infected tissues, as the blue colour was retained in phloem tissue of infected plants only. Detection of MLO infections was reported for RYD in rice by Srinivasan (1982) and for grassy shoot of sugarcane by Bhanasali and Shukla (1985).

Apical stem tissue was found to be the most suitable tissue for detecting sesame phyllody infection, as revealed by the intense dark blue colour of phloem tissue (Table 1).

Infection of sesame plants with SPD MLO could be detected using Dienes' stains 6-10 days before the expression of visible symptoms (Table 2). All the infected plants could be detected at 29 days after inoculation when none of the infected plants showed any visible symptoms. This indicates that the differential host tissue response to the presence of SPD MLO might be observed much earlier as reflected by the reaction with Dienes' stain,

Table 1. Reaction of tissues of different plant parts of sesame to Dienes' stain (0.5%)

| Plant part | Healthy | | Diseased | |
|----------------|---------|---------|--------------|-------------|
| | 15 min. | 30 min. | 15 min. | 30 min. |
| Stem | 0 | 0 | 25* (+++) | 25 (+++) |
| Flower pedicel | 0 | 0 | 14(+) | 17(+) |
| Leaf petiole | 0 | 0 | 0 | 0 |

* Number of sections showing positive reaction out of 25 tested

- : No reaction; + : Low

++ : Moderate; +++ : High

than the expression of visible symptoms, which possibly depend on much higher pathogen concentration to be reached after long period of infection. Several workers have suggested the use of Dienes' stain as a simple and quick method of detecting MLO infections in corn stunt, sandal spike, brinjal little leaf, clover phyllody rubbery wood of apple citrus stubborn (Deelay *et al.*, 1979, Srinivasan, 1982) little leaf of eucalyptus (Ali, *et al.*, 1986), Sugarcane grassy shoot (Bhansali and Shukla, 1985), mulberry dwarf in *Catharanthus roseus*, red clover and *Astragalus sinicus* (Kim *et al.*, 1985).

2, 3, 5-Triphenyl tetrazolium chloride at one per cent concentration failed to detect the

Table 2. Early detection of sesame phyllody infection with Dienes' stain

| Days after inoculation | No. of plants reacting positively out of five | Sesamum phyllody infection (%) | |
|------------------------|---|---|----------------------------------|
| | | Plants showing positive reaction with stain | Plants showing external symptoms |
| 20 | 0 | 0 | 0 |
| 23 | 1 | 20 | 0 |
| 26 | 3 | 60 | 0 |
| 29 | 5 | 100 | 20 |
| 31 | 5 | 100 | 80 |
| 33 | 5 | 100 | 90 |
| 35 | 5 | 100 | 100 |

phyllody infection in sesame. The phloroglucinol test has been applied to detect bud blight infection in groundnut (Narayanasamy and Natarajan, 1974) execortis viroid in *Poincirus trifoliata* raf. (Childs *et al.*, 1958) and leaf roll infection in potato, (Sheffield, 1943). However, under present investigation, this test did not yield positive results with infected tissues from phyllody affected sesame plants.

Flourescence of an extract of carnation plants appears to be a valuable diagnostic aid for carnation mosaic (Thomas *et al.*, 1951). In the present study, consistent results were not obtained with leaf and stem tissues from phyllody affected sesame plants when this test was employed. 4, 6-diamidino-2 phenyl indole-2 HCl (DAPI) was first successfully used for rapid detection of mycoplasmal contamination in animal tissue culture system (Russel *et al.*, 1975). However, this DNA specific flourochrome at 1. Oug- /ml. concentration failed to distinguish the phyllody infected plants from healthy sesame, when sections from stem, leaf petiole and flower pedicel tissue were tested. It is possible that the slimy nature of sesame tissue due to presence of mucilage glands and oil glands on stem, petiole and leaf (Solerder, 1908) may interfere with the stain.

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LITERATURE CITED

- Ali, M.I.M., Balasundaram, B.M. and Ghosh, S.K. 1986. Histopathological detection of little leaf disease of *Eucalyptus* in Kerala. pp. 404-408. In: *Eucalyptus* in India, past, present and future. Ed. J.S. Sharma, C.T.C. Nair, S. Kedharnath, and S.Kondas. Proceedings of the National Seminar held at Peechi, Kerala, India.

- Bhansali, R.R. and Shukla, U.S.** 1985. Stains for detecting mycoplasma like organisms and anatomical changes in grassy shoot diseased sugarcane leaves *J.Pl.Anat.Morph.* 2 : 55-61.
- Childs, J.F.L., Norman, G.G. and Eichhorn, J.L.** 1958. A colour test for exocortis infection *poincirus trifoliata*. *Phytopathology*. 48 : 462-432.
- Deeley, J., Stevens, W.A. and Fox, R.T.V.** 1979. Use of Dienes' stain to detect plant diseases induced by mycoplasma like organisms. *Phytopathology* 69 : 1169-1171.
- Hiruki, C.** 1986. Little leaf disease of *Brugmansia cnadida*: a new disease associated with mycoplasma like organisms. *Ann. Phytopath. Soc. Japan.* 52 : 675-682.
- Kim, Y.H., La., Y.J. and Kim, Y.T.** 1985. Transmission and histochemical detection of mulberry dwarf mycoplasma in several herbaceous plants. *Korean J. Pl. Path.* 1 : 184-189.
- Linder, R.C.** 1961. Chemical tests in the diagnosis of plant viruses *Bot. Rev.* 27 : 501.
- Marimuthu, T., Mchanraj, D. and Rangasamy, M.** 1973. An assessment of crop loss due to phylloidy of sesamum. *Lab. Dev. J. Sci. Technol.* 11 (3-4) : 78-80.
- Narayanasamy, P. and Natarajan, C.** 1974. A rapid test for the identification of virus, infected groundnut. *Curr. Sci.* 43 (21) : 700-701.
- Russel, W.C., Newman, C. and Williamson, D.H.** 1975. A simple cytochemical technique for demonstration of DNA in cells infected with mycoplasmas and viruses. *Nature* 252 : 461-462.
- Sheffield, F.M.L.** 1943. Value of phloem necrosis in the diagnosis of potato leaf roll. *Ann. Appl. Biol.* 30 : 131-136.
- Solender, H.** 1908. Systematic anatomy of the dicotyledons. Clarendon press, Oxford. pp. 245.
- Srinivasan, N.** 1982. Simple diagnostic technique for plant disease of mycoplasma etiology. *Cur. Sci.* 51 : 883-885.
- Thomas, J.M., Baker, R.R. Jr. and Zoril, J.G.** 1951. The use of ultraviolet light as a means of diagnosing carnation mosaic. *Science.* 113 : 576-577.

CONCEPTS OF BREEDING DERIVED FROM EXPERIMENTS ON PEANUTS (*ARACHIS HYPOGAEA* L.)

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ABSTRACT

The initial step of a breeding programme is as vital as the final improved yield desired by a breeder. An analysis of experimental evidence in the light of underlying genetic concepts suggests a choice of parents on genetic divergence given by a multivariate measure. Breeding programmes initiated from heterotic F₁'s envisage a greater probability of success in further generations compared to programmes initiated from any F₁ including non-heterotic ones. Limits to parental divergence are therefore set to realise F₁ heterosis. Large F₂ populations of heterotic F₁'s need an ordering process to locate productive recombinants. A method of forming a ranked F₂ distribution is suggested using values of a selection index based on physiological and yield components. Selection intensity of the order of 25% is most often adequate to derive desirable selections in F₃ and superior lines in F₅.

Key words : Groundnut; Genetic divergence; Breeding; Selection ; Recombination; Heterosis; Selection intensity.

INTRODUCTION

Experiments bearing on the utility of various breeding techniques have been widely reported in all crops. Most of them utilize a limited number of genotypes and a limited number of environments. Consequently most of the results are specific and hardly admit generalisation.

A national project on fundamental genetic studies on enhancing productivity in groundnut was conceived in this background during 1978. It was supported by Indian Council of Agricultural Research and was in operation at the Indian Agricultural Research Institute, Hyderabad and New Delhi during 1978-1990. The main aim of the project was to explore a genetic basis of breeding for high productivity in peanuts. Experiments were therefore formulated to provide continuity of breeding material and to simultaneously uncover or discover genetic concepts of breeding capable of yielding dividends with a high probability. Conceptual results of application potential sifted from the research experiments conducted over a decade are presented in this paper.

1. Parental divergence

Breeding programmes are, in general, initiated from crosses made between diverse parents. The diversity most often is for their geographic origin or for specific attributes concerning resistance to biotic and abiotic stresses, food or oil quality, maturity, plant type and the like. Therefore, the improvement anticipated in successive generations is, most often, for the attribute deciding diversity. If the improvement for such an attribute is accompanied by a correlated response in others including yields, an overall improved strain or variety results as a final product. In other cases, positive improvements registered in one attribute gets diluted by negative or negligible improvements in others forcing the breeding programmes to branch back to initial steps.

Under such circumstances, it is desirable to base the measure of divergence on a number of component characters that have a direct or indirect bearing on the desired final products, most often, yield. Past experience tends to suggest that a profitable choice can be the component characters having a bearing on the

fitness of the genotype under natural selection (Murty and Arunachalam, 1966). A convenient measure of the divergence based on a number of traits is then provided by the Mahalanobis' D^2 - statistic (Rao, 1952). It must be noted that the choice of the basic set of characters measuring genetic divergence is crucial. No definite criteria can be set for its choice; this must depend on the breeder's experience and the nature of the crop. Pilot runs of divergence patterns of known material may provide clues.

2. Parental divergence vis-a-vis heterosis

Genetic divergence, as one of the criteria of selection of parents is, in general, considered in plant breeding as a means to generate crosses which segregate in later generations into genotypes transgressing the performance of the better parent (Murty *et al.*, 1962; Timothy, 1963). Further F_1 heterosis which is of direct interest for developing hybrids in cross-pollinated crops, is also of importance in self-pollinated crops. Such heterotic crosses may produce desirable transgressive segregants in advanced generations. It is increasingly realised that crosses between divergent parents usually produced greater heterosis than those between closely related ones as was pointed out long time ago by East and Hayes (1912) and Hayes and Johnson (1939). In practical situations, it can be reasoned that heterosis occurs because of parental divergence. But when divergent parents are crossed, heterosis is not bound to occur always (Cress, 1966; Matzinger and Wernaman, 1967; Busbice and Rawlings, 1974). It is essential therefore, to explore the possible limits to parental divergence within which there would reasonably be high chances for the occurrence of heterosis.

3. Limits to parental divergence for heterosis

Information of parental divergence and F_1 heterosis for a few important characters was hence examined in 2 diallel crosses with reciprocals in peanut - one with 15 and the

other with 10 parents, and the second, a set of crosses made to a line x tester design with 10 female and 6 male parents in rapeseed (*Brassica campestris*) (Arunachalam and Bandyopadhyay, 1984). The F_1 crosses were evaluated in Randomized Block Design for component characters. The genetic divergence among the parents was measured by D^2 statistic.

Three important yield components were considered on each crop - pod yield, 100- kernel weight and shelling percentage in groundnut and length of main axis, number of siliquae on main axis and number of seeds per siliquae in rapeseed. Heterosis was calculated in all the experiments as the per cent improvement of F_1 over better parent for every character.

A method was devised to delineate parental divergence on four divergence classes (DC). To take into account the variable magnitude of variation in parental divergence in various experiments, the mean (m) and standard deviation (s) of the values of divergence classes were defined as follows:

$$DC1 : D^2 \geq (m + s)$$

$$DC2 : D^2 < (m + s) \text{ and } \geq m$$

$$DC3 : D^2 \geq (m - s) \text{ and } < m$$

$$DC4 : D^2 < (m - s)$$

It may be noted that in this set up, DC1 and DC4 are extremely divergent classes in either direction. This method was found to be the best of the various methods tried.

For each cross, the divergence class to which the D^2 value between their parents belonged was established. The number of crosses (n) falling in each divergence class, the proportion of crosses showing positive values of heterosis (p) and the mean for each character over such crosses (x) were computed. Since, in this process even a very low positive

value of heterosis which may not be of great importance would get included, it was decided to set a norm for heterosis and obtain frequencies of crosses showing heterosis greater than or equal to the norm. The norm (k) was taken to be the mean heterosis value of these crosses with positive value of heterosis for that character. The proportion of crosses (q) showing a heterosis value greater than or equal to K and the mean (y) for each character over such crosses were also worked out.

The divergence classes were ranked for their relative order of importance on the basis of the values of p , x , q and y separately. However, the relative order could vary in each case, also in each experiment and for each character. In order to come to a final conclusion jointly on the ranking based on p , x , q and y a scoring process was adopted. The divergence class which gave the highest value of p was allotted a score 1, the next best a score 2 and so on. Whenever there was a tie, the classes involved in the tie received the same score. The scores over p and x were added across the three characters to obtain a final score for each divergence class. Similar procedure was adopted for q and y . It must be noted that the divergence class with the lowest total score will be the most desirable one with a high frequency of heterotic crosses and high average magnitude of heterosis.

The experimental evidence thus provided by the two crops has suggested a consistent relationship between parental divergence and F_1 heterosis. The relationship was arrived at by methods providing precautions to avoid any bias.

4. Divergence classes and heterosis

The results brought out the consistent superiority of DX2 and DC3 over DC1 or DC4 as far as the occurrence of a high proportion of heterotic crosses (p and x) or of a high value of heterosis (q and y) was concerned (Table 1).

Studies on triticale (Srivastava and Arunachalam, 1977) supported those results, though the delineation of divergence classes was not made there as precisely as in this study. The concept that there are limits to parental divergence for optimum expression of heterosis gained strength even from studies made in the past - for example, the performance of crosses among divergent geographic races in maize (Moll, Lonnqvist, Fortuno and Johnson, 1965). Our studies (Arunachalam and Bandyopadhyay, 1984; Arunachalam *et al.*, 1984) cited above, provide experimental conception to those limits and for the hypothesis in general that -- if m and s are the mean and standard deviation of the values of divergence (given by D^2) among parents, the chances for the occurrence of a high frequency of heterotic crosses and with high values of heterosis are more when the parents are chosen to have their divergence in the interval ($m-s$, $m+s$) compared to the crosses between parents whose divergence falls outside that interval.

5. Combining ability and heterosis

F_1 heterosis is also related to the parental general combining ability effects (*gca*). The *gca* is a direct measure of the breeding value (or additive value) of parents. The data of the 2 diallel crosses with 15 and 10 parents in peanut mentioned earlier were utilised to examine the relationship between *gca* and heterosis.

Plot means were analysed for components of combining ability using method 1 and model 1 of Griffing (1956). The status of the parental genotypes were assessed as High (H) or Low (L), based on their overall general combining ability effects over the 15 characters, following the procedure outlined by Arunachalam and Bandyopadhyay (1979). This procedure consisted essentially of the following steps:

a) the *gca* effects were tested for their statistical significance from the null value for each character.

Table 1. Heterosis* observed in four divergence classes

| Divergence class (DC) | Peanut | | | Rapeseed | | | Overall | | |
|-----------------------|--------|----|-----|----------|----|----|---------|----|-----|
| | a | b | s | a | b | s | a | b | s |
| 1 | 67 | 67 | 134 | 17 | 15 | 32 | 84 | 82 | 166 |
| 2 | 52 | 44 | 96 | 15 | 13 | 28 | 67 | 57 | 124 |
| 3 | 54 | 57 | 111 | 12 | 10 | 22 | 66 | 67 | 133 |
| 4 | 67 | 68 | 135 | 12 | 13 | 25 | 79 | 81 | 160 |

* = Handed on scores across characters; a = Scores based on p %; b = Scores based on q %; for explanation, see text (Adapted from Arunachalam and Bandyopadhyay, 1984)

b) the mean of the significant *gca* effects was taken as the norm. The parents, whose *gca* effects were equal to or above the norm, were given a H status and a score of + 1 and those below, a L status and a score - 1. Others received a zero score.

c) this process was repeated for each character and a total score was computed over the characters for each parent. Based on the mean of the total scores as norm, the final H or L status was assigned to each parent in a manner similar to that in (b).

Genetic divergence among the parents of diallel sets was estimated by D^2 - statistic and the parents were grouped based on genetic divergence following the detailed procedures outlined by Rao (1952). Heterosis was calculated both for direct and reciprocal crosses when the cross mean differed significantly at the 5% level from the superior parent mean in the desired direction. In the rest of the crosses it was taken to be absent.

Out of the 210 and 90 crosses from 15 and 10 parent diallel, 89 and 65 were heterotic for one character or more in the desired direction. Of the 89 heterotic crosses, 46 (52%) occurred in the *gca* class, HL followed by HH (27%) and by LL (20%) in the 15 parent diallel. Similar were the results in the 10-parent diallel and over both of them (Table 2). Earlier work on *Brassica campestris*, triticale and pearl millet gave confirmatory evidence to the higher heterotic potential of High x Low *gca* crosses as compared to the High x High or Low x Low

categories (Table 3). An elegant genetic basis of this result was first provided by Langham, (1961) (see also Arunachalam, 1980).

Table 2. Frequency of heterosis in various classes defined by parental *gca* in peanut

| Diallel | Parental <i>gca</i> classes | | | Total No. of heterotic crosses |
|-----------|-----------------------------|----|----|--------------------------------|
| | HH | HL | LL | |
| 15-parent | 24* | 46 | 19 | 89 |
| 10-parent | 18 | 33 | 14 | 65 |
| Total | 42 | 79 | 33 | 154 |

* = No. of heterotic crosses (adapted from Arunachalam *et al.*, 1982)

Table 3. Distribution of heterotic crosses in various classes defined by parental *gca* in some crops

| Crop | Type of cross | Parental <i>gca</i> | | | Reference |
|----------------------------|---------------|---------------------|----|----|----------------------------------|
| | | HH | HL | LL | |
| <i>Brassica campestris</i> | SC | 29 | 57 | 14 | Arunachalam <i>et al.</i> , 1985 |
| | TC | 33 | 58 | 9 | |
| | MC | 19 | 50 | 31 | |
| Triticale | SC | 31 | 56 | 13 | Arunachalam and Srivastava, 1980 |
| | TC | 21 | 50 | 13 | |
| Pearl millet | SC | 21 | 56 | 23 | Reddy and Arunachalam, 1981 |
| | TC | 22 | 65 | 13 | |
| | FC | 14 | 72 | 14 | |

* Values represent percentage of heterotic crosses (defined heterotic based on a norm, see references cited) falling in the class; SC = Single cross; TC = Three-way cross; FC = Four-way cross; MC = Multiple cross

6. Varietal divergence and heterosis

Studies were made earlier on the pattern of accessions randomly selected from a world collection of peanuts maintained at ICRISAT, near Hyderabad. The 160 accessions represented the four varietal groups, Spanish, Valencia, Virginia bunch and Virginia runner (each represented by 40 accessions). The Spanish and Valencia groups represented bunch types while Virginia bunch represented semi-spreading and Virginia runner, spreading types. An analysis of genetic divergence among the 160 accessions (Durga Prasad *et al.*, 1985) showed a clear separation of bunch and runner (also including semi-runner) types. There was occasional overlap of varieties between Spanish and Valencia groups as well as Virginia bunch and runner groups. But the diversity within bunch and within runner types was quite substantial. This suggested that intra-bunch (especially Spanish x Valencia) crosses, usually allotted a low priority by breeders for the obvious lack of phenotypic diversity, would be potential, particularly in the context of breeding for early maturity and yield. This hypothesis (Arunachalam *et al.*, 1980) was confirmed in the studies relating heterosis to parental divergence (Arunachalam *et al.*, 1982). A review on peanut breeding (Wynne and Gregory, 1981) suggested additive genetic variance to be of prime importance in intra-bunch crosses while non-additive variance could be predominant in bunch x runner crosses, usually attempted by breeders. In-depth genetic divergence studies can thus be of special value not only in locating broad, phenotypically distinct and genetically divergent groups but also in discovering the utility of intra-group (inter-varietal) crosses. A parallel can be drawn from sorghum where tropical x temperate crosses have been exploited much more in comparison to intra-group crosses (Rao, 1982) to increase productivity.

7. F₂ selection

When and how to select for canalising productive derivatives in segregating generations is still an open topic in crop breeding. There are both reports advocating early selection (Cofelt and Hommans, 1974; Kolesnikov, 1979; Kibite, 1981; Gebre-Mariam, 1982) and against (Wynne 1976; McNeal *et al.*, 1978; Whan *et al.*, 1981, 1982). The theoretical studies at Yonezawa and Yamagata (1981) support early generation selection as a cost and time efficient breeding strategy. Experimental evidence in groundnut based on extensive evaluation of F₁ to F₅ generations (Pungle, 1983; Koteswara Rao, 1984) has further shown that selection of heterotic F₁'s followed by index selection in F₂ are valuable components of a resource-efficient breeding strategy. Therefore, a study was conducted with the F₂ generation of the two sets - single and three-way-of crosses in peanut (Bandyopadhyay *et al.*, 1985). The F₂ population was made of F₂ generation of 50 single crosses (SC) in one set and of 49 three-way crosses (TC) in the second.

Observations were recorded on samples of approximately 10 plants (depending on the survival of plants on maturity) per cross. Two sets of plants were marked in each cross. Yield components and some physiological attributes were observed on one set and yield components alone on the other. The two respective sets of SC were denoted as set I (212 plants) and II (256 plants) and of TC as set III (371 plants) and IV (385 plants).

Characters on which observations were made were :

A. Physiological (measured at first flowering) : Height of main axis in cm (SH), number of primary branches (PB), leaf area of 5 fully opened leaves sampled at random in each plant in sq cm (LA), leaf dry weight in g (LW); specific leaf weight (SL).

B. Yield components : Number of mature pods (NM); number of immature pods (IM); number of aerial pegs (AP); weight of mature pods in g (WM); weight of immature pods in g (WI); number of kernels (NK); kernel yield in g (KW); 100-kernel weight in g (TW); percent mature pods $\{NM/(NM + IM) \times 100$ (MP); shelling percentage (SP) and recovery percentage $(NM + IM + AP) \times 100$ (RP).

Only two physiological traits, PB and SL were observed in set I and four, SH, LA, LW and SL in set III, in addition, NK was not measured in sets I and II.

A selection index was set up for each set of F_2 plants using a regression equation. A fair evaluation of F_2 potential across crosses would demand comparable values for various characters of the F_2 plants. These values, however, would be governed to a large extent by the potential of their corresponding parents of the F_1 cross. Hence the F_2 values were expressed as the percentage improvement over the value of the better parent in their F_1 cross. No difference should occur between the analysis based on individual F_2 values and that based on the per cent improvement, if one deals with F_2 of only one cross. The differences would be substantial when more than one cross is dealt with. In this part, we therefore mean by F_2 value of such variables as kernel yield, KW percentage improvement over their better parent.

KW was the dependant variable in the multiple regression equation. The expected values of KW obtained from the equation were ranked in descending order to provide the ranked F_2 distribution (FRD). It was divided into four equal parts: the top 25% was denoted by T_{25} , 26-50% by T_{50} , 51-75% by T_{75} and 76-100% (bottom) by T_{100} .

8. F_3 performance vis-a-vis F_2 selection

The F_3 families of F_2 plants that survived to maturity were raised on a plant to progeny row basis during the rainy season of 1982 in a man-

ner similar to the F_2 . In each F_3 progeny row, selection was made on the most easily-measured trait, pod number, at harvest. Only those plants which yielded more pods than the national check, Robut 33-1 were selected. Based on the number of pods in excess of the check, five types of selection, A to E were made.

A-Plants exceeding pod number of the check by 1 to 10.

B-Plants exceeding pod number of the check by 11 to 20

C-Plants exceeding pod number of the check by 21 to 30

D-Plants exceeding pod number of the check by 31 to 40

E-Plants exceeding pod number of the check by more than 40

The potential of the F_2 groups, T_{25} to T_{100} was assessed by a selection score, WS, defined as

$$WS = \sum_{i=1}^n W_i P_i \text{ where}$$

W_i = score for selection type, 1 for A, 2 for B, 3 for C, 4 for D and 5 for E.

P_i = percentage of plants in selection types A to E

n = number of selection types available in any group under consideration.

Most of the selections in F_3 were found in the progeny of F_2 plants from the segments T_{25} and T_{50} of the FRD, in all the sets I to IV (Table 4). Similarly, selection score (WS) which is a joint measure of the frequency of superior selections of the type A and E was, in general, much higher in top segments T_{25} and T_{50} than in the bottom ones, T_{75} and T_{100} . Further, in comparison to the 16.0% of selections (from

Table 4. Frequency of selections in F₃ with respect to ranked F₂ distribution

| Cross | Set | F ₂ stratum | Selections in F ₃ | | WS | |
|-----------|-----|------------------------|------------------------------|------|------|------|
| | | | n | p | | |
| Single | I | T ₂₅ | 5 | 9.1 | 9.1 | |
| | | T ₅₀ | 4 | 8.2 | 12.3 | |
| | | T ₇₅ | 2 | 4.1 | 4.1 | |
| | | T ₁₀₀ | 1 | 3.5 | 2.5 | |
| | | T _{Total} | 12 | 6.2 | 7.3 | |
| | II | T ₂₅ | 10 | 10.3 | 10.3 | |
| | | T ₅₀ | 2 | 2.4 | 2.4 | |
| | | T ₇₅ | 4 | 4.6 | 5.7 | |
| | | T ₁₀₀ | 1 | 1.3 | 1.3 | |
| | | Total | 17 | 4.9 | 5.2 | |
| Three-way | III | T ₂₅ | 42 | 33.9 | 51.6 | |
| | | T ₅₀ | 27 | 23.1 | 31.7 | |
| | | T ₇₅ | 13 | 13.7 | 14.8 | |
| | | T ₁₀₀ | 9 | 11.0 | 14.6 | |
| | | T _{Total} | 91 | 21.8 | 30.4 | |
| | IV | T ₂₅ | 41 | 30.8 | 42.2 | |
| | | T ₅₀ | 25 | 21.5 | 30.0 | |
| | | T ₇₅ | 21 | 18.8 | 21.5 | |
| | | T ₁₀₀ | 8 | 9.0 | 11.2 | |
| | | Total | 95 | 21.1 | 27.8 | |
| | | I + III | | 103 | 16.9 | 23.1 |
| | | II + IV | | 112 | 14.1 | 17.9 |

n = number of plants; p = as percentage of total number of plants; ws = selection score; I, III = Based on physiological and yield components; II, IV = Based on yield components only (Adapted from Bandyopadhyay *et al.*, 1985)

611 plants) in set I and III put together, only 14.1% of selections (from 795 plants) was obtained in set II and IV. This indicated that selection indices based on key physiological and yield components could locate potential recombinants in F₂ capable of yielding productive selections in F₃ much more efficiently than the selection indices based on yield components alone.

9. Selection intensity in F₂ and role of select physiological traits

The study helped, in a broad sense, to understand the intensity of selection in F₂ that would be adequate to realise selection advance in F₃. The top 25% of ranked F₂ distribution was found to provide most of the selections in F₃. If the number of F₂ plants is not adequate, it is possible to reduce the intensity of selection to 50%. Evidence was robust, however, that the advantages to be gained by reducing selection intensity further would be meagre, if at all. The observation was based on the results of applying four different selection intensities on a ranked F₂ distribution. Two regression indices of selection one based on physiological and yield attributes and the other only on yield components, were used to set up the F₂ distributions. The former index scored high over the latter in detecting desirable F₃ selections. This result is of value to plant breeders who usually place more emphasis on selection based on yield and a few of its direct components. The index employed in the F₂ of three-way crosses used four physiological characters compared to two in the F₂ of single crosses. The results showed a substantial gain in the frequency of selection in the former. Further, the high genetic variability entailed in three-way crosses might also be a cause for such a result.

The need to utilise physiological attributes in selection will gain further ground when we note that early vigour (Bains and Sood, 1980 in

soybean; Gupta and Ahmed, 1982 in wheat), height of main axis and leaf area (Venkateswaran, 1980 in groundnut) were reported to have increased the efficiency of selection indices. A stepwise multiple regression index constructed with a large number of physiological and yield attributes in F₂ indentified 24 of the 53 high yielding F₄ bulks in wheat at 15% selection intensity (McVetty and Evans, 1980). A possible reason appears to be that a large number of characters, including physiological, morphological and yield attributes, measured from seedling to harvest stage, can differentiate between genotypes much better than yield components measured only at harvest. Further, an index using a large number of characters would avoid the need to attach arbitrary weights to them (Sneath and Sokal, 1973). It is known that physiological characters are highly but unequally correlated with yield. The cost of measuring a large number of characters is more than offset by the substantial advantage to raise only the top 25% to the next generation to locate potential derivatives. It is possible to effect economy in the number of characters to be measured, if a few important physiological and yield components are located in the particular crop using stepwise regression analysis (Draper and Smith, 1981) on extensive data.

The above concepts were confirmed by extensive studies in peanut using large F₂ populations from six divergent single crosses (Koteswara Rao, 1984; Arunachalam *et al.*, 1991). Selection index based on physiological and yield components was used in 428 F₂ plants (set A) and on yield components alone in 1259 F₂ plants (set B). Identical results, as enunciated earlier, were obtained. The material from sets A and B was advanced without elimination to F₃ and very large proportion up to F₅. Out of a total of 63 lines found to be superior to a national check in F₅, 66% was found to be derived from the top 40% of the ranked F₂ distribution.

10. Concepts on genetic basis of breeding

The results presented and discussed so far provide the following general concepts for a genetic basis of breeding:

a) Parental choice to obtain F_1 heterosis is a crucial step. A multivariate measure of divergence based on important component characters (provided by D^2 statistic) is most desirable for measuring parental genetic divergence.

b) Limits to genetic divergence to realise F_1 heterosis should be recognised. Most of the heterotic crosses are traced to intermediate (than extreme) divergent classes. It is profitable to choose parents whose divergence value (D^2) falls in the interval $(m-s, m+s)$ where m is the mean and s , the standard deviation of all D^2 values.

c) The probability of occurrence of a high frequency of productive recombinants is high with large F_2 populations. A selection index based on key physiological and yield components can be used to compute and index value for every F_2 plant. The index values are arranged in descending order of magnitude to form a ranked F_2 distribution (FRD). The FRD is partitioned into four equal segments each containing 25% of plants. Productive selections in F_3 and superior lines in F_5 are traceable to the top 25% (or up to top 50%) of FRD. These limits to selection intensity are profitable clues to a breeder in search of a cost, resource and time efficient strategy.

Once productive F_3 families are thus bred, known selection techniques based on intra and inter family variance can be used to select and advance the material further. A large number of options to characterise F_3 and advance it further to obtain commensurate yield gains would be available. They are beyond the scope of this paper. But the concepts postulated from experimental evidence need testing on a wider scale and on a wide range of self and cross

pollinated crops to establish their unequivocal applicability.

LITERATURE CITED

- Arunachalam, V. 1980. Strategies for plant improvement arising from basic genetic studies on some crop plants. *Ann. agric. Res.* 1 : 18-25.
- Arunachalam, V., Koteswara Rao, M.V. and Bandyopadhyay, A. 1991. A selection strategy securing yield gains in groundnut (*Arachis hypogaea*). Communicated.
- Arunachalam, V. and Bandyopadhyay, A. 1979. Are multiple cross - multiple pollen hybrids an answer for productive populations in *Brassica Campestris* var. brown sarson? I. Methods for studying "mucromphs". *Theoretical and appl. Genet.* 54: 203-207.
- Arunachalam, V. and Srivastava, P.S.L. 1980. Assessment of genetic potential of multiple crosses in triticale. *Genetica Agraria (Italy)*. 34 : 245-256
- Arunachalam, V., Bandyopadhyay, A., Nigam, S.M. and Gibbons, R.W. 1980. Some basic results of applied value in groundnut breeding. pp. 1-19. In Proceedings of the national seminar on the application of genetics to the improvement of groundnut, Tamilnadu Agricultural University, Coimbatore, India.
- Arunachalam, V. and Reddy, B.B. 1981. Evaluation of heterosis through combining ability in pearl millet. II. Multiple crosses. *Indian J. Genet. and Pl. Breeding* 41:66-74.
- Arunachalam, V., Bandyopadhyay, A., Nigam, S.N. and Gibbons, R.W. 1982. Heterotic potential of single crosses in groundnut (*Arachis hypogaea* L.) *Oleagineux* 37 : 415-420.
- Arunachalam, V. and Bandyopadhyay, A. 1984. Limits to genetic divergence for occurrence or heterosis. Experimental evidence from crop plants. *Indian J. Genet. and Pl. Breeding* 44 : 548-554.
- Arunachalam, V., Bandyopadhyay, A., Nigam, S. N. and Gibbons R. W. 1984. Heterosis in relation to genetic divergence and specific combining ability in groundnut (*Arachis hypogaea* L.) *Euphytica*. 33 : 33-39.
- Arunachalam, V., Bandyopadhyay, A., Katiyar, R.K. and Das, G.R. 1985. Current status and future prospects

- of rapeseed breeding in India. *Phytobreedon. India* 1: 31-41.
- Bians, K.S. and Sood, K. S.** 1980. Index selection for yield improvement in soybean. *Crop improvement* 7: 102-108.
- Bandyopadhyay, A., Arunachalam, V. and Venkataih, K.** 1985. Efficient selection intensity in early generation index selection in groundnut (*Arachis hypogaea* L.). *Theoretical and appl. Genet.* 71: 300-304.
- Busbice, D.H. and Rawlings, J. O.** 1974. Combining ability in crosses within and between diverse groups of alfalfa introductions. *Euphytica* 23: 86-94.
- Coffelt, T.A. and Hammons, R.O.** 1974. Early generation yield traits of peanuts. *Peanut Sci.* 1: 3-6.
- Cress, C. E.** 1966. Heterosis of the hybrid related to gene frequency differences between two populations. *Genetics* 53: 269-274.
- Draper, W.R. and Smith, H.** 1981. Applied regression analysis. 2nd ed. John Wiley, New York.
- Durga Prasad, M. M. K., Arunachalam, V. and Bandyopadhyay, A.** 1985. Diversity pattern elucidating choice of parents for hybridisation in varieties of groundnut, *Arachis hypogaea* L. *Tropical agric. (Trinidad)* 62: 237-242.
- East, E. M. and Hayes, H.K.** 1912. Heterozygosis in evolution and plant breeding. *USDA Bureau of plant industry Bull.* 243: 1-58.
- Gebre Mariam, M.** 1982. Index selection for genetic improvement of yield, kernel weight and protein content in wheat. *Diss. Abstr. Int. B*, 42 (12,1): 46798.
- Griffing, B.** 1956. Concept of general and specific combining ability in relation to diallel crossing systems. *Aust. J. Bio. Sci.* 9: 463-493.
- Gupta, R. R. and Ahmad, Z.** 1982. Selection parameters for some developmental and component traits in durum wheat. *Indian J. agric. Sci.* 52: 278-284.
- Hayes, S.** 1981. Genetic studies on the breeding for improved selected lines of corn. *J. Am. Soc. Agron.* 31: 710-724.
- Kibite, S.** 1981. Genetic studies on the simultaneous improvement of grain yield and grain protein content on wheat (*Triticum aestivum* L. em. Thell) *Diss. Abstr. Int. B*, 41. (9): 3263 B
- Kolesnikov, I. M.** 1979. The possibility of early prediction of the breeding value of hybrids and the effectiveness of selection in the F₂. *Ref. zh.* 66: 178.
- Koteswara Rao, M.V.K.** 1984. Realised genetic advance by early generation selection for physiological and yield components in groundnut (*Arachis hypogaea* L.) Ph. D., Thesis, Andhra Pradesh Agricultural University, Hyderabad, India.
- Langham, D.G.** 1961. The High - Low method in crop improvement, *Crop Sci.* 1: 376-378.
- Matzinger D.F. and Wernsman, E.A.** 1967. Genetic diversity and heterosis in *Nicotiana*. I. Interspecific crosses. *Der Zuchter.* 37: 188-191.
- McNeal, G. H., Qualset, C. O., Baldrige, D. E. and Stewart, V. R.** 1978. Selection for yield and yield components in wheat. *Crop Sci.* 18: 795-798.
- McVetty, P.B.E. and Evans, L.E.** 1980. Breeding methodology in wheat. I. Determination of characters measured on F₂ spaced plants for yield selection in spring wheat. *Crop Sci.* 20: 583 - 586.
- Moll, R.H., Lonngvist, J.H., Fortuno, J.V. Johnson. E.C.** 1964. The relationship of heterosis and genetic divergence in maize. *Genetics.* 52: 139-144.
- Murty, B.R., Murty, G.S. and Pavate, M.V.** 1962. Studies on quantitative inheritance in *Nicotiana tabacum* L. *Der Zuchter.* 32: 361-369.
- Murty, B.R. and Arunachalam, V.** 1966. The nature of divergence in relation to breeding systems in some crop plants. *Indian J. Genet. and Pl. Breeding* 26A: 188-198.
- Pungle, G.D.** 1983. Genetic investigations on characters related to growth, biological nitrogen fixation and yield in groundnut (*Arachis hypogaea* L.) Ph.D. Thesis, Indian Agricultural Research Institute, New Delhi.
- Rao, C.R.** 1952. Advanced statistical methods in biometric research. John Wiley, New York.
- Rao, N.G.P.** 1982. Transforming traditional sorghum in India. pp. 39-60 *In Sorghum in the eighties.* ICRIASAT.

