Journal of Oilseeds Research

Volume 22
Number 1
June, 2005
ISSN 0970-2776

Indian Society of Oilseeds Research
Estt : 1983

Indian Society of Oilseeds Research
Directorate of Oilseeds Research
Rajendranagar, Hyderabad-500 030, India

THE INDIAN SOCIETY OF OILSEEDS RESEARCH

(Founded in 1983, Registration Number ISSN 0970-2776)

Journal of Oilseeds Research is published biannually by the Indian Society of Oilseeds Research

ISSN 0970-2776
Volume 22
Number 1
June, 2005

Journal of OILSEEDS RESEARCH

DOR-367

Contents

Research Papers

Official publication of
The Indian Society of Oilseeds Research, Hyderabad
***J. Oilseeds Res.,* 22(1) : 1-239 (June, 2005)**

Short Communications

J. Oilseeds Res., **22**(1) : 1-4 (2005)

Review Article

Confectionery groundnuts : issues and opportunities to promote export and food uses in India

S.L. Dwivedi and S.N. Nigam

International Crops Research Institute for the Semi-Arid Tropics, Patancheru-502 324, AP.

(Received: July, 2003; Revised: June, 2004; Accepted: September, 2004)

Abstract

Aflatoxin contamination, presence of chemical residues and high fat content have potential to adversely affect the use of groundnut as food worldwide. Substantial genetic variability exists for physical, sensory, chemical and nutritional traits in groundnut and efforts to incorporate these quality traits into different genetic background have been partially successful in India. With the availability of high oleic fatty acid germplasm in ICRISAT, it should now be possible for breeders in India to incorporate this unique trait into locally adapted cultivars by backcross breeding. The critical issues that may limit the progress in quality breeding are stability of seed mass, crop duration and seed mass, crop duration and degree of resistance, shelf-life and nutritional quality, and freedom from aflatoxin, and these issues must be addressed by plant scientists to make rapid progress in breeding for improved seed quality in groundnut. The confectionary groundnut trails in AICRPO-G should be taken into consideration for identifying varieties for release in India. Contract farming may be explored for commercial production of good quality nuts. A close linkage with farmers, processors/millers, exporters and consumers is vital for promoting export and enhancing domestic use of groundnut as food among rural folks in India.

Key words: Groundnut, *Arachis hypogaea*, quality breeding, seed mass, oil content, aflatoxin contamination, pesticides residues

Groundnut quality

Groundnut is a rich source of oil, protein, minerals and vitamins. Various physical, sensory, chemical and nutritional factors determine the quality of groundnut seed. Physical factors include consistency of seed mass and shape, integrity of seed testa, absence of foreign materials and immature seeds, integrity of the seed at the time of processing and blanching efficiency. Pod colour, size, shape and texture, cleanliness and freedom from damage and absence of blind nuts (pops) influence the quality of 'in-shell' boiled or roasted nuts. Sensory factors include seed colour, texture, flavour and wholesomeness. Chemical and nutritional factors include oil and protein contents, amino acid and fatty acid composition, carbohydrates, minerals and vitamins. Various end-uses also have their specific quality requirements. A confectionery groundnut cultivar must provide a consistent product.

Amino acids and monosaccharides are the precursor of roasted groundnut flavour. Aspartic, glutamic, glutamine, aspergine, histidine and phenylalanine are associated with the production of typical roasted flavour while threonine, tyrosine, lysine and unknown amino acids are associated with the production of atypical flavour in groundnut seed (Newell *et al.*, 1967).

Oleic (O) and linoleic (L) fatty acids together account for 75 to 80 % of the total fatty acids in groundnut seeds (Dwivedi *et al.*, 1993). O/L ratio and iodine value (IV) determine the shelf-life of oil and other groundnut products. The higher the O/L ratio and the lower the IV, the longer the shelf-life of groundnut oil and its products (James and Young, 1983; Branch *et al.*, 1990). The IV (the number of grams of iodine equivalent to halogen reacting with 100 g of lipid) measures the susceptibility of fatty acids to oxidation (rancidification). The acid value or percentage free fatty acid of a lipid indicates the extent of hydrolysis that has occurred in a fat. It is also related to the oxidative stability of the oil.

Challenges to quality in groundnut

Several factors are important in ensuring quality in groundnut products. These issues are particularly important in view of growing consumer awareness and concern about potential health hazards.

Aflatoxin: Aflatoxin contamination is a serious quality problem in groundnut. It is a key consideration in international trade; some countries demand complete freedom from aflatoxin in groundnut. Countries wishing to enter the edible trade market will have to ensure freedom from aflatoxin in their produce.

Chemical residues: Presence of chemical residues in food chain is increasingly attracting consumer's concern. Most edible-grade groundnut is generally grown under high-input management, which includes the use of pesticides. Excessive use of pesticides can adversely affect the quality of the produce. Search for alternatives to chemical control and judicious use of pesticides requires immediate attention of scientific community.

Fat content: Because of health considerations, consumers prefer low-caloric foods and beverages. Technology to reduce the fat content in groundnut seed is available, but, it increases the cost of the finished product. Narrow genetic variability for oil content limits the scope for substantial reduction in oil through conventional breeding.

Certain other quality issues have relevance in the processing and marketing of groundnut products. The issues that most concern to manufactures are (i) excessive foreign material, (ii) seed mass consistency and (iii) the need to provide a reliable consistent product. Failure to address these concerns results in addition processing cost and difficulties in achieving quality levels. The marketing group, who are closest to consumers, seek (i) improved and specific flavour characteristics, (ii) maintenance of a good flavour and aroma throughout processing and on the shelf, (iii) reasonable shelf-life, (iv) improved appearance and (v) product distinctiveness.

Variability in seed quality traits

Physical and sensory traits: Large genetic variability exists for pod length (14-65 mm), pod width (7-20 mm), seed length (4-23 mm), seed width (5-13 mm), 100-seed mass (14-140 g) and seed colour (20 different colours) among the 14000 germplasm accessions evaluated at ICRISAT, Patancheru, India. The preferred seed colours for edible groundnuts are tan or red. Round or elongated seeds with tapering ends are preferred to those with flat ends.

Roasted groundnuts have characteristics flavour attributes. Various desirable (almond, coffee, fresh, nutty, popcorn, smoky and sweet) and off-flavour (aerid, astringent, barnyard, beany, bite, burnt, cardboard, earthy, green, machine oil, mealy, medicinal metallic, musty, onion, off-sweet, oily, rancid, raw, rotten, soapy, solvent, sour, stale, unclean and woody) attributes have been reported in roasted groundnut (Fletcher, 1987). Roasted groundnuts possess a firm and crispy texture. The consumers do not like soft or mushy roasted groundnuts.

Chemical and nutritional traits: In 8000 germplasm accessions analysed at ICRISAT, a range of 32% to 55% for oil and 16% to 34% for protein was observed. However, these ranges of variations were not maintained when selected genotypes with such variation were tested over seasons and locations (Dwivedi *et al.*, 1993). The O/L ratio among 200 germplasm lines of different botanical groups ranged from 0.84 to 1.36 in the Spanish/Valencia group and from 1.0 to 2.2 in the Virginia group. Two breeding lines originating from the natural mutation in Florida, USA, are reported to have very high O/L ratios (=40) (Norden *et al.*, 1987). However, this unique genetic material, because of the pending patent in USA is not available to other researchers for use in breeding. Using this natural variation for high O/L ratios, high yielding large-seeded cultivars such as Sun Oleic 95R and Sun Oleic 97R in USA have been released for commercial cultivation (Gorbet and Knauft, 1997; 2000). In South Africa, two breeding lines (PC 223-K8 and PC 223-K9) with high O/L ratios have been developed. ICRISAT has acquired the seeds of Sun Oleic 95R, PC 223-K8 and PC 223-K9. The former belongs to Virginia runner group while the later two belongs to Spanish bunch group. Groundnut researchers in India could acquired these lines from ICRISAT for use in breeding programmes.

Issues in quality breeding

Raising a good quality groundnut crop requires a high standard of crop husbandry. The crop should not suffer from diseases, insect pests and moisture and nutritional stresses. Further, in the Asian context, the crop duration should be short. Seed mass and productivity should be stable over years and locations. The gains of genetic improvement in quality breeding can easily be nullified by improper post-harvest handling of the crop. Improved post-harvest technology should be used for curing and drying the produce. The produce should be stored in good storage conditions to avoid post-harvest aflatoxin contamination.

There is a lack of full understanding of the quality parameters associated with different end uses. Manufactures and processors generally do not part with the information due to competition within the trade.

Stability of seed mass: Seed mass is highly influenced by genotype x environment interaction. The physiological reasons for such instability in seed mass are not well understood. Multilocational testing is essential to select (i) germplasm with stable seed mass for use in breeding and (ii) breeding lines with good seed quality for commercial exploitation.

Crop duration and seed mass: Most of the present day large seeded cultivars are of relatively long duration. Generally, as the seed mass increases the duration of the crop also increases. In the Asian context, short-duration cultivars with large seeds are required. A better understanding of the physiological processes involved in crop maturity and seed mass accumulation will help breeders to de-link this association between maturity duration and seed mass. Some progress has already been realised to develop breeding lines with early maturity and relatively large-seed (50-60 g/100 seed) at ICRISAT.

Crop duration and degree of resistance: Rust and leaf spots are the major foliar diseases of groundnut. In addition to causing substantial yield losses, they also affect seed quality adversely (Dwivedi *et al.*, 1996). Whenever genetic resistance to foliar diseases is incorporated or the diseases are controlled by chemical means, the crop duration is increased. What level of genetic resistance should be incorporated into improved genotypes or what degree of chemical protection one should give to the crop without increasing the crop duration and impairing quality require more studies.

Shelf-life and nutritional quality: Both oleic and linoleic, the two unsaturated fatty acids are nutritionally important. Linoleic acid is also associated with the stability of oil and groundnut products. Groundnut products or oil obtained from cultivars with high linoleic acid content have shorter shelf-life than those obtained from cultivars with lower linoleic acid content. Oleic and linoleic acids are strongly negatively correlated (Dwivedi *et al.*, 1993). A balance between shelf-life and nutritional requirements should be aimed at in a breeding programme.

Freedom from aflatoxin: Genetic resistance to pre-harvest infection and in vitro seed colonization by *Aspergillus flavus* and aflatoxin production coupled with good crop husbandry helps to minimize aflatoxin contamination in groundnut. However, conventional methods are not sufficient to ensure complete freedom from this contamination. Current research on aflatoxin is focused on understanding its biosynthetic pathway to identify the precursor and enzyme that catalyze the conversion of this precursor into aflatoxin B1. Lipoxygenase (LOX) enzymes and their products could play a role in the *Aspergillus* - seed interaction. The C6-C12 products of the LOX pathway inhibit *Aspergillus* spore germination (Zeringue *et al.*, 1996) and metnyl asmonate inhibits aflatoxin biosynthesis but not fungal growth (Goodrich-Tanrikulu *et al.*, 1995). Peanut seed lipoxygenase gene has been cloned and characterized (Burow *et al.*, 2000). Some of the cloned genes of aflatoxin biosynthetic pathway can be effectively utilized to induce resistance to aflatoxin production. Excellent progress has been reported in development of an efficient tissue culture and transformation systems to introduce foreign DNA into groundnut (Sharma and Anjaiah, 2000) and work is in progress to develop transgenic groundnut with resistance to aflatoxin production at ICRISAT (K.K. Sharma, personal communication).

Prospects in quality breeding

With the availability of several high-yielding large-seeded sequentially branched breeding lines maturing earlier than many Virginia types and elite lines (Sun Oleic 95R, PC 223-K8 and PC 223-K9) with high O/L ratio (=10-20), it should now be possible to develop groundnut varieties that combine early maturity (100 days), large-seed size and high O/L ratio. Two duplicate recessive genes control high oleic acid in groundnut (Moore and Knauft, 1989) and it should be easy to transfer this trait into different genetic background by backcross breeding. Early maturing large seeded cultivars will have a prominent place in South and Southeast Asian agriculture. To make breeding efforts more directed, guidelines are required on minimum acceptance standards of various quality parameters.

Breeding efforts must accompany developments in crop husbandry. To achieve the potential of confectionery cultivars, a suitable package of production technology is required, which will address issues related to seed quality. The package must be environmentally safe and economical to adopt.

India - a case of missed opportunities

China, India, Indonesia, Myanmar and Vietnam in Asia, Nigeria, Sudan, Chad and Cango in Africa, USA in North America and Argentina in Latin America are the major producer of groundnut worldwide. However, the groundnut export is dominated by China, USA and Argentina. Until 1976, India contributed substantially to the world edible groundnut trade. However, in subsequent years export from India became almost negligible and this vacuum was filled mainly by China and Argentina. In the past groundnut was mainly crushed for edible oil in India with less than 5 per cent used for food purpose. There is now a growing interest for both to revive groundnut trade and also promote the use of groundnut as food crop.

The groundnut trade in the past in India was restricted to handpicked selected seeds from otherwise small-seeded cultivars, mainly because of non-availability of large-seeded cultivars with good seed quality. There is an urgent need to identify suitable cultivars with desirable traits to boost India's share of the world market and to promote the use of groundnut as a food among the rural folks in India. Policy decisions adversely affecting access to world markets act as a disincentive to growers, marketers and manufacturers. As the growers lose interest, the breeding efforts become redundant and are often discontinued. Continuity in breeding efforts in India is essential if we are to sustain and improve upon the achievements of genetic gains made so far in quality breeding. Until now the germplasm with high O/L ratios was not available to groundnut researchers in India. However, with the availability of such materials (Sun Oleic 95R, PC 223-K8 and PC 223-K9) at ICRISAT, it should now be possible for groundnut researchers in India to obtain these lines from ICRISAT for enhancing the seed quality of locally adapted groundnut cultivars in India. In many Asian countries including India freshly harvested groundnuts are boiled in saline water and eaten. Large-seeded Valencia groundnuts with 3-4 seeded pods are most preferred class for 'in-shell' boiled nuts use as they are low in oil and sweet in taste. Few germplasm lines (ICG 326, ICG 1307, ICG 2148 and ICG 6224) with such characteristics are available in ICRISAT gene bank (Dwivedi and Nigam, 2003).

There is also a need to revisit the way the trails for confectionery (edible grade) groundnuts are conducted under AICRPO-G. Indian programme in the past tested several large-seeded breeding lines from its own programme as well as ICRISAT under AICORP-G trials. However, none of these could be identified for release mainly because of the faulty system of evaluation. Often these trials are conducted under sub-optimal conditions whereas production of good quality nuts requires that the crop should be grown under high input conditions (20:60:20 NPK/ha : gypsum application @ 400 kg/ha; full irrigation; full protection of pests and diseases) and the crop should be allowed to maturity. Superiority in pod yield has been the main criterion for variety identification ignoring the quality traits (uniformity in seed size and shape, oil content and O/L ratio). A few cultivars though identified and released but were unsuccessful on farmers' fields as these were of late maturity types and appropriate crop husbandry was not worked out for raising good quality nuts. To make the cultivation of confectionery groundnuts success in India, it is also necessary to map the growing regions in the country wherein the good quality groundnut could be grown with minimum risk of aflatoxin contamination. Contract farming may be explored in areas wherein the farmers have large-holdings, inputs are not the constraints and there exists a good infrastructure to take care of post-harvest curing, storage and marketing problems. Linking of farm produce directly with processors/millers and exporters should enable farmers to command a premium price to their good quality nuts. There is also a need to educate producers, processors, millers and exporters for problems/losses associated with post-harvest and storage conditions that often, if sub-optimal, deteriorate the seed quality in groundnut.

References

Branch, W.D., Takayama, T. and Chinan, M.S. 1990. Fatty acid variation among US runner type peanut cultivars. *Journal of American Oil Chemical Society*, **67**:591-593.

Burow, G.B., Gardner, H.W. and Keller, N.P. 2000. A peanut seed lipoxygenase responsive to *Aspergillus* colonization. *Plant Molecular Biology*, **42**:689-701.

Dwivedi, S.L. and Nigam, S.N. 2003. *Variation in* seed and pod characteristics in relation to cooking time among Valencia groundnut (*Arachis hypogaea* L.) germplasm. *Journal of Oilseeds Research*, **21**(2) : 16-24.

Dwivedi, S.L., Nigam, S.N., Jambunathan, R., Sahrawat, K.L., Nagabhushanam, G.V.S. and Raghunath, K. 1993. Effect of genotype and environment on oil content and oil quality parameters and their correlation in peanut (*Arachis hypogaea* L.). *Peanut Science*, **20**:84-89.

Dwivedi, S.L., Nigam, S.N., Nageswara Rao, R.C., Singh, U. and Rao, K.V.S. 1996. Effect of drought on oil, fatty acids and protein contents of groundnut (*Arachis hypogaea* L.) seeds. *Field Crops Research*, **48**:125-133.

Fletcher, M.M. 1987. Evaluation of peanut flavor quality. In: *Peanut Quality : Its Assurance and Maintenance from the Farm to End-Product*. E.M. Ahmed and H.E. Pattee (Eds.). Agricultural Experiment Station, Institute of F o o d and Agricultural Sciences, University of Florida, Gainesville, pp.60-72.

Goodrich-Tanrikkulu, M., Mahoney, N. and Rodriguez, S.B. 1995. The plant growth regulator methyl jasmonate inhibits aflatoxin production by *Aspergillus flavus*. *Microbiology*, **141**:2831-2837.

Gorbet, D.W. and Knauft, D.A. 1997. Registration of Sun Oleic 95R peanut. *Crop Science*, **37**:1392.

Gorbet, D.W. and Knauft, D.A. 2000. Registration of Sun Oleic 97R peanut. *Crop Science*, **40**:1190-1191.

James, S.L.H. and Young, C.T. 1983. Comparison of fatty acid content of imported peanuts. *Journal of American Oil Chemical Society*, **60**:945-947.

Moore, K.M. and Knauft, D.A. 1989. The inheritance of high oleic fatty acid in peanut. *Journal of Heredity*, **80**:252-253.

Newell, J.A., Mason, M.E. and Matlock, R.S. 1967. Precursor of typical and atypical roasted peanut flavor. *Journal of Agriculture and Food Chemistry*, **15**:767-772.

Norden, A.J., Gorber, D.W., Kanuft, D.A. and Young, C.T. 1987. Variability in oil quality among peanut genotypes in the Florida breeding program. *Peanut Science*, **14**:7-11.

Sharma, K.K. and Anjaiah, V. 2000. An efficient method for the production of transgenic plants of peanut (*Arachis hypogaea* L.) through *Agrobacterium tumefaciens*-mediated genetic transformation. *Plant Science*, **159**:7-19.

Zeringue, H., Brown, R., Neucere, J. and Cleveland, T. 1996. Relationship between C6-C12 alkanal and alkenal volatile contents and resistance of maize genotypes to *Aspergillus flavus* and aflatoxin production. *Journal of Agriculture and Food Chemistry*, **44**:403-407.

J. Oilseeds Res., **22(1)** : 5-11 (2005)

Review Article

Conservation and management of water in safflower, *Carthamus tinctorius* L. - A review

P. Padmavathi

Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, AP

(Received: April, 2004; Revised: September, 2004; Accepted: November, 2004)

Abstract

Safflower (*Carthamus tinctorius* L) is an important *rabi* oilseed crop grown under receding moisture conditions on Vertisol in the states of Maharashtra and Karnataka and to some extent in Andhra Pradesh. Soil and water conservation practices have been developed and were quite effective in conserving the soil moisture. In nontraditional areas it is grown under irrigated conditions and crop requires 1 to 3 irrigations in Vertisols depending on the amount of moisture stored in the soil. Provision for proper surface drainage is as important as that of conservation of rain water to improve the productivity of crop. In light soils it requires 3 to 4 irrigations for successful crop production. The response of crop to irrigation was found to increase in conjunction with nutrients application.

Key words: Irrigation, water conservation, safflower

Introduction

Safflower, *Carthamus tinctorius* L. is a member of the family Compositae (Asteraceae), cultivated mainly for its seeds, which yield edible oil. Traditionally, the crop was grown for its flowers, used for colouring and flavouring foods and making dyes. Their importance continued until the synthetic dyes pushed them to the background and the seed oil gained its importance as a source of good edible oil because of its richness in the unsaturated fatty acid i.e., linoleic acid.

It is one of the important *rabi* oilseed crops of India and is cultivated on a wide range of soils ranging from light to heavy soils. In Karnataka and Maharashtra, it is grown on Vertisols and in other states it is cultivated on sandy loams, clay loams and alluvials under irrigated and rainfed conditions. Majority of its area (97%) is concentrated in states of Maharashtra, Karnataka and Andhra Pradesh. On heavy soils it can follow an early *kharif* crop and may often be the single crop of the *rabi* season. On lighter soils it is almost entirely irrigated and may be strip cropped with a cereal or legume (Chavan, 1961).

It is well established that among the management factors, productivity of any crop or cropping system depends to a greater extent on the amount of water stored in the soil profile and amount of irrigation water given to the crop. Adopting suitable water conservation practices and irrigation management practices can substantially increase productivity of rainfed and irrigated safflower respectively. Even on certain irrigable lands only one or two irrigations can be provided due to limited water resources. Hence this resource should be efficiently utilized to achieve maximum benefit.

The research work done related to conservation and management of water for sustainable production of safflower under rainfed and irrigated conditions has been reviewed (Table 1 and 2).

Crop water requirement

Safflower is a drought tolerant crop and is able to extract moisture from deeper layers of soil. The seasonal consumptive use of the crop is 250-300 mm. It is tolerant of water stress at rosette stage. However water stress during period of maximum growth (elongation stage to flowering) will cause marked reduction in growth. Moisture stress during flowering and seed filling stages will reduce yield and hasten maturity. Yield-water relationship is quadratic in safflower. The crop is sensitive to high soil moisture during seedling and maturity phases and to soil water stress during maximum vegetative growth and flowering phases (Sondge *et al.*, 1992). The low soil moisture need at initial and post flowering stages provides the explanation for safflower thriving better on residual soil moisture (Venkataraman *et al.*, 1982).

Water conservation

If the amount of soil moisture stored in the soil is sufficient for growth of the crop, the crop never responds to irrigation. If the soil profile is fully saturated at planting, which can accommodate about 250 mm of available soil moisture, the crop seldom responds to irrigation (Hegde, 2002a). If the soil moisture in the seed zone is not adequate for germination, one light presowing irrigation is needed. Later, depending on the soil moisture status, one irrigation at 35 days after planting in early elongation stage and another at 65 to 70 days during flowering stage are required for good crop yields (Hegde, 2002b).

Soil and water conservation practices: Soil and moisture conservation practices are the basis for successful safflower production programme especially in areas where it is raised as a mono crop on conserved soil moisture in large tracts of traditional safflower growing areas. In these areas it is very important to check soil erosion and conserve maximum amount of rainwater by following appropriate soil and moisture conservation practices. In low to medium rainfall areas graded bunds combined with interterrace cultivation across slopes have been found effective in checking runoff and soil erosion and provide more opportunity time for rainwater to infiltrate into the soil. In inter bunded areas formation of compartmental bunds (4.5 m x 4.5 m) would be very useful for conserving rainwater in low rainfall areas (Radder *et al.*, 1991). Opening furrows every 3 m and tieing the furrow after every 10 m was found very effective in conserving moisture and increasing the yield of safflower in Telangana area (Anonymous, 1996; Hegde and Koli, 1997). Border method of planting (skipping one row of safflower after every 2 rows and opening a furrow) was very effective in conserving moisture and increasing the yield of safflower in Solapur (Hegde and Koli, 1997). The conventional harrowing 3 to 4 times during the monsoon has been found as effective as deep ploughing in controlling weeds and conserving moisture in black soils (Anonymous,1986).

Mulching and antitranspirants: Attempts are made to minimize water loss by reducing transpiration and evaporation by use of antitranspirants and mulches without adverse effect on crop growth. Application of mulch with paddy straw, maize straw, pearlmillet husk has been found to be effective compared to dust mulch and one intercultivation in controlling evaporation and increased the seed yield of safflower (Chordia and Gaur, 1986; Sachan and Bhan, 1986a; Sachan, 1986; 1987; Chaudhary *et al.*, 1997; Patel and Patel, 1997). PMA and kaolin were tried, which increased the seed yield by 32% (Patel and Patel, 1997).

Water management

Irrigation water is a monetary input in crop production and hence its management is very essential for maximizing crop yield. Safflower is usually grown on marginal and submarginal lands with low levels of input and management (Garg and Bhan, 1979). Though safflower is hardy and has ability to do well on soils of poor fertility nevertheless it has been found to respond well to irrigation (Singh and Yusuf, 1981; Bhan and Khan, 1982).

Soil type determines the amount of water per irrigation and number of irrigations to crop. Safflower is sensitive to excess moisture, in such situations crop becomes susceptible to a variety of fungal diseases. In poorly drained soils like heavy black soils, improper surface irrigation may lead to prolonged waterlogging conditions and the associated problems of wilts and root rots (Hegde, 2002a). Under irrigated conditions, safflower can give almost double the yield of rainfed crop. Under scanty soil moisture conditions in drylands, yield can be boosted by 40 to 60% by providing one life saving irrigation (5 to 8 cm) at critical phases of crop growth (early stem elongation or flowering) or before soil moisture becomes limiting for crop growth (Hegde, 2002b). In heavy soils, crop response to irrigation depends on the amount of moisture stored in the soil. In these soils crop requires 1 to 3 irrigations during critical stages (maximum vegetative growth and flowering) of crop growth. In light soils, crop needs 3 to 4 irrigations including preplanting irrigation for successful crop growth. Crop response in terms of seed yield increased with increase in number of irrigations (1 to 4). Very few studies have been conducted on evapometric approach, 0.3 and 0.6 IW/CPE ratios were found to be better at Parbhani and Navsari (MS), respectively. But phenological stage approach was more remunerative than evapometric approach (Sondge *et al.*, 1987).

Interaction: The crop need for irrigation water and nutrients is interrelated. The irrigation can give maximum benefits to the crop only if supply of nutrients during plant growth is maintained in the soil and vice versa. Thus with a given amount of nutrients supplied, oilseeds are producing significantly less seed and require significantly more water (Prihar and Gajri, 1988). Thus interactive technologies related to water and nutrients are herein discussed. Response of crop to nutrients depends on the amount of moisture available in the soil. Very few studies have been conducted to understand the interaction effect between soil and moisture conservation practices and fertilizer application. Under tied ridges and furrows the crop responded even upto 125 % recommended level of NPK application in Telangana area of Andhra Pradesh. Few studies have been conducted to understand the interaction between the mulching and fertilizer application but none of the trials indicated the interaction effect on seed yield. Studies were conducted to understand the interaction effect between irrigation water and nitrogen and phosphorous. Among these, many studies did not discuss the interaction effect and only individual effects were discussed. Fertilizer application (N and P) interacted with irrigation water applied and significantly improved the seed yield and profitability. Safflower responded to N upto 120 kg/ha (depends on soil type and amount of water in the soil profile). Application of N significantly increased the yield under adequate water supply. Application of P_2O_5 upto 20 to 25 kg/ha significantly increased the seed yield under adequate water supply.

Table 1 **Response of safflower to conservation and management of irrigation water**

Location	Soil	Significant response	% increase in seed yield over control	Reference
Allahabad, UP	Alluvial soil	No significant response to irrigation	-	Samarthia and Muldoon, 1995
Jabalpur, MP	Black soil	3 irrigations (6,10, 15 weeks after sowing)	50	Mahapatra and Singh, 1975
Kota, Rajasthan	Black soil	4 irrigations (3,10,13,16 weeks after sowing)	29	
Tarai, UP	Black soil	2 irrigations (6, 15 weeks after sowing)	43	
Dharwad, Karnataka	Black soil	Irrigation 50 mm after 60 mm cumulative can *evaporation*	-	Suryanarayana, 1975
Karnal, Haryana	Black soil	2 irrigations at branching, flowering or at branching, maturity or at flowering, maturity	39 – 42	Rajput *et al.*, 1981
Udaipur, Rajasthan	Black soil	Dust mulch/ maize straw mulch @ 8 t/ha 2 irrigations at preflowering, seed filling stage	9-11 -	Chordia and Gaur, 1986
Parbhani, Maharashtra	Black soil	0.8 IW/CPE	-	Phulari *et al.*, 1986
Ludhiana, Punjab	Black soil	1 presowing irrigation	-	Randhawa *et al.*, 1986
Rahuri, Maharashtra	Black soil	3 irrigations at sowing, branching and flowering	-	Pawar *et al.*,1987
Parbhani, Maharashtra	Black soil	Phenological stage approach is more remunerative than evapometric approach	-	Sondge *et al* 1987
Bijapur, Karnataka	Black soil	Compartmental bunding (4.5 m x 4.5 m)	30	Radder *et al.*, 1991
Rahuri, Maharashtra	Black soil	2 irrigations at rosette stage and 50 % flowering	81	Khade *et al.*, 1991
Kota, Rajasthan	Black soil	3 irrigations (10 cm at presowing + 5 cm at branching + 5 cm at flowering)	-	Ratan Singh *et al.*, 1992
Parbhani, Maharashtra	Black soil	Irrigation at 0.3 IW/CPE	48	Sondge *et al.*, 1992
Akola, Maharashtra	Black soil	4 irrigations at rosette, branching, flowering & seed development Two irrigations at rosette and branching	71 61	Bhalerao *et al.*, 1993
Navsari, Gujarat	Black soil	3 irrigations at grand growth, flowering, seed formation	68	Patel and Patel, 1993a Patel and Patel, 1993b
Navsari, Gujarat	Black soil	0.6 IW/CPE over 0.2 IW/CPE	54	Patel and Patel, 1996a Patel and Patel, 1996b
Navsari, Gujarat	*Black soil*	*Straw mulch* PMA + Kaolin spray	39 32	*Patel and Patel, 1997*
Rahuri, Maharashtra	Black soil	1 irrigation at 30 DAS 2 irrigations at 30 & 60 DAS	28 53	Pawar *et al.*, 1997
Morena, MP	Black soil	1 irrigation at 30 DAS 1 irrigation at 90 DAS	62 56	Sharma et al., 2001
Kanpur, U.P	Sandy loam	1irrigation at preflowering 2 irrigations at preflowering, seed filling	73 147	Garg and Bhan,1977
New Delhi	Sandy loam	4 irrigations at rosette, branching, flowering, seed filling	76	Yusuf *et al.*, 1981
Kanpur, U.P	Sandy loam	Paddy straw mulch + 6 % kaolin spray	74	*Sachan and Bhan, 1986b*
Kalyani, W.B	Sandy loam	3 irrigations at branching, flowering and seed filling 2 irrigations at branching, flowering	113 56	Zaman, 1986, Zaman, 1989 Zaman, 1991, Zaman, 1993
Kanpur, U.P	Sandy loam	Paddy straw mulch @ 2.5 t/ha	44	Sachan, 1987
Kalyani, W.B	Sandy loam	*3 irrigations at branching, flowering, seed filling* Paddy straw 5 t/ha *2 lentil rows in between two safflower rows* 1 irrigation at branching + paddy straw mulch 5t/ha	43 21 9 11	*Zaman and Das, 1990a* Zaman and Das, 1990b
Kanpur, U.P	Sandy loam	1 presowing irrigation + 1 life saving irrigation Paddy mulch @ 5 t/ha	71 24	Chaudhary *et al.*, 1997

Table 2 Response of safflower to conservation and management of irrigation water with nutrient application

Location	Soil type	Significant response	% Increase in seed yield over control	Interaction of water x nutrient	Reference
Jobner, Rajasthan	*Coarse* loamy	*Irrigation at 30 % ASM* 60 kg N + 60 kg P_2O_5 /ha	- 	*Not indicated*	*Bajpai et al., 1978*
Jabalpur, M.P	Clay loam	1irrigation at branching 80-60-40 N P_2O_5 K_2O kg /ha	42 -	Not indicated	Raghu and Sharma, 1978
Kota, Rajasthan	*Clay loam*	Irrigation at 60 % ASM Irrigation at 60 % ASM + 120 kg **N/ha** Irrigation at 60 % ASM + 40 kg P/**ha**	178 215 184	Indicated Significant	Singh and Singh, 1979 Singh and Singh, 1980
Jodhpur, Rajasthan	Clay loam	Optimum water supply (29 cm) 80 kg N /ha	- -	Not indicated	Singh and Yusuf, 1981
Kanpur, U.P	*Sandy loam*	Paddy straw mulching 40 kg N + 40 kg P_2O_5/ha	- -	-	Sachan and Bhan,1986a
Rahuri, Maharashtra	Clay loam	2 irrigations at branching, flowering 2 irrigations at branching, flowering+75 kg **N/ha**	42 70	Indicated Significant	Pisal and Shinde, 1987 Shinde and Pisal, 1993
Udaipur, Rajasthan	Clay loam	1 irrigation at 75 % flowering *1 irrigation at 75 % flowering* + 60 kg **N/ha**	12 29	Indicated Significant	Katole and Meena,1988
Ludhiana, Punjab	Loamy sand	2 irrigations at branching, flowering 40 kg N/ha	51 -	Not indicated	Mahey *et al.*, 1989
Bijapur, Karnataka	Vertisol	Skipping one row after every 2 rows of **safflower** Skipping one row after every 2 rows of **safflower** *with 75 % recommended* NPK	28 -	-	Radder *et al.*, 1991
Sehore, MP	Clay loam	2 irrigations at branching + flowering *2 irrigations at branching, flowering + 20 kg* P_2O_5/ha	56 -	Not indicated	Singh and Singh, **1989**
Kalyani, W.B	Entisol	No response to irrigation *Paddy straw mulch* 30 kg N/ha	- 15	Not indicated	Mandal *et al.*, 1990
Kalyani, W.B	Sandy **loam**	2 irrigations at branching and flowering 3 irrigations at branching, flowering and seed filling *3 irrigations at branching, flowering and seed filling* with 120 kg N/ha	145 197 257	Indicated Significant	Zaman and Das, 1990a & b Zaman *et al.*, 1990 Zaman and Maiti, 1990 Zaman and Das, 1991 Zaman, 1993 Zaman and Maiti, 1993
Bhopal, M.P	Clay loam	3 irrigations at presowing, flowering, seed filling *stage* 3 irrigations + 30 kg N/ha	61	Not indicated	Nimje, 1991
Udaipur, Rajasthan	Clay loam	2 irrigations at branching and flowering 2 irrigations + 60 kg N /ha	34 -	Not indicated	Bansal and Katara, 1993 Katara and Bansal, 1995
Jodhpur, Rajasthan	Loamy sand	42 cm + 100 kg N/ha	-	Indicated Significant	Singh, 1993
New Delhi	Sandy loam	2 irrigations at rosette termination and **flowering** 2 irrigations + 40 kg N /ha	21 -	Not indicated	Gajendra Giri, 1995
Sriganganagar, Gujarat	Sandy loam	2 irrigations at rosette + flowering 2 irrigations + 60 kg P/ha	81 18	*Indicated* Significant	*Ved Singh et al., 1995a* Ved Singh *et a.,l* 1995b
Junagadh, Gujarat	Clay soil	0.6 IW/CPE over 0.4 IW/CPE 50 kg N - 20 kg P_2O_5/ha	11 -	Not indicated	Makavana *et al.*, 1997 Makavana *et al.*, 1996
Pune, Maharashtra	Vertisol	2 irrigations (35 & 75 DAS) 2 irrigations + 50 kg N/ha	71 17	Indicated Significant	Patil and Sabale, 1997a Patil and Sabale, 1997b
Bichpuri, U.P	Sandy loam	1 interculture+pearlmillet husk mulch **@ 2.5 t/ha** One interculture 50 kg N/ha	41 13	Not indicated	Singh and Chauhan, 1999
Solapur, Maharashtra	Black soil	Tied ridges and furrows Border method of planting No response beyond 50 % *recommended* **NPK**	22 33 -	Indicated Significant	Hegde and Koli, 1997
Tandur, A.P	Black soil	Compartmental bunding Tied ridges and furrows 125% recommended NPK	16 22		

Conclusion

1) On the basis of rainfall pattern, soil and water conservation practices have been developed for various locations and were found to be effective in improving the yield levels. 2) Very few studies have been conducted to understand the interaction between the water conservation practices and nutrients under rainfed conditions. 3) Mulching with paddy straw, maize straw and pearlmillet husk were found to be effective in reducing the evaporation. Dust mulch and one intercultivation also increased the yield level by 10 to 20 %. 4) Crop requires 1 to 3 irrigations in Vertisols depending on the amount of moisture stored in the soil. In light soils it requires 3 to 4 irrigations for successful crop production. 5) Many studies have been conducted to understand the interaction between irrigations and fertilizer application but few studies have indicated the interaction effect.

Future research needs

- Mulching with crop residues which do not have economic value have to be explored and studied
- The nature of interaction between nutrients and water needs to be studied with a view to economise and optimize the use of these limited and costly inputs.
- Sulphur is an essential element required by safflower the best combination of S with water has to be developed for different locations.
- Location specific soil and moisture conservation practices x nutrients management technologies have to be generated considering rainfall pattern.
- Thus, both water and nutrients use efficiency has to be increased for higher productivity and sustainability of safflower.

References

Anonymous. 1986. Safflower production technology. *Technologies for better crops.* 29, ICAR, New Delhi.

Anonymous. 1996. *Annual Progress Report, Safflower,* Directorate of Oilseeds Research (ICAR), Hyderabad. pp 65-67.

Bajpai, M.R., Parihar, R.L. and Deshmukh, M.T. 1978. Fertility and water management for safflower. *Annals of Arid Zone,* **17**(3): 298-303.

Bansal, K.N. and Katara, G.S. 1993. Response of safflower to nitrogen and irrigation. *Annals of Arid zone*, **32**(3): 193-194.

Bhalerao, P.D., Jadhao, P.N. and Fulzele, G.R.1993. Response of late sown safflower to irrigation. *Indian Journal of Agronomy*, **38**(1): 150-151.

Bhan, S. and Khan, S.A. 1982. Comparative performance of different rabi oil crops in light textured alluvium of UP. *Indian Journal of Soil Conservation*, **15**(1): 35-38.

Chaudhary, H.P., Pandey, D.K. and Uttam, S.K.1997. Effect of water management practices and inter row spacings on safflower production in eroded soil. *Indian Journal of soil conservation,* **25**(1): 64-67.

Chavan, V.M. 1961. *Niger and Safflower, Indian Central Oilseeds* Committee, Examiner Press, Bombay, India.

Chordia, R.K. and Gaur, B.L. 1986. Effect of irrigation and mulches on seed yield of safflower. *Indian Journal of Agronomy,* **31**(3): 298-299.

Gajendra Giri. 1995. Influence of irrigation and nitrogen on safflower. *Indian Journal of Agronomy*, 40(2): 336-337.

Garg, J.S. and Bhan, S. 1977. Safflower has great potential in UP. *Indian Farming,* **27**(4): 21-22.

Hegde D.M. 2002a. *Package of practices for increasing production – Safflower,* Technical Bulletin, Directorate of Oilseeds Research, Rajendranagar, Hyderabad.

Hegde, D.M. 2002b. Safflower- A successful dryland crop. In *Agrotechnology for dryland farming.* (eds Dhopte, A. M.), pp 517-542.

Hegde, D.M. and Koli, B.D. 1997. Effect of *in situ* moisture conservation practices on the productivity of safflower in India. In Corleto A and Mundel HH (Eds). *IV International Safflower Conference*, BARI, Italy, June 2-7, 1997. pp 58-59.

Katara, G.S. and Bansal, K.N. 1995. Effect of irrigation and nitrogen on yield, uptake and WUE of safflower. *Indian Journal of Agronomy,* 40(2):338-339

Katole, N.S. and Meena, G.P. 1988. Effect of row spacing, N and irrigation on seed yield, oil content and water requirement of safflower. *Indian Journal of Agronomy,* 33(3): 339-341.

Khade, K.K., Dharade, P.B., Patil, A.T. and Pawar, H.K. 1991. Effect of scheduling of irrigation on yield, oil content and uptake of N, P, K by safflower varieties. In Ranga Rao, V and Ramachandram, M (Eds)1991. Proceedings of *II International Safflower Conference* 9-13 January, 1989, Hyderabad, ISOR, Hyderabad, p 301-306.

Mahapatra, I.C. and Singh, N.P. 1975. Water management practices for safflower. *Indian Farming,* **25**(2): 13-14.

Mahey, R.K., Singh, B. and Randhawa, G.S. 1989. Response of safflower to irrigation and nitrogen. *Indian Journal of Agronomy,* **34**(1): 21-23

Makavana, D.R., Sadaria, S.G., Khanpara, V.D., Kaneria, B.B., Mathukia, R.K. 1997. Growth and yield of safflower as influenced by irrigation, nitrogen and phosphorus. *Gujarat Agricultural. University. Research Journal,* 22(2): 110-112

Makavana, D.R., Sadaria, S.G., Khanpara, V.D., Kaneria, B.B. and Mathukia, R.K. 1996. Effect of irrigation, N and P on safflower and economics. *Gujarat Agricultural University Research Journal.* **22**(1): 121-123.

Mandal, B.K., Mandal, B.K. and Das, S.K. 1990. Growth, yield and water use of late sown safflower as influenced by irrigation, nitrogen and mulch. *Indian Journal of Agronomy,* **35**(3): 270-274.

Nimje, P.M. 1991. Influence of irrigation and nitrogen on water use, yield and oil content of safflower. *Indian Journal of Agronomy, 36(suppl): 165-168.*

Patel, N.C. and Patel, Z.G. 1993a. Performance of safflower under different irrigation schedulings in South Gujarat. *Annals of Agricultural Research,* **14**(1): 109-110.

Patel, P.G. and Patel, Z.G. 1996a. Effect of irrigation methods and levels on seed yield and quality of safflower. *Journal of Oilseeds Research,* **13**(1): 53-55.

Patel, P.G. and Patel, Z.G. 1996b. Effect of irrigation on growth, yield and WUE of safflower. *Indian Journal of Agricultural Sciences,* **66**(10):604-606.

Patel. Z.G. and Patel, N.C. 1997. Effect of mulches and antitranspirants on yield attributes, yield and quality of safflower. *Gujarat Agricultural University Research Journal,* **22**(2): 122-126.

Patil, N.Y. and Sabale, R.N. 1997a. Effect of nitrogen and irrigation on safflower yield and its economics under sequence cropping. Proceedings of IV International *Safflower conference*, Bari, Italy, June 2-7, 1997, pp 94-97.

Patil, N.Y. and Sabale, R.N.1997b. Response of safflower to *nitrogen and irrigation under different cropping* sequences. *Journal of Maharashtra Agril. Universities,* **22**(2): 176-179.

Pawar, H.K., More, V.D. and Kenjale, S.T. 1997. Yield water relationship in safflower. *Journal of Maharashtra Agricultural Universities,* **22**(1): 20-22.

Pawar, H.K., Patil, B.R., Khade, K.K., More, V.D., Naik, G.K. and Shinde, S.H. 1987. Effect of irrigation scheduling on yield of safflower varieties. *Journal of Oilseeds Research,* **4**(2): 162-168.

Phulari, D.G., Bharambe, P.R., Sondge, V.D., Quadri, S.J. and Rodge, R.P. 1986. Response of safflower genotypes to irrigation. *Journal of Maharashtra Agricultural Universities,* **11**(1): 99-100.

Pisal, A.A. and Shinde, S.H. 1987. Yield, nitrogen content and uptake of N by safflower as influenced by levels of irrigation and nitrogen. *Journal of Maharashtra Agricultural Universities,* **12**(2): 225-226.

Prihar, S.S. and Gajri, P.R. 1988. National Symposium *Recent Advances in Dryland Agriculture.* 13-16 Sept., 1988. Hyderabad

Radder, G.D., Itnal, C.J., Surkod, V.S. and Biradar, B.M. 1991. Compartmental bunding – An effective *in situ* moisture conservation practice on medium black soil. *Indian Journal of Soil Conservation,* **19**(1&2): 1-5.

Raghu, J.S. and Sharma, S.R. 1978. Response to irrigation and fertility levels by safflower. *Indian Journal of Agronomy,* **23**(2): 93-97.

Rajput, R.K., Singh, S.N. and Yadav, J.S.P. 1981. Effect of irrigation practices and methods of sowing cum irrigation on the performance of safflower. *Indian Journal of Agricultural Sciences,* **51**(5): 316-320.

Randhawa, G.S., Mahey, R.K., Saini, S.S. and Sidhu, B.S. 1986. Scheduling of irrigation to safflower. *Journal of Research Punjab Agricultural University,* **23**(2): 217-222.

Ratan Singh, Verma, B., Prakash, C. and Prasad, S.N.1992. Effect of irrigation on yield and water use of Indian mustard, rocket salad, safflower and pigeonpea. *Indian Journal of Agricultural Sciences,* **62** (4): 254-257.

Sachan, S.S.1986. Studies on effect of mulch row spacing and level of nitrogen on safflower in eroded soil under rainfed conditions. *Farm Science Journal,* **1**(1-2): 78-81.

Sachan, S.S .1987. Performance of safflower as influenced by moisture conservation practices. *Indian Journal of Soil Conservation,* **15**(1): 35-38.

Sachan, S.S. and Bhan, S. 1986a. Moisture conservation practices for mustard and safflower. *Indian Journal of soil conservation,* **14**(1): 20-25.

Sachan, S.S. and Bhan, S. 1986b. Effect of cropping systems, fertility levels and moisture conservation practices on the performance of mustard and safflower under dryland conditions. *Farm Science Journal,* **1**(1-2): 70-76.

Samarthia, T.T. and Muldoon, D.K. 1995. Effect of irrigation schedules and row spacing on the yield of safflower. *Journal of Oilseeds Research,* **12**(2): 307-308

Sharma, R. K., Tiwari, P. N., Rajput, O. P. and Verma, O. P. 2001. Nutrient uptake and biochemical composition of rabi oilseed crops as influenced by irrigation and cropping systems. *Crop Research,* **21**(3): 319-323.

Shinde, S.H. and Pisal, A.A. 1993. Performance of safflower cv. Bhima as influenced by levels of irrigation and nitrogen. In *Li Dajue and Jan Yeanzhan (Eds.) Proceedings of Third International Safflower Conference*, Beijing, China, June 9-13, 1993, pp 677-684.

Singh, J.P. and Chauhan, S.P.S. 1999. Yield and quality of safflower as influenced by moisture conservation practices and nitrogen levels in Agra region. *Indian Journal of Soil conservation,* **27**(3): 202-206.

Singh, R.V. and Singh, M.P. 1989. Response of safflower to moisture regimes, plant population and phosphorus. *Indian Journal of Agronomy,* **34**(1): 88-91.

Singh, S.D. 1993. *Yield – water - nitrogen – row spacing* response analysis in safflower. In. Li Dujue and Han Yuanzhou (Eds) Proceedings of *III International Safflower Conference* June 14-18, 1993.pp 692-699.

Singh, S.D. and Yousuf, M. 1981. Effect of water, N and row spacing on the yield and oil content of safflower. *Indian Journal of Agricultural Sciences,* **51**(1): 38-43.

Singh, U.B. and Singh, R.M. 1979. Consumptive use and its relationship with climatological parameters as influenced by moisture management, N and P application in safflower. *Indian Journal of Agronomy,* **24**(3): 267-275.

Singh, U.B. and Singh, R.M. 1980. Effect of graded levels of moisture regimes, N and P fertilization on seed yield, oil content and NPK uptake by safflower. *Indian Journal of Agronomy,* **25**(1): 9-17.

Sondge, V.D., Rodge, R.P., Dahiphale, V.V. and Oza, S.R. and Bhosale, R.H. 1992. Water stress sensitivity and irrigation scheduling to safflower in vertisols. *Journal of Maharashtra Agricultural Universities*, **17**(1): 19-22.

Sondge, V.D., Rodge, R.P., Quadri, S.J. 1987. Irrigation decisions in safflower under constraint conditions. *Journal of Maharashtra Agricultural Universities*, **12**(1): 19-22.

Suryanarayana, B.C. 1975. Scheduling of irrigations to safflower. *Mysore Journal of Agricultural sciences*, 10: 510-511.

Ved Singh, Ram Deo, Sharma, S.K., Verma, B.L., Singh, V., Deo, R.1995a. Response of safflower to irrigation and phosphorus. *Indian Journal of Agronomy*, **40**(3): 459-464.

Ved Singh, Ram Deo, Sharma, SK., Verma, B.L. and Singh, V. 1995b. Effect of irrigation and phosphorous on safflower yield in Rajasthan. *Indian Journal of Agricultural Sciences*, **65**(9): 644-647.

Venkataraman, S., Sundaram, N.M. and Rao, K.S. 1982. Assessment of the moisture requirements of safflower under north Indian conditions. *Journal of Maharashtra Agricultural Universities*, **7**(2): 181-182.

Venkataraman, S. 1985. Agrometeorological processing of crop *water use data – a case study for safflower. Journal of Maharashtra Agricultural Universities* **7**(2): 181-182.

Yousuf, M., Sadaphal, M.N. and Singh, N.P. 1981. Growth, yield and oil content in safflower as influenced by water supply. *Indian Journal of Agronomy*, **26**(): 423-427.

Zaman, A. 1986. Safflower: Water management in drought affected region of West Bengal. Seeds & Farms, **12**(8): 6-9.

Zaman, A. 1989. *Effect of irrigation levels on safflower yield in* laterite soil of West Bengal. *Journal of Oilseeds Research*, **6**(1): 172-174.

Zaman, A. 1991. Performance of safflower under limited soil moisture supply in laterite soils of West Bengal. *Bangladesh Journal of Agricultural Science*, **18**(1):35-38

Zaman, A. 1993. Safflower research in Semi Arid tropics of Eastern India. In. Li Dujue and Han Yuanzhou (Eds) Proceedings of *III International Safflower Conference* June 14-18, 1993.pp 84-93.

Zaman, A. and Das, P.K. 1990a. Effect of irrigation levels and mulches on yield attributes and seed yield of safflower in Gangetic alluvial soils. *Environment and Ecology*, **8**(3): 864-867.

Zaman, A. and Das, P.K. 1990b. Response of safflower to different moisture regimes and N levels in semi arid tropics. *Journal of Oilseeds Research*, **7**(1): 26-32.

Zaman, A. and Das, P.K. 1991. Effect of irrigation and nitrogen on yield and quality of safflower. *Indian Journal of Agronomy*, **36**(2): 177-179.

Zaman, A. and Maiti, A. 1990. Cost of safflower cultivation and benefit cost ratio at different N levels under limited moisture supply conditions. *Environment and Ecology*, **8**(1A): 232-235.

Zaman, A. and Maiti, A. 1993. Economics of growing safflower *under limited resources. In. Li Dujue and Han* Yuanzhou (Eds) Proceedings of *III International Safflower Conference* June 14-18, 1993.pp 94-100.

Zaman, A., Nayak, R.L., Chatterjee, B.N. and Pandas, P. 1990. Effect of irrigation scheduling and N levels on yield components and seed yield of safflower in lateritic region Indian Sub tropics. *Soil and water resource management*, **1**(1): 13-20.

J. Oilseeds Res., **22**(1) : 12-14 (2005)

Assessment of genetic worth of parents and hybrids in Indian mustard, *Brassica juncea* (L.) Czern. & Coss

M.B. Parmar, K.M. Patel and K.P. Prajapati

Main Castor & Mustard Research Station, Gujarat Agricultural University, Sardarkrishinagar-385 506, Gujarat

(Received: March, 2004; Revised: July, 2004; Accepted: September, 2004)

Abstract

A set of 10 x 10 diallel crosses (excluding reciprocal) of Indian mustard [*Brassica juncea* (L.) Czern. & Coss.] was evaluated during *rabi* 2002-2003 at Main Castor and Mustard Research Station, GAU, S.K.Nagar. The results of this study revealed preponderance of non-additive gene action for seed yield/plant, days to 50% flowering, days to maturity, plant height, length of main branch, number of primary and secondary branches per plant, number of siliquae per plant, 1000-seed weight and oil content. The parents, SKM 9928 for seed yield per plant, primary and secondary branches per plant, PCR 7 for length of main branch, TM 18 for number of siliquae per plant, days to 50% flowering and maturity, SAL 1 for plant height, RH 30 for seed weight and oil content were the best *general combiners*. The crosses GM 1 x GM 2 for seed yield, GM 2 x PCR 7 for primary and secondary branches per plant, GM 1 x SAL 1 for number of siliquae per plant and 1000-seed weight and RH 819 x SKM 9928 for length of main branch and 50% flowering were the best cross combinations.

Key words: General combining ability, Indian mustard and specific combining ability

Introduction

India is a major rapeseed-mustard growing country of the world. In India it is the second most important edible oilseed after groundnut. A high yielding genotype may not transmit its superiority to its progeny. Hence, in order to develop high yielding varieties, it would be desirable to identify better combining parent for different traits. Therefore, proper understanding of combining ability of parents and nature of gene effects governing yield and their component traits could be of great help in selecting parents for hybridization programme. Diallel analysis is a systematic approach for identification of superior parents and crosses. Therefore, the effort has been made to assess the genetic worth of parents and hybrids by using diallel mating design involving ten lines of Indian mustard.

Materials and methods

A set of 55 genotypes comprising of 45 crosses and their parents (TM 18, GM 1, GM 2, RH 819, RH 30, PCR 7, SKM 9585, SKM 9927, SKM 9928 and SAL 1) were sown in a Randomized Block Design with three replications during *rabi* 2002- 2003 at Main Castor-Mustard Research Station, GAU, S.K.Nagar. Each plot consisted of a single row of 4.5 m length, accommodating of 30 plants/plot. The inter and intra- row distance was 45 cm x 15 cm, respectively. Four irrigation and uniform fertilizer level of 50:50:00 NPK kg/ha was applied to all genotypes. Data on 10 characters *viz.*, seed yield/plant, days to 50% flowering, days to maturity, plant height, length of main branch, number of primary branches/plant, number of secondary branches/plant, number of siliquae/plant, 1000-seed weight and oil content were recorded on five randomly selected plants from each plot. Combining ability analysis was carried out as per model 1 and method 2 of Griffing (1956).

Results and discussion

The analysis of variance indicating presence of considerable genetic variability in the materials studied. The estimates of *gca* and *sca* variances showed presence of both additive and non-additive gene action for the expression of different characters. The $\sigma^2_{gca}/\sigma^2_{sca}$ ratio was less than one for seed yield per plant and its components. This indicate the non-additive genetic components played greater role in the inheritance of seed yield per plant, days to 50% flowering, days to maturity, plant height, length of main branch, number of primary and secondary branches/plant, number of siliquae/plant, 1000-seed weight and oil content. These results are in accordance with the finding of Bhateria *et al.* (1995), Sheikh and Singh (1998), Rao and Gulati (2001) and Singh *et al.* (2003).

The estimates of *gca* effect of the parents revealed that no single parent was a good general combiner for all the characters under study. However, the parents SKM 9928, RH 819 and GM 1 were good general combiners for seed yield/plant. For length of main branch PCR 7 and RH 30 exhibited good general combining ability. TM 18, SKM 9585, SAL 1 and GM 1 were good general combiners for days to 50% flowering and plant height, whereas, TM 18 and SAL 1 were good combiners for days to maturity, exhibiting significantly negative *gca* effects. While six parents *viz.*, SKM 9928, SKM 9927, RH 819, TM 18, SKM 9585 and SAL 1 showed good general combining ability for primary branches/plant. For secondary branches/ plant SKM 9928 and TM 18 were good general combiners. TM 18 was good general combiner for siliquae/plant. For 1000-seed weight and oil content, RH 30, RH 819 and GM 1 were good general combiners. The high *gca* is due to the additive and additive x additive gene effects (Griffing, 1956) which are the fixable components of genetic variation. Therefore, it would be worth while to use above parental lines in hybridization programme.

The estimates of *sca* effects revealed that, 11 cross combinations exhibited significant and positive *sca* effects for seed yield/plant. The cross with highest *sca* effects for seed yield was GM 1 x GM 2 (4.49), this cross had also showed significant *sca* effects in the desired directions for number of primary branches and plant height. The cross RH 819 x PCR 7 exhibited significant *sca* effect for plant height, TM 18 X RH 30 for oil content, RH 819 x SKM 9928 for length of main branch and days to 50% flowering, GM 1 x SAL 1 for number of siliquae/plant and 1000-seed weight and GM 2 x PCR 7 for primary and secondary branches/plant. The results of this finding are more or less conformity with those of Rao and Gulati (2001).

The three best crosses selected each for *sca* effects and *per se performance for all the characters are presented in* Table 1. The crosses *viz.*, GM 1 x GM 2, SKM 9927 x SAL 1 and RH 819 x SKM 9927 which recorded high significant *sca* effects for seed yield, resulted from good x average, average x poor and good x average general combiners, respectively. The perusal of the data in the Table 1 revealed that, the crosses having higher estimates of *sca* had resulted from good x good, good x average, good x poor and average x poor general combiners. It may be due to the fact that parents which exhibit low *gca* effect have relatively high magnitude of complementary gene action. Better performance of hybrids involving average x poor general combiner indicated dominance x dominance (epistasis) type of gene action (Jinks, 1956). Such crosses could be utilized in the production of high yielding homozygous lines (Darrah and Hallauer, 1972).

Table 1 Three top ranking parents with respect to *per se* performance and *gca* effects and three top ranking hybrids with respect to *sca* effects in Indian mustard

Character	Best performing parents	Best general combiners	Hybrids with high *sca* effects		*Sca* effects
Seed yield/plant	SKM 9928	SKM 9928	GM 1 x GM 2	G x A	4.49**
	RH 819	RH 819	SKM 9927 x SAL 1	A x P	3.74**
	GM 1	GM 1	RH 819 x SKM 9927	G x A	3.05**
No. of primary branches/plant	SKM 9928	SKM 9928	GM 2 x PCR 7	P x P	0.73**
	SKM 9927	SKM 9927	GM 2 x SKM 9928	P x G	0.56*
	RH 30	RH 819	RH 819 x SKM 9928	G x G	0.54*
No. of secondary branches/plant	SKM 9928	SKM 9928	GM 2 x PCR 7	A x A	2.00**
	SKM 9585	TM 18	GM 1 x SAL 1	P x A	1.60*
	RH 30	SAL 1	RH 819 x SKM 9928	A x G	1.60*
No. of siliquae/plant	TM 18	TM 18	GM 1 x SAL 1	A x A	52.98*
	RH 819	SKM 9928	GM 2 x PCR 7	A x A	49.67*
	SKM 9585	RH 819	TM 18 x SKM 9585	G x A	40.95
Length of main branch	PCR 7	PCR 7	RH 819 x SKM 9928	A x P	8.93**
	SKM 9927	RH 30	GM 2 x SKM 9928	A x P	7.14**
	GM 1	GM 1	GM 1 x PCR 7	A x G	6.67*
Plant height	TM 18	SAL 1	RH 819 x PCR 7	P x P	-14.54**
	SAL 1	TM 18	PCR 7 x SKM 9928	P x A	-13.58**
	SKM 9585	GM 1	GM 1 x GM 2	A x A	-10.95**
1000-seed weight	RH 30	RH 30	GM 1 x SAL 1	G x P	1.05**
	PCR 7	PCR 7	GM 2 x SKM 9928	G x A	0.90**
	RH 819	RH 819	RH 819 x PCR 7	G x G	0.87**
Oil content	GM 1	GM 1	TM 18 x RH 30	P x G	1.16*
	RH 819	RH 30	GM 2 x PCR 7	A x A	1.10*
	SKM 9927	RH 819	GM 2 x SAL1	A x A	1.07*
Days to 50% flowering	TM 18	TM 18	RH 819 x SKM 9928	P x P	-3.28**
	SKM 9585	SKM 9585	GM 2 x SKM 9927	P x A	-2.59**
	GM 1	SAL 1	GM 1 x SKM 9585	G x G	-2.56**
Days to maturity	TM 18	TM 18	GM 2 x SKM 9585	P x A	-1.48
	SAL 1	SAL 1	GM 1 x RH 819	A x P	-1.23
	SKM 9585	SKM 9585	SKM 9585 x SKM 9927	A x A	-1.20

*and **, significant at P=0.05 and P=0.01 levels, respectively; G=Good, A=Average and P=Poor combining ability of parent

The crosses where poor x poor and poor x good general combiners produced high *sca* effects may be attributed due to presence of genetic diversity in the form of heterozygous loci for specific traits. Thus, the ideal crosses would be the one, which have good *per se* performance, high *sca* effects and at least one good general combiner parent. Considering these aspects out of 45 crosses, the two crosses GM 1 x GM 2 and RH 819 x SKM 9927 were identified for higher seed yield.

References

Bhateria, S., Chadha, C., Thakur, S.R. and Thakur, H.L. 1995. Combining ability and gene action in *Brassica juncea* (L.) Czern and Coss. *Himachal Journal of Agricultural Research*, **21** (1-2) : 17-22.

Darrah, L.L. and Hallauer, C. 1972, Genetic effects estimated from generation means in four diallel sets of maize in breds. *Crop Science*, **12**:615-621.

Griffing, D. **1956.** Concept of general and specific combining ability in relation to diallel crossing system. *Australian Journal of Biological Sciences,* **9** : 465-495.

Jinks, J.L. 1956. *The F_2 and back cross generations from a set* of diallel crosses. *Heridity*, **10**: 1-30.

Rao, N.V.P.R. and Gulati, S.C. 2001. Comparison of gene action in F_1 and F_2 diallel of Indian mustard [*Brassica juncea* (L.)]. *Crop Research*, **21** (1) : 72-76.

Sheikh, L. A. and Singh, J.N. 1998. Combining ability analysis for seed yield and oil content in *Brassica juncea* (L.) Czern & Coss. *Indian Journal of Genetics*. **58** (4):507-511.

Singh, K.H., Gupta, M.C., Shrivastava, K.K. and Kumar, P.R. 2003. Combining ability and heterosis in Indian mustard. *Journal of Oilseeds Research*, **20**(1) : 35-39.

J. Oilseeds Res., **22**(1) : 15-17 (2005)

Combining ability analysis over environments in Indian mustard, *Brassica juncea* (L.) Czern & Coss

K.M. Patel, G.S. Sharma, H.C. Pathak and D.A. Thakker

Main Castor and Mustard Research Station, Gujarat Agricultural University, **Sardarkrushinagar, Gujarat**

(Received: June, 2004; Revised: September, 2004; Accepted: October, 2004)

Abstract

Eleven lines of the Indian mustard, *Brassica juncea* (L.) Czern & Coss were evaluated for general and specific combining ability through line x tester cross analysis using six widely diverse testers at four locations. The traits studied were seed yield, number of siliquae/plant, seeds/siliqua and 1000-seed weight. The combining ability analysis revealed that non-additive type of gene effects were important for the seed yield, siliquae/plant and seeds/siliqua, whereas for 1000-seed weight, additive gene effects were more important. The cross RSK 76 x Kranti had the highest SCA effects (7.54) for seed yield, which involved one good general combiner parent (RSK 76) for seed yield and its component characters.

Key words: Combining ability and Indian mustard

Introduction

In planning of an efficient breeding programme in any crop, selection of parents plays a crucial role and combining ability analysis serves as a handy tool for the selection of parents. Information on the relative importance of general and specific combining abilities is also helpful in the analysis and interpretation of the genetic basis of important traits. The present study was, therefore, undertaken to gather such an information in Indian mustard regarding seed yield and its component characters.

Materials and methods

Eleven female lines (RSK 16, RSK 28, RSK 69, RSK 76, RSK 77, RSK 78, Lalpur 17, RJ 9, CSR 164, BIO 902 and RH 7513) were hybridized with six males (GM 1, PM 67, Varuna, Kranti, RL 1359 and Vardan). All the 17 parents and their 66 F_1s were grown in Randomized Block Design with three replications during *rabi* season at four locations *viz.*, Plant Breeding Farm of Rajasthan College of Agriculture, Udaipur; Main Castor-Mustard Research Station, Gujarat Agricultural University, S.K. Nagar; Oilseeds Research Substation, Talod and Main Sorghum Research Station, Surat. Each plot consisted of a single row of 3 m length accommodating 20 plants/plot. The inter and intra row distance was 45 x 15 cm, respectively. Observations were recorded on 10 randomly taken competitive plants of each entry in each replication for seed yield/plant, siliquae/plant, seeds/siliqua and 1000-seed weight. The recommended agronomic practices and plant protection measures whenever necessary were adopted for raising the crop. The analysis of variance for combining ability was done by extending the model of Kempthorne (1957).

Results and discussion

The mean squares due to genotypes were highly significant for all the characters at all the four locations and across the locations (Table 1). This indicated the existence of appreciable amount of genetic variability in the experimental material of the present study. The variance components due to females σ^2_f were higher than that of males σ^2_m for all the characters except seed yield, which indicated greater contribution of females towards the σ^2_{gca} for these traits and of the males for seed yield. The line x tester interaction mean squares were significant for all the characters, which indicated the significant contribution of *sca* variance components. The significant mean squares due to line x tester x location for the traits studied, suggested influence of environment on *gca* as well as *sca* variances. It was observed that the hybrids interacted more with locations as compared to parents. Likewise, the females interacted more with locations for seed yield/plant, siliquae/plant and seeds/siliqua, while they interacted equally for 1000-seed weight.

The *gca, sca* ratio ($\sigma^2_{gca}/\sigma^2_{sca}$) was less than one for seed yield, siliquae/plant and seeds/siliqua, indicating predominance of non-additive component in the inheritance of these characters. These results are in accordance with the findings of Patel *et al.* (1993) for seed yield/plant and seeds/siliqua, Rao and Gulati (2001) for majority of the yield contributing characters and Katiyar *et al.* (2000) for seed yield. Whereas, for 1000-seed weight, additive gene effects were more important. Similar results were reported by Ravindra and Sinhamahapatra (2000). Estimates of *gca* effects revealed that among the lines, good general combiners were RJ 9 for seed yield, RH 7613 for siliquae/plant, RSK 77 for seeds/siliqua and RSK 78 for 1000-seed weight (Table 2). Among the testers, PM 67 was the best general combiner for seed yield, siliquae/plant and seeds/siliqua and RL 1359 for seed weight.

Twenty four crosses showed significant positive *sca* effects for seed yield (Table 3). Most of these crosses involved at least one good general combining parent. Similar results were obtained by Thakur *et al.* (1989) and Yadav *et al.* (1992). The cross with highest *sca* effects for seed yield was RSK 76 x Kranti. The *sca* effect of this cross was high for siliquae/plant. Another important cross was RSK 16 x Varuna where the *sca* effects were significant in desirable direction for seed yield and for all the yield contributing traits. An overall examination of the combining ability analysis revealed that the predominance of non-additive genetic control for seed yield and its component except for 1000-seed weight. This indicated, the potential of heterosis breeding for improving the productivity in this crop. However, the prevalence of additive genetic variance for seed size, this trait could be improved by pedigree method of breeding.

Table 1 Mean squares for combining ability and estimates of variance for different characters over locations

Source	d.f.	Seed yield	Siliquae/plant	Seeds/siliqua	1000-seed weight
Location (L)	3	3520.49**	30114.13**	13.09**	0.13
Genotypes	82	165.00**	4231.30**	15.60**	10.86**
Line (Females)	10	219.02*	27525.78*	40.72**	40.45**
Tester (Males)	5	262.73**	4072.78	8.15	37.03**
Line x Tester	50	104.16**	12112.79**	10.13**	1.03**
Line x Location	30	57.44	6146.99	0.85	0.30*
Tester x Location	15	50.46	3661.73	0.55	0.64**
Line x Tester x Location	150	47.43**	4598.63**	0.70**	0.17**
Error	520	3.15	142.40	0.10	0.03
σ^2 f		1.46	192.56	0.42	0.55
σ^2 *m*		1.18	53.81	0.01	0.27
σ^2 *gca*		1.28	33.14	0.14	0.37
σ^2 *sca* (σ^2 fm)		18.91	2504.72	3.14	0.29
σ^2 fl		0.56	86.02	0.01	0.01
σ^2 ml		0.09	28.39	0.001	0.01
σ^2 fml		14.76	1485.41	0.20	0.04
σ^2 gca / σ^2 sca		0.07	0.01	0.04	1.28

Where, * and ** are the significant at P=0.05 and P=0.01 levels, respectively.

Table 2 Estimates of general combining ability effects for seed yield and its components over location

Parent and pedigree	Seed yield/ plant	Siliquae/ plant	Seeds/ siliqua	1000-seed weight
Lines				
RKS 16 (MR 71-3-2 x TM 4)	1.20**	-21.91**	-0.20**	0.39**
RSK 28 (TM 4 x MR 71-3-2)	-1.84**	-30.83**	0.60**	-0.16**
RSK 69 (*Varuna x [MR 71-3-2 x TM 2]*)	1.07**	-13.90**	-0.57**	0.27**
RSK 76 (Selection from RH 7860)	0.94**	13.62**	0.76**	0.32**
RSK 77 (Selection from PCR 3)	0.18	8.95*	1.38**	0.33**
RSK 78 (Selection from BIO 902)	0.60**	-17.50**	-0.24**	0.89**
Lalpur 17 (Selection from Lalpur Village)	-4.14**	-10.95**	-0.10**	-1.62**
RJ 9 (Selection from local mustard)	1.89**	13.06**	0.13**	0.29**
CSR 164 (-)	-1.2**	11.96**	-1.12**	-0.75**
BIO 902 (Biotech, somaclone of Varuna)	0.40*	17.98**	0.33**	0.72**
RH 7513 (PR 15 x RH 30 A)	0.92**	29.52**	-0.98**	-0.76**
SEm±	0.18	1.20	0.03	0.02
Testers				
GM 1 (MR 71-3-2 x TM 4)	-1.59**	-7.00**	-0.20**	-0.20**
PM 67 (Selection from local mustard)	2.61**	8.03**	0.45**	-0.78**
Varuna (Selection from Varanasi local)	-0.50**	2.12**	-0.20	0.28**
Kranti (Pure line selection of Varuna)	0.25	-4.36**	-0.21**	-0.08**
RL 1359 (RLM 514 x Varuna)	-0.35**	3.52**	0.09**	0.74**
Vardan (RK 1467)	-0.42**	-2.30**	-0.11**	-0.35**
SEm±	0.13	0.85	0.02	0.07

Table 3 Estimates of specific combining ability effects of selected crosses

Crosses	Seed yield/plant	Siliquae/plant	Seeds/siliqua	1000-seed weight
RSK 76 x Kranti	7.54**	95.20**	-0.57**	-0.07
RSK 16 x Varuna	5.24**	29.07**	0.26**	0.43**
RSK 78 x Varuna	4.54**	7.69**	-1.08**	-0.10*
RSK 77 x PM 67	4.08**	66.49**	-0.52**	-0.15**
RJ 9 x Vardan	3.41**	39.15**	-0.03**	-0.15**
BIO 902 x Vardan	2.58**	27.90**	1.51**	-0.36**
RH 7513 x RL 1359	2.42**	21.50**	0.85**	-0.22**
RSK 28 x PM 67	2.41**	-23.18**	1.38**	0.21**
RSK 28 x Vardan	1.87**	21.78**	-0.50**	0.35**
CSR 164 x RL 1359	1.77**	27.64**	0.63**	-0.11**
RH 7513 x PM 67	1.44**	6.92**	-1.04**	0.49**
RSK 78 x Vardan	1.24**	12.44**	0.54**	0.08
Lalpur 17 x PM 67	1.14**	11.11**	-1.09**	0.61**
RSK 28 x Kranti	1.13**	36.86**	0.25**	-0.13**
CSR 164 x GM 1	0.87*	8.03**	0.98**	-0.11**

Where, * and ** are significant at P=0.05 and P=0.01 levels, respectively.

References

Katiyar, R. K., Chamola, R. and Chopra, V.L. 2000. Heterosis and combining ability in Indian mustard. *Indian Journal of Genetics*, **60**(4) : 557-559.

Kempthorne, O. 1957. *An introduction to genetical statistics.* John Willey & Sons, New York, Iowa, p.545.

Patel, K.M., Prajapati, K.P., Fatteh, U.G. and Patel, I.D. 1993. Combining ability and heterosis in Indian Mustard. *Journal of Oilseeds Research*, **10**(1) : 129-131.

Rao, N.V.P.R.G. and Gulati, S.C. 2001. Comparison of gene action in F_1 and F_2 diallels of Indian mustard. *Crop Research*, **21**(1) : 72-76.

Ravindra K. and Sinhamahapatra, S.P. 2000. Inheritance of seed character in Indian Mustard. *Madras Agricultural Research Journal*, **87**(1-3) : 83-86.

Thakur, H.L., Zarger, M.A. and Rana, N.D. 1989. Combining ability for economic traits in Indian mustard. *Journal of Oilseeds Research*, **6**:41-50.

Yadav, O.P., Yadava, T.P. and Prakash Kumar. 1992. Combining ability studies for seed yield, its component characters and oil content in Indian mustard. *Journal of Oilseeds Research*, **9**(1) : 14-20.

J. Oilseeds Res., **22**(1) : 18-21 (2005)

Stability analysis for yield and component traits in soybean, *Glycine max* (L.) Merrill**

M.V. Ramana and A. Satyanarayana*

Regional Agricultural Research Station, Lam, Guntur-522 034, AP

(Received: September, 2004; Revised: November, 2004; Accepted: **December, 2004**)

Abstract

Sixteen soybean genotypes were subjected for stability analysis in five environments. Mean squares for genotypes, linear component of environments were significant for all characters. Genotype x Environment interactions were significant for all characters except for pod length and seeds/pod. On the basis of stability analysis genotypes *viz., JS 335, PK 472, TS 99-76,* MACS 201, PK 1029, TS 99-128 and DSb 1 were identified stable for grain yield. PK 472 was found stable for number of pods/plant, number of branches/plant, 100 seed weight, plant height, pod length and harvest index while JS 335 was stable for days to 50% flowering, days to maturity, plant height, number of branches/plant, plant dry weight, harvest index and number of pods/plant. No genotype was found consistently stable for all characters.