- Reddy, B.B. and Arunachalam, V. 1981. Evaluation of heterosis through combining ability in pearl millet. I Single crosses. *Indian J. Genet. and Pl. Breeding*, 41: 66-74
- Sneath, P.H.A. and Sokal, R.R. 1973. *Numerical taxonomy*. W.H. Freeman, San Francisco, USA.
- Srivastava, P.S.L. and Arunachalam, V. 1977. Heterosis as a function of genetic divergence in triticale. *Zeitschrift fur Pflanzenzuchtung*. 78: 269-275.
- Timothy, D.H. 1963. Genetic diversity, heterosis and the use of exotic stocks in maize in Columbia. Statistical Genetics and Plant Breeding Symposium, Raleigh, 1961. NAS - NRC Publ. 982 : 581-593.
- Venkateswaran, A.N. 1980. Discriminant function as a tool in groundnut breeding. pp. 20-26. In Proceedings of the national seminar on the application of genetics to improvement of groundnut, Tamilnadu Agricultural University, Coimbatore, India.
- Whan, B.R., Rathijien, A. and Knight, R. 1981. The relation between wheat lines derived from the F₂, F₃ and F₃ generation for grain yield and harvest index. *Euphytica* 30: 419-430.
- Whan, B.R., Knight, R. and Rathijien, A. 1982. Response to selection for grain yield and harvest index in F₂, F₃ and F₄ derived lines of two wheat crosses. *Euphytica* 31: 139 -150.
- Wynne, J.C. 1976. Evaluation of early generation testing in peanuts. *Peanut Sci.* 3: 62-66.
- Wynne, J.C. and Gregory, W.C. 1981. Peanut Breeding. *Adv. Agron.* 34: 39-72.
- Yonezawa, K. and Yamagata, H. 1981. Selection strategy in breeding of self-fertilising crops. I Theoretical considerations on the efficiency of single plant selection in early segregating generations. *Japanese J. Breeding* 31: 35-48.

SOIL PHYSICAL FACTORS AND POD YIELD OF SUMMER GROUNDNUT AS INFLUENCED BY IRRIGATION SCHEDULES AND EARTHING UP*

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ABSTRACT

Field experiments conducted for two years at the University of Agricultural Sciences, Bangalore, have revealed that irrigation at 0.5 IW/CPE ratio during 10 to 40 DAS and 0.75 IW/CPE ratio from 40 days onwards recorded higher pod yield. Delayed irrigations at 0.5 IW/CPE ratio either from 70 days to harvest or from 40 days to 70 days reduced yield. Earthing up at 45 DAS recorded higher yield and it reduced the bulk density and soil penetration resistance as compared to no earthing up. There was significant reduction in ratio of pegs with immature pods to total pegs due to earthing up.

Key words : Irrigation schedule; Earthing up; Bulk density; Soil penetration resistance; Available moisture.

INTRODUCTION

Groundnut flowers are fertilized above ground, but the peg containing the fertilized ovary must penetrate the soil surface before pod development takes place. Thus, pegging process is vulnerable to unfavourable physical conditions of the soil. The physical factors which are of much importance in groundnut production are soil penetration resistance (Underwood *et al.*, 1971), bulk density (Venkaiah, 1985), available soil moisture in the top soil (Saini *et al.*, 1973). Hence, the investigation on effect of irrigation schedules and earthing up on soil physical factors and pod yield of summer groundnut was undertaken.

MATERIAL AND METHODS

A field experiment was conducted at the Agronomy field unit, M.R.S. Hebbal, Bangalore, for two years during 1989 and 1990 summer seasons. There were ten treatments comprising five irrigation schedules and two land management practices (Table 1). The ex-

periment was laid out in Factorial Randomized Block Design with four replications with plot size of 4.8 m x 3.5 m. Precautions were taken to prevent lateral movement of water between plots by means of putting vertical polythene barriers and buffer canals.

Irrigation water (40 mm depth) was measured through Parshall flume. Earthing up was done at 45 DAS by forming a high ridge and furrow. This was done after three intercultural operations at 15, 30 and 45 DAS. The soil was sandy loam type with 53.10, 27.15, 8.25 and 11.50 per cent coarse sand, fine sand, silt and clay respectively. The available water 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. TMV-2 variety was used in this study. Nitrogen, phosphorus and potassium were applied at 25:75:37.5 kg/ha in the form of urea, single superphosphate and muriate of potash. The crop was sown in 30 cm rows at 10 cm apart on January 9th and 11th during 1989 and 1990 respectively and was harvested on 25th May in 1989 and 28th May in 1990.

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Table 1. Soil penetration resistance (kg/cm^2) ratio of pegs with mature pods, immature pods and without pods to total pegs per plant and pod yield (q/ha) as influenced by irrigation schedules and earthing up in summer groundnut (Pooled data of 1989 and 1990)

| Treatment | Soil penetration resistance (kg/cm^2) | | | Ratio of pegs | | Pod yield (q/ha) | | | | | |
|--|---|--------------------|--------|------------------|--------------------|------------------------------------|-------------|------|-------|-------|-------|
| | 52 DAS | 62 DAS | 72 DAS | With mature pods | With immature pods | 1989 | 1990 Pooled | | | | |
| Irrigation schedules (IW/CPE ratio) | | | | | | | | | | | |
| 10-40 days | 40-70 days | 70 days to harvest | | | | | | | | | |
| I ₁ : 0.5 | 0.75 | 0.75 | 1.70 | 2.06 | 2.51 | 0.61 | 0.29 | 0.09 | 58.14 | 59.90 | 59.02 |
| I ₂ : 0.5 | 0.5 | 0.75 | 2.44 | 3.58 | 2.71 | 0.60 | 0.30 | 0.09 | 56.68 | 53.33 | 55.00 |
| I ₃ : 0.5 | 0.75 | 0.5 | 1.74 | 2.33 | 2.53 | 0.49 | 0.39 | 0.10 | 42.52 | 50.50 | 46.51 |
| I ₄ : 0.5 | 0.5 | 0.5 | 2.39 | 3.79 | 2.58 | 0.50 | 0.44 | 0.05 | 41.76 | 43.15 | 42.45 |
| I ₅ : 0.75 | 0.75 | 0.75 | 2.08 | 2.13 | 2.40 | 0.57 | 0.34 | 0.08 | 56.83 | 58.08 | 57.45 |
| SEm \pm | | | 0.14 | 0.17 | 0.17 | 0.02 | 0.02 | 0.01 | 1.24 | 1.87 | 1.12 |
| CD at 5% | | | 0.41 | 0.50 | NS | 0.06 | 0.05 | 0.02 | 3.62 | 5.43 | 3.11 |
| Land management practice | | | | | | | | | | | |
| S1 : Earthing up | | | 1.08 | 2.39 | 2.01 | 0.57 | 0.33 | 0.09 | 51.46 | 56.48 | 53.97 |
| S2 : No earthing up | | | 3.06 | 3.16 | 3.08 | 0.54 | 0.37 | 0.08 | 50.91 | 49.51 | 50.21 |
| SEm \pm | | | 0.08 | 0.11 | 0.11 | 0.01 | 0.01 | 0.01 | 0.79 | 1.18 | 0.71 |
| CD at 5% | | | 0.26 | 0.32 | 0.31 | NS | 0.03 | NS | NS | 3.43 | 1.97 |

NS = Not significant

Soil penetration resistance was measured by Hand penetrometer at five random spots in each plot and the average of four replications was worked out and expressed in kg per cm². Bulk density (g/cc) in the top 12 cm soil layer was estimated by using core sampler as suggested by Piper (1966). Available soil moisture per cent before irrigation was calculated by gravimetric method as :

$$\text{Available moisture per cent} = \frac{100(\text{Field capacity} - \text{Actual moisture})}{(\text{Field capacity} - \text{permanent wilting point})}$$

Soil moisture tension (bars) before irrigation was estimated from available soil moisture characteristic curve for the experimental area.

RESULTS AND DISCUSSION

Effect of irrigation schedules : Scheduling irrigation at 0.5 IW/CPE ratio from 10-40 DAS and later at 0.75 IW/CPE ratio (I₁) registered significantly higher pod yield (59.02 q/ha) over rest of the treatments except 0.75 IW/CPE ratio, I₅ (57.45 q/ha) throughout the crop growth. These two irrigation schedules were significantly superior over I₃ (46.51 q/ha) and I₄ (42.45 q/ha) treatments (Table 1). The higher yield may be attributed to the better available soil moisture status and lower soil moisture tension and soil penetration resistance. This was evident from more than 50 per cent available moisture maintained in 0-30 cm depth soil layer at 0.7 to 0.9 bar tension before irrigation from 40 days onwards in I₁ during both the years (Table 3). Scheduling irrigation at 0.5 IW/CPE ratio either from 40 to 70 DAS (I₂) or from 70 days to harvest (I₃) or from 10 days to harvest (I₄) recorded less than 50 per cent moisture in 0-30 cm soil layers and caused reduction in pod yield (55.0, 46.51 and 42.45 q/ha respectively). There was higher ratio (0.61) of mature pods to total pegs in I₁ as compared to 0.49 in I₃ and 0.50 in I₄ irrigation treatments (Table 1). Further, soil penetration

resistance at 52 and 62 DAS was least (1.7 and 2.06 kg/cm²) in I₁ followed by I₅ (2.08 and 2.13 kg/cm²) irrigation treatments indicating favourable conditions for better peg penetration. Soil water available in the top layer of the soil profile is of critical importance for peg and pod development. Soil water deficit during the pod filling stage reduce both initiation and development of pods (Boote *et al.*, 1976 and Pallas *et al.*, 1979). There was hinderance for the pegs to penetrate due to increased penetration resistance of 2.39 and 3.79 kg/cm² on 52 and 62 DAS in I₄ irrigation schedule causing significantly less ratio of mature pods to total pegs per plant (0.5) resulting in greatest reduction in yield.

Effect of earthing up : Earthing up gave significantly more pod yield (53.97 q/ha) than no earthing up (50.21 q/ha) (Table 1), which can be attributed to the more favourable soil physical conditions for peg penetration and pod development. There was significant difference in soil penetration resistance at 52, 62 and 72 DAS due to earthing up. Soil penetration resistance was significantly reduced at 52 (1.08 kg/cm²), 62 (2.39 kg/cm²) and 72 (2.01 kg/cm²) days after sowing in earthing up as compared to no earthing up (Table 1). Further, the rate of increase in soil penetration resistance was gradual due to earthing up while it was rapid and crossed 5.0 kg/cm² on 7th day after irrigation in unearthed treatment (Table 2) indicating more favourable soil condition for peg penetration due to earthing up.

The results on bulk density showed significantly lesser values in earthing up treatment at 52, 62 and 72 DAS (Table 2) indicating less compact soil physical conditions which in turn has favoured easy access for peg penetrations and pod development. Significantly less ratio of immature pods to total pegs (0.33) and more of ratio of pegs with mature pods to total pegs (0.57) due to earthing up resulting in significantly more pod yield than no earthing.

Table 2. Soil penetration resistance (kg/cm^2) during one irrigation cycle with 0.5 IW/CPE ratio and bulk density (g/cc) as influenced by land management practice in summer groundnut (pooled data of 1989 and 1990)

| Treatment | Soil penetration resistance (kg/cm^2) | | | | | | |
|--------------------|--|------|------|------|------|------|------|
| | Days after irrigation | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| S1: Earthing up | 0.54 | 0.58 | 0.68 | 0.97 | 2.38 | 3.37 | 4.47 |
| S2: No Earthing up | 0.86 | 0.87 | 0.94 | 1.52 | 2.82 | 4.04 | 5.00 |

| | Bulk Density (g/cc) | | |
|--------------------|---------------------|--------|--------|
| | 52 DAS | 62 DAS | 72 DAS |
| S1: Earthing up | 1.58 | 1.57 | 1.44 |
| S2: No earthing up | 1.61 | 1.62 | 1.48 |
| SEm \pm | 0.009 | 0.007 | 0.005 |
| CD at 5% | 0.02 | 0.01 | 0.01 |

Thus, it can be concluded that adequate and favourable physical conditions in the fruiting zone of soil are essential for higher yield of groundnut.

LITERATURE CITED

- Boote, K.J., Varnell, R.J. and Duncan, W.G. 1976. Relationships of size, osmotic concentration and sugar concentration of peanut pods to soil water. *Proceedings of soil and Crop Science Society of Florida* 35 : 47-50.
- Pallas, J. E., Stansell, J. R. and Koske, T.J. 1979. Effect of drought on Florunner peanuts. *Agron. J.* 71 : 853-858.
- Piper, C. S. 1966. *Soil and plant analysis*. Academic Press, New York.
- Saini, J. S., Tripathi, H.P. and Cheema, S.S. 1973. Effect of soil moisture and fertilizer levels on groundnut. *Indian J. Agron.* 18 : 362-365.
- Underwood, C. V., Taylor, H.M. and Hoveland, C. S. 1971. Soil physical factors affecting peanut pod development. *Agron. J.* 63 : 953-954.
- Venkaijah, K. 1985. Effect of bulk density on growth and yield of groundnut. *Indian J. Agron.* 30(2): 278-280.

Table 3. Available soil moisture per cent and soil moisture tension (bars) before irrigation in different soil layers as influenced by irrigation schedules

| Irrigation schedules (IW/CPE) | | Soil depths (cm) | 1989 | | | 1990 | | |
|-------------------------------|------------|--------------------|-------------|-------------|-------------|--------------|-------------|-------------|
| | | | 38 DAS | 63 DAS | 87 DAS | 41 DAS | 68 DAS | 89 DAS |
| 10-40 days | 40-70 days | 70 days to harvest | | | | | | |
| I ₁ : 0.5 | 0.75 | 0.75 | 48.12 (1.2) | 55.47 (0.8) | 53.78 (0.9) | 58.33 (0.7) | 56.42 (0.8) | 55.40 (0.8) |
| | | | 67.51 (0.6) | 79.05 (0.4) | 88.16 (0.3) | 82.21 (0.4) | 93.44 (0.3) | 66.30 (0.6) |
| | | | 74.69 (0.5) | 74.03 (0.5) | 84.26 (0.4) | 83.96 (0.4) | 90.83 (0.3) | 70.97 (0.5) |
| I ₂ : 0.5 | 0.5 | 0.75 | 48.12 (1.2) | 45.04 (1.4) | 53.78 (0.9) | 58.33 (0.7) | 45.00 (1.5) | 55.40 (0.8) |
| | | | 67.51 (0.6) | 62.11 (0.7) | 88.16 (0.3) | 82.21 (0.4) | 78.20 (0.4) | 66.30 (0.6) |
| | | | 74.69 (0.5) | 69.60 (0.6) | 84.26 (0.4) | 83.96 (0.4) | 79.68 (0.4) | 70.97 (0.5) |
| I ₃ : 0.5 | 0.75 | 0.5 | 48.12 (1.2) | 55.47 (0.8) | 39.16 (2.0) | 58.33 (0.7) | 56.42 (0.8) | 43.64 (1.6) |
| | | | 67.51 (0.6) | 79.05 (0.4) | 65.14 (0.6) | 82.21 (0.4) | 93.44 (0.3) | 55.55 (0.8) |
| | | | 74.69 (0.5) | 74.03 (0.5) | 66.39 (0.6) | 83.96 (0.4) | 90.83 (0.3) | 64.15 (0.6) |
| I ₄ : 0.5 | 0.5 | 0.5 | 48.12 (1.2) | 45.04 (1.4) | 39.16 (2.0) | 58.33 (0.7) | 45.00 (1.5) | 43.64 (1.6) |
| | | | 67.51 (0.6) | 62.11 (0.7) | 65.14 (0.6) | 82.21 (0.4) | 78.20 (0.4) | 55.55 (0.8) |
| | | | 74.69 (0.5) | 69.60 (0.6) | 66.39 (0.6) | 83.96 (0.4) | 79.68 (0.4) | 64.15 (0.6) |
| I ₅ : 0.75 | 0.75 | 0.75 | 53.04 (0.9) | 55.47 (0.8) | 53.78 (0.9) | 60.87 (0.6) | 56.42 (0.8) | 55.40 (0.8) |
| | | | 75.16 (0.5) | 79.05 (0.4) | 88.16 (0.3) | 100.00 (0.3) | 93.44 (0.3) | 66.30 (0.6) |
| | | | 76.78 (0.4) | 74.03 (0.5) | 84.26 (0.4) | 87.62 (0.3) | 90.83 (0.3) | 70.97 (0.5) |

Figures in parentheses indicate the soil moisture tension (bars)

RESPONSE OF SUNFLOWER TO THE INOCULATION OF VA MYCORRHIZA AND / OR PHOSPHATE SOLUBILIZING BACTERIA IN BLACK CLAYEY SOIL

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ABSTRACT

The response of sunflower (*Helianthus annuus* L.) to the inoculation of *Glomus fasciculatum* and /or *Pseudomonas striata* at four levels of two forms of P was studied in P-deficient black clayey soils. Combined inoculation of *G.fasciculatum* and *P.striata* significantly increased plant height, dry biomass, seed yield, oil content and shoot P concentration. Though all these parameters increased with increase in the level of P in both the forms, super phosphate was proved to be superior to rock phosphate.

Key words : *Glomus fasciculatum*; *Pseudomonas striata*; Phosphorus levels; Sunflower.

INTRODUCTION

Vesicular-arbuscular mycorrhizal (VAM) fungi are inoculated to crop plants to study the possibility of saving phosphatic fertilizers and improving plant growth and yield (Jeffreis, 1987). Phosphorus (P) is usually considered to be the major problem when VAM mycorrhizal infection and responses are poor. High P levels in soil or P-additions are known to reduce VAM colonization of roots and sporulation (Sreenivasa and Bagyaraj 1989). Several studies indicated that addition of an excess readily available P eliminate beneficial mycorrhizal effect (Sreenivas *et al.*, 1992). At the same time use of insoluble forms of P had little or no effect when inoculated with VAM fungi (Graham and Timmer, 1985). Hence the present study was undertaken to know the response of sunflower (*Helianthus annuus* L.) to the inoculation of VAM fungus, *Glomus fasciculatum* and /or phosphate solubilizing bacterium, *Pseudomonas striata* at four levels of two forms of P in black clayey soil.

MATERIAL AND METHODS

A pot trial was conducted using P-deficient black clayey soil with pH 7.9 and available P_2O_5

18.2kg ha^{-1} ($\text{NH}_4\text{F} + \text{HCl}$ extractable). Earthen pots of 12" diameter were filled with 10kg unsterile field soil. The initial population of phosphate solubilizing bacteria in the field soil was $1.4 \times 10^3/\text{g}$ soil while initial VAM spore count was 38/50g soil. Fertilizer N and K were given at the recommended level (62.5kg each) while P was given as rock phosphate (18%P) or super phosphate (16%P) at 0, 25, 50, or 100 per cent of the recommended dose i.e. 0, 521, 1042 or 2084 mg/pot of rock super phosphate (RP) or 0, 586, 1172 or 2344 mg/pot of super phosphate (SP) respectively. Pots were inoculated with VAM fungus, *Glomus fasciculatum* maintained in *Chloris gayana kunth* (Sreenivasa and Bagyaraj, 1988) @ 50 g/pot having inoculum potential of $0.19 \times 10^4/\text{g}$ and/or phosphate solubilizing bacterium, *Pseudomonas striata* @ 10 ml/pot with cell density of $3 \times 10^8/\text{ml}$. comparable uninoculated control pots were maintained. Pots were sown by dibbling three seeds per pot and one healthy seedling was maintained throughout experimentation. There were four replications in each treatment.

Crop was harvested on 83rd day after sowing, plant height dry biomass and seed yield were recorded. The per cent mycorrhizal

colonization of roots was determined after clearing roots in KOH and staining with 0.05% trypan blue and, 100 root bits of one cm each were observed for infection in each replicate sample (Phillips and Hayman, 1970). Chlamydo-spore count in 50g soil was done by wet sieving and decanting technique in each replicate pot (Gerdemann and Nicolson, 1963). Shoot P concentration was estimated by Vanadomolybdate phosphoric yellow colour method (Jackson, 1967) and oil content in seeds was determined by using Nuclear Magnetic Resonance Spectrophotometer (Oxford 2000 Model).

RESULTS AND DISCUSSION

Sunflower plants responded well to the inoculation of *G.fasciculatum* and/or *P.striata*. Percentage root colonization and chlamydo-spore count increased with increase in P level upto 50 per cent of the recommended dose in both the forms of P and later they decreased (Table 1). Dual inoculation of *G.fasciculatum* and *P.striata* produced significantly highest root colonization and sporulation compared to inoculations with either of them or control. SP was found more inhibitory on VAM fungi compared to RP (Table 1). Plant height, plant dry-biomass, seed yield and oil content increased with increase in P levels in both the form of P but there was no significant difference between 50 and 100 per cent of P. Among the two forms, SP showed its superiority compared to RP in causing maximum responses which were observed in plants inoculated with both the organisms (Table 2 and 3). The least was recorded in uninoculated control plants. Higher shoot P concentration was recorded in mycorrhizal plants given SP and it was significantly highest at the recommended dose in the combined inoculations (Table 4).

The principal way in which VAM fungi improves plant growth is through P nutrition. VAM associations have been reported in oil-

seed crops viz., castor and safflower in which the number of spores were directly correlated with host age (Sulochana and Manoharachary, 1989). Cabellow (1987) observed that the number of endogonaceous spores in soil samples from a sunflower field increased during crop growth and per cent root colonization also increased up to flowering. However, root colonization and sporulation of VAM fungi will be inhibited at higher levels of readily available P (Sreenivasa and Bagyaraj, 1989). In this study RP produced highest root colonization and sporulation compared to SP. When plants were inoculated with VAM fungi, both these characters were higher compared to those produced by native endophytes in non-inoculated plants. Further these characters were stimulated by *P.striata* in the dual inoculated plants (Table 1).

Plant height, dry biomass, seed yield and oil content increased with increase in P level and were found highest in the plants inoculated with both the organisms (Table 2 and 3). However these characters did not differ significantly between 50 and 100 per cent of the recommended dose suggesting that the application of phosphate fertilizer could be reduced through inoculation with VAM fungi and phosphate solubilizing microorganisms (Sreenivasa *et al.*, 1992). Possible synergistic interactions between these two organisms has been studied by Azcon *et al.*, (1976) who found that lavender plants treated with VAM fungus and P-solubilizing bacteria recorded increased plant drybiomass and P-uptake. Such synergistic interactions have been reported between *G.fasciculatum* and *Aspergillus niger* or *Penicillium funiculosum* with each organism stimulating the growth of other resulting in consequential improvement in plant growth and P uptake (Gopalakrishna, 1980). Earlier in this study increase in the population of *P.striata* in the inoculated plants was observed up to 60 days and there was slight reduction thereafter. This was maximum in the dual inoculated plants (Jones and Sreenivasa, 1992). In one of

Table 1. Effect of inoculation of *G.fasciculatum* and/or *P.striata* at different forms and levels of P on per cent root colonization and spore count of VAM fungi in sunflower

| Treatment | Per cent root colonization | | | | | | Spore count / 50g soil | | | | | | | | | |
|--|------------------------------------|----|----|------------------------------------|----|----|------------------------------------|-----|-----|------------------------------------|-----|-----|-----------------|-----|-----|-----|
| | Super Phosphate | | | Rock Phosphate | | | Super Phosphate | | | Rock Phosphate | | | | | | |
| | Level of P (% recommended dose) | | | Level of P (% recommended dose) | | | Level of P (% recommended dose) | | | Level of P (% recommended dose) | | | | | | |
| | 0 | 25 | 50 | 100 | 0 | 25 | 50 | 100 | 0 | 25 | 50 | 100 | 0 | 25 | 50 | 100 |
| <i>Glomus fasciculatum</i> | 86 | 90 | 93 | 83 | 87 | 97 | 98 | 90 | 179 | 188 | 189 | 176 | 184 | 212 | 225 | 191 |
| <i>Pseudomonas striata</i> | 54 | 56 | 59 | 52 | 59 | 62 | 65 | 60 | 133 | 142 | 142 | 124 | 136 | 141 | 144 | 133 |
| <i>G.fasciculatum</i> + <i>P.striata</i> | 95 | 97 | 99 | 89 | 97 | 99 | 100 | 94 | 205 | 210 | 218 | 201 | 209 | 240 | 250 | 209 |
| Control | 50 | 52 | 55 | 48 | 55 | 59 | 62 | 58 | 130 | 131 | 135 | 121 | 133 | 139 | 143 | 126 |
| Sources | SEm | | | LSD at P = 0.05 | | | SEm | | | LSD at P = 0.05 | | | LSD at P = 0.05 | | | |
| Organisms (A) | 0.69 | | | 1.93 | | | 2.08 | | | 5.84 | | | | | | |
| P-forms (B) | 0.49 | | | 1.37 | | | 1.47 | | | 4.13 | | | | | | |
| P-levels (C) | 0.69 | | | 1.93 | | | 2.08 | | | 5.84 | | | | | | |
| A x B | 0.97 | | | 2.73 | | | 2.94 | | | 8.26 | | | | | | |
| A x C | 1.37 | | | 3.87 | | | 4.15 | | | NS | | | | | | |
| B x C | 0.97 | | | 2.74 | | | 2.94 | | | 8.26 | | | | | | |
| A x B x C | 1.94 | | | NS | | | 5.87 | | | NS | | | | | | |

Table 2. Effect of inoculation of *G.fasciculatum* and/or *P. striata* at different forms and levels of P on plant height and dry matter of sunflower

| Treatment | Plant height (cms) | | | Plant dry matter (g/plant) | | | | | | | | | | | | | |
|--|------------------------------------|-----|------------------------------------|------------------------------------|----|------------------------------------|-------|-----|----|-----------------|----|----|----|----|----|----|----|
| | Super Phosphate | | Rock Phosphate | Super Phosphate | | Rock Phosphate | | | | | | | | | | | |
| | Level of P (% recommended dose) | | Level of P (% recommended dose) | Level of P (% recommended dose) | | Level of P (% recommended dose) | | | | | | | | | | | |
| | 0 | 25 | 50 | 100 | 0 | 25 | 50 | 100 | | | | | | | | | |
| <i>Glomus fasciculatum</i> | 86 | 88 | 89 | 90 | 83 | 84 | 85 | 86 | 63 | 65 | 68 | 69 | 60 | 62 | 65 | 66 | |
| <i>Pseudomonas striata</i> | 80 | 83 | 84 | 85 | 78 | 80 | 81 | 81 | 81 | 60 | 64 | 67 | 68 | 58 | 62 | 64 | 64 |
| <i>G.fasciculatum</i> + <i>P.striata</i> | 97 | 100 | 101 | 102 | 91 | 92 | 96 | 97 | 97 | 66 | 71 | 75 | 75 | 61 | 65 | 68 | 69 |
| Control | 74 | 76 | 79 | 80 | 73 | 74 | 76 | 76 | 76 | 57 | 58 | 67 | 68 | 56 | 60 | 62 | 70 |
| Sources | S.E.m | | | LSD at P = 0.05 | | | S.E.m | | | LSD at P = 0.05 | | | | | | | |
| Organisms (A) | 0.33 | | | 0.92 | | | 1.50 | | | 4.21 | | | | | | | |
| P-forms (B) | 0.23 | | | 0.65 | | | 0.89 | | | 2.57 | | | | | | | |
| P-levels (C) | 0.33 | | | 0.92 | | | 1.50 | | | 4.21 | | | | | | | |
| A x B | 0.46 | | | 1.84 | | | 2.12 | | | NS | | | | | | | |
| A x C | 0.65 | | | 1.30 | | | 2.99 | | | NS | | | | | | | |
| B x C | 0.46 | | | 1.84 | | | 2.12 | | | NS | | | | | | | |
| A x B x C | 0.92 | | | 2.60 | | | 4.33 | | | NS | | | | | | | |

Table 3. Effect of inoculation of *G.fasciculatum* and/or *P.seriata* at different forms and levels of P on seed yield and oil content in sunflower

| Treatment | Seed Yield (g/plant) | | | | | | Oil Content (%) | | | | | | | | | |
|--|------------------------------------|------|------|------------------------------------|------|------|------------------------------------|------|------|------------------------------------|------|------|------|------|------|------|
| | Super Phosphate | | | Rock Phosphate | | | Super Phosphate | | | Rock Phosphate | | | | | | |
| | Level of P (% recommended dose) | | 0 | Level of P (% recommended dose) | | 0 | Level of P (% recommended dose) | | 0 | Level of P (% recommended dose) | | 0 | | | | |
| <i>Glomus fasciculatum</i> | 15.7 | 16.7 | 17.3 | 18.2 | 15.1 | 15.7 | 15.7 | 16.0 | 35.8 | 37.9 | 38.8 | 39.2 | 33.0 | 35.2 | 37.8 | 38.2 |
| <i>Pseudomonas seriata</i> | 15.0 | 16.1 | 16.5 | 16.9 | 14.1 | 14.4 | 15.5 | 15.8 | 36.1 | 36.3 | 37.4 | 37.5 | 32.2 | 34.6 | 36.0 | 36.7 |
| <i>G.fasciculatum</i> + <i>P.seriata</i> | 21.7 | 22.8 | 25.3 | 25.7 | 19.3 | 20.1 | 22.3 | 22.5 | 39.6 | 42.5 | 43.7 | 44.3 | 40.0 | 40.3 | 42.9 | 42.6 |
| Control | 12.1 | 15.7 | 16.3 | 16.8 | 12.3 | 13.0 | 13.5 | 14.3 | 32.4 | 34.0 | 35.9 | 36.1 | 30.0 | 32.0 | 33.1 | 34.8 |
| Sources | SEM | | | LSD at P = 0.05 | | | SEM | | | LSD at P = 0.05 | | | | | | |
| Organisms (A) | 0.22 | | | 0.63 | | | 0.59 | | | 1.51 | | | | | | |
| P-forms (B) | 0.16 | | | 0.44 | | | 0.51 | | | NS | | | | | | |
| P-levels (C) | 0.22 | | | 0.63 | | | 0.54 | | | 1.51 | | | | | | |
| A x B | 0.32 | | | 0.89 | | | 0.76 | | | NS | | | | | | |
| A x C | 0.45 | | | NS | | | 1.07 | | | 3.01 | | | | | | |
| B x C | 0.32 | | | 0.89 | | | 0.76 | | | NS | | | | | | |
| A x B x C | 0.63 | | | NS | | | 1.51 | | | NS | | | | | | |

Table 4. Effect of Inoculation of *G.fasciculatum* and/or *P.Striata* at different forms and levels of P on shoot P concentration (per cent) in sunflower

| Treatment | Level of P (% recommended dose) | | | | Level of P (% recommended dose) | | | |
|--|---------------------------------|------|------|-----------------|---------------------------------|------|------|------|
| | 0 | 25 | 50 | 100 | 0 | 25 | 50 | 100 |
| <i>Glomus fasciculatum</i> | 0.09 | 0.12 | 0.14 | 0.16 | 0.09 | 0.10 | 0.12 | 0.12 |
| <i>Pseudomonas striata</i> | 0.09 | 0.10 | 0.11 | 0.12 | 0.05 | 0.09 | 0.10 | 0.10 |
| <i>G.fasciculatum</i> + <i>P.striata</i> | 0.12 | 0.14 | 0.22 | 0.27 | 0.13 | 0.19 | 0.20 | 0.23 |
| Control | 0.02 | 0.05 | 0.09 | 0.13 | 0.02 | 0.02 | 0.04 | 0.07 |
| Sources | SEm | | | LSD at P = 0.05 | | | | |
| Organisms (A) | 0.003 | | | 0.008 | | | | |
| P - forms (B) | 0.002 | | | 0.005 | | | | |
| P - Levels (C) | 0.003 | | | 0.008 | | | | |
| A x B | 0.004 | | | NS | | | | |
| A x C | 0.006 | | | 0.015 | | | | |
| B x C | 0.004 | | | 0.011 | | | | |
| A x B x C | 0.008 | | | NS | | | | |

the studies on chillies it was observed that dual inoculation of *G. fasciculatum* and *P. striata* to be best which significantly increased uptake of P, Zn, Cu, Mn and Fe, and plant dry biomass (Sreenivasa and Krishnaraj, 1992). In this study also shoot P concentration increased with increase in P-level in the combined inoculations (Table 4). The activity of Ca^{2+} in soil solution is known to be high in black clayey soils. It is evident from our studies that phosphate solubilizing bacteria rendered more P soluble while mycorrhiza enhanced P uptake. Thus with the combined inoculation there was a synergistic effect on P-supply, uptake and plant dry biomass production. Phosphorus has an influence on seed yield and oil content. Gururaja (1983) reported higher oil content in sunflower inoculated with *Glomus fasciculatum*, *Penicillium glaucum* and *Azotobacter chroococcum*. Our study clearly brought out that dual inoculation of *G. fasciculatum* and *P. striata* to be best in efficient utilization of P and

in turn, increased P uptake, yield and oil content.

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LITERATURE CITED

- Azcon, R., Barera, J.M. and Hayman, D.S. 1976 Utilization of rock phosphate in alkaline soils by plants inoculated with mycorrhizal fungi and phosphate solubilizing bacteria. *Soil Biol. Biochem.* 8: 135-138
- Cabello, M.N. 1987. Vesicular-arbuscular mycorrhizal in a sunflower (*Helianthus annuus* L.) crop *Revista de la Facultad de Agronomia, Universidad Nacional de La Plata* 63: 46-52.
- Gerdemann, J.W. and Nicolson, J.H. 1963. Spores of mycorrhizal Endogone species extracted from soil by wet sieving and decanting. *Tran. Br. Mycol. Soc.* 46: 235-244.

- Gopalakrishna, N.N. 1980. Interaction between VA mycorrhiza and phosphate solubilizing fungi and their effects on rhizosphere mycoflora and growth of finger millet. M.Sc (Agric.) Thesis, University of Agricultural Sciences, Bangalore.
- Graham, J.M. and Timmer, L.W. 1985. Rock phosphate as a source of phosphorus for vesicular-arbuscular mycorrhizal development and growth of citrus in soilless medium. *J. Am. Soc. Hort. Sci.* 110: 489-492.
- Gururaja, R. 1983. Interaction among *Azotobacter* chroococcum, *Glomus fasciculatum* and *Penicillium glaucum* on growth and yield of sunflower. M.Sc (Agric.) Thesis, University of Agricultural Sciences, Bangalore.
- Jackson, M.L. 1967. Soil Chemical Analysis. prentice Hall of India, New Delhi.
- Jeffries, P. 1987. Use of mycorrhizal in agriculture. *CRC critical rev. biotechnol.* 5: 319-359.
- Jones Nirmalnath, P. and Sreenivasa, M.N. 1992. Effect of inoculation of *Glomus fasciculatum* and/or *Pseudomonas striata* on rhizosphere mycoflora of sunflower II *Azotobacter* and phosphate solubilizing bacteria. *J. E cogiol.* (communicated).
- Phillips, J.M. and Hayman, D.S. 1970. Improved procedures for clearing roots and staining parasitic and Vesicular arbuscular mycorrhizal fungi for rapid assessment of infection. *Trans. Br. Mycol. Soc.* 55: 158-161.
- Sreenivasa, M.N. and Bagyaraj, D.J. 1988. *Chloris gayana* (Rhodes grass) a better host for mass production of *Glomus fasciculatum* inoculum. *Plant Soil* 106: 289-290.
- Sreenivasa, M.N. and Bagyaraj, D.J. 1989. Suitable form and level of phosphorus for mass production of the VA mycorrhizal fungus, *Glomus fasciculatum*, *Zentralbl. Mikrobiol.* 144: 33-36.
- Sreenivasa, M.N. and Krishnaraj, P.U. 1992. Synergistic interaction between VA mycorrhizal fungi and phosphate solubilizing bacterium in chilli. *Zentralbl. Mikrobiol.* 147: 126- 130.
- Sreenivasa, M.N. Krishnaraj, P.U., Gangadhara, G.A. and Manjunathaiah, H.M. 1992. Response of chilli to the inoculation of an efficient Vesicular arbuscular mycorrhizal fungus. *Scientia Hortic.* (Accepted. In Press).
- Sulochana, T. and Manoharachary, C. 1989. Vesicular arbuscular mycorrhizal associations of castor and safflower. *Curr. Sci.* 58: 459-461.

EFFECT OF PRE-MONSOON SOWING ON GROWTH AND PRODUCTIVITY IN GROUNDNUT (*ARACHIS HYPOGAEA* L.)

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ABSTRACT

The influence of pre-monsoon sowings on growth and productivity of groundnut and the relationships between growth and yield parameters were examined at the GKVK farm, UAS, Bangalore. Pre-monsoon sowings resulted in higher leaf area index (LAI) and leaf area duration (LAD) particularly during later stages of crop growth. Early Pre-monsoon sowing (D₁) and Pre-monsoon sowing (D₂) resulted in maximum LAI at 90th day after sowing (DAS). Genotype ICG 1697 had significantly higher LAI and LAD at later stages of the crop growth. Net assimilation rate (NAR) was decreased with increase in age of the crop. However, D₁ and Regular monsoon sowing (D₃) maintained same NAR both at 90 and 120th DAS. Crop growth rates (CGR) decreased after 90th DAS in all the treatments excepting D₁ and which had a significantly higher CGR between 90 and 120th DAS. Dry matter accumulation (DMA) were more in D₁ sowing. Early sowings (D₁ and D₂) produced higher pod and seed yields.

Correlation studies indicated a highly significant and positive correlation between LAI, LAD, DMA, CGR and pod yields. Dry matter production was highly dependent on LAI, LAD and CGR and in turn DMA had positive effect on pod yield. Net assimilation rate was negatively related with all parameters excepting a non-significant positive correlation with CGR. These results indicate the importance of LAI and LAD than that of NAR in achieving higher DMA and pod yields in groundnut.

Key words : Groundnut; Growth parameters; Productivity

INTRODUCTION

Productivity of a genotype depends on interception of the photosynthetically active radiation and partitioning of assimilates to the reproductive organs. The leaf area development and its duration are the major contributing factors for the radiation interception. In groundnut the differences in crop growth rates and biomass production in achieving higher pod yields were due to differences in leaf area development and the retention of higher leaf area duration (LAD) specially during reproductive phase under field conditions (Sastry *et al.*, 1980, Choudhari, 1982). However, LAD and biomass of groundnut is highly dependent on the time of the sowing of the crop (Chhonkar and Arvind Kumar, 1985). Groundnut is being predominantly grown under rainfed conditions, unpredictable mois-

ture fluctuation is commonly met-with where, the amount of rainfall and its periodicity contributes significantly towards the productivity of crop (Thorat *et al.*, 1984). Thus maximum utilization of precipitation all along the crop growth period is a pre-requisite to achieve higher pod yields under these conditions.

Southern parts of Karnataka (India) have a bimodal pattern of rainfall with 121 mm during pre-monsoon period (April - May) and 686 mm during monsoon (July-November). In such situations, maximum, utilisation of precipitation can be accomplished by means of sowing long duration genotypes. Sowing such genotypes during the pre-monsoon showers can prolong the crop duration and maximise the resource utilisation. Present study was conducted to assess the effect of pre-monsoon sowing on growth and productivity of

groundnut genotypes under south Karnataka conditions.

MATERIALS AND METHODS

The experiment was conducted during wet season from May to November of the year 1985 at the experimental farm of G.K.V.K., U.A.S. Bangalore on red loamy soils in a split-plot design with three sowing dates (Main plot) and four genotypes viz., ICG 1697, DH-3-30, ICG 799 and ICG 4507 (Sub-plots) replicated four times. The seeds were sown in 30 x 10 cm spacing on 9th May (Early pre-monsoon = D₁), 30th May (Pre-monsoon = D₂) and 16th July (Monsoon = D₃) using irrigation and then left for rains to support crop growth. All agronomic practices were followed according to package of practices for groundnut. The crops as they reached maturity were harvested on 25th October (D₁), 29th October (D₂) and 28th November (D₃) 1985.

Leaf area and dry matter accumulation (DMA) on 30, 60, 90, and 120th day after sowing (DAS) were recorded on five plants selected at random from each plot and the leaf area index (Watson, 1947), leaf area duration (LAD) (Powar *et al.*, 1967), net assimilation rate (NAR) (Gregory, 1926) and crop growth rate (CGR) (Watson, 1952) were computed. The data were analysed for the relationship between yield and different growth components.

RESULTS AND DISCUSSION

The total number of leaves per plant in groundnut increases exponentially from third week to 90-100 days after sowing (Enyi, 1977; Murthy *et al.*, 1983). LAI increased upto 90 DAS in all the treatments and then declined by 120 DAS (Table 1) due to leaf spot and rust diseases which are predominant during reproductive growth phase. The early pre-monsoon sowing (D₁) however, maintained significantly more LAI during 90-120th DAS. High LAI in ICG 1697 might be due to its intrinsic ability to tolerate foliar diseases.

The leaf area duration (LAD) in early sown treatments were significantly more than that of regular monsoon crop (D₃). In crop sown during normal monsoon (D₃) there was inadequate leaf area development after 60th day. Among the genotypes, ICG 1697 maintained markedly higher LAD especially during later stages.

Net assimilation rates (NAR) in (D₂) and (D₃) were more (Table 2) because the late sowings were found to have higher NAR than early sowings (Ishag, 1982). NAR gradually reduced as pod initiation and development proceeds (Janamatti, 1979). However, higher NAR in D₁ and D₃ at 120th DAS as observed in the present situation can be pertained to higher absolute growth rates between 90 and 120th DAS.

Crop growth rates (CGR) were increased upto 90th DAS because of higher LAI and relatively higher NAR (Janamatti, 1979). The CGR decreased during 90-120th DAS in D₂, D₃ and all genotypes (Table 2) except D₁.

Significantly higher dry matter accumulation (DMA) in early pre-monsoon sowing and in genotype ICG 1697 compared to other treatments (Table 3) were attributed at high LAD and CGR. This suggests the dependence of DMA on LAD than that of NAR since no marked variations in NAR were observed between the treatments though it was found significant (Table 2). However, maintenance of higher NAR for a longer period during reproductive phase as it was found by 120 DAS in D₁ is nevertheless useful for higher productivity (Narayanan *et al.*, 1981).

Early sowings seem to favour the leaf growth and maintains higher LAD is a primary factor contributing to DMA and pod yield (Chhonkar and Arvind Kumar, 1985). Thus the pod yield recorded in D₁ and D₂ were 49 and 46 per cent more compared to D₃ (Table 3) indicating a significant yield advantage if crop was sown in pre-monsoon seasons. The low yields of D₃ is attributed to lower leaf area at later stages (Sharma and Shrimali 1981). Ker-

Table 1. Effect of pre-monsoon sowing on leaf area index and leaf area duration in four groundnut genotypes

| Dates/Genotypes | Leaf area index (LAI) (at DAS) | | | |
|-----------------|--------------------------------------|-------|-------|--------|
| | 30 | 60 | 90 | 120 |
| D-1 | 0.99 | 2.40 | 3.88 | 4.76 |
| D-2 | 0.48 | 1.54 | 3.85 | 3.40 |
| D-3 | 0.58 | 1.49 | 2.18 | 0.68 |
| ICG 1697 | 0.84 | 2.25 | 4.08 | 3.76 |
| DH-3-30 | 0.70 | 1.66 | 2.99 | 2.30 |
| ICG 799 | 0.59 | 1.64 | 3.01 | 2.85 |
| ICG 4507 | 0.62 | 1.69 | 3.16 | 2.89 |
| CD (P = 0.05) | | | | |
| Dates | 0.05 | 0.13 | 0.25 | 0.15 |
| Genotypes | 0.04 | 0.13 | 0.20 | 0.19 |
| | Leaf area duration (LAD) between DAS | | | |
| | 0-30 | 30-60 | 60-90 | 90-120 |
| D-1 | 14.9 | 65.9 | 159.7 | 289.4 |
| D-2 | 7.3 | 37.7 | 118.6 | 227.4 |
| D-3 | 8.7 | 39.8 | 94.9 | 137.9 |
| ICG 1697 | 12.6 | 59.1 | 154.1 | 271.5 |
| DH-3-30 | 10.5 | 45.9 | 115.0 | 194.3 |
| ICG 799 | 8.8 | 42.2 | 111.8 | 199.6 |
| ICG 4507 | 9.3 | 43.9 | 116.7 | 207.4 |
| CD (P = 0.05) | | | | |
| Dates | 0.82 | 1.09 | 1.47 | 3.13 |
| Genotypes | 0.56 | 1.43 | 2.27 | 2.58 |

Table 2. Effect of pre-monsoon sowings on net assimilation rate and crop growth rates in four groundnut genotypes

| Dates/Genotypes | Net assimilation rate (NAR) between DAS ($\text{g. dm}^{-2} \text{ week}^{-1}$) | | | |
|-----------------|--|-------|-------|--------|
| | 0-30 | 30-60 | 60-90 | 90-120 |
| D-1 | 1.30 | 0.40 | 0.30 | 0.31 |
| D-2 | 1.47 | 0.46 | 0.48 | 0.13 |
| D-3 | 1.52 | 0.51 | 0.39 | 0.40 |
| ICG 1697 | 1.46 | 0.45 | 0.40 | 0.26 |
| DH-3-30 | 1.43 | 0.43 | 0.37 | 0.25 |
| ICG 79 | 1.40 | 0.48 | 0.40 | 0.35 |
| ICG 4507 | 1.42 | 0.47 | 0.39 | 0.27 |
| CD (P = 0.05) | | | | |
| Dates | 0.031 | 0.022 | 0.015 | 0.056 |
| Genotypes | 0.027 | 0.015 | NS | 0.053 |
| | Crop growth rate ($\text{g. dm}^{-2} \text{ week}^{-1}$) | | | |
| | 0-30 | 30-60 | 60-90 | 90-120 |
| D-1 | 21.3 | 65.2 | 93.4 | 134.6 |
| D-2 | 13.2 | 42.5 | 121.9 | 51.5 |
| D-3 | 15.9 | 48.8 | 70.9 | 49.8 |
| ICG 1697 | 20.3 | 65.5 | 117.5 | 99.4 |
| DH-3-30 | 17.1 | 46.8 | 86.4 | 53.7 |
| ICG 799 | 14.5 | 48.1 | 86.4 | 88.4 |
| ICG 4507 | 15.3 | 48.5 | 91.3 | 72.8 |
| CD (P = 0.05) | | | | |
| Dates | 0.53 | 0.73 | 4.28 | 1.28 |
| Genotypes | 0.47 | 0.99 | 4.71 | 1.84 |

Table 3. Effect of pre-monsoon sowings on dry matter accumulation and yield parameters at harvest in four groundnut genotypes

| Dates/Genotypes | Dry matter accumulation (g/plant) on DAS | | | |
|-----------------|--|--------------------|---------------------|------|
| | 30 | 60 | 90 | 120 |
| D-1 | 4.12 | 16.7 | 34.7 | 60.5 |
| D-2 | 2.55 | 10.8 | 34.1 | 43.9 |
| D-3 | 3.08 | 12.5 | 26.2 | 35.8 |
| ICG 1697 | 3.93 | 16.6 | 39.2 | 58.4 |
| DH-3-30 | 3.31 | 12.3 | 28.7 | 39.0 |
| ICG 799 | 2.81 | 12.1 | 28.8 | 45.8 |
| ICG 4507 | 2.96 | 12.3 | 29.9 | 43.8 |
| CD (P = 0.05) | | | | |
| Dates | 0.24 | 0.96 | 2.67 | 2.68 |
| Genotypes | 0.17 | 0.89 | 1.79 | 2.99 |
| | Pod yield (Kg/ha) | seed yield (Kg/ha) | Shelling percentage | |
| D-1 | 1721 | 1167 | 68.8 (56.0)* | |
| D-2 | 1690 | 1175 | 69.6 (56.6) | |
| D-3 | 1157 | 805 | 69.8 (56.7) | |
| ICG 1697 | 1912 | 1253 | 65.8 (54.2) | |
| DH-3-30 | 1483 | 1037 | 70.2 (56.9) | |
| ICG 799 | 1382 | 971 | 70.4 (56.0) | |
| ICG 4507 | 1315 | 936 | 71.2 (57.5) | |
| CD (P = 0.05) | | | | |
| Dates | 330 | 218 | NS | |
| Genotypes | 257 | 163 | (1.37) | |

*Values in paranthesis are transformed values

nel yields were also higher in early sowings. Variations in sowing dates did not alter the shelling percentage.

Correlation studies show that, LAI and LAD had a highly significant and positive effect on biomass production and pod yield (Table 4). Negative relationship was observed between NAR and pod yield. CGR and DMA had a highly significant and positive relation with pod yield (Ball *et al.*, 1982). This signifies the dependence of pod yield on LAD particularly during reproductive phase (Sastry *et al.*, 1980; Choudhari, 1982).

The results in the present investigation indicates that advancing sowing date in wet season is beneficial to groundnut production in the given environment.

Table 4. Correlation co-efficients between the growth parameters at 120 DAS and yield among four groundnut genotypes

| | LAD | NAR | CGR | DMA | Pod yield |
|-----|------------|--------------|-------------|-------------|------------|
| LAI | 0.97 ** | -0.405 NS | 0.78 ** | 0.89 ** | 0.82 ** |
| LAD | - | -0.371 NS | 0.78 ** | 0.91 ** | 0.74 ** |
| NAR | - | - | 0.237 NS | -0.08 NS | -0.55 * |
| CGR | - | - | - | 0.91 ** | 0.70 ** |
| DMA | - | - | - | - | 0.79 ** |

** significant at $P=0.01$; * significant at $P=0.05$; NS non-significant

LITERATURE CITED

- Ball, S.T., Wynne, J.C. and Nelson, N.A. 1982. Physiological basis for yield differences among peanut cultivars. *Proc. Amer. Peanut Res. Educ. Soc.* 14 : 100.
- Chhonkar, A.K. and Arvind Kumar. 1985. Yield attributes and yield of groundnut varieties as influenced by planting dates in Tarai region of Uttar Pradesh. *J. Oil seed Res.* 2 : 329-334.
- Choudhari, S.D. 1982. Variability in growth and yield attributes, photosynthetic rate and translocation in bunch genotypes of groundnut (*Arachis hypogaea* L.) and their relations to productivity. Ph.D. Thesis. Univ. Agril. Sci. Bangalore (India).
- Enyi, B. A. C. 1977. Physiology of grain yield in groundnut. *Exptl. Agric* 13 : 101-110.
- Gregory, F. G. 1926. The effect of climatic conditions on the growth of barley. *Ann. Bot.* 40 : 1-26.
- Ishag, H. N. 1982. The influence of irrigation frequency on growth and yield of groundnut (*Arachis hypogaea* L.) under arid conditions. *J. agric. Sci.* 99 : 305-310.
- Janamatti, V. S. 1979. Physiological aspects of growth and yield under non-stressed and stressed conditions in four genotypes of groundnut (*Arachis hypogaea* L.) M.Sc. (Agric.) Thesis. Univ. Agril. Sci. Bangalore (India).
- Murthy, P. S. S., Reddy, P. J. R. and Reddy, G. H. S. 1983. Variations in physiological parameters of popular groundnut varieties. *Madras agric. J.* 70 : 603-610.
- Narayanan, A., Reddy, C. B. and Murthy, S. R. K. 1981. Growth and yield analysis of two contrasting groundnut (*Arachis hypogaea* L.) cultivars. *Indian Agriculturist* 25 : 173-180.
- Powar, J. F., Willis, W. O., Grunes, D. L. and Reichman, G. A. 1967. Effect of soil temperature, phosphorus and plant age on growth analysis of barley. *Agron. J.* 59 : 231-234.
- Sastry, K. S. K., Sashidhar, V. R., Mekhri, A. A. and Parameshwara, G. 1980. Final report of the scheme for drought tolerance studies on groundnut, castor and safflower, 1974-1979. Univ. Agric. Sci. Bangalore (India).
- Sharma, K. N. and Shrimali, M. 1981. Effect of defoliation on groundnut varieties. *Food Farm Agric.* 13 : 147-149.
- Thorat, S. T., Kalra, G. S. and Pawar, A. B. 1984. Response of groundnut varieties to different irrigation schedules. *Indian. J. Agron.* 29 : 43-45.
- Watson, D. J. 1947. Comparative physiological studies on the growth of field crops. I. Variation in net assimilation rate and leaf area between species and varieties within and between years. *Ann. Bot. N.S.* 11 : 41-76.
- Watson, D. J. 1952. Physiological basis of variation in yield. *Adv. Agron.* 4 : 101-145.

NATURAL OUTCROSSING IN GROUNDNUT AND ITS IMPLICATIONS IN GROUNDNUT BREEDING

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ABSTRACT

Estimates of outcrossing in four groundnut (*Arachis hypogaea* L.) varieties belonging to different botanical types were made from a rectangular crossing design where the normal plants were surrounded in all directions by a 'Krinkle' dominant leaf marker. In a three year study conducted during the 1983-84 post-rainy season and 1984 and 1985 rainy seasons at ICRISAT Centre, the percentage of outcrossing on individual plants ranged from 0.0 to 5.35 across seasons and genotypes. A marked increase in outcrossing was noticed during the post-rainy season compared to the rainy season. The Spanish and Valencia types showed slightly greater outcrossing than the Virginia types. The levels of outcrossing at various locations in groundnut are reviewed and possible ways of utilising outcrossing in groundnut improvement are discussed.

Key words : Peanut; *Arachis hypogaea* ; Natural hybrids.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is a self-pollinating species. However, as in most other self-pollinating species, some outcrossing occurs in groundnut also. The recovery of natural hybrids in groundnut nurseries where there was concentrated bee activity suggested the involvement of bees as natural outcrossing agents. Heide (1923) was the first to identify the bees as the primary cross-pollinating agents in groundnut. Additional evidence that bees are the pollinating vectors in groundnut was provided by Hammons (1963), who showed that the bee-collected groundnut pollen was fully viable. Girardeu *et al.*, (1975) showed that the honeybee, *Apis mellifera*, can hybridize groundnut plants by conducting a controlled experiment in cages. Other workers (Stokes and Hull, 1930; Kushman and Beattie, 1946; Pelerenis, 1957) indicated that thrips could be the crossing agents without substantiating their claims. Wind pollination in groundnut is virtually ruled out since the stigma lies buried

among the dehiscent anthers in the tightly closed keel of mature flowers.

Several wild bee species have been reported as agents of natural cross-pollination in groundnut. At ICRISAT Centre, Patancheru (18° N, 78° E) India, in fields where pesticides are not used, about 20 different bee species have been found to forage on groundnut (ICRISAT, 1980). In the USA, Middtchell, (1960;1962) reported that, of the several bee pollinators in groundnut *Pyrobombes impatiens* (Cresson), *Megachile mendica* Cresson, *Apis mellifera* L. and *Lasioglossum versatum* (Robertson) were more abundant and widely distributed. In Indonesia, bee species *Xylocopa aestuans* L., *Apis indica* Fab. and *Ceratina bieroglyphica* sm. have been reported as pollinators in groundnut (Heide, 1923). The commonest bee species foraging on groundnut was *Nomia microsoma* in Malawi and *Anthopora concinnia* in Harare, Zimbabwe (Gibbons and Tattersfield, 1969).

In a self-pollinated crop such as groundnut, even a small amount of outcrossing poses problems in maintaining the genetic purity of cultivars. The maintenance of varietal purity in breeding nurseries was considered impossible due to outcrossing in Indonesia (Bolhuis, 1951). On the other hand, natural outcrossing generates additional variability upon which breeders can capitalize (Nigam *et al.*, 1983).

Several factors influence the extent of natural outcrossing that occurs at a given location. They include the abundance of insect pollinators in relation to the available flowers, cropping intensity, flowering habit of varieties, location of the field in relation to the habitat of the pollinators, frequency of pesticide usage, and various environmental factors such as temperature, humidity, wind velocity and direction (Bhatia *et al.*, 1981). Estimates of outcrossing in groundnut have been reported from the USA (Coffelt, 1989; Knauff *et al.*, 1987; Culp *et al.*, 1968; Kushman and Beattie, 1946), Puerto Rico (Stone *et al.*, 1973), Malawi, Zimbabwe, and Zambia (Gibbons and Tattersfield, 1969), Congo (Pelerenis, 1957), Indonesia (Bolhuis, 1951) and India (Srinivasulu and Chandrasekharan, 1958). There has been only one report in literature from India (location, Madras). The present study was undertaken to estimate the outcrossing on four groundnut varieties belonging to different botanical types at ICRISAT Center, Patancheru, India.

MATERIALS AND METHODS

Four groundnut genotypes, M-13, Kadiri 3, J-11, and NC Ac 17090, belonging to different botanical types and growth habits (Table 1) were used as female parents. These parents were planted along with a dominant leaf marker, Krinkle (ICG 8456), with wrinkled leaves (Hammons, 1964a) in a rectangular design where each plant in the female parent rows was surrounded by the krinkle leaf marker

plant in all the directions (Fig. 1). The row-to-row distance was maintained at 60 cm and plant-to-plant within the row at 10 cm. The study was conducted for three seasons, the 1983-84 postrainy season, and the 1984 and 1985 rainy seasons. During the 1983-84 postrainy season, the plot size comprised one row of 4m length which was replicated twice for each variety. During the 1984 and 1985 rainy seasons, the plot size was one row of 9m length

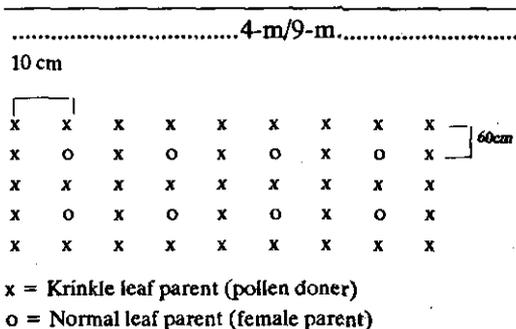


Fig. 1. Field layout used to determine the extent of outcrossing on individual plants in groundnut

which was replicated thrice for each variety. The seeds from each female plant were collected separately and grown in progeny rows the next season.

RESULTS AND DISCUSSION

Observations on the number of female parental families showing krinkle-leaved plants and the total number of krinkle-leaved plants in these families were made. The percentage of families showing outcrossing ranged from 0 to 66.67% across varieties and seasons (Table 1). The differences in the percentage of outcrossed families among the different varieties indicate the preference of bees for one variety over the other. On the basis of mean percentage of outcrossed families across the three seasons, the *fastigiata* types had a higher number of outcrossed families compared to *hypogaea* types. Also, during the 1983-84 postrainy season, the

Table 1. Number of outcrossed families in different botanical types of groundnut at ICRISSAT Center, 1983-85

| Genotype | Botanical type | Growth habit | 1983/84 Postrainy ¹ | | 1984 Rainy | | 1985 Rainy | | Mean percentage of families showing outcrossing |
|-------------|--|----------------|--------------------------------|-------------------------------------|----------------|-------------------------------------|----------------|-------------------------------------|---|
| | | | Total families | No. of families showing outcrossing | Total families | No. of families showing outcrossing | Total families | No. of families showing outcrossing | |
| M 13 | Ssp. <i>Hypogaea</i> Var. <i>Hypogaea</i> (Virginia) | Spreading | 38 | 3 (7.89) ² | 150 | 8 (5.33) | 132 | 8 (6.06) | 5.94 |
| Kadiri | Ssp. <i>Hypogaea</i> Var. <i>Hypogaea</i> (Virginia) | Semi-spreading | 35 | 6 (17.14) | 146 | 9 (6.16) | 110 | 5 (4.55) | 6.87 |
| J 11 | Ssp. <i>Fastigiata</i> Var. <i>Vulgaris</i> (Spanish) | Bunch | 36 | 24 (66.67) | 66 | 4 (6.06) | 120 | 0 (0.00) | 12.61 |
| NC Ac 17090 | Ssp. <i>Fastigiata</i> Var. <i>Fastigiata</i> (Valencia) | Bunch | 35 | 17 (48.57) | 108 | 1 (0.92) | 88 | 8 (9.09) | 11.26 |
| | | | 144 | 50 (34.72) | 470 | 22 (4.62) | 450 | 21 (4.67) | 8.74 |

1. The years and seasons refer to the period of initiation of the experiment and the respective families were raised in the subsequent years/seasons
2. Figures in the parentheses indicate the percentage of families showing outcrossing

Table 2. Estimates of outcrossing in various botanical types of groundnut

| Variety | Year ¹ /season | Total no. of plants studied ³ | No. of plants with kinkle leaf | percentage of outcrossing |
|-------------|---------------------------|--|--------------------------------|---------------------------|
| M 13 | 1983/84 PR ² | 636 | 3 | 0.47 |
| | 1984 Rainy | 1689 | 11 | 0.65 |
| | 1985 Rainy | 1759 | 13 | 0.74 |
| | | 4084 | 27 | 0.66 |
| Robut 33-1 | 1983/84 PR | 670 | 6 | 0.90 |
| | 1984 Rainy | 2375 | 7 | 0.29 |
| | 1984 Rainy | 1965 | 5 | 0.25 |
| | | 5010 | 18 | 0.36 |
| J 11 | 1983/84 PR | 841 | 45 | 5.35 |
| | 1984 Rainy | 872 | 6 | 0.69 |
| | 1984 Rainy | 1895 | 0 | 0.00 |
| | | 3608 | 18 | 1.41 |
| NC Ac 17090 | 1983/84 PR | 774 | 25 | 3.23 |
| | 1984 Rainy | 1731 | 1 | 0.06 |
| | 1984 Rainy | 1080 | 9 | 0.83 |
| | | 3585 | 35 | 0.98 |

1. Year/season refers to the period of initiation of the experiment.

2. Postrainy.

3. Studied during the succeeding year/season

percentage of outcrossed families was higher in all the varieties. This increase in the outcrossed families might be due to concentrated activity of bees as smaller plots were used and no other groundnut crop was in the vicinity of the experimental field, during the 1983-84 postrainy season.

The percentage of outcrossing on individual plant basis ranged from 0 to 5.35 (Table 2). It was higher in the postrainy season than in both the rainy seasons in all varieties except M13 which is late flowering variety. The increased levels of outcrossing during the postrainy season could be due to more concentrated and increased foraging activity of the bees on the crop, because of the lower number of both crop and weed species available for insect foraging.

On a three-season average, spanish and valencia types showed slightly greater percent-

ages of outcrossing compared to the virginia bunch and runner types. This observation is in agreement with that of Gillier and Silvestre (1969), who reported that cross-pollination is always greater in spanish and valencia (subspecies, *fastigiata*) varieties than in virginia (subspecies, *hypogaea*) varieties. The valencia variety, NC Ac 17090, showed a higher percentage of outcrossing compared to the virginia varieties in two out of three seasons. Similar observations were made by Culp *et al.*, (1968) who reported that in the USA, 'Tennessee Red', a valencia variety had greater outcrossing than 'Virginia Bunch 67', a virginia variety. The reason for the increased outcrossing in valencia and spanish types may be their fewer number of branches resulting in more exposure of flowers to bee activity. Also, these types flower early compared to virginia types.

Reports on outcrossing levels in groundnut from various locations are

presented in Table 3. The outcrossing levels observed in the present study are within the range reported in other countries such as the USA and Indonesia. No marked differences were noticed by Culp *et al.*, (1968) in the USA, in the outcrossing estimates made by using two different markers, Krinkle (a dominant leaf marker) and a purple petiole (an incomplete dominant marker).

Table 3. Natural outcrossing levels reported in groundnut

| Location/Country | Outcrossing percentage | Reference |
|--|------------------------|---|
| Lilongwe, Malawi | 0.0 - 0.72 | Gibbons and Tattersfield (1969) |
| Harare, Zimbabwe | 0.25 - 1.67 | Gibbons and Tattersfield (1969) |
| Chipata, Zambia | 0.0 - 0.35 | Gibbons and Tattersfield (1969) |
| Congo | 0.6 - 2.0 | Pelerenis (1957) |
| Java, Indonesia | 2.0 - 6.6 | Bolhuis (1951) |
| Florida, USA | 0.0 - 2.56 | Norden (1980) |
| Georgia, USA | 0.48 - 0.54 | Leuck and Hammons, (1965) |
| Georgia, USA | 0.73 - 2.56 | Hammons (1964) |
| Georgia, USA | 10.0 | USDA (1963) |
| Virginia, USA | 0.09 - 0.27 | Culp <i>et al.</i> , (1968) |
| Virginia, USA | 0.0 - 2.81 | Coffelt (1989) |
| Puerto Rico | 0.27 - 0.99 | Stone <i>et al.</i> , (1973) |
| Madras, India | 0.99 | Sreenivasulu and Chandrasekharan (1958) |
| ICRISAT Center Patancheru, A.P., India | 0.0 - 5.35 | Present study |

Although several modifications have been suggested for artificial hybridization of groundnut ever since Stok (1910) first developed the procedure, it still remains a tedious operation and the number of hybrid seeds obtained per pollination are limited compared to other crops.

While natural outcrossing poses problems in the purity of germplasm, systematic utilization of natural hybrids has been found to be a useful method of groundnut improvement (Nigam *et al.*, 1983). At ICRISAT Center, by utilizing natural hybrids, these researchers developed four groundnut varieties, ICGS 11, ICGS 44, ICGS 37 and ICGS 1, which have been released for cultivation in India. Similarly in Zimbabwe, a groundnut cultivar 'Egret' was developed from selections arising due to natural outcrossing in 'Makulu Red' cultivar (Hildebrand, 1975).

Hammons (1964b), proposed a new technique termed as 'pedigreed natural crossing', as a means to utilize natural outcrossing in groundnut improvement. In this method, both male and female parents are known and can be chosen and sufficient hybrid seeds can be produced if land is not a limitation. The limitations of this method according to Coffelt (1989) are the need for the presence of simple genetic markers along with some desirable characteristics in the male parent and large amount of land and/or labour required for the identification of the hybrids. However, it is not necessary to use unadapted parents with distinct genetic markers to identify genuine F₁ hybrids. Instead, several commonly present simply inherited traits such as testa colour, growth habit and pod reticulation could be employed. Also, hybrid indices involving some quantitative characters can be used.

Land and labour costs can be drastically reduced if outcrossing rates can be enhanced. This may be achieved by growing bee-attractant crops such as sunn hemp and sunflower in the groundnut crossing block as suggested by Gibbons and Tattersfield (1969). Recently, Dutta *et al.*, (1987) reported that low doses of radiations can be utilized to increase the levels of outcrossing in groundnut. They observed that pollen sterility induced through gamma irradiation (5 kR) could produce as high as 33% outcrossing in a groundnut cultivar, M 13. So, if proper male gametocides are identified, the enhanced outcrossing rates can be utilized

in groundnut improvement programmes where manual hybridizations cannot be undertaken.

LITERATURE CITED

- Bhatia, G.K., Gupta, S.C., Green, J.M. and Sharma, D. 1981. Estimates of natural cross-pollinations in *Cajanus cajan* (L.) Millsp. : Several experimental approaches. pp. 129-136. *In: Proceedings of the International Workshop on Pigeonpeas*. Vol. 2. 15-19, December, 1980, Patancheru, A.P., India.
- Bolhuis, G.G. 1951. Natuurlijke bastaardering bij de aardnoot (*Arachis hypogaea*). *Landbouwkundig Tijdschrift* 63 : 447-455.
- Coffelt, T.A. 1989. Natural crossing of peanut in Virginia. *Peanut Sci.* 16 : 46-48.
- Culp, T.W., Bailey, W.K. and Hammons, R.O. 1968. Natural hybridization of peanuts (*Arachis hypogaea*) in Virginia. *Crop Sci.* 8 : 109-110.
- Dutta, M., Arunachalam, V. and Bandopadhyay, A. 1987. Enhanced cross pollination to widen the scope of breeding in groundnut (*Arachis hypogaea* L.) *Theory Appl. Genet.* 74 : 466-470.
- Gibbons, R.W. and Tattersfield, J.R. 1969. Outcrossing trials with groundnuts (*Arachis hypogaea*). *Rhod. J. agric. Res.* 7 : 71-85.
- Girardeau, J.H., Morgan, L.W. and Leuck, D.B. 1975. Honeybees and peanut hybridization. *J. Georgia Entomol. Soc.* 10 : 305-307.
- Gillier, P. and Silvestre, P. 1969. L'arachide. Paris, Maisonneuve et Larose. Techniques agricoles et productions tropicales, 15 : 292 pp.
- Hammons, R.O. 1963. Artificial cross-pollination of the peanut with bee collected pollen. *Crop Sci.* 3 : 562-563.
- Hammons, R.O. 1964a. Krinkle, a dominant leaf marker in the peanut, *Arachis hypogaea* L. *Crop Sci.* 4 : 22-24.
- Hammons, R.O. 1964b. Pedigreed natural crossing - a new genetic technique. pp. 49-53. *In proceedings of the Third National Peanut Research Conference*, Auburn, Alabama, USA.
- Hildebrand, G.L. 1975. Egret groundnut. *Rhodesia agric. J.* 72 (6) : 154.
- Heide, F.P.R. 1923. Biologische onderzoekingen bij Landbouwgewassen. 1. Biologische Waarnemingen bij *Arachis hypogaea* L., Mededeel Algm. Proefsta v.d. Landbouw. 14 : 5-19.
- ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). 1980. Annual Report 1978-79. ICRISAT, Patancheru, p. 152. India.
- Knauff, D.A., Norden, A.J. and Gorbet, D.W. 1987. Peanut. pp. 346-384. *In Principles of cultivar development*. Ed. W.R., Fehr. E.L., Fehr. and H.J., Jessen. Vol 2. Crop Species. Macmillan. New York.
- Kushman, L.J. and Beattie, J.W. 1946. Natural hybridization in Peanuts. *J. Am. Soc. Agron.* 38 : 755-756.
- Leuck, V.B. and Hammons, R.O. 1965. Further evaluation of the role of bees in natural cross-pollination of the peanuts, *Arachis hypogaea* L. *Agron. J.* 57 : 94.
- Mitchel, T.B. 1960. Bees of the Eastern Unites States Vol. I. North Carolina Agricultural Exp. Sta. Tech. Bull. No. 141. pp. 538.
- Mitchell, T.B. 1962. Bees of the Eastern United States, Vol. II. North Carolina Agri. Exp. Sta. Tech. Bull. No. 152. pp. 557.
- Nigam, S.N, Rao, V.R. and Gibbons, R.W. 1983. Utilization of natural hybrids in the improvement of groundnuts (*Arachis hypogaea*). *Expl. agric.* 19 : 355-359.
- Norden, A.J. 1980. Peanut pp. 443-456. *In Hybridization of crop plants*. American Society of Agronomy. Crop Sci. Soc. of America, Madison, Wisconsin, U.S.A.
- Pelerncis, C. 1957. L'arachide a Yangambi. *Bull. Inform. I.N.E.A.C.* 6 : 243-255.
- Srinivasulu, N. and Chandrasekharan, N.R. 1958. A note on natural crossing in groundnut, *Arachis hypogaea* Linn. *Sci. and Culture* 23 : 650.
- Stok, J.E. Van Der. 1910. *Onderzoekingen omtrent Arachis hypogaea* L. (Katjang-tanah). Med. van het Dept. Van Lanbouw. 12 : 176-221.
- Stokes, W.E. and Hull, F.H. 1930. Peanut Breeding, *J. Am. Soc. Agron.* 22 : 1004-1019.
- Stone, E.G., Bailey, W.K. and Bear, J. E. 1973. Natural outcrossing of peanuts, *Arachis hypogaea* in Puerto Rico. *J. Am. Peanut Res. Educ. Assoc.* 5 : 134-140.
- U.S. Department of Agriculture. 1963. A peanut marker. *Agr. Res.* 12 : 11.

STATUS OF POST HARVEST PROCESSING OF SUNFLOWER SEEDS IN INDIA

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ABSTRACT

Sunflower (*Helianthus annuus* L.) seeds contain 35-45% oil. Different post harvest operations required for processing of sunflower seeds are threshing, shelling (de-husking), cleaning, size reduction and mechanical or extrusion and or solvent extraction process. This paper deals with bottlenecks of conventional threshing, problems of mechanical threshing, mechanics of shelling, cleaning and oil extraction process namely screw press expression, extrusion-expression and solvent extraction processes.

Key words : Sunflower; Processing; Threshing; Oil Extraction

INTRODUCTION

Total oil seed and edible oil production in India is 14 and 5 million tonnes respectively (Patil and Shanker, 1992), whereas the current demand is 6.375 million tonnes. The sunflower is an oil seed crop, which contains 35-45% oil, is grown in larger area in Karnataka (8.17 lakh hac) followed by Maharashtra, Tamil Nadu, Uttar Pradesh and Andhra Pradesh. The duration of the crop is 80 to 90 days. The crop can be grown in Kharif, Rabi and in Summer as a sole or mixed crop. It is a versatile crop suitable to several soils (red and black) under rainfed as well as irrigated conditions. The average yield of varieties like morden ranged from 1000 to 1500 kg whereas hybrid varieties yielded 2500 to 4500 kg per hectare.

The moisture content of harvested seeds may vary from 20 to 34%. Conventional methods of threshing require more than 15 to 20 days of field drying to bring moisture content, around 10-12%, which is optimum for efficient threshing. During this period farmers need to protect the crop from pests and climatic factors.

Conventional methods of threshing are beating with sticks, trampling under bullocks/tractors, rubbing ear head face to face and rubbing heads against wire mesh. Major problems with these methods are that they are laborious, tedious and time consuming.

MECHANICAL THRESHING

In mechanical threshing, crushing of sunflower heads requires high energy compared to removal of seeds from the heads. Mechanical thresher cum winnower with basic configuration of concave, drum, screen and blower are commonly used for cereals and oilseeds. On the circumference of the drums, peg teeth or rasp bar or loops are fixed to produce required threshing force.

Naravani (1987) evaluated the performance of Mysore mini thresher for sunflower. Specifications of thresher are given in Table 1. The results showed that capacity of thresher increased from 4 to 132 kg per hour with moisture content of threshed grains reduced from 34 to 7.5%. Mechanical damage in terms of germination of threshed grains was 25 and 12% for 34 and 7.5% moisture content of samples.

The percentage of grains unthreshed was maximum (14%) at 34% moisture content compared to 2.6% at 7.5% moisture content. It is concluded from this study that lower the moisture content, better the threshing performance. The main drawback of rasp bar thresher was additional cleaning of whole kernel seeds from broken sunflower heads.

Naravani (1991) recommended that for better threshing of sunflower rasp bar with 0.8 cm serration and round bar with 2.54 cm diameter was found optimum. The cost of operation of sunflower threshing was 21-23 Rs./q. Also he reported that threshing of sunflower heads above 9.5% moisture resulted in no breakage of flower heads while threshing.

A study was conducted by Malbasar *et al.*, (1986) to find the adoptability of maize sheller for threshing sunflower. Threshing efficiency obtained was higher than rasp bar threshing but it was lower than hand and wooden mallet threshing. Mechanical damage was lower than spike tooth, rasp bar and wooden mallet threshing was in par with hand threshing. In general threshing efficiency and mechanical damage increased with decrease in moisture content of the seeds.