Key words: Stability analysis, soybean

Introduction

Soybean, a non-conventional crop, is emerging as an important crop in A.P. and has vast potential as an alternate crop to cash crops *viz.*, cotton, tobacco and chillies and as intercrop in redgram and cotton. Soybean is cultivated at present in 89,000 ha but has a potential to occupy over 0.5 m.ha in Andhra Pradesh (Satyanarayana and Ramana, 1999). Andhra Pradesh can emerge as a major soybean producing state with proper research backup to develop suitable stable genotypes for different seasons and situations as the genotypes are location and season specific. Studies on genotype x environment interactions for developing stable genotypes for specific environments are essential. Hence, present investigations were taken up utilizing 16 diverse genotypes over five environments to study the nature and magnitude of genotype x environment interaction for yield and yield component traits.

Materials and methods

Sixteen soybean genotypes were grown in a Randomized Block Design with three replications in five environments *viz.*, sole crop situation during *kharif* (E_1), *rabi* (E_2) and summer (E_3) seasons and intercrop situation during *kharif* season in cotton (E_4) and redgram (E_5) during 2001-02. The genotypes were sown in four rows of five meter length in sole crop situation and 1:2 rows with cotton and 1:7 in redgram intercrop situations and planted at 30 x 7.5 cm spacing between and within rows. The observations were recorded on five randomly selected plants for various traits and were analysed for stability parameters after verifying homogeneity of error variances following Eberhart and Russell model (1966).

Results and discussion

Analysis of variance (Table 1) revealed that the genotypes differed significantly for all the characters indicating the presence of variability in the material. Similarly, environments in which the genotypes were grown were also differed significantly for all the characters. Variance due to G x E interactions was highly significant for all the characters except pod length and seeds per pod indicating the differential response of genotypes in expression of the characters to varying environments. These observations are in agreement with Taware *et al.* (1994), Deka and Talukdar (1997), Raut *et al.* (1997), Chandrakar *et al.* (1998), Taware *et al.* (1998) and Rajanna *et al.* (1999). The partitioning of Genotype x Environment interactions indicated that a substantial portion of variation was linear for days to maturity, days to 50% flowering, number of *pods/plant, number of branches/plant, harvest index*, plant dry weight and seeds/pod reflecting the predictability of the performance of genotypes over environments while the non-linear component was important for plant height and 100 seed weight and both linear and non-linear components were equally important for grain yield/plant and pod length.

* Director of Extension, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad-500 030, AP.

** Part of the Ph.D. Thesis submitted to Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad-500 030, AP.

The stability parameters analysed for the characters studied are presented in Table 2. The genotypes, JS 335 and PK 1029 were stable for days to 50% flowering with low mean, average response and *non-significant deviation* from linear regression over environments in desired direction. Two genotypes *viz.*, LSb1 and JS 90-41 were significantly early for days to 50% flowering character compared to general mean. Mean number of days taken to maturity ranged from 68.53 (LSb 1) to 96.13 [JS (SH) 93-37 and TS 99-76] over environments with a general mean of 91.06 days. Four genotypes, LSb 1, JS 90-41, MACS 201 and JS 335 were significantly earlier for maturity compared with general mean. The genotypes, LSb 1, JS 335, JS 90-41 and MACS 201 with low mean and below average response showed predictable performance for days to maturity under unfavourable environments. Mean number of branches/plant ranged from 2.54 (JS 90-41) to 4.90 (JS 335) with a general mean of 3.47. The genotypes, PK 472, JS 335, NRC 51, MACS 201, PK 1029 and LSb 3 with high mean and average response was found to be stable over environments.

Table 1 Analysis of variance for stability in Genotype x Environment interaction studies in soybean

Source of variation	Degree of freedom	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of branches/ plant	No. of pods/ plant	Pod length (cm)	Seeds/ pod	100 seed weight (g)	Plant dry weight (g)	Harvest index (%)	Grain yield/ plant (g)
Genotypes	15	28.174**	264.630**	525.743**	2.189**	247.169**	0.285**	21.353**	12.566**	101.870**	6.977**	12.749**
Environments	4	99.340**	668.582**	93.013**	10.106**	529.089**	0.145**	0.078**	23.780**	251.020**	496.076**	64.200**
Genotype x Environment	60	2.909**	10.744**	15.613**	0.605**	72.991**	0.022	0.021	1.064**	26.210**	28.987**	4.885**
Environment + (Genotype x Environment)	64	8.940**	51.864**	20.457**	1.204**	101.497**	0.030	0.024	2.484**	40.260**	58.181**	8.593**
Environment (Linear)	1	397.409**	2637.971**	372.073**	40.415**	2116.386**	0.579**	0.313	95.124**	1004.085**	1984.300**	256.799**
Genotype x Environment *(linear)*	15	5.787**	30.824**	10.344	0.701	118.955**	0.021	0.028	0.819	27.686++	33.392++	4.289
Pooled deviation	48	1.828**	3.804**	16.284**	0.537	54.065**	0.021**	0.017**	1.074**	24.110**	25.799**	4.767**
Pooled error	150	1.327	2.367	12.088	0.557	50.227	0.053	0.039	0.737	9.131	14.227	3.196

** Significant at 1% level of probability; ++ Significant only when tested against pooled error.

The genotypes, PK 472, TS 99-76, MACS 201 and JS 335 with high mean and average response showed predictable performance and found to be stable over environments for number of pods/plant. Mean number of pods/plant over environments ranged from 21.90 (JS 90-41) to 47.76 (DSb 1) with a general mean of 34.84. Mean pod length ranged from 3.20 (LSb 3) to 4.0 (JS 90-41 and TS 99-128) with a general mean of 3.63 cm. Four genotypes, PK 1029, MAUS 61-2, MACS 694 and PK 472 showed low mean and average response and found to be stable over environments for pod length. The mean number of seeds/pod ranged from 2.12 (MACS 681) to 2.95 (JS 90-41) with a general mean of 2.36. The genotypes, TS 99-128, DSb 1 and MAUS 61-2 recorded low mean with average response and found to be stable over environments for seeds/pod.

The mean 100 seed weight ranged from 8.86 g (JS 90-41) to 15.91 g (TS 99-128) with a general mean of 12.22 g. Four genotypes LSb 1, PK 472, PK 1029 and MACS 694 with high mean and average response were found to be stable over environments. The genotypes, NRC 51, MACS 694, JS 335 and JS (SH) 93-37 with high mean and average response were found stable for plant dry weight. The mean values ranged from 14.12 (JS 90-41) to 30.83 (TS 99-76) with a general mean of 23.25 g.

The genotypes, PK 472, JS 335, TS 99-128 and MACS 730 with high mean and average response were found to be stable for harvest index. Mean values ranged from 27.27 (MACS 694) to 40.17 (PK 1029) with a general mean of 35.04%. Seven genotypes, JS 335, PK 472, TS 99-76, MACs 201, PK 1029, TS 99-128 and DSb 1 with high mean grain yield showed average response with predictable performance and stable genotypes over environments. Mean grain yield ranged from 4.54 g (JS 90-41) to 10.91 g (JS 335) with a general mean of 8.19 g.

Table 2 Stability parameters of soybean genotypes for different characters

Genotype	Days to 50% flowering			Days to maturity			Plant height (cm)			*No. of branches/plant*		
	$\bar{x}$	bi	s^2di	$\bar{x}$	bi	s^2di	$\bar{x}$	bi	s^2di	$\bar{x}$	bi	s^2di
LSb 3	35.33	0.91	3.3477*	94.80	1.60**	5.7210	28.32	2.03*	0.5639	3.87	1.40	0.4145
LSb 1	29.33	0.13**	-0.0556	68.53	-0.01**	-0.0823	25.12	0.83	5.2439	2.67	0.51**	-0.1788
DSb 1	34.20	1.49**	0.7210	91.07	1.39**	0.3676	37.24	1.27	6.4806	3.39	0.85	0.3745
JS 90-41	31.53	0.37**	0.6277	82.00	0.50**	4.1243	36.17	1.56	44.5406**	2.54	1.98	0.2245
PK 1029	35.47	0.85	2.5977	92.27	1.40**	2.3743	26.69	1.72	2.1406	3.68	0.42	0.1278
PK 472	36.80	1.23	4.6377**	94.20	1.44**	-0.7390	24.91	1.27	0.5439	4.05	1.01	0.7145
MACS 201	35.33	0.18**	0.1710	85.73	0.43**	-0.2556	36.66	0.17	45.8572**	4.09	1.21	0.3578
NRC 51	36.00	1.12	2.1977	95.60	1.13**	0.5876	32.91	0.66	6.9039	4.13	0.44	0.7911
MACS 681	35.73	0.79	4.0140*	93.60	0.92**	11.3910**	28.31	1.21	-2.2194	3.22	1.64	0.5178
MACS 730	38.13	1.35**	0.5143	95.60	1.20**	3.9576	28.88	0.53	7.8406	3.72	1.56	1.2345*
JS (SH) 93-37	37.73	1.95**	-0.3256	96.13	0.98	10.1876**	68.37	0.04	41.1639*	2.58	1.44	0.6878
TS 99-128	36.67	1.11	0.8210	93.33	1.05	1.5243	28.34	0.83	13.3272	3.44	0.60	0.0511
TS 99-76	37.20	1.43**	-0.0589	96.13	0.84**	2.9310	37.63	2.18**	0.2139	2.68	0.20**	-0.1755
JS 335	34.27	0.94	0.7310	87.60	0.70**	1.5943	32.15	0.22	10.1406	4.90	0.56	0.0878
MAUS 61-2	38.13	1.23*	0.5710	95.33	1.35**	1.5410	30.68	1.22	10.7039	3.43	1.36	0.2345
MACS 694	37.07	0.92	1.6577	95.07	1.09*	3.0210	30.07	0.26	2.6039	3.17	0.83	0.1611
General Mean	35.56	0.9999		91.06	1.0001		33.28	1.0000		3.47	1.0000	
SEm±	0.68	0.2713		0.9752	0.1509		2.0176	0.8368		0.3665	0.4612	

Table 2 (Contd....)

Genotype	No. of pods/plant			Pod length (cm)			*Seeds/pod*			*100 seed weight (g)*		
	$\bar{x}$	bi	s^2di	$\bar{x}$	bi	s^2di	$\bar{x}$	bi	s^2di	$\bar{x}$	bi	s^2di
LSb 3	37.71	2.21**	16.5408	3.20	0.14*	-0.0078	2.13	-0.86**	-0.0098	11.33	1.23*	0.0475
LSb 1	22.37	-0.01**	-12.1325	3.72	0.68	0.0321	2.33	2.26**	0.0167	13.07	0.90	1.0142
DSb 1	47.76	0.52*	23.6008	3.28	1.73*	-0.0044	2.19	1.33	-0.0065	10.85	0.68	0.5409
JS 90-41	21.90	0.69	17.3675	4.00	2.17**	-0.0144	2.95	0.51	0.0301	8.86	0.50**	-0.0790
PK 1029	35.07	0.03**	-10.2825	3.50	1.09	0.0021	2.27	1.26**	-0.0132	13.17	0.78	0.3842
PK 472	36.96	1.03	35.7908	3.59	1.54	-0.0111	2.21	-0.18**	-0.0098	14.57	0.96	0.3809
MACS 201	37.45	0.75	38.8841	3.65	1.95*	0.0088	2.43	-0.04	0.0534	11.58	0.96	1.5809
NRC 51	39.85	-0.17*	24.4108	3.64	0.62	0.0121	2.61	2.03*	0.0001	11.61	1.29	0.6942
MACS 681	31.51	2.34*	73.4075	3.57	0.01*	0.0255	2.12	-0.20**	0.0001	11.69	0.66	1.8075*
MACS 730	30.47	1.79*	13.1741	3.80	2.30	0.0021	2.35	-0.38**	0.001	12.18	1.67*	1.9475*
JS (SH) 93-37	27.87	-0.53**	3.0808	3.97	0.39	0.0255	2.43	2.49**	0.0101	11.77	1.19	2.3975*
TS 99-128	33.11	0.40*	2.7041	4.00	0.29	0.0055	2.25	1.12	0.0101	15.91	1.38*	0.1509
TS 99-76	39.76	1.39	59.3075	3.69	0.11*	-0.0111	2.47	1.59*	-0.0098	12.32	1.31**	-0.1724
JS 335	44.03	1.10	61.7108	3.67	0.71	-0.0078	2.44	3.50**	-0.0098	11.35	1.36*	0.5342
MAUS 61-2	38.50	2.18*	161.1641*	3.40	0.93	-0.0111	2.27	1.05	0.0001	12.04	0.29*	1.7509*
MACS 694	33.10	2.27*	36.4241	3.42	1.37	0.0088	2.23	0.52*	-0.0098	13.20	0.81	0.2775
General Mean	34.84	1.0000		3.63	0.9998		2.36	1.0007		12.22	1.0000	
SEm±	3.6764	0.6393		0.0725	0.7618		0.0653	0.9333		0.5183	0.4251	

Table 2 (Contd...)

Genotype	Plant dry weight (g)			Harvest index (%)			Grain yield/plant (g)		
	$\bar{x}$	bi	s^2di	$\bar{x}$	bi	s^2di	$\bar{x}$	bi	s^2di
LSb 3	24.01	1.43**	21.9896*	33.41	1.75*	64.1510**	8.24	1.66*	8.6145*
LSb 1	15.02	0.43**	-1.2504	36.78	0.02**	3.7643	5.58	0.36**	-0.8055
DSb 1	23.69	1.52*	5.8196	40.12	0.29**	-1.6856	9.50	0.77	4.3811
JS 90-41	14.12	0.42*	8.1663	31.91	0.44**	-0.6656	4.54	0.56**	-0.3455
PK 1029	21.79	0.72	20.3596	40.17	1.22	33.3843*	8.64	0.84	1.1311
PK 472	25.74	1.52*	23.0196*	35.69	1.03	2.5777	9.11	1.04	1.7378
MACS 201	21.33	1.05	4.3929	37.74	0.95	38.8110*	8.28	1.02	4.2445
NRC 51	24.05	1.07	17.3963	39.54	0.53*	29.8343	9.65	0.69	10.0745*
MACS 681	20.15	0.34*	44.9096**	32.60	1.62*	30.9377	6.95	1.23	10.2678*
MACS 730	19.99	0.74	25.0896**	35.36	1.22	10.0343	7.34	1.30	3.5411
JS (SH) 93-37	24.69	0.69	95.8996**	30.78	0.87	19.7043	7.23	-0.09**	-0.2521
TS 99-128	24.33	0.21**	-1.9270	37.35	0.63	16.4143	9.19	0.70	-0.0088
TS 99-76	30.83	0.44**	0.9329	30.54	1.78*	46.3110*	9.36	1.12	4.5611
JS 335	28.98	1.23	8.9229	36.85	1.25	14.8043	10.91	1.09	1.4778
MAUS 61-2	25.06	2.86**	27.3629*	34.46	1.41*	17.0443	8.57	2.04*	7.0111
MACS 694	28.15	1.32	35.9829**	27.27	1.00	11.4910	7.89	1.36	3.5845
General Mean	23.25	1.0000		35.04	1.0000		8.19	1.0000	
SEm±	2.46	0.6198		2.5396	0.4561		1.0916	0.5449	

* Significant at 5% level of probability; ** Significant at 1% level of probability

From the present study, genotypes viz., JS 335, PK 472, TS 99-76, MACS 201, PK 1029, TS 99-128 and DSb 1 were identified stable for grain yield. The genotype, PK 472 was also stable for number of pods/plant, number of branches/plant, 100 seed weight, plant height, pod length and harvest index while the genotype, JS 335 showed stability for days to 50% flowering, days to maturity, plant height, number of branches/plant, plant dry weight, harvest index and number of pods./plant. The results indicated that none of the genotype studied was found consistently superior for all the characters in all environments. The stable genotypes identified could be used as parents in future breeding programme for development of suitable genotypes for Andhra Pradesh.

References

Chandrakar, P.K., Rajeev Srivastava., Agarwal, S.K. and Rao, S.S. 1998. Stability analysis of soybean (*Glycine max* L.) varieties in rice zone of Madhya Pradesh. *Journal of Oilseeds Research,* **15** : 247-249.

Deka, S.D. and Talukdar, P. 1997. Stability behaviour of some soybean (*Glycine max* L.) genotypes under environmental variability. *Indian Journal of Genetics,* **57** : 36-39.

Eberhart, S.A. and Russell, W.A. 1966. Stability parameters for comparing varieties. *Crop Science,* **6** : 36-40.

Rajanna, M.P., Viswanatha, S.R., Kulkarni, R.S. and Ramesh, S. 1999. Stability analysis for seed yield and its components in soybean (*Glycine max* L.). *Crop Research* (Hisar), **18** : 437-442.

Raut, V.M., Taware, S.P., Halvankar, G.B. and Patil, V.P. 1997. Stability analysis for oil and yield in soybean. *Soybean Genetics Newsletter,* **24** : 92-93.

Satyanarayana, A. and Ramana, M.V. 1999. Soybean as an intercrop in cotton. An approach towards sustainability. *Proceedings of World Soybean Research Conference VI* held at Chicago, p.586.

Taware, S.P., Halvankar, G.B. and Raut, V.M. 1998. Stability analysis of soybean varieties under different plant densities and growing conditions. *Soybean Genetics Newsletter,* **25** : 88-89.

Taware, S.P., Raut, V.M., Halvankar, G.B. and Patil, V.P. 1994. Phenotypic stability analysis of soybean varieties in *kharif* and summer seasons. *Journal of Oilseeds Research,* **11** :237-241.

Based on the results it may be suggested that in case of scarcity of pollen during pollination in hybrid seed production of KBSH-1 the filler material (95 g of finely powdered *Ragi* flour may be mixed with 5 % borax to prepare 5 % borax) may be mixed with pollen grains at the proportion of 3:1 (pollen grain: filler material) to achieve normal seed yield with out compromising the seed quality.

References

Abdul-Baki, A.A. and Anderson, J.D. 1973. Vigour determination in soybean seed by multiple criteria, *Crop Science*, **12**: 630-633.

Anonymous, 1996. International seed Testing Rules, *Seed Science & Technology*, **24**: 1-135.

Anonymous. 2000. Annual report of All India Coordinated National Seed Project (Crops), IARI, New Delhi. pp: 65-66.

Cochron, W.G. and Cox, G.M. 1965. *Experimental design*. Asia Publication House, Mumbai, 2nd Edn. pp. 239-304.

Johri, B.M. and Vasil, I.K. 1961. Physiology of pollen. *Botany Review*, **27**:325-381.

Kempe Gowda, H. 1992. Effect of planting design and staggered sowing of parental lines on seed yield and quality in KBSH-1 hybrid sunflower. M.Sc (Agri) Thesis, University of Agricultural Sciences, Bangalore-65.

Perry, D.A. 1972. Seed vigour and field establishment. *Horticulture Abstract*, **42** : 334-342.

Prasad, K. and Srivastav, V.C. 1991. Teletoxic effect of some weeds on germination and initial growth of groundnut. *Indian Journal of Agricultural Sciences*, **7**:493-94.

Rajashekhara. 2000. Studies on seed production in relation to seed vigour, seed position and pollen viability in KBSH-1, *hybrid sunflower*. MSc (Agri) Thesis, University of Agricultural Sciences, Bangalore-65.

J. Oilseeds Res., **22**(1) : 25-28 (2005)

Phenotypic stability of yield and yield attributes in sesame, *Sesamum indicum* L.

T. Anuradha and G. Lakshmikantha Reddy

Department of Genetics and Plant Breeding, S.V. Agricultural College, Tirupathi, AP

(Received: April, 2004; Revised: January, 2005; Accepted: January, 2005)

Abstract

Genotype x Environment interaction studies of 71 diverse genotypes of sesame at 3 locations *viz.*, ARS., Peddapuram, (E.G. Dt.) ARS, Elamanchili (Vizag Dt.) and RARS, Jagtial (Karimnagar Dt.) revealed that substantial portion of the interaction was due to linear components and Peddapuram location was most favoured for sesame production. None of the genotypes exhibited stable performance for all the traits, however, genotypes EC 355653, EC 351882, EC 357312, EC358039, SI 1618, SI 75, YLM 17, DCB 1791 and NAC 8414 were stable for seed yield/plant.

Key words: Sesame, phenotypic stability

Introduction

Genotype x Environment interactions were known to interfere with the evaluation of genotype and reduces the progress of selection in plant breeding programmes as the genetic nature of a genotype is masked (Comstock and Moll, 1963) and as such, these interactions are of considerable importance in developing improved varieties and rationalization of procedure for future genetic improvement in crop plants. Stable genotypes help to achieve predictable performance through wider adaptability of genotypes (Allard and Bradshaw, 1964). linear regression as a measure of stability was advocated by Finlay and Wilkinson (1963) while, Eberhart and Russel (1966) emphasized the importance of both linear and non linear components. A variety should have fairly high mean in order to be of practical value in the assessment of genotypes.

Materials and methods

The study consisted of 71 diverse genotypes of sesame, studied during *kharif*, 2000 at 3 locations *viz.*, ARS, Peddapuram; ARS, Elamanchili and RARS, Jagtial representing diverse environmental conditions. Data were recorded on 10 random normal and healthy plant son the 12 charters *viz.*, plant height, days to maturity, number of primary branches, capsules on main stem, capsules on primary branches, capsules/plant, capsule length, biological yield, harvest index and seed yield/plant and the mean values were computed and subjected to genotypes x environment interaction as per the procedure suggested by Eberhart and Russel (1966).

Results and discussion

Pooled analysis of variance (Table 1) indicated highly significant differences among the genotypes for all the traits and significance of environment linear effects suggest that the genotypes were evaluated under diverse locations. Most of the variances were attributed due to environments with profound influence of environment on seed yield as reported by Thiyagarajan and Ramanathan (1995).

Significant mean squares due to genotype x environment interaction indicated the differential behaviour of genotype across the locations (Varma and Mahto, 1994). A major portion of genotype interaction was attributed to linear component suggesting that variation in the performance of genotypes is due to the genotypes on environments and as such, performance is predictable in nature.

Grading of environments: Environmental indices (Table 2) for plant height, days to maturity, capsules on main stem, capsules on primary branches, capsules/plant, seed/capsule, 1000 seed weight , biological yield, harvest index and seed yield/plant indicated the suitability of Peddapuram location for sesame production.

Stability parameters: Eberhart and Russel (1966) suggested both linear (bi) and non linear (S^2di) components should be considered in judging the phenotypic stability of a particular genotype and considered three stability parameters *viz.*, mean performance (X), regression coefficient (bi),and deviation from regression (S^2 di) and an ideal genotype depending on the character with high or low mean, unit regression coefficient and non significant deviation from regression. The genotypes were grouped into 3 groups ban d on the stability parameters for all the traits at a time (Table 3).

Table 1 **Pooled analysis of variance (mean squares for stability analysis for various quantitative traits of sesame for genotype x environment interaction**

Source of variation	d.f.	Plant height	*Days to maturity*	No. of primary branches	Capsules on main stem	Capsules on primary *branches*	Capsules/ plant	Capsule length	Seeds/ capsule	1000 Seed weight	Biological yield	Harvest index	*Seed yield/plant*
Genotypes	70	*316.38***	*45.22***	*1.53*	*48.37***	401.17**	609.61**	0.132*	190.70**	0.236*	89.32	49.76	8.19**
Env+(Var+Env.)	142	1303.00**	79.308*	1.06**	63.50**	211.49*	407.59**	0.108	23.36**	0.118**	220.75**	51.94**	21.87**
Environments	2	81439.43**	3798.60**	30.34**	2137.03**	7419.63**	16126.92**	2.23**	2.22	3.673**	12544.79**	1300.0**	1223.02**
Genotypes x environments	*40	*158.20*	*26.17**	*0.64**	*33.88***	108.5*	183.03*	0.07	22.65	0.067**	44.70**	84.12*	4.71**
Environment (linear)	1	162878.87**	7597.20**	60.69**	4274.06**	14839.27**	32253.85**	4.46**	4.45	7.34**	25089.59**	2600.20**	2446.04**
Genotypes x Env. (linear)	70	177.13	50.18**	0.82**	47.47**	134.0*	216.41*	0.08	10.75	0.135**	72.96**	27.12	8.28**
Pooled Deviation	71	137.30**	2.14+ +	0.4 5+ +	20.01++	81.86**	127.54**	0.075++	34.06++	0.0003	16.20++	40.53++	1.43++
Pooled error	210	34.20	0.19	0.29	13.72	35.85	74.16	*0.002*	1.02	0.0039	9.72	15.03	0.41
Total	212	977.88	68.05	1.21	58.5	274.12	474.30	0.116	77.94	0.157	177.36	51.22	17.35

* Significant at 5% level (Tested against pooled deviation;
** Significant at 1% level (Tested against pooled deviation)
++ Significant at 1% level (Tested against pooled error)

Table 2 Environmental indices for various quantitative traits in sesame

Character	E_1 (Peddapuram)	E_2 (Elamanchili)	E_3 (Jagtial)
Plant height	20.24	18.856	-39.099
Days to maturity	-4.24	-4.202	8.446
No. of primary branches	-0.22	0.735	-0.518
Capsules on main stem	6.288	-2.474	-3.814
Capsules on primary branches	11.597	-7.703	-3.984
Capsule/plant	17.308	-10.221	-7.687
Capsule length	0.194	-0.154	-0.040
Seeds/capsule	-0.204	0.092	0.113
1000 seed weight	0.132	-0.263	0.130
Biological yield	15.347	-7.861	-7.486
Harvest index	4.097	-4.440	0.34
Seed yield/plant	4.764	-2.83	-1.954

Table 3 Genotypes classified into different groups of environmental conditions

Character	*Group I*	*Group II*	*Group II*
Plant height	EC 357312, Vinayak Gowri, YLM 11, YLM 21, K 5177, K 5203, JBT 9/29, NKD 1093, DCB 1844, JBT 9/19 K 5176, DCB 1836, NKD 1151	DCB 1874, DCB 1855, DCB 1869, DCB 1858 K 5170, NKD 1093, JBT 9/39, NKD 1110	EC 358022, SI 3012, SI 1618, Madhavi, YLM 17, DCB 1828
Days to Maturity	—	Vinayak, Madhavi, YLM 17, K 5181, *DSR 1974, DCB 1860*	K 5231, DCB 1855, K 5235, K 5199, NKD 1107, DCB 1791, K 5182, DCB 1857, SO 12-2148, DCB 1858, K 5170, PSR 1943, K 5173, DCB 1862, K 5177, K 5203, JBT 9/29, NKD 1160, SO 12-2172, DCB 1799, K 5220, NKD 1093, DCB 1844, JBT 9/39, K 5194, DCB 1836, SO 2152, DCB 1805, K 5163 & DCB 1818, K 5231, NKD 1139
Number of primary branches	EC 355653, EC 351882, EC 357312 EC 357313, EC 358022, SI 3012, SI 1618, SI 320, Gowri, YLM 11, YLM 17, K 5181, DCB 1855, DCB 1869, DCB *1858, K 5170, PSR 1943*, K 5177, K 5201, DCB 1799, K 5220, DCB 1836, NKD 1158, DCB 1818	**EC 358039**, *SI 75*, **Madhavi, YLM** *21*, **DCB 1805**	*DCB 1824*
Capsules on main stem	EC 357313, EC 358022, SI 3012, SI 75, YLM 17, SO 2152, SI 1618, K 5181, SO 12-2154, DSR 1974	**NKD 1110, K 5163, YLM 21**	**Vinayak, SI 320, Gowri, DCB 1874,**
Capsules on primary branches	EC 358039, SI 75, YLM 11, YLM 17, K 5181, DSR 1974, *K 5170, PSR 1943*, SO 12-2172, DCB 1799, DCB 1836	YLM 21	
Capsules/plant	EC 355653, EC 351882, EC 358022, *Vinayak*, SI 1618, SI 320, Tanuku brown, SI 75, PS 201, Gowri, Madhavi, YLM 17, DCB 1874, K 5199, K 5170, SO 12-2172	PSR 1943	
Capsule length	YLM 11, DCB 1844		*SI 75, Madhavi*
Seeds/capsule	EC 351882, EC 357025, PS 201, Gowri, DCB 1855, DCB 1828, K 5199, *DCB 1869, SO 12-2148, K 5170*, PSR 1943, K 5203, JBT 9/29, NKD 1160, SO 12-2172, K 5220, DCB 1818, NKD 1151, DCB 1805, NKD 1070, NKD 1110, K 5163, DCB 1824, K 5176		
1000 Seed weight	NKD 1070, EC 357025	EC 357312, NKD 1107, DCB 1791, WKD 1139, DCB 1857, DCB 1858, DCB 1862, K 5203, NKD 1160, SO 12-2712, *DCB 1799, NKD 1093, JBT 9/19*, DCB 181, NKD 1151, DCB 1805, DCB 1860, NKD 1110, DCB 1824	EC 351882, SI 3012, SI 1618, Tanuku Brown, SI 75, PS 201, Gowri, YLM 17, K 5181, SO-12-2154, SO 2152, K 5235, DCB 1828, K 5220
Biological yield	EC 351882, EC 357313, DCB 1824 EC 358039, Madhavi, YLM 21, DCB 1836, K 5177, DCB 1874, NKD 1160	EC 355653, EC 357025, EC 357312, EC 358022, SI 3012, SI 320, SI 75, PS 201, YLM 11, DCB 1874, K 5170, NKD 1160, DCB 1799, SI 1618, K 5181	Krishna, YLM 17, K 5176
Harvest Index	SI 75, YLM 11, YLM 17, DCB *1828*, K 5199, K 5220, DCB 1805, DCB 1860, NKD 1070, NKD 1110, Madhavi, DCB 1836, DCB 1824, Vinayak, DSR 1974, DCB *1858*	EC 358022, *PS 201*, YLM *21, K 5181*, DSR 1974, DCB 1791, NKD 1139, K 5203, DCB 1799, DCB 1874, SO 12-2154, NKD 1107	*SI 3012, NAC 8414, SO-12-2171*
Seed yield/plant	EC 355653, EC 351882, EC 357312, EC 358039, SI 1618, SI 75, YLM 17, DCB 1791, NAC 8414	EC 358022, SO 3012, Vinayak, SI 320, PS 201, Gowri, Madhavi, YLM 11, YLM 21, DCB 1855, DSR 1974, NKD 1139, K 5170, DCB 1799, DCB 1844, NKD 1138, DCB 1824, DCB 1874, K 5235, NKD 1107	EC 357313, Tanuku Brown, SO-12-**217**

Group I : Stable genotypes for average environmental conditions Genotypes with high mean, regression coefficient near to unity and least deviation from regression.

Group II : Stable genotypes for favorable conditions Genotypes with high mean, regression coefficient significant and higher than unity and least deviation from regression.

Group III : Stable genotypes for poor environmental conditions Genotypes with high mean, less than unity regression and least deviation from regression.

It can be observed that no genotype was suitable for all the character however, genotypes EC 355653, SI , 17 and EC 357039 showed stable performance for yield and some of the component traits under average environmental conditions.

References

Allard, R. W. and Bradshaw, A.D. 1964. Implications of genotypic environment interaction in applied plant breeding. *Crop Science*, **4**: 503-508.

Comstock, R.E. and Moll, R.H. 1963. Genotypic environment interactions. In: *Statistical Genetics and plant breeding*. NAS - NRC Publications 982. 164 -196.

Eberhart, S.A. and Russel, W.A. 1996. Stability parameters for comparing varieties. *Crop Science*, **6** : 36 -40.

Finlay, R.W. and Wilkinson. 1963. The analysis and adaptation in a plant breeding programme. *Australian Journal of Agricultural Research*, **14** : 742 - 754.

Thiyagarajan, K. and Ramanadhan, T. 1995. Inheritance of seed yield in sesame under different environments. *Madras Agricultural Journal*, **82**(12) : 640- 642.

Verma, A.K. and Mahto, J.L. 1994. Stability for yield and yield attributing characters in sesame under rainfed conditions. *Journal of Oilseeds Research*, **11**(2) : 170 - 173.

J. Oilseeds Res., **22**(1) : 29-36 (2005)

Genetic diversity and adaptability in Indian germplasm collection of sesame, *Sesamum indicum* L.

K.M.S. Raghuwanshi and S.S. Duhoon

All India Coordinated Research Project on Sesame and Niger, JNKVV Campus, Jabalpur-482 004, MP

(Received: February, 2004; Revised: November, 2004; Accepted: December, 2004)

Abstract

In the present investigation, an attempt was made to study the genetic diversity of 100 genotypes for 8 characters using D^2 analysis. The multivariate analysis using D^2 statistic revealed that oil content and days to 50% flowering contributed maximum to the divergence, followed by, 1000-seed weight, seed yield, plant height, number of capsules/plant, days to maturity and number of branches/plant. It was interesting to note that the eleven genotypes of exotic origin were included in the present investigation and they did not show much diversity among them, as they fall in two or three clusters of very low cluster distances between them. Although genotypes were received 5 from Bulgaria, 2 from Korea, 2 from Bangladesh and 1 each from Japan and USA. The results indicated that genotypes from exotic origin have genetically similar types. Where as states like Tamil Nadu (total 6 genotypes in 5 clusters), Karnataka (total 3 in 3 clusters), Gujarat (total 6 in 5 clusters) and Rajasthan, total 5 genotypes, which were distributed in 4 clusters. These states were found to be the richest states in respect of the existing genetic diversity. This comparison also in confirmation of the fact that sesame is a crop, which was originated in Indian subcontinent.

Key words: Diversity, D^2, sesame, origin

Introduction

Conventional procedure of indiscriminate hybridization on a massive scale in any crop results in an immense wastage of resources. Qualset (1979) opined that most often asked question among breeders is how to choose parents for crossing. Greater success can be achieved through judicious choice of parents for hybridization based on genetic divergence. Crosses between divergent parents usually produce greater heterosis than those between closely related ones (Moll and Stuber, 1971). Genetic divergence studies are the vital tools for the evaluation of germplasm lines and selection of parents for the breeding programme. So, the present study was undertaken to measure genetic diversity among the germplasm lines. Such information will be helpful for breeders to plan hybridization programme. Inclusive of diverse parents in hybridization programme can serve the purpose of combining desirable genes or to obtain superior recombination. Among several methods of multivariate analysis available to study genetic diversity in biological population, the D^2 analysis had been a perfect test in the quantitative estimation of genetic diversity.

Materials and methods

Genetic diversity of 100 genotypes was studied for 8 characters using D^2 analysis. The generalized distance suggested by Mahalanobis (1936) has been successfully used in measuring the divergence in most of the crops by several workers.

Analysis of covariance was carried out for all possible pairs of 8 characters, chosen for genetic divergence studies. The uncorrelated variables were obtained by the pivotal condenatation of the common dispersion matrix (the error variance and covariance matrix) and the original mean values (X_1 to X_8) of the 100 genotypes were transformed into standardized uncorrelated (Y_1 to Y_2) variables. D^2 values corresponding to all possible combinations taken two genotypes at a time were computed as per Rao (1952) and Anderson (1958).

Hundred genotypes chosen for the present investigation include 17 strains from the NBPGR's (Thrissur and Jodhpur centre) core collection, 16 from Andhra Pradesh (segregating population), 11 from exotic origin (5 from Bulgaria, 2 from Korea, 2 from Bangladesh, 1 from USA, and 1 from Japan), 9 from core collection of NBPGR, Akola center, 8 from Rajasthan, 6 from Uttar Pradesh, 6 from Tamil Nadu, 6 from Gujarat, 5 from Maharashtra, 4 from West Bengal, 4 from Madhya Pradesh, 3 from Karnataka, 3 from Punjab, 1 from Haryana and 1 from Orissa. Thus, the material represented a wide range of geographic diversity; whatsoever was available in the whole country's sesame genetic stock.

Arunachalam and Ram (1967) advocated the use of equal number of varieties from each region in order to find out a true picture of association existing between geographical and genetic divergence. It was not so in this study because the objective here was to pinpoint genetically diverse and desirable parents for initiating effective and intensive sesame breeding programme. Obviously genotypes were included from the major sesame growing regions of the world.

Results and discussion

Group constellation: Analysis to estimate D^2 values was done on the basis of relative magnitude of D^2 values, all the 100 genotypes were grouped into 6, 6, 21, 19 and 15 *clusters in first date of sowing in rabi* summer, second date of sowing in *rabi* summer, first date of sowing In *kharif*, second date of sowing in *kharif* and on pooled basis, respectively (Table 1).

In first date of sowing in rabi summer, the highest inter cluster divergence was observed between genotypes of cluster III and VI (91.29). The intra-cluster divergence varied from 0.00 to 10.28. At second date of sowing in *rabi* summer, the highest cluster divergence was observed between the genotypes of cluster V and VI (90.40). The intra-cluster values varied from 0.00 to 9.08.

In *kharif* at first date of sowing, the highest cluster divergence was observed between the genotypes of cluster XIX and XXI (13.56). The intra cluster divergence varied from 0.00 to 4.17. At second date of sowing in *kharif*, the highest cluster divergence was observed between the genotypes of clusters XVI and XVIII (52.08). *The intra cluster values varied from 0.00 to 10.52.*

On pooled basis, the highest inter cluster divergence was observed between the genotypes of cluster IX and XV (26.85). The intra cluster value varied from 0.00 to 7.00.

In first environment, total genotypes distributed in 6 clusters. In second environment, total genotypes distributed in 6 clusters. In third environment total genotypes were grouped into 21 clusters. In Fourth environment total genotypes were grouped into 19 clusters.

On pooled basis of all the environments studied genotypes grouped into 15 clusters. Cluster I comprised of 48 genotypes out of which 10 from Andhra Pradesh, 7 from NBPGR, 5 from exotic origin, 4 from S core collection, 4 from Rajasthan, 3 form West Bengal, 3 from Maharashtra, 2 each from Punjab, Madhya Pradesh and Gujarat and one each form Karnataka and Orissa. Cluster II comprised of 23 genotypes out of which 5 from exotic origin, 3 from NBPGR, 2 each from Madhya Pradesh, Andhra Pradesh and Rajasthan and one each from Karnataka, Haryana, Punjab, West Bengal, S core collection, Gujarat, Uttar Pradesh, Tamil Nadu and Maharashtra. Cluster III comprised of 8 genotypes out of which 2 each from S core collection and Andhra Pradesh and one each from NBPGR, Gujarat, Uttar Pradesh and Rajasthan. Cluster V comprised of 5 genotypes out of which 2 from Tamil Nadu and one each from S core collection, NBPGR and Rajasthan. Cluster VII included 4 genotypes out of which 3 from NBPGR and one form Tamil Nadu. Cluster XII and XIV both included 2 genotypes each one from Gujarat and Andhra Pradesh and exotic and Tamil Nadu respectively. All other clusters namely cluster VI, VII, IX, X, XI, XIII and XV included only one genotypes each from Tamil Nadu, Gujarat, NBPGR, exotic origin, Andhra Pradesh and S core collection respectively.

Components of Intra-cluster D^2: Cluster means for all eight characters are presented in Table 3. An examination of cluster means in first environment, revealed that genotypes grouped in cluster VI had the highest means (63.75) for days to 50% flowering and the lowest mean for the cluster V (58.50). For days to maturity, cluster VI (100.25) had the highest cluster mean and cluster V (97.00) had lowest mean.

Cluster V had the highest means for plant height (83.72) and the lowest mean was observed for cluster VI (75.82). Cluster V had the highest means for number of branches per plant (6.45) and the lowest was observed for VI (4.25). Number of capsules per plant had the highest means for *cluster II (55.91) and the lowest was observed for cluster* III (42.56). Highest mean for seed yield was recorded by cluster IV (5.57) and the lowest cluster mean by VI (1.94). Cluster II had the highest cluster mean (3.09) for 1000 seed weight and lowest by IV (2.73). % Oil content had the highest means for cluster VI (48.82) and lowest mean was observed by cluster III (27.77).

In the second environment cluster means revealed that cluster VI had the highest mean for days to 50% flowering and the lowest mean for cluster I (52.72), Days to maturity had the highest mean for cluster VI (98.25) and the lowest mean was observed for cluster I (92.22). Plant height had the highest mean for cluster V (79.35) and the lowest mean was observed for cluster I (70.09). Number of branches/plant had the highest mean for cluster V (4.90) and lowest mean for cluster VI (3.57). Number of capsules/plant had the highest mean for cluster II (34.86) and the lowest mean was observed for cluster IV (23.25). Seed yield had the highest mean for cluster V (5.23) and the lowest mean for cluster VI (2.35). Cluster I had the highest cluster mean (2.93) for 1000 seed weight and lowest mean for cluster V (2.73). Cluster VI observed the highest cluster mean (51.22) for % oil content the lowest mean was for cluster V (28.17).

Table 1 **Inter and intra-cluster distance, D^2 and D values in sesame**

E_1 (S_1D_1)

Cluster	I	II	III	IV	V	VI
I	10.28	24.38	36.11	22.42	42.60	56.61
II		9.08	58.02	43.92	20.64	34.39
III			9.78	15.51	77.16	91.29
IV				6.08	62.97	77.12
V					0.00	14.48
VI						0.00

E_2 (S_1D_2)

Cluster	I	II	III	IV	V	VI
I	9.08	20.31	36.44	17.72	58.26	33.55
II		8.74	19.04	34.82	40.14	51.17
III			8.10	51.69	23.11	68.20
IV				6.37	73.81	17.36
V					0.00	90.41
VI						0.00

E_3 (S_2D_1)

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI
I	3.74	5.28	5.57	5.06	4.51	4.28	4.89	6.95	4.53	4.62	4.94
II		0.00	2.58	6.75	7.21	5.96	7.06	9.65	7.76	6.05	7.93
III			3.41	6.86	7.36	6.13	7.29	9.69	7.87	6.27	8.07
IV				3.47	7.09	7.03	7.84	4.61	5.86	7.02	6.90
V					0.00	3.00	2.46	8.65	3.53	2.59	2.71
VI						0.00	2.88	8.80	4.72	3.93	4.55
VII							0.00	9.20	3.97	4.25	3.69
VIII								4.18	6.50	9.22	7.74
IX									0.00	4.84	2.76
X										0.00	4.30
XI											0.00
XII											
XIII											
XIV											
XV											
XVI											
XVII											
XVIII											
XIX											
XX											
XXI											

Cluster	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI
I	4.77	7.03	5.29	5.17	5.36	6.42	5.53	7.19	6.88	8.30
II	8.17	4.12	8.13	8.23	5.52	4.97	5.44	10.36	9.52	8.54
III	8.33	4.48	8.11	8.04	5.61	5.19	5.87	10.22	9.35	8.90
IV	5.33	7.28	7.71	4.96	7.66	5.58	8.62	5.96	5.28	11.52
V	4.57	8.93	2.57	5.29	4.55	8.97	4.29	7.64	8.04	6.03

VI	5.32	8.30	2.52	6.39	5.07	8.33	3.33	8.92	8.61	5.30
VII	4.87	9.55	3.06	6.08	5.09	9.28	3.72	8.32	8.60	5.86
VIII	5.60	10.40	8.78	5.72	10.09	7.97	10.93	6.11	4.96	13.52
IX	3.13	9.73	4.49	3.65	5.49	8.03	6.26	5.13	6.14	8.99
X	5.92	7.12	4.64	5.82	2.96	7.79	4.14	8.26	8.81	6.31
XI	4.90	9.95	3.77	5.32	5.44	9.09	6.89	6.86	7.07	7.67
XII	0.00	9.72	5.17	3.55	7.26	8.47	7.08	5.12	5.80	9.69
XIII		0.00	10.06	8.82	6.79	4.85	8.10	10.83	10.34	10.78
XIV			0.00	6.18	6.19	9.94	5.02	8.49	8.31	5.94
XV				0.00	6.26	7.33	7.84	3.35	4.56	10.92
XVI					0.00	6.80	4.49	8.56	9.28	7.54
XVII						0.00	9.04	8.25	8.72	12.41
XVIII							0.00	10.64	9.98	4.25
XIX								0.00	5.30	13.56
XX									0.00	12.93
XXI										0.00

E_4 (S_2D_2)

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X
I	10.47	14.33	15.72	26.15	14.74	12.72	14.16	14.46	16.21	13.44
II		10.25	23.14	35.58	15.16	13.78	14.17	21.62	24.07	17.72
III			10.53	19.18	22.30	15.54	18.40	17.32	16.52	19.83
IV				8.80	30.31	30.46	32.04	19.62	18.72	27.03
V					10.50	19.09	17.05	14.44	19.33	17.33
VI						0.00	11.43	21.19	22.05	19.18
VII							0.00	20.47	20.13	15.83
VIII								0.00	7.61	13.28
IX									0.00	11.42
X										0.00

Cluster	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX
I	16.55	15.16	21.07	20.04	18.45	32.20	30.45	23.31	18.67
II	17.76	16.56	24.30	27.39	27.54	41.79	39.08	16.40	24.37
III	18.48	18.61	21.13	15.31	16.01	23.92	21.07	32.10	17.59
IV	32.45	28.84	27.15	16.59	14.36	12.13	15.25	45.05	23.32
V	23.11	18.59	23.58	20.93	24.25	36.73	36.71	26.10	20.50
VI	12.83	14.46	21.50	23.03	23.65	36.53	31.54	20.00	17.94
VII	8.25	20.89	28.05	24.61	25.78	36.58	36.54	21.70	23.22
VIII	24.21	21.52	24.69	15.23	12.12	25.69	28.91	32.62	16.22
IX	21.87	24.93	28.74	17.97	10.12	22.54	28.45	34.11	19.82
X	16.87	22.87	29.26	24.94	16.87	31.70	34.89	24.70	24.26
XI	0.00	22.77	29.82	27.95	25.99	36.00	35.46	22.04	27.11
XII		0.00	9.28	20.24	24.32	36.12	28.15	24.19	21.09
XIII			0.00	19.33	26.08	34.69	23.99	32.18	22.75
XIV				0.00	18.04	21.52	20.31	39.60	16.80
XV					0.00	19.34	21.99	36.49	19.17
XVI						0.00	18.16	52.09	31.23
XVII							0.00	47.58	27.22
XVIII								0.00	33.30
XIX									0.00

Pooled

Cluster	I	II	III	IV	V	VI	VII	VIII
I	6.37	11.54	13.28	7.86	10.49	8.26	18.04	10.38
II		6.82	9.98	9.22	14.17	16.47	11.01	8.15
III			7.00	13.42	11.45	16.65	9.66	10.39
IV				0.00	14.47	12.44	16.69	11.49
V					6.17	9.66	16.92	11.03
VI						0.00	22.06	14.43
VII							6.31	12.74
VIII								0.00

Cluster	IX	X	XI	XII	XIII	XIV	XV
I	8.13	8.41	18.58	16.93	12.22	21.72	21.42
II	16.57	9.27	10.00	13.82	12.40	14.06	15.03
III	18.05	14.65	11.26	8.41	8.90	15.41	11.55
IV	11.24	5.69	15.69	18.46	14.70	18.22	20.49
V	12.12	14.66	19.57	11.92	7.22	22.42	18.57
VI	4.78	13.01	23.96	19.15	12.94	26.32	25.08
VII	23.35	17.13	7.57	10.14	14.49	10.12	8.28
VIII	14.63	8.84	12.93	12.92	10.16	17.51	16.83
IX	0.00	11.37	24.42	21.51	14.90	26.60	26.86
X		0.00	16.22	19.28	14.92	18.73	21.82
XI			0.00	13.78	16.38	10.19	10.38
XII				0.00	8.73	17.57	8.78
XIII					0.00	17.95	14.85
XIV						0.00	12.55
XV							0.00

Table 2 Composition of clusters in sesame germplasm

Cluster No.	Total genotypes	Genotypes
I	48	91, 92, 39, 40, 7, 84, 83, 88, 8, 11, 36, 23, 3, 100, 12, 24, 32, 38, 31, 47, 27, 28, 80, 30, 64, 66, 82, 4, 34, 6, 2, 86, 95, 98, 10, 63, 90, 99, 22, 67, 44, 55, 26, 58, 42, 43, 72, 16
II	23	87, 33, 75, 76, 54, 52, 70, 51, 14, 71, 93, 50, 96, 74, 62, 9, 81, 21, 13, 97, 37, 1, 89
III	8	59, 60, 68, 29, 5, 35, 41, 25
IV	1	15
V	5	19, 20, 56, 78, 18
VI	1	79
VII	4	61, 65, 69, 53
VIII	1	46
IX	1	48
X	1	94
XI	1	49
XII	2	45, 77
XIII	1	17
XIV	2	73, 85
XV	1	57

Table 3 Cluster means for eight characters in sesame (pooled)

Character	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of branches/ plant	No. of capsules/ plant	Seed yield	1000 seed weight	% oil content
I	49.76	89.77	69.68	3.72	36.89	2.29	3.19	45.16
II	53.25	93.15	70.54	4.01	41.39	3.16	2.99	39.96
III	58.96	98.68	74.91	4.69	61.30	4.79	3.22	42.53
IV	48.00	88.00	72.00	4.10	47.80	1.92	3.59	41.65
V	56.88	95.69	71.86	4.23	29.60	3.08	3.00	47.81
VI	49.25	89.75	82.83	4.05	32.98	1.41	3.14	49.08
VII	60.25	100.75	84.12	5.40	53.02	3.49	2.86	38.63
VIII	53.75	92.75	62.20	3.60	18.25	4.15	2.34	42.30
IX	46.50	85.50	72.83	4.90	36.23	1.75	3.20	48.20
X	46.75	87.25	64.05	4.03	18.10	2.27	2.96	41.40
XI	58.25	97.75	72.53	3.88	59.18	5.33	2.99	36.15
XII	64.25	103.00	74.15	3.90	49.88	2.42	2.85	43.70
XIII	58.50	97.00	83.73	6.45	45.38	2.78	2.81	45.80
XIV	58.25	97.50	89.30	7.05	30.35	2.60	3.49	34.83
XV	66.25	104.00	82.90	3.50	44.05	2.57	3.29	38.90

In third environment, the highest cluster for days to 50% flowering mean was observed in cluster XXI (60.00) and lowest was in XVII (44.75). For days to maturity highest cluster means was observed by XIV and XXI (99.50) and lowest by XIII (86.25). Plant height had the highest mean for cluster XIX (102.65) and lowest mean for cluster XXI (55.95). Number of branches had observed highest cluster mean for XIX (6.50) and lowest by XXI (2.75). Number of capsules/plant had the highest mean for cluster XIX (69.20) and lowest mean for cluster XXI (18.85). Seed yield had the highest mean for cluster XIX (5.21) and lowest mean for cluster XXI (1.02). The 1000 seed weight had highest cluster means for cluster XII (3.65) and lowest for cluster XIV (2.68). The % oil content had the highest cluster means for cluster XXI (52.70) and lowest mean for VIII (33.37).

In fourth environment, days to 50% flowering had observed the highest cluster mean for cluster X (58.00) and lowest for cluster XIV (44.75), day to maturity had the highest cluster means for cluster X and XVII (99.00) and lowest means for cluster XIV (85.00). Cluster XVI had the highest means for plant height (101.85) and lowest means by XVIII (54.17). Number of branches had highest cluster means for cluster XVI (6.25) and lowest means for XVIII (2.77). Number of capsules had the highest means for cluster XIX (70.70) and lowest for cluster XVIII (19.55). Cluster XVIII (7.35) had the highest mean for seed yield and cluster XVIII (1.06) with the lowest means. 1000 seed weight had the highest cluster means for XV (3.61) and lowest means for XVIII (3.01)..The highest means for % oil content was observed in cluster XVIII (52.70) and lowest by XVI (35.50).

On pooled basis, days to 50% flowering had the highest mean for cluster XV (66.25) and lowest means for IX (46.50). Days to maturity had the highest mean for cluster XV (104.00) and lowest mean for cluster IX (85.50). Plant height had the highest mean for cluster XIV (89.30) and lowest mean for cluster VIII (62.00). Highest cluster mean was observed, for number of branches per plant, in cluster XIV (7.05) and lowest mean in XV (3.50). Number of capsules had the highest mean for cluster III (61.30) and lowest mean for X (18.10). The seed yield had the highest value of cluster mean for cluster XI (5.33) and lowest mean for VI (1.41), for 1000 seed weight cluster IV (3.58), had the highest mean and lowest mean for VIII (2.33). The highest mean observed for % oil content in cluster VI (49.07) and lowest mean for XIV (34.82).

The multivariate analysis using D^2 statistic revealed that oil content and days to 50% flowering contributed maximum to the divergence, followed by, 1000-seed weight, seed yield, plant height, number of capsules/plant, days to maturity and number of branches/plant. Swain and Dikshit (1997) also reported largest contribution to total divergence by seed oil content, followed by, 1000-seed weight and number of days to 50% flowering. But in contrary to these results Manivannan and Natarajan (1996) reported the plant height as the major contributor to the genetic divergence, followed by number of branches/plant, seed yield and number of capsules/plant. Singh *et al.* (1998) also reported that branches/plant contributed to a greater extent.

The genotypes within the cluster had smaller D^2 values among themselves than the genotypes belonging to other cluster. Smaller D^2 values within cluster indicated that these genotypes were closely related. On the other hand, genotypes, belonging to two different clusters had large D^2 values, showing more genetic diversity with each other. The clustering pattern of different genotypes did not follow their geographical distribution.

Based on the D^2 values between the pairs of genotypes, during first environment, 100 genotypes were grouped into six cluster and cluster I consisted of genotypes from A core collection, DOR, Andhra Pradesh, exotic origin, B core collection, Tamil Nadu, Maharashtra, Rajasthan Gujarat and Madhya Pradesh. The largest cluster II consisted of genotypes from DOR, Andhra Pradesh, Uttar Pradesh, Gujarat, A core collection, West Bengal, exotic origin, Rajasthan, Madhya Pradesh, Punjab, Karnataka, Tamil Nadu, Haryana and Orissa.

During second environment the largest cluster I includes genotypes from DOR, Andhra Pradesh, Uttar Pradesh, Gujarat, A core collection, Punjab, Madhya Pradesh, West Bengal, exotic origin, Tamil Nadu, Rajasthan, Karnataka, Haryana and Maharashtra.

The second largest cluster II includes genotypes from A core collection, DOR, Andhra Pradesh, B core collection, exotic origin, Maharashtra, Rajasthan, Tamil Nadu, Gujarat, Madhya Pradesh and Orissa.

In third environment, largest cluster I includes genotypes from A core collection, exotic origin, DOR, Andhra Pradesh, B core collection, Gujarat, Tamil Nadu, Maharashtra, West Bengal, Uttar Pradesh, Rajasthan, Punjab, Orissa and Karnataka. In fourth environment, largest cluster I include genotypes from A core collection, exotic origin, DOR, Andhra Pradesh, Rajasthan, Gujarat, B core collection, Tamil Nadu, Maharashtra, Uttar Pradesh, Madhya Pradesh, Punjab and Orissa.

On pooled basis *largest cluster I includes genotypes from* DOR, Andhra Pradesh, A core collection, exotic origin, B core collection, Rajasthan, Uttar Pradesh, Maharashtra, West Bengal, Madhya Pradesh, Uttar Pradesh, Orissa, and Karnataka.

Based on pooled analysis the genotypes from one geographical region it was observed that the maximum diversity found in the genotypes from A core collection genotypes distributed in 7 clusters followed by Gujarat (in 5 clusters), DOR, Andhra Pradesh (in 5 clusters), Tamil Nadu (in 5 clusters), Rajasthan (in 4 clusters), B core collection (in 3 clusters), Karnataka (3 clusters), Uttar Pradesh (in 3 clusters), West Bengal, Madhya Pradesh, Punjab.

Mahapatra *et al.* (1993) did not observe any relationship with geographical origin in an analysis of twenty-nine varieties. Patil and Sheriff (1994) grouped varieties into fourteen clusters on the basis of genetic distance it was found not to be in accordance with their geographical origin. It was interesting to note that the eleven genotypes of exotic origin were included in the present investigation and they did not show that much diversity among them, as they fall in two or three clusters of very low cluster distances between them. Although genotypes were 5 from Bulgaria, 2 from Korea, 2 from Bangladesh and 1 each from Japan and USA. The results indicated that genotypes from exotic origin had genetically similar types. Where as states like Tamil Nadu (total 6 genotypes in 5 clusters), Karnataka (total 3 in 3 clusters), Gujarat (total 6 in 5 clusters) and Rajasthan, total 5 genotypes, which were distributed in 4 clusters. These states were found to be the richest in respect of the existing genetic diversity. This comparison is in confirmation of the fact that sesame is a crop, which was originated in Indian subcontinent. Thoroughly discussed and concluded by Bedigian (1984), Bedigian and Harlen (1986) and confirmed by Bhat *et al.* (1999) through DNA markers.

In first environment of experiment the highest cluster distance was observed between the genotypes of cluster III and VI and in second environment cluster V and VI. Therefore maximum amount of heterosis is expected in cross combinations involving the parents belonging to most divergent clusters for *rabi* summer. The crosses of S-0186, TWA-4; S-0233 with Tapi would expect to produce the genotype most favorable for *rabi* summer season.

In third environment the highest cluster distance was observed between the genotypes of cluster XIX and XXI and VIII and XXI. In fourth environment between cluster XVI and XVIII and £VIII and XVII. The crosses of No. 2, TWA-4, S-0233, RSS-218 and 77-701 with NIC-9824-H and Tapi would expect to produce the most favourable genotype for *kharif* cultivation.

On pooled basis the cluster means during both the seasons *rabi* and *kharif*, maximum divergence was found between cluster IX towards cluster XIV and XV. The crosses of JLT-7 with and S-0445 expected to produce most favourable hybrid, for the cultivation in the seasons, *rabi* summer and *kharif*. It is important that for obtaining high heterosis, the parents should belong to divergent clusters, which was in agreement with Wei-Wen Xing *et al.* (1994) and Tan and Tau (1996).

Practical *utility: Based on the study of genetic divergence* the following genotypes were identified which can be used in breeding programme.

Genotypes	Desirable characteristics
Tapi	Early, bold seeded, more number of capsules and high oil
RT-54	Tall, bold seeded and more number of branches
CO-1	Tall, bold seeded
IC-204670	Tall, more branches and high yield
TWA-4	High yield
97-71	Early
No. 2	More branches and capsules, high yield
S-0186	Bold seeded
Gouri	Early
E-8	Tall, early and bold seeded
TLG-21	More capsules, high yield
GRT-8340	Early
EC-310420	More number of capsules and high yield
VS-117	High oil
IC-110221	High oil, bold seeded

References

Anderson, T.N. 1958. *Introduction to multivariate statistical analysis.* John Wiley & Sons, New York.

Arunachalam, V. and Ram, J. 1967. Geographical diversity in relation to genetic divergence in cultivated Sorghum. *Indian Journal of Genetics and Plant Breeding,* **27**: 369-380.

Bedigian, D. 1984. *Sesamum indicum* L.: *Origin ,Diversity,* Chemistry and Ethnobotany. Ph.D. Dissertation, *University of Illinois, Urbana-Champaign, ILL.*

Bedigian, D. and Harlan, J.R. 1986. Evidence for cultivation of sesame in the ancient world. *Economic Botany,* **40**: 137-154.

Bhat, K.V., Babrekar, P.P. and Lakhanpaul, S. 1999. Study of genetic diversity in Indian and exotic sesame (*Sesamum indicum* L.) germplasm using random amplified polymorphic DNA (RAPD) markers. *Euphytica,* **110**: 21-33.

Mahalanobis, P.C. 1936. On generalized distance in statistics. *Proceedings of National Institute Science* Indian. **2**: 49-55.

Mahapatra, K.C., Biswal, A.K. and Satpathy, D. 1993. *Relationship of F_2 segregation pattern with genetic* divergence of parents in sesame. *Indian Journal of Genetics and Plant Breeding,* **53**:4, 372-380.

Manivannan, N. and Natarajan, N. 1996. Genetic divergence in sesame. *Madras Agricultural Journal,* **83**: 12, 789-790.

Moll, R.H. and Stuber, C.W. 1971. Comparison of response to alternative selection procedures initiated with two population of maize (*Zea mays* L.). *Crop Science,* **11**: 706-711.

Patil, R.R. and Sheriff, R.A. ***1996.*** Genetic variability, heritability and genetic advance studies in sesame. *Current-Research University of Agricultural Sciences,* Bangalore, **25**: 2, 23-27.

Qualset, C.O. 1979. Mendalian genetics of quantitative characters with reference to adaptation and breeding in wheat. *Proceedings of fifth International Wheat Genetics Symposium.* Indian Society of Genetics and Plant Breeding, New Delhi, **2**: 577-590.

Rao, C.R. 1952. *Advanced Statistical Methods in Biometrical Research,* Edn. I., John Wiley and Sons, New York.

Singh, P.K.,Dixit, R.K. and Yadav, R.K. ***1998.*** *Stability analysis* for seed yield and its components in sesame. Crop *Research Hisar,* 15:2-3, 227-231.

Swain, D. and Dikshit, U.N. 1997. Genetic divergence in rabi sesame (*Sesamum indicum* L.). *Indian Journal of Genetics and Plant Breeding,* **57**: 3, 296-300.

Tan, A.S. and Tan, A. 1996. Morphometric variation analysis on Turkish Sesame (*Sesamum indicum* L.). *Anadolu,* **6** (2) : 1-23.

Wei-WenXing, Zhang-Hong, Lu-FengYin, Wei-ShuangLing, Wei, W.X., Zhang, H., Lu, F.Y. and Wei, S.L. 1994. *Principal component analysis and genetic distance* estimation and their application in sesame breeding programme. *Acta-Agriculturae-Boreali-Sinica,* **9** *(3)* : 29-33.

J. Oilseeds Res., **22**(1) : 37-39 (2005)

Adaptability studies in newly developed strains of safflower, *Carthamus tinctorius* in Maharashtra

A.J. Patil, Vrijendra Singh[1], B.M. Joshi[2] and A.T. Bhongale[3]

All India Coordinated Research Project on Oilseeds (Safflower), Agricultural School Compound, Solapur-413 002, MS

(Received: February, 2004; Revised: August, 2004; Accepted: October, 2004)

Abstract

Stability analysis studies for seed yield was carried out for 16 genotypes of safflower under scarcity and assured rainfall zones of Maharashtra State, India. The differences among the genotypes were significant in assured rainfall zone and across the zones, while they non significant in scarcity zone. The interaction effects i.e. environment+ (genotype x environment) were also observed to be significant. The studies revealed NARI-22, Girna and A-1 as most stable genotypes stainable for all type of environments on the other hand, AKS-215 and hybrid SSFH-10 may be considered responsive to favourable environments.

Key words: Stability, linear regression (bi) deviation from regression (S^2di), scarcity zone, assured rainfall zone

Introduction

Safflower (*Carthamus tinctorius* L.) Is an important *rabi* oilseeds crop of Maharashtra grown on receding soil moisture. Due to its deep root system, it is supposed to be a drought tolerant crop. However, there are great fluctuations in its annual production. Therefore, it is imperative to develop genotypes endowed with high degree of adaptability combined with superior productivity levels over a range of eco-geographical conditions for successfully exploiting its inherent potential. Stability analysis identifies genotypes which give stable performance under the environment fluctuations and also their suitability for rich or poor environments. In the present investigations, an attempt has been made to evaluate 12 new strains developed at 4 different AICRPO (Safflower) centres in Maharashtra State for seed yield ability under two different zones.

Materials and methods

The material comprised of 12 newly developed genotypes *viz.*, SSF-638, SSF-646, SSFH-10, NARI-20, NARI-21, NARI-22, PBNS-142, AKS-215, AKS-2000, JLSF-424, JLSF-426 and four released varieties (Bhima, Girna, Sharda and A-1). They were evaluated for seed yield at three locations in scarcity zone characterized by less than 700 mm rainfall annually *viz.*, Solapur, Mohol and Chas and at five locations in assured rainfall zone characterized by more than 700 mm rainfall annually *viz.*, Phaltan, Parbhani, Badnapur, Akola and Buldhana in the Maharashtra State during *rabi* 2000-2001. The experiment was laid out in a Randomized Block Design with three replications. The net plot size was 1.35 x 4.60 m with the spacing of 45 x 20 cm. All the agronomic practices were followed to raise a good crop. Data on seed yield in kg/plot was recorded and subjected to the stability analysis as per the model suggested by Eberhart and Russell (1966).

Results and discussion

The genotypic differences were observed to be significant in assured rainfall zone and across the zones, while they were non significant in scarcity zone. The sum of squares due to interaction effects of environments (genotype x environment) was noted to be significant in both as well as across the zones indicating strong interaction of genotypes with environments. These results are in confirmation with Makne and Sharma (1979), Narkhede *et al.*, (1984), Ranga Rao and Ramchandran (1979) and Patil *et al.*, (1992).

Eberhart and Russel (1966) considered the linear regression (bi) and deviation from linear regression (S^2di) in addition to the mean yield ($\bar{x}$) for identifying the phenotypic of a genotype. The mean performance, bi and S^2di values for both the zones have been depicted in Table 1. It can be noted that S^2di values in both the zones as well as across the zones are very less i.e. approaching to zero. In scarcity zone, SSFH-10 and SSF-638 have recorded highest seed yield. Their regression values were observed to be very high (1.869 and 1.963 respectively), this suggests that these genotypes are better suited for favorable or rich environments. Similarly SSF-646 and Bhima could be considered in the same category due to high yields coupled with higher bi values (1.234 and 1.582

1 Breeder, AICRPO (Safflower), Nimbkar Agricultural Research Institute, Phaltan-415 523, MS.

2 Breeder, AICRPO (Safflower), Department of Agronomy, Marathwada Agril. University, Parbhani-431 402, MS.

3 Breeder, AICRPO (Safflower), Oilseeds Research Unite, Dr. Punjabrao Deshmukh Krishi Vidyapeeth, Akola-444 104, MS.

respectively). Genotypes A-1 and JLSF-426 produced good yields with lower bi values (0.409 and 0.606 respectively) indicating that they are suitable for poor environments. While, Girna, AKS-215 and NARI-22 have regression values closer to unity (0.961, 1.146 and 1.116 respectively) and good yielding ability confirming thereby that they are most stable and least influenced genotypes to the fluctuating environments. Thus they can be said to be the most suitable genotypes for scarcity zone. Makne and Sharma (1979), Narkhede *et al* (1984) and Patil *et al* (1992) also considered above parameters for classifying the genotypic stability in safflower.

Genotypes AKS-215 and SSFH-10 recorded higher seed yield in assured rainfall zone with higher bi values (1.828 and 1.354 respectively). This proves that they are suitable for this zone i.e. rich environments. NARI-22 gave highest seed yield in this zone however, its bi values are less than unity (0.725). Similarly, Girna, the released variety for Khandesh region exhibited bi values less than unity (0.705) with high yields. Both these genotypes may be well suited for poor environment. While, A-1, the national check variety exhibited bi values closer to unity (0.889) with good yielding ability, hence could be considered as stable genotype as and least responsive to change in environmental conditions.

Table 1 : Estimation of stability parameters for seed yield in safflower genotypes

Genotype	Scarcity zone			Assured rainfall zone			Performance across zones		
	Mean yield kg/ha	bi	S^2di	Mean yield kg/ha	bi	S^2di	Mean yield kg/ha	bi	S^2di
SSF-638	900 II	1.963	0.010	1338	0.994	0.004	1174	0.892	0.010
SSF-646	847	1.234	-0.008	1545	1.153	0.017	1283	1.008	0.009
SSFH-10	910 I	1.869	-0.001	1550 III	1.354	-0.005	1310	1.121	0.002
NARI-20	751	0.711	-0.003	1260	0.969	0.004	1070	0.816	0.001
NARI-21	682	1.124	-0.004	1426	0.977	0.013	1148	1.062	0.005
NARI-22	805	1.116	0.004	1690 I	0.725	0.032	1358 I	1.109	0.019
PBNS-40	580	0.863	-0.003	1390	1.339	0.006	1086	1.221	0.002
PBNS-142	758	0.435	-0.004	1445	1.097	0.010	1188	1.003	0.005
AKS-215	811	1.146	0.027	1659 II	1.828	0.021	1341 III	1.419	0.012
AKS-2000	610	0.705	0.004	1070	0.045	0.001	898	0.490	0.007
JLSF-424	741	0.948	-0.004	1449	0.959	0.045	1184	0.980	-0.022
JLSF-426	826	0.606	-0.001	1392	0.898	0.004	1180	0.843	0.001
Girna	876 III	0.961	-0.003	1630	0.705	0.006	1347 II	0.978	0.004
Bhima	830	1.582	-0.004	1462	0.886	0.005	1225	0.960	0.002
A-1	846	0.409	-0.004	1592	0.889	0.013	1312	0.997	0.007
Sharda	733	0.927	-0.004	1462	1.182	-0.001	1189	1.102	-0.002
General mean	779	1.000		1454	1.000		1200	1.000	
SEm ±	78.9	0.394		104.7	0.332		67.5	0.155	
CD (P=0.05)	223.1			296.1			190.9		

Considering the performance across the zones. NARI-22 was on top position followed by Girna as regards seed yield. Their bi values were recorded to be nearer to unity (1.109 and 0.978 respectively). This suggests that they are the stable genotypes. These genotypes were also observed to be stable under scarcity zone and suitable for poor environment in assured rainfall zones. AKS-215 secured third rank in overall performance. Hybrid SSFH-10 was at par with this genotype. Both of them showed bi values more than one proving to be responsive to the rich environments. These genotypes have expressed their suitability under these situations in both the zones as well. The national check A-1 was found to be stable across the zones due to bi values close to the unity and good yields. It was noted to be stable under assured rainfall zone and was suitable for poor environment under scarcity zone.

The present investigation therefore revealed NARI-22, Girna and A-1 as most stable genotypes suitable for all types of environments. While AKS-215 and hybrid SSFH-10 could be considered as desirable and responsive to rich or favourable environments.

Acknowledgement: The Officer In-charges of Agricultural Research Station, Mohol, Chas, Jalgaon, Buldhana and Badnapur of Maharashtra State are thankfully acknowledged for successful conduct of the experiment.

References

Eberhart, S.A. and Russel, W.A. 1966. Stability parameters for comparing varieties. *Crop Science*, **6**:36-40.

Makne. V.G. and Sharma, D.R. 1979. Stability of yield and yield contributing characters in safflower (*Carthamus tinctorius* L). *Journal of Maharashtra Agricultural Universities*, **4**(3): 287-291.

Narkhede. B.N., Deokar, A.B. and Patil, J.V. 1984. Phenotypic stability for seed yield in safflower. *Journal of Maharashtra Agricultural Universities*, **9**(1) : 179-181.

Patil. P.S., Patil, A.M. and Deokar, A.B. 1992. Stability of yield in rainfed and irrigated safflower. Journal of *Maharashtra Agricultural Universities*, **17**(1) : 66-69.

Ranga Rao. V and Ramchandran, M. 1979. Stability parameters for yield and its components in safflower. *Mysore Journal of Agricultural Science*, **13**: 297-308.

J. Oilseeds Res., 22(1) : 40-41 (2005)

Productivity and economics of different Indian mustard, *Brassica juncea* (L.) Czern & Coss based cropping systems under irrigated conditions

B.S. Sinsinwar, O.P. Premi and Arvind Kumar

National Research Centre on Rapeseed-Mustard, Sewar, Bharatpur-321 303, Rajasthan

(Received: February, 2004; Revised: July, 2004; Accepted: September, 2004)

Abstract

A field experiment was conducted during 1997-98 and 1998-99 at the research farm of National Research Centre on Rapeseed-Mustard; Bharatpur to compare the productivity and economics of five important mustard based cropping systems. Among the cropping systems the most remunerative crop sequence was pearl millet - mustard which gave the highest productivity per unit area per unit time. This system gave 20.96 q/ha mustard equivalent yield and Rs. 15193 per ha net profit followed by black gram-mustard cropping system giving 15.82 q/ha mustard equivalent yield and net profit Rs. 9423/ha. Though mustard yield was higher after black gram but the mustard equivalent yield was highest in pearl millet - mustard cropping systems. Fallow- mustard cropping system mostly followed by the farmers of Rajasthan gave the lowest Indian mustard equivalent yield (12.16 q/ha) and net return (Rs. 7824/ha).

Key words: Mustard, productivity, cropping systems

Introduction

Rajasthan is a leading state in rapeseed-mustard production, which contributes 38% of total production in India. Bharatpur region grows 40% of mustard of Rajasthan. Most of the acreage under this group of crops is monocropped, and generally the farmers follow fallow-mustard cropping sequence, resulting in low cropping intensity and productivity. Therefore to increase the cropping intensity as well as profit per unit area, an experiment was conducted to study the performance of mustard in sequential cropping system under irrigated conditions of Eastern Rajasthan.

Materials and methods

The investigation was carried out during 1997-98 and 1998-99 at Research Farm of National Research Centre on Rapeseed-Mustard, Sewar, Bharatpur. The soil was sandy loam with pH 8.2, medium in available nitrogen (0.6% O.C), phosphorus (23.5 kg P_2O_5 /ha) and rich in potash (320 kg/ha). Five mustard based cropping sequences *viz.*, pearl millet - mustard, black gram - mustard, sesame-mustard, *sesbania* (for green manuring) - mustard and fallow - mustard (common crop sequence of farmers) were taken in main plots and five levels of nitrogen (0, 40, 80, 120 and 160 kg N/ha) were taken in subplots. The experiment was laid out in Split Plot Design with four replications. The rainy (*kharif*) season crops (pearl millet – HHB-67, black gram –T-9, sesame – RT 46 and sesbania – local) were grown with their recommended doses of fertilizers. In winter (*rabi*) season mustard crop (PCR-7) was taken applying half dose of nitrogen (as per treatment) as basal at the time of sowing and remaining half dose of nitrogen was applied after first irrigation at 35 days after sowing. No pre-sowing irrigation was applied because sufficient moisture was available due to late rains in the first week of October. In *kharif* season, green manure crop at 50 DAS and black gram after first flush of pods harvesting were turned down into the soil.