PROBLEMS WITH RASP BAR AND SPIKE TOOTH THRESHERS

The main problem with raspbar, spike tooth and maize sheller threshers is mixing of broken parts of heads of sunflower which needs additional cleaning. Also energy requirement for unit quantity of operation is very high because most of energy is utilized in crushing the sunflower heads rather than removal of seeds. So researchers concentrated on alternative methods, which can thresh the seeds without dropping the sunflower heads into the thresher. Few models were developed by researchers, whose designs are completely different from conventional mechanical threshers. In this paper two such designs are described in detail.

PEDAL OPERATED WHEEL THRESHERS

Model-1 consists of a threshing wheel and fan. Threshing wheel is of 660 mm diameter, placed horizontally on 20 mm shaft at a convenient height. The rim of the wheel is 20 mm diameter pipe. The top cover is provided with four holes on top and wooden plank at bottom. Each hole is of 250 mm diameter to accommodate sunflower heads while threshing. At a given time four flower heads can be threshed. Three labourers are required to operate the thresher. Mixer of seeds and straw are collected in a chamber and winnowed by means of a fan of 215 mm diameter. The velocity of air was around 3.5 m/sec, which was sufficient to separate foreign materials, whose terminal velocity is less than 3.5 m/sec. The mean feed rate observed was 43.5 kg/hr compared to 30 kg of output. Winnowing efficiency was 97% and percentage filled was 1.5. Threshing efficiency was 99% and broken grains were less than 1%. Cost of the operation of unit was Rs. 17.50/100 kg of seeds. (Jadhav and Deshpande, 1988).

A commercial pedal operated knife sharpener (Model-2) was modified by replacing abrasive wheel with a disc of diameter 300 mm to thresh sunflower. The disc was tested with pins of 4 mm and 5 mm diameter and of equal length of 20 mm. The pins are placed in such a way that length decreased from centre to periphery. The speed of disc varied from 700-100 rpm. The results obtained were compared with hand threshing and are reported in Table 3. (Jagdish *et al.*, 1983). The unit was found very economical and efficient with respect to threshing time and man-hour requirement compared to hand threshing.

CLEANING OF SUNFLOWER SEEDS

After threshing generally oilseed mixture contain impurities which are to be removed prior to storage or drying or oil expression. Normally cleaning / separation of foreign materials from oil seeds is done using a vibrating sieve with a

Table 1. Specifications of Mysore mini threshing machine for sunflower (Naravani, 1987)

| Type of the threshing machine | No. of men required | No. of operations | Average speed | Type of power unit | Method of winnowing |
|---|---------------------|---|---------------|-------------------------------|--|
| Rasp bar Cylinder | 3 | 1 to 2 depending on the moisture content, of the crop | 500 | 6 hp air cooled diesel engine | Simultaneous cleaning with blower at 1440-2000 rpm |
| a. Cylinder diameter 2600 mm | | | | | |
| b. No. of blades on the Periphery - 3 | | | | | |
| c. Length of blade : 320 mm | | | | | |
| d. Concave clearance : 1.8 mm | | | | | |
| e. Linear pitch helixes in the blade : 15 mm | | | | | |
| f. Circular pitch of blade : 230 mm | | | | | |

Table 2. Effect of moisture content on threshing efficiency (T.E) and Mechanical damage (M.D) for different threshing methods (Malabasar *et al.*, 1987)

| Seed Moisture (%) | Threshing methods | | | | | | | | | |
|-------------------------|-------------------|------|----------------|------|----------------|------|----------------|-------|----------------|------|
| | T ₀ | | T ₁ | | T ₂ | | T ₃ | | T ₄ | |
| | T.E | M.D | T.E | M.D | T.E | M.D | T.E | M.D | T.E | M.D |
| 16.7 | 100 | 0.68 | 95.5 | 4.40 | 96.8 | 0.99 | 97.3 | 8.95 | 97.5 | 1.47 |
| 14.3 | 100 | 0.69 | 95.0 | 4.52 | 97.5 | 0.47 | 98.0 | 11.05 | 98.0 | 1.76 |
| 8.9 | 100 | 0.71 | 97.8 | 6.15 | 98.5 | 0.99 | 98.5 | 10.01 | 98.0 | 1.89 |

T₀ = Control; T₁ = Rasp bar threshing; T₂ = Maize sheller threshing; T₃ = Spike tooth thresher;
T₄ = Wooden mallet threshing

blower for winnowing. A simple pedal operated siever-winner developed for cereal cleaning was modified by Kachuru and Sahay (1988) to suit sunflower cleaning. The stroke pitch in degree for scalper and grader, were 3.6 and 4.7 degree, stroke length was 20 cm and rpm of eccentric and blower were 280 and 745 respectively. With above specification of winner-blower, velocity observed was 4 m/sec. The capacity of the unit was 1500 kg/kilo watt-hour and cost of operation was Rs. 4/100 kg. The top and bottom screen opening was 8 and 3 mm respectively. When a motor was used instead of pedal operation, it resulted in reduction of cost by 30 paise per 100 kg. The cost of pedal operated equipment was 3000 rupees compared to 4000 for power operated.

DECORTICATING OF SUNFLOWER SEEDS

The cleaned sunflower seeds need to be shelled for further processing. The shelling or decortication is the process of removal of outer husk. Normally this process is done by the principle of impacting the seeds with a harder surface. Nag *et al.*, (1983) developed a sunflower seed decorticator. It consists of a seed hopper, centrifugal impeller, casing, collecting chute and a transmission system. The centrifugal impeller, consists of 6 vanes with inlet and outlet angle of 43.8 and 74.5 degree respectively with height 3.75 cm each. The outer diameter of impeller is 420 mm. Impeller is driven by a motor and gear box assembly. Below the impeller, an inclined plate is provided to collect decorticated sunflower seeds. The speed of impeller is varied from 200 to 2900 m/min. It was observed from the study that decortication was better when the moisture content of seed was low and efficiency of decortication increased with peripheral speed. The speed above 2600 m/min resulted in high seed damage. For optimum decortication and low seed damage, a speed between 200 to 2600 m/min was recommended.

A sunflower seed sheller was developed by Tamil Nadu Agricultural University. The sheller consists of a high speed motor, rubber lined stator, a blower, and sieve assembly for cleaning. The rotor consists of 6 curved vanes with 2 flute in each. Stator is a tapered wooden surface, lined with a thick hard rubber. The graded seeds are fed into hopper by means of a bucket elevator and then into the rotor. The rotor throws the seeds into stator and creates an impact on the seeds. This impact force induced on the seeds due to high revolution of rotor resulted in rapid velocity of seed. The force due to rapid movement of seeds shelled the sunflower. The shelled materials are winnowed to separate the lighter husk and foreign material from the seeds. Since shell contain mainly cellulose, hemicellulose and lignin and removal of these materials increased the oil content by 20% in the seeds.

OIL EXTRACTION FROM SUNFLOWER

Once the sunflower seeds are shelled and cleaned, they are ready for extraction of oil. Oil is stored within sunflower in the form of globules surrounded by tough membrane. Oil from oilseeds are expelled using methods like mechanical screw press, extrusion-expression and solvent extraction (Chakravarthy, 1988). Ninety per cent of oilseeds are crushed mechanically to expel oil using screw press (Singh and Bargale, 1985). In the mechanical screw press expeller due to dynamic compression process, cell wall ruptures, tough membrane broke out and oil ooze out by disintegration. The dynamic compression is a function of pressure gradient between oilseed input and discharge cake output. The components of the pressure applied are radial and axial. These component values are maximum at the feed end (Singh *et al.*, 1990).

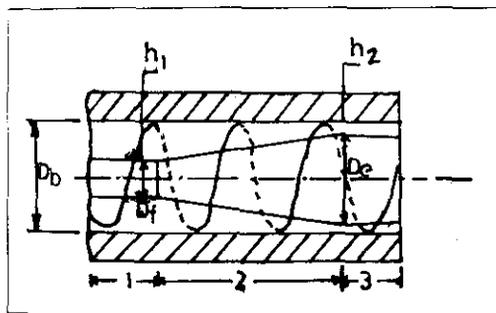
The components of expeller are worm shaft and barrel. Barrel consists of flat steel bars of trapezoidal cross section set edge wise around periphery parallel to worm shaft. The

Table 3. Effect of moisture content and threshing mechanism on threshing man-hour requirement and cost of threshing in three sunflower varieties (Jagadis *et al.*, 1983)

| Treatments | Threshing time in minutes | | | Man-hour requirement for 100 kg uncleaned seed | | | Cost of threshing in Rs. for 100 kg uncleaned seeds | | |
|-------------------------------|---------------------------|----------------|----------------|--|----------------|----------------|---|----------------|----------------|
| | V ₁ | V ₂ | V ₃ | V ₁ | V ₂ | V ₃ | V ₁ | V ₂ | V ₃ |
| M ₁ T ₁ | 10.83 | 8.38 | 12.56 | 18.6 | 14.3 | 21.1 | 9.3 | 7.2 | 10.6 |
| M ₁ T ₂ | 6.08 | 2.80 | 3.66 | 10.5 | 5.1 | 6.4 | 6.7 | 3.2 | 4.0 |
| M ₁ T ₃ | 6.45 | 2.60 | 3.03 | 11.2 | 4.6 | 5.4 | 7.1 | 2.9 | 3.4 |
| M ₂ T ₁ | 8.33 | 7.25 | 7.17 | 14.2 | 12.3 | 12.1 | 7.1 | 6.2 | 6.1 |
| M ₂ T ₂ | 4.80 | 2.32 | 2.94 | 8.1 | 4.2 | 5.2 | 5.1 | 2.7 | 3.3 |
| M ₂ T ₃ | 4.79 | 1.70 | 2.88 | 8.4 | 3.1 | 5.3 | 5.3 | 2.0 | 3.4 |
| M ₃ T ₁ | 8.77 | 6.06 | 4.34 | 15.0 | 10.1 | 7.5 | 7.5 | 5.1 | 3.8 |
| M ₃ T ₂ | 4.28 | 1.34 | 2.62 | 7.4 | 2.6 | 4.6 | 4.7 | 1.6 | 2.9 |
| M ₃ T ₃ | 3.50 | 1.96 | 2.17 | 5.9 | 3.6 | 3.7 | 3.7 | 2.3 | 2.4 |

T₁ = Hand threshing, T₂ = 5mm pins threshing, T₃ = 4 mm pins threshing
M₁, M₂, M₃, = Moisture content

worm shaft is fixed parallel at central axis of barrel. Worm shaft consists of a central shaft and a feed screw. Shaft is circular in shape, approximately 1/5th of barrel inner diameter in the feed portion. In the ram portion, it is of conical shape and at the discharge end clearance between barrel and shaft is very less (Refer Fig 1). Helical screws are fixed over the



1. Feed section; 2. Ram section; 3. Discharge section

D_b . Barrel section;

D_f . Root DIA of screw feed at feed section;

D_e . Root DIA of screw at start of plug

h_1 . Clearance between the barrel and screw root at feed end;

h_2 . Clearance between the barrel and screw root at start of plug section

Fig. 1. Schematic diagram of screw press with Barrel and Worm shaft

shaft to convey and pressurise the materials while conveying from feed to discharge. If D_b is inner diameter of barrel, D_f is the diameter of wormshaft at feed end, D_e is the clearance at discharge end between worm shaft and inner diameter of barrel, then compression ratio (CR) is given by

$$CR = \frac{D_b^2 - D_f^2}{D_b^2 - D_e^2}$$

Pressure, thickness and capacity of cakes coming out of the expeller can be adjusted using a choke. Mechanical expellers are classified based on power used, shape of barrel, expeller at feed and discharge end and type of chokes.

The main disadvantage of mechanical expression using screw expellers are that they require multiple passes for maximum recovery and consumes more time, effort and energy. Therefore, scientists resorted for alternative methods namely continuous solvent extraction, supercritical extraction and extrusion - expression.

SOLVENT EXTRACTION PROCESS

Oil cakes come out of mechanical screw expeller normally contain 10-12% oil. For extraction of this oil as well as direct extraction from seeds, solvent extraction method is used. The process of extraction of oil is performed using n-hexane solvent. This solvent penetrates and diffuses into cells of seeds and picks up oil. This oil is separated from solvent by condensation and the solvent in the oil cakes were extracted by evaporation.

EXTRUSION EXPRESSION

In this extrusion process, oilseed is heated well beyond boiling point of water, which results in buffing and expansion. The main objective of heating is to denature the available amino acid and make cell wall sufficiently brittle so that oil is freed from globules. By this process semi-fluid extrudate is obtained. Normally it is done at high pressure for a short period of time. Thus extruded sunflower oilseed products are expelled to yield oil, cakes and other products. Within a single pass of extruded sunflower oilseed products into the expeller resulted in 70% extraction of oil (Singh and Nawab, 1992).

Among all these methods of oil expression from oilseeds, extrusion-expression was found better in terms of energy requirement, cost and quality of oil.

CONCLUSIONS

The conclusions are :

1. Conventional threshing of sunflower is tedious, laborious and time consuming.

2. Mechanical threshing of sunflower using rasp-bar and spike tooth cylinders resulted in more energy requirement and additional cleaning due to entry of flower heads in the process of threshing.

3. Pedal and power operated horizontal and disc threshers avoided the problems of mechanical threshing listed above however resulted in low output capacity, which increased the cost of operation.

4. Cleaning and separation of sunflower seeds can be done using conventional siever cum cereal winnower.

5. Dry shelling of sunflower seeds requires high impact energy and peripheral speed of impeller was identified as the major parameter, which influence shelling.

6. Methods employed for oil extraction from sunflower seeds are mechanical screw press, solvent extraction, extrusion-expression and rarely super critical extraction.

7. Out of the oil extraction methods, mostly used in India is mechanical screw press. Studies proved that extrusion-expression (Expelling) is highly economical, consumes less energy and quality of oil produced is superior than other methods.

LITERATURE CITED

- Chakravarthy, A. 1988. Post-harvest, technology of cereals, pulses, and oilseeds. Oxford and IBH Publishers, New Delhi.
- Jadhav, R. V. and Deshpande, J. S. 1988. Design and development and performance evaluation of pedal operated sunflower thresher.
- Jagdish, G. V., Shambulingappa, K. G. and Sarpeskar, A. M. 1983 Evaluation of sunflower thresher and its threshing procedure. *Seed Res.* 11 (1): 47-55.
- Kachuru, R. P. and Sahay, K. M. 1988. Separation of oilseeds by pedal cum power operated air screen cleaner. *J. Oilseed Res.* 5 : 132-139.
- Malbasar, I. A., Shasidar, S. D. and Kulkarni, G. N. 1987. Effect of methods of threshing and seed moisture content on threshing efficiency and mechanical damage of sunflower seed crop. *J. agric. Engg.* 24(3) : 250-253.
- Nag, K. N., Singh, P. and Bhandari, R. 1983. A centrifugal impeller type sunflower seed decorticator. *Agricultural Mechanisation in Asia, Africa and Latin America*, 14(1): 55-58.
- Naravani, N. B. 1987. Investigations on the performance of Mysore mini thresher for efficient threshing of sunflower. Proc. XXII annual Convention of ISAE, pp : 62-66.
- Naravani, N. B. 1991. Studies on design and operation parameters for sunflower and safflower threshing. Unpublished Ph. D. thesis, IARI, New Delhi.
- Patil, S. A. and Shanker, I. G. 1992. Research development strategies of sunflower in Karnataka. A lecture delivered at subject matter training on Sunflower production technology at NCTCO, Directorate of Oilseeds Research, Hyderabad from 23-28 Sep. 1992.
- Singh, J. and Bargale, P. C. 1988. Final report (RPP-III), performance and evaluation of mini screw press (Oil expeller) for different oilseeds (cited in Singh et al., 1990)
- Singh, J., Singh, B. P. N., Bargale, P. C. and Shukle, B. D. 1990. An analysis of mechanical oil expeller operation. *J. Oilseed Res.* 7 : 41-50.
- Singh, J. and Nawab Ali, 1992. Recent developments of edible oil extraction technology IB (1), *Journal agric.* 72 : 23-27.

MODEL FOR CHARACTERIZING THE EFFECT OF EVAPORATIVE DEMAND, CANOPY COVER AND SOIL WATER ON SESAME EVAPOTRANSPIRATION

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ABSTRACT

Field irrigation experiments were conducted for two years (1988 and 1989) to study the effect of evaporative demand as reflected by pan evaporation, canopy cover (i.e., leaf area index, LAI) and soil water availability on sesame evapotranspiration (Eta) through an Eta model. Various approaches of this model were tried and all were found to be satisfactory and significant ($p = 0.01$) as shown by the explained total variation (R^2), which was more than 70 per cent. The variation of regression coefficients representing evaporative demand, canopy cover and soil water content agreed well with the established concepts on the nature of interaction of these variables with Eta. Comparison of simulation results with measured Eta was done by calculating the absolute values of relative deviation (RD) and it was found to be 6.125 per cent for 0-60 cm and both years of experimentation.

Key words : Evaporative demand; Leaf area index; Soil water content; Sesame; Evapotranspiration.

INTRODUCTION

Crop Evapotranspiration (Eta) is influenced by various variables viz., evaporative demand, soil water availability, canopy cover etc. The evaporative demand determines the potential Eta, while the latter two variables determine the ratio of actual to potential Eta (Rao *et al.*, 1992). Ritchie (1973) and Shimshi *et al.*, (1975) discussed models that incorporated the first two variables for simulating Eta. While Singh and Wolkewitz (1987) applied only second variable for simulating wheat Eta. On the other hand Nimah and Hanks (1973) studied the interaction of all the three variables on Eta. Such information was lacking for sesame; hence the objectives of the present analysis were to formulate an Eta model and study the nature of interaction of evaporative demand, canopy cover and soil water availability with sesame Eta.

MATERIALS AND METHODS

The input data viz., Eta, LAI, and soil moisture for the present analysis were obtained from a sesame irrigation experiment conducted for

two years at Agricultural College Farm, Marathwada Agricultural University, Parbhani, Maharashtra, India (19°16' N-Latitude, 76°47' East Longitude and 409 m altitude) during 1988 and 1989 summer (January - April) seasons. While the pan evaporation data were obtained from the meteorological observatory located 500 m away. The soil of the experimental site was vertisol, clayey in texture, with an average bulk density of 1.3 g/cm³ in 0-60 cm soil depth. The soil moisture retentivity at 0.033 MPa varied between 0.448 and 0.457 cm³/cm³ and 0.459 to 0.457 cm³/cm³ in the top (0-30 cm) and lower (30-60 cm) soil layers, respectively. The corresponding values at -1.5 MPa were 0.199 to 0.202 and 0.211 to 0.217 cm³/cm³. The treatments consisted of three levels each of irrigation (0.6, 0.9 and 1.2 ID/CPE ratio i.e, irrigation water depth/cumulative pan evaporation ratio), nitrogen (0, 40 and 80 kg N/ha) and phosphorus (0, 13 and 26 kg P/ha) laid out in 3³ partially confounded design with two replications. The ID considered at each irrigation was 6.0 cm. The sesame variety Punjab Til No. 1 was sown on 26th January and 2nd

February in 1988 and 1989, respectively, by adopting a spacing of 45 x 15 cm to achieve a desired plant population of 1.48 lakh/ha. The effective root zone depth considered was 60 cm. The soil moisture was monitored by means of gravimetric method starting from sowing to maturation at 7 day intervals upto 60 cm depth.

The model formulated in this study is based on the assumption that the daily Eta is a function of the following three variables.

$$\text{Eta} = f(\text{Epan}, \text{SW}, \text{LAI}) \dots\dots\dots (1)$$

in which,

Eta = daily evapotranspiration (mm/day)

Epan = daily free water evaporation from class A pan evaporimeter (mm)

SW = soil water content expressed as volume water percentage, and

LAI = cumulative sesame leaf area index

The following three approaches of the model (eq.1) were employed:

$$\text{Eta}_i = a_i + b_i \text{SW}_i + c_i \text{Epan}_i \dots\dots\dots (2) ..$$

$$\text{Eta}_i = a_i + b_i \text{SW}_i + c_i \text{Epan}_i + d_i (\text{SW}.\text{Epan})_i \dots\dots\dots (3) ...$$

$$\text{Eta}_i = a_i + b_i \text{LAI}_i + c_i \text{SW}_i + d_i \text{Epan}_i \dots\dots\dots (4) ...$$

in which, Eta, SW, Epan and LAI are as described earlier; while 'i' is the index of soil layer; 'a' is y-axis intercept and, 'b', 'c' and 'd' are the regression coefficients estimated through multiple regression analysis by using the afore mentioned data. The 'b', 'c' and 'd' are very important and reflect the magnitude of Eta i.e., higher the value greater is the Eta and vice versa.

The reliability of the model (eq.1) was tested by calculating the mean absolute values of relative deviation (RD) between the observed and computed Eta from 0-60 cm soil

depth for both the years of experimentation. The RD is defined as follows :

$$\text{RD}_{ij} = \sum_{k=1}^k | D_{kij} | / K \dots\dots\dots (5) ..$$

with

$$D_{kij} = \frac{W_{kij} - \bar{W}_{kij}}{\bar{W}_{kij}} \times 100$$

in which,

RD_{ij} = the mean absolute value of relative deviation in layer 'i' and month 'j'

k = the index of Eta measurement in layer 'i' and month 'j'

W_{kij} = the measured Eta in layer 'i' and month 'j'

\bar{W}_{kij} = the computed Eta in layer 'i' and month 'j'

K = the number of Eta measurements in layer 'i' month 'j'.

RESULTS AND DISCUSSION

Table 1 presents the empirical estimates for eq.2, 3 and 4 with respect to two soil layers. The high proportion of explained variance (R² = > 70 per cent) in all the approaches of the model tried (eq.2, 3 and 4) suggest that there is a good agreement between the data and the model. Further, the regression coefficients with respect to different independent variables viz., evaporative demand, canopy cover (LAI) and soil water content, included in the model (eq.2 to 4) reflected some note worthy characteristics, such as that the SW, Epan, and their interaction term (SW.Epan) were positively correlated with Eta in the top soil layer. The rate of water loss in the top soil layer is related mainly to surface evaporation and hence positive correlation of SW, Epan and (SW, Epan)

Table 1. Regression relating daily evapotranspiration (Eta) to leaf area index (LAI), soil water content (SW) and class A pan evaporation (Epan)

| Relationship | Regression constants, coefficients and test statistics | | | | |
|-----------------------------------|--|----------------------|----------------------|----------------------|----------------|
| | a | b | c | d | R ² |
| 0-30 cm soil depth | | | | | |
| Eta = f (SW) + (Epan) | -3.5955 | 0.1157** (0.0289) | 0.3366** (0.0732) | | 0.7177** |
| Eta = f (SW) + (Epan) + (SW.epan) | -3.2827 | 0.1080 (0.0892) | 0.8009 (0.3971) | 0.0019 (0.0097) | 0.7208** |
| Eta = f (LAI) + (SW) + (Epan) | -2.5579 | -0.0445 (0.3453) | 0.1436** (0.0327) | 0.2312 (0.1289) | 0.7401** |
| 30-60 cm soil depth | | | | | |
| Eta = f (SW) + (Epan) | 0.2985 | 0.0190 (0.0362) | 0.1270* (0.0640) | | 0.7105* |
| Eta = f (SW) + (Epan) + (SW.Epan) | -4.9365 | 0.0873 (0.1859) | 0.4056 (0.9158) | -0.0012 (0.0211) | 0.7140** |
| Eta = f (LAI) + (SW) + (Epan) | -0.9919 | 0.4523* (0.2031) | 0.0601* (0.0300) | -0.1999* (0.0678) | 0.7077** |

Values in parentheses are standard error of b's; ** significant at P = 0.01; * Significant at P = 0.05

with Eta (Strateener *et al.*, 1975); whereas the explanation for the negative association of LAI with Eta in the top soil layer partly lies in the above observation i.e., as the canopy cover is increased the evaporation from the soil surface is checked due to increased albedo, resulting in less energy load on the soil surface and hence the temperature of the evaporation zone (Hillel, 1980).

Further, the positive correlation of LAI and negative correlation of Epan and SW.Epan with Eta in the lower soil layer might be due to the fact that the root activity is the main agent of water loss in the lower layer. It has been pointed out by Denmead and Shaw (1962) that increased evaporative conditions may paradoxically reduce transpiration by inducing moisture stress and stomatal closure in plants. Since water extraction by roots is essentially equivalent to water loss from the leaves and where direct evaporation is very low (i.e., in the lower soil layer) hence one may expect positive

association of Eta with LAI and negative with evaporation demand (Epan) and its interaction term (SW.Epan).

As expected the values of regression coefficients representing SW and Epan were higher in the top soil layer, which means that more water has been extracted from its layer. This might be because the water loss from surface layer includes both direct evaporation and that due to extraction by plant roots.

The absolute mean value of RD between observed and computed Eta data was 6.125 per cent (Table 2). It should be noted here that the coefficient of variation in Eta measurements by different field methods were shown to be of the order of 15 to 25 per cent (Shimshi *et al.*, 1975). Further the model is based on the established theories and variation in the parameters of model agree well with the conceptual basis on the nature of interaction of these variable on Eta, thus indicating the pos-

sibility of its application under a wide range of environments.

Table 2. Mean relative deviations (%) between observed and computed Eta for 0-60 cm soil layer

| Month | 1988 | 1989 | Mean |
|----------|-------|-------|-------|
| January | 1.257 | - | |
| February | 5.675 | 7.218 | |
| March | 6.127 | 6.127 | |
| April | 6.273 | 9.357 | |
| Mean | 4.833 | 7.597 | 6.125 |

LITERATURE CITED

- Denmead, D.T. and Shaw, R. H. 1962. Availability of soil water to plants as affected by soil moisture content and meteorological conditions. *Agron. J.* 54 : 385-390.
- Hillel, D. 1980 Application of soil physics, Academic Press, New York. pp. 385.
- Nimah, M. N. and Hanks, R. J. 1973. Model for estimating soil, water and plant and atmosphere interactions. II. field test model. *Soil Sci. Soc. Am. Proc.*, 37 : 528-532.
- Rao, V. P., Raikhelkar, S. V. and Sondge, V. D. 1992. Relationship between actual evapo-transpiration rate and soil-water content under different evaporative conditions. *Indian. J. agric. Sci.* 62 : 201-211.
- Ritchie, J.T. 1973. Influence of soil water status and meteorological conditions on evapotranspiration from a corn canopy. *Agron. J.* 65 : 893-897.
- Shimshi, D., Yaron, D., Bresler, E., Weisbrod, M. and Strateener, G. 1975. Simulation model for evapotranspiration of wheat : Empirical approach. *J. Irrig. Drain. Div., ASCE*, 101: 1-12.
- Singh, P. and Wolkewitz, H. 1987. Evapotranspiration, pan evaporation and soil water relationships for wheat (*Triticum aestivum*). *Agric. Water Mgmt.*, 13 : 65-81.
- Strateener, G., Yaron, D., Bresler, E. and Shimshi, D. 1975. Simulation model for evapotranspiration of wheat : Effect of evaporative conditions. *J. Irrig. Drain. Div. ASCE* 101 : 13-19.

SEED SIZE AND QUALITY OF SUNFLOWER CULTIVAR MORDEN AS INFLUENCED BY PLANT DENSITY*

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ABSTRACT

A study was conducted to determine the effect of plant densities (1,66,666; 83,333 and 55,555 pl/ha) on seed size distribution and quality attributes of sunflower cultivar Morden. The range of seed size distribution varied due to plant densities. Optimum sieve size (interception point of distribution and germination curves) varied with the plant densities. At lower, medium and higher plant densities the optimum sieve sizes were 2.32, 2.36 and 2.48 mm respectively. Higher plant density recorded lower per cent of seed recovery and germination even at the optimum recommended sieve size compared to medium and lower plant densities. The sieve size of 3.0 mm (presently recommended sieve size) at medium and lower plant densities gave an increased seed germination but lower seed recovery and higher seed rejection. Lower plant population per ha gave 91.0 per cent (each) seed germination and recovery at 2.32 mm sieve size. The quality attributes such as seed germination, root length, shoot length, seedling vigour index, dry weight of five seedlings, 100-seed weight and oil content showed an increasing trend with the increase in seed size at all plant densities.

Key words : Sunflower; Plant density; Seed size distribution; Seed quality.

INTRODUCTION

Sunflower is an important oil seed crop of South India. Seed size in sunflower varies among the genotypes and the heterogeneity could be seen within the capitulum. Many complaints have been raised by seed growers on the present sieve size (3.0 mm slotted sieve) fixed by the State Seed Certifying Agency (SSCA) of Karnataka for processing the seeds of cultivar Morden, because of higher percentage of seed rejection. As the seed is the basic and scarce commodity to increase the production, due to the rejection, a good amount of seed is not available for sowing. The information on plant population density during seed production and its effect on seed recovery, size distribution and seed quality is meagre. Hence an attempt was made to find out the optimum plant density and optimum size sieve to obtain higher seed recovery and seed quality of sunflower cultivar Morden.

MATERIALS AND METHODS

The seeds of cv. Morden procured from the senior scientists, Oilseed Research Centre, UAS, Dharwad were sown on 15th July, 1991 at three plant densities viz., 1,66,666 (high), 83,333 (medium) and 55,555 (low) plants per ha by providing the spacing of 60 x 10, 60 x 20 and 60 x 30 cm, respectively with four replications. The seed yield of net plot from four replications of each treatment was bulked, cleaned and graded on 4.37, 3.97, 3.57, 3.18, 2.78, 2.38, 1.98 and 1.59 mm metal slotted hole sieves to assess the size distribution of seeds. The seeds retained on each sieve was quantified by weight and expressed in percentage to the total weight of seeds used for sieving. These values of cumulative per cent weight are used to plot the seed size distribution curve against the sieve sizes used for grading. The seeds retained on each sieve were taken and tested for germination by adopting the procedure of

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ISTA Rules (Anon, 1985). Seedling vigour index of seeds retained on each sieve was computed by applying the formula suggested by Abdul-Baki and Anderson (1973) and expressed as a number. The other seed quality parameters were recorded by adopting the standard procedures in vogue for the seeds retained on each sieve. Oil content of various sized seeds was estimated by using Nuclear Magnetic Resonance (NMR) equipment.

Seed size distribution and germination curves were drawn separately for each plant density. A straight line was drawn from the point of interception to the base to denote the optimum sieve size (mm) and depicted in figure.

RESULTS AND DISCUSSION

Seed size distribution:- The size distribution of seeds in Morden ranged from 1.59 to 3.97 mm due to higher plant density (1,66,666 pl/ha) and from 1.59 to 4.37 mm due to medium (83,333 pl/ha) as well as lower (55,555 pl/ha) plant densities (Table 1.). The per cent of seeds retained on 3.18 mm and above size sieves increased with the decrease in plant population per ha.

In Morden, the higher plant density recorded 84.5 per cent of recovery and seed germination at 2.48 mm (Fig). The medium plant density gave 88.5 per cent of recovery and seed germination at 2.36 mm sieve size. Lower plant density gave 91.0 per cent seed germination and recovery at 2.32 mm sieve size. Further, with increase in sieve size upto 3.0 mm (recommended by State Seed Certifying Agency), though the germination was more than 90 per cent but seed recovery was around 57 to 65 per cent showing seed rejection of 35 to 43 per cent. So it is necessary to reduce the sieve size from 3.0 mm (presently recommended sieve size) to 2.3 or 2.4 mm which would give both the good recovery and seed germination of more than 88.0 per cent. Below 2.3 mm size

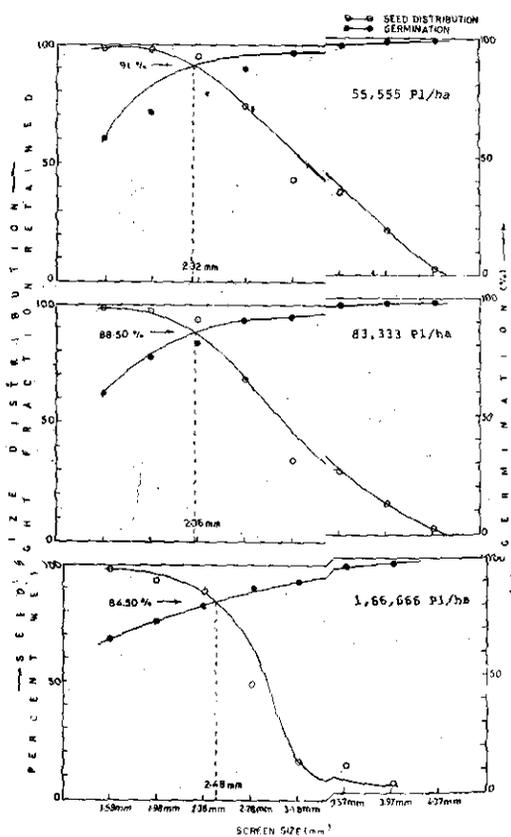


Fig. 1. SEED SIZE DISTRIBUTION AND GERMINATION IN PER CENT AS INFLUENCED BY DIFFERENT PLANT POPULATIONS IN MORDEN

Table 1. Seed size distribution and quality attributes of sunflower cultivar Morden as influenced by plant densities

| Plant density | Slotted screen size | Seed recovery (%) | Cumulative distribution (%) | Germination (%) | Root length (cm) | Shoot length (cm) | Seedling vigour index | Dry wt. of five seedlings (gm) | Hundred seed weight (%) | Oil content (%) |
|----------------|---------------------|-------------------|-----------------------------|-----------------|------------------|-------------------|-----------------------|--------------------------------|-------------------------|-----------------|
| 1,66,666 Pl/ha | 1.59 | 5.03 | 98.92 | 62.0 | 4.55 | 8.45 | 806.0 | 0.013 | 1.175 | 23.4 |
| | 1.98 | 5.03 | 93.89 | 76.0 | 6.23 | 11.06 | 1314.2 | 0.015 | 1.444 | 24.4 |
| | 2.38 | 40.15 | 88.86 | 83.0 | 10.43 | 13.52 | 1987.8 | 0.02 | 1.783 | 25.8 |
| | 2.78 | 32.79 | 48.71 | 92.5 | 11.48 | 14.84 | 2434.6 | 0.027 | 2.47 | 26.8 |
| | 3.18 | 4.89 | 15.91 | 93.0 | 12.63 | 16.24 | 2684.9 | 0.037 | 3.115 | 27.0 |
| | 3.57 | 6.80 | 11.03 | 97.0 | 12.98 | 15.2 | 2733.5 | 0.039 | 3.247 | 28.0 |
| 3.97 | 4.23 | 4.23 | 98.0 | 98.0 | 14.60 | 15.7 | 2969.4 | 0.045 | 3.818 | 29.2 |
| Mean | | | 85.93 | 10.41 | 13.57 | 2132.91 | 0.028 | 2.436 | 26.37 | |
| 83,333 Pl/ha | 1.59 | 2.01 | 99.16 | 68.5 | 4.06 | 11.4 | 1059.0 | 0.013 | 1.205 | 19.8 |
| | 1.98 | 3.17 | 97.16 | 77.0 | 8.09 | 12.99 | 1623.2 | 0.023 | 1.483 | 23.0 |
| | 2.38 | 26.37 | 93.98 | 84.0 | 9.34 | 12.11 | 1801.8 | 0.027 | 2.073 | 27.8 |
| | 2.78 | 33.49 | 67.62 | 92.5 | 10.93 | 13.25 | 2236.6 | 0.037 | 2.773 | 27.5 |
| | 3.18 | 7.73 | 34.13 | 94.75 | 12.75 | 13.25 | 2463.0 | 0.039 | 3.432 | 28.2 |
| | 3.57 | 13.12 | 26.40 | 97.8 | 13.25 | 13.87 | 2652.3 | 0.047 | 3.897 | 28.8 |
| 3.97 | 12.53 | 13.29 | 98.0 | 98.0 | 13.46 | 13.89 | 2680.3 | 0.052 | 4.627 | 30.0 |
| 4.37 | 0.76 | 0.76 | 98.5 | 98.5 | 13.72 | 14.72 | 2801.3 | 0.075 | 5.661 | 32.2 |
| Mean | | | 88.88 | 10.7 | 13.18 | 2164.7 | 0.039 | 3.143 | 27.16 | |

Contd.

Table Conid.

| Plant density | Slotted screen size | Seed recovery (%) | Cumulative distribution (%) | Germination (%) | Root length (cm) | Shoot length (cm) | Seedling vigour index | Dry wt. of five seedlings (gm) | Hundred seed weight (%) | Oil content (%) |
|---------------|---------------------|-------------------|-----------------------------|-----------------|------------------|-------------------|-----------------------|--------------------------------|-------------------------|-----------------|
| 55,555 P/ha | 1.59 | 1.37 | 99.54 | 69.0 | 4.6 | 9.15 | 948.7 | 0.016 | 1.251 | 19.0 |
| | 1.98 | 3.23 | 98.16 | 78.5 | 8.03 | 12.72 | 1628.9 | 0.017 | 1.785 | 23.4 |
| | 2.38 | 21.02 | 94.93 | 88.5 | 9.08 | 13.02 | 1955.8 | 0.023 | 2.165 | 25.8 |
| | 2.78 | 30.46 | 73.91 | 94.0 | 11.77 | 15.29 | 2543.6 | 0.034 | 2.94 | 28.6 |
| | 3.18 | 8.79 | 43.45 | 96.5 | 12.95 | 15.86 | 2780.2 | 0.043 | 3.882 | 29.4 |
| | 3.57 | 15.79 | 34.67 | 98.0 | 13.36 | 15.55 | 2833.2 | 0.054 | 4.368 | 29.8 |
| | 3.97 | 17.03 | 18.88 | 98.5 | 14.60 | 16.36 | 3049.6 | 0.055 | 4.889 | 31.0 |
| | 4.37 | 1.85 | 1.85 | 99.0 | 15.72 | 17.67 | 3305.6 | 0.083 | 5.818 | 32.8 |
| Mean | | | 90.25 | | 11.26 | 14.45 | 2380.7 | 0.041 | 3.387 | 27.48 |

sieve, though the per cent of seed recovery more but it would give less per cent of germination. In the present study it was noticed that higher plant density (1,66,666 pl/ha) would lead to the higher rejection of seeds and in turn caused lower lower recovery when sieve size was increased due to higher competition among the plants. These results are in agreement with the results reported by Holt and Zentner (1985) who noticed in their trials with plant densities ranging from 22,600 to 76,400 plants per ha, found that the percentage of large seeds decreased as plant density increased. The lower plant density (55,555 pl/ha) in this study not only helped to increase the recovery in Morden variety of sunflower but also increased the seed size and improved seed germination, seedling vigour, test weight of seed and oil content in seed (Table).

Seed Quality:- The seed quality attributes such as germination, root length, shoot length, seedling vigour index, dry weight of seedlings, hundred seed weight and oil content showed an increasing trend with the increase in seed size at all the plant densities. The mean values of all the quality attributes were highest at lower plant density whereas the lowest values were recorded in higher plant density. These results are in conformity with the findings of Ashok Kumar *et al.*, (1985) and Ujjinaiah *et al.*, (1990). Oil content and test weight were higher at lower plant density. With the successive increase in plant densities, a decrease in seed oil per cent was noticed by Sankapannavar (1984) and Harmati (1990) in sunflower.

So it can be concluded that it is necessary to reduce the size of slotted sieve from 3.0

mm (recommended by SSCA) to 2.3 or 2.4 mm. It is better to adopt 55,555 plants per ha (60 x 30 cm spacings) as an optimum plant density to obtain higher seed recovery and seed quality in Morden sunflower.

LITERATURE CITED

- Abdul-Baki, A.A. and Anderson, J.D. 1973. Vigour determination in soybean by multiple criteria. *Crop Sci.* 13 : 630-637.
- Anonymous. 1985. International rules for Seed Testing Association. *Seed Sci. and Technol.* 13 : 299-513.
- Ashok Kumar, T.N., Gangadharaiah, Krishna Gowda, K.T. and Seenappa, K. 1985. Effect of season and plant densities on growth, yield and yield components of sunflower. *Oil Seeds J.* 2 : 144-147.
- Harmati, I. 1990. Variety and plant density trials with sunflower on slightly calcareous sand between Donube and Tisza rivers. *Novenytermeles* 39 (2) : 171-180. (Cross Reference : *Field Crop. Abstr.* 43 (11) : 1076.
- Holt, N.W. and Zentner, R.R., 1985. Effect of plant density and row spacing on organic performance and economic returns of non oil seed sunflower in south eastern saskatchewan. *Can. J. Pl. Sci.* 56 : 427-428.
- Sankapannavar, B.G. 1984. Performance of sunflower (*Helianthus annuus* L.) genotypes under varying row spacing and plant populations in dryland conditions. M.Sc. (Agri.) thesis. University of Agricultural Sciences, Bangalore, India.
- Ujjinaiah, U.S., Shambulingappa, K.G. and Murali, N.M. 1990. Effect of different levels of nitrogen and spacing on production and quality of BSH-1 hybrid sunflower II. Influence of levels of nitrogen and spacing on hybrid seed quality. *Mysore J. agric. Sci.* 24 : 450-454.

SHORT COMMUNICATIONS

INFLUENCE OF CULTIVATION PRACTICES AND APPLICATION OF GYPSUM, SAND AND FARM YARD MANURE ON NITROGEN UPTAKE, QUALITY OF KERNELS AND OIL YIELD OF IRRIGATED GROUNDNUT ON BLACK SOILS

The low pod yield and quality of kernels is causing concern to the farmers of medium and deep black soils of Karnataka especially under irrigation. These soils are compact and less aerated due to high clay content and low organic matter. And the present practice of flood irrigation further aggravates aeration problem and also makes it difficult for the penetration of pegs into the soil. Groundnut needs good aeration in the rooting and pegging zones. The inadequate aeration results in abnormal respiration, which in turn inhibits root growth and retards metabolic functions. Further, the plant becomes chlorotic due to deficiency of nitrogen caused by inability of roots to take up nitrogen and ineffectiveness of nitrogen fixing bacteria in oxygen deficient environment.

An investigation was, therefore, conducted at Water Management Research Station, Navalgund (Dharwad district) during Kharif, 1981, on deep black soils (63.9% clay, 8.5 pH and 0.44% organic carbon) under irrigation to study the effect of intercultivation and earthing-up and application of gypsum (500 kg/ha), sand (2000 kg/ha) and farmyard manure (FYM) (2000 kg/ha) on the nitrogen uptake, quality of kernels and oil yield of bunch groundnut (Var. DH-3-30). The crop received two intercultivations (15 and 30 days after sowing) and gypsum, sand and FYM were applied on either side of row after second intercultivation as per treatments. Intercultivations were done with hand drawn hoes (cultivators) up to a depth of 3-5 cm. two days after irrigation when the soil surface was dry.

Later the crop was earthed up. The crop received a common fertilizer dose of 40:80:40 kg ha⁻¹ N:P₂O₅ : K₂O and two sprays of FeSO₄ at 0.05% at 45 and 60 days after sowing.

The nitrogen uptake (Table 1) increased significantly from 86.95 kg ha⁻¹ in control to 118.07 kg ha⁻¹ with intercultivation + earthing up. This was further increased due to application of gypsum, sand and FYM. The highest uptake of 155.89 kg ha⁻¹ was observed with gypsum + sand + FYM. This may be due to increased symbiotic nitrogen fixation and root activity under improved aeration and presence of calcium with this treatment. The improvement in soil physical properties due to cultivation practices (Baver, 1956), gypsum (Sudhakar, 1977), sand (Taylor and Blake, 1979) and FYM (Shanmugam and Ravikumar, 1980) was reported. Further, Nair *et al.*, (1970) observed reduction in nitrogen fixation in the absence of calcium. The increased nitrogen uptake, however failed to increase significantly the kernel nitrogen or protein content.

The cultivation practices had non significant effect on shelling percentage and kernel oil percentage. However, the oil yield (8.12 q/ha) was significantly influenced due to increased pod weight (11.15 g) per plant and pod yield (26.74 q/ha) under intercultivation + earthing up. The shelling percentage, kernel oil and pod and oil yields were also influenced by application of gypsum, sand and FYM and more so under their combined application. The highest kernel oil was recorded with gypsum +

Table 1. Nitrogen content and uptake, kernel protein and oil per cent, shelling percentage, pod yield and oil yield as influenced by cultivation practices and application of gypsum, sand and FYM

| Treatment | Nitrogen content (%) | | | Nitrogen uptake (kg/ha) | Kernel protein (%) | Shelling percentage (%) | Kernel oil (%) | Pod weight (g/plant) | Pod yield (q/ha) | Oil yield (q/ha) |
|--------------------------------|----------------------|-------|-------|-------------------------|--------------------|-------------------------|----------------|----------------------|------------------|------------------|
| | Leaf | Hairt | Shell | | | | | | | |
| No intercultivation | 2.59 | 1.10 | 0.84 | 4.12 | 25.75 | 72.54 | 39.80 | 8.70 | 28.28 | 6.43 |
| Intercultivation | 2.50 | 0.96 | 0.84 | 4.42 | 27.65 | 73.80 | 40.55 | 9.57 | 24.38 | 7.33 |
| Intercultivation + earthing up | 2.60 | 0.98 | 0.84 | 4.81 | 30.04 | 73.96 | 40.75 | 11.15 | 26.74 | 8.12 |
| Gypsum | 2.52 | 1.03 | 0.63 | 4.17 | 26.10 | 75.27 | 42.90 | 12.06 | 28.78 | 9.24 |
| Sand | 2.71 | 0.97 | 1.05 | 4.63 | 28.94 | 74.65 | 41.33 | 11.69 | 27.74 | 8.55 |
| FYM | 2.71 | 1.03 | 0.89 | 4.44 | 27.77 | 74.86 | 42.73 | 12.28 | 29.69 | 9.51 |
| Gypsum + sand | 2.87 | 1.05 | 0.89 | 4.06 | 25.36 | 75.92 | 43.25 | 12.96 | 31.57 | 10.35 |
| Gypsum + FYM | 2.87 | 1.07 | 0.84 | 4.03 | 25.21 | 76.21 | 44.38 | 13.76 | 32.20 | 10.90 |
| Sand + FYM | 2.57 | 0.98 | 0.82 | 4.17 | 26.08 | 75.68 | 42.83 | 12.73 | 30.00 | 9.77 |
| Gypsum + sand + FYM | 2.75 | 0.82 | 0.70 | 4.12 | 25.79 | 77.17 | 43.55 | 16.35 | 33.62 | 11.34 |
| Mean | 2.66 | 0.99 | 0.83 | 4.22 | 26.86 | 75.00 | 42.43 | 12.13 | 28.70 | 9.15 |
| SEM ± | 0.08 | 0.08 | 0.06 | 0.17 | 1.07 | 0.30 | 0.71 | 0.33 | 0.57 | 0.18 |
| CD at 5% | 0.24 | NS | 0.18 | NS | 13.77 | NS | 0.88 | 0.94 | 1.66 | 0.53 |

NS = Not significant

FYM (44.38%) and was on par with the application of gypsum + sand + FYM (43.55%) which recorded significantly highest pod (33.62 q/ha) and oil yields (11.34 q/ha) owing to higher shelling percentage (77.17) and pod weight per plant (16.35 g). The improvement may be attributed to additive and complementary effects of gypsum. Apart from calcium, gypsum contains sulphur which is involved in sulphhydryl

(-SH) linkage in the biosynthesis of oil. Walker and Keisling (1978) observed increased kernel oil with gypsum application.

Thus, from the study, it is evident that the quality of nuts and the yield can be improved by providing better aeration and nutrient supply at rooting and pegging zones in heavy texture soils.

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Baver, L.D. 1956. Soil physics, 3rd Ed. John Willey, New York.

Nair, K.S., Ramaswamy, P.P. and Peruman, R. 1970. Nutritional factors affecting nitrogen fixation in *Arachis hypogaea* L. *Madras agric. J.* 57 : 307-310.

Shanmugam, K. and Ravikumar, V. 1980. Effect of organic residues on physical properties of soil and yield of sorghum (CSH-5). *Madras agric. J.* 67 (7) : 445.

Sudhakar, N. 1977. Effect of organic amendments and gypsum on yield of groundnut (*Arachis hypogaea* L.) under rainfed conditions. *Thesis Abstracts* 3: 23-24. S.V. Agricultural College Tirupati, India.

Taylor, D.H. and Blake, G.R. 1979. Sand content of sand, soil, pest mixtures for turfgrass. *Soil Sci. Soc. Am. Proc.* 43 (2) : 394.

Walker, M.E. and Keisling, T.C. 1978. Response of five cultivars to gypsum fertilization on soils varying in calcium content. *Peanut Sci.* 5 : 57-60.

CHARACTER ASSOCIATION AND PATH ANALYSIS OF CERTAIN QUANTITATIVE CHARACTERS IN SUNFLOWER (*HELIANTHUS ANNUUS* L.)

Correlation and path coefficient studies were made involving one hundred and sixty two accessions of sunflower. They were grown in rows of 6m length. The spacing was 15 cm between the plants and 60 cm between the rows. The experiment was conducted at the Agricultural College Farm, Hyderabad in winter season of 1985. The layout was a Randomised Block Design with three replications. The recommended management practices were adopted. The sampling unit to measure various agronomic traits at harvest constituted five plants in each row selected at random. Correlation coefficients were calculated following Fisher (1954) and path coefficient analysis of Dewey and Lu (1959).

The results showed that the effects of plant height, capitulum diameter, number and area of leaves per plant, number of seeds per capitulum and thousand seed weight were all positively associated with one another and with yield per plant (Table 1). The correlation coefficients were highly significant. The traits which showed highest correlation with yield were the capitulum diameter ($r = 0.538$) and number of

seeds per capitulum ($r = 0.558$). In turn these traits were also strongly associated with each other ($r = 0.631$) and with plant height (0.573 and 0.643). However, Natali and Shaik (1970) observed capitulum diameter to have negative correlation with yield. Akhanda *et al.*, (1979) stated that both capitulum diameter and thousand seed weight have negative correlation with yield. But, Ayyaswamy *et al.*, (1977) and Pathak (1978) reported that the capitulum diameter is positively and significantly correlated with yield. The inconsistency in the relationship of capitulum diameter with seed yield could possibly be ascribed to variations in growth from environment to environment (Jatasra and Paroda, 1978) and the genetic material evaluated. The positive and significant influence of plant height, capitulum diameter, thousand seed weight and number of seeds per capitulum with yield in the present study is in conformity with the findings of Anand and Chandra (1979), Sheriff *et al.*, (1984) and Dhaduk *et al.*, (1985).

The path analysis showed that the direct influence on seed yield was largest through the

Table 1. Correlation Coefficients of the quantitative traits in sunflower

| | Capitulum diameter | No. of leaves | Leaf area | No. of seeds per capitulum | 1000 seed weight | Yield per plant | per |
|-------------------------------|--------------------|---------------|-----------|----------------------------|------------------|-----------------|-----|
| Plant height | 0.573** | 0.300** | 0.326 | 0.643** | 0.275** | 0.379** | |
| Capitulum diameter | | 0.164** | 0.210** | 0.631** | 0.574** | 0.538** | |
| No. of leaves per plant | | | 0.562** | 0.262** | 0.144** | 0.090** | |
| Leaf area per plant | | | | 0.281** | 0.149** | 0.167** | |
| Number of seeds per capitulum | | | | | 0.274** | 0.558** | |
| 100 seed weight | | | | | | 0.316** | |

** Significant at 1 %

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number of seeds per capitulum (Table 2). This trait alone accounted for 72.7% of the correlated response. The indirect positive contribution was through capitulum diameter, test weight and leaf area per plant. Kesteloot *et al.*, (1985) had also stressed the number of seeds per capitulum as the most important character for selection. Capitulum diameter another strongly associated parameter with yield accounted for 51.5% of the correlated response. This in turn was further toned up by the indirect paths via number of seeds per capitulum, test weight and the leaf area per plant. The magnitude of direct effect of test weight was also larger than the indirect effects via number of

seeds per capitulum, capitulum diameter and the leaf area per plant. Interestingly, plant height and number of leaves per plant which indicated significant positive correlations showed both directly and indirectly the negative effect deterring seed yield. Dhaduk *et al.*, (1985) had also observed that though the plant height was positively and significantly correlated the direct and indirect paths were negative.

The results obtained indicate that with their maximum direct and substantial indirect effects, the number of seeds per capitulum and capitulum diameter were the two most important traits influencing seed yield in sunflower.

Table 2. Path coefficient analysis of quantitative traits on seed yield of sunflower

| | Plant height | Capitulum diameter | No. of leaves per plant | Leaf area per plant | No. of seeds per capitulum | 1000 seed weight | Correlation with seed yield |
|---------------------------|--------------|--------------------|-------------------------|---------------------|----------------------------|------------------|-----------------------------|
| Plant height | -0.048 | 0.159 | -0.025 | 0.016 | 0.260 | 0.017 | 0.379** |
| Capitulum diameter | -0.027 | 0.277 | -0.013 | 0.010 | 0.255 | 0.036 | 0.538** |
| No. of leaves per plant | -0.014 | 0.045 | -0.083 | 0.027 | 0.106 | 0.009 | 0.090** |
| Leaf area per plant | -0.015 | 0.058 | -0.046 | 0.048 | 0.113 | 0.009 | 0.167** |
| No. of seed per capitulum | -0.032 | 0.177 | -0.022 | 0.013 | 0.405 | 0.017 | 0.558** |
| 100 seed weight | -0.013 | 0.076 | -0.011 | 0.007 | 0.111 | 0.064 | 0.316** |

** Significant at 1% level.

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Akhanda, A.M., Green V.E. Jr and Prine, G.M. 1979. Influence of row width and plant population on yield components of sunflower. *Bangla Desh J. Agric.* 4(2): 164 - 174.

Anand, I.J. and Chandra, S. 1979. Genetic diversity and inter relationship of oil yielding traits in sunflower. *The Sunflower Newsletter.* 3 (1): 5-8.

Ayyaswamy, M.K., Krishna Raju, J. and Sivasundaran. D. 1977. Biometric studies in sunflower. *Madras Agric. J.* 64 (7): 430- 432.

Dewey, D.R. and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agon. J.* 51: 515-518.

- Dhaduk, L.K., Desai, N.D. Patel, R.H. and Kukadia, M.V. 1985. Correlation and path coefficient analysis in sunflower. *Indian J. agric. Sci.* 55 (1) : 52-54.
- Fisher, R.A. 1954. Statistical methods for research workers. 12th Ed. *Biological monograph and manuals* pp. 1301-1302.
- Jatasra, D.S. and Paroda, R.S. 1978. Character association in three generations of wheat under different environmental conditions. *Cereal Res. Commn.* 6:85-94.
- Kesteloot, J.A., Heursel, J. and Pauwels, F.M. 1985. Estimation of the heritability and genetic variation in sunflower. *Helia.* 8: 17 -20.
- Natali, A.H. and Shaikh, J.M. 1970. Correlation of seed yield with other characters in sunflower. *In Proc. 2122 Pakistan Science Conference.* Fajshhi. Part III Abst.
- Pathak, R.S. 1978. Yield components in sunflower. *Univ. Nairobi Dep. Appl. Plant Sci.* 271-281.
- Sheriff, N.M., Appadurai, R. and Rangaswamy, M. 1984. Parent offspring relationship in sunflower. *Madras agric. J.* 71 (2) : 832-835.

EFFECT OF NITROGEN AND PHOSPHORUS ON GROWTH AND GRAIN YIELD OF SUNFLOWER.

Sunflower is an important oil seed crop in the world and ranks third next only to cotton seed and groundnut in the total world production of oilseed. At present, in India sunflower is being cultivated over an area of 8.94 lakh ha with a production of 3.01 lakh tonnes (Annon., 1987). Now the crop is widely accepted by the Indian farmers because of its desirable attributes such as low seed rate, high seed multiplication ratio (1 to 100), short duration, photosensitivity, higher water use efficiency and high oil content (45.50%). The reasons for the present low yield of sunflower are : it is grown on marginal land of low fertility, poor nutrient supply, lack of irrigation and inadequate plant protection measures. Therefore, there is a need to workout the suitable production techniques for realising the high yield potential of sunflower with all possible efforts to meet the required oilseed production. There is a general belief that sunflower is an exhaustive crop. The information on combined effect of nitrogen and phosphorus is not available under Dharwad condition. Hence, with an objective to find out the optimum dose of nitrogen and phosphorus for sunflower crop under Dharwad condition, the field experiment was initiated.

A field experiment was conducted at Agricultural College farm Dharwad, on black clay soil, during *Kharif*, 1984. The annual rainfall during the year was 726.30 mm. There were 16 treatment combinations of which four levels of nitrogen viz., 30, 60, 90 and 120 kg N/ha and four levels of phosphorus viz., 30, 60, 90 and 120 kg P₂O₅/ha. The experiment was laid out in factorial RBD with four replications. Half of nitrogen, full dose of P₂O₅ and K₂O was applied at the time of sowing. The remaining 50 per cent of nitrogen was top dressed 45 days after sowing. The crop was sown on 14th July,

1984 with a spacing of 60 x 20 cm and a common irrigation was given twice at 40th and 65th DAS when there was a dry spell for 15 days. Plant protection measures were taken as per the recommended package. The crop was harvested on 19th October, 1984 from the net plot (3.6 m x 2.4m) air dried and threshed. The yield and yield components were recorded.

Increased application of nitrogen upto 90 kg N/ha increased the grain yield and further increase to 120 kg N/ha decreased the grain yield (Table 1). Increased application of nitrogen upto 120 kg N/ha increased the number of filled grains and total number of grains and reduced the chaffiness while the increase in 1000-grain weight and grain yield was only upto the level of 90 kg N/ha. The increase in grain yield was 2.80 and 5.82 q/ha and 1000-grain weight was 3.42 and 2.75 g as N application increased from 30 to 60 and 60 to 90 kg/ha respectively. Similarly the increase in filled grains was 134, 177 and 81 and total grain was 109, 173 and 27 as N application increased from 30 to 60, 90 and 120 kg/ha respectively. Nitrogen application not only increased the number of filled grains per head but also significantly reduced the per cent chaffiness in head (Ogunremi, 1985).

The grain yield showed a significant increasing trend with additional doses of phosphorus from 30 to 120 kg P₂O₅/ha. Similarly, increased application of phosphorus upto 120 kg P₂O₅/ha increased the number of filled grains and total number of grain and reduced the number of filled grains and total number of grains and reduced the per cent chaffiness which contributed for increased grain yield (Table 1). The increase in grain yield was 1.36, 1.14 and 1.13 q/ha and 1000-grain weight was 1.10, 0.91 and 1.18 g as the application of phos-

Table 1. Yield attributes of sunflower as influenced by nitrogen and phosphorus levels

| Treatment | Filled grain. | Total grain. | Per cent chaffiness. | 1000 - grain weight. | Grain yield (g/ha) |
|----------------------------------|---------------|--------------|----------------------|----------------------|--------------------|
| Nitrogen levels (kg/ha) | | | | | |
| 30 | 158.71 | 409.26 | 51.81 | 38.53 | 18.62 |
| 60 | 292.98 | 518.37 | 43.69 | 41.95 | 21.42 |
| 90 | 469.95 | 691.68 | 35.07 | 44.70 | 27.24 |
| 120 | 550.96 | 718.69 | 28.71 | 41.68 | 25.99 |
| SEm ± | 47.86 | 3.73 | 0.27 | 0.47 | 0.33 |
| CD at 5% | 136.10 | 10.60 | 0.77 | 1.33 | 0.93 |
| Phosphorus levels (kg/ha) | | | | | |
| 30 | 302.58 | 532.58 | 42.80 | 40.14 | 21.46 |
| 60 | 349.10 | 575.49 | 40.47 | 41.24 | 22.82 |
| 90 | 390.05 | 601.20 | 38.97 | 42.15 | 23.93 |
| 120 | 430.87 | 628.73 | 37.04 | 43.33 | 25.06 |
| SEm ± | 47.86 | 3.73 | 0.27 | 0.47 | 0.33 |
| CD at 5% | NS | 10.60 | 0.77 | 1.33 | 0.93 |

NS = Not significant

phorus increased from 30 to 60, 90 and 120 kg P₂O₅ respectively. While the increase in filled grains was 46, 41 and 41 and total grain was 43, 26 and 27 as the application of phosphorus increased from 30 to 60, 90 and 120 kg P₂O₅/ha respectively.

The interaction effects of N x P was found significant with regard to number of filled grains, total number of grain and per cent chaffiness. However, this could not bring about any significant interaction on 1000-grain weight and grain yield.

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Anonymous. 1987. *Agricultural Situation in India* 42 (4) : 323-327.

ness. *East-African AgricForestry J.* (1980. Publ., 1984) 45(3) : 236-241.

Oguneremi, E.A. 1985. Effect of nitrogen fertilization and harvesting time on sunflower yield and hollow seed-

COMBINING ABILITY AND HETEROISIS IN INDIAN MUSTARD

Six lines of mustard, viz., RLC 1359, RC 1277, RH 7811, CSR 164, CSR 463 and RSK 2 were crossed with four testers viz., Varuna, Pusabold, Krishna and Kranti. The resulting 24 hybrids along with 10 parents were grown in single row of 5m length at a spacing of 45x15 cm in Randomised Block Design with 3 replications. Observations were recorded on seven quantitative characters from 10 competitive plants selected at random.

The analysis of variance for combining ability (Kempthorne, 1957; Table 1) indicated higher *sca* variance for all the characters suggesting predominant nonadditive gene action. (See also Anand *et al.*, 1987; Thakur *et al.*, 1989).

RC 1277, CSR 164 and Kranti were good general combiners for yield, branches and siliquae/plant (Table 2). The female parent RSK2 and male Varuna had good *gca* effects for height and flowering. Only 6 crosses

showed significant and positive *sca* effects for yield (Table 3), of which the heterotic cross, RC 1277 x Kranti involved parents with good *gca* indicates possibilities for pedigree breeding. Three crosses had good combiner female and poor or average combiner male parents, the possibility of isolating transgressive segregants in later generations. Two crosses RLC 1359xPusabold and RSK2 x Pusabold whose parents were poor in *gca* showed high *sca* effects.

Only three crossed RC1277 x Kranti (41.4%), RH7811 x Kranti (27.9%) and RSK2 x Kranti (25.9%) had significant and positive heterosis for seed yield over better parent. In general, crosses that had high heterosis for yield, included at least one parent with good *gca* for yield and its components. Interestingly, all the three heterosis crosses involved Kranti as a pollen, parent, which had good *gca* for yield and its components (See also Malik *et al.*, 1988).

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Anand, I.J. and Reddy, W R. 1987. Estimates of gene effects for seed yield and its components in Indian x exotic mustard, *J. Oilseeds Res.* 4 : 1-8.

Kempthorne, O. 1957. An introduction to Genetic Statistics. John Willey and Sons, New York.

Malik, R. S. and Munshi Singh, 1988. Combining ability in *Brassica carinata* (Karan rai) *J. Oilseeds Res.* 5 : 29-38.

Thakur, H.L., Zarger, M.A. and Rana, N. D. 1989. Combining ability for economic traits in Indian Mustard. *J. Oilseeds Res.* 6 : 41-50.

Table 1. Estimated variances of combining ability for seven characters in Indian mustard

| Source | M.S. | | | | | | |
|----------------------|----------------------|--------------------------|---------------------|--------------|-------------------------------|---------------------------------|--------------------|
| | Seed yield/ plant | Days to 50% flowering | Days to maturity | Plant height | Primary branches/ plant | Secondary branches/ plant | Siliquae/ plant |
| * var (<i>gca</i>) | 1.97 | 0.23 | 0.47 | 4.71 | 0.009 | 0.12 | 233.01 |
| * var (<i>sca</i>) | 21.66 | 0.82 | 4.71 | 43.96 | 0.04 | 0.90 | 1313.28 |

* F- test significant at 5% level

Table 3. Crosses showing significant *sca* effects for seed yield per plant with heterosis values

| Cross | m | s | h |
|---------------------|------|----|---------|
| RLC 1359 x Varuna | 23.8 | -S | -16.9 |
| RLC 1359 x Pusabold | 34.1 | +S | 18.9 |
| RLC 1359 x Kranti | 22.2 | -S | -22.5 |
| RC 1277 x Krishna | 32.0 | -S | -3.5 |
| RC 1277 x Kranti | 46.9 | +S | 41.4** |
| RH 7811 x Pusabold | 28.7 | -S | -13.4 |
| RH 7811 x Krishna | 37.0 | +S | 11.8 |
| CSR 164 x Varuna | 41.0 | +S | 0.8 |
| CSR 164 x Pusabold | 27.2 | -S | -33.2** |
| CSR 164 x Krishna | 38.5 | +S | -5.3 |
| RSK 2 x Pusabold | 33.0 | +S | 9.4 |
| SEm | | | 3.6 |

m: mean, s: *sca* effect, S: significant, h: heterosis % (over better parent)

Table 2. Estimate of *gca* and mean values for various characters in mustard

| Parents | | Seed yield | Days to 50% flowering | Days to maturity | Plant height | No. of primary branches/plant | No. of secondary branches/plant | Siliquae/plant |
|---------------|---|------------|-----------------------|------------------|--------------|-------------------------------|---------------------------------|----------------|
| Female | | | | | | | | |
| RLC 1359 | m | 28.7 | 50.0 | 116.0 | 191.3 | 5.5 | 11.2 | 314.0 |
| | g | -S | N | +S | -S | -S | -S | -S |
| RL 1277 | m | 33.2 | 54.0 | 117.0 | 195.3 | 6.3 | 16.9 | 514.7 |
| | g | +S | +S | N | +S | N | +S | +S |
| RH 7811 | m | 33.1 | 52.7 | 116.0 | 206.3 | 6.7 | 14.2 | 443.9 |
| | g | +S | +S | N | +S | +S | N | N |
| CSR 164 | m | 40.7 | 52.0 | 117.0 | 207.8 | 5.7 | 12.2 | 418.2 |
| | g | +S | +S | N | N | +S | N | +S |
| CSR 463 | m | 30.8 | 44.0 | 110.3 | 156.9 | 5.4 | 14.6 | 474.4 |
| | g | -S | N | -S | N | N | N | N |
| RSK 2 | m | 30.2 | 43.3 | 111.3 | 174.2 | 4.8 | 14.0 | 423.9 |
| | g | N | -S | -S | -S | -S | N | N |
| SEm | | 0.73 | 0.35 | 0.53 | 1.81 | 0.11 | 0.41 | 16.34 |
| Male | | | | | | | | |
| Varuna | m | 18.3 | 43.0 | 112.3 | 175.0 | 4.0 | 8.6 | 247.5 |
| | g | N | -S | -S | -S | +S | N | N |
| Pusabold | m | 25.5 | 44.0 | 111.7 | 177.1 | 4.9 | 10.6 | 343.1 |
| | g | -S | +S | +S | N | N | N | N |
| Krishna | m | 22.8 | 45.0 | 113.0 | 173.0 | 4.4 | 8.1 | 253.5 |
| | g | -S | +S | N | +S | -S | -S | -S |
| Kranti | m | 23.2 | 43.7 | 110.7 | 168.5 | 5.3 | 12.8 | 382.1 |
| | g | +S | N | N | N | N | +S | +S |
| SEm | | 0.59 | 0.29 | 0.43 | 1.48 | 0.09 | 0.33 | 13.34 |

m : Mean, g : *gca* effect, S : Significant at 5% level, N : Nonsignificant.

GENETICS OF TESTA COLOUR IN GROUNDNUT

Seed testa colour in groundnut (*Arachis hypogaea* L.) is an important trait in commercial evaluation of new cultivar. The testa colour different from the marketing standard is considered to be undesirable characteristic. The purple red and variegated kernels impart these colour to the oil than the yellow colour. An inheritance study of testa colour was, therefore, carried out among the crosses of 5 different genotypes of groundnut.

The materials for study consisted of 6 F₁ and F₂ populations involving 5 parents viz., J 11(P₁), Rajkot valencia (P₂), NcAc 17500 (P₃), NcAc 17278 (P₄) and TMV 10 (P₅): F₁ and F₂ populations were scored for purple (P), variegated (V) and rose (R) testa colour. Test of significance performed using (χ^2) Chi-square test.

The testa colour of the parents is presented in Table 1. F₁ phenotypes and phenotypes observed in F₂ generation are given in Table 2. Crosses between P₁ x P₂, P₃ x P₂ and P₄ x P₂ exhibited purple testa colour in F₁. In F₂, the crosses P₁ x P₂ and P₄ x P₂ had plants in the ratio of 3 purple : 1 rose, whereas

the cross P₃ x P₂ gave a phenotypic ratio of 13 purple : 3 rose. F₁ testa colour in cross P₃ x P₁ was rose and in F₂ it segregated in the ratio of 1 purple : 3 rose. These findings except in the cross P₃ x P₁ are in agreement with Patel *et al.*, (1936) and Harvey (1967) who reported purple testa (P and Pr gene to be dominant over rose).

The F₁ hybrid of the cross P₅ x P₁ had variegated phenotype and F₂ segregated in the ratio of 9 purple and 7 rose, which indicated complementary gene action. The F₂ also had 27 red variegated, 21 red, 9 purple variegated and 7 purple plants. The phenotypes of the F₁ of the cross P₅ x P₂ was purple variegated and F₂ segregated for purple and rose in the ratio of 13:3, variegated and non variegated in 3:1 and purple variegated, purple, rose variegated and rose in 39:13:9:3. These findings are in agreement with those of Shrivastava (1968), Giller and Silvestre (1969), Ashri and Yona (1965) and Branch (1965).

Higgins (1950) suggested two duplicate genes D₁D₁ D₂D₂ and F₁ F₁ F₂ F₂ for the production of pigment and rose testa colour

Table 1. Origin, testa colour and probable genotypes of the parents

| Parents | Origin | Testa colour | Genotypes |
|--------------------|-----------|-------------------|---|
| P1 J 11 | Gujarat | Rose | prpr TT D ₁ D ₁ D ₂ D ₂ v ₁ v ₁ v ₂ v ₂ |
| P2 Rajkot Valencia | Gujarat | Purple | PrPr TT D ₁ D ₁ D ₂ D ₂ V ₁ V ₁ v ₂ v ₂ |
| P3 NcAc 17500 | U.S.A. | Purple | PrPr tt D ₁ D ₁ D ₂ D ₂ V ₁ V ₁ v ₂ v ₂ |
| P4 NcAc 17278 | U.S.A. | Rose | prpr TT D ₁ D ₁ D ₂ D ₂ v ₁ v ₁ v ₂ v ₂ |
| P5 TMV 10 | Tamilnadu | Purple variegated | PrPr tt D ₁ D ₁ D ₂ D ₂ V ₁ V ₁ v ₂ v ₂ |

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Table 2. Segregation of testa colour in the F₂

| S. No. | Crosses | F ₁ testa colour | F ₂ Population | | | | Ratio | Chi-square | P value |
|--------|---------------------------------|-----------------------------|---------------------------|-----|----|----|-----------------------------------|------------|---------|
| | | | P | R | PV | RV | | | |
| 1. | P ₁ × P ₂ | P | 79 | 37 | - | - | 3:1 | 2.94 | 5-10 |
| 2. | P ₃ × P ₂ | P | 55 | 14 | - | - | 13:3 | 0.115 | 50-75 |
| 3. | P ₄ × P ₂ | P | 113 | 47 | - | - | 3:1 | 1.633 | 10-25 |
| 4. | P ₃ × P ₁ | R | 55 | 147 | - | - | 1:3 | 0.534 | 25-50 |
| 5. | P ₅ × P ₂ | PV | 125 | 27 | - | - | 13:3 | 0.097 | 75-90 |
| | | | 26 | 12 | 99 | 15 | 13:3:39:9 i.e. | 6.51 | 5-10 |
| | | | 38 | - | - | - | 39:13:9:3 | | |
| | | | 54 | 143 | - | - | 1:3 | 0.00 | 95-99 |
| 6. | P ₃ × P ₁ | RV | 22 | 56 | 32 | 87 | 7:21:9:27: i.e. (21:21:9:7) | 2.003 | 50-75 |
| | | | - | 75 | - | - | 7:9 | 1.397 | 10-25 |

P = purple, R = Rose, PV = Purple variegated, RV = Rose variegated, V = Total variegated

respectively. Shrivastava (1968) observed rose as dominant over red and segregation in ratio of 13 red : 3 rose in F₂. He proposed two different genes for red and single gene 'T' for rose colour. Gene 'T' in place of two duplicate genes F₁ F₁ and F₂ F₂ as suggested by Higgins (1950) acts as hypostatic to red (R). In the present study two crosses viz., P₃ x P₂ and P₅ x

P₂ had F₂ phenotypic segregation of 13 purple : 3 rose. The results indicate that there may be two genes for purple and that the purple is basic colour. The purple colour is expressed in 'Pr' and PrPr conditions. The rose colour of the testa develops in the absence of 'Pr' which acts as epistatic to 'T'. The proposed genotypes of the parents are given in Table 1.

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- Ashri, A. and Yona, J. 1965. Nature and inheritance of seed coat splitting in peanuts. (*Arachis hypogaea* L.). *Israel J. agric. Res.* 15 : 109 Abstr.
- Branch, W.D. 1985. Inheritance of purple strip testa colour in the peanuts: *Heredity*, 3 : 225-226.
- Giller, P. and Silvestre, P. 1969. L. Arachide Masionneuve and Larsoe, Paris pp. 292.
- Harvey, J. R. Jr. 1967. The inheritance of seed coat colour in peanuts. Ph. D. thesis, Univ. Georgia. Diss. Abstr. 28 : 2272 B.
- Haggins, B.B. 1950. Inheritance of seed coat colour in peanuts *J. agri. Res.* 61 : 745-752.
- Patel, J.S., Jhon, C.M. and Seshadri, C.R. 1936. Inheritance of characters in groundnut (*Arachis hypogaea* L.) *Proc. Ind. Acad. Sci.* 3 : 214-233.
- Shrivastava, A.N. 1968. Classification and inheritance studies in groundnut (*Arachis hypogaea* Linn) Ph. D. thesis, Agra Agril. Univ., India. pp. 242

POSSIBILITY OF INCREASING OIL, PROTEIN AND CALORIFIC OUTPUT THROUGH SUNFLOWER - GROUNDNUT INTERCROPPING.

By 2000 A.D India has to face a challenge of feeding 1500 million people implying that the production of food crops has to be increased commensurate with demand. Apart from maximisation of yields, it is worthwhile to consider the nutritive aspects of food to help in raising the level of nutrition. Oilseeds possess high nutritive value and contribute sizeable amounts of not only fats but also proteins (Deosthale and Longvah, 1988) and the role of oils in the human diet as sources of proteins and calories is explorable (Parpia, 1988). Fifteen per cent of the dietary calories is derived from fats alone (Sen, 1979) which makes this aspect important. Keeping these facts in view the experiment was conducted to assess the possibility of increasing the qualitative aspects by growing sunflower and groundnut in intercrop situation.