Results and discussion

Seed yield and mustard seed equivalent yield: During 1997-98 the yield of the mustard was very low because during this year there was continuous foggy weather for more than one month during early growth stage, which resulted in severe infection of white rust disease. Among different cropping systems, maximum mustard seed yield was recorded in the plots preceded by green manuring (1280 kg/ha) in both the seasons with the exception that during 1997-98, green manuring- mustard was at par with black gram- mustard (Table 2). On an average, green manuring (*dhaincha*) - mustard gave 6.2 %, 7.0%, 13.9% and 21.7% more seed yield of mustard over fallow - mustard, black gram - mustard, pearl millet - mustard and sesame – mustard respectively. It may be attributed to a highly favourable soil environment created by green manure (*dhaincha*) resulting in better root growth and availability of nitrogen. Our finding supports those of Sharma and Mitra (1988). The lowest yield of mustard was obtained from the crop preceded by sesame, which was the lowest yielding cropping system for mustard, due to heavy feeding nature of the sesame, as reported by Chandrakar *et al.* (1994). To compare the cropping systems as a whole, the yield of *kharif* crops were converted into mustard seed equivalent yield. Based on mustard equivalent yield, pearl millet-mustard cropping sequence on an average recorded 35.3% higher mustard equivalent yield over rest of the crop sequences. It may be attributed due to the contribution of pearl millet seed (2195 kg/ha) and stover (1942 kg/ha) yield during the *kharif* seasons towards the total production of the sequence. Whereas fallow -mustard sequence produced the lowest equivalent yield due to no contribution toward total production during the *kharif* seasons. Similar was the case with *dhaincha* - mustard sequence. Black gram - mustard produced 2500 kg/ha more mustard seed equivalent yield than sesame - mustard. There was only 250 kg/ha difference in mustard equivalent yield between sesame - mustard and *dhaincha* -mustard sequences. It may be due to low yield of mustard in sesame-mustard sequence, because, sesame is a heavy feeder in nature and less contribution of sesame towards total yield of the system. Incase of *dhaincha* - mustard, the contribution during *kharif* in terms of yield was nil, but the green manure crop improved the soil fertility, which was reflected in the mustard seed yield.

Table 1 **Effect of different cropping systems on seed yield, equivalent seed yield, net returns and benefit cost ratio of mustard under irrigated conditions (mean over two years)**

Cropping system	Seed yield of mustard (kg/ha)			Mustard seed equivalent yield (kg/ha)			Gross returns (Rs/ha)	Cost of cultivation* (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	1997-98	1998-99	Mean	1997-98	1998-99	Mean				
Greengram-mustard	10.42	1364	1203	1280	1884	1582	18984	9561	9423	1.98
Sesame-mustard	8.17	1155	1986	1281	1473	1377	16524	8068	8456	2.04
Pearlmillet-mustard	10.23	1195	1109	1900	2291	2046	25152	9959	15193	2.52
Sesbania-mustard	11.26	1462	1294	1126	1462	1294	15528	6282	9246	2.47
Fallow-mustard	9.91	1442	1216	991	1442	1216	14016	6192	7824	2.26
CD (P=0.05)	1.20	110	-	145	167	-	-	-	-	-

* Cost of cultivation does not include rental value of land

Note: Price of mustard grain pearl millet grain, pearlmillet stover, blackgram grain and sesame was Rs. 1200, Rs.400, Rs. 16, Rs. 1200 and Rs. 1600, respectively.

Economics: The net return was highest in pearl millet - mustard cropping sequence, which was due to higher production of pearl millet in *kharif* season. This was followed by black gram - mustard and green manuring - mustard cropping sequence. The lowest net returns were obtained in fallow-mustard cropping system. It can be concluded from the present study that among the cropping sequences tried, pearl millet -mustard cropping system is most profitable than fallow - mustard cropping system (commonly followed by the farmers due to brackish water).

References

Chandrakar, B.L., Sekhar, N., Tuteja, S.S. and Tripathi, R.S. 1994. Effect of irrigation and nitrogen on growth and yield of summer sesame (Sesamum indicum). *Indian Journal of Agronomy,* **39** (4) : 701-702.

Sharma, A.R. and Mitra, B. N. 1988. Effect of green manuring and mineral fertilizer in growth and yield of crops in rice based cropping on acid literate soil. *Journal of Agricultural Science, Cambridge* **110**: 605-08.

J. Oilseeds Res., **22**(1) : 42-44 (2005)

Response of Indian mustard, *Brassica juncea* (L.) Czern and Coss to levels of nitrogen, phosphorus and potassium

I.B. Pandey and V. Bharati

Department of Agronomy, Rajendra Agricultural University, Bihar, Pusa, Samastipur-848 125, Bihar

(Received: December, 2002; Revised: October, 2004; Accepted: December, 2004)

Abstract

A field experiment was conducted at Research Farm of Rajendra Agricultural University, Pusa during *rabi* season of 1998-99 and 1999-2000 to assess the response of India mustard to levels of nitrogen, phosphorus and potassium. Both the levels of nitrogen (45 and 90 kg/ha), phosphorus (30 and 60 kg/ha) and potassium (30 and 60 kg/ha) recorded significantly higher values of yield attributes i.e., number of primary and secondary branches, siliqua/plant, seeds/siliqua, test weight, grain, stalk yields and N, P, K uptake by the crop over control. Application of 90 kg nitrogen, 60 kg phosphorus and potassium/ha recorded higher values of yield indices, produced significantly higher grain and stalk yields and enhanced NPK-uptake by crop than 45 kg nitrogen and 30 kg phosphorus and potassium/ha. Oil content in grains decreased by increasing levels of nitrogen and not significantly influenced by level of phosphorus and potassium. However, oil yield increased significantly with increasing levels of nitrogen, phosphorus and potassium.

Key words: Mustard, oil, nitrogen, phosphorus, potassium

Introduction

Indian mustard [*Brassica juncea* (L.) Czern and Coss] is one of the most popular edible oilseed crops in northern India, accounts for 21.4% of total oilseed production of the country (Damodaram and Hegde, 1999). Its growth and yield are affected by several factors among which availability of nutrients is of paramount importance. The productivity of oilseeds can be increased by proper fertilizer management in conjunction with other inputs. Some sporadic work on nitrogen fertilization has showed that mustard crop responded to nitrogen upto 120 kg N/ha (Tomar *et al.*, 1996). For producing 1 ton of grain yield mustard crop removed on an average 32.8 kg nitrogen, 16.4 kg phosphorus and 41.8 kg potassium from the soil (Pasricha and Tandon, 1993). But, comprehensive work on balanced fertilization on mustard crop are very meager. Therefore, the present study was undertaken to find out the effect of nitrogen, phosphorus and potassium on growth and yield of mustard.

Materials and methods

A field experiment was conducted at the Research Farm, Rajendra Agricultural University, Pusa (Samastipur), Bihar during *rabi* season of 1998-99 and 1999-2000. The soil of the experimental field was silt loam in texture, low in organic carbon (0.42%) available N (172.4 kg/ha), P_2O_5 (8.67 kg/ha) and K_2O (97.3 kg/ha) contents, with pH 8.4. The experiment was laid out in Randomized Block Design comprised two rates of nitrogen, phosphorus and potassium each *viz.*, 45 and 90 kg N/ha, 30 and 60 kg P_2O_5/ha and 30 and 60 kg K_2O/ha with an additional control (No NPK). The mustard variety 'Varuna' was sown in rows 30 cm apart on 22 and 19 October, respectively in first and second year of experimentation. The plant to plant distance of 15 cm was maintained by thinning. Full dose of phosphorus and potassium and half of nitrogen were applied at the time of sowing. Remaining half of nitrogen was applied after first irrigation. The crop received two uniform irrigation, first 30 days after sowing followed by second one after 45 days of first irrigation. The oil content was estimated through Soxlet's extraction method and the oil yield was calculated.

Results and discussion

Application of nutrients produced significantly higher number of primary and secondary branches, siliqua/plant and seeds/siliqua over control (Table 1). The yield attributes progressively increased with each successive increase in the level of nitrogen, phosphorus and potassium. Among the levels of nutrients, higher level of each nutrient recorded significantly higher values of these indices except primary and secondary branches and test weight with 30 and 60 kg potassium/ha. The primary and secondary branches and test weight recorded at 30 and 60 kg potassium/ha were at par. The effect of nitrogen was more pronounced as compared to phosphorus and potassium in both the years. The chief function of nitrogen in cell multiplication, cell elongation and tissue differentiation which resulted in healthy plant, production of more branches, siliqua/plant, seeds/siliqua. These findings are in conformity with the observation of Bhagat and Soni (2000). Likewise, phosphorus and potassium significantly improved the yield attributes over control in both the years. Similar result was also reported by Tomar *et al.* (1996).

Grain and stalk yields of mustard differed significantly due to different nitrogen, phosphorus and potassium levels in both the years. Higher level of these nutrients produced significantly higher grain and stalk yields over lower level and control. Grain yield increased significantly upto 90 kg N/ha, the magnitude of increase being 67.8 to 70.5 and 120.7 to 111.5%, respectively at 45 and 90 kg N/ha as compared to control in first and second year. Grain yield also increased significantly with increasing level of phosphorus and potassium, highest level of these nutrients produced significantly higher seed yield than their lower levels, the magnitude of increase in seed yield over lower level of phosphorus (30 kg/ha) and potassium (30 kg/ha) were 24.3 to 16.8 and 9.8 to 8.9%, respectively in first and second year. These findings are in conformity with the observations of Khanday *et al.* (1993) and Sharma and Jain (2002).

Oil content and oil yield: It is evident from Table 2 that nitrogen tend to decrease the oil content whereas phosphorus and potassium slightly increased the oil content but not to the extent of the level of significance in both the years. As far as oil yield was concerned nitrogen, phosphorus and potassium increased the total oil yield significantly over control. Among the levels, differences were also found to be significant. The maximum oil yield was recorded with 90 kg N/ha while minimum was associated with control. The significant increase in oil yield was chiefly due to increase in seed yield. Similar results was also reported by Tomar *et al.* (1997) and Mandal and Sinha (2001).

Table 1 Effect of nitrogen, phosphorus and potassium on yield attributes and grain yield of Indian mustard

Treatment	Primary branches/plant		Secondary branches/plant		Siliqua/ plant		Seeds/ siliqua		Test weight (g)		Grain yield (kg/ha)		Stalk yield (kg/ha)	
	1998-1999	1999-2000	1998-1999	1999-2000	1998-1999	1999-2000	1998-1999	1999-2000	1998-1999	1999-2000	1998-1999	1999-2000	1998-1999	1999-2000
Control	7	7	6	7	85	76	7	7	3.8	3.9	673	719	1759	1612
N 45 kg/ha	8	9	8	8	118	120	10	11	4.2	4.2	1129	1226	2956	3170
N 90 kg/ha	11	11	11	11	142	147	12	13	4.6	4.6	1485	1521	3861	3914
P 30 kg/ha	9	9	9	9	120	124	10	11	4.3	4.3	1193	1267	3119	3273
P 60 kg/ha	10	10	10	10	140	143	12	13	4.5	4.5	1420	1480	3698	3812
K 30 kg/ha	9	10	9	9	126	130	11	11	4.3	4.4	1245	1315	3253	3395
K 60 kg/ha	10	10	10	10	135	137	12	12	4.5	4.5	1367	1432	3561	3690
CD (P=0.05)	0.3	0.3	0.9	1.0	1.3	1.4	0.4	0.5	0.2	0.1	62	79	154	173
CD (P=0.05) Control Vs. Rest	0.4	0.5	1.3	1.6	2.0	2.2	0.6	0.7	0.2	0.2	128	154	322	339

Table 2 Effect of nitrogen, phosphorus and potassium on oil content, oil yield and nutrient uptake by mustard

Treatment	Oil content (%)		Oil yield (kg/ha)		N uptake (kg/ha)		P uptake (kg/ha)		K uptake (kg/ha)	
	1998-1999	1999-2000	1998-1999	1999-2000	1998-1999	1999-2000	1998-1999	1999-2000	1998-1999	1999-2000
Control	38.6	38.3	259.6	275.6	26.2	27.4	5.0	5.2	29.7	30.7
N 45 kg/ha	38.2	37.9	431.3	465.3	47.2	49.2	9.2	9.8	55.1	57.6
N 90 kg/ha	37.9	37.6	562.5	571.8	64.5	64.8	11.9	11.8	68.9	69.2
P 30 kg/ha	38.0	37.7	452.9	477.7	51.1	52.7	9.3	9.6	57.5	59.5
P 60 kg/ha	38.1	37.8	541.3	559.4	60.6	61.3	11.8	11.9	66.5	67.7
K 30 kg/ha	38.0	37.7	473.0	495.9	53.3	54.6	10.1	10.5	57.0	58.9
K 60 kg/ha	38.1	38.1	520.8	544.9	58.4	59.3	11.0	11.1	67.0	68.7
CD (P=0.05)	0.2	0.2	5.2	6.3	2.9	3.1	0.5	0.5	3.2	3.4
CD (P=0.05) Control Vs. Rest	0.3	0.3	9.7	10.3	4.2	5.5	0.7	0.6	4.8	5.1

Nutrient uptake by the crop: Nutrients uptake by the crop increased significantly with the application of nitrogen, phosphorus and potassium in both the years (Table 2). Among the fertilizer levels, N, P and K uptake by the crop increased significantly with subsequent increase in the level of nitrogen, phosphorus and potassium. Highest level of each nutrient recorded the maximum uptake of these nutrients by the crop than their lower level in both the years. The higher uptake N, P and K by the crop are closely correlated with their increase availability in the soil by fertilization and increased crop biomass production. Kumar *et al.* (1989) also reported similar results.

References

Bhagat, K.L. and Soni, K.C. 2000. Effect of nitrogen and sulphur on growth, seed and oil yield of mustard (*Brassica juncea*). *Journal of Oilseeds Research*, **17**(1) : 96-99.

Damodaram, T. and Hegde, D.M. 1999. *Oilseed situation : A statistical compendium.* Directorate of Oilseeds Research, Hyderabad, Andhra Pradesh, p.13.

Khanday, B.A., Shan, M.H., Bali, A.S. and Singh, K.N. 1993. Variation in yield and its attributes in Indian mustard (*Brassica juncea*) in relation to planting time, fertility and plant population. *Indian Journal of Agricultural Sciences*, **63**(3) : 175-176.

Kumar, R., Singh, V.P. and Faroda, A.S. 1989. Studies on the oil yield and nitrogen uptake by raya cultivars as influenced by nitrogen levels under irrigated and conserved soil moisture condition. *Haryana Journal of Agronomy*, **4**(2) : 182-191.

Mandal, K.G. and Sinha, A.C. 2001. Growth, agronomic efficiency and yield of mustard (*Brassica juncea*) as influenced by phosphorus and boron. *Journal of Oilseeds Research*, **18**(2) : 267-268.

Pasricha, N.S. and Tandon, H.L.S. 1993. Fertilizer management in oilseeds. In: *Fertilizer Management in Commercial Crops*, (H.L.S. Tandon, ed), FDCO, New Delhi.

Sharma, R.P. and Jain, N.K. 2002. Nitrogen requirement of Indian mustard (*Brassica juncea*) under different crop sequences. *Indian Journal of Agricultural Sciences*, **72**(2) : 101-103.

Tomar, S., Tomar, T.V.S., Kumar, S., Tomar, S., Singh, M. and Singh, S. 1996. Response of Indian mustard (*Brassica juncea*) varieties to nitrogen, phosphorus and potassium fertilizers. *Indian Journal of Agronomy*, **41**(4) : 624-626.

Tomar, T.S., Singh, S., Kumar, S. and Tomar, S. 1997. Response of Indian mustard (*Brassica juncea*) under different crop sequences. *Indian Journal of Agricultural Sciences*, **72**(2) : 101-103.

J. Oilseeds Res., 22(1) : 45-46 (2005)

Influence of organics and inorganics on yield and quality of Indian mustard, *Brassica juncea* (L.) Czern & Coss in semi-arid region of Rajasthan

O.P. Premi, B.S. Sinsinwar, Manoj Kumar and Arvind Kumar

National Research Centre on Rapeseed-Mustard, Sewar, Bharatpur-321 303, Rajasthan

(Received: June, 2004; Revised: September, 2004; Accepted: October, 2004)

Abstract

A field experiment was conducted during *rabi* 2002-03 and 2003-04 to study the effect of organic and inorganic nutrients on growth, yield attributes, seed yield and oil content of Indian mustard. Application of vermicompost @ 5.0 t/ha + 75% recommended dose of fertilizer recorded maximum plant height, number of primary and secondary branches/plant, number of siliquae/plant and number of seeds/ siliqua, which in turn resulted in higher seed yield. It was at par with farmyard manure @ 10.0 t/ha + 75% recommended fertilizer and recommended dose of fertilizer.

Key words: Mustard, farm yard manure, vermicompost, organic and inorganic

Introduction

The soils of Rajasthan are mostly sandy loam to loamy sand in texture and low in organic carbon (0.31%), available nitrogen (156.0 kg/ha) and phosphorus (11.2 kg/ha). Integration of organics and inorganics has been found to be quite promising not only in maintaining higher productivity but also in providing greater stability in crop production (Nambiar and Abrol, 1992). Popularizing the use of organics to reduce the dependence on chemical fertilizers and to contribute to pollution free environment is the greatest need of the hour. Farmyard manure and vermicompost have been advocated as a good organic manure for use in integrated nutrient management programme in field crops (Shroff and Devasthali, 1992). Therefore, there is an urgent need to develop a system using organics and inorganics on a complementary basis, which may enhance the efficiency and simultaneously reduce the requirement of inorganics. In this contest, the present study was planned to find out their suitable combination to get the maximum sustainable production of mustard.

Materials and methods

A field experiment was conducted during *rabi* season of 2002-03 and 2003-04 at National Research Centre on Rapeseed-Mustard, Bharatpur, Rajasthan. The soil of the experimental field was clay loam in texture having pH 8.0, available N and P 175.2 and 6.1 kg/ha, respectively. The treatments consisted of different levels of organics either alone or in combination with 75 % of recommended fertility level (Table 1). The organics were FYM (0.47 % nitrogen and 0.17 % phosphorus) and vermicompost (2.5 % nitrogen and 0.4 % phosphorus). The recommended level of fertilizer for mustard for the state is 80 kg N and 40 kg P_2O_5/ha. The inorganics were supplied through urea and DAP. The experiment was laid out in Randomized Block Design with four replications. The 'RH-30' mustard variety was sown on 20th and 5th October, 2002 and 2003, respectively. The organics were mixed thoroughly in the plots 15 days before sowing as per treatment. Half of nitrogen and whole phosphorus (as per treatment) was applied as basal, and the remaining nitrogen was top-dressed after first irrigation (35 DAS). The remaining package of practices of mustard were followed as recommended. Data on growth and yield attributes (Table 1) were recorded from five randomly selected plants.

Results and discussion

Growth and yield attributes: Maximum plant height, primary and secondary branches/plant, siliquae/plant, seeds/siliqua and siliqua length were recorded where 5 tonnes vermicompost/ha was applied with 75 % recommended fertility level, and it was closely followed by 10 tonnes farmyard manure + 75 % recommended fertility level and recommended dose of fertilizer and minimum in the control during two years of experimentation. This increase in yield attributes was owing to improvement in physico-chemical properties of the soil and more availability of nutrients and moisture to plants (Sharma and Gupta, 1988 and Mandal and Sinha, 2002), which supported the vegetative growth and finally increased the number of siliquae/plant (Table 1).

Seed yield: Application of organics as well as inorganics significantly increased the seed yield of mustard over control (Table 1). Higher level of organics such as FYM and vermicompost in combination with 75 % recommended fertility level proved its superiority in increasing the seed yield compared to their application at lower levels and their individual effects. Application of vermicompost @ 5 t/ha + 75 % recommended dose of fertilizer (RDF) gave significantly higher mean seed yield (1472 kg/ha) of mustard than rest of the treatments barring FYM @ 10 t/ha + 75 % recommended fertilizers. The latter was also remained at par with recommended dose of fertilizers and 75% of RDF + vermicompost @ 2.5 t/ha. Amongst organics alone vermicompost @ 5 or 2.5 t/ha and FYM @ 10 t/ha produced statically similar seed yield. The level of FYM can be reduced to its half by the use of vermicompost. The yield increase was mainly due to improvement in yield contributing characters, with recommended fertility level coupled with FYM (Patel and Meishere, 1997; Jain and Sharma, 2000; Mandal and Sinha, 2002). The oil content did not influenced by different treatments.

Table 1 Growth, yield attributes, seed yield and oil content of mustard as influenced by organics and inorganics application

Treatment	Plant height		Primary branches/ plant (No.)		Sec. Branches/ plant (No.)		Siliquae/ plant (No.)		Seeds/ siliqua (No.)		Siliqua length (cm)		1000-seed wt. (G)		Oil content (%)		Seed yield (kg/ha)		Mean
	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	
Control (no fertilizer)	180	168	4.4	4.0	3.0	2.6	141	116	12.0	12.1	3.4	3.4	5.7	5.7	41.0	43.0	751	773	762
RDF (N:80, P_2O_5: 40 kg/ha)	207	193	6.2	4.9	6.1	4.7	199	239	14.4	14.8	3.8	3.8	5.8	5.9	41.0	42.6	1280	1398	1339
FYM 10 t/ha	203	190	5.1	4.8	3.0	4.3	157	201	12.8	13.9	3.6	3.6	5.8	5.9	41.3	42.9	949	991	970
FYM 5 t/ha	198	191	4.6	4.5	3.5	3.0	147	164	14.1	13.8	3.8	3.5	5.8	5.8	41.1	42.8	800	816	808
Vermicompost 5 t/ha	198	186	5.0	4.3	4.1	3.2	170	181	12.9	14.0	3.5	3.5	5.8	5.6	41.2	42.7	929	958	943
Vermicompost 2.5 t/ha	197	177	4.9	4.3	3.4	3.5	146	160	12.8	12.8	3.5	3.4	5.8	5.9	41.0	42.8	884	930	907
75% RDF + FYM 10 t/ha	204	192	5.8	5.5	4.8	5.5	187	246	13.4	15.9	3.8	3.9	5.8	6.0	41.2	42.7	1128	1579	1353
75% RDF + FYM 5 t/ha	208	183	5.0	4.7	4.6	4.6	164	215	13.1	14.7	3.8	3.8	5.8	5.7	41.0	42.5	1053	1378	1215
75% RDF + Vermi compost 5 t/ha	215	194	6.2	5.8	6.2	6.2	205	261	13.3	16.1	3.9	4.0	5.8	6.0	41.2	42.3	1320	1625	1472
75% RDF + Vermi compost 2.5 t/ha	205	180	5.2	4.6	4.6	4.7	182	239	12.9	14.9	3.8	3.9	5.8	5.9	41.2	42.4	1170	1478	1324
SEm ±	8	6	0.3	0.4	0.8	0.3	15	14	0.3	0.7	0.1	0.3	0.2	0.2	0.1	0.4	81	45	42
CD (P=0.05)	24	17	0.8	1.2	2.4	1.0	45	43	0.8	2.2	0.4	NS	NS	NS	NS	NS	240	131	121

Vermicompost was found superior in increasing the seed yield, but it remained at par with FYM. The possible reason for superiority of vermicompost could be due to its high nutritional composition, which increased the vegetative growth, yield attributes and finally the seed yield.

On the basis of two year study, it could be concluded that application of vermicompost @ 5 t/ha +75 % recommended fertility level or FYM @ 10 t/ha + 75 % recommended fertility level may be adopted for getting the higher mustard production in semi-arid region of Rajasthan.

References

Jain, N.K. and Sharma, P.P. 2000. Integrated nutrient management in mustard. *Journal of Oilseeds Research*, **17**(1):127-129.

Mandal, K.G. and Sinha, A.G. 2002. Effect of integrated nutrient management on growth, yield, oil content and nutrient uptake of Indian mustard (*Brassica juncea*) in foothills soils of eastern India. *Indian Journal of Agronomy*, **47**(1):109-113.

Nambiar, K.K.M. and Abrol, I.P. 1992. Long-term fertilizer experiments in India - An Overview. *Fertilizer News*, **34**(1):11-26.

Patel, R.H. and Meishere, T.G. 1997. Effect of farmyard manure, nitrogen and sources of fertilizers on growth, yield attributes and yield of Indian mustard (*Brassica juncea*). *Indian Journal of Agricultural Sciences*, **67**(6):237-240.

Sharma, R.A. and Gupta, R.K. 1988. Fertility management for soybean-safflower cropping sequence in rainfed vertisols. *National Symposium on Recent Advances in Dryland Agriculture*, Hyderabad, pp.29.

Shroff, V.N. and Devasthali, S. 1992. Earthworm Farming - Scope and limitations. *Proceedings of National Seminar on Natural Farming*, L.L. Somani, K.L. Towat and B.L. Baser (eds.), pp.126-142.

J. Oilseeds Res., 22(1) : 47-50 (2005)

Effect of varieties, crop geometry and weed management practices on growth and development of soybean, *Glycine max* L. Merrill and associated weeds

N. Pandya*, **G.S. Chouhan and V. Nepalia**

Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur-313 001, Rajasthan

(Received: May, 2004; Revised: October, 2004; Accepted: November, 2004)

Abstract

A field experiment was conducted during *kharif* 2001 and 2002 at Udaipur (Rajasthan). Soybean variety, JS 335 recorded significantly higher drymatter/plant at harvest, number of branches/plant, seed yield and oil yield as compared to NRC 37 and JS 7105. There were no significant differences in weed drymatter at 40 and 60 days after sowing (DAS) among the varieties. Crop geometry failed to affect the drymatter of weeds as well as crop. Higher plant drymatter of soybean, seed yield and oil yield were recorded with two hand weedings at 20 and 40 DAS followed by clomazone 1.0 kg/ha pre-emergence (PE)+HW at 40 DAS as compared to other weed control treatments. While, at 60 DAS, the significantly lowest weed drymatter was recorded with clomazone+HW, which was at par with other, hand weeded treatments but statistically superior to individual application.

Key words: Crop geometry, soybean, weed management

Introduction

Soybean is the third largest oilseed crop of India after groundnut and rapeseed-mustard. During 2002-03, soybean occupied an area of 5.68 m.ha with production and productivity of 4.97 m. tonnes and 8.76 kg/ha, respectively in India. Rapid growth of weeds leads to severe crop-weed competition and reduction of crop yields during early growth period. Reduction in seed yield by about 27-71% depending upon the type and intensity of weeds was reported by Tiwari and Kurchania (1990). Rainfall pattern of the region does not permit timely intercultivation and manual weed control is also very difficult on large scale on account of high cost and labour shortage. Adaptation of chemical weed control or an integrated approach is therefore essential. Varieties differ not only in their production potential but also in competing ability with weeds on account of variation in rapid development of foliage and formation of close canopy at the early growth stage (Bussan *et al.*, 1997). Different crop geometry also impart competing ability of crop plants with weeds (Singh and Bhan, 2002). The present investigation was therefore, carried out to study the influence of varieties, crop geometry and weed management on weed growth and development of soybean and associated weeds.

Materials and methods

The experiment was conducted at Udaipur (Rajasthan) during *kharif* season of 2001 and 2002. The experimental soil was clay loam, alkaline (pH 7.9 and 8.0), medium in available nitrogen (285.5 and 292.4 N/ha), phosphorus (23.4 and 24.8 P_2O_5/ha) and potassium (304.4 and 317.0 K_2O/ha). The experiment consisted of three soybean varieties (NRC 37, JS 335 and JS 7105) and two crop geometries (30 cm x 10 cm and 20 cm x 15 cm) as main plots and six weed management practices as sub-plots (Table 1). The experiment was laid out in Split Plot Design with three replications. A uniform dose of 20 kg N and 40 kg P_2O_5/ha was applied through urea and DAP as a basal dose. Total rainfall in the respective seasons during the crop period was 362.7 and 253.2 mm. Two life saving irrigations in 2001 and one in 2002 were also applied as and when needed. Pre and post-emergence herbicides were applied just after sowing and between 15-20 days after sowing (DAS).

The data on weed drymatter (monocot and dicot) at 40 and 60 DAS and drymatter of soybean plant at 40, 60 DAS and at harvest were recorded. Growth characters and yield data were recorded at harvest.

Results and discussion

The major weed species, comprised of *Trianthema portulacastrum* L., *Commelina benghalensis* L., *Parthenium histerophorus* L., *Amaranthus spinosus* L. and *Digera arvensis* L. among broad leaf weeds and *Echinochloa colonum* (L.) Link and *Cynodon dactylon* (L.) Pers among grassy weeds and *Cyperus rotundus* L. among sedges.

* Present Address: Technical Officer, National Research Centre for Soybean, Khandwa Road, Indore-452 017, MP.

Effect on weed growth: Weed drymatter did not influence by varieties and crop geometries at both the stages of observations (Table 1). All the weed control treatments recorded significant reduction in drymatter of monocot and total weeds as compared to weedy check at 40 DAS. The lowest drymatter of dicot and total weeds was recorded with two hand weedings as compared to rest of the treatments, because this treatment resulted in broad spectrum weed control. Clomazone 1.0 kg/ha as PE and clomazone+HW being at par with two hand weedings and significantly reduced the drymatter of monocot weeds significantly as compared to fenoxaprop-p-ethyl at 75 g/ha as POE, fenoxaprop-p-ethyl+HW and weedy check. But, these two treatments were not at par with two hand weedings with respect to drymatter of dicot weeds because clomazone did not control *A. spinosus* and *D. arvensis*. Weed management through fenoxaprop–pethyl at 75 g/ha as POE and fenoxaprop-p-ethyl+HW were also significantly reduced the drymatter of monocot weeds as compared to weedy check because fenoxaprop-p-ethyl 75 g/ha as POE effectively controlled only monocot weeds. At 60 DAS, drymatter of monocot, dicot and total weeds was reduced significantly due to all the methods of weed control compared to weedy check except fenoxaprop-p-ethyl 75 g/ha as POE in case of dicot weeds (Table 1). Among various weed control treatments, two hand weedings, clomazone 1.0 kg/ha PE, clomazone+HW and fenoxaprop-p-ethyl+HW being at par with each other and reduced drymatter of monocot weeds compared to fexonaprop–pethyl alone and weedy check. The integration of herbicides with manual weeding proved its superiority over alone application of herbicides in case of dicot and total weeds. It may be due to the fact that late emerging weeds were effectively controlled by hand weeding at 40 DAS. These results are corroborate with the findings of Vermani *et al.* (2001).

Effect on crop growth: Variety NRC 37 produced tall plants as compared to JS 335 and JS 7105. Soybean drymatter at 40 and 60 DAS was found more or less identical in all the three varieties. However, at harvest, JS 335 recorded significantly higher drymatter, number of branches/plant, seed and oil yield as compared to NRC 37 and JS 7105 (Table 2). The differential behaviour of soybean varieties with respect to these characters could be explained solely by the variation in their genetic make up and adaptability to soil and climatic conditions. The results are in close conformity with the findings of Billore *et al.* (2000).

Table 1 Effect of varieties, crop geometries and weed management practices on categorywise weed drymatter (q/ha) at 40 and 60 DAS (Pooled data of 2001 and 2002)

Treatment	Weed drymatter at 40 DAS (q/ha)			Weed drymatter at 60 DAS (q/ha)		
	Monocot	Dicot	Total	Monocot	Dicot	Total
Variety						
NRC-37	1.12	6.32	7.45	2.37	7.83	10.20
JS-335	1.07	6.10	7.17	2.26	7.45	9.72
JS 7105	1.09	6.18	7.28	2.29	7.68	9.98
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Crop geometry						
30 cm x 10 cm	1.07	6.14	7.22	2.28	7.59	9.88
20 cm x 15 cm	1.11	6.26	7.38	2.33	7.71	10.05
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Weed management						
Weedy check	4.08	11.32	15.41	8.49	19.61	28.11
Two HW at 20 and 40 DAS	0.29	0.56	0.86	0.72	1.26	1.98
Clomazone 1.0 kg/ha PE	0.31	1.48	1.80	0.70	3.36	4.07
Clomazone 1.0 kg/ha PE+HW at 40 DAS	0.30	1.49	1.79	0.67	1.24	1.92
Fenoxaprop-p-ethyl 75 g/ha POE	0.79	11.15	11.95	2.57	19.17	21.74
Fenoxaprop-p-ethyl 75 g/ha POE+HW at 40 DAS	0.79	11.21	12.00	0.69	1.27	1.97
CD (P=0.05)	0.07	0.33	0.34	0.14	0.42	0.49

Hand weeding was done after taking observation

Table 2 **Effect of varieties, crop geometries and weed management practices on drymatter (g/plant) of soybean, plant height, branches/plant, oil yield and soybean seed yield (Pooled data of 2001 and 2002)**

Treatment	Crop drymatter (g/plant)			Plant height at harvest (cm)	Branches/ plant at harvest	Oil yield (kg/ha)	Soybean seed yield (kg/ha)
	40 DAS	60 DAS	Harvest				
Variety							
NRC-37	5.71	9.66	15.27	66.1	3.52	205.0	12.29
JS-335	5.73	10.22	17.42	62.6	3.83	284.2	16.09
JS 7105	5.71	9.80	16.22	57.0	3.42	235.8	12.92
CD (P=0.05)	NS	NS	0.75	2.32	0.17	11.42	0.61
Crop geometry							
30 cm x 10 cm	5.72	9.94	17.41	61.6	3.64	246.5	14.02
20 cm x 15 cm	5.71	9.85	16.22	62.2	3.53	236.9	13.51
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS
Weed management							
Weedy check	4.54	7.30	12.67	63.1	2.95	148.4	8.48
Two HW at 20 and 40 DAS	6.46	11.77	19.01	61.2	4.07	301.8	17.18
Clomazone 1.0 kg/ha PE	6.09	10.50	17.35	61.4	3.77	266.2	15.20
Clomazone 1.0 kg/ha PE+HW at 40 DAS	6.10	11.55	18.60	61.1	4.01	297.9	16.90
Fenoxaprop-p-ethyl 75 g/ha POE	5.56	8.64	14.10	63.0	3.24	191.2	10.91
Fenoxaprop-p-ethyl 75 g/ha POE+HW at 40 DAS	5.55	9.60	15.79	61.6	3.49	244.7	13.93
CD (P=0.05)	0.28	0.42	0.83	NS	0.22	12.09	0.66

Crop geometry failed to cause any appreciable variation in growth and development parameters as well as seed and oil yield.

Soybean plant drymatter increased significantly by the weed control treatments compared to weedy check, though their efficacy varied depending upon weed control efficiency. At 40 DAS, the highest drymatter/plant was recorded with two hand weedings compared to rest of the treatments. Clomazone 1.0 kg/ha as PE and clomazone + HW also recorded significantly higher plant drymatter as compared to fenoxaprop-p-ethyl 75 g/ha as POE, fenoxaprop-p-ethyl+HW and weedy check. While at 60 DAS and at harvest, significantly highest plant drymatter was recorded with two hand weedings (11.77 and 19.01 g/plant) and remained at par with clomazone+HW (11.55 and 18.90 g/plant). The maximum drymatter in aforesaid treatments may be due to the significant reduction in crop-weed competition. Similar views were also extended by Nimje (1996).

Plant height was not affected by weed control treatments. Number of branches/plant was highest with two hand weedings. The maximum seed yield was recorded in two hand weedings and showed non-significant difference with clomazone+HW. The yield enhancement was to the tune of 102.5 and 99.2% as compared to weedy check. However, the remaining treatments differed significantly among themselves. Similar trend was also recorded with oil yield. Present results are in conformity with the finding of Jat (1997). The increase in yield in both these treatments was owing to significant reduction in density and drymatter of weeds, which were unable to compete with the crop plants for different growth factors, which consequently resulted in the better expression of yield components and yield.

On the basis of two years results, it may be concluded that the two hand weedings produced maximum yield and found equally effective to clomazone+HW. The integration of manual weeding at 40 DAS with either pre-emergence or post-emergence gave broad spectrum weed control in soybean as compared to their alone application.

References

Billore, S.D., Joshi, O.P. and Ramesh, A. 2000. Performance of soybean (*Glycine max*) genotypes on different sowing dates and row spacing in Vertisols. *Indian Journal of Agricultural Sciences*, **70**(9):577-580.

Bussan, A.J., Burnside, O.C., Orf, J.H., Ristau, E.A. and Puettmann, K.J. 1997. Field evaluation of soybean (*Glycine max*) genotypes for weed competitiveness. *Weed Science* **45**(1):31-37.

Jat, L.N. 1997. Effect of selected herbicides with and without interculture at varying sulphur levels on soybean [*Glycine max* (L.) Merrill] productivity. M.Sc. (Ag.) Thesis, Department of Agronomy, Rajasthan Agricultural University, Bikaner.

Nimje, P.M. 1996. Effect of row spacing, mulching and weed control on weed growth and yield of soybean (*Glycine max*). *Indian Journal of Agronomy*, **41**(3):427-432.

Singh, V.P. and Bhan, V.M. 2002. Effect of crop geometry and weed control measures in the weed growth and yield of soybean. *Pestology* **26**(1):25-27.

Tiwari, J.P. and Kurchania, S.P. 1990. Survey and management of soybean (*Glycine max*) ecosystem in Madhya Pradesh. *Indian Journal of Agricultural Sciences*, **60**:672-676.

Vermani, A., Palchamy, A., Ramasamy, S. and Rangaraju, G. 2001. Integrated weed management in soybean [*Glycine max* (L.) Merrill] under various plant densities. *Madras Agricultural Journal*, **88**(7-9):451-456.

J. Oilseeds Res., **22**(1) : 51-54 (2005)

Effect of residual fertility and fertilizer application on growth and yield of sunflower, *Helianthus annuus* L.

B.K. Ramachandrappa and H.V. Nanjappa

Department of Agronomy, College of Agriculture, University of Agril. Sciences, GKVK, Bangalore-560 065, Karnataka

(Received: February, 2004; Revised: November, 2004; Accepted: December, 2004)

Abstract

A field experiment was conducted for two years during *kharif* seasons of 2001 and 2002 to study the effect of residual fertility and fertilizer application on growth and yield of sunflower at the Main Research Station, Hebbal, Bangalore. The results revealed that application of 200 : 100 : 53 NPK kg/ha along with 10 t FYM/ha to previous crop baby corn recorded significantly taller plants (130 cm), leaf area (3806.2 cm^2), LAI (2.11) at peak flowering, total dry matter (117.7 g), head diameter (20.5 cm), number of seeds/head (1094), test weight (5.9 g), seed yield (3090 kg/ha) and oil yield (1213 kg/ha) of sunflower as compared to lower level of residual fertility. Application of 63 : 75 : 63 kg NPK/ha resulted in significantly higher seed yield (3165 kg/ha) over residual soil fertility alone (2101 kg/ha).

Key words: Sunflower, residual fertility, fertilizer application

Introduction

Sunflower (*Helianthus annuus* L) is an important oilseed crop of Karnataka having a reputation of being an exhaustive crop, which devours soil nutrients. Vijay *et al.* (1975) recorded higher seed yield of sunflower with the application of 100:100:50 NPK kg/ha under rainfed conditions. While, Reddy *et al.* (2003) observed higher seed yield of sunflower with the application of 35:50:35 NPK kg/ha under Raichur conditions during *rabi* season. Whenever a short duration crop is supplied with more of nutrients, substantial amount of nutrients are left over in the soil, which could be used by a second crop. The studies on the response of sunflower to residual fertility are meager. Hence, a field study was conducted to evaluate the effect of residual fertility after baby corn and the fertilizer application on growth and yield of sunflower during *kharif* seasons of 2001 and 2002.

Materials and methods

A field experiment was conducted on red sandy loam soil at the Main Research Station, Hebbal, Bangalore - 24 during *kharif* seasons of 2001 and 2002 after the harvest of baby corn. The soil has pH of 6.25, low to medium inorganic carbon (0.47 to 0.57 %), low in available nitrogen (131.8 to 161.3 kg/ha), available phosphorus (29.6 to 33.3 kg/ha) and medium in available potassium (221.1 to 249.5 kg/ha) before sowing baby corn crop was taken during both the years. Baby corn hybrid PAC 792 was grown during the previous summer seasons with seven fertility levels (Table 1). After the harvest of baby corn, 4.5 m x 3.0 m plots were divided into two equal parts of 4.5 m x 1.5 m each and brought to fine tilth by thorough land preparation and levelling. Shallow furrows were opened at 60 x 30 cm spacing followed for sunflower. One of the two plots was supplied with the recommended dose of fertilizers (63:75:63 NPK kg/ha) while, the other plot was grown purely on residual soil fertility. Sunflower hybrid SH 3322 was sown on 2nd July and 8th July during 2001 and 2002, respectively. Crop received the nutrients through urea, single super phosphate and muriate of potash according to the treatments. Half of nitrogen and full dose of phosphorus and potassium were applied at planting while the remaining dose of nitrogen was given at 30 days after sowing (DAS). The weather condition prevailed during the crop growth were favourable and the crop received two protective irrigations of 40 mm each during the periods of dry spell. The establishment of crop was uniform with single seedling per hill and two hand weedings (15 and 30 DAS) and earthing up was done to facilitate better crop stand. Two sprays of imidacloprid 0.3 ml/l) were given at 15 and 30 DAS as a preventive measure against necrosis disease. Growth and yield parameters were recorded and the oil estimation was done using Nuclear Magnetic Resonance (NMR).

Results and discussion

Growth and yield attributes: Growth attributes such as plant height, number of leaves, leaf area, leaf area index, leaf area duration, stem girth, days to 50% flowering and dry matter production differed significantly due to residual soil fertility and fertilizer levels (Table 1 and 2). Application of 200 : 100 : 53 kg NPK + 10 t FYM/ha to previous crop of baby corn resulted in significantly higher plant height (130 cm). number of leaves (23), leaf area (3806.2 cm^2), LAI (2.1), LAD (57 days), stem girth (7.3 cm) and total dry matter (117.7 g/plant) of sunflower compared to all other residual soil fertility levels but on par with 200 : 100 : 53 kg NPK/ha. Application of only 10t FYM to previous baby corn caused the lowest growth parameters in sunflower. Similar observations were also recorded with respect to A, B and total chlorophyll content (Table 2). The better performance of sunflower with the highest residual soil fertility level may be due to greater availability of nutrients left after the harvest of baby corn. With respect to yield attributes, application of 200 : 100 : 53 kg NPK + 10 t FYM/ha to previous crop resulted in significantly higher head diameter (20.45 cm), number of seeds (1094.3 seeds), test weight (5.9 g) and seed yield (6.3 g/plant) which was on par with the application of only 200:100:53 kg NPK /ha (Table 4). These were the lowest with 10 t FYM/ha.

Application of recommended dose of fertilizer (63 : 75 : 63 kg NPK/ ha) registered significantly taller plants (135 cm), more number of leaves (23), leaf area (3755.5 cm^2), LAI (2.1), LAD (56 days), stem girth (7.4 cm), total dry matter (119.9 g/plant), chlorophyll A, B and total and lesser days *to 50% flowering (55 days) compared to control (Table 1* and 2). This clearly indicates the need for applying recommended dose of fertilizer to realize better growth and yield of sunflower.

Seed and oil yield: The sunflower seed and oil yield increased linearly with increase in residual soil fertility level registering the highest seed yield (3090 kg/ha) (Table 3) and oil (1213 kg/ha) yields at 200 : 100 : 53 kg NPK + 10 t FYM/ha to previous crop. This was on par with the same fertility level without FYM but significantly superior over all other residual treatments. While, the application of recommended fertilizer dose of 63 : 75 : 63 kg NPK /ha caused significantly higher seed (3165 kg/ha) and oil (1234 kg/ha) yields compared to control (Table 2 and 3). The increased seed yield was a consequence of increased head diameter (20.5 cm), number of seeds (1137) per head, test weight (5.9 g). Further the chlorophyll A, B and total were also higher under direct application of recommended NPK which enhanced the yield attributes and eventually the seed yield of sunflower compared to control. Similar observations of favourable response of sunflower hybrids was also reported by Megur *et al.* (1993): Devi Dayal and Agarwal (1998) under adequate fertilizer supply. The higher yield was due to increased growth and yield components while the increased oil yield was attributed to higher oil content (38.9 %) and increased seed yield. Incidentally, the seed and oil yield of sunflower at the highest residual soil fertility and with recommended NPK are almost similar. Thus indicating the possibility of growing sunflower after baby corn under residual fertility conditions with similar yields under recommended NPK application.

Table 1 Plant height (cm), number of leaves and leaf area (cm^2), LAI, LAD (days), stem girth (cm) and drymatter production *(g/plant) in sunflower as influenced by residual soil fertility and fertilizer application (pooled data of 2001 and 2002)*

Treatment	Plant height (cm)	No. of leaves	Leaf area (cm^2)	LAI	LAD (days) (between button stage and peak flowering)	Stem girth (cm) (At peak flowering)	Drymatter accumulation (g/plant) (At peak flowering)			
							Leaf	Stem	Head	Total
(A) Residual soil fertility levels (NPK kg/ha)										
F_1 : 10 t FYM	106	20	2732.9	1.5	41	6.6	38.9	49.1	12.6	100.6
F_2 : 100 : 50 : 27	107	20	2888.6	1.6	43	6.7	39.2	50.3	12.5	102.0
F_3 : 100 : 50 : 27 + 10 t FYM	112	20	3138.6	1.7	46	6.8	40.2	53.2	13.3	106.7
F_4 : 150 : 75 : 40	115	20	3334.7	1.9	49	6.8	40.9	54.1	13.7	108.7
F_5 : 150 : 75 : 40 + 10 t FYM	121	21	3496.4	1.9	52	7.1	41.3	56.4	14.3	112.1
F_6 : 200 : 100 : 53	125	22	3676.3	2.0	54	7.2	42.1	57.5	14.6	114.2
F_7 : 200 : 100 : 53 + 10 t FYM	130	23	3806.2	2.1	57	7.3	42.4	60.1	15.3	117.7
SEm±	2.5	0.6	81.96	0.05	0.9	0.13	1.9	2.0	0.6	3.0
CD (P=0.05)	7.2	1.6	232.23	0.13	2.5	0.36	NS	5.6	1.8	8.6
(B) Fertilizer levels (NPK kg/ha)										
F_1 : Control	98	19	2837.0	1.6	41.46	6.4	38.1	47.52	12.2	97.9
F_2 : 63 : 75 : 63	135	23	3755.5	2.1	56.17	7.4	43.3	61.21	15.3	119.9
SEm±	1.4	0.3	43.81	0.02	0.47	0.07	1.02	1.1	0.3	1.61
CD (P=0.05)	3.8	0.9	124.13	0.07	1.34	0.19	2.9	3.0	1.0	4.57
Interaction (A x B)										
SEm±	3.6	0.8	115.90	0.06	1.25	0.18	2.69	2.79	0.90	4.27
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS : Non-significant

Table 2 Days to 50% flowering, chlorophyll A, B and total content (mg/100 g), seed and stover yield (q/ha) of sunflower as influenced by residual soil fertility and fertilizer application (pooled data of 2001 and 2002)

Treatment	Days to 50% flowering	Chlorophyll content (mg/100 g)			Seed yield (kg/ha)	Stover yield (kg/ha)
		A	B	Total		
(A) Residual soil fertility levels (NPK kg/ha)						
F_1 : 10 t FYM	60	0.71	0.44	1.31	2199	2292
F_2 : 100 : 50 : 27	60	0.72	0.44	1.31	2267	2362
F_3 : 100 : 50 : 27 + 10 t FYM	58	0.75	0.46	1.38	2522	2543
F_4 : 150 : 75 : 40	58	0.75	0.46	1.38	2625	2604
F_5 : 150 : 75 : 40 + 10 t FYM	57	0.77	0.48	1.42	2793	2774
F_6 : 200 : 100 : 53	57	0.77	0.48	1.43	2933	2853
F_7 : 200 : 100 : 53 + 10 t FYM	57	0.79	0.49	1.46	3090	2993
SEm±	-	0.008	0.009	0.012	56	59
CD (P=0.05)	-	0.023	0.025	0.033	159	168
(B) Fertilizer levels (NPK kg/ha)						
F_1 : Control	61.2	0.70	0.43	1.30	2101	2293
F_2 : 63 : 75 : 63	54.7	0.80	0.50	1.46	3165	2970
SEm±	-	0.004	0.005	0.006	30	32
CD (P=0.05)	-	0.012	0.013	0.018	85	90
Interaction (A x B)						
SEm±	-	0.011	0.012	0.017	79	84
CD (P=0.05)	-	NS	NS	NS	225	NS

NS : Non-significant

Table 3 Head diameter (cm), number of seeds, test weight (g), seed yield (g/plant), oil content (%) and oil yield (kg/ha) of sunflower as influenced by residual soil fertility and fertilizer application (pooled data of 2001 and 2002)

Treatment	Head diameter (cm)	No. of seeds/head	Test weight (g)	Seed yield (g/plant)	Oil content (%)	Oil yield (kg/ha)
(A) Residual soil fertility levels (NPK kg/ha)						
F_1 : 10 t FYM	16.8	863	5.1	46.7	38	843
F_2 : 100 : 50 : 27	17.5	912	5.2	49.0	39	875
F_3 : 100 : 50 : 27 + 10 t FYM	18.3	945	5.2	52.2	39	974
F_4 : 150 : 75 : 40	18.8	976	5.4	53.9	39	1014
F_5 : 150 : 75 : 40 + 10 t FYM	19.5	1019	5.6	55.8	39	1090
F_6 : 200 : 100 : 53	20.0	1058	5.7	58.6	39	1148
F_7 : 200 : 100 : 53 + 10 t FYM	20.5	1094	5.9	61.3	39	1213
SEm±	0.27	31.1	0.17	0.84	0.3	23.3
CD (P=0.05)	0.76	87.9	0.49	2.4	NS	66.0
(B) Fertilizer levels (NPK kg/ha)						
F_1 : Control	17.1	825	5.02	45.6	38.49	811
F_2 : 63 : 75 : 63	20.5	1137	5.85	62.3	38.96	1023
SEm±	0.14	16.6	0.09	0.5	0.16	12.4
CD (P=0.05)	0.41	47.0	0.26	1.3	0.46	35.3
Interaction (A x B)						
SEm±	0.38	43.71	0.24	1.18	0.43	32.9
CD (P=0.05)	NS	NS	NS	NS	NS	93.3

NS : Non-significant

The interaction was found significant with respect to seed and oil yield (Table 4). Application of 200:100:53 kg NPK + 10 t FYM/ha to previous crop baby corn along with the application of 63:75:63 kg NPK/ha to sunflower produced significantly higher seed yield (34.57 q/ha) and oil yield (1213 kg/ha) compared to all other treatment combinations but on par with 200:100:53 kg NPK /ha and 150:75:40 kg NPK + 10 t FYM /ha to previous crop at the recommended dose of fertilizer application to sunflower.

From these study, it may be concluded that sunflower can perform well under residual soil fertility with 200: 100 : 53 kg NPK + 10 t FYM /ha applied to previous baby corn which is harvested in 65 - 75 days.

Table 4 Seed yield (g/plant & kg/ha) and oil yield (kg/ha) of sunflower as influenced by the interaction of residual soil fertility and fertilizer application (pooled data of 2001 and 2002)

Treatment	Seed yield (g/plant)			Seed yield (kg/ha)			Oil yield (kg/ha)		
	F_1: Control	F_2 63 : 75 : 63 (NPK kg/ha)	Mean	F_1: Control	F_2 63 : 75 : 63 (NPK kg/ha)	Mean	F_1: Control	F_2 63 : 75 : 63 (NPK kg/ha)	Mean
(A) Residual soil fertility levels (NPK kg/ha)									
F_1 : 10 t FYM	36.39	57.08	46.74	1579	2820	2199	595	1092	843
F_2 : 100 : 50 : 27	38.70	59.20	48.95	1661	2874	2267	631	1119	875
F_3 : 100 : 50 : 27 + 10 t FYM	42.01	62.35	52.18	1977	3067	2522	758	1190	974
F_4 : 150 : 75 : 40	45.13	62.62	53.87	2026	3224	2625	782	1247	1014
F_5 : 150 : 75 : 40 + 10 t FYM	47.85	63.80	55.83	2249	3337	2793	868	1312	1090
F_6 : 200 : 100 : 53	52.97	64.23	58.60	2492	3374	2933	973	1324	1148
F_7 : 200 : 100 : 53 + 10 t FYM	56.11	66.50	61.30	2723	3457	3090	1072	1355	1213
Mean	*45.59*	*62.26*		*2101*	*3165*		*811*	*1234*	
SEm±		1.18			0.79			32.9	
CD (P=0.05)		3.35			2.25			93.3	

NS : Non-significant

Acknowledgement: The authors sincerely acknowledge the financial support received from the Indian Council of Agricultural Research, New Delhi and physical facilities given by the University of Agricultural Sciences, Bangalore for this research.

References

Devi Dayal and Agarwal, S.K. 1998. Response of sunflower (*Helianthus annuus* L) to organic manures and fertilizers. *Indian Journal of Agronomy*, **43**(3) : 469-473.

Megur, N.C., Prabhakar, A.S., Hosmani, N.J. and Kalghatagi, S.B. 1993. Effect of nitrogen and phosphorus on growth and yield of sunflower. *Journal of Oilseeds Research*, **10** (1) : 127-128

Reddy, B.N., Chandranath, H.T., Lokesha, K.R. and Muralidharudu, Y. 2003. Effect of nutrients and moisture conservation practices on growth, yield and economics of *rabi* sunflower under rainfed vertisols. *Journal of Oilseeds Research*, **20**(2) : 244-248.

Vijay, M.K., Joshi, S.N. and Kabania, M.M. 1975. Response of sunflower to variable levels of nitrogen, phosphorus, potassium, spacing and population. *Gujarat Agricultural University Research Journal*, **1**(1) : 36-39.

J. Oilseeds Res., **22**(1) : 55-58 (2005)

Effect of time of sowing on the productivity of sunflower, *Helianthus annuus* L. cultivars in rice fallows

B.N. Reddy, S.N. Sudhakara Babu, B. Sahadeva Reddy and A. Jayaprada

Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, AP

(Received: April, 2004; Revised: July, 2004; Accepted: September, 2004)

Abstract

Field experiments were conducted during post rainy season of 1997-98 and 1998-99 on red sandy loam soil at Hyderabad to study the effect of sowing time on the performance of sunflower cultivars grown under rice fallow situation. Early sowing resulted in better growth; seed yield and yield attributes. During 1997-98, early planting recorded significantly higher seed yield (553 kg/ha) over other two dates. During 1998-99, the highest seed yield of 1758 kg/ha was obtained in early sowing (10-12-1998) which was significantly superior to subsequent dates, which were similar in seed yield. During first year, the hybrids *viz.*, PAC-36, KBSH-1 and MSFH-8 were significantly superior to Morden. The performance of PAC-36 was significantly superior (599 kg/ha) followed by KBSH-1. The hybrid PAC-36 also recorded higher stalk and oil yield compared to other cultivars. The interaction effect of time of sowing and cultivars revealed that PAC-36 recorded the highest yield (716 kg/ha) under early sowing.

Key words: Sunflower, time of sowing, rice fallows

Introduction

Andhra Pradesh is emerging as fastest sunflower growing state in the country. The area under sunflower increased over two times from 0.16 m. ha in 1990-91 to 0.37 m. ha in 1998-99. In the same period production increased from 0.14 m. tones to 0.24 m. tones. During 2000-01 in Andhra Pradesh, the crop occupied an area of 1.97 lakh ha with production of 1.68 lakh tones (Damodaram and Hegde, 2002). Sunflower is being mostly cultivated in late *kharif* and *rabi* season under rainfed conditions. In recent years, the limitation of irrigation water for post rainy season/ winter rice in irrigated command areas as well as tank fed and well irrigated areas necessitated the cultivation of aerable dry crops in rice fallows. Sunflower has emerged as one of the potential oilseed crops under rice fallow situations. The farmers in the command areas of Sriramsagar project and Nagarjunasagar project found sunflower more profitable than other crops. The profitability of cultivating sunflower in rice fallows has been reported in Andhra Pradesh (Krishna and Ananda Reddy, 1997), Orissa (Shah *et al.*, 1998) and West Bengal (Sarkar *et al.*, 1995).

The crop growing conditions in rice fallows are entirely different than the cultivation in upland areas. The low monetary agronomic practices like choice of appropriate cultivars and time of sowing are crucial to realize maximum yield. Reddy and Kumar (1996) reported 10th October as the optimum time of sowing sunflower during post rainy season in Telangana region of Andhra Pradesh under upland conditions. There are a wide range of sunflower varieties and hybrids of varying duration and productivity (Damodaram and Hegde, 2002) that need to be assessed for their ideal sowing time under paddy fallow situations. Hence, studies were carried out to identify optimum time of sowing and suitable cultivar of sunflower for growing in rice fallow situations in Alfisols of Andhra Pradesh.

Materials and methods

A field experiment was conducted during post rainy season of 1997-98 and 1998-99 at College Farm, Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad on sandy loam soil, having pH 7.3, low in available nitrogen (185 kg N/ha) and available phosphorus (18.5 kg P_20_5/ha) and high in available potassium (265 kg K_2O/ha) after the harvest of rainy season puddled rice. The land was prepared by working with tractor drawn cultivator twice followed by harrowing twice. Treatments consisted of three sowing dates *viz.*, sowing 7 (early), 15 (middle) and 21 days (late) after the harvest of rice with four sunflower cultivars *viz.*, Morden (variety), KBSH-1, PAC-36 and MSFH-8 (hybrids) in Randomized Block Design replicated thrice. The planting dates were January 2, 27 and February 28 in 1998 (first year) and December 10, 17 and 24 in 1999 (second year), respectively. The spacing adopted was 45 x 30 cm for Morden and 60 x 30 cm for KBSH-1, PAC-36 and MSFH-8. The uniform fertilizer dose of 75:90:60 kg N, P_20_5 K_20/ha was applied in the form of urea, single super phosphate and muriate of potash, respectively. Full dose of phosphorus, potassium and 50% nitrogen were applied as basal and remaining half of nitrogen was applied in two equal splits at 30 days after sowing and at 50% flowering. The crop was grown under irrigation. Oil content in seed was analysed through Nuclear Magnetic Resonance. During 1997-98 the weekly maximum temperature ranged from 28.7°C to 40°C. and minimum temperature from 13.3°C to 25.1° C. The mean relative humidity during crop period was between 64.5% and 39.5%. The temperatures increased gradually from sowing to maturity and relative humidity was low (39.5 to 46 %) during seed filling stage. During 1998-99, the maximum temperature was between 27.4 to 38.7°C and minimum temperature varied from 9.0°C to 23.2°C. The relative humidity ranged from 42.0% to 86.5%.

Results and discussion

Sowing time: Plant height and head diameter were not influenced by sowing time whereas 1000 seed weight was higher in early sown crop during 1997-98. During 1998-99, time of sowing had significant influence on head diameter, days to 50% flowering, 1000 seed weight, (Table 1 and 2). Head diameter and 1000 seed weight was higher in early planted crop.

The seed yield of sunflower during first year was lower compared to second year due to higher air temperatures starting from sowing to flowering and maturity period. There was decrease in seed yield of sunflower as the time of sowing was delayed. Early sowing recorded significantly higher yield (553 kg/ha) over other dates. Second date of sowing was also significantly superior to late sowing. The stalk yield was also maximum in early sowing followed by mid sowing time. Although sowing time did not influence the oil content, oil yield was significantly higher (152 kg/ha) in early sown crop. During 1998-99, the seed yield in early sowing was significantly the highest (1758 kg/ha) and recorded additional yield of 336 kg/ha over second and 329 kg/ha over third date of sowing. The yield levels were at par in second and third date of sowing. The oil yield was maximum during 1997-98 (152 kg/ha) and 1998-99 (569 kg/ha) with early sowing and reduced with delayed sowing.

The better performance of sunflower when sown early can be attributed to favourable weather parameters in terms of temperature and relative humidity at flowering and seed filling stages. Temperature of 20-25°C has been reported as optimum for higher productivity of sunflower. Late sown crop experienced higher temperature (>38.6° C) during seed filling stage of 1997-98, resulting in reduced yield due to poor seed set because of pollen dehydration (Hegde and Sudhakara Babu, 2002). Higher head diameter with higher seed filling, increased 1000 seed weight in early sown crop were responsible for higher seed yield in early planted crop. Besides, early sown crop took more number of days to reach 50% flowering thereby producing enough photosynthetic source to enable the crop to perform better. The beneficial effect of early sowing of sunflower after the harvest of rice has been reported by Bajpai and Singh (1995) and Srivastava *et al.* (1998).

Cultivars: During 1997-98, Hybrids recorded higher plant height and stem girth compared to Morden. The hybrids took more number of days to attain 50% flowering. During 1998-99, the head diameter, 1000 seed weight recorded higher values as compared to subsequent dates of sowing and the early sown crop took more number of days to attain 50% flowering. The cultivars differed significantly in respect of seed yield (Table 1 and 2). The hybrids KBSH-1, PAC-36 and MSFH-8 were significantly superior to Morden. The highest seed yield (599 kg/ha) was obtained in PAC-36 followed by KBSH-1, which recorded significantly higher yield than MSFH-8. The stalk yield was the highest in MSFH-8 followed by PAC-36.The oil content was not significantly influenced by cultivars.

During 1998-99, cultivars did not differ significantly in respect of seed yield. The stalk yield was the highest in MSFH-8 followed by PAC 36 and the lowest stalk weight was obtained in Morden. The oil content was significantly influenced by cultivars. The hybrid KBSH-1 had higher oil content (34.53%) while the lowest oil content was recorded in Morden. The PAC-36 recorded the highest oil yield (562 kg/ha) followed by KBSH-1 (545 kg/ha). The increase in oil yield of PAC-36 was due to increase in oil content and seed yield.

Differences in yield of hybrids over Morden is due to their difference in duration. Hybrids matured in 95-100 days while Morden mature in 75-80 days. The higher yield of PAC 36 is attributed to increased plant height, stem girth, head diameter and 1000 seed weight.

Interaction effect of sowing time and cultivar: Significant interaction effects between sowing time and cultivars were noticed in respect of seed yield, stalk yield and oil yield during 1997-98 (Table 3). Seed and stalk yields were significantly higher with early sown crop of PAC 36. The oil yield was also highest in PAC 36 under early sowing. However, the oil yield was similar to the early sown hybrid KBSH-1.

The results indicated that early sowing soon after the harvest of *kharif* rice realized higher productivity of sunflower. The cultivars like PAC-36 and KBSH-1 were superior than variety Morden to achieve higher seed and oil yields of sunflower in rice fallow Alfisols.

Acknowledgements: The authors are thankful to the Indian Council of Agricultural Research for financial assistance through A.P. Cess Fund Project and ANGRAU, Hyderabad for providing infrastructure.

Table 1 Effect of time of sowing and cultivars on the growth attributes of sunflower in rice fallows

Treatment	Plant height (cm)		Stem girth (cm)		Head diameter (cm)		Days to 50% flowering	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Time of sowing								
Early	75	112	4.4	4.9	6.5	15.5	63	66
Middle	80	113	5.7	4.6	6.8	14.3	62	62
Late	82	111	5.0	4.4	6.6	13.9	60	60
SEm±	2.09	2.84	0.3	0.2	0.3	0.3	0.3	0.1
CD (P=0.05)	NS	NS	0.8	NS	NS	0.8	0.8	0.3
Cultivar								
Morden	50	66	4.2	4.1	6.5	14.6	54	59
KBSH-1	88	130	5.5	4.5	6.9	13.6	63	61
PAC-36	91	130	5.4	4.9	6.4	14.5	65	65
MSFH-8	87	122	5.2	5.0	6.6	15.5	64	66
SEm±	2.42	3.28	0.3	0.2	0.3	0.3	0.3	0.1
CD (P=0.05)	7.10	9.62	1.0	0.7	NS	1.0	0.9	0.4

Table 2 Effect of time of sowing and cultivars on seed yield and oil content of sunflower

Treatment	1000 seed weight (g)		Seed yield (kg/ha)		Stalk yield (kg/ha)		Oil content (%)		Oil yield (kg/ha)	
	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99	1997-98	1998-99
Time of sowing										
Early	32.4	44.3	553	1758	1494	2108	27.3	32.2	152	569
Middle	31.2	39.8	433	1422	1169	1834	25.7	33.9	111	482
Late	27.6	39.9	380	1429	1026	1958	25.9	33.2	97	473
SEm±	0.7	0.9	12.5	75.7	33.6	93.1	0.5	0.4	5.22	26.5
CD (P=0.05)	1.9	2.7	36.5	222	98.6	NS	NS	1.1	15.34	77.7
Cultivar										
Morden	32.6	36.3	325	1411	877	1653	26.4	30.8	86	435
KBSH-1	29.7	40.9	499	1580	1347	1726	26.7	34.5	135	545
PAC-36	31.2	49.3	599	1689	1617	1897	25.2	33.4	153	562
MSFH-8	28.2	38.9	399	1467	1078	2588	26.8	33.7	107	491
SEm±	0.8	1.1	14.4	87.45	38.8	107.5	0.6	0.4	6.03	30.6
CD (P=0.05)	2.2	3.1	42.2	NS	113.9	315.3	NS	1.3	17.7	89.7

Table 3 Interaction effects of time of sowing and cultivars on seed yield, stalk yield and oil yield of sunflower in rice fallows (1997-98)

Cultivars/ Time of sowing	Seed yield (kg/ha)			Stalk yield (kg/ha)			Oil yield (kg/ha)		
	Early	Middle	Late	Early	Middle	Late	Early	Middle	Late
Morden	348	306	320	941	827	863	92	77	89
KBSH-1	636	488	373	1717	1317	1007	183	124	97
PAC-36	716	579	503	1933	1563	1357	194	150	114
MSFH-8	513	359	325	1386	970	878	139	95	88
SEm±		24.90			67.24			10.44	
CD (P=0.05)		73.04			197.21			31.00	

References

Bajpai, R.P. and Singh, V.K. 1995. Response of sunflower (*Helianthus annuus* L.) to planting date and seed rate in rice fallows. *Indian Journal of Agronomy*, **40**(2): 331-332.

Damodaram, T. and Hegde, D.M. 2002. *Oilseeds situation: A statistical compendium 2002*, Directorate of Oilseeds Research, Hyderabad .150.

Hegde, D.M. and Sudhakara Babu, S.N. 2002. Sunflower. (In) *Text book of field crop production*. (Ed.) Rajendraprasad, ICAR Publication , pp. 463-513.

Krishna, A. and Ananda Reddy, K. 1997. Production potential and economics of different rice based cropping systems in Andhra Pradesh. *Indian Journal of Agricultural Sciences*, **67** (12): 551-553.

Reddy, M.D. and Kumar, K.A. 1996. Performance of sunflower at different times of sowing during post-rainy season in Northern Telangana zone of Andhra Pradesh. *Journal of Oilseeds Research*, **13**(2): 260-262.

Sarkar, R.K., Chakravarthy, A. and Bala, B. 1995. Response of sunflower (*Helianthus annuus*) to crop geometry, nitrogen and phosphorus application on rice-fallow Gangetic alluvial soil. *Indian Journal of Agronomy*, **40**(4): 657-569.

Shah Sanjay, Murthy, B.T.S. and Jha, K.P. 1998. Performance of sunflower cultivars in rice fallow situations under alluvial tract of Orissa. *Journal of Oilseeds Research*, **15**(2): 288-292.

Srivastava, G.K., Khanna, P. and Tripathi, R.S. 1998. Response of sunflower (*Helianthus annuus* L.) cultivars to nitrogen and sowing time. *Journal of Oilseeds Research*, **15** (2): 357-359.

J. Oilseeds Res., 22(1) : 59-62 (2005)

Conjunctive use of biological, organic and inorganic fertilizers in sunflower, *Helianthus annuus* L.

P. Maheswara Reddy, Y. Reddiramu and Y. Ramakrishna

Department of Agronomy, S.V. Agricultural College, Tirupati-517 502, AP

(Received: August, 2004; Revised: September, 2004; Accepted: October, 2004)

Abstract

Field experiment was conducted to study the effect of conjunctive use of different sources of nutrients (*Azospirillum*, phosphobacterium, FYM and NPK fertilizers) on growth, yield attributes, yield and nutrient uptake of sunflower during *rabi*, 1999 at S.V. Agricultural College, Tirupati. Application of biofertilizers along with nutrient sources resulted in higher growth parameters than sole application of nutrient sources. Recommended NPK +*Azospirillum* + phosphobacterium has resulted in tallest plants, largest LAI and highest total drymatter at all the stages of crop growth, but it was on par with recommended NPK + phosphobacterium. Recommended NPK + *Azospirillum* + phospho-bacterium registered the higher filled seeds/ head, shelling percentage, test weight and highest seed and stalk yield which were however on par with recommended NPK + phosphobacterium. The lowest yield attributes and yields were recorded with control. Similar trend was observed with regard to NPK uptake at harvest.

Key words: Sunflower, biofertilizers, FYM and inorganic fertilizers

Introduction

Integrated nutrient management enhanced the yield of sunflower remarkably as the crop is exhaustive in nature and require more energy for growth and development. The cost of chemical fertilizers is steadily escalating due to progressive decontrol policy by the Government. More over imbalanced and continuous use of mineral fertilizers in intensive cropping systems is leading to unfavourable soil nutrient status, which has an adverse effect on soil physicochemical properties and also crop yield. Soil health and ecological hazards due to excessive use of chemical fertilizers on long term basis also pose serious problems to defy the concept of much advocated sustainable crop production. Use of organic manures and biofertilizers to substitute part of nutrient requirement through fertilizers has added advantages. Besides cost effectiveness, they found to help in proliferation and survival of beneficial microorganisms of soil, fix atmospheric nitrogen to plant in usable form, solubilize insoluble native phosphorus. Release phytohormones, vitamins as well as auxins to favour plant growth and improve soil environment for sustained soil fertility. Organic manures and biofertilizers are eco-friendly and pollution free too. Combined use of organic manures and biofertilizers along with mineral fertilizers improve the soil fertility and productivity. However, information on the combined effect of FYM and biofertilizers with chemical fertilizers on sunflower is meagre. Keeping this in view, an experiment was conducted to study the conjunctive use of different sources of nutrient on growth, yield and nutrient uptake of sunflower.

Materials and methods

The present investigations was carried out on sandy loam soil at the S.V. Agricultural College, Tirupati during *rabi*, 1999. The experiment was laid out in a Randomized Block Design with three replications. The experimental field was low in organic carbon (0.29%) and available nitrogen (172.6 kg/h), medium in available phosphorus (32.1 kg/ha), potassium (176.0 kg/ha) and neutral in reaction (pH 7.6). Well decomposed FYM (0.05%, 0.2% and 0.5% N P_2O_5 and K_2O) respectively was incorporated ten days before sowing. *Azospirillum* and phosphobacterium each @ 2 kg/ha were mixed with FYM and sand (1:5:5), uniformly broadcasted and thoroughly incorporated, just before sowing. An uniform basal application of whole amount of phosphorus in the form of single super phosphate and potassium in the form of murate of potash along with ½ dose of nitrogen through urea was applied. The remaining quantity of nitrogen was top dressed after one month. The growth parameters, yield attributes, yield and nutrient uptake were studied. Estimation of N content was done by using microkjeldhal method. The test variety MFSH 17 was hand dibbled with a spacing of 60 x 30 cm.

Results and discussion

Growth and yield attributes: The growth characters of sunflower *viz*., plant height, leaf area index and total drymatter production were considerably influenced by nutrient management practices. Recommended NPK + *Azospirillum* + Phosphobacterium (T_6) has resulted in the production of tallest plants, largest leaf area index and highest total drymatter, but was on par with recommended NPK + phosphobacterium (T_5) (Table 1). This might be attributed to the supplemental application of *Azospirillum* or phosphobacterium or both. These bio-inoculates might have enabled supply of additional quantity of nutrient to the crop either through fixing atmospheric nitrogen or through solubilising phosphorus or both. Supplemental application of phosphobacterium enabled the plants with better root proliferation and enhanced nutrient uptake resulting in tallest plants with larger leaf area index. Similar results were reported by Mohanamba (1992) and Mishra *et al.* (1995). Higher drymatter production in the above treatments might be due to taller plants and large leaf area. Similar results of increased drymatter with nitrogen levels + *Azospirillum* has been reported by Savalgi and Savalgi (1990) and Polazzo *et al.* (1997).