The field experiment was conducted under rainfed conditions in 1988 at the College of Agriculture, Rajendranagar, Hyderabad. The soil was medium red loam with low available nitrogen and medium in phosphorus and potassium contents. The experiment was laid out in Randomized Block Design with four replications. Sunflower Cv. Morden and groundnut Cv. Robut 33-1 were tested in 9 intercrop combinations and also in a sole crop of each. Treatments were as follows :

Sunflower plant populations 55,555 plants ha⁻¹

- T₁ Sunflower equidistant rows (60 x 30 cm) + 2 rows of groundnut
- T₂ Sunflower paired rows (40 - 80 x 30cm) + 3 rows of groundnut
- T₃ Sunflower skipped rows (60 - 120 x 20cm) + 4 rows of groundnut

Sunflower plant populations 66,666 plants ha⁻¹

- T₄ Sunflower equidistant rows (75 x 20cm) + 2 rows of groundnut
- T₅ Sunflower paired rows (50 - 100 x 20cm) + 3 rows of groundnut
- T₆ Sunflower skipped rows (75 - 150 x 20 cm) + 5 rows of groundnut.

Sunflower plant populations 74, 074 plants ha⁻¹

- T₇ Sunflower equidistant rows (45 x 30cm) + 1 row of groundnut
- T₈ Sunflower paired rows (30 - 60 x 30cm) + 2 rows of groundnut
- T₉ Sunflower skipped rows (45 - 90 x 20 cm) + 3 rows of groundnut
- T₁₀ Sole crop of sunflower (45 x 30 cm)
- T₁₁ Sole crop of groundnut (30 x 10 cm)

The groundnut populations was maintained at sole optimum of 3,33,333 plants ha⁻¹ in all the intercrop treatments. Sunflower was fertilised with 80:60:40 and groundnut with 30:40:40 kg N, P₂O₅ and K₂O ha⁻¹. The intercrop treatments were fertilised with 110:100:80 kg N, P₂O₅ and K₂O ha⁻¹. The application of phosphorus and potassium was basal to each treatment while sunflower received 1/2 of the nitrogen at sowing and rest in two splits. The nitrogen content in sunflower achenes and groundnut kernels was estimated by the method described by Jackson, 1967. The protein per cent was worked out by multiplying per cent nitrogen thus obtained with the factor 6.10 for sunflower and with 6.25 for groundnut (Robinson, 1976). Calorific equivalents were worked out using the values 567 K Cal per 100

g for groundnut pods and 667 K Cal per 100 g for sunflower seed (Gopalan *et al.*, 1980) and reported as million kilo calories per hectare.

The results showed that the oil percentage of sunflower or groundnut was not influenced by growing them in solitary stands or in intercrop system with varying planting density and geometry treatments. Sunflower grown at a density of 74, 074 plants ha⁻¹ with paired or skipped row manipulation and intercropped with groundnut yielded 283 and 280 kg oil/ha respectively. However, it was on par with the oil yield obtained from the sole sunflower (324 kg/ha). In rest of the treatments sunflower yielded significantly less oil as compared to sole sunflower. The oil yield from intercropped groundnut was significantly less than from its sole crop. The total yield of oil obtained from any intercrop combination was significantly more than from the sole crop of sunflower. Best intercropping systems were those with sunflower density of 55,555 or 74, 074 plants ha⁻¹ with paired or skipped rows as they enhanced the total oil yield significantly more than either of the sole crops. This is very important in the prevailing oilseed crisis in our country and substantial increase in the quantity of edible oil could be achieved by growing the two oilseed crops together on a unit land area. **However, this needs confirmation.**

The nutritive value of sunflower improved with the associated growth of groundnut as an intercrop particularly at its high density treatments of 66,666 and 74,074 plants/ha. Both the percentage as well as the absolute yield of proteins were commendable. Groundnut had substantially higher percentage and yield of proteins than sunflower. Though protein per cent remained unaltered,

groundnut yielded significantly less in all the intercrop treatments compared to the sole crop mainly due to the substantially depressed yield of kernels. Even the total yield from different intercrop treatments could not exceed the protein yield realised from the sole crops of sunflower, intercropping was significantly superior in this nutritional aspect.

Sunflower seed had low calorific equivalents in different intercrop treatments although it was on par with that of its sole crop at the high density treatment of 74,074 plants/ha. But, groundnut invariably registered low values compared to that of its sole crop. Notwithstanding this, the total calorific gains was significant when groundnut was intercropped in paired or skipped rows of sunflower with a population of 66,666 or 74,074 plants ha⁻¹. At a low density of 55,555 plants ha⁻¹ intercropping of groundnut in equidistant rows enhanced the total calorific output significantly more than from groundnut. The calorific values of sunflower seed was significantly less than the total values obtained from any intercrop treatment.

As both protein yields and calorific equivalents are a function of the total seed/kernel yield the effects due to intercropping seem to be vital. The studies indicate that intercropping enhance the protein and calorific equivalent per unit area compared to the sole crops and could thus go a long way in solving the food and nutrition crisis of our country. The increased output of oil, protein and energy equivalents in terms of calories can be utilised and preserved for human consumption thereby reducing the pressure on purely proteinaceous crops and augment the supply of energy and proteins through non-traditional sources.

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Table 1. Influence of various treatments on oil yields, protein contents, protein yields and calorific equivalents.

| Treat- ment | Oil % | | Oil yield (Kg ha ⁻¹) | | Protein (%) | | Protein yield (kg ha ⁻¹) | | Calorific equivalents mKcal ha ⁻¹ | | | |
|-----------------|----------------|----------------|----------------------------------|----------------|----------------|----------------|--------------------------------------|----------------|---|----------------|-------|-------|
| | Sun- flower | Groun- dnut | Sun- flower | Groun- dnut | Sun- flower | Groun- dnut | Sun- flower | Groun- dnut | Sun- flower | Groun- dnut | Total | |
| T ₁ | 33.6 | 43.0 | 263 | 245 | 12.5 | 23.6 | 87.7 | 135.12 | 222.90 | 4.40 | 5.13 | 9.53 |
| T ₂ | 33.1 | 42.0 | 264 | 247 | 12.2 | 23.8 | 97.4 | 140.17 | 237.60 | 5.00 | 5.21 | 10.31 |
| T ₃ | 32.5 | 43.9 | 230 | 297 | 12.1 | 23.6 | 85.3 | 159.27 | 244.87 | 4.41 | 5.70 | 10.11 |
| T ₄ | 33.6 | 42.1 | 262 | 197 | 15.3 | 21.2 | 119.1 | 99.12 | 218.31 | 4.87 | 4.20 | 9.07 |
| T ₅ | 33.6 | 43.5 | 260 | 230 | 16.3 | 22.4 | 126.3 | 119.24 | 245.59 | 4.86 | 4.60 | 9.46 |
| T ₆ | 33.7 | 44.1 | 252 | 240 | 16.1 | 21.2 | 120.5 | 119.24 | 245.59 | 4.68 | 4.80 | 9.48 |
| T ₇ | 32.8 | 43.7 | 241 | 190 | 14.4 | 20.5 | 105.7 | 89.87 | 195.64 | 4.58 | 3.80 | 8.38 |
| T ₈ | 33.4 | 42.8 | 283 | 236 | 14.6 | 22.4 | 123.8 | 123.27 | 247.19 | 5.32 | 5.10 | 10.42 |
| T ₉ | 33.8 | 42.1 | 280 | 316 | 13.9 | 21.4 | 115.0 | 116.57 | 231.23 | 5.18 | 5.00 | 10.18 |
| T ₁₀ | 34.9 | - | 324 | - | 12.4 | - | 115.0 | - | 115.07 | 5.77 | - | 5.77 |
| T ₁₁ | - | 42.9 | - | 448 | - | 23.9 | - | 250.12 | 250.12 | - | 8.23 | 8.23 |
| SEM ± | 0.9 | 1.2 | | 44 | 0.9 | 1.5 | 9.2 | 16.78 | 19.62 | 0.27 | 0.49 | 0.58 |
| CD at 5% | NS | NS | | 91 | 2.0 | NS | 19.0 | 34.7 | 40.0 | 0.55 | 1.00 | 1.19 |

- Deosthale, Y. G. and Longvah, 1988. Oilseed cakes as source of protein and some micronutrients. Abst. National Seminar on Strategies for making India Self reliant in vegetable oils. Sept. 5-9, pp. 118, DOR, Hyderabad.
- Gopalam, C., Ramasastry, B.V. and Balasubramanian, S. C. 1980. Nutritive value of Indian foods . National Institute of Nutrition, Hyderabad. Citizen press, Secunderabad pp. 82.
- Jackson, M. L. 1967. Soil chemical analysis. Prentice Hall New Delhi.
- Parpia, H. A. B. 1988. Oilseed proteins for human consumption. Abst. National seminar on Strategies for making India self reliant in vegetable oils. Sept. 5-9 pp. 107, DOR Hyderabad.
- Robinson, G. 1976 Amino acid in sunflower seed and nitrogen to protein conversion factor. Proc. Sunflower Forum. 8 Jan, 1976. North Dakota, USA.
- Sen, D. P. 1979. Newer sources of oil and fats. Abst. Technical papers. International congress on oilseeds and oils, Feb. 9-13. New Delhi. pp. 30.

CORRELATION STUDIES FOR OIL AND PROTEIN CONTENTS IN GERmplasm COLLECTIONS OF FIVE *BRASSICA* SPECIES.

The oleiferous brassicas occupy second position amongst oilseed crops and play an important role in the economy of Indian agriculture. The most commonly cultivated *Brassica* species are *Brassica juncea* (Indian mustard) and *B. campestris* (toria, brown sarson and yellow sarson). More recently, cultivation of *B. napus* (Gobhi sarson or rape) is picking-up in northern India for higher yields and superior oil quality whereas *B. carinata* (Ethiopian mustard) is a newly introduced species in the country (Rai, 1989) known to have tolerance to a number of biotic and abiotic stresses. In the negative phase, plants are used as source of leafy vegetable and green forage but at maturity, oils are extracted from seeds for edible and industrial purposes, besides the residual protein rich oil cakes used in fortifying cattle feeds. Since oil and protein contents of seed provide about 80% of the monetary value of *Brassica*, the present studies were undertaken with the objectives to analyse the variation of the oil and protein level within different germplasm lines as well as amongst five species of oleiferous *Brassicac*s. Correlation between oil and protein have been established to have a first hand information about the pattern of variation among the different species and also how an incremental increase of oil level affects the protein levels in germplasm lines under study.

Three replicated sets of 104 accessions of different *Brassica* species namely *B. Campestris* var. toria (24), *B. campestris* var. yellow sarson (24); *B. juncea* (22); *B. napus* (19) and *B. carinata* (15) of diverse origin and oil values were selected from *Brassica* germplasm maintained at NBGPR, New Delhi. The collections were dried to 4-5% moisture levels in an oven at 105°C for 16-18 hours.

The oil content of the seed samples were determined by non-destructive method using Newport NMR Analyser (Model-4000) from Oxford Analytical Instruments Ltd., U.K. after calibrating with pure oil extracted with hexane by conventional solvent extraction method. The protein contents were determined by the conventional Kjeldahl method in Kjeltec Auto 1030 analyser from Tecator, Sweden and multiplication factor 6.25 was used to convert nitrogen to protein.

Amongst five species, highest mean oil contents was recorded in collections of *Brassica campestris* var. yellow sarson (47.05%) followed by toria (45.61%) and lowest in *B. carinata* (38.26%) whereas almost similar levels in *B. napus* (42.86%) and *B. juncea* (42.36%). Maximum variability in oil content was observed in germplasm of *B. carinata* (27.84 to 44.34%) and *B. juncea* (33.20 to 48.59%) whereas extent of variability in toria and yellow sarson was found relatively narrower. Some of the high oil content accessions in yellow sarson were IB-1556 (51.50%), IB-1362 (50.58%), IB-1956 (50.14%) and IB-1397 (50.12%) and in toria germplasm were IB-195 (49.39%) and IB-294 (49.11%).

The highest mean value of protein content was observed in *B. carinata* (25.88%), followed by yellow sarson (23.35%), *B. juncea* (22.74%), toria and *B. napus* (22.25%). At the same level of oil, yellow sarson showed comparatively higher protein value followed by toria, whereas *B. carinata*; *B. juncea* and *B. napus* showed almost the same levels of protein. Highest protein content was recorded in two accessions of *B. carinata* viz., BEC-226 (30.28%) and BEC-185 (29.89%).

The oil and protein content values were negatively correlated in these *Brassica* germplasm samples. Maximum correlation coefficient (r), of 0.9259 was found in *B. carinata* followed by *B. juncea* (0.9211); yellow sarson (0.9177); *B. napus* (0.8978) and minimum in toria (0.8569). Estimated linear regression between protein (Y) and oil content (X) for the five *Brassica* species are given in Figure I. From the estimated linear regressions it is inferred that with the existing oil levels, there is similar change of protein levels due to an incremental increase in oil percentage.

Yellow sarson germplasm lines are observed to possess genes for high oil contents, whereas seeds of *B. carinata* although contains lower oil content but possess higher level of protein. It is evident that protein content is negatively correlated with oil content and all

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the five regression co-efficients are homogenous within the oil variation of different germplasm of these five species. With the incremental decrease of 1% oil content, there is uniform increase in protein level to the extent of 0.58 to 0.72% in the seeds. The estimated linear regressions between protein and oil contents established in the present studies are useful in predicting protein values of different *Brassica* samples from oil values determined by an easy and non-destructive NMR techniques.

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Rai, B. 1989. *Brassicas*. pp. 150-170. In *Plant Breeding Theory and Practice*. Ed. V.L. Chopra, Oxford and IBH, New Delhi.

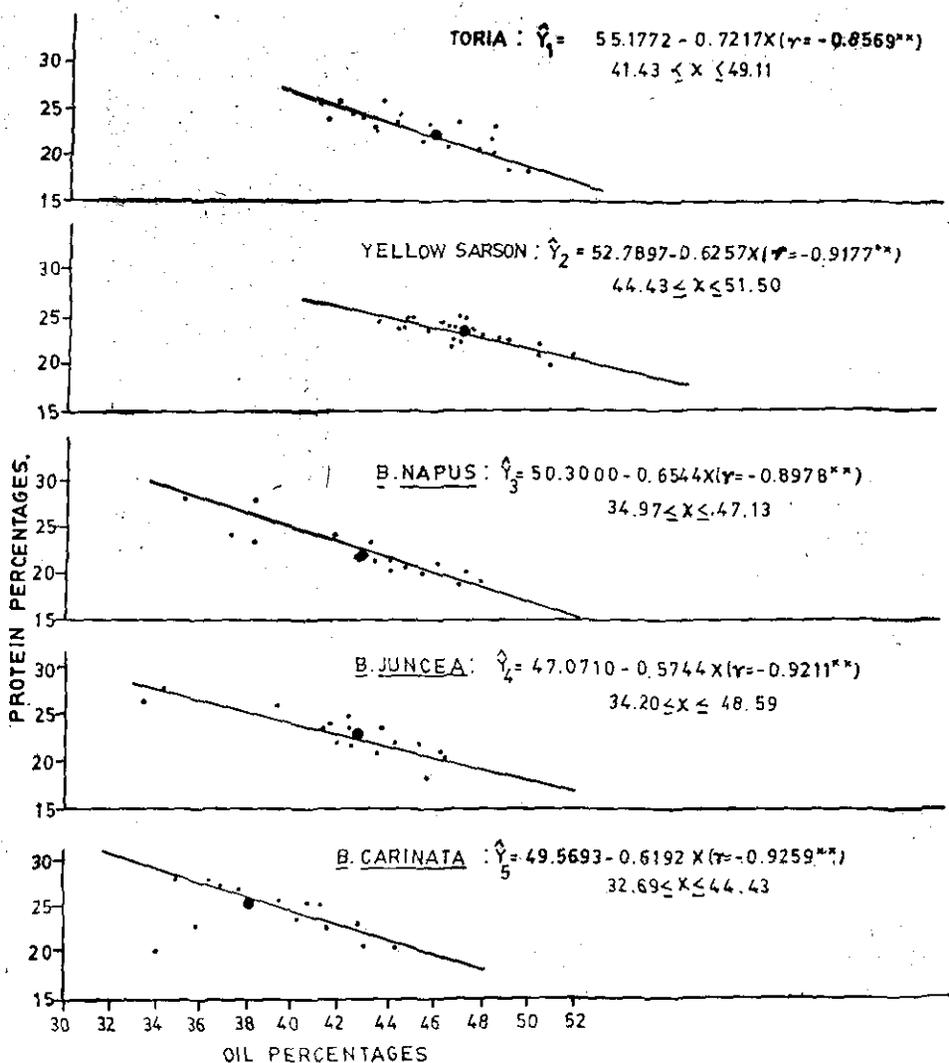


FIG. 1. ESTIMATED LINEAR RELATIONSHIPS BETWEEN PROTEIN CONTENT (Y) AND OIL CONTENT (X) OF FIVE BRASSICA SPECIES : TORIA, YELLOW SARSON, B. NAPUS, B. JUNCEA AND B. CARINATA

INDUCED LEAF MUTANTS IN *ERUCA SATIVA* L. : CYTO-MORPHOLOGICAL STUDIES.

Taramira (*Eruca sativa* L.) one of the important oleiferous crucifer known for its drought and pest tolerance has remained an under utilised crop due to its low productivity. Spontaneous leaf variant was observed by Singh (1975). However, no systematic study has been carried out to create variabilities through Ionizing irradiation for various morphological and seed yield characters. The role of induced mutations through ionizing irradiation in creating the variabilities which either does not occur in nature or lost during the course of evolution is well known and practically all kinds of characters in various crop plants have been improved through mutation breeding.

Dry seeds of T-27 variety were treated with 50, 100, 150 and 200 kR of ⁶⁰Co gamma rays. Thirteen leaf mutants were isolated in M₂ generation (Fig. 1) and evaluated in M₃ generation for various Cyto-morphological characters (Table 1). For cytological observations, flower buds were collected in modified

cornoy's fluid and anthers were squeezed in Carbol fuchin stain and temporary slides were prepared by Smear technique.

Mutants showed significant variability for various desirable characters like reduced plant height (Mutants-1,3), increased branches per plant (Mutants - 1,4,7 and 8) and increased yield per plant (Mutant-1). The various types of meiotic aberrations in the form of bridges and laggards at A-I and T-I were observed (Fig 2). The frequency of chromosomal abnormalities ranged from 0.0 per cent (Mutant-8) to as high as 6.84 per cent (Mutant-4) and these meiotic anomalies often lead to deficiencies, duplication, translocation and inversion. As mutants, particularly mutant-1, showed lot of significance for various desirable characters, so it is quite beneficial to use them in future breeding programme aimed at improving ideotype of *Eruca sativa* L. (Taramira) for better productivity.

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Singh R.N. 1975. Note on breeding behaviour of a new leaf shape variant in Taramira (*Eruca sativa* L.). *Science and Culture*, 41 : 422.

Table 1. Average performance of mutants

| Genotype/Mutant | Height of plant (cm) | Number of branches per plant | Yield per plant (g) | Meiotic aberration (%) Bridges & laggard at A-I, T-I |
|-----------------|----------------------|------------------------------|---------------------|--|
| Mutant No. 1 | 132.60* | 7.7* | 17.5* | 0.41 |
| Mutant No. 2. | 145.00 | 5.6 | 8.97 | 1.60 |
| Mutant No. 3. | 123.00* | 5.7 | 6.53 | 3.66 |
| Mutant No. 4 | 155.60* | 8.8* | 6.89 | 6.84 |
| Mutant No. 5. | 140.02 | 5.7 | 3.51* | 1.73 |
| Mutant No. 6 | 143.10 | 5.8 | 8.90 | 1.21 |
| Mutant No. 7 | 144.10 | 8.0* | 8.90 | 1.85 |
| Mutant No. 8 | 149.00 | 8.5* | 6.23 | 0.00 |
| Mutant No. 9 | 149.50 | 5.9 | 10.84 | 4.77 |
| Mutant No. 10 | 136.00 | 4.3 | 7.22 | 1.20 |
| Mutant No. 11 | 150.00 | 5.3 | 6.87 | 1.52 |
| Mutant No. 12 | 143.10 | 4.4 | 3.08* | 1.84 |
| Mutant No. 13 | 137.10 | 5.8 | 10.89 | 1.94 |
| T-27 (Check) | 145.20 | 5.6 | 8.09 | 0.00 |

* Significance at 5% level.



Figure -1 : Leaf morphology of mutants

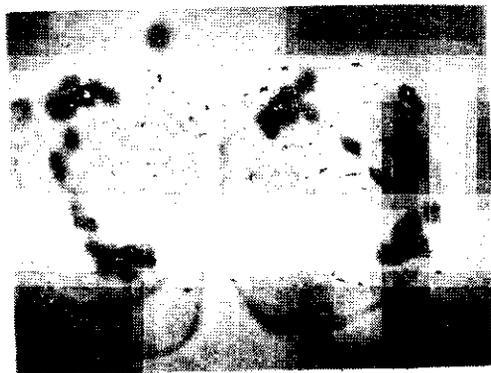


Figure -2 : Meiotic aberration in cell of mutants

EFFECT OF THINNING ON GROWTH AND YIELD OF MUSTARD

Among the oilseed crops, mustard is an important *rabi* crop which is widely spread in the northern belt of the country particularly in Uttar Pradesh where it occupies nearly seventy per cent area. Many aspects of production agronomy have been studied but little attention has been paid on the proper stage of thinning of the crowded plants in the field. Any omission or delay in thinning may adversely affect the crop yield. Information is scanty on the effect of stage and frequency of thinning on the yield and yield attributes of mustard crop. With this objective in view an experiment was undertaken to assess the effects of thinning on mustard.

Investigations were carried out at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur during winter season of 1985 and 1986 with mustard variety Varuna. The soil of the experimental site was sandy loam, medium in fertility having a soil reaction of 7.8 and 7.7 in the reported years of experimentation. The total nitrogen, available phosphorus and potash were estimated to be 0.035 and 0.079, 51.4 and 22.6 and 236 and 200 kg/ha respectively, during 1985 and 1986. The crop was sown on 25 October in 1985 and 24 October in 1986 using 5 kg seed/ha. A set of 12 treatments (Table 1) was tested in Randomized Block Design with four replications. The crop was raised following the recommended agronomic practices. Observations were made on final plant stand, number of siliqua/plant, number of seeds/siliqua, seed yield/plant, thousand seed weight, seed yield/ha and oil content.

Data pooled across two years elucidated that thinning line sown mustard crop at 15 and 25 days after sowing (2377 kg/ha) remaining equal to thinning at 15 and 35 DAS (2032 kg/ha.), 15 and 45 DAS (1914 kg/ha.), thinning at 15 DAS (2050 kg/ha.), thinning at 25 DAS (1939 kg/ha.) and thinning at 15 DAS in broadcast crop (1993 kg/ha.) offered significantly higher seed yield than no thinning and the other thinning treatments imposed at various stages of crop growth (Table 1). The second thinning at 23 DAS was statistically no way inferior to second thinning at 25 DAS. Irrespective of method of sowing, the crop when thinned at early stage of crop growth from 15 to 25 days after sowing remained superior to no thinning provided comparable yields, indicating the crucial nature of thinning. With subsequent delay in thinning, the per day reduction in seed yield noticed was to the tune of 11.1, 22.5 and 16.9 kg/ha. in T₃, T₄, T₅ against T₂ and 34.5, 23.2 and 21.8 kg/ha. in T₇, T₈ and T₉ against T₆ respectively. This was probably due to massive root injury caused during uprooting of excess plants from the field in advanced stage, thereby rendering short time physiological imbalances in the absorption and translocation of nutrients and solutes; as a consequence yield diminished. The increase in seed yield due to thinning at early stages of 15 to 25 days was due to increased number of siliqua per plant, though the variations were not statistically significant; higher number of seeds/siliqua, and greater seed yield/plant (Table 1). Thousand seed weight does not seem to have appreciable influence in increasing seed yield (Singh *et al.*, 1963). Tripathi and

Table 1. Effect of thinning at various stages on yield attributes, seed yield and oil content of mustard (Mean of 2 years)

| Treatments | Final plant stand/m ² | Number of siliqua/plant | Number of seeds/siliqua | Seed yield/plant (g) | Thousand seed weight (g) | Seed yield (kg/ha.) | Oil per cent |
|-------------------------------|----------------------------------|-------------------------|-------------------------|----------------------|--------------------------|---------------------|--------------|
| Line sowing | | | | | | | |
| T1 - No thinning | 10.4 | 196.4 | 8.0 | 11.6 | 4.7 | 1363.0 | 38.9 |
| T2 - Thinning at 15 DAS | 8.1 | 327.9 | 10.6 | 17.7 | 4.9 | 2050. | 40.2 |
| T3 - Thinning at 25 DAS | 8.0 | 326.1 | 9.6 | 16.1 | 4.9 | 1939.0 | 40.0 |
| T4 - Thinning at 35 DAS | 7.8 | 282.2 | 9.1 | 13.4 | 4.9 | 1600.0 | 39.9 |
| T5 - Thinning at 45 DAS | 8.2 | 259.5 | 8.5 | 13.8 | 4.6 | 1543.0 | 39.6 |
| T6 - Thinning at 15 & 25 DAS | 8.1 | 364.7 | 11.9 | 22.1 | 4.9 | 2377.0 | 40.6 |
| T7 - Thinning at 15 & 35 DAS | 8.0 | 344.7 | 10.8 | 18.5 | 4.9 | 2032.0 | 3.7 |
| T8 - Thinning at 15 & 45 DAS | 8.0 | 328.2 | 10.3 | 18.8 | 4.8 | 1914.0 | 39.6 |
| T9 - Thinning at 15 & 55 DAS | 9.7 | 305.8 | 9.6 | 17.1 | 4.8 | 1722.0 | 38.7 |
| T10 - Thinning at 15 & 23 DAS | 7.8 | 368.0 | 11.6 | 20.9 | 4.9 | 2200.0 | 40.3 |
| Broadcasting | | | | | | | |
| T11 - No Thinning | 16.8 | 226.5 | 8.6 | 12.6 | 4.6 | 1450.0 | 38.8 |
| T12 - Thinning at 15 DAS | 8.6 | 309.7 | 9.7 | 19.1 | 4.7 | 1993.0 | 39.5 |
| CD at 5% | 2.0 | N.S. | 1.5 | 5.5 | 0.2 | 508.0 | N.S. |

Singh (1977) opined that the yield of a crop is determined by the plant population per unit area and yield per plant. In the present investigation the seed yield and yield attributes were the lowest in unthinned plots, irrespective of method of sowing. Higher plant populations per unit area restricts the development of individual characters in mustard with reduced yield (Tripathi, 1969) while improvement in yield attributes due to spacing was reported by Singh and Yadav (1972) and Shastry and Kumar (1981). Verma and Singh (1984) concluded that thinning of plants at wider spacing reduces the plant stand for seed and fodder yield in mustard but favours better root

development crop growth, yield attributes, and seed yield. Oil content of mustard seed was unaltered by thinning (Singh *et al.*, 1978 and Prakash and Verma, 1981). From the foregoing account it could be inferred that thinning of mustard crop provides discernible increase in seed yield over no thinning and the operation should invariably be performed between 15 and 25 days after sowing for achieving desired yields.

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-
- Prakash, V. and Verma, B.S. 1982. Effect of nitrogen, phosphorus and row spacing on yield, yield attributes and oil content of rainfed mustard. *Indian J. Agron.* 26 (1): 37-41.
- Shastry, A.B. and Kumar, A. 1981. Variation in yield, its attributes and quality of Indian mustard in relation to planting time and levels of plant population. *Indian J. agric. Sci.* 51 (1): 27-32.
- Singh, B.P. and Yadav, T.R. 1972. Effects of plant populations and fertilizer variation in yield and yield attributes of Indian. rape. *Indian J. agric. Sci.* 42 (7): 596-600.
- Singh, R.P., Dubey, H.S. and Singh, K.C. 1978. Response of mustard to different levels of nitrogen and row spacing in field having limited moisture supply. *Indian J. agric. Sci.* 48 (4): 234- 238.
- Singh, S.P., Saxena, H.K. and Watial, P.M. 1963. Effect of spacing, sowing date and nitrogen supply on growth and yield of toria. *Indian Oilseed J.* 7: 20-38.
- Tripathi, H.N. 1969. Differential fertilization of *Brassica juncea* Coss. variety RT-11 appressed mutant at different spacing. M.Sc. (Ag.). Thesis submitted to Kanpur University, Kanpur (U.P.).
- Tripathi, H.N., and Singh, R. 1977. To find out the optimum row spacing of Varuna (T-59) for different combinations of irrigation. M.Sc. (Ag.) thesis submitted by second author to Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.).
- Verma, V.S. and Singh, P.P. 1984. Plant population and topping studies with mustard. Ph.D. Thesis submitted by second author to Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, (U.P.).

SOURCES OF FIELD RESISTANCE TO ALTERNARIA LEAF SPOT IN SUNFLOWER

Alternaria leaf spot of sunflower by *Alternaria helianthi* (Hansf.) Tubaki and Nishihara, has been considered as a potentially destructive disease in India, Yugoslavia, Australia, Tanzania, Uganda and South Africa (Balasubrahmanyam and Kolte, 1980; Mukewar *et al.*, 1974; Zimmer and Hoes, 1978). The disease can cause severe leaf, stem and head spots resulting in premature defoliation and stem breakage. It can infect all parts of the plant viz., stem, leaves, capitulum ray and disc florets. It is a more serious disease in India and the yield losses may go up to 80 per cent under favourable conditions (Agrawat *et al.*, 1979; Balasubrahmanyam and Kolte, 1980). In spite of the encouraging results with the chemicals, genetic resistance would however be the most economic means of reducing losses.

Although destructive levels of alternaria blight have been reported in India, no concerted efforts to screen systematically the available germplasm is made to locate the resistance. The information available so far, both from India and overseas indicate that absolute resistance is not available both in cultivated and in other related wild species (Morris *et al.*, 1983). However, significant genetic variability for *alternaria* resistance has been reported in sunflower (Agrawat *et al.*, 1979; Carson, 1985) and the usefulness of the available level of resistance in reducing the loss was uncertain (Carson, 1985). The objective of this investigation was to study the variability which exist in the germplasm collection for reaction to alternaria leaf spot and identification of germplasm lines showing stable resistance over seasons for further exploitations.

One hundred germplasm lines along with the susceptible cultivars, Morden and L-101 were evaluated for alternaria leaf spot under natural epiphytotic conditions in the

kharif (rainy) season of 1989 and 1990. The occurrence and severity of alternaria leaf spot on sunflower is highest during the rainy season under Bangalore conditions. In 1989, the entries were planted during June. While in 1990, planting was done in July. Each entry was grown in a single row length of 3.6 metres with a spacing of 45 cm between rows and 30 cm between the plants, replicated three times. Susceptible check entries were grown at every 5 rows of test entries and also all around the plot as infector rows to supplement the inoculum. Since the growth of different accessions varied, disease severity was assessed when most plants in a particular germplasm line were at grain filling stage. Disease severity was determined on the basis of visual rating of all the plants in a row. All the entries were assessed visually for percentage of leaf area damaged by disease. For this purpose, total leaf/plant area covered by the disease expressed as percentage is taken. Observation on percentage area damaged on each plant in a test entry is recorded and average of all the plants in that entry is calculated to arrive at per cent disease severity and the same procedure is followed for all the test entries. The gradation and the percentage leaf area damaged under each gradation following on a 0-9 scale is as follows.

| Grade | Reaction | Disease severity |
|-------|---|-------------------------|
| 0 | Immune | No reaction |
| 1 | Highly resistant | < 1 % area covered |
| 3 | Resistant | 1 to 5 % area covered |
| 5 | Moderately resistant/Moderately susceptible | 5 to 25 % area covered |
| 7 | Susceptible | 25 to 50 % area covered |
| 9 | Highly susceptible | > 50 % area covered |

None of the tested entries showed either immune or highly resistant reaction in both the seasons indicating their susceptible nature to the disease. The actual disease severity ranged from 4.60 to 25 per cent during 1989 while its ranged from 4.00 to 11.50 during 1990, among the tested entries. Where as it was as high as 70 and 65 per cent during 1989 and 1990, respectively on the susceptible check varieties, Morden and L- 101. Many genotypes that showed high infection in one year, showed low infection in the other. This probably could be due to variability among the genotypes because of sowing practices followed in maintaining seed material as the crop is highly cross pollinated. Hence, the classification of a line based on the disease score alone may not reflect the true stable resistance. So, the resistance of a genotypes in the present study was its relative performance in each year when the alternaria inoculum was highest and weather conditions are favourable for it. The consistency of its relative performance over years reflected the stability of resistance. The relative performance in each environment was determined by

a new method using mean infections and standard deviation (Table 1). Based on relative performance, the lines were classified into three groups namely resistant, susceptible and highly susceptible (Table 2) as there were none either immune or highly resistant line to this disease.

In the present study, 16 genotypes showed resistance during 1989 and 14 during 1990 season. All the accessions showing resistance in 1989 did not show resistance in 1990. Only one genotype namely Acc. NO. 1040 showed resistance in both the years (Table 3) and is considered to be a source of resistance.

The results of this study indicate that a wide variability exists in the germplasm collections and a few lines show consistently higher resistance, if not to'al immunity. However, the usefulness of these levels of resistance in reducing losses is uncertain (Carson, 1985), which has to be further evaluated. Efforts will be made for phase-wise evaluation of the available germplasm to locate such stable resistance sources. And these lines will be improved for resistance by employing breeding methods.

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- Agrawat, J. M., Chippa, H. P. and Mathur, S. J. 1979. Screening sunflower germplasm against *Alternaria helianthi*. *Indian. J. Mycol. Plant. pathol.* 9 : 85-86.
- Anonymous. 1989. Annual progress report of AICRP on Oilseeds, Directorate of Oilseeds Research, ICAR Rajendranagar, Hyderabad India, 196 pp.
- Balasubrahmanyam, N. and Kotte, S. J. 1980. Effect of alternaria blight on yield components, oil content and seed quality of sunflower *Indian. J. agri. Sci.* 50 : 701-706.
- Carson, M. L. 1985. Epidemiology and yield losses associated with alternaria blight of sunflower. *Phytopathology* 75 : 1151-1156.
- Morris, J. B., Yang, S. M. and Wilson, L. 1983. Reaction of *Helianthus* species to *Alternaria helianthi*. *Plant disease* 76 : 539-540.
- Mukewar, P. M., Lambat, A. K., Ram Nath, Majumdar, A., Indra Ravi, and Jagdishchandra, K. 1974. Blight disease of sunflower caused by *Alternaria helianthi* (Hansf.) Tubaki and Nishihara in India. *Curr. Sci.* 43 : 436-347.
- Zimmer, D. L. and Hose, J. A. 1978 Diseases. pp 225-262. In : *Sunflower Science and Technology*. ASA Monograph 19. Ed. J.F. Carter. American Society of Agronomy, Madison, W.I.

Table 1. Range and mean severity of alternaria leaf spot/blight in 100 sunflower lines in two seasons

| Season | Range (%) | Mean \pm SE | Variances | $\frac{\text{Variance of 1989}}{\text{Variance of 1990}}$ |
|--------------------|--------------|-------------------|-----------|---|
| 1989 <i>kharif</i> | 4.00 - 25.00 | 9.135 \pm 0.365 | 13.348 | 4.807** |
| 1990 <i>kharif</i> | 4.00 - 11.50 | 7.615 \pm 0.167 | 2.777 | |

** Significant at 1% level

Table 2. Frequency of resistant, susceptible and highly susceptible lines in 100 sunflower genotypes

| Classification | Frequency | |
|-----------------------|-----------|------|
| | 1989 | 1990 |
| 1. Resistant | 17 | 14 |
| 2. Susceptible | 69 | 70 |
| 3. Highly susceptible | 14 | 16 |
| Total | 100 | 100 |

Resistant = Mean - S.D; Susceptible = (mean - S.D); Highly susceptible = (Mean + S.D)

Table 3. Sunflower lines showing resistant reaction to alternaria leaf spot in different seasons

| Sunflower accessions resistant in 1989 | Sunflower accessions resistant in 1990 | Sunflower accessions resistant in both the years |
|--|--|--|
| Acc. No. 97, 192, 249, 435, 664, 687, 690, 802, 892 920, 1007, 1029, <u>1040</u> , 1092, 3032, IB-24 | Acc. No. 120, 154, 188, 284, 286, 392, 417, 433, 826 1013, <u>1040</u> , 1041, 1050, IB-2. | Acc. No. 1040 |

Randhawa, N.S., and Venkateswarulu, J. 1980. Indian experience in semi arid tropics: Prospect and retrospect. pp. 207-220. In Proc. of the International Symposium on Development and Transfer of Technology for Rainfed Agriculture and Farmers, ICRISAT, A.P., India..

Subba Reddy, G., Venkateswarulu, B. and Vittal, K.P.R. 1991. Effect of substitution of fertilizer nitrogen with

subabul (*Leucaena leucocephala*) leaves on growth and yield of rainfed sorghum in Alfisols. *Indian J. agric Sci.* 61 (15): 316-9.

Tondon, H.L.S. and Kanwar, J.S. 1984. A review of fertilizer use research on sorghum in India. Research Bulletin, No. 8, International Crops Research Institute for Semi Arid Tropics, Patancheru, A.P., India.

Table 1. Yield components of castor and N uptake as influenced by different levels and sources of nitrogen

| Treatment | Spike length (cm) | Bean weight (g/pl) | Capsule weight (g/pl) | Test weight (1000 seeds) | Total N uptake (mg/pl) |
|---------------------------|----------------------------|--------------------|-------------------------|--------------------------|------------------------|
| Level of N (kg/ha) | | | | | |
| 0 | 11.73 | 5.84 | 8.27 | 128.08 | 199 |
| 25 | 13.92 | 11.85 | 16.92 | 155.60 | 604 |
| 50 | 16.47 | 14.56 | 20.96 | 161.94 | 804 |
| 100 | 19.11 | 16.88 | 24.58 | 166.87 | 997 |
| CD (P = 0.05) | 0.48 | 0.63 | 0.77 | 1.02 | 31 |
| Source of N | | | | | |
| <i>Leucaena</i> | 17.57 | 16.08 | 23.23 | 168.27 | 923 |
| <i>Sesbania</i> | 15.85 | 14.39 | 20.75 | 163.08 | 758 |
| <i>Glyricidia</i> | 19.72 | 17.28 | 24.88 | 172.43 | 1060 |
| Pearlmillet | 13.34 | 10.61 | 14.39 | 142.59 | 525 |
| Urea | 16.01 | 13.80 | 20.80 | 160.97 | 745 |
| CD (P = 0.05) | 0.62 | 0.81 | 0.98 | 1.31 | 40 |
| Source | Regression Equation | | | | R² |
| <i>Leucaena</i> | BY = 3.62 + 0.51 FN | | -0.004 FN ² | | 0.54* |
| <i>Sesbania</i> | BY = 8.34 + 0.20 FN | | -0.001 FN ² | | 0.41* |
| <i>Glyricidia</i> | BY = 7.87 + 0.17 FN | | -0.001 FN ² | | 0.33* |
| Urea | BY = 6.14 + 0.22 FN | | -0.001 FN ² | | 0.50* |
| Pearl millet | BY = 9.28 + 0.28 FN | | -0.001 FN ² | | |
| <i>Leucaena</i> | UN = 0.37 + 0.02 FN | | -0.0001 FN ² | | 0.72* |
| <i>Sesbania</i> | UN = 0.29 + 0.02 FN | | -0.0001 FN ² | | 0.67* |
| <i>Glyricidia</i> | UN = 0.39 + 0.01 FN | | -0.0001 FN ² | | 0.56* |
| Urea | UN = 0.34 + 0.01 FN | | -0.0001 FN ² | | 0.68* |
| Pearl millet | UN = 0.28 + 0.01 FN | | -0.0001 FN ² | | |

EFFECT OF DIFFERENT ORGANIC MATERIALS AS SOURCE OF NITROGEN ON GROWTH AND YIELD OF CASTOR

A pot culture study on the effects of different organic materials as source of nitrogen on castor variety Aruna was conducted at the Central Research Institute for Dryland Agriculture, Hyderabad during 1988 and 1989 using 30 kg capacity plastic pots filled with loamy sand soil (pH 6.70, organic carbon 0.41%, available N 180 kg ha⁻¹, available P 11 kg ha⁻¹). Leaves and twigs of *Glyricidia maculata* (S₁), *Leucaena leucocephala* (S₂), *Sesbania grandiflora* (S₃), Urea (S₄) and Pearlmillet straw (S₅) were added individually to supply, 25, 50 and 100 kg ha⁻¹ N and incorporated in the pot in powdered form by mixing in the top 30 cm soil layer. The soil without organic materials or urea served as control. Single superphosphate at 30 kg P ha⁻¹ was applied uniformly to all pots. Four seeds of castor were sown in each pot and finally only two plants were retained. The pots were arranged in a Randomized Block Design with six replications. Observations on dry matter, leaf area and N uptake were recorded at vegetative phases, flowering of primaries and final harvest in each season. Total bean yield and N uptake were subjected to regression analysis with fertilizer N as independent variable.

RESULTS AND DISCUSSION

Levels of organic sources : Bean yield increased significantly with increased levels of N in both seasons. Higher bean yield was due to higher dry matter, leaf area and yield components. Dry matter accumulation and N uptake were maximum at 100 kg N ha⁻¹ at all phenological stages. Positive and significant in-

crease in response to N application under rainfed conditions have also been reported by Randhawa and Venkateswarulu (1980), Tandon and Kanwar (1984) and Subba Reddy *et al.*, (1991).

Sources of organic materials : *Glyricidia* and *Leucaena* leaves at varied levels of N gave significantly higher bean yield, yield components (capsule weight, spike length and test weight of seeds) than application of urea alone. *Leucaena* produced 0.56, 0.35, and 0.2 g of beans/plant/kg of N at 25, 50 and 100 kg ha⁻¹. N use efficiency was higher with *Glyricidia* and *Leucaena* than others.

Bean N uptake at harvest at 50 kg ha⁻¹ through *Leucaena* and *Glyricidia* was comparable to that obtained at 100 kg N ha⁻¹ through urea. The regression analysis of bean yield and N uptake indicated that the models for *Glyricidia* provided the highest predictability followed by *Leucaena sesbania*, urea and pearlmillet. The mean observed values of different variables and the prediction equations of bean yield and N uptake are given in Table 1. The equations are useful for yield prediction and N uptake and drawing conclusions for future research. The study has clearly shown that leaves and twigs of *Glyricidia* and *Leucaena* can substitute for fertilizer nitrogen requirement of castor with enhanced N use efficiency while pearl millet straw was found to be not suitable for substituting fertilizer N.

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Table 1. Effect of gamma-rays treatment on JI 24 and KRG 1 groundnut varieties

| Character | Dose | JI 24 M ₃ generation | | KRG 1 M ₃ generation | |
|----------------------------|-------|------------------------------------|----------|------------------------------------|----------|
| | | Mean | Variance | Mean | Variance |
| Plant height (cm) | 0 kR | 28.00 | 10.18 | 27.73 | 30.45 |
| | 30 kR | 26.43 | 16.61** | 27.04 | 41.01 |
| | 40 kR | 26.08 | 14.88* | 25.35 | 45.45* |
| Primary branches per plant | 0 kR | 4.56 | 1.56 | 3.78 | 0.64 |
| | 30 kR | 4.73 | 2.00 | 3.66 | 0.93* |
| | 40 kR | 4.84 | 1.89 | 3.72 | 0.99* |
| Pods per plant | 0 kR | 23.52 | 69.29 | 22.62 | 65.60 |
| | 30 kR | 24.68 | 104.98* | 21.22 | 98.52* |
| | 40 kR | 25.05 | 89.45 | 21.53 | 116.26** |
| Pod yield per plant (g) | 0 kR | 17.68 | 78.23 | 14.58 | 34.76 |
| | 30 kR | 18.79 | 108.60* | 14.00 | 50.91* |
| | 40 kR | 17.91 | 88.51 | 11.72 | 55.98** |
| Kernel yield per plant (g) | 0 kR | 10.68 | 34.09 | 9.26 | 23.07 |
| | 30 kR | 11.27 | 57.03** | 9.56 | 31.79 |
| | 40 kR | 11.05 | 57.95** | 7.84 | 35.85* |
| Shelling (%) | 0 kR | 63.27 | 104.25 | 63.50 | 93.53 |
| | 30 kR | 60.40 | 160.90* | 68.18 | 143.35* |
| | 40 kR | 59.25 | 160.52* | 66.83 | 158.73** |

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

GAMMA-RAY INDUCED VARIABILITY FOR SOME QUANTITATIVE CHARACTERS IN GROUNDNUT

Advantages of mutagenesis to increase variability for characters of economic importance in groundnut (*Arachis hypogaea* L.) was demonstrated by Gregory (1955). The present study reports variability induced by gamma-rays for some quantitative characters in two groundnut cultivars.

Two-hundred seeds each of two groundnut cultivars, JL 24 and KRG 1 were treated with 30 kR and 40 kR doses of gamma-rays. Treated seeds alongwith untreated controls were planted in a single row plot in split-plot design with varieties as main plots and mutagen doses as sub-plots, using four replications. In the M₁ generation the number of plants that survived till maturity were 127 in JL 24 30 kR, 128 in JL 24 40 kR, 130 in KRG 1 30 kR, and 125 in KRG 1 40 kR. These M₁ plants harvested separately were advanced to M₂ generation in progeny rows. One-hundred M₂ progenies not segregating for qualitative characters were bulked, treatment wise and a random sample of about 2000 M₃ seeds was taken from each bulk constitute a trial. This trial with six treatments was planted in Randomized Block Design using four replications. Each treatment was planted in 10 rows which were 5 m long and 30 cm apart with 10 cm plant-to-plant distance. Necessary agronomic practices were followed to raise a good crop. Twenty-five random plants from middle eight rows of each plot were tagged to record observations on plant height, number of primary branches, pods per plant, pod yield per plant, shelling percentage and kernel yield per plant.

Analysis of variance for Randomized Block Design was conducted to test the significance of differences among treatments for different quantitative characters in the M₃ generations. To test whether treated populations had significantly more variability in com-

parison with that of untreated control for different quantitative characters, 'F' test was used (Snedecor and Cochran, 1967). It was assumed that the untreated control population could provide an estimate of environmental variability and the treated populations would include environmental as well as induced genetic variability.

The treatment with 30kR and 40kR in JL 24 and 40 kR in KRG 1 reduced the mean plant height at maturity by 2cm and significantly increased the intrapopulation variance compared to their respective untreated controls. The mean number of primary branches was not affected by gamma-rays in either of the varieties. However, the intrapopulation variance in KRG 1 treated with 30 and 40 kR was significantly higher than the control.

There was no significant alterations in number of pods per plant by irradiation with gamma-rays and an average of 20-25 pods per plant were recorded in all the treatments. Similarly the pod yield per plant was not affected in treated population except KRG 1 40 kR in which it was reduced by about 3 g from the control mean plant yield of 14.59 g. Three treatments, JL 24 30 kR, KRG 1 30 kR and KRG 1 40 kR showed significantly higher variability than their control populations indicating induction of genetic variability for number of pods and pod yield per plant (Table 1). Similar trends were noticed for kernel yield per plant, wherein KRG 1 40 kR (7.84 g) has less kernel yield than its control (9.26 g). Shelling outturn of KRG 1 30 kR treatment was 5% higher than its control (63.5%) and in JL 24 40 kR it was 4% less than its control (63.27%). While all the four treatments showed higher variability populations for shelling outturn, that for kernel yield was higher in all except KRG 1 30 kR.

RELATIVE CONTRIBUTION OF COMPONENT PLANT PARTS TO TOTAL DRY MATTER PRODUCTION IN SESAME

Sesame (*Sesamum indicum* L.) is an important edible oil seed crop but with low yield potential. It is gaining maximum importance on account of its high economic value of oil besides edible oil shortage. However, critical analysis on the contribution of different plant parts towards total dry matter production (TDMP) in sesame genotypes is very meagre. The knowledge on the pattern of dry matter partitioning efficiency of genotypes to different plant component parts is essential to sesame breeder for planning crop improvement. The present study was therefore, intended to understand the contribution of various plant parts towards TDMP in diverse genotypes of sesame.

A total of 59 genotypes belonging to various geographic regions in India viz., Andhra Pradesh (9), Bihar (1), Gujarat (7), Madhya Pradesh (3), Maharashtra (15), Karnataka (1), Orissa (8), Punjab (3), Rajasthan (6) and Tamilnadu (6) were grown in a Randomized Block Design with three replications during *kharij* (rainy season) 1989. The plot size was 2 rows of 4m long with 30 cm between rows and 10 cm between hills within a row. All cultural operations were uniformly carried out. Five plants in every genotype and in each replication were randomly chosen at harvest. The plant components viz., roots, stem, leaves, capsule rind and seeds were separated in each plant and oven dried at 70° C till constant weight. Dry weight of all these parts were used to obtain TDMP of the plant. The contribution of each constituent plant part by weight and also by parentage in each of the 59 genotypes were estimated (Table 1). Data on mean plant basis were utilized for computing analysis of variance as proposed by Panse and Sukhatme (1957).

High significant differences for all the five plant parts in 59 genotypes were observed (Table 2) indicating existence of wide spectrum of variation in the material. The maximum partitioning of dry matter on an average in the genotypes was found to stems (31.6 per cent) followed by capsule rind (26.5 per cent), seed (19.7 per cent), leaves (14.1 per cent) and least to root (8.2 per cent). The percentage accumulation of dry matter in roots was found to be minimum (5.03) in genotype RT 54 and maximum (12.14) in genotype DORS 3. Among genotypes, the contribution of stem to TDMP ranged from 19.6 per cent (AT 6) to 48.1 per cent (TMV 3). The minimum contribution (5.3 per cent) to leaves of TDMP was observed in R 84-102 while it was maximum (25.0 per cent) in genotype B 85-88-6. The genotype, Broad leaf mutant contributed very less 16.1 per cent to TDMP through capsule rind while the maximum contribution (39.3 per cent) was observed in AT 11.

Table 2. Analysis of variance for five plant components contributing to total dry matter in 59 genotypes

| Characters | Mean sum of squares | | |
|----------------------------|------------------------|-----------------------|-------------------|
| | Replications df = 2 | Treatments df = 58 | Error df = 116 |
| Weight of root (g) | 0.26 | 1.40** | 0.17 |
| Weight of stem (g) | 2.37 | 25.48** | 0.88 |
| Weight of leaves (g) | 0.65 | 7.91** | 0.46 |
| Weight of capsule rind (g) | 0.50 | 14.05** | 0.69 |
| Weight of seeds (g) | 1.30* | 4.74** | 0.26 |

* Significant at P = 0.05 ; ** Significant at P = 0.01

The yielding ability of crop plants is a complex quantitative character showing continuous variation and highly influenced by environmental factors. In spite of the difficulty of detecting micromutations influencing yield, there is no doubt about their possible occurrence. A significant increase in variance of treatments for different yield components over untreated control, as discussed above is the indication of the occurrence of micromutations. This offers a possibility for further selection and improving these characters. In most of the cases, the

mean of treatment was either similar to or slightly better than that of untreated control. This suggested that the micromutations detected by this study were in positive as well as negative directions. These results are in conformity with those of Gregory (1955) and Ramanathan (1983) who also observed increased variability for quantitative characters in treated populations of groundnut. Thirty-four superior single plants isolated from these four treatments are being evaluated for yield and other quantitative characters.

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Gregory, W. C. 1955. X-ray breeding of peanuts (*Arachis hypogaea* L.) *Agron. J.* 47 : 396-399.

Ramanathan, T. 1983. Induced mutations for quantitative characters in groundnut (*Arachis hypogaea* L.) *Madras agric. J.* 70 : 377- 381.

Snedecor, G. W. and Cochran, W. G. 1967. *Statistical methods.* Oxford and IBH Publishing, New Delhi.

Table 1. *Contd ...*

| Genotype | Dry weight of | | | | Total dry matter |
|-------------|---------------|--------------|-------------|-------------|------------------|
| | Root | Stem | Leaves | Seeds | |
| JLSC 8 | 3.11 (11.8) | 11.20 (42.4) | 1.50 (05.7) | 6.53 (24.7) | 26.40 (100) |
| JLT 3 | 2.45 (07.2) | 10.90 (31.9) | 6.85 (20.1) | 8.81 (25.8) | 34.13 (100) |
| JLT 4 | 3.26 (9.1) | 10.50 (29.3) | 5.90 (16.4) | 9.64 (26.9) | 35.88 (100) |
| JLT 5 | 1.58 (6.3) | 7.03 (28.3) | 3.75 (16.1) | 6.20 (24.9) | 24.91 (100) |
| JLT 6 | 2.41 (9.4) | 5.93 (23.2) | 4.05 (15.9) | 6.86 (26.9) | 25.55 (100) |
| JLT 7 | 2.45 (9.2) | 8.50 (31.9) | 5.04 (18.9) | 6.33 (23.8) | 26.65 (100) |
| JLT 9 | 2.13 (6.4) | 9.43 (28.2) | 8.23 (24.6) | 8.14 (24.3) | 33.46 (100) |
| MT PT 82-2 | 1.50 (8.2) | 4.44 (24.3) | 3.89 (21.3) | 4.01 (21.9) | 18.30 (100) |
| OMT 3 | 1.47 (7.9) | 5.23 (28.2) | 3.00 (16.2) | 4.88 (26.3) | 18.57 (100) |
| OMT 11-6-3 | 1.64 (8.4) | 5.77 (29.3) | 3.27 (16.7) | 4.22 (21.5) | 19.63 (100) |
| OMT 11-6-5 | 1.38 (8.2) | 5.53 (33.0) | 1.30 (07.8) | 5.34 (31.9) | 16.68 (100) |
| PBMT 82-6 | 1.38 (5.8) * | 6.33 (26.4) | 4.07 (17.0) | 6.55 (27.4) | 23.94 (100) |
| PDP 1-2 | 1.64 (6.5) | 9.07 (35.7) | 3.90 (15.3) | 6.80 (26.7) | 25.43 (100) |
| PDPh 2 | 1.67 (6.7) | 6.53 (26.3) | 4.37 (17.6) | 5.54 (22.3) | 24.84 (100) |
| Phule-Til 1 | 2.00 (9.1) | 5.70 (25.8) | 5.27 (23.9) | 7.16 (32.5) | 22.06 (100) |
| Phule-Til 3 | 1.41 (6.7) | 5.70 (26.7) | 3.21 (15.1) | 6.05 (28.2) | 21.46 (100) |
| R 84-102 | 0.87 (6.5) | 3.97 (29.7) | 0.70 (05.3) | 4.76 (35.7) | 13.33 (100) |
| R 84-1-7 | 2.55 (8.1) | 13.47 (42.8) | 1.79 (05.7) | 8.17 (26.0) | 31.45 (100) |
| R 84-4-2 | 1.90 (9.1) | 7.04 (33.1) | 1.97 (09.5) | 4.16 (20.7) | 20.83 (100) |
| R 84-360-3 | 1.57 (8.1) | 6.90 (35.7) | 1.41 (07.3) | 5.69 (29.5) | 19.32 (100) |
| Rauss 17-4 | 1.63 (10.1) | 4.70 (29.2) | 2.30 (14.3) | 4.21 (26.2) | 16.08 (100) |

Contd ...

Table 1. Dry weight (g/plant) and percentage contribution of five component plant parts to total dry matter production in 59 sesame genotypes

| Genotype | Dry weight of | | | | | Total dry matter |
|--------------------------|---------------|--------------|--------------|--------------|-------------|------------------|
| | Root | Stem | Leaves | Capsule rind | Seeds | |
| AT 3 | 2.17 (6.7)* | 9.51 (29.4) | 6.21 (19.2) | 9.16 (28.3) | 5.26 (16.3) | 32.32 (100) |
| AT 4 | 1.53 (7.5) | 5.77 (28.1) | 2.62 (12.8) | 5.89 (28.7) | 4.72 (23.0) | 20.54 (100) |
| AT 6 | 1.25 (5.7) | 4.30 (19.6) | 3.35 (15.7) | 6.59 (30.1) | 6.44 (29.4) | 21.94 (100) |
| AT 11 | 1.22 (7.7) | 3.33 (20.9) | 2.45 (15.4) | 6.24 (39.3) | 5.67 (16.7) | 25.90 (100) |
| AT 12 | 1.33 (5.6) | 6.45 (27.3) | 4.37 (18.5) | 6.20 (26.2) | 5.31 (22.4) | 23.66 (100) |
| AT 14 | 1.57 (8.9) | 4.51 (25.6) | 3.43 (19.5) | 4.72 (26.8) | 3.36 (19.1) | 17.59 (100) |
| AT 18 | 1.33 (6.5) | 4.85 (23.6) | 3.95 (19.2) | 6.76 (32.9) | 3.68 (17.9) | 20.57 (100) |
| B 9 | 1.80 (7.5) | 9.97 (41.4) | 1.76 (9.4) | 6.68 (27.7) | 3.86 (16.0) | 24.08 (100) |
| B14 | 2.65 (11.3) | 7.72 (33.1) | 2.73 (11.9) | 4.08 (17.5) | 6.18 (26.5) | 23.36 (100) |
| B 67 | 1.35 (7.2) | 4.90 (26.3) | 2.17 (11.60) | 4.39 (23.5) | 5.84 (31.3) | 18.65 (100) |
| B 84-4-2 | 1.50 (8.0) | 6.15 (32.8) | 1.68 (9.0) | 4.56 (24.3) | 4.87 (26.0) | 18.76 (100) |
| B 85-88-6 | 2.67 (9.4) | 8.08 (28.5) | 7.11 (25.0) | 6.60 (23.2) | 3.95 (13.9) | 28.40 (100) |
| Broad leaf mutant (I 29) | 3.90 (11.9) | 15.03 (45.8) | 4.80 (14.6) | 5.29 (16.1) | 3.77 (11.5) | 32.79 (100) |
| DORS 1 | 2.50 (7.6) | 10.39 (31.4) | 4.26 (12.9) | 12.03 (36.3) | 3.92 (11.9) | 33.09 (100) |
| DORS 2 | 3.00 (3.2) | 11.43 (31.3) | 5.36 (14.7) | 11.78 (32.2) | 4.98 (13.6) | 36.56 (100) |
| DORS 3 | 3.40 (12.1) | 9.17 (32.7) | 3.96 (14.1) | 8.07 (28.8) | 3.42 (12.2) | 28.01 (100) |
| DORS 5 | 2.63 (7.3) | 12.23 (34.0) | 6.19 (17.2) | 10.58 (29.5) | 4.29 (11.9) | 35.92 (100) |
| Gopi-Til | 2.27 (7.4) | 7.50 (24.5) | 4.05 (13.3) | 10.37 (33.9) | 6.38 (20.9) | 30.57 (100) |
| Gouri | 1.00 (7.2) | 4.27 (30.9) | 1.58 (11.4) | 3.01 (21.8) | 3.96 (28.7) | 13.82 (100) |
| I 14 | 1.17 (6.2) | 5.13 (27.2) | 2.89 (15.4) | 4.55 (24.2) | 5.08 (27.0) | 18.81 (100) |
| JISC 6 | 1.49(8.3) | 5.70 (31.6) | 2.60 (14.4) | 4.61 (25.6) | 3.61 (20.1) | 18.02 (100) |

Contd...

The contribution of seed weight towards TDMP among the genotypes varied from 8.8 to 31.3 per cent. Reddy and Narayanan (1987) reported the contribution of roots and leaves to the extent of 11.09 and 18.59 per cent respectively to TDMP. The capsule dry weight (capsule rind + seeds) indicated that about 43 per cent was contributed by seed and remaining 57 per cent by capsule rind. Hence, the poor contribution of seed to cap-

sule weight and also to TDMP of plant might be responsible for low yields in sesame crop as also reported by Saha and Bhargava (1980). Among the 59 genotypes evaluated in the present study, genotypes B 67, VS 80, AT 6, Gouri and R 84-4-2 in that order had high per cent dry matter partitioning to seed. These genotypes may profitably be utilised in hybridization programmes in evolving genotypes with high seed yield potential.

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Anitha, N. 1988. Studies on genetic divergence, heterosis and combining ability in *Sesamum indicum* (L.). M. Sc., (Ag) Thesis, TNAU, Coimbatore.

Panse, V.G. and Sukhatme, P.V. 1957. Statistical methods for agricultural workers. ICAR Publication.

Reddy, K.B. and Narayanan, A. 1987. Dry matter production and nutrient uptake in sesame (*Sesamum indicum* L.) genotypes. Sesame and Safflower News letter 3 : 35.

Saha, S. N. and Bhargava, S.C. 1980. Physiological analysis of growth, development and yield of oilseed sesame. *J. agric. Sci., Cambridge* 95 : 733-736.

Table 1. *Conud...*

| Genotype | Dry weight of | | | | Total dry matter | |
|----------------|---------------|--------------|-------------|--------------|------------------|-------------|
| | Root | Stem | Leaves | Capsule rind | Seeds | |
| RCR 3 | 2.47 (10.2) | 7.80 (32.3) | 2.57 (10.7) | 4.65 (19.3) | 6.63 (27.5) | 24.11 (100) |
| RT 54 | 1.58 (05.0) | 7.97 (25.4) | 4.93 (15.7) | 8.63 (27.4) | 8.34 (26.5) | 31.44 (100) |
| T 85 | 3.25 (8.4) | 14.45 (37.1) | 4.27 (10.9) | 12.37 (31.8) | 4.60 (11.8) | 38.93 (100) |
| TC 25 | 1.83 (9.2) | 6.75 (34.0) | 1.90 (09.6) | 5.18 (26.1) | 4.19 (21.1) | 19.85 (100) |
| TC 167 | 1.13 (6.0) | 4.26 (22.5) | 3.13 (16.5) | 7.24 (38.2) | 3.18 (16.8) | 18.94 (100) |
| TC 229 | 1.99 (8.2) | 6.97 (28.7) | 3.31 (13.2) | 7.20 (29.6) | 4.91 (20.2) | 24.25 (100) |
| TMV 3 | 2.61 (11.2) | 11.30 (48.1) | 1.60 (06.8) | 4.56 (19.4) | 3.41 (14.5) | 23.48 (100) |
| TNAU 10 | 2.20 (10.1) | 7.90 (36.3) | 1.71 (07.9) | 4.89 (22.4) | 5.09 (23.4) | 21.79 (100) |
| TNAU 28 | 2.17 (8.2) | 9.22 (35.0) | 3.33 (12.7) | 5.51 (20.8) | 6.12 (23.3) | 26.32 (100) |
| Vinayak | 1.30 (8.5) | 4.49 (29.3) | 1.80 (11.7) | 3.91 (25.5) | 3.84 (25.0) | 15.34 (100) |
| VS 2 | 2.02 (8.8) | 8.53 (37.4) | 1.45 (06.4) | 5.72 (25.0) | 5.11 (22.4) | 22.84 (100) |
| VS 16 | 2.00 (7.0) | 8.73 (30.6) | 3.23 (11.3) | 8.30 (29.0) | 6.32 (22.1) | 28.58 (100) |
| VS 80 | 1.90 (10.1) | 5.81 (20.8) | 1.65 (08.7) | 3.72 (19.5) | 5.84 (30.9) | 18.88 (100) |
| X 79-1 | 1.43 (7.3) | 5.43 (27.5) | 4.90 (24.9) | 4.16 (29.1) | 3.77 (19.2) | 19.68 (100) |
| X 198 | 2.02 (7.5) | 7.53 (28.0) | 3.45 (12.8) | 7.59 (28.2) | 6.31 (23.5) | 19.63 (100) |
| X 198-C | 3.47 (10.4) | 16.07 (48.0) | 1.90 (05.7) | 8.63 (25.8) | 3.44 (10.2) | 33.50 (100) |
| Madhavi | 1.87 (7.4) | 8.90 (35.4) | 3.03 (12.1) | 5.46 (21.7) | 5.87 (23.4) | 25.13 (100) |
| General Mean | 1.98 (8.2) | 7.67 (31.6) | 3.41 (14.1) | 6.44 (26.5) | 4.78 (19.7) | 24.28 (100) |
| SEM \pm | 0.47 | 1.07 | 0.77 | 0.95 | 0.58 | 2.53 |
| CD at P = 0.05 | 0.66 | 1.52 | 1.09 | 1.35 | 0.82 | 3.58 |
| CV per cent | 20.64 | 12.26 | 19.83 | 12.93 | 10.67 | 9.11 |

* The values in parenthesis are percentages.

Maximum hull percentage of 39.26 was recorded in EC 98326 and minimum of 21.60 in EC 163505 (Table 1). Sabir *et al.*, (1975) reported about 42% hull in sunflower seeds.

The contribution of oil of the whole seed for hull and kernel varied from 0.37 to 3.87% and 29.33 to 42.15% respectively. Similarly protein, contribution to the whole seed for hull and kernel varied from 1.0 to 2.46% and 17.58 to 24.96% respectively.

No statistically significant correlation was found between oil and protein ($r = 0.148$) in the whole seed. However, highly significant negative correlation was observed between these two parameters in the kernel portion of the seed ($r = 0.8096$, $P < 0.01$).

Correlation between the seed oil and kernel to hull ratio was highly significant and positive ($r = 0.8755$, $P < 0.01$). Due to this good level of significance, eleven lines out of fourteen showed nearly same level of ranking (± 2) when oil percentage of the seed and kernel to hull ratio were compared.

Correlation between kernel oil and kernel to hull ratio was found just significant and positive ($r = 0.538$, $P < 0.05$). Because of this lower significance of correlation, genotypes

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like EC 198078, EC 211896 and EC 179756 showed lesser oil percentage in the seed although having comparatively high oil percentage in the kernel.

Hundred seed weight of the lines varied from 3.798 to 9.982 grams; 6.85 grams being the mean value. No significant correlation was observed ($r = 0.374$) between hundred seed weight and kernel to hull ratio. But a highly significant positive correlation ($r = 0.784$, $P < 0.01$) was observed between the seed oil percentage and hundred seed weight. Protein of the seed had non-significant relationship ($r = 0.206$) with hundred seed weight.

Except for oil and protein correlation, which is negative in the kernel part of the seed, all other correlations, studied in the present experiment are positive in nature. A sharp increase in oil level could probably be achieved through selections for thin hull types, more seed weight and high oil percentage in the kernel. Success of such selections would result in higher oil yield.

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Fick, G.N. 1978. Breeding and Genetics. pp. 279-338. In: Sunflower science and technology. Ed. J.F. Carter American Society of Agronomy, Madison, U.S.A.

Sabir, M.A., Soulski, F.W. and Hamon, N.W., 1975. Sunflower Carbohydrates. *J. Agric. Food Chem.* 23: 16-19.

OIL AND PROTEIN CONTENTS IN SUNFLOWER GENOTYPES

Sunflower (*Helianthus annuus* L.) seed contains appreciable proportion of hull, with very little amount of oil. For quality assessment it is important to study oil-protein level both in the kernel and whole seed along with kernel-hull proportion. In the present communication sunflower genotypes with a wide variation in oil content were analysed for their seed composition, oil-protein contents in kernel, hull and whole seed to establish quality criteria for the selection of sunflower germplasm.

One hundred and twenty four accessions of sunflower consisting of cultivars and hybrids of diverse origin from Egypt, Hungary, India, U.S.A., U.S.S.R., and Yugoslavia were grown during three *rabi* seasons of 1986-87, 1988-89 and 1989-90 at NBPGR, New Delhi.

Based on seed characteristics 14 diverse lines varying in seed size and oil content were selected. The collections were oven dried at 130°C for two hours. Samples were dehulled manually and weights of the hull and kernel of filled seeds as well as 100-seed weight recorded. Oil and protein contents of hull, kernel and whole seed were determined using NMR and kjeltec equipments.

Oil and protein content in whole seed varied from 29.33 to 44.19% and 20.36 to 27.68% respectively, and in kernel, these constituents varied from 46.19 to 57.25% and 23.66 to 33.77% (Table 1). Protein percentage of seeds has been reported to vary from 9 to 24 and of kernels 24 to 40% (Fick, 1978).

Table 1. Hundred seed weight, kernel percentage and oil-protein percentage to kernel and whole seed of selected sunflower lines.

| Germplasm | 100 seed weight | Kernel (%) | Oil (%) | | Protein (%) | |
|------------|-----------------|------------|---------|------------|-------------|------------|
| | | | Kernel | Whole seed | Kernel | Whole seed |
| BSH-1 | 4.156 | 69.258 | 50.15 | 36.81 | 26.235 | 20.365 |
| Surya | 6.799 | 67.055 | 48.82 | 34.60 | 33.000 | 23.576 |
| MSFH-1 | 5.677 | 70.148 | 51.37 | 36.40 | 31.311 | 25.415 |
| Ec-98326 | 7.225 | 60.740 | 48.29 | 29.33 | 32.541 | 20.381 |
| EC-163505 | 5.956 | 78.396 | 52.83 | 42.82 | 28.011 | 24.463 |
| EC-179756 | 3.798 | 67.796 | 47.63 | 35.70 | 32.134 | 25.393 |
| EC-179756A | 9.949 | 72.800 | 57.25 | 40.30 | 25.807 | 20.670 |
| EC-198078 | 7.785 | 74.306 | 56.72 | 44.19 | 23.662 | 20.876 |
| EC-191895 | 9.982 | 77.151 | 50.54 | 42.60 | 31.285 | 25.781 |
| EC-201846 | 8.202 | 68.171 | 47.15 | 35.26 | 33.770 | 23.860 |
| EC-210243 | 9.157 | 73.090 | 46.19 | 36.09 | 32.470 | 25.642 |
| EC-210257 | 6.343 | 69.878 | 49.51 | 38.36 | 33.365 | 24.563 |
| EC-210298 | 6.767 | 75.148 | 50.24 | 39.29 | 33.210 | 27.677 |
| EC-211896 | 8.049 | 74.996 | 53.72 | 44.16 | 26.883 | 24.033 |
| Mean | 6.846 | 71.350 | 50.76 | 38.28 | 30.260 | 23.760 |

Table 1. Yield and yield components of soybean in maize based intercropping system

| Treatment | Plant height (cm) | IDM/plant (g) | Number of pods/plant | Grain weight/plant (g) | 100-seed yield (g) | Grain yield (q/ha) | Maize grain yield (q/ha) | Soybean equivalent (g/ha) |
|--------------------------------------|-------------------|---------------|----------------------|------------------------|--------------------|--------------------|--------------------------|---------------------------|
| Sole soybean : | | | | | | | | |
| Monetta | 27 | 13.7 | 27.6 | 6.6 | 14.0 | 19.3 | - | 19.3 |
| Hardy | 65 | 24.1 | 41.1 | 8.5 | 18.9 | 23.6 | - | 23.6 |
| KHSB-2 | 73 | 22.1 | 43.9 | 7.0 | 13.6 | 30.5 | - | 20.5 |
| Sole Maize | | | | | | | | |
| Sole maize 60 x 30 cm | - | - | - | - | - | - | 63 | 35.2 |
| Sole Maize 90 x 20 cm | - | - | - | - | - | - | 60 | 33.5 |
| Maize + Monetta (1:1) | 25 | 8.5 | 22.0 | 4.3 | 13.0 | 8.4 | 62 | 42.9 |
| Maize + Hardy (1:1) | 68 | 15.9 | 29.7 | 5.0 | 13.1 | 7.8 | 58 | 40.3 |
| Maize + KHSB-2 (1:1) | 74 | 11.5 | 24.4 | 4.9 | 12.9 | 7.9 | 57 | 39.7 |
| Maize + Monetta (1:2) | 27 | 7.4 | 19.2 | 4.4 | 12.9 | 10.2 | 64 | 45.7 |
| Maize + Hardy (1:2) | 62 | 13.2 | 23.3 | 5.8 | 13.9 | 8.3 | 57 | 39.9 |
| Maize + KHSB-2 (1:2) | 78 | 12.4 | 25.3 | 5.1 | 12.9 | 8.3 | 57 | 40.0 |
| C.D. at 5% | 9.2 | 3.0 | 6.9 | 1.8 | 0.8 | 3.0 | NS | 3.6 |
| Cropping system | | | | | | | | |
| Sole crop | 55 | 19.9 | 37.5 | 7.4 | 15.5 | 21.1 | 61 | - |
| Inter crop | 56 | 11.5 | 24.0 | 4.9 | 13.1 | 8.5 | 59 | - |
| C.D. at 5% | NS | 1.5 | 3.5 | 0.9 | 0.4 | 1.1 | NS | - |
| Row proportion | | | | | | | | |
| 1:1 | 56 | 12.0 | 25.4 | 4.8 | 13.0 | 8.0 | 59 | - |
| 1:2 | 56 | 11.0 | 22.6 | 5.1 | 13.2 | 9.0 | 59 | - |
| C.D. at 5% | NS | NS | NS | NS | NS | NS | NS | - |
| Soybean cultivar as intercrop | | | | | | | | |
| Monetta | 26 | 7.9 | 20.6 | 4.3 | 12.9 | 9.3 | 63 | - |
| Hardy | 65 | 14.5 | 26.5 | 5.4 | 13.5 | 8.1 | 58 | - |
| KHSB-2 | 76 | 11.9 | 24.8 | 5.0 | 12.9 | 8.0 | 57 | - |
| C.D. at 5% | 6.5 | 2.1 | NS | NS | NS | NS | NS | - |

Price (Rs/q) : Maize = 250, Soybean = 450.

STUDY ON MAIZE-BASED INTERCROPPING WITH SOYBEAN

An investigation was undertaken during *khariif* 1989-90 to evaluate the performance of three soybean cultivars viz., Monetta, Hardy and KHSB-2 as intercroppers in 1:1 and 1:2 row proportions in maize (Cv. Deccan, 103) spaced at 60x30 and 90x20 cm, respectively. The experiment was conducted at Agriculture College Farm, Dharwad, Karnataka on black clay loam soil with 7.5 pH. The per cent N, available P₂O₅ and K₂O were 0.049, 0.022 and 0.0113, respectively. There were eight treatments including two sole crops of maize. Randomized Block Design with four replications was used for experimentation. Soybean seeds were sown at an intra row spacing of 10 cm. A common fertilizer dose of 120:85:35 kg/ha N, P₂O₅ and K₂O was applied to field before sowing. Nitrogen was split into two; half was used at planting time and the second half was top dressed to maize 30 days after sowing. The rainfall during the year was 730.5 mm which was well distributed during the growing season. The soybean cultivar Monetta was harvested after 80 days while the others were harvested after 105 days, and maize cobs were removed after 120 days of sowing. Observations on plant height and yield components were recorded and analysed (Table 1). Soybean equivalent for maize was worked out by multiplying maize yield with a factor obtained by dividing price per unit quantity of maize with price of soybean for same quantity.