Table 1 Growth parameters and yield attributes of sunflower as influenced by conjunctive use of nutrients

Treatment	Plant height (cm)	Leaf area index	Total drymatter (kg/ha)	Filled seeds/head	Filling percentage	Test weight (g)
T_1	106	0.46	2899	415	78	39.6
T_2	142	0.89	4944	1010	84	42.1
T_3	118	0.53	3258	565	87	40.7
T_4	144	0.92	5335	1031	84	42.2
T_5	142	0.97	5888	1118	84	42.4
T_6	144	0.98	6212	1147	84	42.6
T_7	123	0.55	3388	580	87	40.7
T_8	123	0.53	3396	570	87	40.7
T_9	124	0.56	3510	611	87	40.6
T_{10}	128	0.56	3906	701	81	41.3
T_{11}	133	0.61	4388	810	82	41.5
T_{12}	132	0.60	4420	804	82	41.5
T_{13}	137	0.72	4582	921	85	41.8
T_{14}	123	0.53	4004	559	83	40.7
T_{15}	121	0.52	3108	530	83	40.7
SEm±	1.6	0.01	149	20.2	0.2	0.07
CD (P=0.05)	4.7	0.03	445	60	0.5	0.2

T_1 : Control
T_2 : Recommended NPK (80 : 50 : 30 N, P_2O_5, K_2O kg/ha)
T_3 : FYM at 10 t/ha
T_4 : Recommended NPK + *Azospirillum*
T_5 : Recommended NPK + Phosphobacterium
T_6 : Recommended NPK + *Azospirillum* + Phosphobacterium
T_7 : FYM at 10 t/ha + *Azospirillum*
T_8 : FYM at 10 t/ha + Phosphobacterium
T_9 : FYM at 10 t/ha + *Azospirillum* + Phosphobacterium
T_{10} : FYM at 10 t/ha + 50% recommended NPK
T_{11} : FYM at 5 t/ha + 50% recommended NPK + *Azospirillum*
T_{12} : FYM at 5 t/ha + 50% recommended NPK + Phosphobacterium
T_{13} : FYM at 5 t/ha + 50% recommended NPK + *Azospirillum* + Phosphobacterium
T_{14} : 50% recommended NPK + *Azospirillum* + Phosphobacterium
T_{15} : FYM at 5 t/ha + *Azospirillum* + Phosphobacterium

Significantly higher plant height and leaf area index was found with recommended NPK (T_2) than application of FYM 10 t/ha (T_3) and its combination with either or both the biofertilizers (T_7, T_8 and T_9) as well as FYM 5 t/ha + 50% recommended NPK (T_{10}) and its combination with either or both the biofertilizers (T_{11}, T_{12} and T_{13}). Application of FYM @ 10 t/ha could supply 50 kg N and 20 kg P_2O_5/ha, whereas the recommended level was 80 kg N and 50 kg P_2O_5/ha. Even, combination of FYM 5 t/ha + 50% recommended NPK and their combination with biofertilizers could not compensate the recommended levels. Thus, insufficient nutrient application through the above treatments might be the reason for lesser plant height, lower leaf area index and lower drymatter. This has been reported by Khokhani *et al.* (1993) and Amruthavalli (1993). Reduced growth stature of sunflower (plant height, LAI and drymatter production) was noticed with the control (T_1). This might be due insufficient quantity of nutrients denying satisfactory level of growth due to retarded cell division and multiplication. This has been established by Mohanamba (1992), Bhowmik *et al.* (1994) and Yadav *et al.* (1998). Yield attributes like filled seeds/head and test weight, were maximum with recommended NPK + *Azospirillum* + phosphobacterium (T_6) (Table 1), which were however, comparable with recommended NPK + phosphobacterium (T_5) and these two were significantly superior to rest of the treatments. This might be due to the beneficial effect of higher growth parameters *viz.*, plant height, LAI and drymatter production in these treatments. Larger available stored photosynthates are translocated into various yield attributes in these treatments. Similar increased yield due to application of biofertilizers in addition to recommended levels of nutrients were reported by (Amurthavalli, 1993). The next best treatment was application of recommended NPK + *Azospirillum* (T_4) which was on par with recommended NPK (T_2). This higher yield attributes and yield in the above treatments might be due to presence of higher growth parameters (Table 1). Reduced growth parameters reflected in poor yield attributes in control plot (T_1). FYM 10 t/ha (T_3) and FYM 10 t/ha along with biofertilizers (T_7, T_8 and T_9) resulted in higher filling percentage. Slow and continuous mineralisation and availability of nutrients during later stages of crop growth might be the reason for higher filling of percentage with FYM.

Yield and nutrient uptake: Seed and stalk yield is the reflection of yield attributes and growth parameters, respectively. The highest seed and stalk yield was obtained with recommended NPK + *Azospirillum* + Phosphobacterium (T_6) which was however comparable with recommended NPK + Phosphobacterium (T_5) and these two were significantly superior to rest of the treatments (Table 2). Application of *Azospirillum* + Phosphobacterium along with recommended NPK (T_6) and recommended NPK + Phosphobacterium (T_5) produced 23.0 and 20.0% higher yield than recommended NPK (T_2) respectively. Similar increase in yield due to application of biofertilizers in addition to recommended level of nutrients were reported by Amruthavalli (1993) and Reddy (1997). Highest harvest index was recorded with recommended NPK + *Azospirillum* + Phosphobacterium (T_6) which was in parity with recommended NPK + Phosphobacterium (T_5), recommended NPK + *Azospirillum* (T_4), recommended NPK (T_2) and FYM 5 t/ha + 50% recommended NPK + *Azospirillum* + phosphobacterium (T_{13}) (Table 2). This might be due to the result of lesser stalk yield. Insufficient supply of plant nutrients along with reduced growth parameters and poor yield attributes might be the reason for lower yield in the above treatments (T_1). The present findings were in agreement with the results of Bhowmik *et al.* (1994) and Manoharan *et al.* (1994).

Table 1 Growth parameters and yield attributes of sunflower as influenced by conjunctive use of nutrients

Treatment	Seed yield (kg/ha)	Stalk yield (kg/ha)	Harvest index (%)	Nitrogen uptake (kg/ha)	Phosphorus uptake (kg/ha)	Potassium uptake (kg/ha)
T_1	846	1668	33.6	34	8	41
T_2	2173	2482	46.7	59	21	68
T_3	1173	1783	39.7	40	11	59
T_4	2262	2552	46.6	64	22	69
T_5	2608	2965	46.8	64	25	73
T_6	2669	3034	46.8	66	27	74
T_7	1271	1822	41.1	41	12	61
T_8	1227	1826	40.2	40	13	62
T_9	1285	1895	40.4	42	14	63
T_{10}	1456	2123	40.7	49	15	63
T_{11}	1773	2254	44.0	60	19	67
T_{12}	1734	2200	44.1	60	21	67
T_{13}	2010	2357	46.0	62	21	69
T_{14}	1255	2168	36.7	45	11	55
T_{15}	1100	1992	35.6	40	10	49
SEm±	56.4	134.5	2.04	0.8	0.9	1.3
CD (P=0.05)	163	389	5.9	2.3	2.7	3.8

Recommended NPK + *Azospirillum* + Phosphobacterium (T_6) recommended NPK + *Azospirillum* (T_4) and recommended NPK + Phosphobacterium (T_5) recorded higher N uptake, this might be due to the steady and continuous availability of nitrogen as a result of fixation of atmosphere rice nitrogen by the *Azospirillum* in the rhizosphere coupled with enhanced drymatter production. Increase in nitrogen uptake with the application of nitrogen + *Azospirillum* was also reported by Karunakaran and Jalaniapan 1989). Phosphorus uptake was significantly higher with recommended NPK + *Azospirillum* + phosphobacterium (T_6) + compared to other treatments, which was however comparable with recommended NPK + phosphobacterium. This was due to increased supply of phosphorus in the rhizosphere owing to continuous solubilization of native, insoluble, phosphorus by the phosphobacterium coupled with enhanced dry accumulation.

Jones and Srinivas (1993) observed similar enhanced phosphorus uptake with the application of biofertilizers along with inorganic phosphorus source. Potassium uptake was higher with recommended NPK + *Azospirillum* + Phosphobacterium (T_6) as well as recommended NPK + Phosphobacterium (T_5) (Table 2). Higher uptake of nitrogen and phosphorus favoured higher uptake of potassium. The lowest nitrogen, phosphorus and potassium uptake was found in control (T_1) treatment. This might be due to insufficient availability of mineral nutrients coupled with poor drymatter production. It can be inferred from the above results, application of biofertilizers along with recommended NPK produced significantly higher drymatter and seed yield in sunflower.

References

Amruthavalli, S. 1993. Effect of nitrogen and *Azospirillum* on growth and yield of sunflower. M.Sc. (Ag.) Thesis submitted to Andhra Pradesh Agricultural University, Tirupati.

Bhowmik, N.K., Sarkar, R.K. and Raui, N.M. 1994. Response of sunflower to phosphorus and potassium application. *Indian Agriculturist*, **38**:141-143.

Jones, N.H.P. and Srinivas, M.N. 1993. Effect of inoculation of mycorrhiza culture, phosphate solubilizing bacteria on rhizosphere microflora of sunflower *Azotobacter* and phosphate solubilizing bacteria. *Journal of Ectoxcol Environment*, **3**:55-58.

Karunakaran, A. and Palaniappan, S.P. 1989. Evaluation of nitrogen management techniques for rainfed sunflower, *Helianthus annuus* L. *Indian Journal of Agricultural Sciences*, **59**(5):671-673.

Khokhani, M.G., Ahlawat, R.P.S. and Trivedi, S.T. 1993. Effect of nitrogen and phosphorus fertilizers on yield and nutrient uptake in sunflower, *Helianthus annuus* L. *Indian Journal of Agronomy*, **38**(2):330-332.

Manoharan, S., Senthivel, S. and Balakrishnan, K. 1994. Effect of different levels of nitrogen on sunflower. *Madras Agricultural Journal*, **81**:344-345.

Mishra, A., Das, P. and Paikaray, R.K. 1995. Yield and nutrient uptake by winter sunflower, *Helianthus annuus* L. as influenced by nitrogen and phosphorus. *Indian Journal of Agronomy*, **40**(1):137-138.

Mohanamba. 1992. Influence of nitrogen on growth and yield of sunflower varieties. M.Sc. (Ag.) Thesis submitted to Andhra Pradesh Agricultural University, Hyderabad.

Polazzo, D., Capoturti, G., Montemurro, F. and Sunseri, F. 1997. Productive response of herbaceous crops to inoculation of *Azospirillum*. *Informatore - Agrorio*, **53**(12):53-55.

Reddy, P.V.M. 1997. Integrated nutrient management in *rabi* sunflower. M.Sc. (Ag.) Thesis submitted to Acharya N.G. Range Agricultural University, Hyderabad.

Savalgi, V.P. and Savalgi, V. 1990. Diaztrophic rhizocoenosis of *Azospirillum brasilense* with the roots of sunflower. *Science and Culture*, **56**(3) : 125-127.

Yadav, N., Tiwari, O.P. and Shrivastava, G.K. 1998. Influence of nitrogen and row spacing with different inter crops on growth and nitrogen uptake of sunflower. *Journal of Oilseeds Research*, **15**(2):360-362.

J. Oilseeds Res., **22**(1) : 63-65 (2005)

Fertilizer management in sesame, *Sesamum indicum* Linn. based intercropping system in Tawa command area

P.B. Sharma

Jawaharlal Nehru Krishi Vishwa Vidyalaya, Krishi Vigyan Kendra, Aron District, Guna, MP

(Received: July, 2004; Revised: November, 2004; Accepted: January, 2005)

Abstract

The study on fertilizer management in sesame based intercropping system was carried out on deep black soils of Tawa command area in Madhya Pradesh during *kharif* seasons of 1998, 1999 and 2000. It was aimed to find out optimum fertilizer dose for sesame + soybean (2:2) and sesame + urdbean (2:2) intercropping system. Sesame + urdbean (2:2) proved superior over sesame + soybean (2:2) in terms of sesame equivalent yield (SEY) and net monetary returns (NMR). As regards the fertilizer doses, 100% recommended fertilizer to sesame and no fertilizer to urdbean gave higher SEY, NMR and B:C ratio; in case of sesame + soybean (2:2) the fertilizer dose 100% of sesame + 50% of soybean recorded higher yield and economic returns.

Key words: Sesame, intercropping, fertilizer management, urdbean, soybean

Introduction

Intercropping is known to be a remunerative system since long. It is commonly suggested to enhance the efficiencies of resource use *viz., land, water, nutrient and light* (Yadav and Prasad, 2000). In this system, the crop compatibility based upon a number of principles play very important role. However, the nutrient uptake pattern of crops as well as the yield of main crop has been noted to change due to companion crop (Subba Rao, 1994). This suggests for careful selection of intercrop combination and optimization of nutrient dose for desired results.

In Tawa command area of Hoshangabad (Madhya Pradesh), the intercropping of sesame with soybean or urdbean has been recommended to the farmers. The nutrient requirement of these intercrops is quite different. Whereas, no information is available regarding doses of fertilizer to be applied in these intercropping system. Therefore, the present experiment was undertaken with the objective to find out fertilizer needs of the recommended intercropping system involving sesame.

Materials and methods

The field experiment was conducted under All India Coordinated Research Project on Oilseeds at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Zonal Agricultural Research Station, Pawarkheda, Hoshangabad, Madhya Pradesh during *kharif* seasons of 1998, 1999 and 2000. The soil of the experimental field was vertisols having low available nitrogen (200 kg N/ha), medium phosphorus (18 kg P_2O_5/ha), high potassium (279 kg K_2O/ha), pH 7.8 and EC 0.4 mmhos/cm. The treatments consisted of two intercropping system i.e., sesame + soybean 2:2 and sesame + urdbean 2:2 as main plot treatment and fertilizer dose i.e., control, 100% fertilizer of main crop to the system, 100% fertilizer of both crops, 100% fertilizer of main crop + 50% fertilizer of intercrop, 100% fertilizer to main crop only (on area basis), sole sesame and sole soybean/urdbean as sub plot treatments. The sole crops of sesame, soybean and urdbean were given the recommended fertilizer dose of 60:40:20; 20:60:20 and 20:40:20 kg $N:P_2O_5:K_2O$/ha, respectively. The experiment was laid out in Split Plot Design with three replications, keeping the sub plot of 5.0 x 4.2 m. Sowing was done at a common row spacing of 30 cm on 10th, 7th and 11th July during 1998, 1999 and 2000, respectively. TKG 21, JS 335 and T9 varieties of sesame, soybean and urdbean were grown with recommended package of practices. The monetary returns have been computed on the basis of market prices prevailing during 2000-01.

The quantum and distribution of rainfall during cropping season in different years varied substantially as given in Table 1.

Table 1 **Quantity and distribution of rainfall during cropping season in different years at Pawarkheda**

Month	1998		1999		2000	
	Rainfall (mm)	No. of rainy days	Rainfall (mm)	No. of rainy days	Rainfall (mm)	No. of rainy days
June	-	-	-	-	70.1	10
July	230.0	15	454.9	20	419.9	21
August	133.0	14	396.4	19	232.2	16
September	202.0	17	530.9	22	11.6	3
October	9.8	01	88.2	10	-	-
Total	**574.8**	**47**	**1470.4**	**71**	**733.8**	**50**

Results and discussion

The data on seed yield of different crops (Table 2) revealed that the season had considerable influence on the seed yield of the crop under study. During 1998 and 2000 low and well distributed rainfall i.e., 574.8 mm and 733.8 mm, respectively, favoured crop growth and podding in sesame which resulted in optimum seed yield. Whereas, during 1999 heavy rainfall of 1470.4 mm in 71 days resulted in adverse effect on growth and yield of sesame. In both the intercropping systems the seed yield of main crop of sesame under different fertility levels was substantially higher when compared to that under control plot in each year. The results indicate responsiveness of sesame to fertilizer application (Sharma *et al.*, 1996). Though the area allotted to sesame crop in both the intercropping system was 50% but its seed yield under most of the fertilizer treatments was more than the proportion which could be attributed to the elastic nature of this crop to adjust its branching.

As regards the yield of intercropped soybean and urdbean, an inverse relationship with sesame was found. During 1998 and 1999, the soybean showed positive response to fertilizer application while during 2000 the crop yield under control plot was more than that with fertilizers. During 2000, the sesame with 100% fertilizer dose grewup with full vigour and put competitive effect on intercropped soybean. In case of control plot, the sesame crop without fertilizer attained limited growth which allowed soybean to perform better and consequently the soybean yield under control plot was more than that with fertilizer in this year. The seed yield of intercropped urdbean under control plot was found to be consistently more than that obtained with fertilizer application. The intercropped urdbean with fertilizer doses was observed to grow luxuriously but it had less number of pods. The land equivalent ratio (LER) in sesame + soybean (2:2) intercropping was found to be maximum (1.11) when 100% fertilizer of sesame + 50% of soybean was applied while in case of sesame + urdbean (2:2) the highest value (1.18) was recorded with 100% fertilizer to sesame only.

The pooled data on sesame equivalent yield (SEY) indicated that the SEY under sesame+urdbean intercropping (780 kg/ha) was significantly higher than that with sesame+soybean (747 kg/ha). The combination of sesame+urdbean performed better at Tikamgarh also (Bajpai *et al.*, 1998). Among different fertility levels, 100% fertilizer of sesame + 50% of intercrop in sesame+soybean (2:2) combination and 100% fertilizer of sesame and no fertilizer to intercrop in sesame+urdbean proved superior in yield. However, the mean value of SEY over the intercropping was maximum (841 kg/ha) when 100% fertilizer of sesame+50% of intercrop was applied. The SEY per rupee invested on fertilizers was maximum when 100% fertilizer was applied to sesame only in both the intercropping systems.

The economic analysis of different treatment presented in Table 3 showed that the sole crop of sesame gave significantly maximum net monetary return (NMR) of Rs. 10239/ha. Among different fertilizer doses for intercropping system 100% fertilizer to sesame and no fertilizer to intercrop gave maximum NMR of Rs. 8738/ha which was closely followed by the returns (Rs. 8705/ha) with 100% fertilizer of sesame and 50% of intercrop. The benefit : cost ratio was also higher (1.81 and 1.84, respectively) under both these treatments as compared to others except sole sesame (2.10). The crop combination sesame + urdbean (2:2) proved significantly superior over sesame + soybean (2:2) due to better yield of sesame and urdbean in the year 1998 and 2000 when the rainfall was very low (574.8 and 733.8 mm, respectively) during cropping period. On the other hand, the reduced market price of soybean (Rs. 8/kg) has also made this crop less profitable.

Table 2 Seed yield of sesame and intercrops and land equivalent ratio as influenced by fertilizer doses

Treatment		1998		1999		2000		LER (for pooled data)	
		S+S (2:2)	S+U (2:2)	S+S (2:2)	S+U (2:2)	S+S (2:2)	S+U (2:2)	S+S	S+U
Control (no fertilizer) - T_1	Sesame	362	391	110	116	282	267	0.86	1.03
	Intercrop	462	685	949	352	1321	720		
100% Fertilizer of sesame to system - T_2	Sesame	671	601	171	176	604	713	1.04	1.11
	Intercrop	567	438	942	352	898	491		
100% Fertilizer to both crops - T_3	Sesame	561	512	127	151	681	769	1.06	1.09
	Intercrop	620	387	1204	391	808	530		
100% Fertilizer of sesame + 50% of intercrop - T_4	Sesame	512	690	176	153	898	748	1.11	1.16
	Intercrop	648	426	1058	336	780	562		
100% Fertilizer to sesame only - T_5	Sesame	540	434	160	127	780	727	1.06	1.18
	Intercrop	579	475	885	319	956	586		
Sole sesame - T_6	Sesame	996	989	266	210	1479	1435	1.00	1.00
Sole soybean/Urid - T_7	Intercrop	1352	833	1720	699	1593	843	1.00	1.00

Table 3 Sesame equivalent yield and monetary return with different treatments (pooled data of 3 years)

Treatment	Sesame equivalent yield (kg/ha)			SEY (kg)/Rupee invented on fertilizer		Cost of cultivation (Rs/ha)		Net monetary return (Rs/ha)			B:C Ratio	
	S+S	S+U	Mean	S+S	S+U	S+S	S+U	S+S	S+U	Mean	S+S	S+U
T_1	583	681	632	-	-	8852	8612	3976	6360	5168	1.45	1.74
T_2	774	807	791	0.14	0.09	10223	9983	6804	7778	7290	1.67	1.78
T_3	775	794	785	0.14	0.09	10263	9828	6681	7647	7164	1.66	1.78
T_4	830	852	841	0.24	0.18	9901	9563	8236	9174	8705	1.84	1.96
T_5	786	864	825	0.30	0.27	9538	9298	7769	9708	8738	1.81	2.04
T_6	914	889	902	-	-	9594	9594	10509	9969	10239	2.10	2.04
T_7	565	576	571	-	-	10928	10058	1509	2604	2057	1.14	1.23
Mean	747	780	-	-	-	-	-	6498	7606	7052	1.67	1.80

Market prices - Soybean Rs. 8/kg; Sesame Rs. 22/kg and Urd Rs. 16/kg

Source	For SEY		For NMR	
	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
Intercropping	12	33	259	730
Fertility	*22*	*62*	*485*	*1365*
I/C x Fertility	31	NS	686	NS

From the present study it has been concluded that in sesame + soybean (2:2) intercropping system 100% fertilizer of sesame + 50% of soybean should be applied, whereas in sesame + urdbean (2:2) combination 100% fertilizer to sesame and no fertilizer to urdbean should be given.

References

Bajpai, R.P., Chourasia, S.K., Tomar, R.K.S. and Verma, M.L. 1998. Productivity and economic viability of intercropping of sesame (*Sesamum indicum* L.) with oilseed and pulse crops. First International *Agronomy* Congress, Extended Summaries, IARI, New Delhi, p.389.

Yadav, R.L. and Prasad Kamta. 2000. Modern concept for ecofriendly management of cropping system. International Conference of Managing Natural Resources for Sustainable Agricultural Production in the 21st Century held at IARI, New Delhi, Feb. 14-18, 1 : 122.

Sharma, P.B., Parashar, R.R., Ambawatia, G.R. and Pillai, P.V.A. 1996. *Response of sesame varieties to plant* population and nitrogen levels. *Journal of Oilseeds Research*, **13**(2):254-255.

Subba Rao, I.V. 1994. Integrated nutrient management for sustainable productivity of oilseeds in India. M.V.R. Prasad *et al.* (Ed.). *Sustainability in oilseeds*. Indian Society of Oilseeds Research, Hyderabad, pp.264-270.

J. Oilseeds Res., **22**(1) : 66-70 (2005)

Improving linseed, *Linum usitatissimum* L. productivity through identification of tolerant genotypes and management technologies in salt affected soils under rainfed condition

V.S. Verma, C.V. Raghavaiah*, Vineet Kumar, Rajendra Prasad and G.S. Singh

C.S. Azad University of Agriculture and Technology, Kanpur-208 002, UP

(Received: February, 2004; Revised: July, 2004; Accepted: September, 2004)

Abstract

A series of trials was conducted under controlled and farmers' field conditions during three consecutive *rabi* seasons of 2000-01 to 2002-03 for screening linseed genotypes and developing management technologies suitable for salt affected soils under rainfed condition to improve productivity. Sweta, Padmini and Shubhra followed by Padmini and Sweta were initially identified salt tolerant cultivars at 8, 6 and 4 dS/m salinity levels, respectively. Sweta followed by Meera and Shubhra during 2000-01 and Padmini followed by Sweta during 2001-02 and 2002-03 performed better in salt affected fields under rainfed condition. During 2000-01, improved management comprising sowing on the side of ridges and FYM application improved the crop performance while other improved management technologies (line/seed drill sowing, application of FYM @ 2 t/ha and use of straw mulch) during 2001-02 and 2002-03 played significant role in improving linseed productivity in salt affected farmers fields under rainfed condition. This has increased Benefit : Cost ratio from 2.08 to 2.58 over farmers practice.

Key words: Linseed, improved agro-techniques, genotypes, salt affected soils, rainfed condition

Introduction

In India, linseed, *Linum usitatissimum* L. is one of the important *rabi* oilseed crops. About 20 – 25% of the total linseed oil is used for house hold purposes and the remaining 75-80% oil goes to industrial purposes. Linseed is cultivated under stress conditions on neglected or problematic lands, such as salt affected soils with poor crop management practices. Soil salinity is a serious concern due to continued upward movement of salts and their redistribution in upper surface as a result of evaporation. Among the oilseed crops, linseed is most suitable for the cultivation in salt affected soils because of its salt tolerance potential (Dubey *et al.*, 2003) under rainfed conditions. Salt affected soils are one of major constraints causing 25-100% yield loss (Chauhan *et al.*, 2003). Introduction of high yielding linseed varieties with improved management technologies can play a vital role in increasing production and productivity in salt affected soils under rainfed condition. Therefore, the present studies were made with a view to improve linseed productivity under such stressed soil and agro-climatic conditions.

Materials and methods

A series of trials was conducted under controlled conditions at students experimental farm of C. S. A. University of Agriculture and Technology, Kanpur and onfarm trials in Benda, Chaubepur, Ayodhyapur, Serpur, Naveri, Muiya, Juriyan and Rampur villages of Ghatampur Tehsil of Kanpur District during three consecutive *rabi* seasons of 2000-01 to 2002-03.

A. Lab studies: Initially 23 genotypes were screened against three salinity levels of 4, 6 and 8 dS/m in Petri plates during 2000-01. The screening process was continued during *rabi* 2001-02 and 2002-03 in pots deleting Sheela, Shekhar and RLC 29 making the number of genotypes 20 and including one additional level of salinity as control (<1 dS/m). The experiments were laid in Completely Randomized Design with three replications. Hundred sterilized seeds were placed in plastic Petri plates of 15 cm size on the double layer of filter paper containing 20 ml of salt solution of desired salinity concentrations.

The salt solution was prepared for creating graded levels in Petri plates and pots by dissolving NaCl, $CaCl_2$, $MgCl_2$ and $MgSO_4$ in distilled water using different ratios (Na:Ca+Mg as 1:1, Ca:Mg as 1:3 and Cl:SO_4 ratios as 7:3). In case of pot culture, the soil was divided into four equal parts for creating three salinity levels of 4, 6 and 8 dS/m by spraying of diluted stock solution of required salinity concentrations over thin layer of soil and mixed thoroughly in sufficient quantity for filling into 20 pots each of the size of 30 x 30 cm for each replication. The normal untreated soil was used for filling the control pots. Observations were recorded on seedling vigour index and

* Principal Scientist (Agronomy), Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, AP.

dry matter/seedling (20 days after sowing) in Petri plates and per plant (at harvest) along with seed yield/plant in pots. The seedling vigour index was calculated as per Abdul-Baki and Anderson (1973).

B. On-station studies: Six promising cultivars *viz.*, Laxmi-27, T-397, Sweta, Meera, Shubhra and Kiran were tested under field conditions in Randomized Block Design with three replications during *rabi* 2000-01. The soil of the experimental field was clay loam, saline-alkaline in reaction (EC 2.5 dS/m and pH 8.4), low in organic carbon (0.35%), phosphorus (31.5 kg P_2O_5/ha) and potassium (210 kg K_2O/ha). The counted seeds treated with thiram @ 2.5 g/kg were sown in mid of October. The observations were recorded on germination, final plant stand, plant height and seed yield.

C. On-farm studies: In the on-farm trial, the effect of two land configurations (flat bed and side of ridge sowing) and application of FYM (10 t/ha) versus (no FYM) on two cultivars (Sweta and T-397) was studied in Split Plot Design with four replications keeping land configurations and FYM in main plot and cultivars in sub plots during *rabi* 2000-01. Soil samples of the study area were analysed prior to fertilizer application. The soils had 7.90-8.18 pH, EC 1.85 to 2.33 dS/m, exchangeable sodium 8.18-13.45 meq/100 g, organic carbon 0.3- 0.4%, phosphorus 8.1-10.8 kg/ha and potassium 210-290 kg/ha. The crop was sown on October 13, 2000 in rows spaced at 25 cm using an uniform seed rate of 30 kg/ha. The observations were recorded on germination, plant stand, plant height and seed yield.

D. On-farm studies: Further on-farm trials were conducted on 20 farmers' fields i.e. 8 during 2001-02 and 12 during 2002-03. Soil samples of the farmers fields were analysed prior to sowing the experimental crop. The soil had pH between 8.2- 9.2, exchangeable sodium 2.75-11.50 meq/100g, organic carbon 0.26- 0.63, available phosphorus 9-18.5 kg/ha and potassium between 210-430 kg/ha. The treatments comprised two management technologies (improved and farmers practice) and three cultivars (Sweta, Padmini and Bijuri local). The improved practices consisted of line/seed drill sowing, application of 2 t FYM/ha one month before sowing and use of straw mulch after sowing; while no FYM and no mulch was used in the crop sown by broadcast in farmers' practice. The trials were laid out in Split Plot design considering each farmer as a replication, keeping technologies and cultivars in main and sub plots, respectively. The crop was sown in the middle of October in larger sized plots (300 m^2) keeping row to row distance of 25 cm using 30 kg seed/ha during both the years. Seeds were treated with thiram @ 2.5 g/kg to control pre and post emergence seedling blight diseases. The observations were recorded on germination, final plant stand, plant height, drymatter/ plant and seed yield. Benefit cost ratio was also calculated. The recommended dose of fertilizers i.e. 40 kg N and 40 kg P_2O_5/ha was applied uniformly. A total of 719.3 and 838.9 mm precipitation was received in 43 and 37 rainy days from June 2001 to May 2002 and June 2002 to May 2003 respectively.

Results and discussion

Screening genotypes for salinity tolerance under controlled condition: On the basis of seedling vigour index recorded in Petri plates during *rabi* 2000-01, Rashmi at 8 dS/m; JLSJ-9, Meera and Mukta at 6 dS/m; while Padmini, Mukta and Rashmi at 4 dS/m (Table 1) were proved superior to the remaining genotypes. The seedlings of Rashmi (0.25 g), JLSJ-9 (0.42 g) followed by Meera and Mukta while Padmini (0.55 g) followed by Mukta, Rashmi, Gaurav, Meera, Parvati, Shikha, T-397, Shubhra, Kiran, Hira, Jawahar-23, Garima and JLSJ-9 accumulated higher dry matter/plant at 20 days after sowing than the rest of the genotypes at 8, 6 and 4 dS/m salinity levels, respectively. Pooled results revealed that the seedling vigour index of Padmini closely followed by Sweta was higher as compared to remaining genotypes at all the levels of salinity including control. Significantly higher dry matter/plant was observed in Sweta (4.45 g) at 8 dS/m, Padmini (7.42 g) at 6 dS/m and Shubhra (9.26 g) followed by *Padmini (8.69 g) and Sweta (8.63 g) at 4 dS/m.* Padmini produced higher seed yield/plant with increasing levels of salinity (4 to 8 dS/m), while in control pots, Hira proved superior to Padmini.

On-farm testing of promising cultivars in salt affected soils: Germination and plant height of six promising cultivars were found non-significant (Table 2). However, Rai *et al.* (1984) reported the variable interaction of linseed cultivars to soil alkalinity. Different genotypes showed significant variations in their seed yield. The cultivar, Sweta (642 kg/ha) followed by Meera (602 kg/ha) and Shubhra (592 kg/ha) yielded higher than remaining genotypes due to more survival of their plants as evident by final plant stand.

Effect of land configuration and FYM on promising cultivars: Data presented in Table 3 indicated that sowing on side of ridge had an edge over flat bed on the basis of plants/m row length, plant height and seed yield, though the germination was numerically lower. The marginal superiority of sowing on side of ridge over flat bed could be due to the low concentration of salts as a result of relatively more soil moisture.

Application of FYM @ 10 t/ha one month before sowing improved the crop performance over no FYM in respect of germination, plant/m row length and plant height, though FYM application in respect of seed yield was observed numerically superior to no FYM.

Higher plant stand (7.3 plants/m row length) and greater plant height (46.0 cm) along with higher germination (89%)

proved Sweta to be more salt tolerant than T-397. As a result, Sweta produced slightly higher seed yield than T-397.

Improved management technologies and cultivars for salt affected soils: Improved management technologies (line/seed drill sowing, application of FYM @ 2 t/ha one month before sowing and use of straw mulch after sowing) improved the germination, final plant stand, plant height and dry matter/plant significantly (Table 4). As a result, the seed yield increased significantly during 2001-02 (55.1%), 2002-03 (48.5%) and in the pooled data (52.4%) due to improved technologies as compared to farmers' practice.

Table 1 **Seedling vigour index, drymatter/plant and seed yield of linseed genotypes during *rabi* 2000-01 (lab study) and pooled data of 2001-02 and 2002-03 (plot study)**

Salinity (dS/m)	2000-01						Pooled over 2001-02 and 2002-03											
	Seedling vigour index			Drymatter/seedling (g)			Seedling vigour index				Drymatter/plant (g)				Seed yield/plant (g)			
Genotypes	4	6	8	4	6	8	Control	4	6	8	Control	4	6	8	Control	4	6	8
Shikha	25.47	12.16	12.24	0.27	0.13	0.13	34.3	26.4	12.7	8.9	8.23	7.78	5.74	*	3.2	2.6	2.0	*
Rashmi	48.01	23.93	23.05	0.50	0.25	0.25	45.9	33.6	24.6	12.5	9.24	5.01	4.53	3.20	4.4	1.7	1.6	0.55
T-397	24.75	22.47	14.50	0.27	0.27	0.16	47.9	41.0	31.3	16.0	7.53	6.33	5.54	3.24	2.9	2.2	1.93	1.05
Garima	24.37	14.15	13.32	0.26	0.16	0.15	38.5	27.2	12.9	8.3	7.82	6.22	5.05	*	3.2	2.1	1.81	*
Sweta	12.51	11.58	10.66	0.14	0.13	0.13	56.9	48.1	37.7	30.3	10.25	8.63	6.24	4.45	3.4	2.7	1.95	1.34
Shubhra	25.34	12.82	10.24	0.27	0.14	0.11	32.3	21.6	10.4	5.1	10.70	9.26	4.42	2.78	4.0	3.3	2.03	1.34
Meera	40.25	39.65	16.32	0.42	0.41	0.18	43.3	30.1	15.8	8.8	7.25	6.30	3.17	*	2.3	1.7	1.38	*
Kiran	25.44	23.89	14.11	0.27	0.26	0.15	39.5	29.4	19.0	10.1	10.73	8.17	5.60	*	2.4	1.8	1.08	*
Padmini	52.80	26.18	12.63	0.55	0.27	0.14	58.3	52.7	39.5	30.4	9.68	8.69	7.42	4.05	4.8	3.4	3.01	1.53
Janki	12.44	12.11	5.79	0.14	0.13	0.07	33.4	24.5	13.0	9.1	8.44	6.80	5.95	3.68	3.7	3.0	2.04	1.51
Mukta	51.32	39.24	14.30	0.53	0.40	0.15	32.1	25.5	16.8	10.6	10.51	8.23	5.23	*	4.8	3.3	1.62	*
Hira	24.45	12.16	11.41	0.27	0.14	0.13	51.5	34.6	25.3	6.9	11.84	6.05	3.11	*	7.4	2.1	1.20	*
Jawahar-23	25.89	13.48	10.78	0.27	0.14	0.11	33.6	23.8	17.9	8.1	8.05	5.39	3.88	*	2.2	1.4	1.19	*
Parvati	38.22	25.81	13.51	0.39	0.27	0.14	41.8	34.7	27.0	19.6	5.71	4.28	3.14	*	2.5	1.6	1.09	*
Himalini	12.03	5.81	4.39	0.13	0.07	0.05	41.9	28.0	12.8	1.1	7.35	5.29	3.17	*	3.5	2.6	1.58	*
Surbhi	12.50	5.80	3.88	0.13	0.07	0.05	44.7	27.0	7.1	1.0	5.28	4.19	3.05	*	2.4	1.6	1.09	*
R-552	12.30	6.94	4.06	0.14	0.08	0.05	38.2	26.1	11.0	4.6	6.97	4.73	3.09	*	3.7	2.1	1.34	*
JLSJ-9	24.14	40.96	6.53	0.25	0.42	0.07	50.6	39.7	22.6	15.7	7.85	2.61	1.99	1.10	3.7	1.1	0.89	0.48
Gaurav	39.77	25.05	12.76	0.43	0.27	0.14	51.0	34.2	15.8	5.5	8.44	7.00	4.85	*	2.5	1.3	0.93	*
Laxmi-27	12.32	11.52	7.09	0.15	0.14	0.09	42.3	35.8	30.0	16.9	7.54	6.28	4.50	1.06	3.4	2.5	1.69	1.43
Sheela	1.32	0.60	0.40	0.05	0.04	0.04	-	-	-	-	-	-	-	-	-	-	-	-
Shekhar	11.46	9.52	5.30	0.14	0.13	0.08	-	-	-	-	-	-	-	-	-	-	-	-
RLC-29	3.33	5.01	2.20	0.13	0.25	0.06	-	-	-	-	-	-	-	-	-	-	-	-
SEm±	2.05	3.43	1.95	0.02	0.04	0.02	2.55	2.49	1.71	1.33	0.53	0.49	0.33	0.16	0.28	0.15	0.11	0.06
CD (P=0.05)	5.85	9.76	5.55	0.06	0.11	0.06	5.07	4.97	3.41	2.64	1.06	0.98	0.66	0.33	0.55	0.31	0.22	0.12

* : denotes no survival up to harvest

Table 2 **On-farm growth and yield of linseed cultivars during *rabi*, 2000-01**

Cultivar	Germination (%)	Final plant stand (000/ha)	Plant height (cm)	Seed yield (kg/ha)
Laxmi-27	89	491	38	460
T-397	95	889	36	516
Sweta	95	1078	40	642
Meera	96	912	41	602
Shubhra	95	895	45	592
Kiran	94	790	40	568
SEm±	3.4	39	4.1	22
CD (P=0.05)	NS	118	NS	71

Padmini with poor germination than Sweta established higher final plant stand as compared to Sweta and Bijuri local as a result of better survival of plants in salt affected soils under rainfed condition. Padmini having markably higher dry matter/plant with dwarfer plants utilized soil moisture more efficiently under rainfed condition and showed better tolerance to salts as compared to Sweta and Bijuri local. The studies of Kumar (2002) and Kumar (2002) support these findings.

Table 3 **Growth and yield of linseed cultivars in relation to land configuration and FYM application during *rabi*, 2000-01**

Genotype	Germination (%)	Plants/m row length	Plant height (cm)	Seed yield (kg/ha)
Land configuration				
Sowing on flat bed	89	6.8	43.0	545
Sowing on side of ridge	87	7.0	43.5	598
SEm±	1.1	0.2	0.9	25
CD (P=0.05)	NS	NS	NS	NS
FYM Application				
FYM @ 2 t/ha	90	7.8	47.0	598
No. FYM	87	6.0	39.5	545
SEm±	1.1	0.2	0.9	25
CD (P=0.05)	3.6	0.7	2.9	NS
Linseed genotype				
Sweta	89	7.3	46.0	579
T 397	87	6.5	40.5	564
SEm±	1.2	0.3	0.5	11
CD (P=0.05)	NS	NS	1.5	NS

Table 4 Effect of management and cultivars on linseed growth and yield (mean of 2001 and 2002)

Genotype	Germination (%)	Final plant stand (000/ha)	Plant height (cm)	Drymatter/ plant (g)	Seed yield (kg/ha)		
					2001-02	2002-03	Pooled
Management technologies							
Improved technology	72	56.5	50.1	8.8	715	677	701
Farmers practice	65	30.5	40.2	8.5	461	456	460
SEm±	0.5	0.5	0.3	0.4	31	11	14
CD (P=0.05)	1.5	1.5	1.0	1.1	104	37	41
Linseed genotype							
Sweta	74	41.8	56.5	8.0	658	642	653
Padmini	72	57.9	37.4	9.5	725	685	710
Bijuri local	60	30.9	41.6	8.5	384	372	378
SEm±	0.6	0.5	0.4	0.5	21	16	13
CD (P=0.05)	1.8	1.4	1.2	1.4	61	46	36

Benefit:cost ratio: Although improved practices involved more inputs than farmers practice, but as a result of sizeable increase in the seed yield and gross return, the net returns were considerably higher (Rs. 7,741/ha) as compared to Rs. 4,313/ha in farmers practice. The benefit cost ratio was 2.58 and 2.08 in case of improved and farmers practice, respectively.

It is concluded that the above findings fully established the superiority of improved management technologies which consist of line/seed drill sowing, application of FYM @ 2 t/ha one month before sowing and use of straw mulch after sowing over traditional practices adopted by the farmers (broadcast sowing, without use of FYM and without straw mulch) in salt affected soils under rainfed condition. On the basis of growth, yield attributes and seed yield, the varieties Padmini followed by Sweta was superior to Bijuri local with improved management technologies in comparison to farmers' practice. Padmini having markably higher dry matter/plant with dwarfer plants utilized soil moisture more efficiently under rainfed condition and showed better tolerance to salts as compared to Sweta and Bijuri local.

Acknowledgement: The authors are grateful to the NATP (ICAR) for providing financial support through ROPS-16 project to carry out the present studies.

References

Abdul-Baki, A.A. and Anderson, J.D. 1973. Vigour determination in soybean by multiple criteria. *Crop Science*, **10** : 31-34.

Chauhan, M.P., Singh, N.B., Singh, D.P. and Maurya, K.N. 2003. Varietal response in salt tolerance in linseed. Paper presented in *National Seminar on Stress Management in Oilseeds for Attaining Self-reliance in Vegetable Oils* held at DOR, Hyderabad, January 28-30,2003.

Dubey, S.D., Srivastava, R.L., Kerkhi, S.A. and Chandra, R. 2003. Response of linseed genotypes under salinity stress. *Paper presented in National Seminar on Stress Management in Oilseeds for Attaining Self-reliance in Vegetable Oils* held at DOR, Hyderabad during January 28-30,2003.

Kumar, D. 2002. *Salinity and its management in oilseed crops. Oilseeds and Oils Research and Development Needs*, Rai, M., Singh, H. and Hegde, D.M. (eds). Published by Indian Society of Oilseeds Research, DOR, Hyderabad, pp., 265-268.

Kumar, R. 2002. Effect of drought on growth, leaf rolling, plant – water status and yield of rice (*Oryza sativa*). *Indian Journal of Agronomy*, **47** (1) : 61-66.

Rai, M., Dubey, S.D. and Singh, R. 1984. A note on the relative tolerance of linseed varieties and species to alkalinity conditions. *Journal of Oilseeds Research*, **1**: 225-228.

J. Oilseeds Res., **22**(1) : 71-74 (2005)

Adaptability analysis in niger, *Guizotia abyssinica* Cass.

S.S. Duhoon and H.S. Patil*

Project Coordinating Unit (Sesame & Niger), J.N. Krishi Vishwa Vidyalaya, Jabalpur-482 004, MP

(Received: August, 2004; Revised: December, 2004; Accepted: January, 2005)

Abstract

Nine elite genotypes of niger, *Guizotia abyssinica* Cass with two check varieties were evaluated over six locations across the country for seed yield, days to maturity, number of capsules/plant and number of branches/plant through six stability parameters. Genotype x environment interaction was found significant. On partitioning of it in to linear and nonlinear components, both were significant. However, linear component has its major share in inheritance of these characters; indicating that the prediction can be possible across the environment. With considering the individual adaptability parameter studied, the genotypes *viz*; JNS - 17, IGPN - 9628 and IGPN - 9629 were found responsive and adaptable for seed yield and the genotype BNS - 6 was found responsive and adaptable to specific favourable environment (below average stability). Whereas for remaining traits the genotype IGPN - 9628 and IGP - 76 were responsive and adaptable (average stability) to all traits. In the study of correlation among the stability parameters, it is revealed that the stability parameters appears to be under control of different gene or genes in combination in niger.

Key words: Yield prediction, stability, *Guizotia abyssinica*, correlation

Introduction

It is commonly observed that the relative performance of different genotypes varies in different environments, i.e., there exists a genotype - environment interaction. The occurrence of genotype - environment interaction has long provided a major challenge to obtaining fuller understanding of the genetic control of variability. In order to study stability, the present research work was undertaken in niger, a minor neglected oilseed crop, so that stable high yielder line be selected for its further use in breeding programme. With these objectives in mind the present investigation was planned and the experiment was conducted at six different locations across the country.

Materials and methods

The experimental material consisted of nine elite genotypes (Table 2) developed by Niger Breeders all over India with one national check and one local check. These genotypes were evaluated under multilocation testing at six locations of Semiliguda (Orissa), Chhindwara (Madhya Pradesh), Igatpuri (Maharashtra), Raichur and Bangalore (both from Karnataka) and Jagadalpur (Chhattisgarh) in Randomized Block Design (RBD) with three replications in a 30 x 10 cm spacing during *Kharif*, 2001 - 2002 under rainfed conditions. Each genotype was sown in a plot size of 4.0 x 3.0 m. Recommended package of practices and plant protection measures were followed to raise a good and healthy crop stand. The data were collected on four quantitative traits *viz*. seed yield kg/ha, days to maturity, number of branches/plant and number of capsules/plant. The data collected so far were subjected to stability analysis as suggested by Eberhart and Russel (1966). The coefficient of determination and ecovalence were worked out as per the procedure outlined by Bilbro and Ray (1976) and Becker (1981) respectively. The stability factor was calculated by using the formula of Levis (1954).

Results and discussion

The mean square due to genotypes, G x E linear and pooled deviation was significant for all the traits against pooled error (Table 1) indicating thereby the genotypes differ significantly for their stability parameters. The linear portion was higher for all the traits except for days to maturity where reverse trend was observed. The present results are in general agreement with those of Hegde *et. al.* (1999 and 2000), Patil (2001), Duhoon and Patil (2002) and Patil *et. al.* (2000 and 2002).

All the parameters of adaptability including coefficient of determination (r^2) and ecovalence (Wi) are presented in Table 2. An ideally adaptable genotype is one having high mean performance, a unit regression coefficient, coefficient of determination and stability factor and Nonsignificant value of deviation from regression and ecovalence.

Out of eleven genotypes, eight were significant for linear component (bi) and three were significant for nonlinear component ($\bar{S}^2$ di) of genotype x environment interaction; indicating thereby, genotype x environment interaction was

* Zonal Agricultural Research Station, Igatpuri-422 403, Maharashtra.

linear in nature, suggesting possibility of prediction for seed yield across the environments. This also confirmed from overall information obtained from pooled analysis of variance, where linear genotype x environment was almost 1.96 times more than the nonlinear genotype x environment variance. Earlier workers were also of the same opinion except *Joshi and Patil, (1982)*, who have reported the maximum share of nonlinear component of genotype x environment interaction in the expression of *seed yield in niger. On perusal of individual parameter* of adaptability, the genotypes *viz*; JNS - 17, IGPN - 9628, IGPN - 9629 and IGP - 76 were found responsive and adaptable (average stability) for seed yield across the environment. However, the genotype BNS - 6 was found responsive and specifically adaptable to favourable environment (below average stability).

Table 1 Pooled analysis of variance for *adaptability in niger*

Source	d.f.	Mean sum of squares			
		Seed yield Kg/ha.	Days to maturity	No of Branches/ plant	No of Capsules /plant
Genotypes	10	31.10*	87.50**	01.52*	25.84**
Environments	05	2327.90**	2356.83**	60.72**	3299.87**
(G x E)	50	19.30*	18.51**	1.44*	43.96**
Environment + (G x E)	55	67.00**	249.27**	7.11**	339.96**
Environment (linear)	01	20.08*	11784.19**	303.63**	16499.35**
G x E (linear)	10	41.13*	23.20**	01.71*	78.91**
Pooled deviation	44	00.21*	38.49**	01.66*	32.03**
Pooled error	120	00.08	00.48	00.33	00.569

*, ** Significant at P-0.05 and 0.01 level, respectively.

Table 2 Adaptability parameters for different traits in niger

Genotype	Seed yield (kg/ha)						Days to maturity					
	$\bar{x}$	bi	$\hat{S}^2di$	r^2	Wi	's' factor	$\bar{x}$	bi	$\hat{S}^2di$	r^2	Wi	's' factor
JNS-16 (M. P.)	383	1.29*	1.19	0.79	0.018	1.42	95	1.01*	35.55*	0.885	0.371	1.51
JNS-17 (M. P.)	426	0.97*	0.05	0.90	0.014	1.01	93	0.93*	02.39	0.949	0.141	1.04
IGPN-9628 (M.S.)	428	0.99*	0.02	0.95	0.007	0.99	94	0.98*	05.37	0.979	0.058	1.04
IGPN-9629 (M.S.)	414	0.98*	0.03	0.94	0.025	1.02	98	1.23*	26.41*	0.939	0.432	1.60
ONS-109 (Orissa)	352	0.83*	1.48	0.87	0.019	1.38	102	1.16*	18.51*	0.951	0.269	1.47
ONS-123 *(Orissa)*	*341*	*0.53*	*7.42**	0.11	0.070	1.60	99	0.92*	53.23*	0.810	0.571	1.33
SNC-15 (Orissa)	323	0.31	1.50	0.10	0.065	1.70	101	*1.07**	*31.44**	*0.906*	*0.341*	*1.41*
BNS-6 (Jharkhand)	396	1.19*	1.20	0.82	0.020	1.69	94	1.00*	11.37*	0.959	0.119	1.44
BNS-7 (Jharkhand)	340	1.80*	8.43*	0.44	0.083	1.55	94	0.95*	03.60	0.984	0.044	1.01
IGP-76 (N. C.)	409	0.98*	0.04	0.98	0.030	1.00	96	1.03*	01.51	0.986	0.125	1.05
Local check	382	0.49	*10.45**	*0.23*	*0.094*	*2.00*	105	*0.66*	*212.25**	0.356	252.34	2.11
Mean	381	0.987					97	1.09				
	Correlations											
$\bar{x}$	--	0.81*	0.15	0.70*	0.89*		--	0.84*	0.72*	0.76*	0.87*	
bi	--	--	- 0.12	0.41	0.83*		--	--	*0.52*	*0.51*	*0.88**	
$\hat{S}^2di$	--	--	--	- 0.56	0.45		--	--	--	- 0.51	0.42	
r^2	--	--	--	--	- 0.24		--	--	--	--	*- 0.21*	

Table 2 (Contd...)

Genotype	Seed yield (kg/ha)						Days to maturity					
	$\bar{x}$	bi	$\bar{S}^2$di	r^2	Wi	's' factor	$\bar{x}$	bi	$\bar{S}^2$di	r^2	Wi	's' factor
JNS-16 (M. P.)	8.2	0.92*	1.11*	0.828	0.288	2.04	41	0.72	53.00*	0.789	0.734	2.24
JNS-17 (M. P.)	8.8	0.95*	1.19*	0.957	0.058	1.04	43	0.65	37.12*	0.810	0.752	2.25
IGPN-9628 (M.S.)	9.3	0.93*	0.25	0.915	0.003	0.99	45	1.09*	3.72	0.969	0.156	1.01
IGPN-9629 (M.S.)	9.4	1.41*	1.51*	0.894	0.637	2.80	47	0.70	81.95*	0.694	1.043	2.42
ONS-109 (Orissa)	7.8	0.71	1.13*	0.739	0.412	2.00	41	0.97*	32.30*	0.916	0.298	4.17
ONS-123 (Orissa)	8.4	0.89	0.27	0.934	1.105	2.07	41	0.87*	8.05	0.972	0.127	3.13
SNC-15 (Orissa)	8.4	0.89	1.03	0.828	0.279	1.75	45	1.19*	58.52*	0.901	0.662	3.34
BNS-6 (Jharkhand)	8.7	0.90*	0.25	0.939	0.097	1.05	45	1.00*	2.79	0.968	0.212	1.04
BNS-7 (Jharkhand)	8.2	0.77	0.79	0.822	0.284	2.07	43	1.11*	27.43*	0.944	0.295	3.15
IGP-76 (N. C.)	8.9	1.05*	1.00	0.918	0.456	1.01	45	1.03*	2.54	0.995	0.017	1.03
Local check	8.1	1.21*	2.82*	0.675	0.676	1.86	42	1.18*	19.77*	0.963	0.297	6.41
Mean	8.6	0.98					43	1.00				
Correlations												
$\bar{x}$	--	0.75*	0.24	0.73*	0.86*		--	0.84*	0.31	0.60*	0.80*	
bi	--	--	-0.32	0.40	0.81*		--	--	-0.28	0.41	0.83*	
$\bar{S}^2$di	--	--	--	-0.41	0.46		--	--	--	-0.44	-0.42	
r^2	--	--	--	--	-0.23		--	--	--	--	-0.23	

* Significant at P=0.05

Out of eleven genotypes, ten and seven for days to maturity, seven and five for number of branches/plant; eight and seven for number of capsules/plant were significant for linear and nonlinear component of genotype x environment interaction respectively, indicating the preponderance of linear component of genotype x environment interaction in the inheritance of these traits and suggesting the prediction can be possible across the environments. Thus, the present results are in consonance with those of earlier workers like Patil *et. al.* (2000 and 2002), Hegde *et. al.* (1999 and 2000). With considering the individual parameter of adaptability, it revealed that the genotypes IGPN - 9628 and IGP-76 were responsive and adaptable (average stability) for all these traits. However, the genotype BNS-6 for number of branches/plant and number of capsules /plant; BNS-7 and JNS-17 for days to maturity were responsive and adaptable (average stability).

It was observed that mean performance was positively and significantly associated with regression coefficient, coefficient of determination and ecovalence for all the traits studied, indicating that the genotype with high mean performance for these traits were in general responsive to favourable environments (Table 2). Moreover, the regression coefficient was found independent of deviation from regression for all the traits except days to maturity, where it was positively associated but not significantly. Thus, indicating that the late maturing genotypes were responsive to favourable environment. Accordingly, the adaptability parameters appears to be controlled by different gene or genes in combination in niger, as was also reported by Hegde *et. al.* (1999 and 2000).

It is therefore, concluded that the genotypes like IGPN - 9628, IGP - 76 and JNS -17 showing average adaptability for seed yield and other related traits may be utilized in further hybridization programme to converge the stability characteristics in niger improvement programme to have a stable genotype.

References

Becker, H. C. 1981. Correlations among some statistical measures of phenotypic stability. *Euphytica,* **30** : 835 - 840.

Bilbro, J. D. and Ray, L.L. 1976. Environmental stability and adaptation of several cotton cultivars. *Crop Science,* **16**: 821 - 824.

Duhoon, S. S. and Patil, H.S. 2002. Seed yield stability in niger (*Guizotia abyssinica* Cass). *Advances in Agricultural Research in India,* **17** : 81 - 85.

Eberhart, S. A. and Russel, W.A. 1966. Stability parameters for comparing varieties. *Crop Science,* **6**(1): 36 - 40.

Hegde, D. M., Patil, H.S., Singh, B.R. and Goswami, U. 1999. Analysis of adaptation in niger (*Guizotia abyssinica* Cass). *Indian Journal of Agricultural Sciences,* **69**(12): 813 - 816.

Hegde, D. M., Patil, H.S., Singh, B.R. and Goswami, U. 2000. Phenotypic stability in niger (*Guizotia abyssinica* Cass). *Crop Research,* **19**(1): 97 - 101.

Joshi, B. P. and Patil, R.C. 1982. Stability of grain yield in niger. *Journal of Maharashtra Agricultural Universities,* **7**(2): 137 - 138.

Levis, D. 1954. Genotype - environment interaction. A relationship between dominance, heterosis, phenotypic stability and variability. *Heredity,* **8**: 333 - 356.

Patil, H. S. 2001. Stability analysis in niger (*Guizotia abyssinica* Cass). *Crop Research,* **21**(2):192 - 197.

Patil, H. S., Borole, R.D. and Purkar, J.K.. 2000. Analysis of stability for yield and yield attributes in niger (*Guizotia abyssinica* Cass). *Indian Journal of Agricultural Research,* **34**(1): 63 - 66.

Patil, H. S., Purkar, J.K. and Duhoon, S.S. 2002. Adaptability analysis in niger (*Guizotia abyssinica* Cass). *Journal of Oilseeds Research,* **19**(1): 82 - 85.

J. Oilseeds Res., 22(1) : 75-78 (2005)

Identification of linseed, *Linum usitatissimum* L. genotypes for high salinity tolerance

V.S. Verma, C.V. Raghavaiah*, Vineet Kumar and Rajendra Prasad

C.S. Azad University of Agriculture and Technology, Kanpur-208 002, UP

(Received: February, 2004; Revised: July, 2004; Accepted: September, 2004)

Abstract

Twenty linseed genotypes (Shikha, Rashmi, T 397, Garima, Sweta, Shubhra, Meera, Kiran, Padmini, Janki, Mukta, Hira, Jawahar-23, Parvati, Himalini, Surbhi, R 552, JLSJ 9, Gaurav and Laxmi-27) were evaluated against increasing levels of salinity (<1, 4, 6 and 8 dS/m) in pot culture during *rabi* 2001-02 and 2002-03. The experiment was laid out in Completely Randomized Design with three replications. In order to identify salinity tolerant genotypes, parameters like germination, seedling vigour index and salt content in plant were recorded at 20 days after incubation of pots with salinity; while branches/plant, capsules/branch, seeds/capsule, drymatter/plant, thousand seed weight and seed yield/plant were recorded at maturity. The genotypes viz., Padmini, Janki, Laxmi 27, Sweta and Shubhra have been identified as tolerant to high salinity.

Key words: Linseed genotypes, salinity, growth, salt content in plant

Introduction

Linseed (*Linum usitatissimum* L.) is an important industrial crop mostly grown on marginal, sub-marginal and neglected lands under rainfed situation in India. About 80% of linseed oil goes for industrial use such as manufacturing of pad ink, varnish, paints, printing ink, etc., and the remaining 20% is used for edible purposes. In India, more than 7 m ha lands are estimated to be salt affected. Salinity is a serious problem for raising a host of crops due to continued upward movement of salt and their redistribution in upper surface as a result of evaporation. Oilseed crops like linseed possessing salt tolerance potential can be used to exploit the yield under rainfed conditions as this crop has specific adaptive morpho-physiological features (Dubey *et al.*, 2003). Salt affected soils are one of the major constraints causing 25-100% yield loss in the country (Chauhan *et al.*, 2003). Hence, there is a need to identify suitable linseed cultivars having high salt tolerance by which an increase in production is possible vertically. The information is scanty on the recently developed genotypes/released cultivars of linseed for such situations. The present study was, therefore, undertaken to identify the linseed genotypes for their tolerance to salinity.

Materials and methods

A pot experiment was conducted at students' experimental farm of C.S. Azad University of Agriculture and Technology, Kanpur during *rabi* 2001-02 and 2002-03. Twenty genotypes of linseed were evaluated for their tolerance to four different salinity levels i.e. 4, 6 and 8 dS/m and compared with control (<1). The trial was laid out in Completely Randomized Design with three replications. The required soil having <1 dS/m salinity level for filling in the pots was procured from students' experimental farm. The soil was divided into four equal parts for creating graded levels of salinity. The salt solution was prepared by dissolving NaCl, $CaCl_2$, $MgCl_2$ and $MgSO_4$ in distilled water using different ratios (Na:Ca+Mg as 1:1; Ca:Mg as 1:3: and Cl:SO_4 ratios as 7:3). Three salinity levels of 4, 6 and 8 dS/m were created separately by spraying diluted stock solution of required salinity concentration over the thin layer of soil. The soil was thoroughly mixed repeatedly after each spraying. Adding a thin layer of soil over the previous layer followed by spraying and mixing was repeated to obtain sufficient quantity of treated soil for filling into 20 pots each of the size of 30 x 30 cm @ 10 kg soil/pot for each salinity level. The normal untreated soil was used for filling the control pots. After filling the pots, 100 seeds of selected genotypes were sown in each pot. The seeds before sowing were treated with thiram @ 2.5 g/kg of seed to control pre and post emergence seedling blight diseases. Germination percentage, seedling vigour index were recorded and salt content in plant was estimated at 20 days after incubating the pot. Six plants in each pot were maintained for recording the data on number of branches/plant, number of capsules/branch, number of seeds/capsule, drymatter/plant, thousand seed weight and

*Principal Scientist (Agronomy), Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, AP.

seed yield/ plant. Seedling vigour was calculated by the following formula as suggested by Abdul-Baki and Anderson (1973):

Seedling vigour = Germination % x mean dry weight of seedling

Results and Discussion

Growth and yield attributes: The results pooled over *rabi* 2001-02 and 02-03 revealed that at 4 dS/m the germination of Padmini, Sweta and Shikha in control pots (89-95%) was satisfactory. At 6 dS/m, Padmini and Sweta showed equal germination (80%). The germination of Sweta (73%) and Padmini (71%) was relatively less at 8 dS/m but was significantly better than other genotypes. The seedling vigour index of Padmini closely followed by Sweta was higher as compared to remaining genotypes/cultivars at all the levels of salinity including control (<1) which was 58.3, 52.7, 39.5 and 30.4 for Padmini, and 86.9, 48.1, 37.7 and 30.3 for Sweta in <1, 4, 6 and 8 dS/m, respectively (Table 1).

Shubhra followed by Padmini produced significantly more number of branches/plant in control pots (6.17 & 6.13) and 4 dS/m (5.83 and 5.55); while Padmini was superior to remaining genotypes/cultivars at 6 and 8 dS/m levels of salinity. The capsules/branch of Padmini followed by Laxmi 27; Himalini followed by Padmini and only Padmini were significantly higher at 4, 6 and 8 dS/m than remaining genotypes, respectively. Rashmi, Sweta and Shubhra with equal values followed by T 397 and Padmini produced more number of seeds/capsule at 8 dS/m; while almost all the remaining genotypes failed to produce seeds at this level of salinity. At lower levels of salinity including control (<1) many genotypes possessed more number of seeds/capsule (Table 2). These results are partially supported by the work of Rai (1984).

Sweta at 8 dS/m, Padmini at 6 dS/m, Shubhra followed by Padmini and Sweta at 4 dS/m produced significantly higher drymatter/plant. On the basis of thousand seed weight, Sweta followed by Padmini showed more tolerance to highest level of salinity (8 dS/m). But at lower levels including control, other cultivars also had higher thousand seed weight. Padmini produced higher seed yield per plant at increasing levels of salinity (4 to 8 dS/m); while in control pots, Hira was found superior to Padmini (Table 3).

Salt content in plant: Increasing levels of salinity increased the plant Na/K and Na/Ca ratio of all the genotypes/cultivars. Sweta followed by Padmini along with other cultivars possessed comparatively plant lower Na/K ratio at all the levels of salinity including control. Padmini followed by Sweta and other cultivars, by and large, maintained lower Na/Ca ratio (Table 4).

Table 1 Germination and seedling vigour index of linseed genotypes as influenced by different levels of salinity (mean of 2001 and 2002)

Genotype	Germination (%)				Seedling vigour index			
	Control	4 dS/m	6 dS/m	8 dS/m	Control	4 dS/m	6 dS/m	8 dS/m
Shikha	89	83	57	53	34.3	26.4	12.7	8.9
Rashmi	76	65	64	38	45.9	33.6	24.6	12.5
T 397	88	79	75	42	47.9	41.0	31.3	16.0
Garima	82	63	32	26	38.5	27.2	12.9	8.3
Sweta	92	85	80	73	56.9	48.1	37.7	30.3
Subhra	64	45	29	21	32.3	21.6	10.4	5.1
Meera	82	61	38	25	43.3	30.1	15.8	8.8
Kiran	88	73	63	39	39.5	29.4	19.0	10.1
Padmini	95	95	80	71	58.3	52.7	39.5	30.4
Janki	80	68	51	44	33.4	24.5	13.0	9.1
Mukta	76	70	61	45	32.1	25.5	16.8	10.6
Hira	88	67	61	22	51.5	34.6	25.3	6.[illegible]
Jawahar-23	80	60	52	31	33.6	23.8	17.9	8.1
Parvati	76	76	67	55	41.8	34.7	27.0	19.6
Himalini	77	62	34	4	41.9	28.0	12.8	1.1
Surbhi	82	63	32	4	44.7	27.0	7.1	1.0
R-552	75	58	30	15	38.2	26.1	11.0	4.6
JLSJ-9	83	74	48	39	50.6	39.7	22.6	15.7
Gaurav	81	69	35	15	51.0	34.2	15.8	5.5
Laxmi-27	76	72	65	45	42.3	35.8	30.0	16.9
SEm±	3.36	4.07	3.81	3.56	2.55	2.49	1.71	1.33
CD (P=0.05)	6.69	8.11	7.60	7.10	5.07	4.97	3.41	2.64

Table 2 Branches/plant, capsules/branch and seeds/capsule of linseed genotypes as influenced by levels of salinity (mean of 2001 and 2002)

Genotype	Branches/plant				Capsules/branch				Seeds/capsule			
	Control	4 dS/m	6 dS/m	8 dS/m	Control	4 dS/m	6 dS/m	8 dS/m	Control	4 dS/m	6 dS/m	8 dS/m
Shikha	5	4	4	-	11	10	9	-	10	9	9	-
Rashmi	5	3	4	3	11	9	8	7	9	9	9	9
T 397	4	4	4	3	11	9	8	8	9	9	9	8
Garima	4	3	3	-	10	9	9	-	9	8	8	-
Sweta	5	4	3	3	10	10	6	7	9	9	9	9
Subhra	6	6	4	3	10	9	9	8	9	9	9	9
Meera	4	4	3	-	9	9	9	-	9	8	8	-
Kiran	5	4	3	-	10	10	7	-	11	9	9	-
Padmini	*6*	*6*	*5*	*4*	*14*	*12*	*10*	*10*	8	8	8	8
Janki	5	4	3	3	10	10	9	5	9	9	9	4
Mukta	5	4	4	-	12	10	7	-	10	9	9	-
Hira	5	3	3	-	11	8	7	-	10	9	9	-
Jawahar-23	4	4	3	-	10	9	8	-	8	7	7	-
Parvati	4	3	3	2	8	8	8	3	9	8	8	4
Himalini	4	4	3	-	11	11	10	-	10	10	9	-
Surbhi	5	4	4	-	11	10	9	-	9	8	8	-
R-552	4	3	3	-	11	10	8	-	10	9	9	-
JLSJ-9	5	2	2	2	9	4	4	3	10	5	5	4
Gaurav	4	3	3	-	9	6	6	-	8	8	8	-
Laxmi-27	4	4	4	2	12	11	8	3	8	8	7	3
SEm±	*0.35*	*0.28*	*0.28*	*0.12*	*0.51*	*0.60*	*0.35*	*0.28*	*0.65*	*0.70*	*0.78*	*0.36*
CD (P=0.05)	0.71	0.55	0.55	0.23	1.03	1.20	0.70	0.55	1.30	1.39	1.56	0.71

Dash (-) denotes no survival up to harvest

Table 3 Drymatter, thousand seed weight and seed yield/plant of linseed genotypes as influenced by levels of salinity (mean of 2001 and 2002)

Genotype/Cultivar	Drymatter/plant (g)				Thousand seed weight (g)				Seed yield/plant (g)			
	Control	*4 dS/m*	*6 dS/m*	*8 dS/m*	*Control*	*4 dS/m*	*6 dS/m*	*8 dS/m*	*Control*	*4 dS/m*	*6 dS/m*	*8 dS/m*
Shikha	8.23	7.78	5.74	-	7.1	6.8	6.3	-	3.2	2.6	2.0	-
Rashmi	9.24	5.01	4.53	3.20	9.1	8.0	7.3	5.6	4.4	1.7	1.6	0.55
T 397	7.53	6.33	5.54	3.24	7.7	7.3	7.0	4.6	2.9	2.2	1.9	1.05
Garima	7.82	6.22	5.05	-	9.5	8.1	7.5	-	3.2	2.1	1.8	-
Sweta	10.25	8.63	6.24	4.45	7.4	7.3	6.7	6.6	3.4	2.7	2.0	1.34
Subhra	10.70	9.26	4.42	2.78	7.8	7.1	6.4	6.0	4.0	3.3	2.0	1.34
Meera	7.25	6.30	3.17	-	7.2	6.4	5.6	-	2.3	1.7	1.4	-
Kiran	*10.73*	*8.17*	*5.60*	-	5.8	5.3	5.2	-	2.4	1.8	1.1	-
Padmini	9.68	8.69	7.42	4.05	7.9	7.3	7.2	6.5	4.8	3.4	3.0	1.53
Janki	8.44	6.80	5.96	3.68	9.2	8.4	7.5	3.6	3.7	3.0	2.0	1.51
Mukta	10.51	8.23	5.23	-	9.1	8.8	7.5	-	4.8	3.3	1.6	-
Hira	11.84	6.05	3.11	-	10.4	8.4	7.3	-	7.4	2.1	1.2	-
Jawahar-23	8.05	5.39	3.88	-	7.2	6.6	6.1	-	2.2	1.4	1.2	-
Parvati	5.71	4.28	3.14	-	7.8	6.9	8.5	2.8	2.5	1.6	1.1	-
Himalini	7.35	5.29	3.17	-	6.9	6.7	6.1	-	3.5	2.6	1.6	-
Surbhi	5.28	4.19	3.05	-	5.4	4.7	4.2	-	2.4	1.6	1.1	-
R-552	6.97	4.73	3.09	-	8.5	6.9	6.4	-	3.7	2.1	1.3	-
JLSJ-9	7.85	2.61	1.99	1.10	8.8	3.6	3.0	2.6	3.7	1.1	0.9	0.48
Gaurav	8.44	7.00	4.85	-	7.5	6.7	6.4	-	2.5	1.3	0.9	-
Laxmi-27	7.54	6.28	4.50	1.06	7.9	7.7	7.3	3.1	3.4	2.5	1.7	1.43
SEm±	0.53	0.49	0.33	0.16	0.5	0.2	0.1	0.2	0.3	0.2	0.1	0.06
CD (P=0.05)	1.06	0.98	0.66	0.33	0.9	0.4	0.3	0.4	0.6	0.3	0.2	0.12

Dash (-) denotes *no survival up to harvest*

Table 4 Plant Na/K and Na/Ca ratios of linseed genotypes as influenced by levels of salinity (Mean of 2001 and 2002)

Genotype	Na/K ratio				Na/Ca ratio			
	Control	4 dS/m	6 dS/m	8 dS/m	Control	4 dS/m	6 dS/m	8 dS/m
Shikha	0.070	0.086	0.114	-	0.060	0.078	0.098	-
Rashmi	0.062	0.086	0.112	0.148	0.065	0.080	0.101	0.093
T 397	0.048	0.111	0.138	0.317	0.057	0.098	0.121	1.115
Garima	0.054	0.110	0.125	-	0.056	0.106	0.115	-
Sweta	0.050	0.085	0.113	0.164	0.057	0.072	0.099	0.133
Shubhra	0.067	0.074	0.108	0.217	0.059	0.069	0.110	0.195
Meera	0.074	0.124	0.137	-	0.076	0.110	0.124	-
Kiran	0.065	0.123	0.145	-	0.077	0.117	0.114	-
Padmini	0.040	0.068	0.085	0.142	0.048	0.053	0.073	0.127
Janki	0.063	0.083	0.111	0.168	0.068	0.082	0.102	0.155
Mukta	0.052	0.112	0.156	-	0.052	0.108	0.122	-
Hira	0.074	0.126	0.155	-	0.065	0.119	0.145	-
Jawahar-23	0.065	0.111	0.161	-	0.059	0.118	0.133	-
Parvati	0.092	0.129	0.175	-	0.100	0.121	0.158	-
Himalini	0.076	0.072	0.153	-	0.070	0.082	0.132	-
Surbhi	0.086	0.113	0.169	-	0.066	0.098	0.150	-
R-552	0.065	0.092	0.145	-	0.066	0.084	0.127	-
JLSJ-9	0.070	0.048	0.061	0.142	0.066	0.041	0.058	0.132
Gaurav	0.075	0.126	0.152	-	0.069	0.115	0.130	-
Laxmi-27	0.064	0.090	0.117	0.202	0.053	0.083	0.111	0.160
SEm±	0.004	0.007	0.006	0.004	0.005	0.003	0.005	0.017
CD (P=0.05)	0.007	0.015	0.012	0.007	0.010	0.008	0.010	0.033

(Dash (-) denotes no survival up to harvest

It is evident from the above results that the performance of linseed genotypes/cultivars varied with the changes in soil salinity. Rai and Sinha (1980) reported earlier that linseed variety KL 69 showed twin tolerance to salinity (EC 12 dS/m) and sodicity (pH 9.2) on loamy light textured arid soils. Rai *et al.* (1984) also reported variable reaction of linseed cultivars to soil alkalinity. The results of current study based on growth and yield parameters confirm that five cultivars (Padmini, Janki, Laxmi 27, Sweta and Shubhra) could survive effectively up to the highest test salinity level of 8 dS/m. These could be considered as genotype of high salinity tolerance.

References

Abdul-Baki, A. A. and Anderson, J.D. 1973. Vigour determination in soybean by multiple criteria. *Crop Science*, **10** : 31-34.

Chauhan, M. P., Singh, N.B., Singh, D.P. and Maurya, K.N. 2003. Varietal response on salt tolerance in linseed. Paper presented in *Stress management in oilseeds for attaining self-reliance in vegetable oils* held at Directorate of Oilseeds Research, Hyderabad, January 28-30, 2003.

Dubey, S.D., Srivastava, R.L., Kerkhi, S.A. and Chandra, R. 2003. Response of linseed genotypes under salinity stress. Paper presented in National Seminar on **Stress management in oilseeds for attaining self-reliance in vegetable oils** held at Directorate of Oilseeds Research, Hyderabad, Jan. 28-30, 2003.

Rai, M. 1984. Character association and path of action in linseed as influenced by soil salinity. *Journal of Oilseeds Research*, **1** : 103-108.

Rai, M., Dubey, S.D. and Singh, R. 1984. A note on the relative tolerance of linseed varieties and species to alkalinity conditions. *Journal of Oilseeds Research*, **1** : 225-228.

Rai, M. and Sinha, T.S. 1980. Genetic adaptation to saline soil conditions in linseed. Annals of Arid Zone, **19**: 231-237.

J. Oilseeds Res., **22**(1) : 79-82 (2005)

Modified Mitscherlish-Bray equation in estimating castor, *Ricinus communis* L. and safflower, *Carthamus tinctorius* L. response to applied sulphur

I.Y.L.N. Murthy

Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, AP

(Received: September, 2004; Revised: December, 2004; Accepted: January, 2005)

Abstract

Response of different sulphur sources *viz.*, ammonium sulphate, single super phosphate, elemental sulphur and gypsum and four levels *viz.*, 0, 15, 30 and 45 kg/ha was studied with safflower as test crop at various locations. Similarly, response of castor to three sulphur sources *viz.*, single super phosphate, elemental sulphur and gypsum and four levels *viz.*, 0, 10, 20 and 30 kg/ha was studied under irrigated and rainfed conditions. Published yield data of these experiments was utilised to examine the validity of Modified Mitscherlich-Bray (MMB) equation in estimating the yield response since the available soil sulphur status information was not available. Fertilizer and soil efficiency factors computed for safflower at different locations varied from -0.027 to 0.605 and 0.010 to 0.060, respectively. For castor fertilizer efficiency values varied from 0.288 to 1.149. The MMB equation predicted the yield response to sulphur application excellently for both safflower and castor to a given yield level in sulphur responsive soils irrespective of irrigated and rainfed conditions.