Plant height of soybean did not vary significantly due to intercropping. However, the cultivar Monetta recorded significantly lower plant height than Hardy and KHSB-2 in sole as well as under intercropping situations.

KHSB-2 was the tallest among cultivars especially under intercropping. There was substantial reduction in dry matter of soybean intercropping with maize (11.5 g/plant) compared to sole cropping (19.9 g/plant), which was due to increased intercrop competition. Variation in soybean row proportion had no significant effect. Among cultivars, Hardy recorded significantly higher drymatter (14.5 g/plant) than the rest.

The number of pods/plant varied significantly among cropping systems. Sole crops recorded higher number of pods/plant (37.5) than intercrop (24.0). Similar trend was also observed in grain weight/plant, 100 seed weight and grain yield/ha. Soybean yield under intercropping was lower (8.5 q/ha) than that of sole cropping (21.1 q/ha) due to reduced population of soybean (50 and 66% of sole in 1:1 and 1:2 row proportions).

Maize grain yield did not show significant variations due to intercropping of soybean. On the other hand, often it is observed that benefits from legume based intercropping are considerable. Intercropping maize + Monetta in 1:2 row proportion (45.7 q/ha) followed by maize + Monetta in 1:1 row proportion (42.9 q/ha) provided substantially higher soybean yield equivalent than the rest of the test treatments (Table 1). Thus, from the study it is evident that in the northern transitional tract of Karnataka, soybean, particularly cv. Monetta seems to be the ideal intercrop and growing soybean as an intercrop in maize is more beneficial than raising it as sole crop.

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Table 1. Interaction of antagonists and *Azospirillum* on sesame growth

| Treatments | Shoot length (cm) | | Root length (cm) | | Shoot dry wt. (mg) | | Root dry wt. (mg) | |
|--|-------------------|--------|------------------|--------|--------------------|--------|-------------------|--------|
| | 30 DAS | 45 DAS | 30 DAS | 45 DAS | 30 DAS | 45 DAS | 30 DAS | 45 DAS |
| <i>T.viride</i> + <i>M.phaseolina</i> | 19.5 | 32.3 | 2.5 | 3.6 | 424 | 813 | 23.8 | 31.8 |
| <i>T.viride</i> + <i>Azospirillum</i> + <i>M.phaseolina</i> | 21.1 | 36.7 | 2.7 | 3.9 | 436 | 842 | 25.5 | 35.2 |
| <i>Azospirillum</i> + <i>M.phaseolina</i> | 19.9 | 32.7 | 2.6 | 3.2 | 435 | 826 | 24.3 | 30.9 |
| <i>B.subtilis</i> + <i>M.phaseolina</i> | 19.3 | 32.5 | 2.6 | 3.4 | 430 | 816 | 22.2 | 27.5 |
| <i>B.subtilis</i> + <i>Azospirillum</i> + <i>M.phaseolina</i> | 21.2 | 35.7 | 3.1 | 3.8 | 441 | 887 | 25.6 | 35.2 |
| <i>M.phaseolina</i> alone (control) | 18.5 | 30.9 | 2.3 | 2.7 | 422 | 798 | 21.3 | 26.5 |
| CD | 1.5 | 2.4 | 0.6 | 0.4 | 4.6 | 14.7 | 1.9 | 3.9 |

The shoot and root dry weight were increased significantly at 45 DAS when either *T. viride* or *B. subtilis* was treated in combination with *Azospirillum*.

Positive interaction effects on antagonists with bio-fertiliser *Rhizobium* have been recorded by Haral and Konde (1983) and Uma Maheswari (1991). But reports on interaction effects of antagonists with bio-fertilizer *Azospirillum* is negligible. But the present investigation indicated that there is a positive interaction among the antagonists and *Azospirillum*.

Both *T. viride* and *B. subtilis* in combination with *Azospirillum* reduced the root rot to 31.6 and 25.0% respectively. Significantly lesser when compared to control (85%) (Table 2.).

T. viride and *B. subtilis* treated crop recorded 41.6% and 33.5% root rot incidence respectively which was significantly lesser than control. (85%).

Reduction of root rot incidence caused by *M. phaseolina* due to treatment with antagonists has been recorded by Turner and Backman on groundnut (1991), Jeyarajan and

Ramakrishnan (1991) on urdbean, Umamaheswari (1991) on groundnut and Elad *et al.*, (1986) on groundnut. In the present study sesame root rot caused by *M. Phaseolina* was effectively controlled by *T. viride* and *B. subtilis*. Thus by combined seed treatment with antagonists and *Azospirillum* increased plant growth and reduced root rot incidence can be achieved in sesame.

Table 2. Interaction of antagonists and *Azospirillum* on the sesame root rot

| Treatments | % Root rot |
|--|----------------|
| <i>T.viride</i> + <i>M.phaseolina</i> | 41.6 (40.2) |
| <i>T.viride</i> + <i>Azospirillum</i> + <i>M.phaseolina</i> | 31.6 (34.2) |
| <i>Azospirillum</i> + <i>M.phaseolina</i> | 76.5 (61.3) |
| <i>B.subtilis</i> + <i>M.phaseolina</i> | 33.5 (35.2) |
| <i>B.subtilis</i> + <i>Azospirillum</i> + <i>M.phaseolina</i> | 25.0 (29.9) |
| <i>M.phaseolina</i> alone (control) | 85.0 (67.4) |
| CD | 6.9 |

Figures in parenthesis are arc sin values

STUDIES ON THE INTERACTION EFFECTS OF ANTAGONISTS AND AZOSPIRILLUM ON THE GROWTH AND ROOT ROT OF SESAME

Biological control of soil borne plant pathogens by seed treatment with antagonistic organisms is gaining importance at present. Seed bacterization with *Bacillus subtilis* has been found to be effective against soil borne plant pathogens. This treatment has also considerably improved the yield and dry matter of plants (Chang and Kommedahel, 1968). Seed treatment with *Azospirillum* helps in the increase of sesame yield (Sridhar *et al.*, 1988). Use of *Trichoderma viride* was reported to be effective in reducing the propagules of seed as well as soil borne pathogens (Papavizas, 1984). The effectiveness of *T. viride* against *M. phaseolina* was already reported by Norton (1954). *Macrophomina phaseolina* root rot disease often results in the loss of sesame yield. The present study was undertaken to find out the effect of seed treatments with the antagonists individually and in combination with biofertilizer *Azospirillum* on the growth and root rot incidence of sesame. The symptoms of the disease is as follows. The affected plants dry suddenly and roots show decaying symptoms. Black sclerotia are seen on the roots and minute black pycnidia are seen on the stem. Shredding of bark occurs in the case of severe disease incidence. The severely infected plants will die.

The antagonism of *T. viride* (T.v.6) and *B. subtilis* (B.s.9) against root rot fungus *Macrophomina phaseolina* under *in vitro* conditions has been proved in our laboratory. These antagonists were used in the present investigations. *Azospirillum* peat based culture was used for seed treatment. The variety used was Co.1. Pot culture experiment was laid out with the following treatments. Sterilized soil was used for the studies @ 2.5 kg/pot. The treatments were replicated four times. In each treatment 30 plants were maintained.

The treatments were as follows :

- T1 - *Trichoderma viride* + *Macrophomina phaseolina*
- T2 - *T. viride* + *Azospirillum* + *M. phaseolina*
- T3 - *Azospirillum* + *M. phaseolina*
- T4 - *Bacillus subtilis* + *M. phaseolina*
- T5 - *B. subtilis* + *Azospirillum* + *M. phaseolin*
- T6 - Control (*M. phaseolina* alone)

Seeds were treated with *T. viride* powder formulation @ 4g/kg of seed. *B. subtilis* and *Azospirillum* were used @600 g peat based inoculum for seeds, required for one hectare. The sclerotia of *M. phaseolina* was incorporated @ 500 mg/kg of soil (Elad *et al.*, 1980). Growth parameters like length and dry weight of shoot and root were recorded on 30 and 45 DAS. Root rot incidence was recorded on 60th day.

Per cent root rot incidence was calculated as follows :

$$\frac{\text{Number of plants died}}{\text{Total number of plants in a treatment}} \times 100$$

In the dead plants no yield is realised, so percentage of root rot incidence is indirectly measured by calculating the percentage of dead plants.

The observations regarding the shoot length and dry weight, root length and dry weight as influenced by various treatments, is shown in Table 1. The results revealed that either *T. viride* or *B. subtilis* when combined with *Azospirillum* enhanced shoot length and root length marginally at 30 DAS and significantly at 45 DAS compared to *Azospirillum* treatment alone.

CHARACTERISTICS OF FARMERS INFLUENCING ADOPTION OF SCIENTIFIC OILSEEDS PRODUCTION TECHNOLOGY

Despite the fact that India is one of the leading oilseeds producing countries in the world it has not been able to meet the edible oil requirements of its increasing population. This indicates that the improved technology recommended for oilseeds production need to be critically examined with respect to adoption of production technology at farmers level (Verma *et al.*, 1990). Several important factors related to research institution, extension agents, innovation itself and clientele system are involved in transfer of technology and their adoptability at farmers level (ICAR, 1988; Singh and Rajindra, 1990; Singh and Sharma, 1990; Napier, 1991, Singh, 1992). In this paper efforts have been made to investigate the influence of socio-psychological variables/characteristics of the farmers on the adoption of scientific oilseeds production technology.

The study was conducted with 200 farmers randomly selected from 20 villages of 4 districts of Haryana state during 1991. The data were collected from farmers by holding personal interview and 'adoption scale' was used to measure the adoption of 7 oilseeds production technology. The responses were obtained on three point scale continuum i.e., fully adopted, partially adopted and not adopted which were assigned the weightage of 4, 2 and 0. The 14 socio-psychological characteristics of oilseeds growers were measured with the help of standard scales and indices with slight modification (independent variable).

Majority (55% of the farmers were partially adopted the recommended technology while about one-fourth (28%) of the total farmers belonged to low adoption category. As far as full adoption is concerned, only 17 percent of the respondents were followed the recommendations made by the HAU scientists

regarding scientific oilseeds production technology. These results confirm the earlier findings of Peter (1986), Kessaba (1987), Verma *et al.*, (1990), Singh and Singh (1992), Singh *et al.*, (1992) reported that majority of the farmers belonged to medium or low category of adoption of agricultural crops. The magnitude of correlation coefficients indicated that out of the 14 various characteristics of the farmers, only five variables, namely, education, socio-economic status, localite cosmopolitaness, extension contact and management-orientation had positive and significant correlation with adoption. It implies that well educated farmers having high socio-economic status in the society, better exposed to the latest developments of oilseeds technology, well connected with the extension agencies and having some management-orientation were fully adopted the oilseeds recommendations on their fields. The positive correlation with these variables have also been reported by (Rolling 1990, Singh and Sharma (1990) and Singh *et al.*, (1992). All the other remaining characteristics like attitude, risk orientation, social participation, production satisfaction, aspiration etc. did not play any significant role in adoption of oilseeds production technology.

The path analysis revealed that socio-economic status of the farmers exerted direct positive influence (6.26) on adoption followed by education and management-orientation. Caste of the farmers had high magnitude of negative direct influence on adoption followed by localite-cosmopolitaness and their income. As far as indirect influence is concerned, by and large all the variables/characteristics of the farmers shown their indirect effect through production satisficaiton, aspiration, attitude and social participation. The results obtained are similar to that of Singh (1992) and Singh *et al.*, (1992).

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- Chang, I., Pin and Kommedahl, T. 1968. Biological control of seedling blight of corn by coating kernels with antagonistic microorganisms. *Phytopathology*, 58: 1395-1401.
- Elad, Y., Chet, I. and Katan, J. 1980. *Trichoderma harzianum*. A biocontrol agent effective against *Sclerotium rolfsii* and *Rhizoctina solani*. *Phytopathology*, 70: 119-121.
- Elad, Y., Zvieli, Y. and Chet, I. 1986. Biological control of *Macrophomina phaseolina* by *Trichoderma harzianum*. *Crop production*, 5: 282-292.
- Haral, A.K. and Konde, B.K. 1983. Biological management of soil borne plant pathogen. Effects on nodulation and dry matter of chickpea. *J. Maharashtra agric. Univ.* 8: 112-113.
- Jeyarajan, R. and Ramakrishnan, G. 1991. Efficacy of *Trichoderma* formulation against root rot disease of grain legumes. *Petria* 1(2): 137-138.
- Norton, D.C. 1954. Antagonism in soil between *Macrophomina phaseolina* and selected soil inhabiting organisms. *Phytopathology*, 44: 522-524.
- Papavizas, G.C. 1984. Soil borne plant pathogens: New opportunities for biological control. *British crop production conference on pest and diseases*, 4: 371-378.
- Sridhar, R., Ramalingam, R.S. and Sivaram, M. R. 1988. *Azospirillum*- A biofertilizer for sesame. *Oil crops Newsletter*, 5: 66-67.
- Turner, J. T. and Backman, P.A. 1991. Factors relating to peanut yield increase after seed treatment with *Bacillus subtilis*. *Plant Dis.* 75: 347-353.
- Uma Maheswari, C. 1991. Biological control of dry root rot of groundnut (*Arachis hypogaea* L.) caused by *Macrophomina phaseolina* (Maub.) Ashby M.Sc. (Ag.) Thesis, TNAU, Coimbatore, p. 90.

SESAME SEED BALL

Because of small size of sesame seeds and limited exploitation under transplanting technique, line planting becomes very problematic and hence population per unit area and sesame yield is thus affected. In order to maintain population under field condition, larger quantity of sesame seeds is used per unit area by the farmers (5 kg ha^{-1}) against the actual requirement of 1.320 kg ha^{-1} , which could maintain the recommended plant population.

Hence, in order to reduce the seed rate per hectare, considering the huge waste of seed material and also simultaneously looking for the maintenance of optimum population, laboratory study was conducted at Krishi Vigyan Kendra, Vridhachalam during *kharif* 1992 to make sesamum seed as a ball like peanut seed with packing materials for better establishment. Longden (1975) described that although pelleting was adopted at first to make seed round to facilitate accurate precision sowing, it also has potential for accurate dosing seeds with chemicals.

Lonergan and Mayer (1955) reported that lime pelleted seed improved nodulation and dry matter yield in the acid soils by overall improving legume performance. If pelleting material is proper, it is easy to obtain good plant population (Millier and Sooter, 1967). These reviews clearly indicated that seed pelleting presents a unique opportunity of giving the crop a good start. So pelleting is an important key for successful agriculture through which uniform and vigorous field stand could be accomplished.

Hence, work was initiated on this line to determine the suitable packing materials and its effects on germination of sesame seeds under laboratory condition.

The study was conducted at Krishi Vigyan Kendra, Vridhachalam during *Kharif* 1992. A completely Randomized Block Design was used with two replications for evaluating seed germination of sesame seed ball.

TMV 4 sesame seeds were treated with carbendazim following wet seed treatment and then shade dried. Pre-germination test was conducted and four seeds per pellet was condensed. Ten different packing materials were selected for making seed ball based on the study requirements (Porous nature, consistency, dispersion when contact to soil moisture/water, nutritive value, local availability and non toxicity of the packing materials). Water was the sticker for all the materials used for pelletization. Seeds were packed both interior and exterior of the seed ball separately for each packing materials through manual process.

Ten different materials (Table 1) were dried and powdered separately. The quantity of water required for obtaining optimum consistency was worked out and hence the measured quantity was added to each materials and pellet was prepared manually with four seeds packed inside each pellet in one group of treatments.

In another group, pellet was prepared in the same way except seeds pasted externally using Rice kanji as sticker. All the pellets were shade dried for further study. These two groups consisting 20 such treatments were compared with control.

Disintegration study with water was conducted as detailed below. Fifty ml of water was taken in each petridish and dried five pellets from each group were immersed in water separately. The time taken for disintegration by

The majority of the farmers belonged to low socio-economic status resulting the low adoption of production technologies in oilseeds. Therefore, it is suggested that agricultural inputs at subsidised rates and agricultural loan at the cheaper rates of interest to purchase

these inputs should be provided to the farmers. Campus as well off campus farmers training should be organised to propagate and educate the farmers regarding latest developments in oilseed crops.

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- ICAR. 1988. Appropriate agricultural technologies for farm women. New Delhi. India.
- Kessaba, A.M. 1987. Factors affecting system for resource - poor farmers. FAO, Rome.
- Napier, T. L. 1991. Factors affecting acceptance and continued use of soil conservation practices in developing societies. Accepted for publication in *Agriculture, Ecosystem and Environment*.
- Peter, W.C.H. 1986. Strategies in the transfer of technology. In *Investing in rural extension strategies and goals*. Ed. Gwyn, E. Jones. Elsevier Applied Science Publishers, London, U.K.
- Rolling, N. and Engel, P. 1990. Knowledge management and information: a knowledge system perspective. In *Making the link: agricultural research and technology transfer in developing countries* Ed. Kaimowitz. Westview Press.
- Singh, S.P. 1992. Constraints in transfer of scientific agricultural technology: A factor analysis. Paper presented in International Conference on Experimental Learning held at Pondichery from March, 9-15. 1992.
- Singh, S.P. and Singh, J.P. 1992. Technological gaps and socio-psychological constraints in adoption of agricultural research in semi-arid region of northern India: A discriminant analysis approach. paper presented in International Conference on Agricultural and Extension Education held at Columbus Ohio State University U.S.A. from May, 12-16, 1992.
- Singh, S.P. and Rajendra. 1990. a study on adoption of improved sugarcane variety. *Indian J. Ext. Edu.* 26 (1&2): 110-111.
- Singh, S.P. and Sharma, R.K. 1990. Technological gaps in gram production in Haryana. *Res. and Dev. Repr.* 7 (1&2): 178-181.
- Singh, S.P., Singh, J.P. and Dalal, R.S. 1992. A discriminant function approach for discriminating the adopters from non-adopters of oilseeds production technology in Haryana. Paper presented in International conference of Experimental learning held at Pondichery from March, 9-15, 1992.
- Verma, H.K., Kumar, K and Singh, S.P. 1990. Farmers acceptability and adoption of rapeseed and mustard production technology under rainfed conditions. *Indian J. Ext. Edu.* 26 (3&4): 39-43.

Table 3 Effect of pelleting materials on seed germination.

| Sl. No. | Materials | Mean Germination per cent | | | |
|---------|-----------------|---------------------------|----------|-------------|----------|
| | | Interior | | Exterior | |
| | | Transformed | Original | Transformed | Original |
| 1. | Cowdung | 90.0 | 100.0 | 75.0 | 87.5 |
| 2. | Red earth | 4.5 | 0.0 | 90.0 | 100.0 |
| 3. | Super phosphate | 4.5 | 0.0 | 4.5 | 0.0 |
| 4. | Lime | 4.5 | 0.0 | 67.5 | 75.0 |
| 5. | Wood ash | 45.0 | 50.0 | 75.0 | 87.5 |
| 6. | Gypsum | 90.0 | 100.0 | 67.5 | 75.0 |
| 7. | Lignite | 4.5 | 0.0 | 67.5 | 75.0 |
| 8. | Silt | 75.0 | 87.5 | 90.0 | 100.0 |
| 9. | White clay | 75.0 | 87.5 | 90.0 | 100.0 |
| 10. | Press mud | 90.0 | 100.0 | 75.0 | 87.5 |
| | Mean | 48.3 | - | 70.2 | - |

CD at 5% level; Between Treatments = 26.76; Between Groups = 36.90

each pellet was observed and expressed in minutes.

Shade dried pellets to the original moisture was taken for germinating study. Five such pellets for each packing material were dibbled in each petridish at 3 cm depth (sand medium). Petridish were surface-watered to keep the soil near field capacity. Emergence was recorded at 3 days after sowing.

The data pertaining to quantity of packing material required, its disintegration with water and germination count was furnished in Tables 1 to 3.

Analysis of the data were done after due transformation as per the method suggested by Gomez and Gomez (1984).

The data presented in Table 1. showed that cowdung pellets recorded maximum moisture content of 204.65 per cent followed by gypsum pellet (157.14 per cent). Red earth, press mud, and wood ash could hold only limited moisture percentage. This variation was mainly due to nature of the materials handled.

Table 1. Moisture content of each pellet (per cent) at the time of making seed balls

| Sl. No. | Materials | Wet weight (g) | Dry weight (g) | Moisture content (%) |
|---------|-----------------|----------------|----------------|----------------------|
| 1. | Cowdung | 1.31 | 0.43 | 204.65 |
| 2. | Red earth | 2.34 | 2.18 | 7.34 |
| 3. | Super phosphate | 2.01 | 1.64 | 22.56 |
| 4. | Lime | 1.81 | 0.93 | 94.62 |
| 5. | Wood ash | 1.35 | 1.07 | 26.17 |
| 6. | Gypsum | 1.80 | 0.70 | 157.14 |
| 7. | Lignite | 1.88 | 1.09 | 72.48 |
| 8. | Silt | 1.86 | 1.25 | 48.80 |
| 9. | White clay | 2.32 | 1.83 | 26.78 |
| 10. | Press mud | 1.21 | 1.06 | 14.15 |

The quantity of materials required to prepare 110000 pellets ha⁻¹ (optimum population per meter square is 11) was worked out and presented in Table 2. The requirement of cowdung was found to be less with 47 kg ha⁻¹ as compared to other materials. The materials used must be weaken or break down easily when come in contact with water to prevent any physical impedance for seed germination (Biradar, 1988). Hence the time taken for disintegration was studied and that gypsum pellet disintegrated very quickly and released the seed. Though cowdung pellet did not disintegrate, it absorbed the moisture and retained for longer time.

Table 2. Physical properties of materials

| Sl. No. | Materials | Qty. of water required for pellet preparation Lit ha ⁻¹ | Qty. of materials required (kg ha ⁻¹) | Time taken for disintegration (minutes) |
|---------|-----------------|--|---|---|
| 1 | Cowdung | 97.80 | 47.00 | Does not disintegrate |
| 2 | Red earth | 18.60 | 238.80 | 7 |
| 3 | Super phosphate | 41.70 | 180.00 | 15 |
| 4 | Lime | 97.80 | 102.00 | Does not disintegrate |
| 5 | Wood ash | 31.80 | 118.00 | 5 |
| 6 | Gypsum | 121.00 | 77.00 | 1 |
| 7 | Lignite | 87.90 | 120.00 | 2 |
| 8 | Silt | 68.10 | 138.00 | 240 |
| 9 | White clay | 54.90 | 201.00 | 3 |
| 10 | Press mud | 17.50 | 117.00 | 180 |

The germination of seeds (Table 3.) was significantly influenced by different pelleting materials. Between the two groups there was no significant difference in germination per cent. However, considering the practical utility

STUDIES ON CONTROL OF TRIANTHEMA ON SESAME

Sesame (*Sesamum indicum* L.) is sown as irrigated crop after the harvest of rice in Cauvery Delta Zone (CDZ) in North Western Zone (NWZ) of Tamil Nadu during February-March in a rice based cropping system. Weeds are one among the reasons referred for lower yield in sesame. (Swaminathan, 1980). The yield loss in sesame due to weeds is estimated to be between 49 to 70 per cent (Subramanian and Sankaran, 1977). A weed free environment is absolutely necessary from 15 to 30 DAS, (As-thana *et al.* 1982). Even though the manual weeding is the common practice, it is time consuming process, cumbersome and expensive (Ghosh and Mukhopadhyay, 1980). Herbicides offer effective weed control, (Gupta *et al.*, 1978).

At Cauvery Delta Zone and North Western Zone, the weed *Trianthema protulacestrum* causes severe damage to sesame, which germinates, between 20 and 30 DAS of sesame. Canal irrigation coupled with continued application of Farm Yard Manure (which contain weed seeds) and field to field irrigation to previous rice crop were the identified reasons for the carry over of weed seeds.

The on-station findings of pre-emergence application of herbicides (application of herbicides with in 3 days of sowings) does not work under this situation, since the weed seed germinates only after 20 DAS. Hence on farm research trials were conducted under farmers, holdings to find out suitable management technology to control this problematic weed at Cauvery Delta Zone and North Eastern Zone during summer, 1992.

The test crop was TMV.6 sesame. The treatments studied at Cauvery Delta Zone were : Pre-sowing incorporations of alachlor at 2 kg ai ha⁻¹ + pre-emergence application of alachlor at 1.25 kg ai ha⁻¹ on 20th day after hand hoeing followed by irrigation (t₁) and pre-

emergence application of alachlor at 2 kg ai ha⁻¹ on 20th day after hoeing followed by irrigation (t₂). These two herbicide application methods were evaluated under stale bed preparation (a₁) and non stale bed preparation (a₂). The plot size was 1000m². Recommended management practices were adopted. The stale and non stale bed preparations were done as follows.

Stale bed preparation

Rice-harvest-two ploughings with optimum soil moisture and drying-one pre-sowing irrigation to induce weed germination 17 days before proposed sesame sowing-Two ploughings on the 5th day of irrigation to kill the germinating weeds-Another two ploughings 10 days after irrigation - 2nd pre-sowing irrigation on 14 days after first pre-sowing irrigation- on the 3rd day of 2nd pre-sowing irrigation, herbicide application and sowing.

Non-stale bed preparation

One pre-sowing irrigation 3 days before proposed sesame sowing-on the 3rd day of first pre-sowing irrigation, herbicide application and sowings.

The trial was laid out in four villages as replication units and sowing was done on 4.3.1992 (Puduchattiram) on 11.3.1992 (Maharajapuram) on 21.3.1992(Nadupadugai) and on 14.3.1992 (Anbil 3 locations). The recorded sesame yield is presented in Table 1.

At North Western Zone the treatments consisted of pre-sowing incorporation of alachlor at 2 kg ha⁻¹ (a₁); No pre sowing incorporation (a₂); application of alachlor at 1.25 kg ha⁻¹ on 20th day after one hoeing followed by irrigation (b₁) and No application on 20th day (b₂). These were combined to form four treatments per replication. This trial was sown in four villages viz., Poolampatti (26.2.1992);

interior packing of seeds in the packing materials (pellet) found to be superior than exterior pasting of seeds. Pelleting with cowdung or gypsum or press mud and packing of seeds internally registered significantly higher germination per cent (100). There was no significant difference in germination per cent between different packing material in external pasting group seeds except super pellets.

From the above experiment considering the availability and cost, cowdung pellets with interior packing of seeds would definitely pave the way for sowing sesame under line sowing through available seed drills. Cowdung pellets had the following advantages :

1. It is locally and chiefly available, on a commercial basis.
2. Quantity requirement is less.
3. Cowdung pellet is porous and allow movement of air to the seed.

It is not toxic to seed.

It supports extra nutrients to seed.

Further, fundamental studies on storage of seed balls, their germination under field condition, mechanisation of seed ball production are some of the works identified for future work at this Kendra.

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Biradar, B.B. 1988. Precision planting of seed pelleting. *Seeds and Farms*. 14 (5) : 32-34

Gomez, K.A. and Gomez, A.A. 1984. Statistical procedures for Agricultural Research. John Wiley and Sons.

Longden, P.C. 1975. Sugar beat pelleting, *Adas Quart. Rev.* 18 : 73-80

Loneragan, J.F. and Meyer, J.F. 1955. Lime pelleted seed for nodulation on acid soils. *J. Abst. Inst. Agril. Sci.* 21 : 264 - 65.

Miller, W.F. and Sooter, C. 1967. Improving emergence of pelleted vegetable seed. *Transactions of the ASAE* : 658-666.

hoeing followed by irrigation (1144 kg ha^{-1}). The control did record only a lower yield of 946 kg ha^{-1} . The increase in yield for $a_1 b_1$ was 34 percent over $a_2 b_2$.

The results of both Cauvery Delta Zone and North Western Zone has proved the re-

quirement of herbicides application both at the time of sowing as well as on 20th day to control the trianthema weeds. Since the severity was much more greater at CDZ as compared to NWZ, integration of stale bed preparation is a required element along with herbicide application.

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Asthana, K. S., Nasifalli, S. and Roy, S.N. 1982. Sure, sesamum can do better. *Intensive agric.*: 15-16.

Balasubramanian, T.N., Palaniappan, S.P., Sivanatham, M. and Somasundaram, D. 1990. Technology design and testing relationship between on station and on-farm research for sesame based cropping system. Abstract. Asian Farming System Research and Extension Symposium, 19-21 Nov. 1990, Bangkok : 49.

Ghosh, D.C. and Mukhopadhyay, S.K. 1980. Weeds and weed control in sesame. *Pesticides* 14 (11) : 24-29.

Gupta, R.K., Singh, S.S. and Ghosh, A.K. 1987. Response of groundnut (*T64*) to chemical weed control in the presence and absence of lime, *Pestology*. 11-12: 45.

Subramanian, A. and Sankaran, S. 1977. Studies on relative efficiency of pre-emergence herbicides in the sesame under graded levels of nitrogen. Proceedings of ISWS/APAU. Weed Science conference, Hyderabad.

Swaminathan, M.S. 1980 National programme for increasing the production of pulses and oilseeds during 1979-90. *Pestology*. 4(3) : 36-37.

Nedunkulam (1.3.1992), Devoor (1) (23.2.1992) and Devoor (2) (1.3.1992). Recommended management practices were adopted. The recorded sesame yield is furnished in Table 2.

crop growth. It was reported that, application of alachlor at 2 kg ha⁻¹ as sand mix during first crop irrigation (20 DAS) had controlled trianthena weeds effectively with 20 per cent phytotoxic symptoms (97 per cent weed control

Table 1. Sesame yield kg ha⁻¹ (CDZ)

| Tr. V | Puduchetti- ram | Maharaja- puram | Nadupadugai | Anbil (1) | Anbil (2) | Anbil (3) | Mean |
|-------|--------------------|--------------------|-------------|-----------|-----------|-----------|------|
| a1 t1 | 866 | 2325 | 1391 | 1030 | 1179 | 2684 | 1579 |
| a1 t2 | 734 | 2256 | 1349 | 920 | 1072 | 2420 | 1458 |
| a2 t1 | 493 | 2165 | 1150 | 990 | 1008 | 977 | 1131 |
| a2 t2 | 405 | 2142 | 1133 | 860 | 927 | 932 | 1067 |
| Mean | 625 | 2222 | 1255 | 950 | 1046 | 1753 | 1309 |

SE_d = 196; CD at (P = 0.05) = 409.6

Higher yield of 2222 kg ha⁻¹ was recorded at Maharajapuram village followed by one location (3rd) at Anbil. Due to black-stem disease, the yield level was brought down at Puduchattiram village.

There was statistical difference between treatments evaluated. The treatment a₁ t₁ (Stale bed preparation + pre-sowing incorporation of alachlor at 2 kg ha⁻¹ + pre-emergence application of alachlor at 1.25 kg ha⁻¹ on 20th day after one hoeing followed by irrigation) had shown significantly higher yield with better *Trianthema* weed control. This treatment was comparable with a₁ t₂ (Stale bed preparation + pre-emergence application of alachlor at 2 kg ai ha⁻¹ on 26th day after one hoeing followed by irrigation).

The increase in yield for a₁ t₁ over a₂ t₂ was 48 per cent. Both pre-sowing and pre-emergence application of herbicides were required in order to control the trianthena weeds, since for the past ten years, there was heavy accumulation of trianthena seeds in the soil profile. It was also observed with the application of herbicides on 20th day that there was 5 per cent phytotoxic symptom upto one week and there upon it disappeared with fresh

with 0 weed index against 25 weed index in control plots) (Balasubramanian, *et al.*, 1990). Hence with the combination of stale bed preparation, the level of phytotoxic symptoms on crops got reduced. In the case of North Western zone, the result, on sesame yield is given in Table 2.

Table 2. Sesame yield kg ha⁻¹ (NWZ)

| T L | Poolam- patti | Nedun- kulam | Devoor (1) | Mean |
|-------|------------------|-----------------|---------------|------|
| a1 b1 | 1190 | 1190 | 1429 | 1270 |
| a1 b2 | 1138 | 952 | 1234 | 1108 |
| a2 b1 | 1134 | 1049 | 1250 | 1144 |
| a2 b2 | 800 | 866 | 1172 | 946 |
| Mean | 1066 | 1014 | 1271 | 1117 |

SE_d = 58.04; CD at (P = 0.05) = 142.00

There was significant difference between treatments evaluated. The treatment pre-sowing incorporation of alachlor at 2 kg ha⁻¹ + application of alachlor at 1.25 kg ha⁻¹ on 20 day after one hoeing followed by irrigation had recorded the highest yield of 1270 kg ha⁻¹ with better trianthena control (a₁ b₁) and this was comparable with the treatment (a₂ b₁) no pre-sowing incorporation plus application of alachlor at 1.25 kg ha⁻¹ on 20th day after one

investigator(s) duly authenticated by the Head of the institution where it was carried out, and

- d) detailed technical report as per proforma given below.
- ii) Nominations should reach the General Secretary, Indian Society of Oilseeds Research, Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030 by January 31, 1994

Judging Committee

- i) Consists of (a) **President of Indian Society of Oilseeds Research** or his representative from Executive Committee, (b) Director of IARDF or his representative and (c) three experts in each disciplines nominated by the President or Executive Committee of ISOR.
- ii) In all matters relating to the awards, the decision of the Judging Committee is final and no correspondence on this account shall be entertained.

PROFORMA FOR TECHNICAL REPORT OF THE WORK TO BE SUBMITTED FOR IARDF AWARDS

1. Title of the Project/Research Programme
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3. Investigator(s) with proportion of contribution of each
4. Year of initiation
5. Year of completion
6. Brief background of the project indicating the importance of the research project/programmes.
7. Objectives
8. Description of the work done.
9. Pooled results
10. Implications of the research work
11. Publications in journals of repute based on results of research work
12. Signature of the investigator (s)
13. Signature of the Head of the Institute.

INDIAN SOCIETY OF OILSEEDS RESEARCH
DIRECTORATE OF OILSEEDS RESEARCH
Rajendranagar, Hyderabad - 500 003

HARDF AWARDS FOR OUTSTANDING OILSEEDS RESEARCH FOR 1991 AND 1992

Background of awards

Indian Society of Oilseeds Research founded in 1983 is a registered society of individuals and organisations/institutions engaged in oilseeds research and development and vegetable oil technology in India. The foremost amongst its objectives is the promotion of research in various aspects of oilseeds production. The society firmly believes that the initiative and dedication on the part of the scientific community is the prime driving force to accelerate the pace of oilseeds research in the country. In our endeavour to recognise outstanding research contributions in various disciplines of oilseeds research and to provide some incentive to the scientists it has been decided to institute fifteen awards, through the kind courtesy of Hexamar Agricultural Research and Development Foundation. The awards are named **HARDF AWARDS FOR OUTSTANDING OILSEEDS RESEARCH**.

Nature of awards

Cash awards of Rs. 3000/- each and a citation in the following disciplines of oilseeds research :

- i) Four awards for varietal improvement of groundnut, rapeseed-mustard, sesame, safflower, sunflower, soybean, castor, linseed and niger.
- ii) Five awards for insect pest management. Of these one each is earmarked for groundnut and rape-seed mustard and the rest for sesame, safflower, sunflower, soybean, castor, linseed and niger.
- iii) Four awards for disease management. Of these one each is earmarked for groundnut and rapeseed-mustard and the rest for sesame, safflower, soybean, castor, linseed and niger.
- iv) Two awards for chemical weed control one each in groundnut and soybean.

Eligibility for awards

- i) All scientists essentially members of Indian society of Oilseeds Research (for atleast three consecutive years preceding the year of awards) and working in research centres or departments or laboratories of universities, research institutes, directorates and na-

tional research centres under ICAR, CSIR, BARC etc., in India.

- ii) Original Research work carried out during 5 years preceding the year of award which has bearing on finding solution to any important problem in the disciplines and crops specified.
- iii) Outstanding basic research leading to inventions or discoveries in the disciplines concerned duly supported by publications in journals of repute.
- iv) Results of routine experiments and the research work already submitted or to be submitted for award of any degree or diploma are not considered.

Presentation of awards

- i) Awards will be presented at Annual General Body Meeting of Indian Society of Oilseeds Research.
- ii) Hexamar Agricultural Research and Development Foundation will pay TA and DA for recipients of awards as per their entitlement.
- iii) Indian Society of Oilseeds Research reserves the right to publish the results of research works selected for the awards and/or submitted for the awards in Journal of Oilseeds Research.

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- i) Nominations for the award may be made by the Directors of Research Institutes, Vice-chancellors of Agricultural Universities and Presidents of recognised scientific societies. The nominations should invariably be accompanied by eight typewritten copies of proposals containing :
 - a) Bio-data giving full name, designation, office address, date of birth, academic qualification starting from Bachelor's degree and experience.
 - b) an abstract of research contribution not exceeding 500 words.
 - c) certificate stating the research work submitted for HARDF award is the original contribution of the

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New Book from ISOR

SUSTAINABILITY IN OILSEEDS

What is the publication about?

This publication is a record of proceedings of the National Seminar on "Oilseeds Research and Development in India : Status and Strategies" held during 2-5, August 1993 in Hyderabad, India. The meeting was co-sponsored by eleven prestigious organisations like ICAR, ICRISAT, NABARD, APSSDC, HARDF, NDDDB, APSAIDC, IOPEA, POC, ITC and MAHYCO. The seminar was organised in five different sessions, and attended by over 500 registrants and special invitees from different sectors within India, added to FAO and ICRISAT. The meeting featured presentations by eminent personalities in oilseeds research, development and allied areas. Also included in the proceedings are around 50 invited presentations, other full papers of the 117 poster presentations and session-wise discussions.

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