Key words: Safflower, castor, sulphur, Mitscherlich-Bray *equation, fertilizer* and soil efficiency factors

Introduction

Soil test value of an essential nutrient in assessing the nutrient's *bio-availability vis-a-vis* its response on fertilizer application and to realise the optimum/economic seed yields is imperative. It also helps to make proper interpretation of observations. For various reasons sometimes, it may not be possible to estimate the nutrient availability at the initial stage of the field experiments. Besides, the soil of the experimental sites differs markedly in their physico-chemical characteristics. For each conditions, Ghosh and Misra (1996) proposed the modified Mitscherlich-Bray equation (MMB), which was found useful in predicting the seed yield response to a given level of fertilizer in soils responsive to phosphorus treatment. In the present studies, validity of this equation and response to applied sulphur through different sources was re-examined for the safflower and castor crops which were *cultivated under irrigated and rainfed* conditions (AICRP, 1998-2004), wherein the initial soil available sulphur values are not available.

Materials and methods

The published yield data (All India Coordinated Project Reports on Safflower and Castor, 1997-2001 and 2002-04, respectively) of eight field experiments conducted at various Project Coordinating centres *viz.*, Phaltan, Parbhani, Annigeri, Tandur, Solapur, Indore, etc. for safflower and Yethapur and Mandor for castor were considered to verify the MMB equation in estimating the yield response of these crops to different sources and levels of sulphur on sulphur responsive soils.

Ghosh and Misra (1996) proposed the modified Mitscherlich-Bray (MMB) equation as follows:

$$\text{Log}\ (A-y) = \log\ (A-yo) - C \log\ (x+1)$$

Where, 'y' is the yield corresponding to 'x' *units of fertilizer* nutrient; yo is yield obtained without S treatment, C is the fertilizer efficiency factor and 'A' is the maximum or limiting yield.

Results and discussion

The yields actually obtained and those calculated for different sources and levels of S on the basis of MMB equation under irrigated and rainfed conditions are shown in Tables 1 and 2, respectively, for safflower and in Table 3 for castor. The parameters of the equation were computed as per the procedure outlined by Ghosh and Misra (1996).

A comparison of the yields of safflower obtained with *different sources at varying rates* of S application and those calculated using the MMB equation shows close agreement between the values for each of the three experiments conducted under irrigated and rainfed conditions (Table 1). The mean difference values between yield obtained and calculated for various sources and S rates ranged from 0.1 to 5.9% and 0.2 to 10% in the three experiment conducted under irrigated and rainfed conditions, respectively. The chi-square test values computed (not presented) also indicated that there is a goodness of fit between the obtained and calculated seed yields of safflower. Overall mean per cent difference between yield obtained and calculated across the locations and S sources was found to be 1.24 and 3.14 under irrigated and rainfed conditions. A better yield response and S use efficiency by the *safflower crop*, irrespective of sources, locations and seasons was evident under irrigated conditions.

Similar observations with castor crop were also observed. The mean difference values between obtained and calculated for various sources and rates of S ranged from 0.4 to 1.3 and 0.1 to 2.6 for irrigated and rainfed conditions, respectively. Overall mean per cent difference between yield obtained and calculated among the S sources was lower (i.e., 0.76) under irrigated conditions *than under rainfed (i.e., 1.0)* indicating a better use efficiency of applied S by the crop under favourable moisture conditions. The computed C value was smaller for single super phosphate and elemental sulphur is an indication that they are required in larger quantity to obtain *the expected yield* at Yethapur and Mandor, respectively.

Soil efficiency (SE) factors were computed by using *modified Bray's equation (1954) Log (A-y) = Log A-c1b1*, where c1 is the soil efficiency factor and b1 is the soil test value, a and y are already described above. These were derived for two soil test values of available S, i.e., 18 and *40.3 kg/ha. This is the critical* nutrient range reported for various oilseed crops under different soil types and conditions with various extractants (Tandon, 1991). It is assumed that SE values in the experimental sites may be much lower or oscillate in this range since there was a *response to S application*. In general, *all* the S sources have recorded higher mean SE values over control at all the safflower grown locations (Table 4). Lower values of these over fertilizer efficiency values is an indication that safflower crop has drawn the S mainly from fertilizer source *irrespective* of locations, S sources and conditions. SE value will be invariably lower than FE value when there is a response to fertilizer application and *vice versa*. SE values were relatively higher for single super phosphate under irrigated conditions at Phaltan and Solapur while *under rainfed situation* except gypsum *all* the other three sources gave higher values i.e., 0.056, 0.066 and 0.049 at Indore, Annigeri and Tandur, respectively. In the *safflower* field studies it is interesting to note that S sources, ammonium sulphate, elemental sulphur and gypsum under irrigated and rainfed conditions, respectively, have not recorded higher SE values. This could be attributed to various soil factors and inherent characters of S sources and their time and method of application.

Table 1 Safflower seed yields obtained and calculated for varying sources/doses of sulphur under irrigated conditions

Sulphur source	Dose (kg/ha)	Parbhani (1998-99)			Phaltan (1999-00)			Solapur (2000-01)		
		Obtained yield (kg/ha)	Calculated yield (kg/ha)	Per cent difference	Obtained yield (kg/ha)	Calculated yield (kg/ha)	Per cent difference	Obtained yield (kg/ha)	Calculated yield (kg/ha)	Per cent difference
	0	1195	1195	-	530	530	-	988	988	-
Ammonium sulphate	15	1481	1609	8.6	645	709	9.9	923	956	3.6
	30	1684	1664	1.2	742	739	0.4	955	948	0.7
	45	1723	1692	1.8	788	755	4.2	974	943	3.2
Mean				1.9			1.7			0.1
Single super phosphate	15	1493	1630	9.2	645	839	4.2	1005	1159	15.3
	30	1691	1685	0.3	742	869	1.3	1077	1188	10.3
	45	1754	1713	2.4	788	883	1.9	1308	1203	8.0
Mean				2.2			1.2			5.9
Elemental sulphur	15	1511	1656	9.6	621	702	13.0	847	1018	20.2
	30	1703	1711	0.5	709	731	3.1	982	1025	4.4
	45	1785	1737	2.7	803	747	7.0	1151	1029	10.6
Mean				2.5			3.1			4.7
Gypsum	15	1528	1670	9.3	618	660	6.9	836	935	11.8
	30	1713	1724	0.6	651	685	5.2	908	921	1.4
	45	1798	1750	2.7	752	699	7.1	989	912	7.7
Mean				2.4			1.7			1.8
	A		1900 kg/ha			950 kg/ha			1400 kg/ha	
C for Ammonium sulphate			0.319			0.200			-0.027	
Single super phosphate			0.346			0.480			0.193	
Elemental sulphur			0.383			0.190			0.028	
Gypsum			0.404			0.134			-0.044	

Table 2 Safflower seed yields obtained and calculated for varying sources/doses of sulphur under rainfed conditions

Sulphur source	Dose (kg/ha)	Indore (1997-98) Obtained yield (kg/ha)	Indore (1997-98) Calculated yield (kg/ha)	Indore (1997-98) Per cent difference	Annigeri (1998-99) Obtained yield (kg/ha)	Annigeri (1998-99) Calculated yield (kg/ha)	Annigeri (1998-99) Per cent difference	Tandur (2000-01) Obtained yield (kg/ha)	Tandur (2000-01) Calculated yield (kg/ha)	Tandur (2000-01) Per cent difference
	0	1051	1051	-	1411	1411	-	750	750	-
Ammonium sulphate	15	1123	1232	9.7	1759	1972	12.1	838	938	11.9
	30	1119	1265	13.1	2233	2056	7.9	954	965	1.2
	45	1409	1284	8.9	2002	2099	4.9	1022	979	4.2
Mean				4.6			3.0			3.0
Single super phosphate	15	1123	1269	13.0	1813	2297	26.7	819	879	7.3
	30	1248	1306	4.7	2431	2364	2.8	903	901	0.2
	45	1421	1327	6.7	2417	2393	1.0	944	914	3.2
Mean				3.7			7.6			1.3
Elemental sulphur	15	1200	1428	19.0	1892	2064	9.1	780	835	7.0
	30	1264	1470	16.3	2153	2149	0.2	884	852	3.7
	45	1574	1490	5.4	2250	2192	2.6	871	861	1.1
Mean				10.0			2.1			0.7
Gypsum	15	1107	1130	2.1	1971	1880	4.6	825	883	7.0
	30	1127	1147	1.8	1848	1958	5.9	941	906	3.7
	45	1180	1157	2.0	2012	1999	0.6	924	919	0.6
Mean				0.6			0.2			0.9
	A		1600 kg/ha			2500 kg/ha			1100 kg/ha	
C for Ammonium sulphate			0.144			0.261			0.278	
Single super phosphate			0.182			0.605			0.165	
Elemental sulphur			0.419			0.330			0.100	
Gypsum			0.056			0.203			0.172	

Table 3 Castor seed yields obtained and calculated for varying sources/doses of sulphur under irrigated and rainfed conditions

Sulphur source	Dose (kg/ha)	Mandor (Irrigated) (2003-04) Obtained yield (kg/ha)	Mandor (Irrigated) (2003-04) Calculated yield (kg/ha)	Mandor (Irrigated) (2003-04) Per cent difference	Yethapur (Rainfed) (2002-03) Obtained yield (kg/ha)	Yethapur (Rainfed) (2002-03) Calculated yield (kg/ha)	Yethapur (Rainfed) (2002-03) Per cent difference
	0	1512	1512	-	559	559	-
Single super phosphate	10	1543	1610	4.35	747	829	10.95
	20	1605	1626	1.33	859	875	1.85
	30	1666	1635	1.88	946	899	4.99
Mean				1.3			2.6
Gypsum	10	1666	1688	1.32	866	875	1.05
	20	1697	1694	0.16	909	923	1.49
	30	1697	1696	0.04	963	946	1.77
Mean				0.4			0.3
Elemental sulphur	10	1528	1581	3.46	908	903	0.57
	20	1612	1595	1.08	931	950	2.03
	30	1612	1602	0.61	985	973	1.26
Mean				0.6			0.1
	A		1600 kg/ha			1100 kg/ha	
C for Single super phosphate			0.308			0.288	
Gypsum			1.149			0.366	
Elemental sulphur			0.190			0.421	

Table 4 Soil efficiency factors* derived by Bray's equation for lower and upper critical S levels i.e., 18 and 40.3 kg/ha

Sulphur source	Safflower												Castor			
	Irrigated								Rainfed				Irrigated		Rainfed	
	Parbhani		Phaltan		Solapur		Indore		Annigeri		Tandur		Mandor		Yethapur	
	18	40.3	18	40.3	18	40.3	18	40.3	18	40.3	18	40.3	18	40.3	18	40.3
Control	0.023	0.010	0.019	0.008	0.029	0.013	0.025	0.011	0.020	0.009	0.028	0.012	0.053	0.024	0.017	0.008
Ammonium sulphate	0.010	0.021	0.035	0.015	0.027	0.012	0.036	0.016	0.040	0.018	0.049	0.022		-	-	-
Single super phosphate	0.050	0.022	0.057	0.025	0.043	0.019	0.039	0.017	0.066	0.029	0.041	0.018	0.074	0.033	0.037	0.017
Elemental sulphur	0.053	0.023	0.034	0.015	0.031	0.013	0.056	0.025	0.045	0.020	0.036	0.016	0.066	0.030	0.047	0.021
Gypsum	0.055	0.024	0.030	0.013	0.025	0.011	0.030	0.013	0.036	0.016	0.041	0.019	0.133	0.060	0.043	0.019

* Mean of three S levels.

Soil efficiency values for castor under irrigated conditions at Mandor varied from 0.053 to 0.133 at 18 kg/ha soil available S level and higher value was observed with gypsum followed by single super phosphate. At Yethapur, these values varied from 0.017 to 0.047 at the same soil S level and elemental sulphur had a higher SE value followed by gypsum. However, these are lower than fertilizer efficiency values indicate the S availability to castor is mainly through fertilizer source under both irrigated and rainfed conditions. Low SE values indicate that the soils were having poor efficiency with respect to those sources of S. Hence, these sources should be applied with caution to improve seed/economic yield of either safflower or castor.

Thus, use of this equation enabled in predicting the yield response of safflower and castor crops to a given level of S fertilizer in soils responsive to S treatment. The S fertilizer requirement for a specific yield of a given crop in a soil testing low in S may be calculated by knowing the S soil test value and the other parameters of this equation *viz.*, A, C1 and C, which can be determined from previous field studies.

Acknowledgement: Author is thankful to Dr. D.M. Hegde, Project Director, Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030 for his keen interest and encouragement in the study.

References

Anonymous. 1997-2001. Annual Progress Reports, Safflower, 1998-2004. Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030.

Anonymous. 2002-2004. Annual Progress Reports, Castor 1998-2004. Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, AP.

Bray, R.H. 1954. A nutrient mobility concept of soil plant relationships. *Soil Science,* **78**:9-22.

Ghosh, P.C. and Misra, U.K. 1996. Modified Mitscherlich-Bray equation for calculation of crop response to applied phosphate. *Journal of the Indian Society of Soil Science*, **44**(4) : 786-788.

Tandon, H.L.S. 1991. *Sulphur Research and Agricultural Production in India.* Fertilizer Development and Consultation Organization, 204-204A, Bhanot Corner, 1-2 Pomposh Enclave, New Delhi.

J. Oilseeds Res., **22**(1) : 83-85 (2005)

Effect of nutrients and moisture conservation practices on growth, yield and economics of safflower, *Carthamus tinctorius* L. under rainfed vertisols

P.B. Gawand, A.N. Deshpande, S.I. Tambe, A.L. Pharande and B.N. Reddy

AICRP for Dryland Agriculture, Mahatma Phule Krishi Vidyapeeth, Solapur-413 002, **Maharashtra**

(Received: August, 2004; Revised: November, 2004; Accepted: December, 2005)

Abstract

On farm trials were conducted to study the effect of nutrient and moisture conservation practices on growth, yield and economics of safflower, *Carthamus tinctorius* L. during *rabi* 2001-02 and 2002-03 on vertisols of Solapur district (Maharashtra). The results revealed that recommended method of moisture conservation along with recommended fertilizer practice recorded higher seed yield (1440 kg/ha) and net return (Rs.14740/ha) in medium to high P soils *than rest of the treatments.* The cultivar DSH-129 showed the favourable response with respect to growth and yield, recording higher net returns than rest of cultivars. The performance of DSH-129 was better both under stress and normal conditions of moisture and nutrients.

Key words: Safflower, nutrient, moisture, vertisols

Introduction

India is a leading country in the world both in terms of area and production of safflower, however, productivity is very low. Safflower is the most important *rabi* oilseed crops grown in scarce rainfall zone of Maharashtra. Safflower is solely raised on vertisols in Maharashtra under residual soil moisture without application of adequate nutrients. The crop has a reputation of possessing drought resistance and can tap soil moisture which other crops cannot tap (Hegde, 1997). In safflower culture harrowing during monsoon was found to conserve soil moisture in black soils (Anonymous, 1986). Safflower nutrition depends upon soil moisture availability and native soil fertility. Economic response to N application has been observed at a number of locations beyond 60 kg/ha. (Umrani *et al.*,1981) Response of safflower to applied P varied from 25-40 kg P_2O_5/ha. (Kumar *et al.*, 1989). Differential response of safflower cultivars was observed to applied fertilizers. Since the farmers of this area have poor investment capacity on cash inputs. The choice of appropriate cultivar for variable nutrient and moisture situation is of paramount importance to enhance the productivity of safflower in the region. Improvement in productivity of safflower under rainfed environment has necessitated the evaluation of cultivars for moisture and nutrient constraints under real farm conditions.

Materials and methods

On farm trials were conducted during *rabi* season of 2001-02 and 2002-03 in six villages of Solapur district (Maharashtra) to study the effect of nutrients and moisture conservation practices on growth, yield and economics of safflower. The combination of three moisture conservation and fertilizer practices *viz.*, farmers method of moisture conservation (intercultivation twice) with farmers fertilizer practice, (20:0, N P_2O_5 kg/ha) farmers moisture conservation with recommended fertilizer (50:25 kg, N : P_2O_5/ha), recommended method of moisture conservation (cultivation across the slope and soil mulch upto flowering) with recommended fertilizer were tested in main plot with three cultivars (Bhima, Sharada and DSH-129) in sub plots in Split Plot Design treating each farmer as a replication. The average soil analysis of six experimental sites were slightly alkaline (pH 8.20) with 0.58% organic carbon, (223 kg/ha) available N, medium phosphorus (15.6 kg/ ha) and high potassium (815 kg/ha). The crop was planted at 45 x 20 cm spacing with plot size 300 m^2. The rainfall received was 346.7 mm during 2001-02 while it was deficit by 57% than the normal rainfall during 2002-03. However, stored moisture in the soil profile was adequate to sustain the growth and yield of safflower .The observations were recorded on growth and yield attributes. The oil content of safflower seed was estimated by using Nuclear Magnetic Resonance (NMR) method.

Results and discussion

Growth and yield attributes: The growth and yield attributes of safflower cultivars as affected by moisture conservation, fertilizer practices and cultivars are presented in Table 1. The recommended method of moisture conservation along with recommended fertilizer practice recorded significantly higher plant height as compared to rest of the treatments. The lowest values of plant height were with *farmer's method* of moisture conservation and fertilizers. Significantly more number of branches, increased number of capsules and higher 1000 seed weight was recorded in recommended method of moisture of conservation along with recommended fertilizer practices.

Potential hybrid DSH-129 recorded significantly higher plant height, test weight and numerically more number of branches, capsules at harvest compared to rest of cultivars.

Seed yield and oil yield: Seed yield of safflower differed due to the combined effect of nutrient and moisture as well as cultivars. The mean seed yield of two years revealed that higher seed yield of 1356 kg/ha was obtained under recommended method of moisture conservation along with recommended dose of fertilizer, followed by farmer's method of moisture conservation with recommended dose of fertilizer application (1129 kg/ha) and the lowest yield was recorded in farmer's practice (Table 1).

The magnitude of the seed yield increase under recommended method of moisture conservation along with recommended dose of fertilizer was 11% and 4% over the farmers method of moisture conservation and fertilizer practice, and farmers method of moisture conservation along with recommended dose of fertilizer, respectively. The higher seed yield in recommended moisture and fertilizer practice was due to increased number of capsules and 1000 seed weight as a result of better availability of moisture that helped the better utilisation of nutrients. The response to application of nutrients in rainfed safflower was also observed by Ahmed *et al.*(1985) and Zaman (1988). Significant differences were observed in oil content and oil yield due to different moisture conservation and fertilizer practices and cultivars. The higher oil yield in recommended moisture and fertilizer practice was due to increase in oil content and seed yield. The potential cultivar DSH-129 had given higher seed yield (1391 kg/ha) over Sharda (1187 kg/ha) which was to the extent of 7% increase over Bhima the check cultivar. The DSH-129 being hybrid has better genetic potential due to hybrid vigour and more number of branches resulting in higher number of capsules and higher 1000seed weight that were responsible for higher yield of this cultivar.

The oil content and oil yield of DSH-129 was higher than the rest of the cultivars. The increased oil content and seed yield contributed to the higher oil yield of DSH-129. The interaction effect between cultivars as well as moisture conservation and fertilizer application was significant for seed yield.

The maximum significant seed yield (1468 kg/ha) was recorded in DSH-129 under recommended moisture conservation and fertilizer practice in medium/high P soils. The lowest seed yield (1140 kg/ha) was recorded in Sharada under farmer's method of moisture conservation and fertilizer (Table 2). It can be concluded that the potential cultivar DSH-129 gives better response to recommended moisture conservation and fertilizer practices.

Table 1 Effect of moisture conservation and fertilizer on yield, growth and yield attributes of safflower cultivars (pooled data of 2001-02 and 2002-03)

Treatment	Seed yield (kg/ ha)	Oil content (%)	Oil yield (kg/ ha)	Plant height (cm)	Number of branches/ plant	Number of capsules/ plant	1000 seed weight (g)
Farmer's method MC + FA	1211	28.1	360	71.5	17	51	55.4
Farmer's method of MC + RDF	1299	28.6	394	74.1	19	55	57.9
Rec. MC + RDF	1356	28.8	415	86.5	22	63	63.0
SEm ±	45.0	0.05		4.0	0.3	3.3	1.5
CD (P=0.05)	135.2	0.19		12.0	1.7	20.2	4.6
Bhima	1287	28.7	393	72.0	20	58	58.1
Sharada	1187	27.6	347	74.8	16	50	54.3
DSH-129	1391	29.2	431	85.2	23	62	64
SEm ±	37.3	0.06		2.3	0.94	2.7	1.7
CD (P=0.05)	112.0	0.18		7.9	3.3	9.5	5.2
Interaction (M x S)							
SEm ±	65.0	-	-	-	-	-	-
CD (P=0.05)	195.2	-	-	-	-	-	-

MC : Moisture conservation; FA : Fertilizer application; RDF : Recommended dose of fertilizer

Table 2 Interaction effect of moisture conservation and fertilizer on seed yield (kg/ha) of safflower cultivars

Main plot/ Sub-plot	Bhima	Sharada	DSH-129	Mean
Farmer method MC+FA	1200	1140	1292	1210
Farmer method MC+RDF	1312	1172	1413	1299
Rec. MC+RDF	1350	1251	1468	1356
Mean	1287	1187	1391	1283
	Main (M)	Sub (S)	M x S	
SEm±	45.0	37.3	65.0	
CD (P=0.05)	135.2	112.0	194.2	

Economics: The maximum gross monetary returns were obtained under recommended method of moisture conservation combined with recommended dose of fertilizer (Rs.20,942). Among different cultivars, DSH-129 registered maximum gross return of (Rs. 21,493). The higher net returns (Rs.14,343) recorded were higher under recommended method of moisture conservation and fertilizer among different treatments and in DSH-129(Rs.14,740) among different cultivars under medium/high P soils. The B:C ratio was found to be higher under farmer's practices (3.47) and check cultivar Bhima whereas lower B:C ratio (3.18) was obtained with recommended practices and potential cultivar DSH-129. Higher cost of cultivation under recommended practices and higher seed cost of hybrid (Rs.150/kg) were responsible for decrease in B:C ratio.

The maximum additional net returns were obtained under recommended method of moisture conservation combined with recommended dose of fertilizer followed by farmer's method of moisture conservation and recommended dose of fertilizer over farmer's method of moisture conservation and fertilizer. The potential hybrid DSH-129 (Rs.14,740) registered more additional net return over Sharada (Rs.12,226) and Bhima (Rs.14,171).

Interaction effect between moisture conservation, fertilizer and cultivars was not significant

Therefore, it can be concluded that DSH-129 hybrid was best suited under recommended method of moisture conservation along with recommended dose of fertilizer application to achieve increased seed yield of safflower under rainfed Vertisols.

Acknowledgements: The financial support received by the National Agricultural Technology Project under Rainfed Oilseed Production System (Project Code ROPS-12) is thankfully acknowledged.

References

Ahmed, Z., Medekkar, S. and Mohammad, S. 1985. Response of Safflower to nitrogen and Phosphorus. *Indian Journal of Agronomy*, **30**(1): 128-130.

Anonymous. 1986. *Safflower Production Technology, Technologies for better crops*, 29,ICAR, New Delhi

Hegde, D.M. 1997. *Safflower*. 1997. Efficient management of *Dryland crops in India - Oilseeds*. Indian Society of Oilseed Research, Hyderabad.

Kumar, R.N., Sinha, M.N. and Rai, R.K. 1989. Response of safflower (*Carthamus tinctorius*) to levels and depth of phosphorus placement under the moisture regimes, *Haryana Agriculture University Journal of Research*, **19** (1): 31-36.

Umrani, N.K., Kale, S.P. and Bhoi, P.G. 1981. Response of safflower to application of nitrogen under rainfed conditions. *Indian Journal of Agronomy*, **25**(4): 265-270.

Zaman, A. 1988. Effect of nitrogen and phosphorus on yield attributes, seed yield and oil content of irrigated safflower in laterite soil. *Annals of Arid Zone*, **27**(1): 37-40.

J. Oilseeds Res., 22(1) : 86-89 (2005)

Evaluation of management technology and genotypes for optimization of safflower, *Carthamus tinctorius* L. production under saline conditions

S.D. More, D.S. Hangarge and C.V. Raghavaiah*

Department of Agricultural Chemistry and Soil Science, Marathwada Agricultural University, Parbhani-431 402, MS

(Received: November, 2003; Revised: September, 2004; Accepted: October, 2004)

Abstract

The study on evaluation of management technology for optimization of safflower production under saline conditions was conducted at eleven farmers' fields having different salinity levels during *rabi* 2001-2002 and 2002-2003. The study revealed that the recommended practice i.e. soaking of seed in 1% NaCl solution, sowing on side of the ridge and application of FYM @ 2t/ha was effective as it had recorded highest germination, soil moisture content, also improved yield contributing characters and yields as compared to farmers practice (no seed soaking in 1% NaCl solution, sowing on flat bed without application of FYM). The recommended practice recorded 25 % higher seed yield than farmers practice. The genotypes A-1 and S-13-5 were found salt tolerant under field conditions.

Key words: Germination, soil moisture, saline soil, management, genotypes, safflower

Introduction

The safflower (*Carthamus tinctorius* L.) is an important crop of Marathwada region of Maharashtra state. A sizable area of 0.54 lakh ha is under salinity in the State. In saline soils, accumulation of salts results in reduction of seed germination and plant growth (Abel and Mackenzie, 1964). Besides, under problematic soil like salinity etc. reduction in yield is an established fact world over (Muralidharudu *et al.*, 1997). To over come this situation, reclamation of salt affected soil is recommended, however it takes long time and involves capital expenditure.

Safflower is considered as medium salt tolerant crop (Gupta, 2000). However, growing salt tolerant varieties and adoption of suitable agronomic practices is a better option for optimization of safflower production under saline conditions. Hence, the present investigation was under taken to evaluate technology and identify tolerant genotypes under field conditions.

Materials and methods

The studies on evaluation of management technology for optimization of safflower production under field conditions were conducted during *rabi* (post-rainy season), 2001-2002 and 2002-2003. To conduct the experiment, survey of salt affected area was carried out during each year and soils were characterized for salinization levels. Soils were classified as low, medium and high salinity and farmers (eleven) representing these three categories were selected for field study (Table 1 and 2). Each farmer was considered as one replication. The experiment was conducted in Split Plot Design. Recommended practices were assigned to main plots and genotypes in sub-plots. The recommended practice consists of seed soaking in 1 % NaCl solution for 3 hours, sowing on side of the ridge and FYM application @ 2t/ha. Farmers practice consisted of no seed soaking in 1 % NaCl solution, sowing on flat bed and without application of FYM. In sub-plots, prerelease variety S-13-5, recommended variety A-1 and farmers variety - Sharda were tested. The experimental layout was done and implemented the main plot treatment and sub- plot treatment at each farmers field. The ridges and flat bed were made before sowing. The recommend spacing of 45 cm between rows and 20 cm between plants in a row was adopted. The recommended dose of fertilizer 60:30:0 N , P_2O_5 and K_2O kg/ha was applied prior to sowing. In all fields FYM @ 2t/ha was applied in row placement in recommended practice. The germination count was taken on 4, 14 and 25 DAS and percent germination was calculated. The observations on days to 50 % flowering, number of capitulum/plant, 100 seed weight, dry matter yield, seed yield and soil moisture content at seedling , grand growth, flowering, seed setting and maturity were recorded. Statistical analysis was done as per standard methods.

Results and discussion

The two years field study revealed that germination percentage was significantly higher with recommended practice i.e. involving seed soaking in 1 % NaCl solution, sowing on side of the ridge and application of FYM @

* Principal Scientist (Agronomy), Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, AP.

2t/ha as compared to farmers practice (without seed soaking in 1 % NaCl solution , sowing on flat bed and no FYM application). Accumulation of soluble salts on the surface of the soil by upward capillary movement was also noticed. However, due to preparation of ridges and sowing on side of the ridge and the seed placement away from the zone of salt accumulation, thus avoided salinity hazard and resulted in higher germination of seeds (Table 3). The Genotypes S-13-5 recorded maximum germination followed by A-1 and Sharda indicating salinity tolerance capability of genotypes S-13-5 and A-1. Reduction in germination at higher levels of salinity was also reported by Patil *et al.* (1992), More *et al.* (2002) and Rai (1977). The reduction in germination could be due to increased osmotic pressure of the soil solution resulting in diminished water uptake. Repp *et al.* (1959) reported salinity tolerant plants ability to accumulate salts in cellular fluid leading to increased osmotic potential. The soil moisture declined with advancing growth stages of the crop (Fig.1). Significantly higher soil moisture content was recorded with recommended practice as compared to farmers practice, indicating moisture conservation due to preparation of ridges and furrow and application of FYM. Ridges and furrow land layout and FYM application also reduced evaporation losses of moisture form soil and increased soil moisture retention capacity. Management technology as well as genotypes differed significantly with respect to days to 50 % flowering. Recommended practices recorded higher number of days to 50 % flowering as compared to farmers practice. It might be due to higher moisture content, soil moisture conservation and reduced evaporation losses of moisture from soil. The genotype S-13-5 recorded less number of days to 50 % flowering as compared to A-1 and Sharda (Table 3).

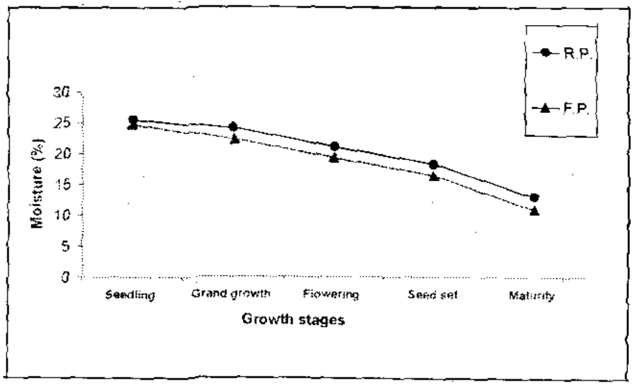


Fig. 1 **Influence of management technology on soil moisture content at various growth stages of safflower**

***Table 1* Soil characteristics of farmers fields selected for the study (2001-02)**

Name of the farmer	Village	pH	ECe dS/m		ESP	Available nutrients (kg/ha)			Sowing date
						N	P	K	
Sahebrao Abaji Deshmukh	Zari	8.41	2.36	L	12.03	272.0	13.4	289.2	23.10.01
Lakshuman Gunaji Kachhave	Daithana	8.45	2.92	L	12.08	270.0	13.1	294.0	24.10.01
Nandkumar Gunaji Kachhave	Daithana	8.49	2.96	L	11.62	268.2	13.0	290.4	24.1001
Shivaji Babanrao Kachhave *	Daithana	8.49	3.01	L	11.90	263.2	12.9	288.3	25.10.01
Ramchandra Munjaji Avad	Parva	8.50	4.52	M	13.40	274.1	15.3	310.0	19.10.01
Subhanrao Tukaram Dhas	Allapur	8.40	4.80	M	12.89	253.1	12.8	274.0	22.10.01
Raosaheb Gangadhar Javale	Asola	8.50	4.83	M	12.50	231.2	12.1	262.0	21.10.01
Amrathrao Reshmaji Dhas	Allapur	8.40	4.99	M	13.02	258.4	12.9	278.3	21.10.01
Sakharam Tukaram Londhe	Parva	8.49	7.83	H	13.50	234.8	11.9	260.0	20.10.01
Shankarrao Bapurao Swami	Jam	8.48	8.39	H	13.89	220.4	9.3	259.3	20.10.01
Prabhakar Sakharam Paike	Parva	8.44	8.68	H	14.03	236.2	11.8	268.3	19.10.01
Ajit Uttamrao Magar	Allapur	8.28	9.08	H	14.20	240.4	12.3	272.2	22.10.01

L = Low salinity; M = Medium salinity; H = High salinity

Table 2 Soil characteristics of farmers fields selected for the study (2002-03)

Name of the farmer	Village	pH	ECe dS/m	ESP	Available NPK (kg/ha)			Sowing dates
					N	P	K	
Maroti Uttamrao Thithe	Zari	8.10	2.03 L	10.30	248	19.2	358	25.10.02
Dnyandoba Mobanaro Dhas	Allapur	8.09	2.08 L	10.08	298	18.4	450	12.10.02
Nandkumar Gunaji Kachhave	*Daithna*	8.43	2.24 L	10.82	228	16.2	328	13.10.02
Gunderao Kondiba Degonkar	Allapur	8.38	3.92 M	12.30	239	17.5	297	16.10.02
Sahebrao Ajabrao Desmukh	Zari	8.30	4.18 M	12.80	317	20.2	468	20.10.02
Amrath Rajmayi Dhas	Allapur	8.21	4.20 M	12.88	308	22.8	458	21.10.02
Ajit Uttamerao Magar	Allapur	8.12	6.96 H	13.30	312	20.3	478	22.10.02
Sakharam Tukaram Londhe	Parva	8.50	7.18 H	13.48	254	14.2	308	23.10.02
Bapura Kishahrao Gaikwad	Zari	8.42	7.39 H	13.22	228	18.3	289	24.10.02
Prasant Pandit Savandkar	Allapur	8.16	8.96 H	14.18	328	19.6	460	22.10.02
Sadashiv Bapurao Mutkhle	Parva	8.40	9.03 H	14.32	210	17.2	299	19.10.02

L = Low salinity; M = medium salinity; H = High salinity

Table 3 Effect of management technology on different characters of safflower (Pooled 2001-02 and 2002-03)

Treatment	Germination (%)	Days to 50% flowering	No. of capitulum/plant	100 seed weight (g)	Drymatter yield (q/ha)	Seed yield (kg/ha)	Oil content (%)
Management technology							
Recommended practice	82.7	90	23.4	6.2	27.3	1056	28.9
Farmers' practice	79.9	86	20.0	5.9	23.6	852	28.0
SEm±	0.7	0.15	0.44	0.1	0.2	12	0.1
CD (P=0.05)	2.6	0.54	1.62	0.3	0.9	43	0.3
Genotypes							
S-13-5	83.4	87	23.5	5.9	27.2	1035	28.4
A-1	82.2	88	22.3	6.2	26.8	1007	28.0
Sharda	78.3	89	19.3	6.0	22.4	821	28.9
SEm±	0.7	0.29	0.19	0.01	0.22	15	0.04
CD (P=0.05)	2.6	1.05	0.69	0.04	0.78	55	0.14
Management x Variety							
SEm±	1.0	0.41	0.27	0.02	0.31	0.22	0.06
CD (P=0.05)	3.7	1.5	0.98	0.06	1.10	0.79	0.20

The number of capitulum per plant was also increased due to adoption of improved technology as compared to farmers practice. The number of capitulum was maximum in genotype S-13-5, whereas Sharda recorded lowest number of capitulum/plant. The cultivar A-1 recorded significantly higher 100 seed weight than the other genotypes. The 100 seed weight was also higher with recommended practice than farmers practice (Table 3).

The different treatments and salinity levels influenced dry matter yield of safflower. Dry matter production of S-13-5 and A-1 were at par with each other, however, the difference was significantly higher over farmers variety Sharda. The dry matter yield was higher with recommended practice as compared to farmers practice (Table 3).

The recommended practice provided higher seed yield as compared to farmers practice. The increased yield in recommended practice was the result of improvement in all growth parameters and yield contributing characters. The yield difference between S-13-5 and A-1 was non significant where as both varieties showed about 24 % higher seed yield than Sharda on saline soils. Similarly recommended practice recorded 25 % higher safflower yield over farmers practice. Present findings are in agreement with Yermonas *et al.* (1964) who reported safflower yield reduction under salinity due to decrease in number of heads and seed yield/head, the latter being affected by seed weight but not by seed number. The recommended practice also recorded higher oil content than farmers practice (Table 3). Based on the present study it is suggested to adopt recommended practice and grow salt tolerant genotypes like 5-13-5 and A-1 for optimization of safflower production under saline conditions.

Acknowledgement: The Authors are thankful to Indian Council of Agricultural Research for financial support through the NATP ROPS-16 Project.

References

Abel, G. and Mackenzie, A.J. 1964. Salt tolerance of soybean varieties (*Glycine max*) germination and late growth. *Crop science*, **4** : 157-161.

Gupta, S.K. 2000. Techniques for managing water logged soils. *Indian Farming*, **49**(11) : 47-52.

More, S.D., Hangarge, D.S. and Raghavaiah, C.V. 2002. Screening of safflower genotypes for salinity tolerance. *Journal of Oilseeds Research*, **19**(2) : 129-130.

Muralidharudu, Y., Ravishankar, G. and Patil S.G. 1997. Screening of safflower cultivars against salt tolerance. *Journal of Oilseeds Research*, **14** (2) : 294-299.

Patil, S.G., Srinivas, S., Dinesh Kumar, M. and Hebbara, M. 1992. Evaluation of safflower (*Carthamus tinctorius* L.) genotypes for salt tolerance. *Annals of Arid Zone*, **31**(2) : 107-110.

Rai, M. 1977. Salinity tolerance in Indian mustard and safflower. *Indian Journal of Agricultural Sciences*, **47**(2) : 70-73.

Repp, G.L., Mcallister, R., Devere and Wiebe, H.H. 1959. Salt resistance of protoplasm as a test for salt tolerance of agricultural plants. *Agronomy Journal*, **5**:311-314.

Yermonas, D.M., Francois, L.E. and Bernstein, L. 1964. Soil salinity effects on chemical composition of the soil and oil content of safflower seed. *Agronomy Journal*, **56**:35-37.

J. Oilseeds Res., **22**(1) : 90-92 (2005)

Thrips incidence and necrosis disease in sunflower, *Helianthus annuus* L.

Harvir Singh

Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, AP

(Received: April, 2004; Revised: September, 2004; Accepted: October, 2004)

Abstract

Necrosis disease of sunflower, *Helianthus annuus* L. incited by tobacco streak ilarvirus and spread by thrips was more severe in sunflower inbred (Morden) as against hybrid (KBSH-1). Necrosis disease manifested various types of symptoms *viz.*, yellow mosaic, local lesions, necrosis of tissues, mottling, chlorosis, leaf enations/narrowing and mixed infection of which necrosis type symptoms were more serious. July and August sown crops had severe incidence of necrosis disease followed by December however, October sown crop had least incidence of necrosis disease. Flared up incidence of thrips owing to dry weather and moderate temperature resulted in increased incidence of necrosis disease.

Key words: Thrips, sunflower, necrosis disease

Introduction

Sunflower Necrosis Disease (SND) came into prominence about eight year back i.e., 1997 when it was first reported at Bagepally, Kolar District near Bangalore (Singh *et al.*, 1997). The disease intensity varied from 5 to 70 % in traditional sunflower growing states in India. In Andhra Pradesh, this disease was observed for the first time in *kharif* 2000 as a new virus disease in groundnut *Arachis hypogaea* L. resulting in death of young plants in Anantpur district. Initially, it was suspected as peanut bud necrosis tospovirus (PBNV) because of characteristic necrosis of terminal buds in groundnut plant (Jain *et al.*, 2000). In subsequent studies tobacco streak ilarvirus (TSV) was found associated with the disease and was named as peanut stem necrosis disease (Reddy *et al.*, 2002). Tobacco streak virus was found to cause necrosis disease in sunflower crop (Prasada Rao *et al.*, 2000; Bhat *et al.*, 2002). Actually, the sunflower and groundnut were the hosts of this new disease. TSV belongs to ilarvirus group, which is spread through thrips. Present studies were carried out to find out the role of thrips, dates of sowing and cultivars in the spread of necrosis disease in sunflower.

Materials and methods

Two cultivars of sunflower i.e., Morden and KBSH-1 were planted on 27.7.2001 at Directorate of Oilseeds Research, Rajendranagar Farm in a plot size of 90 sq.m. (25 rows spaced 60 cm apart of 3 m length each for two cultivars). During 2002-03, the effect of dates of swing on necrosis disease incidence in Morden and KBSH-1 was observed by taking four dates of sowing i.e., June, August, October and December 2002-03 (Table 2). All agronomic practices except plant protection measures were followed to raise the good sunflower crop. The population of thrips and leafhoppers was regularly observed on 20 randomly selected plants in a 45 sq.m. area for Morden and a hybrid KBSH-1 at weekly (standard weeks) interval throughout crop growth period starting a month after sowing. The thrips from the sunflower crop collected during August and were sent to The Zoological Survey of India (ZSI) for identification. Necrosis disease incidence was recorded throughout the crop season. Simple correlation coefficients were calculated between the abiotic factors and the thrips population for two cultivars. Sunflower necrosis disease manifested various types of external symptoms on sunflower plants *viz.*, yellow mosaic, local lesions, necrosis of tissues, mottling, chlorosis, leaf enations/narrowing and mixed infection. The symptomatology expressed by necrosis disease was further confirmed by ELISA test (Anonymous, 2001).

Results and discussion

Three new species of thrips were identified by ZSI as *Karnyothrips flavipes* (Jones), *Thrips hawaiiensis* (Morgan) and *Microcephalothrips abdominalis* (Crawford) besides the two commonly available species i.e., *Frankliniella schultzi* (Trybom) and *Scirtothrips dorsalis* (Hood). Two peaks in thrips population were recorded during third week of August and fourth week of September coinciding with the dry spell after moderate rains (Table 1 and 2). Necrosis disease was noticed in the second week after germination. Intensity of thrips population ranged from 1 to 9/plant (3 leaves) on Morden and 1 to 6/plant (3 leaves) on (1 to 6 in Morden and 1 to 4 in KBSH-1) throughout the season because of dry weather (average RH ranged 58 to 76.5 %). There existed a positive correlation between RH and the thrips population. However, rainfall presented a negative correlation with thrips population (Table 3). This indicated that dry weather enhanced the population of the thrips in turn the intensity of necrosis disease was also more.

Table 1 ***Incidence of necrosis disease in sunflower cultivars as influenced by abiotic and biotic parameters (Kharif, 2001)***

Standard week	Abiotic parameter: Temperature (°C) Max.	Min.	RH (%) Mor. Eve.	Rainfall (mm)	Sunflower cultivars: Morden Thrips/plant (3 leaves)	Morden Leafhopper/plant (3 leaves)	KBSH-1 Thrips/plant (3 leaves)	KBSH-1 Leafhopper/plant (3 leaves)
32	28.5	22.3	76	93.2	5	1	4	1
33	29.3	22.3	70	21.4	9	1	6	1
34	29.7	22.6	60	1.4	8	1	4	1
35	31.4	22.8	58	0.0	3	1	3	1
36	31.3	28.5	60	17.4	5	1	3	1
37	28.7	22.6	60	10.5	6	1	3	1
38	31.4	22.0	67	23.4	1	1	1	1
39	31.5	21.6	68	96.4	1	2	-	1
40	26.3	21.8	76	139.6	-	1	-	1
41	29.8	22.2	58	27.4	1	6	1	1
42	30.4	21.2	61	31.1	-	-	-	4
Necrosis disease incidence (%)						92.9		86.7

Table 2 ***Incidence of necrosis disease in sunflower cultivars as influenced by abiotic and biotic parameters***

Standard week	Abiotic parameters: Temperature (°C) Max.	Min.	R.H (%) Mor.	Eve.	Rainfall (mm)	Morden Thrips/plant (3 leaves)	Morden Leafhopper/plant (3 leaves)	Morden Necrosis (%)	KBSH-1 Thrips/plant (3 leaves)	KBSH-1 Leafhopper/plant (3 leaves)	KBSH-1 Necrosis (%)
(A) Date of sowing : 22.06.2002											
27	34.8	24.2	71	39	16.2	15	1	22	14	1	29
28	30.7	22.4	78	61	41.6	14	1	23	1	2	30
29	31.3	21.9	85	61	48.2	1	1	31	1	1	32
30	31.8	23.2	85	70	10.8	1	1	31	1	1	33
31	27.6	21.1	91	76	95.4	18	-	31	15	-	33
32	29.7	22.1	85	62	8.6	12	-	31	31	-	33
33	28.5	21.7	88	71	35.2	6	-	31	12	-	33
(B) Date of sowing : 21.08.2002											
36	30.0	21.6	88	61	76.0	1	1	4	2	1	3
37	32.6	21.0	83	46	-	2	1	21	2	1	28
38	33.5	22.0	83	55	-	4	1	29	3	1	22
39	34.2	21.1	76	59	-	4	-	34	2	1	22
40	35.6	20.4	77	47	-	3	1	34	3	1	22
41	32.0	22.5	88	59	3.0	8	2	34	8	1	22
42	30.3	20.0	94	53	3.0	-	-	34	15	2	22
(C) Date of sowing: 21.10.2002											
46	29.9	15.0	86	37	-	1	1	0.6	1	1	1.2
47	29.7	12.0	91	30	-	1	1	3.0	1	1	3.0
48	31.4	11.4	82	26	-	1	1	3.0	1	1	4.2
49	29.6	13.2	88	35	-	3	1	3.0	2	1	4.2
50	29.9	12.6	87	32	-	5	2	3.0	5	1	4.2
51	31.3	11.4	81	25	-	32	2	4.2	30	1	4.2
(D) Date of sowing : 21.12.2002											
2	28.6	14.1	86	38	-	-	1	1	-	1	6
3	28.1	10.7	84	26	-	-	1	5	-	2	10
4	32.7	14.8	84	25	-	1	2	10	1	2	14
5	32.6	15.5	79	29	-	1	1	12	1	1	14
6	31.4	18.1	79	35	-	12	4	15	12	3	18
7	33.9	19.8	77	39	7.4	11	2	17	11	2	18
8	33.5	18.7	85	35	-	-	-	17	-	-	18

Table 3 Simple correlation coefficients between abiotic parameters and thrips in sunflower, 2002-03

Abiotic parameter	D_1		D_2		D_3		D_4	
	Morden	KBSH-1	Morden	KBSH-1	Morden	KBSH-1	Morden	KBSH-1
Temperature °C (Max.)	-0.515	-0.592	0.555	0.541	0.401	0.364	0.870	0.839
Temperature °C (Min.)	-0.649	-0.668	-0.203	-0.202	-0.892	-0.784	0.763	0.760
RH % (Mor.)	0.918	0.942	-0.242	-0.270	-0.408	-0.118	-0.657	-0.611
RH % (Eve.)	0.771	0.843	-0.296	-0.583	-0.779	-0.597	0.112	0.114
Rainfall (mm)	0.131	0.110	-0.901	-0.975	-	-	0.381	0.362
R^2	0.984	0.990	0.976	0.992	0.930	0.980	0.889	0.904

A severe incidence of necrosis disease was noticed i.e., 92.9 and 86.7 % in Morden and KBSH-1 with 66.9 and 85.9 % yellow mosaic type of symptoms in two cultivars, respectively (Table 1). Surprisingly, the intensity of necrosis type of symptom was quite low i.e., 25% in Morden and only 0.8% in KBSH-1. Apparently, the incidence of necrosis disease was more in Morden as compared to KBSH-1 as the former had 8% healthy plants as against 13% in the latter cultivar. Plants manifesting necrosis type of symptoms did not flower at all. Such plants remained stunted and did not reach to reproductive stage leading to total yield loss. Plants with yellow mosaic type of symptoms showed recovery mechanism and could yield some viable seeds. Since the symptoms of necrosis type are easily recognized but give the unrealistic status of necrosis disease. However, to get remunerative yield all types of symptoms are to be observed to ascertain the status of necrosis disease. Efforts are on to find the differential yield loss in relation to various symptoms shown by the sunflower necrosis disease.

In general, incidence of necrosis disease was more in Morden as against KBSH-1. Necrosis disease incidence was high in July/August sown crop irrespective of inbred/hybrid. Cultivars sown in October harboured very low incidence of necrosis disease as only 4.2% each in Morden and KBSH-1. Necrosis incidence was more coinciding the incidence of thrips. Dry weather (July/August) with moderate temperature was conducive to thrips incidence.

References

Anonymous. 2001. *DOR Annual Report*, 2001-02. Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, AP, p.55.

Bhat, A.I., Jain, R.K. and Ramaiah, M. 2002. Detection of tobacco streak virus from sunflower and other crops by reverse transcription polymerase chain reaction. *Indian Phytopathology*, **55**:216-218.

Jain, R.K., Bhat, A.I., Byadgi, A.S., Nagaraju, Singh, Harvir., Halkeri, A.V., Anahosur, K.H. and Varma, A. 2000. Association of tospovirus with sunflower necrosis disease. *Current Science*, **79**(12):1730-1705.

Prasada Rao, R.D.V.J., Reddy, A.S., Chander Rao, S., Varaprasad, K.S., Tirumala Devi, K., Nagaraju, Muniappa, V. and Reddy, D.V.R. 2000. Tobacco streak ilarvirus as a causal agent of sunflower necrosis disease in India. *Journal of Oilseeds Research*, **17**:400-401.

Reddy, S., Prasada Rao, R.D.V.J., Tirumala Devi, K., Satyanarayana, T., Suramanium, K. and Reddy, D.V.R. 2002. Occurrence of tobacco streak virus on peanut (*Arachis hypogaea* L.) in India. *Plant Disease*, **86**:173-178.

Singh, S.J., Nagaraju, Krishna Reddy, K.M., Muniappa, V. and Virupakshappa, K. 1997. *Symposium*. Economically important diseases of crop plants. 18-20 December, 1997, Bangalore.

J. Oilseeds Res., 22(1) : 93-99 (2005)

Incidence of green leafhopper, *Empoasca flavescens* Fab. on castor, *Ricinus communis* L. in relation to morphological characters and date of sowing*

P. Vijaya Lakshmi, J. Satyanarayana, Harvir Singh and T. Ratnasudhakar

Department of Entomology, College of Agriculture, ANG Ranga Agril. University, Rajendranagar, Hyderabad-500 030, AP

(Received: October, 2004; Revised: December, 2004; Accepted: January, 2005)

Abstract

An experiment was laid out in a Split Plot Design at College Farm, College of Agriculture, Rajendranagar, Hyderabad during *Rabi*, 2002-03. Most popular and high yielding varieties of castor such as Kranti, Jyothi, Kiran and Hybrids *viz.*, DCH-177 and GCH-4 were tested for their reaction under field conditions against leaf hoppers. These cultivars are sown in three different dates *viz.*, 11-10-2002, 26-10-2002 and 10-11-2002 with three replications. Based on leafhopper population and hopper burn, hybrid DCH-177 (single bloom) were categorized as highly susceptible, varieties *viz.*, Kranti, Jyothi and Kiran (double bloom) as less susceptible and GCH-4 (Triple bloom) as tolerant to leafhoppers incidence. The incidence of leafhopper decreased with increase in the intensity of bloom. The intensity of bloom was found to play a major role with infestation of leaf hopper than other morphological characters. Among three dates of sowings leafhopper incidence was more in October second fortnight, than October first fortnight and November first fortnight sowings. These were statistically significant with each other.

Key words. Castor, morphological characters, bloom characters, leaf hopper, *E. flavescens*, dates of sowing

Introduction

Castor (*Ricinus communis* L.) is one of the most important non-edible and industrial oilseed crop cultivated in India. It plays a major role in Agriculture economy of arid and semi-arid regions of the country and grown mostly in poor and marginal lands. Castor crop suffers from many biotic stresses. So far, 100 insect pests are recorded on castor and about half a dozen insect are of economic importance (Basappa and Lingappa, 2001). Green leafhopper, *Empoasca flavescens* Fab. is one of the serious sucking pests at vegetative stage. By the introduction of high yielding varieties and Hybrids, leafhopper became a serious problem from last two decades (Vijay Singh *et al.*, 1993). Morphological characters of host plant serve as a antibiotic mechanisms to feeding and oviposition by the insect in addition to the biochemicals of host plant (Painter 1951). In castor morphological characters especially bloom character played a major role in determining the resistance or susceptibility to the leafhopper. The use of resistant varieties in the IPM programmes is the most economic approach and would be inexpensive in long run. Hence, the present study, on incidence of leaf hopper on different morphological characters of castor varieties /hybrids in relation to date of sowing gives better understanding of plant-Insect relationships especially mechanism of resistance in the plant and aid in selection and breeding of resistant varieties was conducted.

Materials and methods

The experiment was conducted at College Farm, College of Agriculture, Rajendranagar, Hyderabad during *rabi*, 2002-03. Five popular high yielding varieties and hybrids in India were selected for the present studies *viz.*, Kranti, Jyothi, Kiran, DCH-177 and GCH-4. The seed material of various cultivars was obtained from Regional Agricultural Research Station, Palem, Mahaboobnagar District, A.P. and Directorate of Oilseeds Research (DOR), Rajendranagar, Hyderabad. The castor genotypes selected for this experiment were categorized based upon distinct morphological characters i.e., stem colour, bloom hairiness, shape of leaf, spike compactness and number of nodes to primary spike. The studies were carried out in a Split Plot Design with three dates of sowing *viz.*, Ist DOS -11.10.2002; IInd DOS-26.10.2002 and IIIrd DOS - 10.11.2002 as main plots and five castor genotypes *viz.*, Kranti, Jyothi, Kiran, DCH-177 and GCH-4 as sub-plots which were replicated thrice. Field was divided into 45 plots, each plot measuring 4.5 x 3.6 m. The spacing adopted was 90 x 60 cm. The recommended dose of fertilizers, other agronomic practices to raise the good castor crop were applied as and when required except plant protection measures.

The nymphs and adults populations and hopper burn symptoms were recorded from 3 leaves/plant on 5 randomly selected plants in each cultivar at weekly

* Part of M.Sc., Thesis submitted to the Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad-500 030, AP.

intervals from one month after germination till the harvest. Three leaves were selected *viz.*, one leaf from top (excluding two top most leaves), one from middle canopy and one from bottom (leaving one or two bottom most leaves) on main shoot. Population of nymphs and adults was represented as number of individuals/3 leaves/plant whereas, hopper burn represented as per cent leaf area burnt/leaf (average of three leaves/plant). All the observations were taken in the early morning (0600 to 0800 hrs). Hopper burn injury on leaves was taken in the following standard grades as per All India Coordinated Research Project on Castor:

Grade (score)	Hopper burn on leaves (% injury)
0	No injury
1	Hopper burn 0-10%
2	Hopper burn unto 11-25 %
3	Hopper burn unto 26-50%
4	Hopper burn above 50%

Results and discussion

Plant morphological characters: Castor plant morphological characters plays a significant role in the pest population build up of leafhopper. The castor cultivars selected *viz.*, Kranti, Jyothi, Kiran, DCH-177 and GCH-4, for the experiment were categorized based on intensity of waxy coating (bloom) on leaf area, stem colour, number of nodes to primary raceme, spike compactness, (loose/compact), spiny characters etc. The various morphological characters recorded on the selected cultivars are presented in Table 1.

Incidence of leafhopper: Leafhopper incidence on five cultivars *viz.*, Kranti, Jyothi, Kiran, DCH-177 and GCH-4 were significantly different in all three dates of sowing *viz.*, 11-10-2002, 26-10-2002 and 10-11-2002. The significant variation in leafhopper recorded in the cultivars was mainly due to the variation in the morphological characters of the cultivars.

Observations were recorded starting from 4 weeks after sowing (WAS) of crop. In general, the incidence of leafhopper was present throughout the crop growth period. Hybrids *viz.*, DCH-177 and GCH-4 were more preferred by the leafhopper in comparison to the varieties *viz.*, Kranti, Jyothi and Kiran. The crop was harvested during 25 WAS.

First date of sowing (11.10.2002): In Kranti and Jyothi, leafhopper population reached its peak i.e., 412.5 and 376.7 at 13 WAS (3rd STW) of crop (Table 2). The hopper burn injury was more than 50% (score 4) by the end of 12 WAS (2 STW) in Jyothi, whereas in Kranti, the hopper burn injury reached its peak (score 4) by 15 WAS (15th STW). In case of Kiran cultivar, the leafhopper population reached its peak (426.53) at 15 WAS (5th STW), but, the hopper burn injury was reached >50% at 13 WAS (3rd STW). In the hybrid, DCH-177, leafhopper population was reached its maximum (510.17) at 14 WAS (4th STW). The hopper burn score of 4 was recorded much earlier i.e., 11 WAS (1st STW) in DCH-177. The hybrid GCH-4 supported maximum leafhopper population during crop growth period. A maximum population of 632.87 was recorded at 16 WAS (6th STW) with a hopper burn score of three. Among the cultivars tested, DCH-177 was most susceptible. There was a significant difference in leafhopper population between the cultivars.

Incidence of leafhopper was maximum in DCH-177 followed by Kiran, Jyothi and Kranti. Even though, leafhopper population on Kranti was more than Jyothi i.e., 412.5 and 376.7, respectively, the hopper burn injury was maximum in Jyothi. Similarly, in GCH-4 hybrid, the leafhopper population was maximum (632.9) when compared with other four cultivars. The hopper burn injury never crossed 50% level in GCH-4, throughout the crop growth period. Therefore, the GCH-4 hybrid is designated as tolerant to leafhopper population.

In DCH-177, the sudden decline in leafhopper population from 16 WAS onwards was mainly due to severe hopper burn injury of leaves and subsequently, shedding of leaves.

During 19 WAS, the leafhopper population on DCH-177 was again appeared on fresh leaves of castor are produced due to rainfall received during 17 WAS of crop. Again due to receipt of rainfall (80.6 mm) during 21 WAS of crop, the population of leafhopper declined afterwards.

Second date of sowing (26.10.2002): Leafhopper population on castor cultivars sown during last week of October was maximum compared to other dates of sowings. Leafhopper population reached its peak (618.3) during 11 WAS (3rd STW) in DCH-177 (Table 3). The hopper burn injury recorded was maximum (score-4) i.e., at 8 WAS (52nd STW) in DCH-177. In Jyothi and Kiran cultivars, the leafhopper population reached its peak at 14 WAS (6th STW) i.e., 623.93 and 526.93, respectively. The hopper burn score of 4 was recorded at 11 WAS (3rd STW) in Jyothi and 15 WAS (7th STW) in Kiran. A peak leafhopper population of 591.47 and 703.83 in Kranti and GCH-4, respectively was recorded at 15 WAS (7th STW). Hopper burn injury was more than 50% (score-4) at 14 WAS (6th STW) when the leafhopper population was around its peak in Kranti. In GCH-4 hybrid, the hopper burn injury not crossed 50% during the entire crop growth period. Among the cultivars tested, DCH-177 was most susceptible to leafhopper. Leafhopper population was nil on DCH-177 from 16 WAS (8th STW) onwards. There was a significant difference in leafhopper population between the cultivars.

The single bloom cultivar (DCH-177) was highly susceptible to the leafhopper. The hopper burn injury was

> 50% from 8 WAS of the crop. The triple bloom cultivar (GCH-4) was tolerant to the attack of leafhopper supporting maximum population without crossing the hopper burn injury level of 50%. Among the double bloom cultivars, Jyothi was more susceptible compared to Kiran and Kranti with respect to hopper burn injury.

The decline in the population from 16 WAS in DCH-177 was mainly due to severe hopper burn symptoms, whereas in other cultivars the sudden decline in leafhopper population from 20 WAS was mainly due to receipt of rainfall during 19 WAS of crop (11^{th} STW).

Third date of sowing (10.11.2002): Leafhopper incidence in the November sowing was comparatively less (Table 4). Leafhopper population reached its peak during 13 WAS (7^{th} STW) in Kranti (282.87), Jyothi (287.87), DCH-177 (562.83) and GCH-4 (399.10), whereas in Kiran the population reached its peak (277.80) in 12 WAS (6^{th} STW). The hybrid DCH-177 was highly susceptible. The hopper burn symptoms were started on leaves from 4 WAS and attained its peak by 9 WAS (3^{rd} STW). The GCH-4 hybrid is tolerant to leafhopper incidence. The hopper burn injury has never crossed 25% during the crop growth period of GCH-4. In the variety, Kranti and Kiran, the hopper burn injury was less than 50% during the crop growth period. There was a significant difference in leafhopper population between the cultivars.

Like in other two sowings, the leafhopper population was maximum in hybrids compared to varieties. DCH-177 hybrid was highly susceptible to leafhopper incidence as the hybrid has less waxy coating (single bloom). The other hybrid GCH-4 that has bloom in all parts (triple bloom) was moderately resistant to leafhoppers. Double bloom varieties, Kranti, Jyothi and Kiran were statistically on par and recorded a population around 280 with less than 50% hopper burn injury. During the entire crop growth period, only DCH-177 recorded > 50% hopper burn injury whereas, the injury was less than 50 per cent in other cultivars. In GCH-4, hopper burn was less than 25 per cent. The rainfall during 17 WAS (9^{th} STW), caused decline in leafhopper population from 18 WAS onwards.

Based on leafhopper infestation and expression of hopper burn, hybrid, GCH-4 was designated as moderately resistant whereas DCH-177 was highly susceptible. Varieties Kranti, Jyothi and Kiran were less susceptible to leafhopper infestation in comparison to DCH-177.

Painter (1951) opined that plants with waxy bloom were resistant to the attack of leafhoppers. Seshadri and Seshu (1956), Dorairaj *et al.* (1963), Lakshminarayana *et al.* (1992) also reported that the cultivars with waxy bloom were comparatively more resistant to leafhopper. In the present studies, it was found that GCH-4 was moderately resistant and DCH-177 was susceptible. Hybrid GCH-4 has waxy coating in all the plant parts (triple bloom), whereas, the DCH-177 has waxy coating only on stem (single bloom). The rest of the cultivars *viz.*, Kranti, Jyothi and Kiran are double bloom types.

Table 1 Morphological characters of castor cultivars

Morphological character	Variety / hybrid				
	Kranti	Jyothi	Kiran	DCH-177	GCH-4
Growth habit	Medium	Normal-medium	Medium	Normal-medium	Median to tall
Stem colour	Red	Red	Red	Red	Light red
Bloom	Double	Double	Double	Single	Triple
No. of nodes to primary raceme	9-15 (12)	9-12 (10)	10-12 (10)	10-15 (13)	14-18 (16)
Leaf shape	Flat	Flat	Flat	Flat	Flat
Nature of spike	Semi compact	Compact	Loose	Compact	Loose
Nature of capsules	Spiny and bold	Spiny	Non-spiny	Spiny	Partially spiny
Seed size	Bold	Medium bold	Medium bold	Medium bold	Medium bold
Seed colour	Light chocolate	Deep chocolate	Light brown	Light chocolate	Light chocolate
Seed weight (100)	-	25.7 (g)	22-26 (g)	27.8 (g)	27.0 (g)
Duration	90-150 days	90-150 days	90-180 days	90-150 days	110-240 days

Table 2 Incidence of leaf hopper (*E. flavescens* F.) on castor (Ist DOS - 11.10.2002)

WAS	Standard week	Leafhopper/plant (3 leaves)					CD (P=0.05)	Hopper burn score				
		Kranti	Jyothi	Kiran	DCH-177	GCH-4		Kranti	Jyothi	Kiran	DCH-177	GCH-4
4	46	9.60 (3.18)	10.27 (3.28)	6.4 (2.61)	19.40 (4.43)	0.00 (0.70)	0.78	0	0	0	0	0
5	47	11.63 (3.48)	14.37 (3.85)	11.27 (3.41)	38.07 (6.18)	23.33 (4.71)	2.28	0	0	0	0.31	0
6	48	24.73 (5.01)	24.73 (5.01)	15.20 (3.96)	67.63 (8.24)	68.13 (8.17)	2.28	0.03	0.2	0	0.8	0
7	49	33.67 (5.83)	39.93 (6.31)	28.40 (5.33)	103.93 (10.18)	85.40 (9.25)	2.48	0.4	0.5	0.3	1.5	0
8	50	83.40 (9.10)	114.47 (10.70)	85.93 (9.28)	151.07 (12.23)	130.67 (11.45)	4.49*	0.7	0.8	1.0	2.2	0.1
9	51	140.40 (11.80)	174.13 (13.20)	160.33 (12.67)	189.13 (13.72)	159.50 (12.65)	4.21	1.4	1.5	2.1	3.2	0.1
10	52	203.27 (14.22)	217.27 (14.75)	214.63 (14.65)	258.07 (16.06)	199.50 (14.13)	2.72	2.5	2.7	3.1	3.7	0.5
11	1	288.43 (16.99)	268.00 (16.37)	262.70 (16.79)	317.30 (17.81)	230.60 (15.19)	1.53	3.4	3.2	3.6	4	1.1
12	2	338.97 (18.40)	341.37 (18.46)	317.60 (17.83)	401.77 (20.04)	274.93 (16.6)	4.90	3.7	4	3.9	4	1.4
13	3	412.53 (20.32)	376.73 (19.41)	360.33 (18.98)	452.20 (21.25)	373.33 (19.3)	6.95	3.8	4	4	4	1.9
14	4	288.87 (16.91)	319.57 (17.87)	396.30 (19.91)	510.17 (22.55)	457.07 (21.38)	3.42	3.9	4	4	4	2.3
15	5	119.13 (10.65)	215.93 (14.6)	426.53 (20.64)	229.7 (9.22)	587.27 (24.24)	7.42	4	4	4	4	2.9
16	6	78.33 (8.58)	72.20 (8.39)	210.80 (14.33)	22.77 (3.24)	632.87 (25.16)	5.80	4	4	4	4	3.1
17	7	48.00 (6.57)	61.87 (7.68)	150.73 (12.13)	3.77 (1.62)	295.23 (17.11)	3.45	4	4	4	4	3.2
18	8	27.27 (4.72)	36.77 (5.81)	77.93 (8.32)	0 (0.71)	235.43 (15.29)	2.35	4	4	4	4	3.5
19	9	16.50 (3.26)	27.4 (4.84)	49.33 (6.38)	3.33 (1.55)	128.53 (11.32)	2.94	4	4	4	2.7	3.5
20	10	2.43 (1.55)	19.93 (4.14)	37.47 (5.24)	6.33 (1.94)	90.53 (9.44)	2.77	4	4	4	2.7	3.7
21	11	6.53 (1.97)	19.73 (4.25)	22.13 (3.99)	4.67 (1.74)	68.77 (8.19)	2.71	4	4	4	2.7	3.7
22	12	0 (0.71)	2.47 (1.41)	0 (0.71)	8.00 (2.12)	33.93 (3.84)	2.63	4	4	4	2.7	3.7
23	13	0.67 (1)	0 (0.71)	0 (0.71)	3 (1.50)	0.4 (0.91)	1.51	2.7	2.7	1.3	1.3	2.7
24	14	9.53 (3)	2.67 (1.44)	4.33 (1.70)	3.67 (1.60)	11.33 (3.02)	1.88*	0	0	0	0	0

Figures in parenthesis are the transformed values.
* Significant at P=0.05
WAS = Weeks after sowing

Table 3 Incidence of leaf hopper (*E. flavescens*) on castor (IInd DOS - 26.10.2002)

WAS	Standard week	Leafhopper/plant (3 leaves)					CD (P=0.05)	Hopper burn score				
		Kranti	Jyothi	Kiran	DCH-177	GCH-4		Kranti	Jyothi	Kiran	DCH-177	GCH-4
4	48	27.87 (5.30)	8.60 (2.97)	12.07 (3.54)	27.80 (5.32)	27.93 (5.29)	0.78	0	0	0	0.9	0
5	49	61.13 (7.83)	42.13 (6.50)	39.50 (6.32)	49.67 (6.48)	62.83 (7.92)	2.28	0.3	0.4	0.4	0.9	0.3
6	50	95.40 (9.77)	61.27 (7.77)	86.13 (9.25)	129.87 (11.40)	124.03 (11.15)	2.28	0.6	0.7	0.9	2.4	0.7
7	51	130.53 (11.44)	136.57 (11.70)	138.87 (11.70)	225.60 (15.03)	175.47 (13.25)	2.48	1.3	1.6	1.5	2.8	0.8
8	52	167.20 (12.93)	190.03 (13.79)	181.80 (13.46)	212.95 (13.18)	249.17 (15.74)	4.49*	1.6	2.1	2.0	4	1.2
9	1	218.53 (14.76)	259.67 (16.10)	247.33 (15.70)	391.87 (19.79)	280.10 (16.71)	4.21	2.2	2.9	2.7	4	1.5
10	2	274.27 (16.55)	326.40 (18.04)	309.20 (17.57)	447.07 (22.30)	363.67 (19.05)	2.72	2.7	3.5	3.0	4	1.9
11	3	328.00 (18.11)	400.80 (20.01)	348.67 (18.66)	618.30 (24.87)	425.80 (20.60)	1.53	3.2	4	3.3	4	2.3
12	4	395.40 (19.89)	446.07 (21.13)	393.03 (19.77)	528.30 (21.83)	499.53 (22.27)	4.90	3.7	4	3.9	4	1.4
13	5	462.40 (21.51)	519.00 (22.79)	466.20 (21.56)	274.97 (11.55)	561.60 (23.64)	6.95	3.9	4	3.9	4	3.2
14	6	586.40 (24.18)	623.93 (24.98)	526.93 (22.93)	65.67 (6.72)	642.60 (25.25)	3.42	4	4	3.9	4	3.7
15	7	591.47 (23.96)	550.20 (23.01)	475.33 (21.57)	11.07 (2.41)	703.83 (26.44)	7.42	4	4	4	4	3.8
16	8	199.40 (13.86)	215.60 (13.98)	209.20 (14.06)	0 (0.71)	167.07 (11.81)	5.80	4	4	4	4	3.8
17	9	124.83 (11.02)	71.17 (8.27)	86.40 (9.22)	0 (0.71)	71.10 (8.34)	3.45	4	4	4	4	3.8
18	10	66.93 (8.16)	50.00 (6.83)	65.23 (8.01)	0 (0.71)	65.27 (8.11)	2.35	4	4	4	4	3.8
19	11	38.73 (6.03)	30.03 (5.39)	48.07 (6.86)	0 (0.71)	35.90 (5.84)	2.94	4	4	4	4	3.8
20	12	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	2.77	4	4	4	4	2.5
21	13	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	7 (2.02)	2.71	2.7	4	4	4	2.5
22	14	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	7 (1.4)	2.63	2.7	4	2.7	2.7	2.5
23	15	8 (2.72)	19 (4.4)	2 (1.32)	8.33 (2.49)	18.33 (4.31)	1.51	0	0	0	0	0
24	16	18.67 (4.37)	26.67 (5.19)	9.67 (3.11)	11 (3.38)	23 (4.69)	1.88*	0	0	0	0	0

Figures in parenthesis are the transformed values.
* Significant at P=0.05
WAS = Weeks after sowing

Table 4 Incidence of leaf hopper (*E. flavescens* F.) on castor (III[rd] DOS - 10.11.2002)

WAS	Standard week	Leafhopper/plant (3 leaves)					CD (P=0.05)	Hopper burn score				
		Kranti	Jyothi	Kiran	DCH-177	GCH-4		Kranti	Jyothi	Kiran	DCH-177	GCH-4
4	50	2.37 (1.69)	0 (0.71)	0 (0.71)	32.93 (5.77)	2.20 (1.36)	0.78	0	0	0	0.9	0
5	51	6.03 (2.54)	0.31 (0.87)	6.20 (2.57)	82.00 (9.08)	18.13 (2.58)	2.28	0	0	0	2.3	0
6	52	16.27 (4.07)	5.60 (2.22)	31.40 (5.52)	137.80 (11.76)	36.80 (4.98)	2.28	0	0	0.1	3.0	0
7	1	36.73 (6.01)	24.53 (4.31)	53.57 (7.34)	191.10 (13.84)	76.60 (8.22)	2.48	0	0	0.3	3.5	0
8	2	46.83 (6.66)	51.17 (6.09)	93.07 (9.62)	264.30 (16.27)	127.63 (11.03)	4.49*	0.1	0.1	0.7	3.9	0
9	3	106.53 (10.13)	98.13 (8.91)	237.77 (15.04)	313.33 (17.17)	151.07 (11.25)	4.21	0.4	0.3	0.8	4	0
10	4	145.73 (11.91)	146.77 (11.88)	173.97 (13.16)	371.53 (19.28)	238.03 (15.38)	2.72	1.4	0.6	1.3	4	0
11	5	187.53 (13.60)	201.10 (13.89)	224.30 (14.98)	441.70 (21.03)	304.80 (17.47)	1.53	1.8	1.1	1.8	4	0.1
12	6	272.27 (16.29)	232.60 (15.03)	277.80 (16.66)	529.47 (23.01)	345.40 (18.57)	4.90	2.3	1.7	2.1	4	0.6
13	7	282.87 (16.78)	287.87 (16.87)	246.80 (15.39)	562.83 (23.69)	399.10 (19.96)	6.95	2.8	2.7	2.4	4	1.7
14	8	63.97 (7.82)	40.73 (6.18)	71.97 (8.17)	96.20 (9.23)	106.87 (9.89)	3.42	3.1	2.9	2.1	4	1.7
15	9	55.23 (7.27)	16.60 (4.10)	52.27 (7.07)	47.77 (5.84)	73.03 (8.32)	7.42	3.1	3.0	2.4	4	1.7
16	10	38.93 (6.00)	13.53 (3.7)	34.7 (5.75)	35.17 (5.04)	48.77 (6.76)	5.80	3.2	3	2.4	4	1.7
17	11	23.0 (4.05)	4.63 (2.05)	44.97 (6.55)	13.93 (2.64)	30.80 (5.31)	3.45	3.2	3	2.4	4	1.7
18	12	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	0 (0.71)	2.35	3.2	3	2.4	4	1.4
19	13	0 (0.71)	0 (0.71)	0 (0.71)	3.47 (1.57)	0 (0.71)	2.94	3.2	3	2.4	2.7	1.7
20	14	4.53 (1.72)	0 (0.71)	0 (0.71)	9.03 (2.22)	0 (0.71)	2.77	2.2	3	2.4	1.3	1.0
21	15	14.80 (3.9)	5.47 (2.20)	8.23 (2.92)	15.60 (3.64)	19.97 (4.52)	2.71	0	0.7	0	0	0
22	16	14.17 (3.74)	12.47 (3.45)	15.07 (3.93)	11.9 (3.52)	25.7 (4.96)	2.63	0.7	0	0	0	0
23	17	3.33 (1.77)	2.53 (1.61)	2.63 (1.63)	0 (0.71)	4.47 (2)	1.51	0	0	0	0	0
24	18	6.7 (2.38)	11.80 (3.51)	5.27 (2.02)	3 (1.71)	18.67 (3.79)	1.88*	0	0	0	0	0

Figures in parenthesis are the transformed values.
*Significant at P=0.05
WAS = Weeks after sowing

Srinivasa Rao *et al.* (2000) reported high leafhopper population on zero and single bloom entries resulted in higher degree of hopper burn. Also triple bloom entries with moderate leafhopper population exhibited low hopper burn symptoms. The above results are in concurrence with the present findings.

Colour of the stem did not seem to have any influence on the infestation of leafhoppers as varieties and hybrids possessing the same stem colour (red) with different bloom types varied significantly in their reaction to leafhoppers. Studies by Jayaraj (1967) also revealed that stem colour did not influence the level of leafhopper infestation.

Other morphological characters like shape of the leaf, number of nodes, number of days to flower did not affect incidence of leafhopper and expression of hopper burn symptoms in the cultivars tested.

References

Basappa, H. and Lingappa, S. 2001. Studies on damage potential of *Achaea janata* at different phenological stages of castor. *Indian Journal of Plant Protection*, **29**:17-24.

Dorairaj, M.S., Savithri, V. and Aiyadurai, S.G. 1963. Population density as a criterian for evaluating varietal resistance of castor (*Ricinus communis* L.) to jassid infestation. *Madras Agricultural Journal*, **50** :100.

Jayaraj, S. 1967. Studies on the resistance of castor plants (*Ricinus communis* L.) to the leafhopper *Empoasca flavescens* (F.) (Homoptera :Jassidae). *Zeitschrift fur angewandte entomologic*, **59** :117-126.

Lakshminarayana, M., Basappa, H. and Vijay Singh. 1992. Report on the incidence of hitherto unknown leaf miner, *Liriomyza trifolii* Burgess on castor. *Journal of Oilseeds Research*, **9**(1): 175-176.

Painter, R. H. 1951. *Insect Resistance in Crop Plants*. Macmillan & Co., New York, pp.520.

Seshadri, C. R. and Seshu, K. A. 1956. Preliminary observations on jassid injury in castor. *Madras Agricultural Journal*, **43** :197-199.

Srinivasa Rao, T., Lakshminarayana, M. and Anjani, K. 2000. Studies on the influence of bloom character of castor germplasm accessions on jassid and thrips infestation. National Seminar on Oilseeds and Oils : *Research and Development Needs in the Millennium*. February 2-4, 2000, DOR, Hyderabad-30.

Vijay Singh, Lakshminarayana, M. and Ranga Rao, V. 1993. Changing scenario of insect pest problem in annual oilseed crops. In: *Pests and Pest Management in India : The Changing Scenario* (Ed.) Sharma S.C. and Veerabhadra Rao M. Plant Protection Association of India, National Plant Protection Training Institute, Hyderabad, pp.78-87.

J. Oilseeds Res., **22**(1) : 100-102 (2005)

Estimation of economic threshold level for bud fly, *Dasyneura lini* Barnes in linseed, *Linum usitatissimum* L.

Yash P. Malik

Project Coordinating Unit (Linseed), C.S. Azad University of Agriculture and Technology, Kanpur-208 002, UP

(Received: June, 2004; Revised: August, 2004; Accepted: September, 2004)

Abstract

The economic threshold level for bud fly, *Dasyneura lini* Barnes on linseed, *Linum usitatissimum* L. cv. Neelum was worked out for four consecutive years during 1998-2002 at Kanpur, Uttar Pradesh. Linseed seed yield was reduced to the tune of 26.4 kg/ha with every percent increase in bud infestation due to this pest and the avoidable yield loss on mean basis over years was estimated up to 41.7%. Highly significant negative correlation (r= –0.96) was noticed between bud fly infestation and seed yield. The economic injury levels (EILs) for four consecutive years were determined as 12.6, 9.5, 10.5 and 11% bud infestation, while the economic threshold levels (ETLs) for these values were estimated to be 9.5, 7.1, 7.9 and 8.3% bud infestation, respectively.

Key words: Linseed, bud fly, *Dasyneura lini*, EIL, ETL

Introduction

Need based application of any insecticide for the management of insect- pests in an IPM programme requires prior knowledge of damaging threshold levels of the population and vulnerable stage of the crop. Linseed bud fly (*Dasyneura lini* Barnes) is a key pest of linseed during flowering stage of the crop in India causing up to 75% losses in seed yield (Malik, 2000, Malik *et al.*, 2001). Several insecticides have been recommended for the control of bud fly in the past in India. Often the insecticides are applied injudiciously, when the pest incidence does not require it at a particular stage of the crop growth, thus leading not only to unnecessary expenditure but disturbing the eco- system also along with several other problems *viz.*, pest resurgence, pest resistance to pesticides, pesticides residues, pollution to water, soil and atmosphere, high cost and hazards in the usage (Singh *et al.*, 2003). However, the information on economic threshold level (ETL) for bud fly in linseed is lacking for timely application of the insecticides for proper pest management. It was, therefore, felt need of the hour to estimate the ETL for bud fly in linseed for effective and economic control measure fitted well in IPM programme.

Materials and methods

Field experiments for four consecutive years during *rabi* 1998 – 2002 were laid out at C.S.A. University of Agriculture & Technology, Kanpur on linseed cv. Neelum to establish the economic threshold level of bud fly. The crop was sown in 2^{nd} fortnight of November during each year and raised under recommended agronomic practices except insect- pest management. The experiments were executed in Randomized Block Design having seven treatments replicated thrice. Seven exposure period of bud fly infestation were maintained by spraying deltamethrin 2.8 EC (0.002%) at weekly intervals. Treatment having 42 days exposure to bud fly was considered as untreated check having no insecticide application. Two fortnightly sprays of mancozeb (0.25%) were also provided uniformly to the crop starting from bud initiation stage for the management of Alternaria bud blight, *Alternaria lini* Dey.

The bud fly infestation was observed at dough stage of the crop, as the pest-infested buds remained on the plant till harvest of the crop (Malik, 2000). The seed yield was recorded after harvest and, thus, the data obtained on pest infestation as well as seed yield were computed for their critical differences. Linear regression model was established between bud fly infestation and seed yield on yearly as well as mean basis. The economic injury level of bud fly infestation was determined as per Stone and Pedigo (1972), while economic threshold level as per Pedigo (1991) and Reddy *et al.* (2001).

Results and discussion

The crop exposed to different periods showed different degree of bud infestation. Significantly lowest bud fly infestation was noticed being 10.7, 6.8, 7.5 and 6.4% during four consecutive years, when crop was kept under complete protection against bud fly. This quantum of bud fly infestation under complete protection was treated as unavoidable losses for individual year with the mean value of 7.8% bud infestation (Table 1). The bud fly infestation was increased with the enhancement in exposure period of the crop to the pest and significantly higher bud infestation being 36, 32.3, 36.3 and 40.9% was recorded on the untreated crop having 42 days exposure period during respective years with an average of 36.4% bud infestation. Seed yield has decreased with the increase in pest infestation during each year. Significantly maximum seed yield (1934 kg/ha) on over years mean basis was obtained from the crop treated completely, against lowest yield (1128 kg/ha) from untreated plots. Views of Singh *et al.* (1991) and Malik *et al.* (1999) are in conformity with these results. Highly significant negative simple correlation (r) -0.96 was found between bud fly infestation and seed yield. *The quantum of avoidable loss in seed yield was estimated to the tune of 41.7%.*

Table 1 Effect of different exposure periods on bud fly infestation and seed yield in linseed

Exposure period (days)	Bud fly infestation (%)					Seed yield (kg/ha)				
	1998-99	1999-2000	2000-01	2001-02	Mean	1998-99	1999-2000	2000-01	2001-02	Mean
0	10.7	6.8	7.5	6.4	7.8	2174	1861	1951	1750	1934
	(19.1)*	(15.2)	(15.8)	(14.7)	(16.2)					
7	14.6	11.1	12.4	10.6	12.2	2031	1708	1783	1604	1781
	(22.5)	(19.5)	(20.6)	(19.0)	(20.4)					
14	20.8	17.4	16.5	13.5	17.0	1857	1520	1611	1479	1617
	(27.16)	(24.7)	(23.9)	(21.6)	(24.3)					
21	27.6	23.1	22.4	18.4	22.8	1746	1417	1494	1417	1518
	(31.7)	(28.7)	(28.2)	(25.4)	(28.5)					
28	29.1	25.8	25.1	27.9	27.0	1603	1305	1387	1354	1412
	(32.7)	(30.5)	(30.1)	(31.9)	(31.3)					
35	31.0	29.3	32.5	35.4	32.0	1556	1160	1281	1208	1301
	(33.9)	(32.8)	(34.7)	(36.5)	(34.5)					
42	36.0	32.3	36.3	40.9	36.4	1143	1139	1126	1104	1128
	(36.9)	(34.7)	(37.1)	(39.8)	(37.1)					
SEm±	2.07	1.70	0.9	1.0	0.8	103.1	74.6	49.5	83.1	33.3
CD (P=0.05%	6.4	5.2	2.9	3.1	2.6	317.6	229.9	152.6	256.0	102.8

NB: *Figures in parentheses are angular transformed values.*

Table 2 Economic threshold levels based on seed yield/bud fly infestation relationship in linseed

Year	Grain threshold (kg/ha)	Pure intercept (a)	Regression coefficient (b)	Correlation coefficient (r)	Unavoidable bud fly infestation (%)	EIL		ETL
						Calculated	Actual	
1998-99	68.7	2590.9	-35.5	-0.958	10.7	1.9	12.6	9.5
1999-00	76.7	2039.4	-28.6	-0.995	6.8	2.7	9.5	7.1
2000-01	81.8	2111.9	-27.2	-0.991	7.5	3.0	10.5	7.9
2001-02	75.9	1776.3	-16.5	-0.971	6.4	4.6	11.0	8.3
Mean	74.9	2112.7	-26.4	-0.995	7.8	2.8	10.6	8.0

The economic injury level was calculated on the basis of a significant linear regression model of Y = a + bx for a yield/infestation relationship. The gain threshold values were calculated to be 68.8, 76.7, 81.8 and 75.9 kg/ha for different years with their mean value of 74.9 kg/ha based on the cost of treatment for two sprays of deltamethrin 2.8 EC (0.002%) and the price of linseed during the respective years (Table 2). The yield has decreased 16.5 to 35.5 kg/ha with every percent increase in bud infestation due to this pest and average reduction of 26.4 kg/ha was noticed over years. Mean linear regression model as Y (yield) = 2112.7 -26.4x (bud infestation) was established and economic injury level (EIL) was calculated to be 2.8% bud infestation, but there was 7.8% unavoidable bud infestation for the experimental period. So, the actual EIL will be the sum of calculated EIL and unavoidable bud infestation, which is 10.6% bud infestation. Earlier work on EIL by Malik *et al.* (1996) and Malik (1999) support strongly these findings, who reported 8.65% bud infestation as EIL for two fortnightly application of deltamethrin, while 11.20% for two applications of phosphamidon 85 SL (0.03%).

Economic threshold level (ETL) indicates the pest population density at which control measures should be initiated to check the further increase of the pest population in reaching EIL. According to Pedigo (1991) "We may choose to set ETs at levels conservatively below EIL, say at 75% of EILs." Accordingly in present study, ET values from EIL's following Pedigo (1991) and Reddy *et al.* (2001) were determined being 9.5, 7.1, 7.8 and 8.3% bud fly infestation for the respective years with the average value of 8% bud infestation. Results of the present study showed that the control measures should be initiated in linseed for bud fly management when the bud fly infestation reaches at 8%, in order to prevent the pest infestation in reaching economic injury level (10.6 or say 11%). The bud fly threshold is determined for a specific area, which can be utilized as guideline for other areas. The location, cost of treatment, degree of prevention of loss in yield and the price of crop produce often influence the economic threshold of any pest. Any increase in the price of the crop produce or the cost of treatment will lead in change of the threshold level.

Acknowledgement: The author is highly thankful to Dr. S.A. Kerkhi, Project Coordinator (Linseed) for providing the necessary facilities during the period of this study.

References

Malik, Y. P. 1999. Varietal preference and economic injury level of bud fly (*Dasyneura lini* Barnes) in linseed. *Journal of Oilseeds Research,* **16**(1): 97-100.

Malik, Y. P. 2000. Assessment of yield loss due to host pest interactions in linseed (*Linum usitatissimum*). *Indian Journal of Agricultural Science,* **70**(1): 53-54.

Malik, Y. P., Chandra, R. and Srivastava, R. L. 2001. Evaluation of some insecticidal schedules for the management of bud fly (*Dasyneura lini*) in linseed (*Linum usitatissimum*). *Indian Journal of Agricultural Sciences,* **71**(4): 249-251.

Malik, Y. P., Singh, B., Pandey, N. D. and Singh, S. V. 1996. Assessment of economic threshold level of bud fly, *Dasyneura lini* in linseed. *Indian Journal of Entomology,* **58**(2):185-189.

Malik, Y. P., Singh, S. V. and Kerkhi, S. A. 1999. Effectiveness of number and time of insecticidal application against insect pests infestation during productive phase of linseed. Abst. (in) *National Symposium on Crop Pests and Disease Management: Challanges for Next Millennium,* held during Nov. 27-28, 1999 at MPKV, Rahuri (MS), p 32.

Pedigo, L. P. 1991. *Entomology and Pest Management,* Mac Millan Publishing Company, New York.

Reddy, Narendra C., Singh, Yeshbir and Singh, S. Vijai. 2001. Economic injury level of gram pod borer (*Helicoverpa armigera*) on pigeonpea. *Indian Journal of Entomology,* **63**(4): 381-387.

Singh, B., Katiyar, R. R., Malik, Y. P. and Pandey, N. D. 1991. Efficacy of some insecticides alone and in combination with urea against linseed bud-fly *Dasyneura lini* Barnes. *Indian Journal of Entomology,* **53**(2): 270-275.

Singh, R.V., Sardana, H.R., Bambawale, O.M. and Nigam, G.L. 2003. Use of neem: *a biopesticide for sustainable crop* production, *Indian Farming,* **53**(9): 4-7.

Stone, J. D. and Pedigo, L. P. 1972. Development of economic injury level of the green cloverworm on soybean in Iowa. *Journal of economic Entomology,* **65**(1): 197-202.

J. Oilseeds Res., 22(1) : 103-104 (2005)

Biointensive management of collar rot, *Aspergillus niger* and stem rot, *Sclerotium rolfsii* Sacc. in groundnut, *Arachis hypogaea* L.

T. Srinivas, M. Manjulatha[1] and D. Venkateswarlu[2]

District Agril. Advisory and Transfer of Technology Centre, ANGRAU, AMC Campus, Throvagunta, Ongole-523 262, AP

(Received: June, 2004; Revised: October, 2004; Accepted: November, 2004)

Abstract

The effect of some plant extracts and bio protectants on the management of collar rot and stem rot of groundnut (*Arachis hypogaea* L.) was investigated by conducting an experiment under field conditions. Results indicated that, the *Calotropis procera* leaf extract 10ml/kg seed + *Trichoderma viride* 4g/kg seed gave significant control of collar rot and stem rot with increased yield after mancozeb seed treatment 3g/kg seed. The seed treatment with *C. procera* leaf extract and *T.viride* alone also gave significant control of collar rot and stem rot over control with increased yields. Seed treatment with neem products alone and in combination with *T.viride* gave lower yields than control (with out any treatment) because neem products hindered the growth of the plant initially and also could not control collar rot and stem rot. More over, these products also hindered the antagonistic effect of *T.viride* on collar rot and stem rot.

Key words: Collar rot, stem rot, groundnut, *Trichoderma viride, Calotropis procera*

Introduction

Collar rot caused by *Aspergillus niger* is a wide spread disease in groundnut. It causes rotting of seed, pre emergence soft rot of hypocotyls and post emergence collar rot of seedlings. Stem and pod rots caused by *Sclerotium rolfsii* Sacc. is another constraint in most of the groundnut growing areas in India (Menon *et al.*, 1995). Both the diseases spread through the spores adhering to the seeds and pods from one season to the other. Several workers tried to manage these diseases by seed dressing with different fungicides (Sidhu and Chohan, 1971; Whitehead and Thirumalachari, 1974) and by various cultural practices. However, the application of chemicals was found affective up to 20 - 25 days only besides causing soil and air pollution, hazards for human, animals and beneficial rhizosphere organisms. Therefore an alternative method of biological control of these diseases was tried.

Materials and methods

Present studies were conducted at the Agricultural Research Station, Darsi, Prakasam District, Andhra Pradesh, India for two seasons i.e., during rainy season of 2000-2001 and 2001-2002 on collar rot and stem rot susceptible variety Vemana (K134). The crop was sown during 1st fortnight of August and harvested during 1st fortnight of December. The crop was line sown with a spacing of 30cm x 10cm in 3x5 m^2 plots. A basal fertilizer dose of 20kg N, 60kg P_2O_5, and 40kg K_2O/ha was applied. The experiment was conducted with nine treatments *viz.*, Seed treatment with *Calotropis procera* leaf extract 10ml/kg seed; neemex 10ml/kg seed; neem oil 10ml/kg seed; *T.viride* 4g/kg seed; *C. procera* leaf extract 10ml/kg + *T.viride* 4g/kg seed; neemex 10ml/kg + *T.viride* 4g/kg seed; neem oil 10ml/kg + *T.viride* 4g/kg seed; mancozeb 3g/kg seed and control with out any seed treatment. *C. procera* leaves were crushed in a mixer without any water and filtered to obtain crude extract. It was applied to the seed after adding carboxy methyl cellulose for adhering the liquid to the seed. Neemex was a formulation of neem used for coating the urea. The treatments were fit in to Randomized Block Design with four replications. The data on incidence of stem rot and collar rot was collected starting from 15 days after sowing to 55 days after sowing with ten days interval. The disease incidence data collected for every 15 days interval were added and the percentage incidence was calculated for the initial plant population collected at 15 days age of the plants. The yield and other yield parameters were also collected and analyzed statistically and presented below.

Results and discussion

Effect of botanicals and bio agents on the disease incidence: Among the treatments, mancozeb seed treatment 3g/g seed gave highest average control of collar rot (6.0%) and stem rot (0.7%) followed by *Calotropis procera* leaf extract 10ml/kg + *Trichoderma viride* 4g/kg (9.0;1.4) during both the years. Significant difference was not observed between these two treatments. This was followed by seed treatment with *T.viride* 4g/kg alone and proved to be significant compared to control. *C. procera*

1 District Water Management Agency - APRLP, Ongole, Prakasam District, AP.
2 Remandated Krishi Vigyan Kendra, Darsi, Prakasam District, AP.

leaf extract alone 10ml/ kg seed was also found to be significantly superior in controlling the diseases compared to control (Table 1). Seed treatment with *T.viride* and calotropis leaf suspension alone were on par in controlling collar rot and stem rot for 2000-2001 and varied significantly for both the diseases during 2001-2002. Seed treatment with neem products like neemex and neem oil alone and in combination with *T.viride* did not show any affect in controlling collar rot and stem rot during both the years of study and these were non significant when compared to control (Table 1).

Table 1 Effect of botanicals and bio-agents on disease incidence and yield in groundnut

Treatment	% incidence of collar rot			Pod yield (kg/ha)	100 kernel weight (g)	Shelling (%)	% incidence of stem rot			Pod yield (kg/ha)	100 kernel weight (g)	Shelling (%)
	2000-01	2001-02	Mean				2000-01	2001-02	Mean			
Calotropis procera leaf extract 4ml/kg seed	14.8	15.2	15.0	834	30	68.7	2.8	3.0	2.9	750	29.3	68.6
Neemex 10ml/kg seed	26.0	28.5	27.3	430	30	69.5	4.4	5.5	5.0	347	32.6	65.8
Neem oil 10ml/kg seed	29.6	31.7	30.7	459	30	68.2	5.0	6.5	5.8	448	33.1	67.5
Trichoderma viride 4g/kg seed	10.5	10.4	10.5	958	30	52.7	1.5	1.7	1.6	927	32.0	68.1
C. procera leaf extract 4ml/kg seed + *T. viride* 4g/kg seed	9.4	8.5	9.0	1090	31	69.1	1.4	1.3	1.4	1072	31.8	69.3
Neemex 10ml/kg seed + *T. viride* 4g/kg seed	23.8	24.6	24.2	600	29	71.6	3.9	4.7	4.3	636	29.7	70.3
Neem oil 10ml/kg seed + *T. viride 4g/kg seed*	24.3	10.8	17.6	382	28	67.8	4.1	4.3	4.2	423	28.3	67.8
Mancozeb 3g/kg seed	6.0	6.6	6.3	1376	30	70.1	0.8	0.5	0.7	1388	30.0	69.7
Control (With out any treatment)	29.5	28.6	29.1	704	31	66.7	5.0	5.3	5.2	663	32.2	68.2
SEd $\pm$	2.6	1.9		57.8	1.2	7.7	0.7	0.4		47.3	1.6	1.3
CD (P=0.05)	5.5	4.0		119.4	NS	NS	1.5	0.9		97.6	NS	NS

Effect of antagonists on yield and yield parameters: Seed treatment with mancozeb 3g/kg seed resulted in high seed yield during both years (Table 1). Seed treatment with *C. procera* leaf extract also gave significantly increased yield over control and all other treatments except mancozeb. Seed treatment with *T.viride* and *C. procera* leaf suspension alone were found to be significantly different from each other in yield and among the two treatments the former was better. Seed treatment with neem oil and neemex alone and in combination with *T.viride* recorded low yields than control (with out any treatment) because initially the plant growth was hindered due to these products when used at 10ml/kg seed. Moreover these products also hindered the antagonistic activity of *T.viride.* The data pertaining to 100 kernel weight and shelling percentage were found to be non significant statistically. Mancozeb has been proved effective for the management of collar rot and stem rot in groundnut (Sidhu and Chohan, 1971; Whitehead and Thirumalachari, 1974). Information on the use of bio protectants for the control of soil borne and seed borne pathogens was reported earlier in groundnut by Sheela and Packiaraj (2000). Even though the seed treatment of *T.viride* along with *C. procera* leaf suspension occupied second place after mancozeb, the other factors like organic content in the soils and time for colonization of the antagonist have influenced greatly for effective functioning of *T.viride.* It was also observed that the botanical *C. procera* leaf suspension along with *T.viride* acted synergistically for the management of collar rot and stem rot in groundnut. Hence continuous usage of *T.viride* and other botanicals alone or in combination will open a light about their effectiveness in plant protection.

References

Menon, V.K., Mayee, C.D., Benneman, T.B and Mc Donald, D. 1995. *Stem and pod rots in groundnut.* Information bulletin No.44. Patancheru, Andhra Pradesh, India: International Crops Research Institute for Semi Arid Tropics 19pp.

Sheela, J. and Packiaraj, D. 2000. Management of collar ort of groundnut by *Pseudomonas fluorescens. International Arachis Newsletter,* **20** : 50-51.

Sidhu, G.S. and Chohan. J.S. 1971. The field scale testing of different fungicides for controlling collar rot of groundnut. *Journal of Research. Punjab Agricultural University.* Ludhiana, **8**:211-213.

Whitehead, M.D. and Thirumalachari, N.J.1974. Effect of fungal diseases and *Aspergillus flavus* infestation in peanuts. *Hindusthan Antibiotics Bulletin,* **13** : 79-80.

J. Oilseeds Res., 22(1) : 105-107 (2005)

Resistance to tobacco streak virus in groundnut, *Arachis hypogaea* L.

G. Kalyani, S. Sonali, A.S. Reddy, A.G.S. Reddy, F. Waliyar and S.N. Nigam

International Crops Research Institute for the Semi-Arid Tropics, Patancheru-502 324, AP

(Received: July, 2004; Revised: September, 2004; Accepted: October, 2004)

Abstract

Peanut stem necrosis disease (PSND), caused by tobacco streak virus (TSV), is a new disease in groundnut, which appeared in 2000 in Anantapur district of Andhra Pradesh in India. Eleven peanut bud necrosis disease (PBND) field resistant genotypes of groundnut, *Arachis hypogaea* L. along with JL 24 (susceptible control) were screened in glasshouse for resistance to TSV. Plants were inoculated mechanically at 14 days after sowing (DAS) with two virus concentrations, 1:10 and 1:100. Five genotypes showed tolerance to TSV as compared to JL 24. These genotypes along with JL 24 were again screened in the glasshouse with larger plant population with two virus concentrations (1:10 and 1:100) and at two plant ages (14 DAS and 21 DAS) under Split-Split Plot Design. Among the six genotypes screened, ICGV 99029 (29.4%), ICGV 01276 (34.2%), ICGV 92267 (35.0%), and ICGV 00068 (37.4%) recorded less TSV infection than JL 24 (68.6%). In addition to their tolerance to TSV, these genotypes also possess tolerance to PBND, rust and late leaf spot. These would make good parents in a multiple disease resistance breeding program in groundnut.

Key words: Peanut stem necrosis disease, peanut bud necrosis disease, resistance sources, sap inoculation, peanut

Introduction

Peanut stem necrosis disease (PSND) of groundnut, caused by tobacco streak virus (TSV), occurred in epidemic proportion in the 2000 rainy season in Anantapur district of Andhra Pradesh. The disease affected nearly 0.23 m ha of the total 0.7 m ha, resulting in an estimated loss of Rs. 3 billion (Prasada Rao *et al.*, 2003b). The typical symptoms of PSND are necrosis of terminal portion of the stem (leaflets and terminal bud), which spreads rapidly to the entire stem resulting in complete death of the plant (Reddy *et al.*, 2002). The virus infects several crops and weed species. It is carried through pollen. When the vector thrips (*Frankliniella schultzei* (Trybom), *Megalurothrips usitatus* (Bagnall) and *Scirtothrips dorsalis* Hood.) with infected pollen on their bodies land on groundnut plants, the pollen dislodge. During thrips feeding both damaged leaf tissue and pollen come in contact and the virus is transmitted. In the case of groundnut, *Parthenium hysterophorus* appears to play a significant role in natural spread of PSND (Prasada Rao *et al.*, 2003a).

To date, there are no satisfactory measures that can effectively control this disease in the field. However, disease management is possible following an integrated approach involving border cropping, intercropping, weed control, seed treatment with imidacloprid, and host plant resistance (Prasada Rao *et al.*, 2003b). Host plant resistance, if available, provides an effective, economical and environment friendly option to control the disease. In an earlier glasshouse screening (mechanical inoculation using sap from virus-infected plant at 1:10 virus concentration), all 150 released varieties of groundnut in India were susceptible. Similarly, all 51 wild *Arachis* accessions screened were susceptible to TSV and showed disease symptoms, except for one accession of *A. chacoense* (ICG 4983), which did not show symptoms inspite of TSV infection (Prasada Rao, unpublished data). The main aim of the present investigation was to identify TSV tolerant groundnut genotypes among the bud necrosis disease (PBND) resistant and thrips resistant groundnut genotypes. As both PBND and PSND are prevalent in peninsular India, a combined resistance to both the diseases is required.

Materials and methods

Eleven PBND and thrips tolerant groundnut genotypes, ICGV 99029, TCGS 647, ICGV 86590, ICGV 00068, ICGV 01270, ICGV 00005, ICGV 00064, ICGV 01276, ICGV 92267, ICGS 37, and ICGV 87486, identified at ICRISAT and elsewhere, and one susceptible control JL 24 were screened for resistance to TSV in glasshouse at ICRISAT Center during April-May 2003. This experiment was conducted in a randomized complete block design. Groundnut seedlings were raised in 20-cm plastic pots containing sterilized sand:soil mixture (2:1) in two replications. Each replication consisted of two pots/cultivar and each pot contained five plants. The plants were sap inoculated at 14 DAS following the procedure described by Prasada Rao *et al.*, 2003b. In addition to the groundnut genotypes, with each inoculation (1:10 and 1:100 virus concentrations) five control plants of cowpea were also inoculated. The inoculated cowpea plants provided standard for virus infectivity. Among the 11 groundnut genotypes screened, promising genotypes were screened again with larger plant population and at two plant ages during August-September 2003, under Split-Split Plot Design. These tolerant genotypes were raised in 25-cm plastic pots in six replications. Each replication consisted of 3 pots/cultivar and each pot contained 5 plants. Plants were inoculated at 14 and 21 DAS using two virus concentrations 1:10 and 1:100. Observations on disease appearance were taken at weekly intervals and later all plants were tested by ELISA for the presence of the virus.

Virus culture: TSV was originally taken from groundnut and inoculated onto cowpea. Single lesion isolation was made from cowpea to cowpea. Following three successive single lesion transfers by mechanical sap inoculations, virus was multiplied on cowpea (Prasada Rao *et al.*, 2003b).

Mechanical sap inoculations: Cowpea infected leaves were harvested from the glasshouse grown plants. Two virus dilutions 1:10 (1 g of infected tissue : 9 ml of inoculation buffer) and 1:100 were made to inoculate groundnut plants. Inoculations were performed with the help of mortar and pestle after dusting the plants with carborundum.

Observations on disease appearance were recorded at weekly intervals on the inoculated plants. After 25 days of inoculation, leaf samples from all the plants were collected for ELISA tests for the presence of virus. From symptomatic plants, only young leaflets that showed early disease symptoms were tested, and from the nonsymptomatic plants, young leaflets from three branches were pooled and tested. Samples were processed by using direct antigen coating (DAC) ELISA method (Hobbs *et al.*, 1987).

As the data sets in both screenings satisfied the assumption of homogeneity of variance, they were analysed without transformation.

Results and discussion

In preliminary studies, conducted during October - November 2002, the virus failed to produce symptoms in groundnut (symptom expression in cowpea was delayed), probably due to prevailing low temperatures (minimum temperature was 8-9°C). Considering the influence of temperature on disease expression, the present experiments were conducted during April-September 2003 (minimum temperature 20-22°C), which resulted in a high level of TSV infection. Olorunju *et al.* (1995) also observed that warm to hot temperatures in May and July apparently caused groundnut rosette virus (GRV) to appear earlier and to be more severe than cooler temperatures in October and December in susceptible groundnut plants in Nigeria. Cowpea plants inoculated along with test plants showed 100% infection. Groundnut plants without the disease symptoms gave negative results in ELISA.

At a higher virus concentration (1:10), the disease incidence among the 11 genotypes ranged from 35 to 100%. ICGV 01276 recorded the lowest and ICGV 87846 the highest disease incidence. ICGV 99029 and ICGV 92267 had 55% disease incidence. In the remaining genotypes the disease incidence was 80% and above (Table 1). Inoculation with lower virus concentration (1:100) provided a more discernible disease picture among the genotypes. Two genotypes ICGV 92267 and ICGV 00068 did not show any disease symptoms or infection of TSV. The maximum disease incidence observed was 80% in ICGV 87846. ICGV 99029 and ICGV 01276 showed 15%, ICGS 37 showed 30% and ICGV 00005, ICGV 00064 and TCGS 647 showed 40% disease incidence (Table 1).

Table 1 Reaction of peanut bud necrosis disease field tolerant groundnut genotypes to tobacco streak virus (TSV) in glasshouse, ICRISAT Centre, April-May, 2003

Genotype	TSV infection (%) Virus concentration 1:10	1:100	Average TSV infection (%)
ICGV 99029	55	15	35.0
TCGS 647	100	40	70.0
ICGV 86590	95	65	80.0
ICGV 00068	85	0	42.5
ICGV 01270	80	55	67.5
ICGV 00005	90	40	65.0
ICGV 00064	80	40	60.0
ICGV 01276	35	15	25.0
ICGV 92267	55	0	27.5
ICGS 37	80	30	55.0
ICGV 87846	100	80	90.0
Control : JL 24	95	75	82.5
CD (P=0.05)			34.2

Based on the above results, five genotypes, ICGV 99029, ICGV 00068, ICGV 01276, ICGV 92267 and ICGS 37, were identified as promising against TSV infection and screened further using larger plant population at two plant growth stages (14 DAS and 21 DAS). The results are summarized and presented in Table 2. At the higher virus concentration, the mean disease incidence (51.7%) was significantly more than the lower virus concentration (35.9%). Similarly, at young plant age the disease incidence (48.1%) was significantly more than the older plant age (39.4%). If virus infection occurs at later stages of plant growth, more plants are likely to escape the disease. At 1:10 virus concentration and plant age 14 DAS, the disease incidence ranged from 21% in ICGV 01276 to 59.8% in JL 24, whereas at the same virus concentration and plant age 21 DAS, the disease incidence ranged from 13.3% in ICGV 00068 to 57.7% in JL 24. At 1:100 virus concentration and plant age 14 DAS, the disease incidence ranged from 30% in ICGV 99029 to 86.6% in JL 24, whereas at the same virus concentration and plant age 21 DAS, the disease incidence ranged from 21% in ICGV 00068 to 70.2% in JL 24. All the five genotypes screened further had significantly lower disease incidence than the control JL 24 (68.6%). Although, the disease incidence in ICGV 99029 was the lowest (29.4%), other genotypes, ICGV 01276 (34.2%), ICGV 92267 (35.0%), and ICGV 00068 (37.4%), did not differ significantly from it. In addition to bud necrosis disease (another virus disease caused by peanut bud necrosis virus), which is prevalent in peninsular India, these varieties also have tolerance to TSV/PSND. They can provide field protection against both the virus diseases.

Table 2 Reaction of promising groundnut genotypes for resistance to tobacco streak virus (TSV) in glasshouse, ICRISAT Centre, August-September, 2003

Genotype	Average TSV infection (%)												
	P_1			P_2			VC_1			VC_2			Overall mean
	VC_1	VC_2	Mean	VC_1	VC_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean	
ICGV 92267	28.8	55.5	42.2	23.3	32.2	27.7	28.8	23.3	26.1	55.5	32.2	43.9	35.0
ICGS 37	43.3	68.8	56.1	53.5	66.7	60.1	43.3	53.5	48.4	68.8	66.7	67.8	58.1
ICGV 99029	32.0	30.0	31.0	18.8	36.8	27.8	32.0	18.8	25.4	30.0	36.8	33.4	29.4
ICGV 00068	47.5	67.7	57.6	13.3	21.0	17.2	47.5	13.3	30.4	67.7	21.0	44.4	37.4
ICGV 01276	21.0	36.5	28.8	31.3	47.8	39.6	21.0	31.3	26.2	36.5	47.8	42.2	34.2
Control: JL-24	59.8	86.7	73.3	57.7	70.2	64.0	59.8	57.7	58.8	86.7	70.2	78.5	68.6
Mean		48.1			39.4			35.9			51.7		

CD (P=0.01): Genotype (G) = 11.4; Plant age (P) = 6.2; Virus conc. (VC) = 7.2; G x P = 15.1; P x VC = NS; G x VC = NS; G x P x VC = NS

NS = Non-significant; P_1 = Plant age 1 (14 DAS); P_2 = Plant age 2 (21 DAS)
VC_1 = *Virus concentration 1 (1:100)* VC_2 = Virus concentration 2 (1:10)

ICGV 99029 is also tolerant to rust (caused by *Puccinia arachidis* Speg.) and ICGV 00068 to both rust and late leaf spot (caused by *Phaeoisariopsis personata* Berk and Curt.) diseases (ICRISAT, unpublished data). ICGV 92267, besides being tolerant to rust and late leaf spot, is early maturing and is also tolerant of low temperature at germination (Upadhyaya *et al.*, 2002). All these genotypes will make good parents in a multiple disease resistance breeding program in groundnut.

Acknowledgement: This work was supported by the Indian Council of Agricultural Research-National Agricultural Technology Project-ROPS:18. The first author express her gratitude to Dr. S.N. Nigam, Principal Investigator, NATP-ROPS:18 for his technical guidance and support.

References

Hobbs, H.A., Reddy, D.V.R., Rajeswari, R. and Reddy, A.S. 1987. Use of direct antigen coating and protein A coating ELISA procedures for detection of three peanut viruses. *Plant Disease*, **71**:747-749.

Olorunju, P.E., Kuhn, C.W., Ansa, O.A., Misari, S.M. and Demski, J.W. 1995. Mechanical inoculation procedure to screen for resistance to groundnut rosette virus in peanut. *Peanut Science*, **22**:56-58.

Prasada Rao, R.D.V.J., Reddy, A.S., Reddy, S.V., Thirumala Devi, K., Chander Rao, S., Manoj Kumar, V., Subramaniam, K., Yellamanda Reddy, T., Nigam, S .N. and Reddy, D.V.R. 2003a. The host range of Tobacco streak virus in India and transmission by thrips. *Annals of Applied Biology*, **142**:365-368.

Prasada Rao, R.D.V.J., Reddy, D.V.R., Nigam, S.N., Reddy, A.S., Waliyar, F., Yellamanda Reddy, T., Subramaniam, K., John Sudheer, M., Naik, K.S.S., Bandyopadhyay, A., Desai, S., Ghewande, M.P., Basu, M.S. and Somasekhar. 2003b. *Peanut Stem Necrosis: A New Disease of Groundnut in India. Information Bulletin no. 67.* Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics.

Reddy, A.S., Prasada Rao, R.D.V.J., Thirumala Devi, K., Reddy, S.V., Mayo, M.A., Roberts, I., Satyanarayana, T., Subramaniam, K. and Reddy, D.V.R. 2002. Occurrence of Tobacco streak virus on peanut (*Arachis hypogaea*) in India. *Plant Disease*, **86**:173-178.

Upadhyaya, H.D., Nigam, S.N., Reddy, A.G.S. and Yellaiah, N. 2002. Registration of early-maturing, rust, late leaf spot, and low temperature tolerant peanut germplasm line ICGV 92267. *Crop Science*, **42**:2220-2221.

J. Oilseeds Res., 22(1) : 108-110 (2005)

Lipid compositional changes due to *Alternaria* blight in the leaves of Indian mustard, *Brassica juncea* L.

A.K. Atwal, R. Toor and R.K. Raheja

Department of Plant Breeding, Genetics and Biotechnology, Punjab Agricultural University, Ludhiana-141 004, Punjab

(Received: April, 2004; Revised: September, 2004; Accepted: October, 2004)

Abstract

A significant decrease in oil, triglyceride and 18:2 and 22:1 fatty acid content was observed in different parts of infected leaves of Indian mustard as compared to healthy ones. The level of different lipid classes (PL, GL and sterols) decreased with age as well as infection. The changes in the protein profile of the infected and healthy tissue when subjected to PAGE, showed disappearance of sub-fractions of intermediate molecular weight proteins whereas 7S protein fractions remained persistent even at high severity of infection.

Key words: *Brassica juncea, Alternaria brassicae,* oil content, fatty acids, lipid profile

Introduction

Lipids being the membrane components, play a vital role to maintain the integrity of the plant tissue membrane which act as a barrier against penetration of fungus. Infestation by *Alternaria* blight leads to deterioration of the quality of the oil and hence the fatty acid make up due to various metabolic disturbances in the plant. Changes in sugars and phenol levels during infestation have been reported in Brassica (Singh *et al.*, 1999), however the fate of lipids under disease conditions is still to be explored. The present paper reports therefore on the compositional changes in the lipid profile under diseased conditions in different parts of the infected leaf (necrotic, chlorotic, green), the major source of assimilates to the developing fruits and the first tissue to be affected by *Alternaria* blight.

Materials and methods

The crop was sown in the month of October (2001) following standard packages of practices. Healthy and infected leaves of *Brassica juncea* (L.) Czern & Coss collected from lower, middle and upper portion of the plants at 80, 100 and 120 days (DAS) were brought to laboratory under cold conditions. The leaves were dried with filter paper after washing with sterile distilled water. Data on infection and severity of disease was recorded as per scale suggested by Conn *et al.* (1990). For dry weight, the leaves were dried at 50°C in triplicate till constant weight was obtained. The necrotic, chlorotic and green areas of infected leaves were separated and subjected to biochemical analysis.

Total lipids were extracted by repeatedly grinding the tissue in a glass pestle morter in chloroform : methanol (2:1 v/v) mixture. The pooled extract was subjected to Folch washings (Folch *et al.*, 1957) to remove water soluble impurities. The solution was evaporated to dryness and residue was suspended in 10 ml chloroform. The percentage of total lipids was determined by evaporating a suitable aliquot of this extract to a constant weight. The remaining lipid was stored at -10°C until use for lipid analysis. Phospholipids, glycolipids, sterols and free fatty acids were estimated by standard procedures (Ames, 1966; Roughan and Bhatt, 1968; Zak, 1957 for sterol and Lowery and Tinsley, 1976 for free fatty acids) respectively. Total triglycerides were calculated as relative percentage by substracting the sum of PL's, GL's, sterols and free fatty acids out of 100.

Results and discussion

The percentage of infection and severity showed a positive correlation with each other as well as with the age of the plant. The oil content of lesioned areas of infected leaves was considerably low as compared to that of healthy leaves of *Brassica juncea* infested with *Alternaria brassicae*. There was an increase in the oil content in case of healthy leaves with the age of the plant (Table 1). Similar trend was observed in green areas of infected leaves. However, the oil content of necrotic and chlorotic tissues showed a significant decline with the increase in infection. Shah and Ali (2002) have also reported that with the increase in infection the oil content decreased in infected tissues of various rapeseed-mustard varieties.

Various lipid classes such as phospholipids, glycolipids and sterols showed a decrease in their content at maximum infection (120 DAS) and with advancement in age whereas, the free fatty acid content increased with the infection and was maximum at 120 DAS. On the contrary triglycerides (TG's) showed an increase with infection and maximum content of triglycerides was found in necrotic area at 120 DAS. The increased free fatty acid content could be due to increased lipase activity of fungus. Rai and Saxena (1980) also showed an increase in the free fatty acid content with the increase in infection in Indian mustard.

Data on lipid classes revealed that the proportion of membrane lipids like phospholipids, glycolipids and sterols decreased while that of free fatty acid and triglycerides increased with the age of the plant and infection. The proportion of 16:0, 18:1 and 18:3 fatty acids was more in infected as compared to healthy leaves at all the three stages of infection (Table 2). However, the content of 18:1 increased till 100 DAS and then showed a decline to 120 DAS. 18:2 and 22:1 showed a decrease in their proportion in case of infected leaves as compared to healthy at all the three stages of infection. Since the membrane lipid composition is altered under diseased conditions a change in its fatty acids might also be expected. Gupta *et al.* (1990) also reported an increase in polyunsaturated fatty acid with infection of *Alternaria*.

Table 1 **Oil content (%) and various lipid classes (g/100 g oil) in the leaves of Indian mustard influenced by *Alternaria* blight (Dry weight basis)**

DAS	Healthy	Infected		
		Necrotic	Chlorotic	Green
Total oil content				
80 DAS	1.92±0.12	0.12±0.18	1.36±0.02	1.81±0.13
100 DAS	5.30±0.23	1.81±0.13	1.19±0.08	4.26±0.11
120 DAS	6.81±0.31	1.82±0.11	0.98±0.09	6.17±0.18
CD (P=0.05)	Sampling	1.47		
	Infected x healthy	1.21		
Phospholipids				
80	1.8±0.09	0.9±0.21	1.1±0.03	1.7±0.13
100	1.2±0.06	0.5±0.22	0.9±0.01	1.3±0.23
120	0.9±0.06	0.2±0.13	0.5±0.07	1.1±0.21
CD (P=0.05)	Sampling	1.34		
	Infected x healthy	0.06		
Glycolipids				
80	5.8±0.09	1.2±0.12	2.5±0.03	5.3±0.17
100	4.6±0.06	1.1±0.11	1.3±0.06	4.8±0.12
120	3.1±0.17	0.6±0.18	1.1±0.08	3.7±0.18
CD (P=0.05)	Sampling	1.43		
	Infected x healthy	0.07		
Sterols				
80	2.8±0.12	0.8±0.13	1.6±0.12	2.7±0.11
100	2.3±0.11	0.5±0.21	1.1±0.14	2.2±0.16
120	1.2±0.13	0.2±0.22	0.6±0.21	1.5±0.13
CD (P=0.05)	Sampling	1.71		
	Infected x healthy	0.09		
Free fatty acids				
80	0.7±0.09	0.2±0.12	0.6±0.21	1.1±0.13
100	1.8±0.04	0.4±0.07	1.4±0.22	1.6±0.18
120	2.0±0.04	0.9±0.03	2.3±0.23	2.4±0.21
CD (P=0.05)	Sampling	1.63		
	Infected x healthy	0.08		
Triglycerides				
80	88.9±0.09	96.9±0.11	94.2±0.51	89.2±0.32
100	90.1±0.02	97.5±0.12	95.3±0.42	90.1±0.14
120	92.2±0.02	98.1±0.12	95.5±0.31	91.3±0.32
CD (P=0.05)	Sampling	0.03		
	Infected x healthy	0.01		

DAS – Days after sowing

Table 2 Fatty acid composition (%) in the oil obtained from leaves of Indian mustard influenced by *Alternaria* blight

Fatty acid	DAS					
	80		100		120	
	Healthy	Infected	Healthy	Infected	Healthy	Infected
16:0	3.9	24.2	4.1	18.9	2.0	18.4
18:0	-	-	1.0	-	0.9	-
18:1	9.6	11.1	11.5	17.5	9.8	10.3
18:2	17.4	12.1	15.5	15.0	16.1	8.4
18:3	11.8	15.7	9.8	25.7	12.4	18.3
20:1	7.5	-	5.0	-	6.0	-
22:1	48.4	32.8	52.5	22.0	52.6	44.3

DAS – Days after sowing

The total salt extractable proteins of leaves of *Brassica juncea* at different percentage of infection when subjected to PAGE - electrophoresis resolved into a major high molecular weight globulin (12S) and four other protein fractions with intermediate molecular weights. At initial stage of infection, (80 DAS) no remarkable protein damage due to *Alternaria* blight was observed. However, with increase in infection, the lower fractions of intermediate molecular weight proteins were mostly affected along with 12S globulins. The major 7S protein fraction remained persistent throughout even at high percentage of infection.

Presence of more negatively charged lipids (phospholipids, glycolipids) increase the sensitivity of the fungus towards plant defense mechanism (Anzlovar *et al.*, 1998). The decrease in negatively charged lipids of Brassica leaves therefore could be expected as a defensive step against penetration of the fungus.

References

Ames, B.N. 1966. Assay of inorganic phosphate and phosphatases. In : Nenfeld, E.F. and Ginsburg, V. (eds). *Methods in Enzymology.* Vol 8 pp. 115, Academic Press, New York.

Anzlovar, S., Serra, M.D., Dermastia, M. and Menestrina, G. 1998. Membrane permeability activity of pathogenesis related protein linusitin from flax seed. *Molecular Plant Microbiology*, **11** : 610-617.

Conn, K.L., Tewari, J.P. and Awasthi, R.P. 1990. A disease assessment key for *Alternaria* black spot in rapeseed and mustard. *Canadian Plant Disease Survey*, **70** : 19-22.

Folch, J., Lewas, M. and Stanley, G.H.S. 1957. A simple method for the isolation and purification of total lipids from animal tissues. *Journal Biological Chemistry*, **226** : 497-509.

Gupta, S.K., Gupta, P.P., Yadava, T.P. and Kaushik, C.D. 1990. Metabolic changes in mustard due to *Alternaria* leaf blight. *Indian Phytopathology*, **43** : 64-69.

Lowery, R.R. and Tinsley, I.J. 1976. Rapid colorimetric determination of free fatty acids. *Journal American Oil Chemical Society*, **53** : 470-472.

Rai, J.N. and Saxena, A. 1980. Effect of some seed-borne fungi on the physiochemical properties of the oil of Indian mustard. *Indian Journal Agricultural Sciences*, **50** : 769-771.

Roughan, P.G. and Bhatt, R.D. 1968. Quantitative analysis of sulfolipids and galactolipids in plant tissue. *Analytical Biochemistry*, **22** : 74-88.

Shah, S.J.A. and Ali, I. 2002. Effect of grey leaf spot on oil content or rapeseed and mustard. *Pakistan Journal of Scientific and Industrial Research*, **45** : 412.

Singh, D.N., Singh, N.K. and Srivastava, S. 1999. Biochemical and morphological characters in relation to *Alternaria* blight resistance in rapeseed-mustard. *Annals Agricultural Research*, **20** : 472-477.

Zak, B. 1957. Simple rapid microtechnique far serum total cholesterol. *American Journal of Clinical Pathology*, **27** : 583-588.

J. Oilseeds Res., **22**(1) : 111-113 (2005)

Occurrence, avoidable yield loss and management of white rust, *Albugo candida*, in late sown mustard, *Brassica juncea* (L.) Czern & Coss

R.B. Singh and Ram Bhajan

Department of Genetics and Plant Breeding, Narendra Dev University of Agril. & Technology, Faizabad-224 229, UP

(Received: November, 2003; Revised: September, 2004; Accepted: October, 2004)

Abstract

White rust, *Albugo candida* (Pers. ex. Lev.) Kuntze, disease occurs in moderate to severe form across eastern Uttar Pradesh. The disease appears between 2nd December (1997-98) to 3rd February (2001-02). The highest disease intensity ranged from 25.3% (1998-99) on Narendra Rai to 70.8% (2001-2002) on Varuna. Highest avoidable seed yield loss due to disease was noted up to 28.2 % in Varuna. Sporadic occurrence of stag head was noted only in *Diara* land areas. Two sprays of Ridomil MZ @ 0.25% resulted in significantly lowest disease intensity (11.8%) and highest seed yield (1925 kg/ha), followed by seed treatment with Apron @ 6g/kg seed coupled with three sprays at 15 days interval with Mancozeb @ 0.2% (PDI: 25.3; yield: 1837 kg/ha) over the check (PDI: 56.3; yield: 1383 kg/ha).

Key words: Mustard, *Albugo candida*, white rust, occurrence, fungicide

Introduction

Rapeseed- mustard is one of the chief sources of edible oil in India. It suffers from a number of destructive foliar diseases, out of which, white rust, *Albugo candida* (Pers. ex. Lev.) Kuntze, causes severe losses, both qualitatively and quantitatively in late sown crop of mustard in Uttar Pradesh. All the aerial plant parts get infected due to this disease and causes yield loss up to 89.8 % (Lakra and Saharan, 1989). Each per cent white rust intensity and stag head formation is reported to cause 82 and 22 kg/ha reduction in seed yield/ha, respectively (Meena *et al.*, 2002). A number of comprehensive studies have been under taken on different aspects of this disease in the states of north-west India (Kolte, 1985; Saharan, 1992; Verma and Saharan, 1996; Mehta *et. al*, 1996, Bhargava *et. al*, 1997). There appears near absence of published information of any consequence on this disease from mid-eastern India. In view of the observed capacity of this disease to cause substantial losses, investigations were under taken to study its occurrence, avoidable yield loss and management through fungicidal suppression.

Materials and methods

The investigations were carried out at the Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (UP) under field, laboratory and glass house conditions during 1995-96 to 2001-02. Recommended agronomic practices including 80:40:40 NPK kg/ha were followed for raising the good crop.

Survey trips were organized covering different areas in different years across the mustard growing regions of eastern Uttar Pradesh. Samples collected from farmers' fields and experimental plots were studied. Disease incidence and severity were recorded in commercially popular mustard, *Brassica juncea* (L.) Czern & Coss, varieties-Varuna, Kranti, Narendra Rai (NDR-8501), Vardan and Rohini. Disease intensity was recorded following Lakra and Saharan (1989). Percent disease intensity (PDI) was calculated. Avoidable yield loss (AYL) due to white rust disease was calculated using seed yield data from the fungicidal treatments.

Experiment on control of the disease was conducted in Randomized Complete Block Design with four replications in the same experimental plot during 2000-01 and 2001-02 crop seasons. Test variety Varuna was sown in the third week of November with row-to-row and plant-to-plant spacings of 30 and 10 cm respectively in plots of 5 x 3 m size. All the fungicides except Ridomil MZ-72 were sprayed at first appearance of disease and subsequent at 15 days intervals. Ridomil MZ was sprayed at 60 days after sowing (DAS) followed by the second spray at 80 DAS (Table 1). Efficacy of the fungicides in managing the disease was ascertained by comparing the PDI in respective treatments. Overall efficacy of these treatments in managing the disease was worked out by comparing their mean disease intensity and increased seed yield over the control. Cost-benefit ratio was calculated using seed yield and additional input for individual treatments.

Results and discussion

Occurrence of white rust disease on mustard was found to be widely distributed in the area surveyed in eastern Uttar Pradesh. A variety of symptoms of white rust individually and in mixed infection were observed, which were also reported earlier from the states of north-western India

J. Oilseeds Res., **22**(1) : 114-118 (2005)

Study on segregation patterns and linkages between morphological characters and wilt resistance in castor, *Ricinus communis* L.

C. Hanumantha Rao, M.A. Raoof and C. Lavanya

Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, AP

(Received: April, 2003; Revised: September, 2004; Accepted: October, 2004)

Abstract

Genetics of wilt resistance in castor was estimated using the segregating population (F_2) of two wilt resistant sources - Baker and 48-1 and two wilt susceptible lines - VI-9 and VP-1. Wilt resistance to *Fusarium oxysporum* f.sp. *ricini* was governed by a single dominant gene in Baker and by two complementary genes in 48-1. The purple colour in stem and petiole was governed by single dominant genes. Cup shaped leaf in VP-1 was due to two duplicate recessive genes while non-spiny capsule was governed by a single recessive gene. Close linkage was noticed between genes controlling purple stem and purple petiole. All the other characters segregated independently of each other.

Key words: Wilt, resistance, *Fusarium oxysporum, Ricinus communis*

Introduction

Castor, *Ricinus communis* is grown for industrial oil in 3.45 lakh ha in Gujarat, Rajasthan, Maharashtra under irrigated conditions and in 4.39 lakh ha in Andhra Pradesh, Karnataka, Tamil Nadu and Orissa under rainfed conditions (Damodaram and Hegde, 2002). Wilt, a soil borne disease is a major biotic stress affecting plant population and consequently yields. In India, Nanda and Prasad (1974) first reported Fusarium wilt from Udaipur and Sirohi districts of Rajasthan and Palampur district of Gujarat and established the casual organism as *Fusarium oxysporum* f.sp. *ricini*. Intensive cultivation of the crop without proper crop rotation resulted in endemic development of wilt resulting in considerable yield loss in all castor hybrids (Dange *et al.*, 1977). The extent of yield loss depends on the stage at which plants wilt - 77% at flowering, 63% at 90 days and 39% in later stages on secondary branches (Pushpavathi *et al.*, 1997). Fusarium wilt can be efficiently managed through cultivation of wilt resistant varieties and hybrids of castor. Breeding for wilt resistance is the most durable method to minimize the plant population losses and consequently seed yield. Accessions like 48-1, Baker 239, Co-I and JM-6 have been identified as resistant source to this pathogen (Anon., 1992; 1993 and 1994). Crop improvement programme at DOR, Hyderabad and Gujarat aimed at involving the resistant sources in crossing programme and screening the advanced material in wilt sick plots under AICRP network. Though all the sources have been used in the breeding programme, genetics of resistance to this pathogen is not well understood which is essential for handling the segregating material either through backcross method, pedigree method or recurrent selection. Castor, being a cross pollinated crop, requires large population of segregating generations for recovery of wilt resistant genes. Identification of linkage of morphological markers with wilt resistance would greatly help in selection of resistant plants in the very early stage of the crop in segregating generations. Hence, the present study was undertaken to study the genetics of wilt resistance and linkage of morphological markers with wilt resistance.

Materials and methods

Two independent crosses using wilt resistant accessions *viz.*, 48-1 and Baker 239 with wilt susceptible female lines *viz.*, VI-9 and VP-1 respectively were made in 1996 in pathogen free plot while, F_1s were raised in 1997 in a wilt sick plot at Research Farm, Directorate of Oilseeds Research, Hyderabad consisting of red sandy loam soil (Alfisol) with pH : 6.2, EC : 0.13 dS/m, organic C : 0.36% available N : 210 kg/ha; P : 11.5 kg/ha and K : 40 kg/ha. The sick plot was developed by repeated incorporation of diseased plant debris and cultivation of wilt susceptible cultivar Aruna. Besides, the soil inoculum load in sick plot was maintained at CFU 2.1 x 10^3 by mass multiplication of the pathogen isolate DOR1 on sorghum grains, band application by the side of plants 25 days after planting and incorporation in the top 5-10 cm soil. Wilt incidence was recorded at 30 days of crop growth and thereafter at monthly intervals. The susceptible check Aruna recorded 80-100 % infection. These accessions were selfed to F_2 in pathogen free plots. The F_2 population of the above crosses along with parents was raised in the same wilt sick field in 1998. Nematodes population was controlled by soil application of carbofuran (1 kg a.i./ha) before sowing and normal management practices were taken for the control of other pests and diseases. Observations were taken on individual plant basis in parents and F_2 for stem colour, petiole colour and nature of leaf at early vegetative stage and nature of capsule at flowering of the main racemes. Observations on susceptible plants were recorded from the first appearance of the wilt at an interval of 15 days upto the crop maturity (150 days) and healthy plants remaining in the field upto maturity were counted as resistant plants. Susceptible plants included the wilted plants showing symptoms like chlorosis, stunting and blackening of the stem and up ward curling of the leaves leading to complete drying of the plants at early vegetative stage (<35 DAS) and flowering stage (25-45 DAS). Different shades of purple colour were observed on stem and petiole. All of them were grouped as a single class 'Purple' the other class without pigment being 'Green'. Similarly, capsules with spines of different intensities and lengths were grouped as a single class as 'spiny' the other class being 'non-spiny'. The data was analysed for pattern of segregation and linkages based on the formulae developed by Richharia *et al.* (1996). The F_2 ratios were confirmed by F_3 population.

Results and discussion

Purple colour on stem and petiole, flat leaves, spiny nature of capsules and resistance to wilt were found dominant over green colour on stem and petiole, cup shaped leaves, non-spiny capsule and susceptibility to wilt in F_1 of the crosses VI-9 x 48-1 and VP-1 x Baker, respectively (Table 1). Pattern of F_2 segregation indicated that purple colour on stem and petiole was controlled separately by a single dominant gene. Similar results indicating monogenic dominance for purple colour was reported by Kulkarni (1977), White (1918), Harland (1922 and 1928), Solanki and Joshi (2001), while Seshadri and Muhammed (1951) reported complimentary gene action for purple pigment in stem. A single dominant gene governed wilt resistance in Baker while two complementary genes controlled resistance in 48-1. Sviridov (1988) observed two types of resistance. In one type, a recessive gene controlled it while in the second type it was due to the interaction of two duplicate genes. On the other hand, wilt resistance due to polygenes was reported by Desai *et al.* (2001). Cup shaped leaf in VP-1 was determined by two duplicate recessive genes. It is also observed that all plants with cup shaped leaves had condensed internodes indicating pleotropic affect. A single recessive gene governs non-spiny capsule in 48-1 (Table 2). Harland (1920), Seshadri and Mohammed (1951), Narayana (1961) and Anjani (1997) reported incomplete dominance of sparse spiny nature and monogenic control of spiny capsule.

The study on joint segregation analysis indicated the presence of close linkage between genes controlling purple stem and purple petiole (Table 3). Purple colour in stem and petiole on one hand segregated independent of cup shaped leaves, non-spiny capsules and wilt resistance. Further, the latter three characters also segregated independent of each other. Hence, none of the characters under study at seedling and flowering stages were found linked with wilt resistance. Studies conducted by Solanki and Joshi (2001) also indicated that sulphur white spike colour, purple stem colour and condensed internode segregated independent of each other.

Table 1 Pigmentation and morphological characters in the parents and two crosses in *Ricinus communis*

Parents/ Crosses	Stem colour	Petiole colour	Reaction to wilt*	Shape of leaf	Nature of capsules
			Cross - 1		
VP-1	Green (P)	Green (P)	Susceptible	Cup	Spiny
Baker 239	Purple (P)	Purple (P)	Resistant	Flat	Spiny
VP-1 x Baker 239 (F_1)	Purple (P)	Purple (P)	Resistant	Flat	Spiny
			Cross - 2		
VI-9	Green (P)	Green (P)	Susceptible	Flat	Spiny
48-1	Purple (P)	Purple (P)	Resistant	Flat	Non-spiny
VI-9 x 48-1 (F_1)	Purple (P)	Purple (P)	Resistant (R)	Flat	Spiny

* In wilt sick plot

Resistant : 0-20% wilt incidence; Susceptible : 21-100 % wilt incidence

Table 2 Pattern of segregation in F_2 of the Cross-1 and Cross-2 of *Ricinus communis* for different characters

Character	Cross	Purple	Green	X^2	Ratio proposed	Gene symbol
Stem colour						
Cross-1	Observed	165	63	0.83	3:1	Pst/pst
	Expected	171	57			
Cross-2	Observed	121	36	0.32	3:1	
	Expected	118	39			
Petiole colour						
Cross-1	Observed	167	61	0.37	3:1	Ppet/ppet
	Expected	171	57			
Cross-2	Observed	125	32	1.79	3:1	
	Expected	118	39			
Reaction to wilt		Resistant	Susceptible			
Cross-1	Observed	169	59	0.09	3:1	Rw/rw
	Expected	171	57			
Cross-2	Observed	83	74	0.73	9:7	Rw1, Rw2/ rw1, rw2
	Expected	88	69			
Shape of leaves		Flat	Cup			
Cross-1	Observed	217	11	1.79	15:1	Fl 1 / Fl 2 fl 1 / fl 2
	Expected	214	14			
Nature of capsules		Spiny	Non-spiny			
Cross-2	Observed	127	30	2.99	3:1	Spc/spc
	Expected	117	39			

Table 3 **Pattern of joint segregation in Crosses 1 and 2 of *Ricinus communis* for different characters**

Cross	Genetic ratio used	Observed/ Expected	AB	Abs	aB	ab	χ^2	Nature of association
					Stem colour vs. Petiole colour			
Cross-1		Observed	165	0	2	61	248.49	L-2%
	3:1 vs. 3:1	Expected	128.25	42.75	42.75	14.25		
Cross-2		Observed	121	0	4	32	118.55	L-2%
	3:1 vs. 3:1	Expected	88.4	29.4	29.4	9.8		
					Stem colour vs. Reaction to wilt			
Cross-1		Observed	118	47	51	12	3.19	IA
	3:1 vs. 3:1	Expected	128.25	42.75	42.75	14.25		
Cross-2		Observed	60	61	23	13	3.40	IA
	3:1 vs. 9:7	Expected	66.23	51.51	22.08	17.18		IA
					Stem colour vs. Nature of leaf			
Cross-1		Observed	157	8	60	3	**1.64**	IA
	3:1 vs. 15:1	Expected	160.31	10.68	53.44	3.57		IA
					Stem vs. Nature of leaf			
Cross-2		Observed	99	22	28	8	**3.53**	IA
	3:1 vs. 3:1	Expected	**88.4**	29.3	29.4	9.8		
					Petiole colour vs. Reaction to wilt			
Cross-1		Observed	120	47	49	12	**2.22**	IA
	3:1 vs. 3:1	Expected	128.25	42.75	42.75			
Cross-2		Observed	62	63	21	11	**5.10**	IA
	3:1 vs. 9:7	Expected	66.23	51.51	22.08	17.18		
					Petiole colour vs. Shape of leaf			
Cross-1		Observed	159	8	58	3.57	1.16	IA
	3:1 vs. 15:1	Expected	160.31	10.68	53.44	3.57		
					Petiole colour vs. Nature of capsules			
Cross-2		Observed	101	24	26	6	**4.65**	**IA**
	3:1 vs. 3:1	Expected	88.4	29.3	29.3	9.3		
					Reaction to wilt vs. Nature of leaves			
Cross-1		Observed	161	8	56	3	**0.89**	IA
	3:1 vs. 15:1	Expected	**160.31**	10.68	53.44	3.57		
					Nature of capsule vs. Reaction to wilt			
Cross-2		Observed	67	60	16	14	3.67	IA
	3:1 vs. 9:7	Expected	66.23	51.51	22.08	17.18		

IA = Independent Assortment; L = Linkage;

References

Anonymous. 1992. All India Coordinated Research Project on Oilseeds. Annual Progress Report Castor 1991-92. Directorate of Oilseeds Research, Hyderabad.

Anonymous. 1993. All India Coordinated Research Project on Oilseeds. Annual Progress Report Castor 1992-93. Directorate of Oilseeds Research, Hyderabad.

Anonymous. 1994. All India Coordinated Research Project on Oilseeds. Annual Progress Report Castor 1993-94. Directorate of Oilseeds Research, Hyderabad.

Anjani, K. 1997. Inheritance of spininess of capsule in castor (*Ricinus communis* L.). *Crop Improvement*, **24**(1):113-114.

Damodaram, T. and Hegde, D.M. 2002. Oilseeds Situation - A *Statistical Compendium. Directorate of Oilseeds* Research, Hyderabad.

Dange, S.R.S., Desai, A.G. and Patel, D.B. 1997. Management *of wilt of castor in Gujarat State of India. In: International Conference on Integrated Plant Disease Management for Sustainable Agriculture*. Nov. 10-15, IARI, New Delhi, India, pp.107.

Desai, A.G., Dange, S.R.S. and Pathak, H.C. 2001. Genetics of Resistance to wilt in Castor Caused by *Fusarium oxysporum* f.sp. *ricini* (Nanda and Prasad). *Journal of Mycology and Plant Pathology*, **31**:322-326.

Harland, S.C. 1920. Inheritance of *Ricinus communis* L. Part-I. *Journal of Genetics*, **10**:207-218.

Harland, S.C. 1922. Inheritance of *Ricinus communis* L. Part-II. *Journal of Genetics*, **12**:251-253.

Harland, S.C. 1928. The genetics of *Ricinus communis* L. Part-II. *Bibilie Genetica*, **4**:171-177.

Kulkarni, L.G. and Ramanamurthy, G.V. 1977. *Castor*, Indian Council of Agricultural Research, *New Delhi, pp.38.*

Nanda, S. and Prasad, N. 1974. Wilt of castor-A new record. *Indian Journal of Mycology and Plant Pathology*, **4**:103-105.

Narayana, A. 1961. Inheritance of spininess of capsule in castor. *Indian Journal of Genetics and Plant Breeding*, **20**:223-224.

Pushpavathi, B., Sarwar, H.A.K., Raoof, M.A. and Ravindra Babu, R. 1997. *Integrated management of castor wilt (Fusarium oxysporum* f.sp. *ricini*). In: *International Conference on Integrated Plant Disease Management for Sustainable Agriculture*, Nov. 10-15, New Delhi.

Richharia, R.H., Ghosh, A.K., Prakasa Rao, S.V.S. and Misro, B. 1966. Formulae for the estimation of linkage from F_2 data. Bulletin No.5. Central Rice Research Institute, Cuttack, India.

Seshadri, C.R. and Muhammed, V.S. 1951. Study on inheritance of *certain characters* in castor. Proceedings of the first scientific workers conference. Agricultural College *and Research Institute*, Coimbatore.

Solanki, S.S. and Joshi, P. 2001. Inheritance study of some morphological traits in castor (*Ricinus communis* L.). *Indian Journal of Genetics and Plant Breeding*, **61**:136-139.

Sviridov, A.A. 1988. *Inheritance* of resistance to Fusarium in castor bean. *Genetika*, **24**:908-913.

White, O.E. 1918. Inheritance studies on castorbean. *Brooklyn Botanical Garden Memorial*, **1**:513-521.

J. Oilseeds Res., **22**(1) : 119-124 (2005)

Influence of imposition of soil moisture-deficit stress on some quality components of groundnut, *Arachis hypogaea* L. kernel

J.B. Misra and P.C. Nautiyal

National Research Centre for Groundnut, Post Bag No.5, Ivnagar, Junagadh-362 001, Gujarat

(Received: March, 2002; Revised: June, 2004; Accepted: September, 2004)

Abstract

Four Spanish cultivars of groundnut *viz.* Ak 12-24, J 11, GAUG 1, and GG 2 were studied for the quality components of kernel such as total sugars, phenolics, protein, and fatty acid composition as influenced by the soil moisture-deficit stress imposed during different phenophases, in the summer season. Increase due to stress during pod development phase, in plamitic acid was observed only in cv. GAUG 1. For stearic acid, increase due to stress during pod development, was observed in all the cultivars except GG 2. Oleic acid percentage increased due to stress at pod development in cv. AK 12-24, and only marginally in GAUG 1 and GG 2. Compared to control, soil moisture-deficit stress caused a significant increase in the protein content. There was, however, a greater increase in protein content due to stress during flowering, and pod development as compared to the stress during vegetative phases. Stress during vegetative (short), and flowering phases caused a significant reduction in sugar content. The interaction between cultivars and treatments were significant only for the changes in fatty acid composition, protein and sugar contents, while it was not significant for phenolics. In conclusion, the changes in the composition of fatty acids and contents of sugars and phenolics are governed more by cultivar and its interaction with the environmental conditions rather than by the time or the intensity of imposed soil moisture-deficit stress.

Key words: Kernels quality, soil moisture-deficit stress, groundnut, fatty acid composition, proteins, sugars, phenolics

Introduction

Groundnut is an important oilseed crop of India as well as of the world. In India, besides a limited area under irrigated conditions, the crop is generally raised in rain fed conditions owing to its drought tolerant nature. As such, the crop is quite popular among the marginal farmers of Saurashtra region of Gujarat, where due to erratic and frequent low precipitation; the crop is often subjected to water deficit stress. The adverse effects of drought on yield of groundnut crop are well known (Ravindra *et al.* 1991, Nautiyal *et al.* 1999) but how the water-deficit stress affected the kernel quality of this crop has not been studied extensively. The major constituents of groundnut kernel are oil (42-56%), protein (12-36%), and carbohydrates (22-32%) - starch, sucrose, mono-saccharides and some oligosaccharides. Oleic and linoleic acids are the major fatty acids of groundnut oil and together with palmitic acid they account for 90% of the total fatty acids of groundnut oil (Savage and Keenan, 1994). Though present in relatively small quantities free amino acids, phenolics, minerals, tocopherol *etc.* also have a bearing on the quality of kernels.

There are only a limited number of reports on the effect of water deficit stress on the quality of the groundnut kernels. Musingo *et al.* (1989) studied the effect of drought and temperature stress on chemical components of quality and also market grade seeds (jumbo, medium and No.1) by raising a single cultivar, Florunner, in environmental control plot facility at Dawson, USA. Eight identical cultivars were raised by Ross and Kvien (1989) and by Conkerton *et al.* (1989) at Tifton, USA to study the effect of drought on seed composition whereas Hashim *et al.* (1993) raised only one cultivar, Florunner, at the same farm to find out the effect of drought on fatty acid composition and tocopherol content of seed. In India, Sarma and Sivakumar (1989) raised a single Indian cv. Robut 33-1 at Patancheru (Andhra Pradesh) to study the effect of drought on oil and protein content which was followed by another experiment, conducted by Dwivedi *et al.* (1996), at the same place by raising twelve cultivars, including one popular Indian cv. J 11, to study the effect of drought on oil and protein contents whereas Bhalani and Parameswaran (1992) studied the effect of differential irrigation on kernel lipid profile of one cv. GG 2 by conducting experiments at Anand (Gujarat). However, there is no consistency in the results reported by various authors. As Saurashtra region of Gujarat is considered to be the groundnut bowl of India, it was of interest to conduct experiments in this region with four Indian cultivars to generate information on the effect of water deficit on quality of kernels.

Materials and methods

Four cultivars of groundnut (*Arachis hypogaea* L. ssp. *fastigiata*), Ak 12-24, J 11, GAUG 1, and GG 2 were raised in summer season (February-June) of 1993 at the experimental farm of the National Research Centre for Groundnut at Junagadh (latitude 21°31'N, longitude 70°36'E; soil: Vertic Ustochrept, pH 8.5; low in organic matter, available nitrogen and phosphorus). The crop was raised following standard cultural practices. The seeds were sown in 5 m x 3 m plots, with an inter-row spacing of 30 cm and intra-row spacing of 10 cm. Thus a 4 x 5 factorial (4 cultivar and 5 stress treatments) experiment was arranged in a Randomized Block Design with 3 replicates. Urea (25 kg N/ha) and single superphosphate (40 kg P_2O_5/h) were applied as fertilizers at the time of sowing. The crop was irrigated regularly at 10-day intervals during February to March and subsequently 8-day intervals from April onward to meet the enhanced evaporative demand.

A differential irrigation schedule was, however, followed for imposing moisture-deficit stress at various vegetative and reproductive stages of the crop. The treatments included i) Control, regular irrigation at 10-d intervals during the vegetative phase and 8-days(d) intervals, until harvest; ii) V1, a stress in the vegetative phase (prolonged), irrigation withheld for 30 days (starting 20 d after sowing); iii) V_2, a moderate stress in the vegetative phase (short), irrigation withheld for 25 d (starting 20 d after sowing) followed by two successive relief irrigations at an interval of 5 d; iv) F, stress in the flowering phase, irrigation withheld for 30 d (starting 40 d after sowing); and v) P, stress in the pod development stage, irrigation withheld for 20 d starting 60 d after sowing. Thus withholding of irrigation during certain phenophases constituted the moisture stress treatments and except for the periods of stress the irrigation for all the treatments was same as that for control plots. The crop was sown in 5 m x 3 m plots, with 30 cm between rows and 10 cm between plants within rows. Each experiment was a 4 x 5 factorial (4 cultivar and 5 drought treatments) arranged in a Randomized Block Design with 3 replicates. Fertilizers were applied as urea (25 kg N/ha) and single superphosphate (40 kg P_2O_5/ha).

Produce obtained in the summer season was shelled after one month of harvest and kernels were used for various chemical analysis. The fatty acid composition of the oil was determined after converting the constituent fatty acids into their methyl esters (Morrison and Smith, 1964) which were then separated on Nucon Gas Chromatograph (AIMIL, India) model 5700, fitted with a DEGS column (I.D. 2 mm, length 180 cm). The temperature of the column was kept at 195°C while that of injection and FID detector ports was kept at 250°C. The flow rates of carrier (nitrogen), fuel (hydrogen), and air were 40, 30, and 300 ml/min., respectively. The fatty acids were identified by comparison of their retention time with those of authentic samples. The area of a peak as fraction of the total area under all the peaks was expressed as percent. Percentages of only 6 fatty acids have been indicated here. The stability index (SI) was defined as the ratio of oleic acid to linoleic acid (Ahmed and Young, 1982).

The nitrogen content was determined by micro-Kjeldahl method (Ballentine, 1957) using a Kjeltech auto nitrogen analyzer and the protein content was obtained by multiplying the nitrogen content of meal with a factor of 5.46 (St. Angelo and Mann, 1973). Groundnut meal (200 mg) was extracted twice in 80% methanol under reflux for 1 hour. Both the extracts were pooled. The phenolics in the alcoholic extract were determined according to Bray and Thorpe (1957). Total sugars were first obtained in aqueous medium by evaporating methanol in vacuum and then determined by the method described by Ashwell (1957).

Results and discussion

Fatty acid composition, stability index and nutritive value index: The cultivar differences though too narrow, were significant for palmitic, oleic, linoleic, and arachidic acids only and were not significant for stearic and behenic acids. The contents of palmitic, stearic, oleic, linoleic, and arachidic acids were significantly affected by all the treatments but the differences were marginal whereas the content of behenic acid remained unaffected. Compared to control, the palmitic and stearic acids were affected the most due to stress in pod development registering a reduction by 7.7% and 13.1%, respectively; oleic and linoleic acids due to stress in vegetative (short) phase registering a reduction by 2.9% and an increase by 6.6%, respectively; and arachidic acid due to stress in vegetative (short) and pod development phases registering and equal increase of 3.5%. The interactions between the cultivars and treatments were also significant for of all the fatty acids but the effect did not differ much from the general trends.

Values of both stability index (SI) and nutritive value index (NVI) are derived on the basis of fatty acid composition. Thus any change in fatty acid composition is bound to affect the values of both these indices. The SI values of the cultivars ranged from 1.20 to 1.28. The soil moisture-deficit stress affected significant changes in the SI values as compared to control. Stress during vegetative (prolonged), flowering, and pod development phases significantly improved the SI value, with a maximum of improvement by 6.9% due to stress in vegetative (prolonged) phase. There was, however, a significant reduction (3.3%) in SI value due to stress in vegetative (short) phase. The NVI values of cultivars ranged from 2.12 (J 11) to 2.42 (GAUG 1) and compared to control, all the treatments effected an improvement in the NVI value except stress (short) during vegetative phase.

Table 1 **Fatty acid composition of kernels of four spanish groundnut cultivars subjected to various transient soil moisture-deficit stress**

Cultivar	Treatment	Palmitic (16:0)	Stearic (18:0)	Oleic (18:1)	Linoleic (18:2)	Arachidic (20:0)	Behenic (22: 0)
Ak 12-24	C	13.96	1.50	45.43	35.36	2.00	0.83
	V_1	13.60	1.50	46.80	35.33	2.03	0.80
	V_2	14.60	1.56	43.50	37.10	2.40	0.83
	F	14.56	1.26	46.53	34.63	2.10	0.83
	P	13.26	1.13	47.60	35.80	1.86	0.90
J 11	C	15.50	1.30	45.23	34.90	1.90	0.90
	V_1	14.40	1.80	45.40	35.16	2.20	0.90
	V_2	14.03	1.20	43.50	38.43	1.76	0.90
	F	13.60	1.60	45.70	36.70	1.76	0.60
	P	12.73	1.06	45.20	38.50	2.10	0.76
GAUG 1	C	15.10	1.40	44.86	35.20	1.70	0.90
	V_1	16.33	1.36	44.26	35.30	1.60	0.90
	V_2	14.80	1.30	45.10	36.30	1.66	0.60
	F	14.76	1.60	45.76	35.23	1.76	0.76
	P	15.80	1.21	45.60	35.10	2.20	0.86
GG 2	C	15.10	1.26	45.10	35.53	2.03	0.80
	V_1	15.56	1.21	46.70	34.36	1.20	0.63
	V_2	14.43	1.36	43.20	38.50	2.06	0.86
	F	14.10	1.76	44.03	37.40	2.05	1.04
	P	13.26	1.33	44.53	38.46	1.76	0.86
	CD (P=0.05)	0.24	0.14	0.51	0.33	0.18	0.12
Treatment	C	14.91	1.37	45.16	35.25	1.91	0.86
	V_1	14.97	1.47	45.79	35.04	1.76	0.81
	V_2	14.46	1.36	43.83	37.58	1.98	0.80
	F	14.25	1.56	45.52	35.99	1.93	0.82
	P	13.76	1.19	45.73	36.96	1.98	0.85
	CD (P=0.05)	0.12	0.07	0.25	0.16	0.09	N.S.
Cultivar	Ak 12-24	14.00	1.39	45.97	35.65	2.08	0.84
	J 11	14.05	1.40	45.01	36.74	1.95	0.81
	GAUG 1	15.36	1.38	45.12	35.43	1.79	0.81
	GG 2	14.49	1.39	44.72	36.85	1.83	0.85
	CD (P=0.05)	0.11	N.S.	0.23	0.15	0.08	N.S.

C= 10 d interval; V_1= 20 DAS for 30 days; V_2= 20 DAS for 25 days; F= 40 DAS for 30 days; P= 60 DAS for 20 days

Table 2 Stability nutritive value indices and protein, sugars and phenolic contents of kernels of four groundnut cultivars subjected to various transient soil-moisture-deficit stresses

Cultivar	Treatment	Stability Index	Nutritive Value Index	Proteins mg/g	Sugars mg/g	Phenolics mg/g
Ak 12-24	C	1.22	2.25	113.3	192.1	3.57
	V_1	1.32	2.34	152.3	238.7	3.47
	V_2	1.17	2.32	125.3	151.2	2.50
	F	1.34	2.14	171.0	167.1	2.58
	C	1.33	2.45	188.6	238.2	5.78
J 11	C	1.20	2.21	135.9	145.3	2.62
	V_1	1.28	2.17	182.5	221.0	3.06
	V_2	1.12	2.53	172. 9	151.2	1.63
	F	1.25	2.41	190.7	167.0	2.21
	P	1.17	2.79	173.3	198.7	5.06
GAUG 1	C	1.23	2.00	150.0	154.1	2.97
	V_1	1.24	1.98	139.7	221.7	3.11
	V_2	1.25	2.38	177.2	186.8	1.82
	F	1.30	2.15	189.7	94.8	1.93
	P	1.30	2.06	173.1	174.2	5.19
GG 2	C	1.20	2.03	195.6	190.5	3.06
	V_1	1.36	2.04	182.6	182.1	3.36
	V_2	1.12	2.43	172.6	120.5	2.01
	F	1.16	2.33	202.1	175.4	2.16
	P	1.16	2.68	228.8	116.0	4.85
	CD (P=0.05)	0.03	0.14	28.7	0.4	N.S.
Treatment	C	1.21	2.12	148.7	170.5	3.02
	V_1	1.30	2.14	164.3	215.9	3.25
	V_2	1.17	2.42	162.0	152.5	1.99
	F	1.26	2.26	190.6	151.1	2.22
	P	1.24	2.50	191.0	181.8	5.22
	CD (P=0.05)	0.02	0.07	14.4	0.7	0.27
Cultivar	Ak 12-24	1.28	2.30	150.1	197.5	3.58
	J 11	1.21	2.42	171.1	176.7	2.92
	GAUG 1	1.27	2.12	167.7	166.3	2.97
	GG 2	1.20	2.31	196.3	156.9	3.0[illegible]
	CD (P=0.05)	0.01	0.06	12.8	0.6	0.24

C= 10 d interval; V_1= 20 DAS for 30 days; V_2= 20 DAS for 25 days; F= 40 DAS for 30 days; P= 60 DAS for 20 days

Protein: Cultivars differed significantly in their protein content, which ranged from 150 to 196 mg/g. Compared to control; all the treatments caused a significant increase in the protein content. There was, however, a greater increase due to stress during flowering and pod development phases (28% each) than due to stress during vegetative phase, both prolonged and transient (10.1 and 8.7%, respectively). The interactions between the cultivars and treatments were also significant.

Sugars: The total soluble sugar content of cultivars ranged between 157 and 198/g. Stress during vegetative (prolonged) and pod development phase caused a significant increase in sugar content. However, the increase caused due to stress in vegetative phase (prolonged) was substantial (26.6%) and that due to stress in pod development was relatively small (6.6%). Stress during both vegetative (short) and flowering phase caused a significant reduction in sugar content and the extent of reduction was also comparable (10.6 and 11.4%, respectively). The interaction between the cultivars and treatments also was significant but pattern of effect varied with cultivars.

Phenols: The phenolic content of seed of cv. Ak 12-24 was slightly higher than the other three cultivars which all had statistically equal phenolic contents. Prolonged stress during vegetative phase did not significantly affect the phenolic content while transient stress during vegetative and flowering phases caused a significant reduction (34.1 and 26.5%, respectively) and stress during pod development caused a substantial significant increase (72.8%). The interaction between cultivars and treatments were not significant.

Hashim *et al.* (1993) have reported that imposition of stress at pod maturation phase (for 20 days, commencing 80 days after planting) in cv. Florunner caused an increase in percentages of palmitic and linoleic acids and decrease in percentages of stearic and oleic acids. Bhalani and Parameswaran (1992), however, did not find any significant effect of imposition of differential irrigation on the fatty acid composition in cv. GG 2. Whereas Dwivedi *et al.* (1996) in their experiments conducted with 12 cultivars (eight confectionery type, two drought resistant types, a popular Indian cultivar and an early-maturing type) observed that there was no significant effect of mid-season drought on the fatty acid composition but the end-of-season drought reduced the percentages of linoleic and behenic acids while the percentages of stearic and oleic acid increased. In the present experiment, however, a significant increase, due to stress during pod development, in plamitic acid was observed only in cv. GAUG 1. In case of stearic acid, increase due to stress during pod development was observed only in three cultivars, while a decrease was observed in GG 2. As far as changes in the fatty acid composition are concerned, the trends observed in present study agree neither with those reported by Dwivedi *et al.* (1996) nor with those reported by Musingo *et al.* (1989). Thus the results of the present study and those reported earlier lead us to believe that the effect of various types moisture deficit stresses, on the fatty acid composition (and consequently on SI and NVI) of groundnut may be highly cultivar specific and on the basis of published data it may be difficult to give a general picture. As far as increase in protein content due to imposition of end-of-season drought is concerned, the results of this study confirm the earlier observations of Dwivedi *et al.* (1996) but disagree with those of Conkerton *et al.* (1989) and Musingo *et al.* (1989) as both of these groups did not observe any significant change on protein content. Ross and Kvien (1989) have reported an increase in phenolics due to imposition of mid-season drought irrespective of cultivar, however, cultivars differed considerably in their response to end-of-season drought, some registering an increase while others registering a decrease indicating there by a significant cultivar by treatment interaction. In the present study, however, all the four cultivars responded in the similar fashion and the cultivar by treatment interaction was not significant. The pattern of variation in the total soluble sugar content of seed was by and large similar to those reported by Ross and Kvien (1989) for sucrose (which comprises most of the soluble sugars) content in the seed with a significant cultivar by treatment interaction. Musingo *et al.* (1989), on the basis of experiments conducted under environmental control facilities, have reported increase in both total and soluble carbohydrates as a result of drought stress.

As a matter of fact it is not possible to compare the results obtained by various authors due to differences in the cultivars used, agro-climatic conditions of crop growth and also the duration and the intensity of the drought imposed besides the methods of imposing water deficit stress i.e. either by withholding a flood irrigation due (this report and Bhalani and Parameswaran) or by creating a gradient on the basis of distance from sprinkler irrigation system (Sarma and Sivakumar, 1989; Dwivedi *et al.*, 1996). Moreover, it now known that imposition of soil moisture-deficit stress on groundnut cultivars by withholding irrigation may not result into a uniform physiological moisture-deficit-stress as is reflected by significantly different relative water content of leaves (Nautiyal *et al.*, 1995). This could, to some extent, explain the lack of uniformity in pattern of response of groundnut cultivars under uniform soil-moisture deficit conditions.

Though in the present experiment oil content of kernels was not determined there are reports to indicate that imposition of the end of season drought results in reduction in oil content of the seed (Conkerton *et al.*, 1989; Sarma and Sivakumar 1989; Bhalani and Parameswaran, 1992). This type of decrease however, may not be universal (Dwivedi *et al.*, 1986), as in some cultivars the oil content may remain unaffected (Musingo *et al.*, 1989; Dwivedi *et al.*, 1986). Thus on the basis of the results obtained in the present investigation and those reported earlier it can be concluded that the imposition of soil moisture-deficit- stress in end-of-season may result in increased protein content and reduced oil content. So far as changes in the composition of fatty acids and contents of sugars and phenolics are concerned, they are governed more by cultivar and its interaction with the conditions of growth and crop management practices than by the time or the intensity of imposed soil moisture-deficit.

References

Ahmed, E.M. and Young, C.T. 1982. Composition, quality and flavour of peanuts. In: H.E. Pattee and C.T. Young, (eds) *Peanut Science and Technology.* pp. 655-688. American Peanut Research and Education Society, Yoakum, Texas, USA.

Ashwell, G., 1957. Colorimetric analysis of sugars. In: S.P. Colowick and N.O. Kaplan (eds) *Methods of Enzymology.* vol 3, pp. 73-105. Academic Press, New York.

Ballentine, R., 1957. Determination of total nitrogen and ammonia. In: S.P. Colowick and N.O .Kaplan, *Methods of Enzymology.* 3:984-995. Academic Press, New York.

Bhalani, G. K. and Parameswaran, M. 1992. Influence of differential irrigation on kernel lipid profile in groundnut. *Plant Physiology and Biochemistry,* **19**, 11-14.

Bray, H.G. and Thorpe, W.B. 1954. Analysis of phenolic compounds of interest in metabolism. In D. Glick (ed) *Methods in Biochemical Analysis,* Vol. 1. pp 27-52. Interscience Publishers, New York.

Conkerton, E.J., Ross, L.F., Daigle, D.J., Kvien, C.S. and McCombs, C. 1989. The effect of drought stress on peanut seed composition. II. Oil, protein and minerals. *Oleagineux* **44**: 593-599.

Dwivedi, S.L., Nigam, S.N., *Nageswara Rao,* R.C., *Singh, U.* and Rao, K.V.S. 1996. Effect of drought on oil, fatty acids and protein contents of groundnut (*Arachis hypogaea* L.) seeds. *Field Crops Research,* **48**: 125-133.

Hashim I.B., Koehler, P.E., *Eitenmiller,* R.R. *and Kvien,* C.K. 1993. Fatty acid composition and Tocopherol content of drought stressed Florunner peanuts. *Peanut Science,* **20**: 21-24.

Morrison, W.R. and Smith, L.M. 1964. Preparation of fatty acid methyl esters and dimethyl acetates from lipids with boron fluoride-methanol. *Journal of Lipid Research,* **5**: 600-608.

Musingo, M.N., Basha, S.M., Sanders, T.H., Cole R.J. and *Blankenship, P.D. 1989.* Effect of drought and temperature stress on peanut (*Arachis hypogaea* L.) seed composition. *Journal of Plant Physiology,* **134**: 710-715.

Nautiyal, P.C., Ravindra, V. and Joshi, Y.C. 1995. Gas exchange and leaf water relations in two peanut cultivars of different drought tolerance. *Biol. Plant.,* **37**: 371-374.

Ravindra, V., *Nautiyal, P.C. and Joshi, Y.C. 1991.* Physiological analysis of drought resistance and yield in groundnut (*Arachis hypogaea* L.), *Tropical Agriculture,* Trinadad **67**: 290-296.

Ross, L.F. and Kvien, C.S. 1989. The effect of drought stress on peanut seed composition. I. Soluble carbohydrates, tartaric acid, and phenolics. *Oleagineux,* **44**: 295-299.

Savage G.P. and Keenan, J.I. 1994. The composition and nutritive value of groundnut kernels. In: *The Groundnut Crop: A Scientific Basis for Improvement* (ed. J Smartt). *Chapman & Hall, London. ISBN 0 412 480201,* pp. 173-213.

St. Angelo, A.J. and Mann, G.E. 1973. Peanut proteins. In: *Peanut culture and uses.* pp 559-592. American Peanut Research and Education Society. Stone Printing Co. *Raonoke, USA.*

Sarma, P.S. and Sivakumar, M.V.K. 1989. Response of groundnut to drought stress in different growth phase. *Agricultural Water Management* 15: 301-310. Elsevier Science Publishers BV, Amsterdam, The Netherlands.

J. Oilseeds Res., **22**(1) : 125-128 (2005)

Effect of drying methods on seed germination and seed protein profile in groundnut, *Arachis hypogaea* L.

P.C. Nautiyal and J.B. Misra

National Research Centre for Groundnut, Post Bag No.5, Junagadh-362 001, Gujarat

(Received: May, 2004; Revised: November, 2004; Accepted: January, 2005)

Abstract

To conduct studies on pod drying and protein profile analysis, groundnut (*Arachis hypogaea* L.) crop grown in the summer season (February-June) and harvested in the month of June. Pods dried at 39, 50, and 60°C temperatures in the controlled conditions, and under field ambient conditions by five different methods *viz.* windrows, shade, the Directorate of Oilseeds Research; National Research Centre for Groundnut, and conventional methods. Drying temperatures had a significant bearing on both germination immediately after drying and its subsequent loss during storage. Pods dried at 60°C lost germination by about 26% and were lacking in protein bands of very high molecular weight in PAGE analysis. The drying methods and temperatures had clearly discernible effects on the PAGE band patterns and indicated that the seed continued to be physiologically active during curing and drying. Pods dried in the fields under ambient conditions by various drying methods showed variation in germination due to drying methods. Seed dried in windrows showed germination about 74% immediately after drying and 13% after nine months of storage. Whereas, seed dried by the NRC for Groundnut method maintained germination up to 66% even after nine months of storage.

Key words: Groundnut, drying methods, germination, SDS-PAGE

Introduction

In groundnut storage, pod moisture plays an important role in the maintenance of the seed viability and quality. Groundnut crop, being indeterminate in nature, at maturity contains pods of various stages of development. Thus maturity stage contributes significantly in the variations (between 35 and 50%) in pod moisture content at harvest. The groundnut pods lose considerable amount of moisture during post-harvest curing and drying. This loss of moisture is accompanied by several biochemical and physical changes in the seed. Curing of groundnuts under controlled as well as ambient conditions has a significant influence not only on the seed viability but quality also (Ahmed and Young, 1982; Nautiyal and Zala, 1991). Chung *et al.* (1998) reported that a number of dehydrin-proteins are related with various maturity and curing stages of groundnut seed. The present experiment was under taken to study the influence of various drying methods and temperature on the germinability and band pattern of seed proteins discernible by PAGE.

Materials and methods

Drying under controlled conditions: Groundnut (*A. hypogaea* ssp. *fastigiata* var. *vulgaris*) cv. GG 2 was sown in summer season in 1998 and 1999 in 30 x 20 m plot area. Plants were harvested randomly from an area of 1 m^2 in triplicate at the physiological maturity i.e., 110 days after sowing. All the pods from individual plant, except a few immature, were stripped immediately after harvest, and pods were pooled from all the replicates. From the pooled lot after through cleaning 1 kg of pods, which was at about 45-50% moisture content was dried separately at 39°C, 50°C, and 60°±1°C in forced hot-air-flow drier (spread in an area of 0.09 m^2 areas, at an airflow rate of 2.48 m^3/minute and velocity 0.46 m^2/sec).

Drying under natural ambient conditions: Crop at maturity i.e., 110 days after sowing was harvested manually and about 500 plants containing pod moisture about 45-50% were dried in a replicated manner by one of the following methods.

Windrows : Crop after harvest was spread in row in single layer, and plants were allowed to dry in the field under direct sunlight for six days. At the end of 6[th] day of drying, pods generally attained moisture content about 12%.

Shade drying: Plants were tied in bundles (approx 1 m diameter) and bundles were dried in an inverted position (i.e., haulms towards the floor and the pods towards the roof) in a three side open shed (i.e. not exposed to direct sunlight) for six days, and pods were separated from the plants manually at 18% moisture content.

National Research Centre for Groundnut method: A pyramid like structure was fabricated using three bamboo sticks (about 1.5 m), the sticks were tied together at one end and the free ends were placed on corners of triangle drawn on ground. About 20 cm above the ground and at every 15-18 cm subsequently, a coir rope was tied around the structure to form triangular loops. The plants were hung on these rope-loops in inverted position i.e. pods towards sky and haulms towards earth (Nautiyal *et al.*, 2001). Plants were allowed to dry in the structure for six days, at 16% pod moisture content.

Directorate of Oilseeds Research method: In this method pods were dried following the method of the Directorate of Oilseeds Research (Anonymous, 1983). After harvest plants were tied in bundles of about 1 m in diameter. These bundles were dried in pairs. One bundle was kept inverted in the field while the other was placed upright on the first thus the pods from both the bundles remained above the ground sand-witched between the two layers of haulms. In the evening the upper bundle was removed and placed over the field in inverted position i.e., haulms down and pods up side, again in the next morning the bundle was kept in an inverted position over the other. Same process was followed for six days, and then pod attained 16% moisture.

Conventional method: Pods were dried in field by heaping together in a random manner for seven days in open sun. At the end of drying period pod attained moisture about 15%.

Storage and seed germination: After seven days drying in the respective method pods were stripped manually from the plants and dried uniformly for 2-3 days in thin layers to a moisture level between 8-9%. Pods at this moisture level were stored in cotton bags and all the bags were stored in galvanized bins. Seed germination was tested during different storage periods by shelling the pods. Germination studies were conducted in rolled germination towels by placing 50 sterilized seeds in triplicate over the moistened germination towel. Seed germination was recorded after seven days of incubation at 30°C following the ISTA method (1993).

The data recorded on germination during storage, in the year 1998 and 1999, was pooled and analysed statistically in a Complete Randomized Block Design following Gomez and Gomez (1984).

SDS-PAGE analysis: For SDS-PAGE, five seeds from each treatment were ground in a pestle with mortar after removal of testa, and 100 mg meal was extracted with 1 ml of Tris-HCl buffer (pH 7.5, 50 mM) by shaking in cold for 30 minutes. The extract was centrifuged and the protein in the supernatant was estimated by the method of Bradford (1976). The extract was subjected to SDS-PAGE by the method described by Laemmli (1970). Samples containing about equal amounts of protein were treated with TRIS buffer containing sodium dodecyl sulfate (SDS), glycerol and bromophenol blue. For each treatment, 30 mg of protein was electrophoresed, on 10% bisacrylamide SDS gel (stacking gel), and 12.5% (w/v) polyacrylamide (1 mm thickness) separating gels. The gels were later stained with coomassie Brilliant Blue G-250. The variation in the position of the bands in any lane was expressed in Resolution factor (R_f) values. The bromophenol blue dye front at the bottom of gel was arbitrarily given the value 1, while the top of the gel was given a value of zero. The standard proteins used were glumatic dehydrogenase (53 kDa, R_f 0.66), transferage 76 (kDa, R_f 0.41), β-galactosidase (116 kDa, R_f 0.24), α-2-macroglobulin 170 (kDa, R_f 0.09) and myosin (220 kDa, R_f 0.02). In both the years, SDS-PAGE was repeated at least three times to get uniform results.

Results and discussion

The drying temperatures had a significant bearing on both germination and its subsequent loss during storage (Table 1). Seed from pods dried at 39°C and 50°C apparently did not lose much viability during drying as both showed a germination of 92% soon after drying. Whereas, the seed from pods dried at 60°C had only 74% germination indicating that there was a considerable loss in germination during the drying process itself. Moreover, this rapid loss of germination continued to be there even during storage and after three months of storage these seeds were left with only 15% germination.

Table 1 **Germination of seed (in-shell) dried by artificial drying at *three different temperatures in the laboratory***

Temperature of drying (°C)	Germination (%)*	
	After completion of drying process	After post-drying storage (3 months)
39	92	64
50	92	21
60	74	15
LSD (P=0.05)	6.0	4.2

When the pods were dried in fields under ambient conditions, the seed obtained from these pods soon after the drying process was completed, showed significant differences in germinability due to drying methods (Table 2). The germinability ranged from 74 to 97%. The Directorate of Oilseeds Research, National Research Centre for Groundnut, shade drying and conventional methods, all showed >90% germination, however, seed from the pods dried by windrow method had only 74% germination.

Except for windrow method, which adversely affected seed germination during the process of drying to bring it as low as 74%, for all other methods there was not any substantial loss of germination as the germination was more than 94%. Irrespective of drying method, there was a considerable loss of germination during post drying storage for nine months. In case of seed dried by windrow, the germination after storage reached as low as 13%. Among all the drying methods, during nine months storage, there was least loss of germination in shade and the National Research Centre for Groundnut methods, which had nearly the same level of germination i.e. 65 and 66%, respectively. On the other hand a much greater and nearly equal loss was observed for conventional and the Directorate of Oilseeds Research method, which also had nearly, equal germination i.e. 47 and 48%, respectively (Table 2).

Table 2 Seed germination percentage and pod temperature (°C) under the natural curing conditions in the field

Method of drying	Average day temperature during drying (°C)	Germination (%)*	
		After completion of drying process	After post-drying storage (9 months)
DOR**	39	94	48
NRCG**	38	97	66
Windrows	40	74	13
Conventional	39	95	47
Shade	38	93	65
LSD (P=0.05)	-	10.2	

* Values pooled for the year 1998 and 1999.
** DOR and NRCG; the Directorate of Oilseeds Research and the National Research Centre for Groundnut methods, respectively.

When seed proteins were subjected to SDS-PAGE, differences due to drying temperature were easily discernible. Seed protein profiles for drying at 60°C virtually lacked a few high molecular weight protein bands, which were otherwise conspicuous in the seed dried at 50° and 39°C (Fig 1).

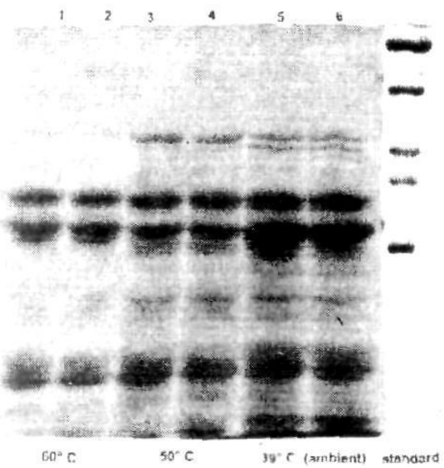


Fig. 1 SDS-PAGE analysis of proteins from cotyledons and embryonic axes of seeds from the pods dried at three different temperature (1, 2, 60°C; 3, 4, 50°C; 5, 6, 39°C) in the laboratory

Some differences were also observed for drying methods. These differences, however, were by and large quantitative and confined to the differences in relative densities of bands rather than qualitative i.e. in number or position of bands (Fig 2).

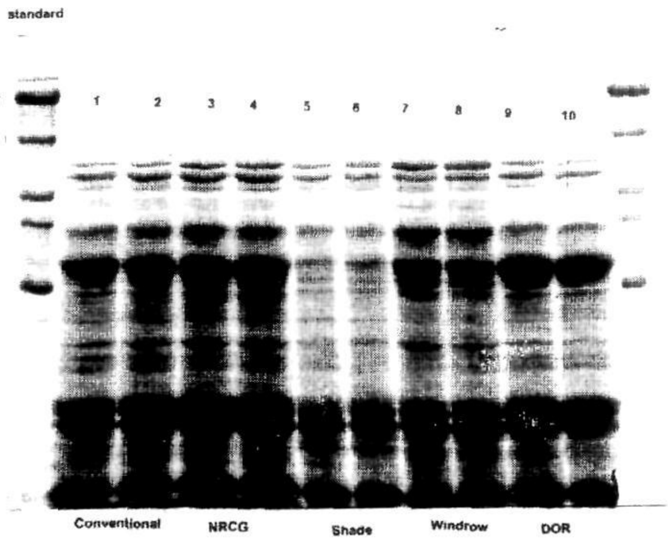


Fig. 2 SDS-PAGE analysis of proteins from cotyledons and embryonic axes of seeds from the pods dried by various methods (1, 2, conventional; 3, 4, NRCG; 5, 6, shade; 7, 8, window and 9, 10, DOR methods) in the field

The electrophoretic patterns for drying at different temperatures indicated that the seed continued to be physiologically active during curing and drying and some proteins of molecular weight a little more than 120 kDa are produced during curing. The drying at 60°C may have prevented synthesis of these proteins due to denaturation of certain enzymes associated with production of these proteins and hence these samples showed the least germinability after completion of drying process.

Stress proteins are induced in plants in response to environmental changes in temperature, oxygen or water levels. It was hypothesized that stress proteins occur in groundnut seed during maturation and curing because these processes are known to be associated with water deficit and anaerobic metabolism in seed. Recently, in groundnut a number of dehydrin-related stress proteins have been detected in seed of different maturity and curing stages (Chung *et al.*, 1998). In leguminous seed, desiccation tolerance occurs at later times during development i.e. at maturity drying (Matthews, 1973; Eliss *et al.*, 1987). Acquisition of desiccation tolerance is associated with several cellular and metabolic events leading to the biosynthesis and accumulation of potentially protective molecules such as late- embryogenesis abundant (LEAs) and dehydrin proteins (Kermode, 1997), and sucrose, oligosaccharides or glactosyl cyclitols (Koster and Leopold, 1988). However, the exact role of these proteins in determining seed viability needs further investigations.

Acknowledgements: The authors thank to Mr. P. V. Zala, and Mr. V. K. Jain, for their technical assistance.

References

Ahmed, E.H. and Young, C.T. 1982. Composition, nutrition and flavour of peanut. In: *Peanut Science and Technology*, (eds. Pattee, H.E. and Young, C.T. 1982). American Peanut Research and Education Society, Inc. Yoakum, Texas, USA, pp.655-688.

Anonymous, 1983. Simple and efficient post-harvest technique for increasing seed viability of the rabi/summer groundnut. Directorate of Oilseeds Research Newsletter, **2** : 1-5.

Bradford, M.M. 1976. A rapid and sensitive method for the quantitation of microorganism quantities of protein utilizing the principle of protein-dye binding. Analytical Biochemistry, **72**: 248-254.

Chung, Si Yin, Vercellotti, J. R., Sanders, T.H, Chung, S.Y. 1998. Evidence of stress proteins and potential maturity marker in peanuts. *Journal of Agricultural and Food Chemistry*, **46**: 4712-4716.

Eliss, R.H. Hong, T.D. and Roberts, E.H. 1987. The development of desiccation-tolerance and maximum seed quality during seed maturation in six grain legumes. *Annals of Botany*, **59**: 23-29.

Gomez, K. A. and Gomez, A.A. 1984. *Statistical Procedures for Agriculture Research*. Wiley, New York.

International Seed Testing Association. 1993. International rules for seed testing. *Seed Science and Technology*, **13**: 322-441.

Kermode, A. R. 1997. Approach to elucidate the basis of desiccation-tolerance in seeds. *Seed Science Research*, **7**: 75-95.

Koster, K.L. and Leopold, A.C. 1988. Sugars and desiccation tolerance in seeds. *Plant Physiology*, **88**: 829-832.

Laemmli, U.K. 1970. Cleavage of structural proteins during the assembly of the head of bacteriophage T4. *Nature* (London), **227**: 680-685.

Matthews, S. 1973. Changes in developing pea (*Pisum sativum* L.) seeds in relation to their ability to withstand desiccation. *Annals of Applied Biology*, **75**: 93-105.

Nautiyal, P.C, Ravindra, V. and Zala, P. V. 2001. A new method for drying groundnut pods for better seed storability. *International Arachis Newsletter*. **21**: 26-30.

Nautiyal, P.C. and. Zala, P.V. 1991. Effect of drying methods on seed viability and seedling vigour in Sapnish groundnut (*Arachis hypogaea* L.). *Seed Science and Technology*, **19**: 451-459.

J. Oilseeds Res., **22**(1) : 129-135 (2005)

Rhizosphere mycoflora of groundnut, *Arachis hypogaea* L. in different organic and inorganic amended soil under field condition

S.K. Raj, D. Mandal and Srikanta Das

Department of Plant Pathology, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur-741 252, WB

(Received: December, 2003; Revised: September, 2004; Accepted: October, 2004)

Abstract

Population fluxes in the total and component rhizosphere mycoflora in groundnut experimental plots *receiving differential nitrogen in relation to* sources (organic and inorganic) and dose level (3) revealed that both source and level of N brought about differential shifts in total and component parameters of the mycoflora as the function of the season in which the crop is grown as well as the age of the plants. The primary component of the mycoflora included *Aspergillus niger, Aspergillus flavus, Penicillium* sp., *Pythium* sp., *Rhizopus* sp., *Verticillium* sp., *Thielavia* sp., *Sclerotium* sp., *Trichoderma* sp. and *Fusarium* sp., of which *Penicillium* and *Aspergillus* were most dominant in all the samples. In inorganic N (irrespective of dose) treatments the rhizosphere population was most abundant throughout crop growth stages in both seasons. Among the organics as de-oiled cakes population was least throughout the investigation period (90 days) in *mahua* and neem cake treated soil. Component wise, population shifts in rhizosphere mycoflora as a function of N source, N-level, season and crop age were recorded and are reported. The rhizosphere mycoflora generally peaked at 60 days of crop growth and declined thereafter irrespective of the treatment. Diversity of mycoflora was significantly less in plots treated with *mahua* cake but aspergilli remained predominant.

Key words: Fertilizers, groundnut, manures, mycorhizosphere, soil amendment

Introduction

Productivity of soil and crop yield is known to be related to microbial diversity and intensity that includes both pathogens and nonpathogens. The microbial population, specially rhizosphere population shows significant shifts as a function of edaphic conditions (Soil pH, temperature, moisture, *texture etc.) and soil nutrient status* - (Rovira, 1965). Such shifts in rhizosphere population may alter the growth, development and ultimately yield of the crop plants. The effect of different amendments (organic or inorganic) could vary the behaviour of pathogenic micro-organisms in soil. Keeping these in view, the present study was under taken for understanding the extent and nature of the microbial population fluxes in rhizosphere of groundnut during one crop period (seedling to harvest) in different organic and inorganic amended plots for a critical *evaluation of facultative saprophytes for framing a suitable* and sustainable management strategy.

Materials and methods

The experiment was conducted at the University Teaching Farm, Mohanpur, West Bengal, India. The land is topographically medium and the soil texture is sandy loam. The groundnut cultivar "Phulepragati" (JL-24) was sown during winter and rainy seasons of 1998-1999. The plot size was 2m x 2m with three replications. The seeds were sown in a spacing of 30 cm row to row and 20 cm plant to plant. The design of the experiment was Factorial Randomized Block Design with seven main treatments and three sub treatments. The main treatments were five different organic amendments with one inorganic and one untreated control (without organic or inorganic fertilizers) were used. The sub treatments were three different doses of these amendments. The main treatments and their different doses were T_1 (FYM) = @ 40; 20; 10 t/ha; T_2 = mustard cake @ 67.61; 33.80; and 16.90 q/ha, T_3 = neem cake @ 34.19; 17.09 and 8.54 q/ha; T_4= groundnut cake @ 69.28; 34.64 and 17.3 q/ha; T_5 = *mahua* cake @ 11.61; 5.80 and 2.90 t/ha; T_6 = NPK @ 30:70:30 kg/ha; 15:35:15 kg/ha and 7.5:17.5:7.5 kg/ha and T_7 = untreated control. All the manures, fertilizers and cakes were applied as basal dose before sowing of seeds.

Soil samples were collected at 15 days intervals starting *from 0 day through 90 days after sowing (DAS)* from the rhizosphere of the groundnut crops in both winter and rainy seasons. "O" days means soils were collected initially before sowing from the plots after amendments. Groundnut seedlings selected randomly in the different treated plots were uprooted carefully and brought to the laboratory at stipulated date. The soil particles adhering to *the roots were removed carefully.* One gram of this soil was taken and thoroughly mixed in 100 ml of sterile distilled water, which served as stock solution. Serial dilution technique was used to estimate the number of mycoflora in the rhizosphere of groundnut. From the stock solution, subsequent dilutions were prepared. A dilution series of collected soil was made upto to 10-4 following Warcup (1960) for estimating c f u present in test solution.

The *Martins dextrose peptone Rose Bengal Agar medium* amended with streptomycin sulphate was used to isolate the rhizosphere mycoflora. Dilutions were poured into medium and distributed in sterilized five petriplates. For each treatment five petriplates with no inoculation of stock solution served as control. After inoculation the petriplates (treated and control) were incubated in a BOD at 28 ± 1°C. Sterilized glasswares and media (Tuite, 1969) were used for conducting the experiments.

After fifth day of incubation the c f u of different mycoflora growing in the petriplates were identified following Raper and Fennel (1977), Bernet and Hunter (1972) and John and Hocking (1985).

Results and discussion

Rhizosphere mycofloral population: Quantitative nature of mycofloral colonies was assessed from different treatments at different crop stages in two different seasons. It has been observed that in winter season except initial population, the highest population of mycoflora was observed in FYM treated plots and lowest in neem cake treated plots. In rainy season, the highest population was observed in NPK treated plots and lowest again in neem cake treated plots except in initial sample where the lowest population was in FYM treated plot. The initial population density was highest in NPK treated plots (4.28×10^4 cfu/g soil) and lowest in groundnut cake treated plots (2.94×10^4 cfu/g) soil and the difference between these data were statistically significant. The mycofloral populations of other organic amended plots were statistically at par with groundnut cake treated plots (Fig. 1).

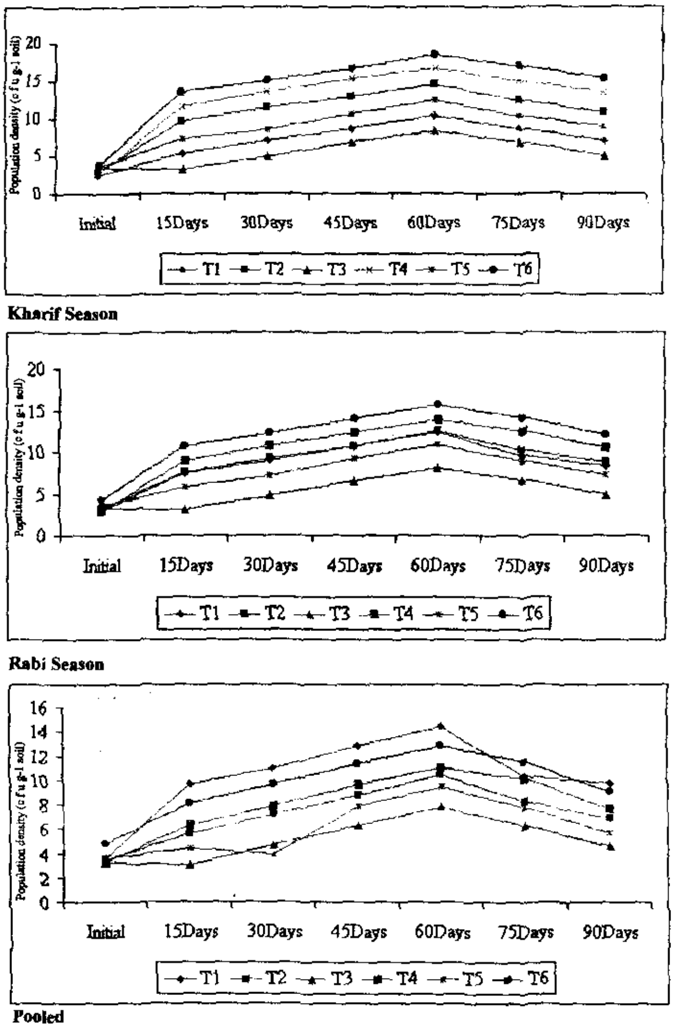


Fig. 1 Effect of organic matter amendment on rhizosphere mycoflora population (10^{-4} dilution) of groundnut

The pooled data mean of two seasons showed that after 30 DAS the mycoflora population was similar to that of 15 DAS (Fig. 1). After 45 DAS highest mycoflora population was recorded in FYM treated plots (12.89 x 10^4 cfu/g soil) followed by NPK (11.33 x 10^4 cfu/g soil). These differences, however, were not statistically significant. Lowest population was recorded in neem cake treated plots (7.89 x 10^4 cfu/g soil) in winter. In rainy season, the mycobial population was highest in NPK (16.67 x 10^4 cfu/g soil) followed by groundnut cake (15.22 x 10^4 cfu/g soil), which was similar with that of earlier observations (Fig. 1).

Similarly, after 60, 75 and 90 DAS the highest mycobial population was observed in FYM treated plots in winter and NPK in rainy and lowest in neem cake treated plots in both the seasons. In winter, it was observed, that highest population in FYM treated plots and lowest in neem cake treated plots except at initial sample where NPK showed maximum fungal population. It was also found that mycobial population gradually increased up to 60 days and decreased gradually (Fig. 1) with the age of the crop.

In rainy season, the initial rhizosphere mycoflora population was highest in NPK treated plots and lowest in FYM treated plots. Here mustard, neem and *mahua* cake treated plots, the differences in mycofloral population were not statistically significant. In all the ages of the crop, the highest population was observed in NPK treated plots and lowest in neem cake treated plots. The pooled mean data showed that the mycofloral population increased upto 60 DAS and thereafter decreased gradually (Fig. 1).

So in both the seasons, the lowest mycofloral population was observed in neem cake treated plots. It may be due to production of Azadiractin by neem cake which inhibit the growth and reproduction of the rhizosphere mycoflora (Dhanapal, 1993; Singh, 1993).

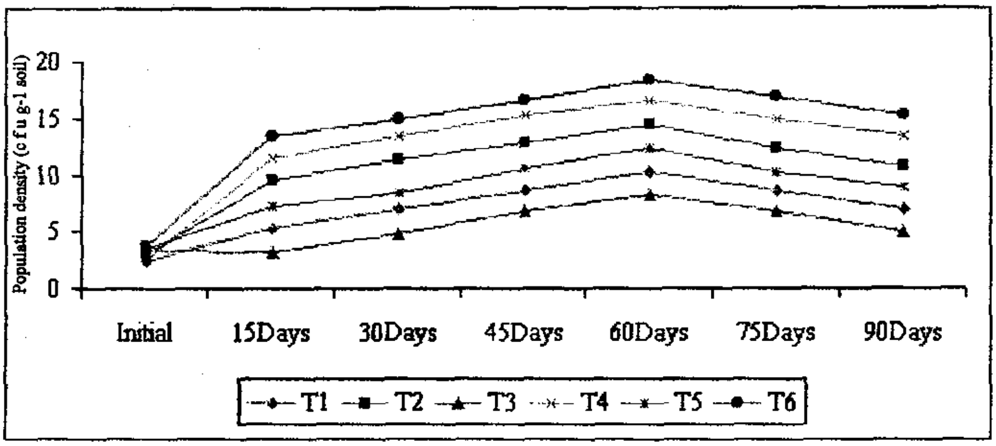
It was also found that quantitative nature of rhizosphere mycoflora was lower in winter season as compared to rainy season except in the plots treated with FYM. This could be due to low temperature during winter months, causing poor decomposition of organic matter, thus inhibiting the normal growth and reproduction of the rhizosphere mycoflora. Maximum mycofloral count was observed in rainy season that may be due to high soil moisture and favourable temperature that favoured rapid decomposition of organic manure and cakes leading to adequate nutrient availability for saprophytic growth of the soil mycoflora.

It was also observed that the total rhizosphere mycofloral counts of various treatments gradually increased with age of the crop upto 45-60 DAS and then decreased with increasing crop age. This may be due to initial increase of nutrient supply to the mycofloral population which is gradually depleted with great vigour of plants that lead to luxuriant uptake of nutrients and secretion of some toxic metabolites (McDonald, 1969; Gangwane and Despande 1977).

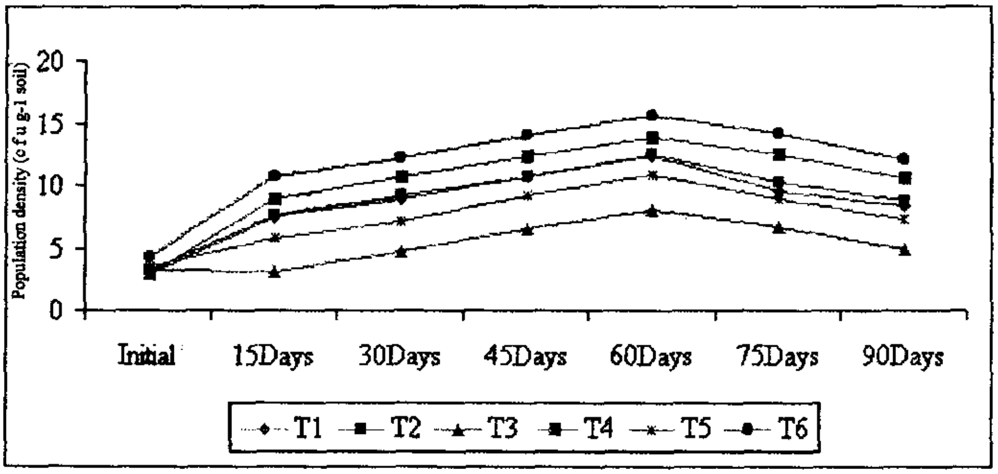
Effect of different doses of manure and fertilizers on mycofloral population: The different dose showed no significant difference among themselves at 15 DAS and lowest was observed in neem cake and highest in NPK treated plots. For every dose within a treatment, there was a significant difference in population (Fig. 2). The pooled data for two seasons at 30 DAS also showed that a gradual increase in population in different treatments was statistically significant but doses showed no significant difference among themselves. Here also NPK treated plots showed highest mycofloral population (12.50 x 10^4 cfu/g soil). With increase in age there was a increase in rhizosphere mycofloral population. The pooled data showed that highest population was recorded in NPK treated plots (14.33 x 10^4 cfu/g soil) followed by groundnut cake (12.67 x 10^4 cfu/g soil) and lowest in neem cake (6.67 x 10^4 cfu/g soil). FYM and mustard cake showed no significant difference in mycofloral population irrespective of their doses (11.00 x 10^4 cfu/g soil). This general trend continued upto 60 DAS and started decreasing thereafter. Thus, doses had no significant effect in altering the mycofloral population. These results showed that in all the three doses of neem cake treated plots at all stages of crop growth the population of rhizosphere mycoflora was minimum. Similar findings were made by earlier workers (Frank, 1969; Reddy, 1980).

Qualitative assay of rhizosphere mycoflora: The qualitative assay showed that *Aspergillus niger, Penicillium* sp., *Aspergillus flavus, Pythium* sp., *Rhizopus* sp., *Verticillium* sp. and 4 to 5 unidentified fungi were regular residents in the experimental plot treated with FYM (Fig. 3). Among them, *Aspergillus niger* was more abundant in comparison to others. It was also observed that some of the unidentified ones along with *Pythium* were observed upto 60 DAS and then disappeared in FYM @ 20 t/ha and 13.34 t/ha amended plots. *Verticillium* sp. showed no regular pattern.

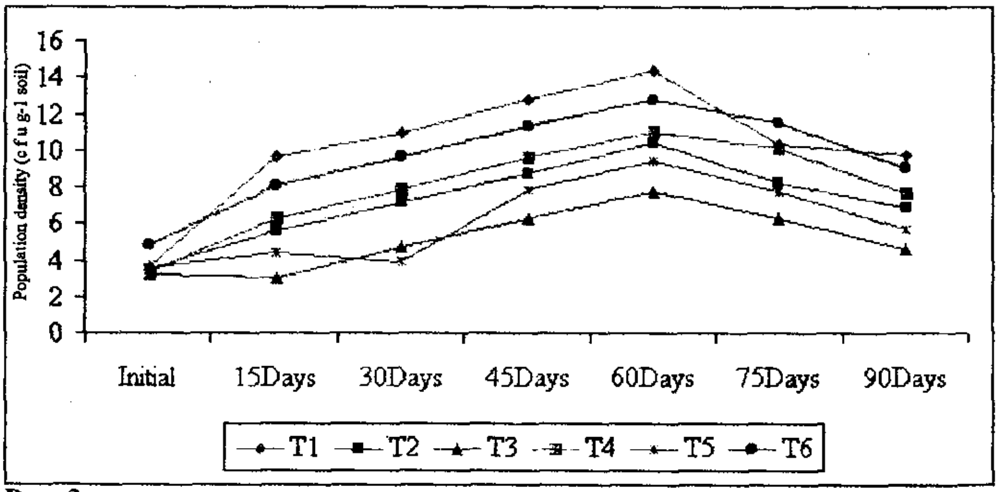
In mustard cake amended plots, *Aspergillus flavus* was dominant followed by *Penicillium* sp. *Thielavia* sp. was observed at 30 DAS and lasted upto 75 DAS. *Verticillium* sp. and *Trichoderma* sp. were observed at 45 DAS and lasted upto 60 to 75 DAS respectively. In this treatment, *Aspergillus niger* was characteristically absent. Here, it was also observed that with decreasing dose, there was increase in colony number of different unidentified fungi (Fig.4).



Dose 1



Dose 2



Dose 3

Fig. 2 Effect of organic matter amendments at different doses on rhizosphere mycoflora population(10^{-4} dilution) of groundnut

FIG 3 Relative mycofloral percentage under different doses (D_1, D_2 and D_3) of FYM at different ages of crop growth

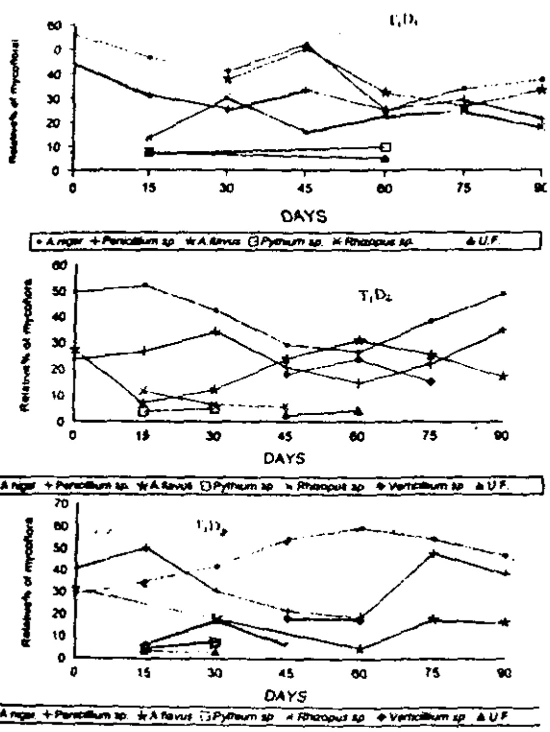


FIG 4 Relative mycofloral percentage under different doses (D_1, D_2 and D_3) of mustard cake at different ages of crop growth

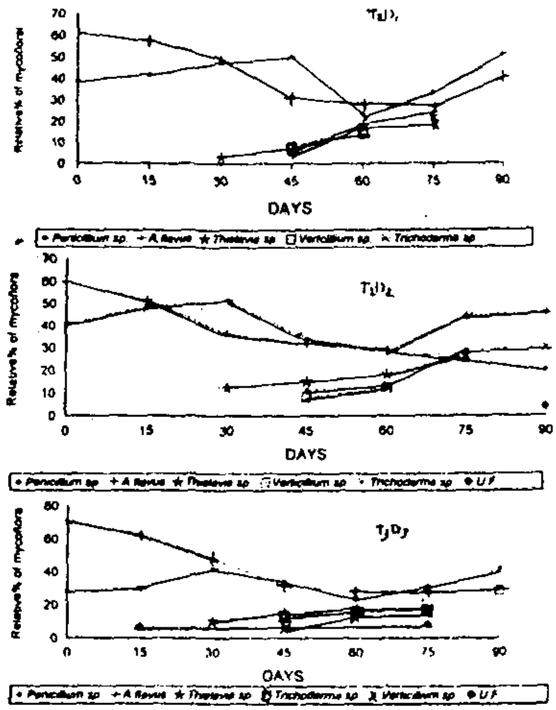


FIG 5 Relative mycofloral percentage under different doses (D_1, D_2 and D_3) of neem cake at different ages of crop growth

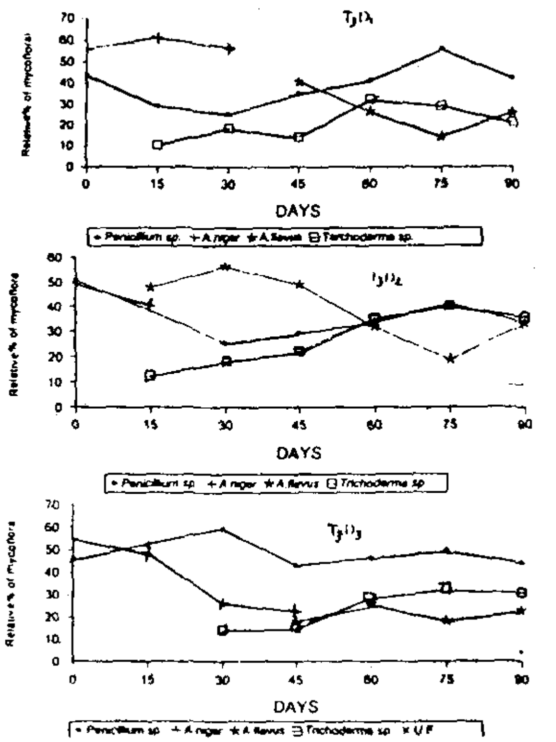


FIG 6 Relative mycofloral percentage under different doses (D_1, D_2 and D_3) of groundnut cake at different ages of crop growth

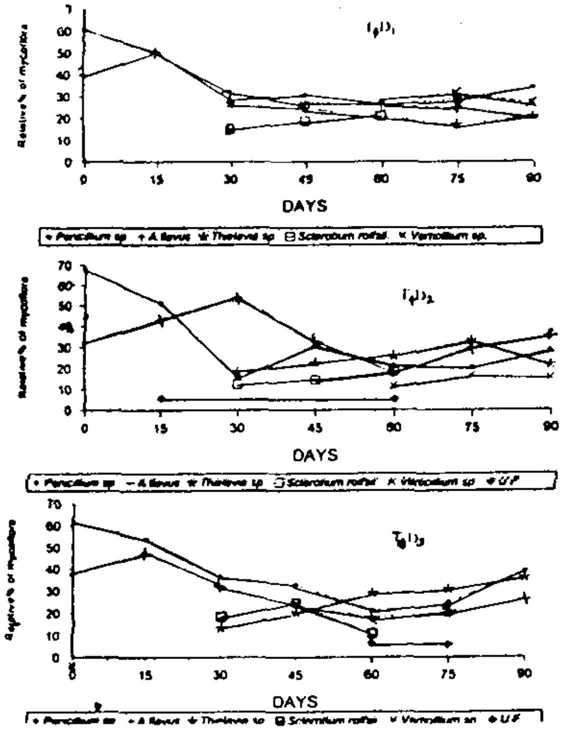


FIG 7 Relative mycofloral percentage under different doses (D_1, D_2 and D_3) of mahua cake at different ages of crop growth

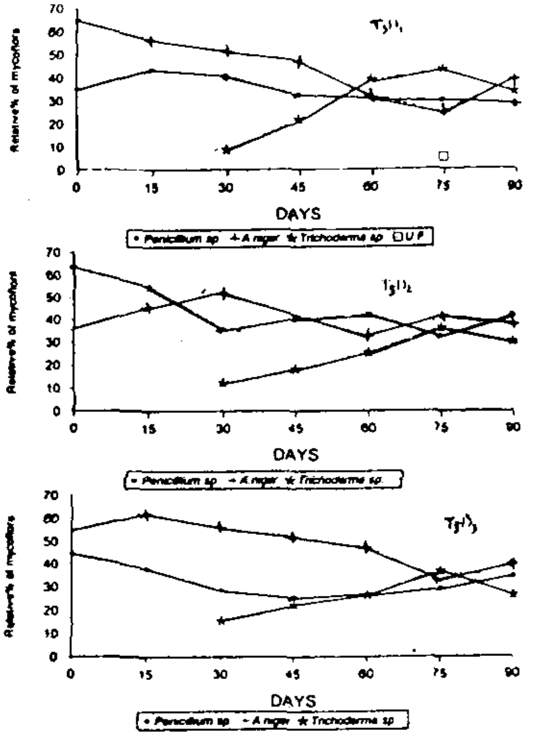
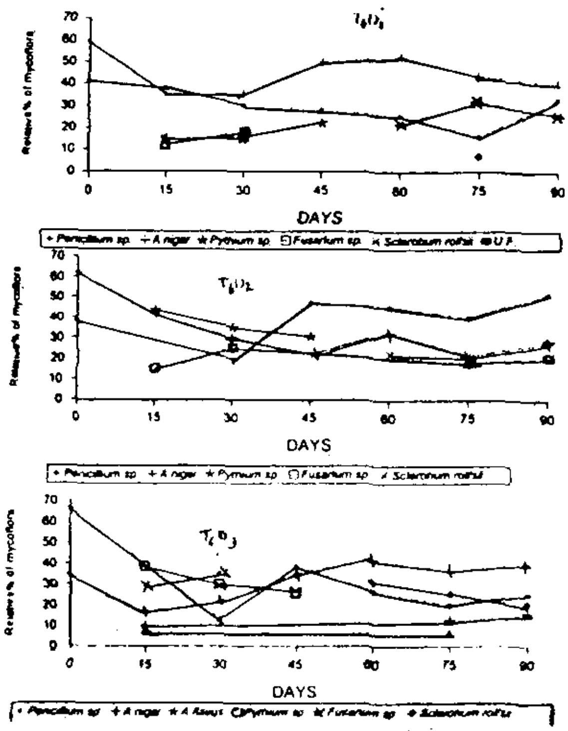


FIG 8 Relative mycofloral percentage under different doses (D1, D2 and D3) of NPK at different ages of crop growth



Penicillium sp. was more predominant in neem cake treated plots (Fig.5) followed by *Trichoderma* sp., though it appeared at 15 DAS and in lower doses at 30 DAS. Here it was observed that *Aspergillus niger* was prevalent from initial to 30 DAS and in lower doses upto 45 DAS. *Aspergillus flavus* appeared at 45 DAS in higher doses at 15 DAS in medium doses and 45 DAS in lower doses.

Penicillium sp. was dominant in groundnut cake amended plots followed by *Aspergillus flavus* from initial to 90 DAS where as *Thielavia* sp. was observed at 30 DAS. A new fungus *Sclerotium* sp. was observed in this amended soil at 30 to 60 DAS and disappeared later while *Verticillium* sp. appeared at 60 to 90 DAS (Fig. 6). Only three components of mycoflora *viz*., *Penicillium* sp., *Aspergillus niger* and *Trichoderma* sp. were observed in *mahua* cake amended soil. Among them, *Aspergillus niger* was predominant followed by *Penicillium* sp. at initial to 90 DAS.

Trichoderma sp. appeared at 30 DAS and increased with decrease in dose and with maturity of crop (Fig. 7).

Highest mycoflora count was observed in NPK treated plots irrespective of their doses. Here, two additional fungi *Pythium* sp. and *Fusarium* sp. appeared at 15 DAS and their irregular appearance was noted at different growth stages. Here, also *Aspergillus niger* was predominant followed by *Penicillium* sp. and *Pythium* sp. (Fig. 8).

Thus, this experiment revealed that rainy season represented a season supporting higher percentage of mycofloral population than winter. Minimum mycofloral population was observed in neem cake amended plots followed by *mahua* cake from initial to 90 DAS both in winter and rainy seasons. Maximum population was observed in NPK treated plots both in winter and rainy seasons. Among the organic amendments, groundnut cake supported higher mycofloral population both in winter and rainy seasons and increased gradually with increasing crop age, up to 60 DAS and decreased gradually irrespective of their doses.

Acknowledgement: Thanks are due to Prof. C.Sen, Deptt. of Plant Pathology (Retd.) for critical review of the manuscript.

References

Bernet, H.L. and Hunter, B.B. 1972. *Illustrated Genera of Imperfact Fungi*. 3rd Ed. Burg Pub. Co. Minnesota, pp. 241.

Dhanapal, K., Thomas, J. and Naidu, R. 1993. Antifungal properties of neem products against rhizome rot of small cardamon. *Neem and Environment*, pp.793-798.

Frank, Z.R. 1969. Location of seed borne innoculum and combined control of *Aspergillus* and *Rhizopus* rots of groundnut seedlings by seed treatment. *Israel Journal of Agricultural Research*, **19** : 109-114.

Gangwane, L.V. and Deshpande, K.B. 1977. Agronhomic treatments and changes in the rhizosphere mycoflora of groundnut. *Acta Agronomica Academiae Scientiarum Hungaricae*, p.26.

John I.P. and Hocking, A.D. 1985. Fungi and food spoilage. *In: Food Sc. And Tech. A series of monograph. Academic Press Australia*, pp.279-304.

McDonald, D. 1969. The influence of the developing groundnut fruit on soil mycoflora. *Transaction of British Mycological Society*, **53**:393-403.

Raper, K.B. and Fennel, D.I. 1977. The genus Aspergillus. *Williams and Wilkins Co. Bastimore*, p.476.

Reddy, M.N. 1980. Studies on groundnut hypocotyl exudates and the behaviour of *Rhizoctonia solani* in influencing the disease. *Plant and Soil*, **55**: 445-54.

Rovira, A.D. 1965. Interaction between plant roots and soil microorganisms. *Annual Review of Muicrobiology*, **19**: 241-68.

Singh, H.B. 1993. Antifungal activity of neem oil and its efficacy in biocontrol measures in combination with *Trichoderma harzianum* (abstract). In: *World Neem Conference*, 24-28 Feb.; Bangalore, India, p.46.

Tuite, J. 1969. Plant Pathological Methods: *Fungi and Bacteria. Burg. Pub. Co. Minn.* p.239.

Warcup, J.H. 1960. *Methods for isolation and estimation of activity of fungi in soil.* In: D. Parkinson and J.S. Waid (eds). *Ecology of soil fungi. Liverpool University Press, Liverpool*, pp.3-21.

J. Oilseeds Res., **22**(1) : 136-140 (2005)

Association of linolenic and oleic acid content in soybean, *Glycine max* L. with seed size and maturity period

Anita Rani, Vineet Kumar, S.M. Hussain and Om Prakash Joshi

National Research Centre for Soybean, Khandwa Road, Indore-452 017, MP

(Received: September, 2003; Revised: October, 2004; Accepted: December, 2005)

Abstract

Soybean varieties with high oleic acid and low linolenic content are desirable for better oxidative stability of oil. The information on the association of maturity periods and seed size on fatty acid composition of soybean oil is scarce. Eighty three Indian soybean genotypes, comprising all the cultivars (75) and few breeding lines (8), were grown and the maturity period and seed size were observed. The mature seeds of all the genotypes were evaluated for fatty acid composition to identify cultivars/ lines with comparatively low linolenic and high oleic acid content. High variability existed for different fatty acids; with oleic, linoleic and linolenic acid ranging from 18.5-48.5, 30.0-56.4 and 4.6-9.0% respectively. Negative association of oleic with linoleic acid ($p<0.001$) and linolenic acid ($p<0.001$) were observed along with positive association between linoleic acid and linolenic acid ($p<0.001$). Maturity period of the genotypes showed negative correlation with oleic acid ($p<0.001$) and positive with linoleic ($p<0.001$) and linolenic acid ($p<0.01$). Significant associations were observed between seed size and different fatty acids. Seed size showed positive association with oleic acid ($p< 0.001$) and negative with linoleic ($p<.001$) and linolenic acid ($p<0.01$). M/P (monounsaturated / polyunsaturated fatty acids) ratio, an indicator of oxidative stability, ranged between 0.30-1.39 and exhibited very high negative correlation with maturity period ($p<0.001$) and positive correlation with seed size ($p<0.001$). The results observed suggest that maturity period and seed size may be considered in soybean breeding programme for developing high oleic and low linolenic lines.

Key words: Soybean, oleic acid, linolenic acid, seed size, maturity period

Introduction

Despite being one of the nutritious and the most economical vegetable oil in market, soybean oil does suffer from the shortfall of poor shelf life ascribed to its poor oxidative stability. The partial hydrogenation of soybean oil employed by industries to impart fairly good oxidative stability is not only cost-ineffective but also leads to formation of trans fatty acids about which serious concerns are being raised by medical fraternity (Zock and Katan, 1992;Willet and Ascherio,1994).On the other hand, oleic acid, a monounsaturated fatty acid, besides being equally effective in reducing serum total and LDL cholesterol levels as polyunsaturated fatty acids (Matteson and Grundy, 1985) impart oxidative stability.

Globally, soybeans with low linolenic and high oleic acid have been identified and developed (Fehr *et al.*, 1992; Rahman *et al.*, 2001); however, the information on association of agronomic characteristics *viz.*, maturity period and seed size on these two important characteristics is scanty (Maestri *et al.*, 1998; Liu *et al.*, 1995). In the present investigation, 83 genotypes, comprising all the released cultivars, of Indian soybean, were grown and their maturity period and seed size were observed. The mature seeds of these genotypes were evaluated for fatty acids composition to assess the association of oleic and linolenic acid with maturity period and seed size.

Materials and methods

Eighty three Indian soybean genotypes, comprising of released cultivars (75) and few breeding lines (8), were sown in the fields of National Research Centre for Soybean (Indian Council of Agricultural Research) at Indore (22°N) on 25th June 2002. All the cultivars and breeding lines were harvested on their respective maturity.

Seed size and maturity period: Soybean seed has been categorized into bold, medium and small based upon 100 seed weight. Hence, in our investigation, weight was recorded from random sample of 100 oven-dried grains in triplicate to express seed size and mean value is given in Table 1. Maturity date was recorded when 95% of the pods on the plants attained their mature colour.

Estimation of fatty acids: The seeds from single plant of all the varieties and breeding lines were crushed into flour.

Oil was extracted from freshly ground seed flour using petroleum ether (boiling point 40-60°C) and transesterified in methanol with 1N sodium methoxide as catalyst following Luddy *et al.* (1968). Fatty acid methyl esters (FAMEs) were separated and analyzed in gas liquid chromatograph (GLC), Shimadzu GC 17A, using polyethylene glycol packed SGE BP20 capillary column, with length and diameter of 30 m and 0.32 mm respectively. Oven temperature of the gas liquid chromatograph was programmed at 140°C for 3.6 min, subsequently increased to 170°C at the rate of 13.5°C/minute and maintained for 3.8 min and finally increased to 182°C at the rate of 5°C/minute for best resolution of methyl esters. The temperatures of flame ionization detector (FID) and injector were maintained at 240°C. Nitrogen, the carrier gas used, was maintained at a flow rate of 15 ml/min. The peaks for individual fatty acid methyl esters were identified by comparing the retention times with those of standard methyl esters (procured from Sigma-Aldrich). Data given in Table 1 for different unsaturated fatty acids are means of triplicate determinations.

Statistical analysis: Correlation studies were conducted out by MSTAT-C programme developed by Russel D. Freed.

Results and Discussion

Oleic acid, a monounsaturated fatty acid which has good oxidative stability, varied between 18.4-48.5% with a mean value of 26.11%. Only four varieties *viz.*, LSb1, MACS330, MACS58 and Shilajeet, were observed to possess oleic acid 35 % or more. LSb1, the latest released variety for Southern India, showed the highest oleic acid percentage (48.5). The polyunsaturated fatty acids *viz.*, linoleic and linolenic acid ranged between 30.0-56.4 and 4.6-9.0 with mean values of 49.01 and 6.59 respectively (Table 1). Linolenic acid, the main culprit for poor oxidative stability, was observed minimum in MACS58 and JS80-21 but no variety/advanced line showed linolenic content below 4%, a desirable characteristic for improving oil quality of soybean. M/P (monounsaturated/polyunsaturated fatty acids) ratio of the genetic material studied ranged between 0.30-1.39. The highest value for M/P ratio was observed in LSb 1 while the lowest was observed in PK416 and PK1024. Fifty three varieties/ lines showed M/P ratio less than 0.5 while twenty five showed between 0.5-0.7 and only five varieties/lines *viz.*, LSb1, MACS330, MACS58, Pusa24, Shilajeet showed values 0.7 or more (Table1). Xia (1995) reported the ranges of oleic acid, linoleic acid and linolenic acid among seventy soybean cultivars cultivated in China as 16.9-27.3, 46.9-58.3, 6.6-13.2% with mean values of 21.47, 53.99 and 9.93%, respectively. In comparison to these results, our cultivars/lines in the present study showed comparatively low values for linolenic and higher values for oleic acid.

There was a very strong negative correlation (Table 2) of oleic acid with linoleic and linolenic acid ($p<0.001$). This result is in agreement with the earlier report of Liu *et al.* (1995). Seed size, expressed in terms of 100 seed weight of the genetic material studied, varied between 7.0-25.0 g (Table1). Maximum value for seed size was observed in Bhawali Bold followed by LSb1 while minimum was observed in CO1. Significant correlations were observed between seed size and individual fatty acids. Seed size showed a positive association with oleic acid ($p<0.001$) and negative association with linoleic ($p<0.001$) and linolenic acid ($p<0.01$). These correlations observed between seed size and unsaturated fatty acids are consistent with the earlier reports (Liu *et al.*, 1995; Maestri *et al.*, 1998). The results obtained suggest that seed size and its relationship with individual fatty acids may be considered in soybean breeding programme.

Maturity period of the genetic material grown ranged from 70-112 days. Maturity period exhibited strong associations with individual fatty acids (Table 2). It exhibited very strong negative correlation with oleic acid ($p<0.001$). Positive associations were observed between maturity period and linoleic and linolenic acid. However, the association between maturity period and linoleic acid has been found to be more stronger ($p<0.001$) than with linolenic ($p<0.01$). Decrease in oleic acid accompanied by increase in linoleic and linolenic acid with increasing maturing period in segregating generation of a cross between the normal cultivar Tracy and line 79-202 selected for high oleic acid content reported by Carver *et al.*, (1983) support our results. Oleic acid content has also been reported to have positive association with earliness in sunflower, another oilseed crop (Fernandenz-Martinez *et al.*,1989).Our results also indicated a very high negative correlation ($p<0.001$) of M/P ratio with maturity period and positive correlation with seed size ($p<0.001$).

Results obtained indicated that early maturing genotypes with bolder seed size may yield oil with higher oxidative stability and to establish it further studies involving population derived from crosses between early and late maturing varieties are required to establish the fact. However, in view of the fact that oleic acid is a quantitatively inherited character, the varieties identified for comparatively higher levels of oleic in the study may be used for pyramiding genes for high oleic acid.

Table 1 Composition of unsaturated fatty acids (%), ratio of mono to polyunsaturated fatty acids, maturity period and seed size in different genotypes of soybean

Variety / Breeding material	Oleic (C18:1)	Linoleic (C18:2)	Linolenic (C18:3)	M/P[a]	MP[b]	SZ[c]
ADT1	30.2	45.6	5.9	0.59	92	8.2
Alankar	24.5	49.0	7.3	0.44	96	12.5
Ankur	21.5	53.5	7.8	0.35	101	9.0
Bhatt Black	31.4	48.0	5.6	0.59	93	11.0
Bhatt yellow	28.8	49.2	5.6	0.53	91	11.3
Bhawali Bold	32.9	42.5	5.3	0.69	81	25.0
Bragg	21.5	55.0	7.0	0.35	102	11.0
BS1	27.5	48.5	5.6	0.51	96	12.1
CO1	25.3	48.6	7.0	0.46	97	7.0
COSoya2	30.9	45.1	6.3	0.60	87	11.0
Hardee	22.3	52.5	6.1	0.38	102	11.7
Hara soya	30.2	45.6	5.9	0.59	94	9.9
His1	22.6	52.6	7.7	0.37	102	9.3
GS1	24.5	48.9	7.2	0.44	95	10.1
GS2	22.0	51.0	9.0	0.37	100	8.7
Improved pelican	25.0	47.6	7.5	0.45	105	9.0
I S9	26.7	50.0	6.4	0.47	98	11.2
JS2	23.6	49.0	5.9	0.43	92	10.0
JS71-05	24.5	51.6	6.5	0.42	90	12.0
JS75-46	22.8	49.5	8.0	0.40	99	10.0
JS72-44	23.5	50.5	8.2	0.40	101	7.7
JS72-280	30.9	45.6	5.2	0.61	100	11.0
JS76-205	24.5	52.0	6.2	0.42	95	9.4
JS79-81	27.2	48.6	5.2	0.51	96	12.4
JS80-21	30.3	43.3	4.6	0.63	101	9.7
JS90-41	31.8	44.8	4.9	0.64	89	8.3
JS93-05	27.2	49.6	6.1	0.49	92	10.0
JS93-06	31.0	45.5	5.0	0.61	90	9.8
JS335	22.7	50.0	7.6	0.39	102	9.8
Kalitur	21.5	53.0	7.0	0.36	99	7.6
KB79	28.2	47.5	7.3	0.51	96	12.2
KhSb2	31.1	46.2	5.4	0.60	98	12.6
Lee	25.5	49.0	7.4	0.45	101	10.2
LSb1	48.5	30.0	4.8	1.39	72	18.0
MACS13	28.0	46.1	6.1	0.54	98	10.3
MACS124	28.5	47.0	6.0	0.54	95	10.5
MACS57	28.9	44.8	5.9	0.57	95	8.7
MACS58	37.7	39.2	4.6	0.86	96	10.2
MACS450	23.5	52.0	7.0	0.40	98	10.3
MACS330	38.3	34.5	6.9	0.93	70	14.1
MAUS1	23.9	51.3	6.2	0.42	100	9.8
MAUS2	22.8	51.0	6.9	0.39	102	13.2

Table 1 (Contd....)

Variety	Oleic (C18:1)	Linoleic (C18:2)	Linolenic (C18:3)	M/P[a]	MP[b]	SZ[c]
MAUS32	24.7	51.7	7.0	0.42	102	12.0
MAUS61	25.0	46.9	6.2	0.47	102	9.6
MAUS61-2	25.2	49.5	6.5	0.45	103	8.9
MAUS71	33.4	43.5	6.3	0.67	95	9.6
MAUS47	30.0	44.5	6.6	0.59	88	10.8
Monetta	31.0	45.5	6.4	0.60	90	12.0
NRC2	24.5	50.5	7.4	0.42	98	9.6
NRC 7	29.0	48.4	6.4	0.53	92	14.0
NRC 12	22.0	50.5	6.8	0.38	103	11.7
NRC 37	21.1	50.8	8.9	0.35	106	8.8
Palam Soya	27.0	48.1	5.8	0.50	95	11.0
PK262	23.5	51.5	6.5	0.41	101	10.5
PK308	27.6	47.5	6.3	0.51	100	9.5
PK327	23.0	53.5	7.6	0.38	93	7.5
PK416	18.5	55.0	7.2	0.30	101	11.1
PK471	24.4	52.2	7.3	0.41	99	12.3
PK472	24.5	51.8	6.6	0.42	100	8.2
PK564	21.1	54.0	7.9	0.34	92	9.4
PK1024	18.4	53.3	7.4	0.30	107	8.4
PK1029	23.7	51.8	6.5	0.41	108	9.9
PK1042	19.6	55.5	8.7	0.31	102	9.5
PK1092	21.5	51.5	6.7	0.37	102	9.3
Punjab1	23.5	49.5	6.7	0.42	108	13.0
Pusa16	19.4	53.6	8.6	0.31	106	10.0
Pusa20	24.0	52.5	5.8	0.41	108	13.0
Pusa22	19.9	52.3	8.5	0.33	104	10.0
Pusa24	33.9	42.5	5.5	0.71	102	12.0
Pusa37	25.2	51.5	6.7	0.43	105	10.0
Pusa40	24.0	53.1	6.1	0.41	110	9.1
RAUS5	29.0	46.5	6.8	0.54	95	12.0
Samrat	22.5	52.0	6.0	0.39	100	10.0
Shilajeet	35.0	44.5	5.4	0.70	90	13.2
Shiwalik	21.5	53.9	6.8	0.35	108	8.1
SL96	24.6	52.1	6.7	0.42	105	8.6
SL295	29.0	43.5	7.5	0.48	104	9.8
SL459	25.2	49.6	6.2	0.45	106	8.9
T 49	25.0	49.5	6.5	0.45	112	8.2
VLS1	20.0	56.4	7.1	0.31	104	12.3
VLS2	32.0	45.0	4.9	0.64	100	9.4
VLS21	23.6	50.5	7.4	0.41	102	10.1
VLS47	25.2	51.3	6.0	0.44	100	10.4

a = Monounsaturated/polyunsaturated fatty acids, and the values given are mean of triplicate determination
b = Maturity period in days
c = Weight of 100 seeds and the values are means of triplicate observations

Table 2 Correlation among different fatty acids, maturity period and seed size

	Linoleic acid	Linolenic acid	M/P ratio	Maturity period	Seed size
Oleic acid	*-938****	*-0.656****	*0.962****	*-0.663****	*-.461****
Linoleic acid		0.534***	-0.933***	0.607***	-0.426***
Linolenic acid			-0.626***	0.396***	-0.338**
M/P ratio				-0.644***	0.469***
Maturity period					-0.443***

References

Carver, B.F., Burton, J.W., Carter, T.E. and Wilson, R.F. 1983. Influence of maturity date on the oil content of soybeans with genetically altered fatty acid composition. *Soybean Genetics Newsletter*, **10**: 193-195.

Fehr, W.R., Welke, E. G., Hammond, D.N., Duvick, D.N. and Cianzio, S. R. 1992. Inheritance of reduced linolenic acid content in soybean genotypes A16 and A 17. *Crop Science*, **32**: 903-906.

Fernandenz-Martinez, J., Jimenez, A., Dominguez, J., Garces, R. and Mancha, M. 1989. Genetic analysis of high oleic acid in cultivated sunflower. *Euphytica*, **41**: 39-51.

Liu, K. S., Orthoefer, F. and Brown, E.A. 1995. Association of seed size with genotypic variation in the chemical constituents of soybean. *Journal of American Oil Chemists' Society*, **72** (2): 189-192.

Luddy, F.E., Barford, R.A., Herb, S.E., and Magidman, P. 1968. A Rapid and Quantitative Procedure for the preparation of methyl esters of butter oil and other fats. *Journal of American Oil Chemists' Society*, **15**: 549-552.

Maestri, D.M., Labuckas, D.O., Gujman, C.A. and Giorda, L.M. 1998. Correlation between seed size, protein and oil content and fatty acid composition in soybean genotypes. *Grasus -y-Aceites-Sevilla*, **49**(5-6): 450-453.

Matteson, F.M. and Grundy, S.M., 1985. Comparison of effects of dietary saturated, monounsaturated and polyunsaturated fatty acids on plasma lipids and lipoproteins in man. *Journal of Lipid Research*, **26**: 194-202.

Rahman, S.M., Kinoshita, T., Anai, T. and Takagi, Y. 2001. Combining ability in loci for high oleic and low linolenic acids in soybean. *Crop Science*, **41**: 26-29.

Willet, W.C. and Ascherio, A. 1994. Trans fatty acids: Are the effects only marginal? *American Journal of Public Health*, **84**: 722-724.

Xia, C. 1995. Study on oil content and fatty acid composition of soybean cultivars cultivated in Heilongjiang province in China. *Soybean Genetics Newsletter*, **22**: 99-102.

Zock, P.L. and Katan, M.B. 1992. Hydrogenation alternatives: effects of trans fatty acids and stearic acid versus linoleic acid on serum lipids and lipoproteins in humans. *Journal of Lipid Research*, **33**: 399 - 410.

J. Oilseeds Res., **22**(1) : 141-149 (2005)

Growth and instability of groundnut, *Arachis hypogaea* L. production in Andhra Pradesh : districtwise analysis

I.V.Y. Rama Rao* **and V.T. Raju**

National Academy of Agricultural Research Management, Rajendranagar, Hyderabad-500 030, AP

(Received: March, 2004; Revised: June, 2004; Accepted: September, 2004)

Abstract

The present study was an attempt to find the patterns of growth and magnitude of instability in area, production and productivity and relationship between *the production and the explanatory variables affecting viz.,* area and productivity of groundnut in Andhra Pradesh. The time series data for the period 1980-81 to 2001-02 regarding area, production and productivity *of groundnut was collected from various sources* published by the Bureau of Economics and Statistics, Government of Andhra Pradesh. Compound growth rate was employed to know the growth trends. Results revealed that growth performance of groundnut production was stagnant. Besides recording high degree of instability in production, the results of Decomposition and Path analysis revealed that contribution of area has higher effect on production.

Key words: Groundnut, growth, instability, path analysis, decomposition

Introduction

India is one of the leading groundnut producing countries of the world with cultivated area of 6.4 m. ha and production of 7.21 m. ha tonnes during 2001-02. In India, leading states in Groundnut cultivation are Gujarat, Tamilnadu and Andhra Pradesh (Agricultural Statistics at a Glance, 2003). In Andhra Pradesh, total cultivated area was 1.69 Million hectares and production was 1.25 m. tonnes during 2001-02. Umadevi *et al.* (2003) had stated that, for India, during the period 1980-81 to 1989-90 groundnut has shown significant growth in area only. While, during period 1990-91 to 1999-2000 groundnut has registered significant decline in area and steady growth in production and productivity. Further, the low growth in production and productivity will adversely affect the prospective production employment and income both at micro and macro levels and as such hamper economic growth of the country. The present study was conducted with the objectives:

1. To find the growth rates in area, production and productivity of groundnut in Andhra Pradesh.
2. To examine the extent of instability in area, production and productivity of groundnut in Andhra Pradesh.
3. To identify the districts and regions having combinations of different degrees of growth and instability of groundnut in Andhra Pradesh.
4. To know the sources of instability in production of groundnut in Andhra Pradesh.

Material and methods

The study pertains to all the districts ie., 22 districts (data for Hyderabad District is not available), three geographical regions of Andhra Pradesh *viz.*, Coastal Andhra, Rayalaseema, Telangana; and state as a whole. Time series data of 22 years from 1980-81 to 2001-02 was collected from various sources published by Bureau of Economics and Statistics, Government of Andhra Pradesh. For the calculation of CGR, CV, CII and Decomposition of change in production whole period was divided into two sub periods resulting in the formation of three periods *viz.*, Period-1 (1980-81 to 1990-91), Period-II (1991-92 to 2001-02) and Overall Period (1980-81 to 2001-02).

Analytical tools

Estimation of growth rates: Compound growth rates of area, production and productivity of groundnut for the all districts, three regions and the state as a whole for periods mentioned earlier by fitting an exponential function of the following form:

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

Where, Y = Area/Production/Productivity
A = Constant
b=(1+r)
r = compound growth rate
t = time variable in years (1, 2, 3, ...n)

Estimation of extent of instability

Coefficient of variation (CV): which explains the fluctuations over the period

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

* Research Associate

Where,

N = Number of years

X_t = *Area/production/*productivity in the year 't'

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

Coppock's instability index: Coppock's instability index is a close approximation of the average year-to-year percentage variation adjusted for trend (Kaur and Singhal, 1988). In algebraic form:

$$C.I.I = [\text{Anti} \log \sqrt{\log V - 1}] \times 100$$

$$\log V = \frac{[\log(X_{t+1}/X_t) - m]^2}{N-1}$$

Where,

X_t = Area/production/productivity in the year 't'

log V = Logarithmic variance of the series

N = Number of years

m = Arithmetic mean of the difference between the logs of X_{t+1} etc.

Growth v/s Instability: *By taking in conjugation of growth* rates and instability indices then only we can identify whether the crop's performance is stabilized higher growth *rate or instabilized lower growth rate. Accordingly,* production in district(s) or region(s) was classified into four categories (as shown in Table 3). So, this enables the development of district or *region specific strategies rather* than old blanket strategy of state as a whole. For rating the district(s) or region(s) as high or low growth rates and *instability, CGR and CII of state as a whole were taken as* critical point.

Estimation of sources of instability

Decomposition analysis: Decomposition of change in production will result into *area effect, productivity effect* and interaction effect of area and productivity. In formulae form:

$\Delta P = Ao.\Delta Y + Yo.\Delta A + \Delta A.\Delta Y$

Where,

ΔP = Production difference

$Yo.\Delta A$ = Area effect

$Ao.\Delta Y$ = Productivity effect

$\Delta A.\Delta Y$ = Interaction effect of area and productivity

Path analysis: Path analysis was employed to study the *association between the production and factors influencing* it *viz.*, area and productivity. A path co-efficient *is simply* a standardized partial regression co-efficient. It would *measure the direct influence of one variable upon others* and permit the separation of the correlation co-efficient into components of direct and indirect effects.

$$P_{1y} + r_{1.2.}\, P_{2y} = r_{1y}$$

$$P_{2y} + r_{2.1.}\, P_{1y} = r_{2y}$$

where,

r_{1y} and r_{2y} are the correlation coefficients between area and production and between yield and production respectively. P_{1y} and P_{2y} are the direct effects on production due to area and yield. The remaining term in the equation (rij) represents the indirect effects.

Unexplained variance (residual) not accounted by the *variables included could be obtained by the formula:*

$$P_{ry} = \sqrt{1 - (P_{1y}\, r_{1y} + P_{2y}\, r_{2y})}$$

The correlation coefficients between production and each of the independent variables (r_{iy}) were tested for significance by students 't' test:

$$t = \frac{r}{\sqrt{1-r^2}} \qquad \sqrt{n-2}$$

Where, r = Correlation coefficient
n = Number of years

Results and Discussion

Growth rates: *Results and discussion proceeded* levelwise. Among the districts, during the overall period significant growth rates in area, production and productivity *were observed in five, five and ten districts respectively* (Table1). Growth rates in area and production were registered the highest in Adilabad (4.87% *and* 8.10% respectively) and the lowest in East Godavari (-5.93% and -4.21% respectively) and in productivity growth rates varied between -0.14 % (Ananthapur) and 3.08 % (Adilabad). Thus Adilabad (Telangana Region) has registered the highest significant growth rates in area, production and productivity. During the period I, fourteen, eleven and two districts has registered significant growth rates in area, production and productivity respectively. *During the period II, significant growth rates* in area, production and productivity were observed in two, two and three districts respectively. Further, Adilabad has registered the highest growth rate in area, production and productivity during all the periods, except in area during the period II.

Among the regions, during the overall period, *only area* in Rayalaseema and productivity in Telangana has recorded with significant growth rates (Table 2). Further out of nine *districts in Coastal Andhra seven districts in area* had *showed negative non-significant growth rates.* Growth rates in area varied between -0.71 % (Coastal Andhra) *to* 1.15 % (Rayalaseema) in production varied between -0.44 (Coastal Andhra) and 1.09 % (Rayalaseema) and in productivity varied between -0.06 % (Rayalaseema) and 0.53 % (Telangana). Growth in productivity has contributed more to the growth in production in Coastal and Telangana regions. Whereas, growth in area has contributed more to the growth in production in Rayalaseema. During the period I area and production of all the regions has registered significant growth rates. Further, Telangana registered the lowest growth rates in area, production and productivity. During the period II, no variable has registered significant growth rates. Further, area, production and productivity during the period II has registered negative growth rates in all the regions, except productivity in Telangana.

State as a whole, significant growth rates were observed in area (0.64%) during the overall period and area and production (2.57% and 2.99% respectively) in period I. During the overall period growth in production (0.70%) was more contributed by growth in area (0.64%) than by the growth in productivity (0.07%). This was similar in period I and period II. Inter period comparison between period I and period II has showed that, in all the three variables, good performance in period I was reversed in period II by showing negative trend. So, all in all, groundnut production during the overall period was stagnant.

Umadevi *et al.* (2003) had stated that, for India, during the period IV (1980/81 to 1989/90) groundnut shown significant growth in area only. Further, they stated that during period V (1990-91 to 1999-2000) groundnut has registered significant decline in area and steady growth in production and productivity. Results emanated from present study revealed that in Andhra Pradesh during the period I (1981/82 to 1990/91) groundnut has registered significant growth not only in area (2.57%) but also in production (2.99%). Whereas, during the period II (1991/92 to 2000/02) all three variables registered non-significant negative growth rates, this *vis-à-vis* period V of reference is contrasting. Reasons for dismal performance of groundnut in our present study during the period II were people were motivated to consume palm oil (which is a substitute for groundnut), cheap palm oil imports from Philippines (due to liberalized import policy) and other common problems like lack of Farming system specific high yielding varieties, natural calamities, non accessibility of new technology and etc.

II. Instability Analysis: One should not oblivious of instability by taking the growth rates only. Because growth rates will explain only rate of growth over the period whereas instability will judge, whether the growth performance is stable or unstable for the period for the pertinent variable. Results and discussion was proceeded period wise and in each period all levels were discussed thoroughly.

During the overall period, among the districts, instability in productivity was higher than instability in area in terms of CV and CII in 12 and 11 districts respectively and like wise they contributed towards production fluctuations. The lowest instability in area (11.14% CV and 4.60% CII) and production (18.70% CV and 7.94% CII) were recorded in Srikakulam, whereas, in productivity (14.52% CV and 6.66% CII) was observed in Visakhapatnam. The highest instability in area (65.02% CV and 56.17% CII) was recorded in East Godavari, whereas, in production (213.04% CV and 66.53% CII) and productivity (149.02% CV and 37.60% CII) were recorded in Adilabad.

Thus, the highest and the lowest instability in production and productivity were respectively noticed in districts of Telangana and Coastal Andhra regions. Out of 22 districts, area variability more than productivity variability and vice versa were observed in 11 districts each. Among the regions, the lowest variability in area (17.79% CV and 7.60% CII) and production (23.86% CV and 10.88% CII) were noticed in Telangana, whereas, in productivity (8.34% CV and 3.65% CII) was in Coastal Andhra. The highest instability in area (22.78% CV and 10.89% CII) was recorded in Coastal Andhra, whereas, in production (34.32% CV and 16.57% CII) and productivity (24.02% CV and 11.47% CII) were noticed in Rayalaseema. Variability in area was higher than variability in productivity in Coastal Andhra and Telangana, whereas, opposite in Rayalaseema and likewise they contributed towards production variability in respective regions. State as a whole, variability in productivity (17.42% CV and 8.05% CII) was marginally higher than variability in area (16.89% CV and 7.01% CII) and likewise, they contributed towards production variability (26.7% CV and 12.74% CII).

During the period I, among the districts, instability in area was higher than instability in productivity in terms of CV and CII in 14 and 12 districts respectively and like wise they contributed towards production fluctuations. Among the regions and state as a whole, variability in area was more than variability in productivity and like wise, their effect on production variability.

During the period II, among the districts, instability in productivity was higher than instability in area in terms of CV and CII in 11and 8 districts respectively and like wise they contributed towards production fluctuations. Among the regions, instability in area was higher than instability in productivity in Coastal Andhra and Telangana whereas, reverse case observed in Rayalaseema and like manner, their effect on production variability. State as a whole, in contrast with period I, productivity variability (22.27% CV and 10.62% CII) has contributed more towards production variability (25.90% CV and 13.39% CII) in relation to area variability (11.40% CV and 4.49% CII).

Table 1 Compound growth rates of area, production and productivity of groundnut in Andhra Pradesh during 1980-81 to 2001-02

Districts , Regions and State		Overall period (1980-81 to 2001-02)			Period-I (1980-81 to 1990-91)			Period-II (1991-92 to 2001-02)		
		Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
Srikakulam	CGR	0.145	0.05	-0.09	1.32 *	0.65	-0.66	-1.25	-2.18	-0.94
	S.E.	0.0019	0.0032	0.0029	0.0040	0.0096	0.0109	0.0027	0.0042	0.0045
Vizianagaram	CGR	0.39	0.68	0.29	2.38 * *	3.15 *	0.75	-1.61	-2.01	-0.41
	S.E.	0.0028	0.0043	0.0029	0.0055	0.0112	0.0096	0.0032	0.0067	0.0074
Visakhapatnam	CGR	-0.38	-0.15	0.23	2.19	2.40	0.20	-2.58	-1.30	1.32
	S.E.	0.0031	0.0037	0.0025	0.0031	0.0077	0.0079	0.0040	0.0097	0.0061
East-Godavari	CGR	-5.93	-4.21	1.83	-1.10	-1.08	0.02	-7.54	-7.54	-0.01
	S.E.	0.0108	0.0056	0.0088	0.0089	0.0109	0.0096	0.0407	0.0124	0.0348
West-Godavari	CGR	-1.29	-0.58	0.73 * *	1.02 *	0.95	-0.07	-4.61	-4.00	0.63
	S.E.	0.0039	0.0042	0.0020	0.0042	0.0053	0.0039	0.0062	0.0098	0.0067
Krishna	CGR	-2.42	-1.16	1.29 * *	-0.27	0.86	1.14 *	-6.66	-5.26	1.50 *
	S.E.	0.0046	0.0043	0.0015	0.0045	0.0049	0.0042	0.0066	0.0046	0.0049
Guntur	CGR	-4.34	-3.25	1.14 * *	-1.50	-0.25	1.26 *	-7.70	-5.90	1.95
	S.E.	0.0063	0.0068	0.0033	0.0183	0.0229	0.0054	0.0112	0.0104	0.0125
Prakasam	CGR	-1.11	-1.03	0.09	6.28 * *	6. 50 * *	0.20	-9.16	-9.39	-0.25
	S.E.	0.0098	0.0108	0.0029	0.0114	0.0173	0.0082	0.0081	0.0123	0.0091
Nellore	CGR	-0.42	0.11	0.53*	5.31	5.74 * *	0.40	-5.87	-4.72	1.22
	S.E.	0.0072	0.0072	0.0023	0.0113	0.0105	0.0047	0.0060	0.0125	0.0079
Coastal Andhra	CGR	-0.71	-0.44	0.27	2.21* *	2.72 * *	0.50	-3.93	-4.01	-0.08
	S.E.	0.0038	0.0043	0.0013	0.0036	0.0059	0.0040	0.0024	0.0031	0.0035
Kurnool	CGR	1.03* *	1.21 *	0.18	2.65* *	3.01*	0.351	-2.21	-2.08	0.12
	S.E.	0.0035	0.0051	0.0030	0.0059	0.0105	0.0073	0.0038	0.0132	0.0107
Ananthapur	CGR	1.59 * *	1.44 *	-0.14	3.39 * *	3.59 *	0.20	0.30	0.01	-0.29
	S.E.	0.0022	0.0068	0.0059	0.0046	0.0123	0.0117	0.0027	0.0246	0.0224
Cuddapah	CGR	1.10	1.08	-0.02	4.69 * *	6.16 *	1.41	-2.72	-1.86	0.89
	S.E.	0.0047	0.0078	0.0056	0.0044	0.0135	0.0139	0.0070	0.0225	0.0183
Chittoor	CGR	0.27	0.34	0.074	1.20*	2.06	0.85	-1.36	-2.16	0.806
	S.E.	0.0020	0.0051	0.0038	0.0031	0.0124	0.0103	0.0042	0.0144	0.0118
Rayalaseema	CGR	1.156* *	1.09	-0.069	2.939 * *	3.419 * *	0.47	-0.88	-1.068	-0.19
	S.E.	0.0025	0.0056	0.0044	0.0039	0.0099	0.0083	0.0029	0.0189	0.0165
Ranga Reddy	CGR	-0.07	0.72	0.75*	0.54	1.42	0.872	-1.122	-0.16	0.97
	S.E.	0.0032	0.0056	0.0029	0.0089	0.0169	0.0089	0.0095	0.0163	0.0087
Nizamabad	CGR	0.69	2.548**	1.858**	0.438	0.128	-0.31	3.28*	6.44**	3.05*
	S.E.	0.0056	0.0082	0.0039	0.0189	0.0253	0.0101	0.0110	0.0182	0.0098
Medak	CGR	2.26**	3.43**	1.15**	4.64**	5.51*	0.83	0.08	1.02	0.94
	S.E.	0.0039	0.0057	0.0028	0.0101	0.0178	0.0088	0.0074	0.0126	0.0081
Mahabcobnagar	CGR	-0.44	-0.06	0.38	0.45	0.724	0.27	-1.98	-1.35	0.64
	S.E.	0.0030	0.0060	0.0049	0.0096	0.0213	0.0166	0.0050	0.0127	0.0124
Nalgonda	CGR	0.18	-0.36	-0.54	1.46*	1.62	0.16	-1.80	-3.54	-1.78
	S.E.	0.0025	0.0050	0.0034	0.0059	0.0125	0.0089	0.0029	0.0109	0.0104
Warangal	CGR	-0.07	0.19	0.26	3.13**	2.27	-0.83	-3.06	-2.1	0.94
	S.E.	0.0039	0.0041	0.0028	0.0052	0.0123	0.0090	0.0027	0.005	0.0062
Khammam	CGR	-2.37	-0.59	0.80**	1.62	2.77*	1.13	-7.57	-6.37	1.29*
	S.E.	0.0062	0.0060	0.0019	0.0076	0.0090	0.0057	0.0077	.00-0	0.0050
Karimnagar	CGR	-0.07	0.98	1.06**	4.97**	5.62*	0.61	-4.64	-4.3	0.32
	S.E.	0.0060	0.0074	0.0035	0.0075	0.0176	0.0123	0.0032	0.0080	0.0079
Adilabad	CGR	4.87**	8.10**	3.08**	7.14**	10.40*	3.05	2.91**	9.01*	5.93
	S.E.	0.0054	0.0109	0.0105	0.0191	0.0307	0.0301	0.0080	0.0337	0.0317
Telangana	CGR	-0.24	0.28	0.53*	1.76*	2.09	0.33	-2.50	-1.77	0.75
	S.E.	0.0030	0.0041	0.0025	0.0065	0.0125	0.0081	0.0030	0.0075	0.0068
Andhra Pradesh	CGR	0.64*	0.70	0.07	2.57**	2.99**	0.41	-1.52	-1.58	-0.06
	S.E.	0.0026	0.0046	0.0031	0.0037	0.0080	0.0058	0.0022	0.0137	0.0118

** = 1% level of significance; CGR = Compound Growth Rate (%)
* = 5% level of significance S.E. = Standard Error of Coefficient B

Table 2 **Coefficient of variation (CV) and Coppock's Instability Indices (CII) of area production and productivity of groundnut among the districts, regions and state in Andhra Pradesh during 1980-81 to 2001-02**

Districts, Regions and State	Overall period						Period - I						Period - II					
	Area		Production		Productivity		Area		Production		Productivity		Area		Production		Productivity	
	C.V.	C.I.I.	C.V.	C.I.I.	C.V.	C.I.I.	C.V.	C.I.I.	C.V.	C.I.I.	C.V.	C.I.I.	C.V.	C.I.I.	C.V.	C.I.I.	C.V.	C.I.I.
Srikakulam	11.14	4.60	18.70	7.94	16.01	7.63	12.11	4.82	19.64	8.25	20.42	9.96	10.37	4.51	18.05	6.71	11.30	3.58
Vizianagaram	16.07	6.76	26.09	11.60	17.09	7.86	19.03	7.71	31.76	13.69	19.13	8.90	12.67	5.66	19.93	7.09	15.26	5.38
Visakhapatnam	17.74	7.75	21.11	9.60	14.52	6.66	15.79	5.14	21.41	9.37	15.00	6.90	19.42	8.08	20.91	9.58	14.81	6.07
East Godavari	65.02	56.17	52.92	32.32	134.7	27.89	21.10	8.64	22.10	9.54	19.11	6.85	85.36	45.55	63.58	24.29	131.5	34.22
West Godavari	24.46	13.17	23.55	11.61	15.35	6.55	10.66	4.73	12.40	5.25	7.75	3.32	33.15	14.19	32.07	15.25	13.31	5.53
Krishna	33.68	19.65	26.41	13.55	19.91	8.09	9.34	2.62	11.35	5.05	11.52	4.15	47.78	21.41	37.57	16.46	14.12	5.85
Guntur	59.03	34.75	55.84	29.07	25.87	10.91	33.49	17.39	38.97	21.59	13.69	5.88	59.58	27.06	46.39	18.29	27.02	12.89
Prakasam	54.44	28.85	61.58	31.85	15.72	7.42	48.57	22.08	53.64	26.91	15.27	6.95	63.17	30.79	72.57	31.42	16.79	7.56
Nellore	37.37	19.53	35.14	18.77	15.72	6.48	36.99	18.53	38.25	18.64	10.13	4.05	39.31	18.08	33.78	18.70	18.06	7.22
Coastal Andhra	22.78	10.89	25.45	11.54	8.34	3.65	16.76	6.90	22.42	9.36	8.68	3.80	28.04	11.68	29.38	11.32	7.02	2.79
Kurnool	23.90	10.55	33.95	15.44	18.67	7.96	23.01	9.37	30.35	13.50	15.09	6.28	16.54	7.30	29.45	13.85	21.97	9.45
Ananthapur	22.49	10.22	44.13	20.33	32.49	16.08	25.93	10.38	33.80	15.46	23.65	10.55	5.75	2.50	44.02	23.37	40.58	21.08
Cuddapah	28.43	12.37	44.06	22.67	30.64	14.52	31.45	12.58	47.12	23.74	27.59	12.17	22.24	9.71	42.26	21.95	34.97	17.21
Chittoor	11.83	5.26	26.82	13.90	20.27	9.88	10.18	4.41	25.14	12.99	19.61	9.20	11.92	5.55	28.04	14.79	21.84	10.92
Rayalaseema	19.73	8.68	34.32	16.57	24.02	11.47	22.27	8.91	28.97	13.98	16.46	7.31	8.07	3.50	33.87	17.95	30.74	15.11
Rangareddy	17.59	8.36	30.55	15.76	20.19	9.11	17.11	7.95	32.66	15.99	18.13	8.28	18.97	8.53	28.11	14.58	18.91	8.33
Nizamabad	33.25	15.70	62.17	28.74	37.20	15.71	37.12	17.56	48.93	24.17	19.51	8.81	31.02	13.36	56.83	24.35	30.95	11.47
Medak	35.42	16.20	51.66	26.07	22.42	10.15	45.18	16.10	66.61	23.82	18.64	8.23	14.90	6.25	26.51	11.84	16.99	7.46
MahaboobNagar	17.98	8.02	33.95	15.78	28.80	12.28	17.64	8.17	41.49	19.47	34.36	12.95	18.37	4.67	25.64	11.74	24.19	11.13
Nalgonda	14.83	6.35	27.93	13.03	19.15	9.39	15.56	6.58	25.78	10.76	16.35	6.89	14.11	5.02	31.40	13.80	21.80	10.55
Warangal	22.34	9.36	22.62	10.38	15.57	7.37	23.96	8.82	26.92	12.57	17.02	8.26	21.76	8.42	19.00	6.93	14.19	6.18
Khammam	37.33	23.42	34.82	19.26	15.20	7.39	20.56	7.42	24.82	9.85	13.62	5.61	48.55	25.22	42.32	20.26	13.24	5.72
Karim Nagar	33.68	14.62	41.94	19.72	22.88	11.37	36.97	13.91	51.73	22.74	22.27	11.30	31.70	13.61	33.17	13.84	15.91	7.09
Adilabad	56.36	32.00	213.0	66.53	149.0	37.60	61.70	25.94	132.1	46.31	103.3	31.41	24.05	8.05	168.4	44.13	146.2	37.41
Telangana	17.79	7.60	23.86	10.88	15.73	7.20	17.52	7.75	28.45	13.08	16.04	6.85	18.76	6.33	18.61	7.57	13.93	6.37
Andhra Pradesh	16.89	7.01	26.71	12.74	17.42	8.05	19.72	7.70	25.83	11.60	11.53	5.04	11.40	4.49	25.90	13.39	22.27	10.62

Table 3 **Districts and regions of Andhra Pradesh with combinations of different magnitudes of growth rates and instability indices in groundnut**

	High growth rate and low instability		High growth rate and high instability		Low growth rate and low instability		Low growth rate and high instability	
	District(s)	Region(s)	District(s)	Region(s)	District(s)	Region(s)	District(s)	Region(s)
	-	-	Nellore Kurnool Ananthapur Cuddapah Ranga Reddy Nizamabad Medak Karim Nagar Adilabad	Rayalaseema	Srikakulam Vizianagaram Visakhapatnam West Godavari Warangal Khammam	Coastal Andhra Telangana	East Godavari Krishna Guntur Prakasam Chittoor Mahaboobnagar Nalgonda	-
% to the state average production	-	-	56.14	64.85	13.83	35.15	30.04	-

Note:
1. CGR for groundnut production for state as a whole during the period 1980-81 to 2001-02 is 0.7048 %.
2. CII for groundnut production for state as a whole during the period 1980-81 to 2001-02 is 12.74 %.
3. Total average groundnut production for the period 1980-81 to 2001-02 is 1806159 tonnes.

Inter-period comparison revealed that, during the period I in all the regions area variability was higher than productivity variability but, it was reversed during the period II in Rayalaseema region. State as a whole, instability in area's dominance over instability in productivity towards production variability in period I was reversed in period II. Further, greater ness of productivity variability over variability in area during the period II was high enough that it shrouded the area's variability dominance over productivity variability during the period I, as shown in during overall period.

Growth v/s Instability: (i) High Growth Rate and Low Instability (highly preferable): None were in this category. (ii) **High Growth Rate and High Instability** (this category is preferable based on the grater ness of growth rate over instability index): Rayalaseema region and 9 districts were placed in this category. Separately Rayalaseema region and total of 9 districts shares 64.85% and 56.14% respectively to the state's average production. So, in region wise identification this category should be given prime importance. In this category primary concern should be given to production stabilization. **(iii) Low Growth Rate and Low Instability** (less preferable): Among the districts six were constituted in this category. But, they contribute merely 13.83%of the state average production. Further, among the regions, Coastal Andhra and Telangana with the production of 35.15% of total state average were in this category. Stagnant production is of much concern in this category, **(iv) Low Growth Rate and High Instability** (not preferable): Wonder to know, seven districts with the share of 30.03% in state average production were constituted in his category. This means nearly 1/3rd of Groundnut -oduction was in dismal situation of low growth rate and high variability condition. This requires strategies to increase the growth and decrease the instability. **(IV) Sources of Variability in Production:** Discussion was proceeded level wise i.e., districts to regions then to state:

I. Decomposition Analysis

Among the districts, during the period I, in 17 districts area effect was higher than other components of change in production was noticed (Table 4). In Kurnool the highest area effect (145.45%) and in Guntur higher yield effect (232.78%) were observed. In 16 districts area effect was higher than other components of change in production was recorded during the period II and overall period. Thus, change in area, in majority of districts, has dominant role on production differential.

Among the regions, in all the regions area effect was major component effecting production differential observed in period I. During the period II, area effect in Coastal Andhra (91.98%) and Telangana (158.09%) and yield effect (150.3%) in Rayalaseema were higher than other components in their respective regions. During the overall period, dominance of area effect in Coastal Andhra (117.62%) and Rayalaseema (66.85%) and yield effect (209.49%) in Telangana was observed. Thus, greater effect of change in area on production differential was observed in majority of regions in all the periods.

State as a whole, area effect in during the period I (5923%), period II (107.41%) and overall period (58.5450 had higher effect than its counterparts on production differential.

Bhavaniprasad (1993) stated that during period 1970-71 to 1991-92, for State as a whole, change in area (76.53%) has contributed more towards production differential than the yield effect (13.94%) and interaction effect (9.53%). Present study revealed that during the period 1980-81 to 2001-02, area effect (58.54%) was higher than yield effect (31.28%) and interaction effect (10.18%) on production differential. Thus, area effect has still dominance but it was decreased from 76.53 % (reference period) to 58.14 % (present study period) whereas, yield effect increased from 13.94 % to 31.28 %. Because development of high yielding varieties in groundnut due to impact of technology mission on oilseeds.

II. Path Analysis

Among the districts, significant correlation with production was recorded by area and productivity respectively in twenty-one and fifteen districts (Table 5). Further, correlation coefficients of area were higher than correlation coefficients of productivity were recorded in thirteen districts. Whereas, the lowest and the highest path values of area were noticed in Karimnagar (0.13) and Krishna (1.37) respectively. The lowest and the highest direct effects of productivity were respectively recorded in East Godavari (0.12) and Srikakulam (1.04). In 12 districts path values of area were higher than productivity. Thus, area has prominent effect on production than by productivity.

Among the regions, both area and productivity has recorded significant correlation with production in all the regions. The lowest path value of area (0.57) and the highest path value of production (0.67) were recorded in Rayalaseema. Whereas, the highest path value of (0.85) and the lowest path value of productivity (0.39) were registered in Coastal Andhra correlation coefficients of area were higher than correlation coefficients of productivity in Coastal Andhra and Telangana, whereas, vice versa was observed in Rayalaseema. Similar results were observed in path values. Thus, area has more association with production than the its counterpart.

Table 4 Components of change in production of groundnut at district, region and state level during the period I, period II and overall period

Districts, Regions and State	Overall period				Period-I				Period-II			
	Differential Production (Δp)	Area Effect (Δa)	Yield Effect (Δy)	Inter-action Effect (Δa.Δp)	Differential Production (Δp)	Area Effect (Δa)	Yield Effect (Δy)	Inter-action Effect (Δa.Δp)	Differential Production (Δp)	Area Effect (Δa)	Yield Effect (Δy)	Inter-action Effect (Δa.Δp)
Srikakulam	100.00	51.68	46.93	1.39	100.00	88.87	9.27	1.86	100.00	49.49	61.87	-11.36
Vizianagaram	100.00	88.14	10.42	1.43	100.00	85.16	9.73	5.12	100.00	58.65	56.14	-14.79
Visakhapatnam	100.00	586.70	-508.71	22.02	100.00	125.55	-14.60	-10.95	100.00	194.65	-159	64.35
East Godavari	100.00	99.88	1.15	-1.02	100.00	41.71	67.66	-9.37	100.00	101.33	-9.95	8.62
West Godavari	100.00	260.34	-292.99	132.65	100.00	97.02	2.40	0.58	100.00	139.94	-98.09	58.15
Krishna	100.00	151.55	-211.94	160.39	100.00	-60.05	181.62	-21.57	100.00	120.13	-79.03	58.90
Guntur	100.00	118.59	-120.13	101.54	100.00	-98.55	232.78	-34.24	100.00	108.25	-31.76	23.51
Prakasam	100.00	93.25	12.37	-5.61	100.00	117.51	-6.49	-11.03	100.00	97.23	14.51	-11.74
Nellore	100.00	133.02	-54.58	21.56	100.00	101.00	-0.42	-0.58	100.00	105.76	-25.19	19.43
Coastal Andhra	100.00	117.62	-25.70	8.08	100.00	84.28	10.66	5.06	100.00	91.98	17.51	-9.49
Kurnool	100.00	55.35	32.79	11.87	100.00	145.45	-26.50	-18.96	100.00	-793.5	1,251	-357.68
Ananthapur	100.00	54.41	21.89	23.70	100.00	144.77	-23.62	-21.15	100.00	15.65	74.64	9.71
Cuddapah	100.00	99.22	0.40	0.38	100.00	111.95	-4.73	-7.22	100.00	-308.8	618.9	-210.10
Chittoor	100.00	418.09	-337.43	19.34	100.00	60.91	31.93	7.17	100.00	161.73	-83.70	21.97
Rayalaseema	100.00	66.86	20.29	12.85	100.00	124.48	-13.98	-10.51	100.00	-34.48	150.3	-15.80
Ranga Reddy	100.00	-148.40	323.05	-74.65	100.00	36.16	57.41	6.43	100.00	775.39	-985.1	309.67
Nizamabad	100.00	18.84	55.40	25.76	100.00	119.48	-16.00	-3.48	100.00	21.32	45.70	32.98
Medak	100.00	46.71	25.55	27.74	100.00	67.22	9.51	23.27	100.00	-14,45.	20,042	-5,488.02
Mahaboobnagar	100.00	55.55	51.47	-7.02	100.00	93.14	4.70	2.16	100.00	238.80	-262.08	123.29
Nalgonda	100.00	-4.23	105.13	-0.90	100.00	44.35	37.96	17.69	100.00	82.15	27.79	-9.94
Warangal	100.00	3.20	96.01	0.80	100.00	130.32	-14.25	-16.08	100.00	140.34	-82.02	41.68
Khammam	100.00	135.72	-118.97	83.24	100.00	53.04	31.50	15.46	100.00	108.15	-41.59	33.44
Karimnagar	100.00	2.56	95.57	1.86	100.00	66.01	11.40	22.58	100.00	118.91	-53.51	34.60
Adilabad	100.00	51.02	6.12	42.79	100.00	76.33	6.43	17.24	100.00	46.03	28.06	25.91
Telangana	100.00-	90.87	209.49	-18.63	100.00	81.40	10.95	7.64	100.00	158.09	-111.9	53.76
Andhra Pradesh	100.00	58.54	31.28	10.18	100.00	107.41	-4.37	-3.03	100.00	5,923	-7,710	1,886.95

Table 5 Districtwise, regionwise and state path values of groundnut during overall period

Districts, Region and State		Area	Productivity	Correlation with production	Residual
Srikakulam	Area	0.51	-0.35	0.16	0.01
	Productivity	-0.17	1.05	0.88**	
Vizianagaram	Area	0.58	0.19	0.76**	0.01
	Productivity	0.16	0.67	0.83**	
Visakhapatnam	Area	0.80	-0.05	0.76**	0.01
	Productivity	-0.05	0.65	0.60**	
East Godavari	Area	0.97	-0.06	0.91**	0.16
	Productivity	-0.50	0.12	-0.33	
West Godavari	Area	0.94	-0.13	0.81**	0.02
	Productivity	-0.21	0.59	0.37	
Krishna	Area	1.32	-0.55	0.83**	0.03
	Productivity	-0.98	0.76	-0.22	
Guntur	Area	1.08	-0.14	0.94**	0.03
	Productivity	-0.49	0.31	-0.17	
Prakasam	Area	0.90	0.07	0.97**	0.01
	Productivity	0.28	0.23	0.80*	
Nellore	Area	0.98	-0.08	0.90**	0.01
	Productivity	-0.18	0.44	0.26	
Coastal Andhra	Area	0.85	0.07	0.92**	0.01
	Productivity	0.14	0.39	0.54*	
Kurnool	Area	0.68	0.17	0.85**	0.01
	Productivity	0.21	0.55	0.76**	
Ananthapur	Area	0.49	0.15	0.64**	0.03
	Productivity	0.10	0.76	0.86**	
Cuddapah	Area	0.63	0.15	0.78**	0.0422
	Productivity	0.15	0.61	0.76**	
Chittoor	Area	0.38	0.45	0.83**	0.01
	Productivity	0.24	0.71	0.95**	
Rayalaseema	Area	0.57	0.20	0.76**	0.02
	Productivity	0.17	0.67	0.83**	
Ranga Reddy	Area	0.50	0.43	0.93**	0.01
	Productivity	0.39	0.57	0.94**	
Nizamabad	Area	0.52	0.34	0.86**	0.03
	Productivity	0.30	0.59	0.89**	
Medak	Area	0.62	0.34	0.96**	0.01
	Productivity	0.49	0.42	0.92**	
Mahaboobnagar	Area	0.47	0.09	0.55*	0.02
	Productivity	0.05	0.83	0.87**	
Nalgonda	Area	0.59	0.22	0.81**	0.01
	Productivity	0.20	0.63	0.83**	
Warangal	Area	0.96	-0.10	0.87**	0.01
	Productivity	-0.19	0.51	0.32	
Khammam	Area	1.10	-0.17	0.93**	0.03
	Productivity	-0.50	0.38	-0.12	
Karimnagar	Area	0.74	0.18	0.92**	0.01
	Productivity	0.32	0.42	0.73**	
Adilabad	Area	0.13	0.37	0.50*	0.03
	Productivity	0.05	0.93	0.98**	
Telangana	Area	0.70	0.14	0.85**	0.01
	Productivity	0.18	0.55	0.73**	
Andhra Pradesh	Area	0.61	0.24	0.85**	0.01
	Productivity	0.25	0.58	0.83**	

** : 1% level of significance; * : 5% level of significance

State as a whole, both area (0.85) and productivity (0.83) has registered significant correlation with production. Path values of area and productivity were recorded respectively as 0.61 and 0.58. Indirect effect of area (0.24) and productivity (0.25) were lower than their respective path values. So, both correlation coefficients and path coefficients of area were higher than productivity. Thus, area has marginally higher role in effecting the production *vis-à-vis* productivity.

Conclusions

To sum up, for State as a whole, growth rate in area (0.6389%) was higher than the productivity (0.0654%) (Table 1). Productivity (17.42% CV and 8.03% CII) has higher instability than area (16.89% CV and 7.01% CII) and likewise contribution towards the production fluctuations (Table 2). Decomposition analysis revealed that area effect (58.54%) was higher than yield effect (31.28%) and interaction effect of area and yield (10.18%) on production differential (Table 4). Path analysis revealed that, area has more direct association ship with production than the productivity (Table 5).

Policy implications

- Production was more contributed by area in groundnut this indicates there is a need of in depth study about factors influencing the area expansion like assured and timely supply of farm inputs and providing remunerative prices to farmers.
- As area under cultivation cannot be increased beyond certain level, the growth in production should come from yield attributing factors like development of High Yielding farming system specific varieties and improvement in input use efficiency.
- Growth in production was not up to the expected level. This necessitates thorough yield gap analysis.
- Identified high and low growth rate districts and regions for groundnut will be better utilized in the local specific and crop specific research schemes and growth oriented development programmes.
- Steps to be taken for the stabilisation of productivity.

References

Bhavaniprasad, Y. 1993 *Growth and instability of oilseeds production in Andhra Pradesh.* M.Sc. (Ag.) thesis, unpublished, Department of Agricultural Economics, Agricultural College, Bapatla, Andhra Pradesh Agricultural University, Hyderabad.

Kaur, N. and Singhal, K.C. 1988. India's export instability. *Margin*, **21**:54-61.

Umadevi, K. Eswara Prasad, Y. and Jyothirmai, V. L. 2003 Growth and instability of groundnut in India. Paper presented in National Seminar on *Stress Management in Oilseeds for Attaining Self-reliance in Vegetable oils, conducted by Directorate of Oilseeds Research*, Rajendranagar, Hyderabad during 28-30 Jan 2003.

J. Oilseeds Res., **22**(1) : 150-154 (2005)

Instability analysis of castor production in Andhra Pradesh : District-wise analysis

I.V.Y. Rama Rao[1] and V.T. Raju[2]

National Academy of Agril. Research Management, Rajendranagar, Hyderabad-500 030, AP

(Received: June, 2004; Revised: October, 2004; Accepted: November, 2004)

Abstract

The present study is an attempt to know the magnitude of instability, to ascertain the factors influencing the change in production, and to estimate the direct and indirect effects of area and productivity on production. The time series data for the period 1980-81 to 2001-02 regarding area, production and productivity of castor was collected from various sources published by the Bureau of Economics and Statistics, Government of Andhra Pradesh. Analytical tools Coppock's Instability Index (C.I.I). Decomposition analysis and Path analysis were employed to achieve the objectives. The results revealed that instability was very high in area and production. Decomposition analysis revealed that area effect has contributed higher than the any component towards destabilization of production. Path analysis revealed that direct effect of area was higher than the direct effect of productivity on production.

Key words: Castor, instability, path and decomposition analysis

Introduction

India is one of the leading castor producing countries of the world with cultivated area of 0.89 m.ha and production of 0.84 m tonnes during 2000-01. In India, leading states in castor cultivation are Gujarat, Andhra Pradesh and Rajasthan. Andhra Pradesh is one of the leading state in cultivation of castor with cultivated area of 0.40 m.ha and production of 0.14 m tonnes during 2001-02. India exports and imports castor and their products to and from many countries. Hazell (1984) stated that increased instability in productivity of cereals was a major source of instability in production in India. Bhavaniprasad (1993) has stated that during the period 1970-71 to 1991-92, in Andhra Pradesh, area had marginally higher significant correlation with production than by productivity. To further the enquiry present study was conducted to estimate and decomposition of instability in castor production in AP.

Materials and methods

The study pertains to all the districts (data for Srikakulam and Vizianagaram are not available), three geographical regions *viz.*, Coastal Andhra, Rayalaseema and Telangana; and AP State as a whole. Time series data on area, production and productivity from 1980-81 to 2001-02 was collected from various sources published by the Bureau of Economics and Statistics, Government of Andhra Pradesh. For the calculation of CII, Decomposition of change in production whole period was divided into two sub periods *viz.*, Period-1 (1980-81 to 1990-91), Period-II (1991-92 to 2001-02) and the Path analysis was performed for the overall period.

Analytical tools

Estimation of extent of instability: For the calculation of extent of instability CII were employed:

Coppock's Instability Index (CII): Coppock's Instability Index (CII) is a close approximation of the average year-to-year percentage variation adjusted for trend. In algebraic form:

between the logs of X_{t+1}, X_t, etc.

$$\text{C.I.I.} = \left[\text{Anti}\log\sqrt{\log V - 1}\right] \times 100\,^*$$

$$\log V = \frac{\left[\log(X_{t+1}/X_t) - m\right]^2}{N-1}$$

* Kaur Narinder and Singhal (1988)

Where,

X_t = Area/production/productivity in the year 't'
log V = Logarithmic variance of the series
N = Number of years
m=Arithmetic mean of the difference between the logs of X_{t+1}, X_t etc.

Estimation of sources of instability

Path analysis: Path analysis was employed to study the association between the production and factors influencing it *viz.*, area and productivity. A path coefficient is simply a standardized partial regression coefficient. It would

---

[1]Research Associate

[2] Professor & University Head, Department of Agricultural Economics, Agricultural College, ANGRAU, Bapatla-522 101, AP.

measure the direct influence of one variable upon others and permit the separation of the correlation coefficient into components of direct and indirect effects.

$$P_{1y} + r_{1,2}.\ P_{2y} = r_{1y}$$
$$P_{2y} + r_{2,1}.\ P_{1y} = r_{2y}$$

Where,

r_{1y} and r_{2y} are the correlation coefficients between area and production between yield and production, respectively. P_{1y} and P_{2y} are the direct effects on production due to area and yield. The remaining term in the equation (rij) represents the indirect effects.

Unexplained variance (residual) not accounted by the variables could be obtained by the formula:

$$P_{ry} = \sqrt{1 - (p_{1y}\ r_{1y} + p_{2y}\ r_{2y})}$$

The correlation coefficients between production and each of the independent variables (r_{1y}) were tested for significance by students 't' test

$$t = \frac{r}{\sqrt{1 - r^2}} \qquad \sqrt{n - 2}$$

Where, r = correlation coefficient
n = number of years

Decomposition of change in production: Decomposition of change in production will result into area effect, productivity effect and interaction effect of area and productivity. In formulae form:

$$\Delta P = Ao.\Delta Y + Yo.\Delta A + \Delta A.\Delta Y$$

Where, ΔP = Production difference
$Yo.\Delta A$ = Area effect
$Ao.\Delta Y$ = Productivity effect
$\Delta A.\Delta Y$ = Interaction effect of area and productivity

Results and discussion

During the overall period, among the districts, lowest instability in area, production and productivity were recorded in Nalgonda (Table 1). The highest instability in area and production were noticed in West Godavari, whereas, in productivity was in Guntur. Further, in 17 districts instability in area was higher than the instability in productivity and likewise contributed towards the instability in production. Among the regions, the lowest instability in area, production and productivity were registered in Telangana. The highest variability in area, production and productivity were noticed in Coastal Andhra. State as a whole, instability in area (37.15%) in relation to productivity (5.85%) has contributed more towards production variability (31.09%).

Table 1 **Coppock's Instability Indices (CII) of area, production and productivity of castor among the districts, regions and state as a whole (Values in percentages)**

District, Region, and State	Overall period			Period-I			Period-II		
	Area	Production	Productivity	Area	Production	Productivity	Area	Production	Productivity
Visakhapatnam	35.34	39.12	10.19	39.83	49.43	10.60	16.41	14.92	7.52
East Godavari	29.47	37.78	13.42	20.20	30.13	13.85	36.84	42.65	9.24
West Godavari	81.03	95.33	17.20	41.17	51.19	18.16	65.53	76.96	12.55
Krishna	34.98	28.99	14.24	17.58	16.02	15.19	36.49	31.71	7.45
Guntur	42.22	38.71	49.00	57.88	18.84	70.23	22.91	49.93	23.84
Prakasam	20.09	34.01	27.49	12.34	18.88	33.61	20.97	34.97	16.68
Nellore	54.49	57.36	13.83	40.16	46.66	15.38	56.53	63.96	6.92
Coastal Andhra	**32.64**	**32.27**	**25.30**	**35.81**	**18.00**	**30.53**	**22.32**	**34.78**	**15.48**
Kurnool	36.16	47.27	26.03	10.04	23.13	24.49	54.00	58.34	7.81
Ananthapur	30.54	34.62	25.87	11.69	27.84	24.40	29.10	40.19	11.35
Cuddapah	35.31	58.49	25.62	18.24	40.04	24.41	39.25	43.64	11.62
Chittoor	13.38	35.18	26.81	14.42	27.29	24.35	12.32	30.40	27.56
Rayalaseema	**32.12**	**32.94**	**22.40**	**33.14**	**19.00**	**36.59**	**21.89**	**31.69**	**15.00**
Rangareddy	14.57	28.82	24.31	4.06	32.04	31.42	17.86	24.41	9.12
Hyderabad	46.54	50.42	15.58	58.36	67.09	19.21	28.18	25.53	7.51
Nizamabad	14.32	22.40	9.65	15.48	19.75	6.03	12.15	22.02	11.20
Medak	18.33	15.67	15.43	8.18	10.47	8.36	6.31	18.89	12.67
Mahaboobnagar	14.82	20.88	8.92	8.88	13.95	7.72	17.72	23.42	9.09
Nalgonda	12.70	11.45	8.07	2.16	5.44	5.87	7.54	10.94	6.80
Warangal	23.73	23.05	20.02	7.19	21.10	20.05	8.09	11.40	13.51
Khammam	62.64	43.99	24.13	43.93	43.83	5.61	50.00	33.63	25.19
Karimnagar	39.36	35.69	11.58	14.20	19.44	9.98	24.97	28.93	9.35
Adilabad	21.23	26.89	12.62	23.41	20.99	6.58	13.51	16.76	10.08
Telangana	**13.56**	**31.90**	**10.68**	**33.12**	**13.12**	**3.00**	**12.31**	**34.77**	**14.36**
Andhra Pradesh	**37.15**	**34.75**	**5.85**	**33.92**	**29.67**	**5.36**	**37.27**	**34.48**	**5.48**

During the period I, among the districts, the lowest instability in area, production and productivity were recorded in Nalgonda district. The highest instability in area, production and productivity were noticed respectively in Khammam, Visakhapatnam and Guntur. Thus, the lowest and the highest variability in area were noticed in districts of Telangana region. Further, in 12 districts instability in area was higher than the instability in productivity and likewise contributed towards the instability in production. Among the regions, the lowest instability in area, production and productivity were recorded in Telangana region. The highest instability in area was noticed in Coastal Andhra, whereas, in production and productivity were observed in Rayalaseema. Further, in all the regions, area variability in relation to productivity variability has contributed more towards production variability. State as a whole, instability in area was higher than instability in production and productivity.

During the period II, among the districts, the lowest instability in area was observed in Medak, whereas, in production and productivity were noticed in Nalgonda. The highest instability in area and production were recorded in West Godavari, whereas, in productivity was noticed in Chittoor. Further, in 17 districts instability in area was higher than the instability in productivity and likewise contributed towards the instability in production. Among the regions, the lowest instability in area production and productivity were noticed in Telangana. Whereas, the highest instability in area, production and productivity were observed in Coastal Andhra. In all the regions instability in area in relation to instability in productivity has contributed towards fluctuations in production. State as a whole, instability in area, production and productivity were recorded respectively as 37.27%, 34.48%t and 5.48%. Inter period comparison revealed that instability in all the three variables was high in period II than period I. Reasons behind the high variability in area, and production were due to low efficiency in input usage, growing the crop under rainfed conditions, presence and preparation of substitutes to castor crop and its products and less remunerative crop in comparison with commercial crops.

Estimation of sources of instability

Path Analysis: Among the districts, significant correlation with production by area and productivity were recorded respectively in nineteen and twelve districts (Table 2). In thirteen districts, out of 21, correlation coefficients of area were higher than productivity. The lowest and the highest direct effects of area were recorded in Chittoor and Krishna, whereas, in productivity were registered in Khammam and Kurnool. In thirteen districts path values of area was higher than productivity. Indirect effects of area and productivity were less than their respective direct effects. Further, in twelve districts these were recorded negatively. Thus, area has more say in production than by productivity.

Among the regions, area and productivity in Coastal Andhra and Rayalaseema registered significant correlation with production. Further, correlation coefficients of area were higher than productivity were observed in Rayalaseema and Telangana whereas, vice versa was observed in Coastal Andhra. The lowest path value of area and the highest path value of productivity were recorded in Coastal Andhra. Whereas, the highest path value of area and the lowest path value of productivity were noticed in Telangana. Path values of area were higher than productivity in Rayalaseema and Telangana, whereas, vice versa was observed in Coastal Andhra. In all the regions, indirect effect of area and productivity were lower than their respective direct effects. Further, these were recorded negatively in Telangana. Thus, area has more say in production in majority of regions.

State as a whole, correlation with production was significant by area, whereas, it was non significant by productivity. Further, path value of area was substantially higher than productivity. Whereas, indirect effects of area and productivity were less than their respective direct effects. Thus, area has predominant role in production.

Bhavaniprasad (1993) has stated that during the period 1970-71 to 1991-92, State as a whole, area has marginally higher significant correlation with production than by productivity. Further, path coefficient of area was higher than productivity. Present study has also revealed similar results during the period 1981-82 to 2000-01 with variation in magnitude. Further, correlation and path coefficients of area have increased from reference period to present study period as respectively from 0.8599 to 0.9871 and from 0.6270 to 1.0480. That shows area's dominant role in production is further consolidating.

Decomposition Analysis: State as a whole, role of area effect during the period I, period II and overall period was higher than other components (which were recorded negatively) of change in production (Table 3). Thus, area effect is predominant during all periods. Among the regions, during the period I, area effect in Coastal Andhra and Rayalaseema and yield effect in Telangana has dominated. Yield effect was negatively contributed to production differential in Coastal Andhra. During the period II, yield effect in Coastal Andhra and Telangana and area effect in Rayalaseema were higher than other component of change in production in their respective regions. During the overall period, dominant role of yield effect in Telangana, interaction effect in Rayalaseema and equal importance of both area effect and yield effect in Coastal Andhra on production differential was clearly felt. Thus, more or less, equal importance of change in area and yield on production differential.

Table 2 District-wise, region-wise and state as a whole path values for castor

District, Region and State		Area	Productivity	Correlation with production	Residual
Visakhapatnam	Area	0.9861	-0.0464	0.9397**	0.0612
	Productivity	-0.1902	0.2407	0.0504	
East Godavari	Area	0.7761	0.1485	0.9247**	0.0268
	Productivity	0.3078	0.3745	0.6823**	
West Godavari	Area	0.9595	0.0055	0.9650**	0.0484
	Productivity	0.0368	0.1427	0.1795	
Krishna	Area	1.1199	-0.4767	0.6432**	0.1906
	Productivity	-0.6764	0.7893	0.1129	
Guntur	Area	0.7049	-0.2422	0.4627	0.5826
	Productivity	-0.3336	0.5117	0.1781	
Prakasam	Area	0.4596	0.2859	0.7454**	0.0467
	Productivity	0.1897	0.6924	0.8821**	
Nellore	Area	1.0084	-0.0609	0.9475**	0.0426
	Productivity	-0.2440	0.2517	0.0077	
Coastal Andhra	Area	0.4761	0.2507	0.7268**	0.0502
	Productivity	0.1715	0.6960	0.8675**	
Kurnool	Area	0.6682	-0.6478	0.0204	0.0619
	Productivity	-0.3715	1.1651	0.7935**	
Ananthapur	Area	0.9062	-0.4357	0.4705*	0.0908
	Productivity	-0.4215	0.9368	0.5153*	
Cuddapah	Area	0.6915	0.1483	0.8399**	0.0233
	Productivity	0.1894	0.5417	0.7310**	
Chittoor	Area	0.2684	0.2664	0.5349*	0.0179
	Productivity	0.0817	0.8759	0.9575**	
Rayalaseema	Area	0.5763	0.2769	0.8532**	0.0469
	Productivity	0.2905	0.5494	0.8399**	
Ranga Reddy	Area	0.3465	0.1350	0.4815*	0.0042
	Productivity	0.0529	0.8844	0.9373**	
Hyderabad	Area	0.9448	0.0144	0.9592**	0.0371
	Productivity	0.0658	0.2073	0.2732	
Nizamabad	Area	0.6292	0.2194	0.8486**	0.0207
	Productivity	0.2490	0.5544	0.8034**	
Medak	Area	1.0066	-0.4809	0.5257*	0.0538
	Productivity	-0.5100	0.9492	0.4393	
Mahaboobnagar	Area	0.6864	0.1171	0.8035**	0.0114
	Productivity	0.1346	0.5973	0.7318**	
Nalgonda	Area	0.8810	-0.3664	0.5146*	0.0152
	Productivity	-0.3492	0.9242	0.5750**	
Warangal	Area	0.8709	-0.3315	0.5394*	0.0462
	Productivity	-0.3284	0.8791	0.5506*	
Khammam	Area	0.9914	-0.0561	0.9353*	0.1129
	Productivity	-0.4461	0.1246	-0.3215	
Karimnagar	Area	0.9384	-0.0135	0.9248**	0.0462
	Productivity	-0.0404	0.3141	0.2736	
Adilabad	Area	0.6356	-0.0343	0.6012**	0.0293
	Productivity	-0.0279	0.7813	0.7533**	
Telangana	Area	1.0002	-0.0002	1.0000	0.0000
	Productivity	-0.4242	0.0005	-0.4237	
Andhra Pradesh	Area	1.0480	-0.0609	0.9871**	0.0047
	Productivity	-0.4065	0.1570	-0.2495	

** 1% level of significance; * 5% level of significance

Table 3 **Components of change in production of castor at district, region and state level during the Period I, Period II and overall period**

District, Region and state	Overall period				Period I				Period II			
	Differential production (Δp)	Area effect (Δa)	Yield effect (Δy)	Interaction effect (Δa. ΔP)	Differential production (Δp)	Area effect (Δa)	Yield effect (Δy)	Interaction effect (Δa. ΔP)	Differential production (Δp)	Area effect (Δa)	Yield effect (Δy)	Interaction effect (Δa. ΔP)
Visakhapatnam	100.00	102.88	-35.98	33.10	100.00	99.32	13.64	-12.95	100.00	0.00	100.0	0.00
East Godavari	100.00	111.35	-50.45	39.10	100.00	40.50	76.77	-17.27	100.00	89.89	34.84	-24.73
West Godavari	100.00	46.39	38.27	15.35	100.00	96.56	61.57	-58.13	100.00	32.81	0.24	66.94
Krishna	100.00	111.75	-52.87	41.12	100.00	-259.26	230.95	128.31	100.00	83.63	37.42	-21.05
Guntur	100.00	94.21	7.08	-1.30	100.00	-814.72	434.14	480.58	100.00	74.88	49.92	-24.80
Prakasam	100.00	42.74	38.19	19.06	100.00	896.12	-377.29	-418.83	100.00	44.13	67.40	-11.54
Nellore	100.00	-24.04	131.89	-7.85	100.00	71.42	64.44	-35.86	100.00	141.37	-3.14	-38.23
Coastal Andhra	**100.00**	**42.93**	**42.71**	**14.36**	**100.00**	**3,969.40**	**-1,885**	**-1,984.18**	**100.00**	**51.17**	**62.67**	**-13.84**
Kurnool	100.00	32.86	4.82	62.32	100.00	-1,333	1,577	-143.98	100.00	139.21	-1.54	-37.67
Ananthapur	100.00	15.50	55.16	29.34	100.00	109.34	-20.71	11.38	100.00	158.38	-15.45	-42.93
Cuddapah	100.00	32.03	7.31	60.66	100.00	75.51	16.92	7.57	100.00	149.26	-8.73	-40.53
Chittoor	100.00	22.32	35.28	42.40	100.00	76.01	16.35	7.65	100.00	-1,142	930.3	311.62
Rayalaseema	**100.00**	**28.83**	**16.60**	**54.57**	**100.00**	**123.35**	**-36.15**	**12.80**	**100.00**	**145.71**	**-6.16**	**-39.55**
Ranga Reddy	100.00	-505.67	1,083.6	-477.94	100.00	8.69	80.76	10.54	100.00	91.04	18.36	-9.40
Hyderabad	100.00	99.01	22.99	-22.00	100.00	85.71	50.00	-35.71	100.00	90.00	33.33	-23.33
Nizamabad	100.00	-140.88	334.88	-94.00	100.00	349.47	-351.98	102.51	100.00	-13.64	118.6	-4.99
Medak	100.00	119.06	-77.86	58.79	100.00	143.19	-67.03	23.84	100.00	272.17	-274.7	102.59
Mahaboobnagar	100.00	38.20	20.17	41.63	100.00	39.14	38.81	22.05	100.00	42.81	29.70	27.49
Nalgonda	100.00	141.21	-59.10	17.88	100.00	84.90	13.25	1.85	100.00	88.69	18.24	-6.93
Warangal	100.00	211.03	-457.50	346.48	100.00	-89.74	253.93	-64.19	100.00	118.90	-47.93	29.03
Khammam	100.00	700.43	-1,088	487.85	100.00	206.90	-163.16	56.26	100.00	64.99	8.75	26.26
Karimnagar	100.00	100.32	-5.72	5.40	100.00	91.74	24.57	-16.31	100.00	115.37	-58.77	43.40
Adilabad	100.00	-14.85	191.66	-76.81	100.00	-96.12	562.79	-366.67	100.00	46.68	35.62	17.69
Telangana	**100.00**	**28.80**	**51.87**	**19.34**	**100.00**	**36.61**	**52.16**	**11.23**	**100.00**	**31.03**	**60.40**	**8.57**
Andhra Pradesh	**100.00**	**157.68**	**-10.99**	**-46.69**	**100.00**	**144.57**	**-23.22**	**-21.35**	**100.00**	**287.19**	**-67.92**	**-119.26**

Among the districts, area effect was higher than other components of change in production was noticed in fourteen, seventeen and eleven districts respectively in period-I, period-II and overall period (Table 2). Thus, in majority of districts, during the all periods area has predominant effect on production differential. So, in majority of districts, regions and State as a whole area effect on production differential was higher than other components of change.

Policy Implications:

- Instability in production was more influenced by area indicates there is a need of in depth study about factors influencing the area expansion like assured and timely supply of farm inputs and providing remunerative prices to farmers.
- But, as area under cultivation cannot be increased beyond certain level, the growth in production should come from yield attributing factors.
- *Steps to be taken for the stabilisation of yield by development of high yielding farming system specific varieties and improvement in input use efficiency.*

References

Bhavaniprasad, Y. 1993. Growth and instability of oilseeds production in Andhra Pradesh. M.Sc. (Ag.) Thesis, unpublished, Department of Agricultural Economics, Agricultural College, Bapatla, Andhra Pradesh Agricultural University, Hyderabad.

Hazell, P.B.R. 1984. Sources of increased instability in India and US cereal production. *American Journal of Agricultural Economics*, **66**: 302-311.

Kaur, Narinder and Singhal, K.C. 1988. India's export instability. *Margin*, **21**:54-61.

J. Oilseeds Res., **22**(1) : 155-158 (2005)

Training needs of oilseeds researchers : an assessment study

M. Padmaiah

Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, AP

(Received: April, 2004; Revised: June, 2004; Accepted: September, 2004)

Abstract

The study was carried out during the year 2000-01. The results indicate that majority (73.4%) of researchers belonged to middle aged group and had Ph.D. as educational qualification. The trainings under went by them were found to be low. Majority (75.5%) of them agreed the existence of motivation at their organizations. Only 44.4% of them satisfied over the infrastructure facilities and 60% of them agreed the existence of information facilities. The duration as perceived by high majority (44.5%) was two weeks with frequency of three years once. The major training needs perceived by them were recent trends in production technology of oilseed crops (ranked first) followed by use of statistics in oilseeds research and post harvest technology for oilseeds development ranked II and III respectively in oilseeds research management. While in communication management, information technology and computer application in oilseeds development and use of multi media in out reach of oilseeds technology ranked I and II respectively. The suggestions offered by them for effective training, in which more number of visits to research and development organizations followed by emphasis laid more on practicals. The other suggestions made were also considered to be important for effectiveness of training.

Key words: Training needs, training, assessment

Introduction

In all of the fields of science, there is none that is more basic to the needs of humanity than agricultural research. The work of agricultural researchers has played an important role in the Indian agriculture especially in raising production and productivity of cereals, pulses and oilseeds. Of late, the establishment of Technology Mission on Oilseeds and Pulses has made an impact on the vegetable oil production in the country to shift from a stagnation stage to swift growth stage (Ramanjaneyulu *et al.*, 1988-89 to 1997-98). However, in recent years, the aberration in monsoon and stiff competition from the global forces after the liberalization, the agriculture as such is passing through critical stages. The change in agriculture in general and oilseeds in specific is very faster today, requiring continual upgradation of knowledge and skills of researchers who have engaged in research and development for enhanced oilseed production. Now, the rapid changing in communication and technical knowledge systems are accessible for sharing information among the researchers for achieving the quality technical out put, it necessitates a need based training among the researchers, the present trends in oilseeds and training needs in view, a study was conducted to assess the training needs of researchers engaged in the research and development of oilseeds technology with the following objectives:

1. To know the profile characteristics of researchers engaged in the oilseeds research and development.
2. To study duration and frequency of training and working condition at organization as perceived by researchers
3. To assess the training needs for upkeeping knowledge and skills and suggestions for effective training as perceived by them.

Materials and methods

A total of 45 researchers working on oilseed crops at Directorate of Oilseeds Research and oilseed research centres mostly under Agricultural Universities located across the country formed the clientele of the study. A questionnaire developed after a pilot survey was sent to researchers, who have been associated with the research and development of oilseeds. Out of 100 questionnaires mailed during the year 2001-01 and responses were received from only 45 researchers. The data were tabulated and analysed with suitable statistical tools.

Results and discussion

Large majority of researchers (73.4%) belonged to middle aged group followed by young aged group (22.2%). The representation of old aged group was only 4.4% (Table 1). Further, the results showed that high, majority (77.8%) had Ph.D. degree. While only 22.2% of them had Master's Degree in their educational qualifications.

It could be seen from Table 2, that high majority (37.8%) belonged to medium service followed by low and high service experience of 33.3 and 28.9 % respectively. The highest number of trainings underwent during their service period was 10.5 times by the high service group, while the least only 3.5 times trainings under went by low service experience group. The medium service experience group had 6.8 times training during service. It could be inferred that in the rapid changing agriculture scenario, the trainings underwent by them during service period were considerably low and there was a need for more need based trainings for upkeeping of subject knowledge and skills for quality research and development. Cursory look at the Table 3 indicated that high majority (44.5%) of them perceived training duration of 2 weeks as optimum. While 33.3 per cent of them perceived training duration was one week as optimum. Only 13.3 % of them perceived three weeks duration as optimum. More than three weeks training duration was suggested by 8.9 % of respondents.

Table 1 Distribution of researchers according to their age and education (n=45)

Particulars	Frequency No.	Percentage
Age (years)		
Young (upto 35)	10	22.2
Middle (36-55)	33	73.4
Old (above 55)	2	4.4
Education		
Master degree	10	22.2
Ph.D.	35	77.8

Table 2 Distribution of researchers according to their experience and trainings underwent

Category	Frequency (No.)	Percentage	Trainings underwent (average)
Low service experience (1-11 years)	15	33.3	3.5 times
Middle service experience (11-22 years)	17	37.8	6.8 times
High service experience >22 years	13	28.9	10.5 times

(Optimum 33 years of service considered as full pension accordingly categorized into three groups based on the experts opinion)

Table 3 Distribution of researchers based on perceived duration and frequence of training programmes

Duration of training period category	Frequency (No.)	Percentage
One week	15	33.3
Two weeks	20	44.5
Three weeks	6	13.3
>Three weeks	4	8.9
Total	45	100.0
Gaps between trainings		
One year	5	11.1
Two years	15	33.3
Three years	25	55.6
Four years	-	
Total	45	100.0

Further, the results indicate that the frequency between trainings was three years as perceived by high majority 55.6 %. While 33.3 % of them perceived two years gap between trainings as optimum frequency. Only 11-1 % of them perceived every year as optimum frequency for training for up gradation of knowledge and skills in research and development.

High majority (75.5%) of them agreed upon existence of motivation for researchers in their organization (Table 4). Sixty per cent of them opined that the existence of researchers performance appraisal, while 28.9 % of them disagreed. About 45 % of them satisfied with the availability of well equipped infrastructure facilities for research, whereas 36 % of them disagreed with the available facilities. Large majority (60%) of researchers satisfied with the availability of information system to the researchers. While 22.2 % disagreed. In case of incentive system for best performed researchers, in which 45 % of them expressed disagreement, while only 29 % agreed and 27 % of them had undecided. It could be inferred that a conducive organizational climate helps to excel in the research activities by the researchers.

The data presented in Table 5 indicated that recent trends in production technology of oilseed crops ranked first similar finding was reported by Jerry Gibson and Hillson, 1994 followed by use of statistics, post harvest technology for oilseeds development and SWOT analysis of research projects ranked II, III and IV, respectively. The other research areas perceived by them were also equally important for upkeeping of knowledge trends in oilseeds development in the oilseeds research management area.

In case of communication area, information technology and computer application in oilseeds ranked first. The other needs perceived by them were use of multimedia in out reach of oilseeds technology and writings to media and Journal for effective presentation ranked II and III respectively.

Further, results on other needs perceived by them indicate that the administrative and financial procedural management ranked first followed by participatory technology development and assessment and refinement of traditional heritage system ranked II and III respectively. Surprisingly, the upgradation of skills in handling of subject related equipment ranked II and rural appraisal techniques ranked V.

The data presented in Table 6 indicate that the suggestion on more number of visits to research and development organizations ranked first. While emphasis laid on practical and supply of information kit well in advance ranked II and III respectively. The suggestion on conducting training during slack period ranked IV.

Table 4 Distribution of respondents based on their opinion about organization (n=45)

	Agree		Undecide		Disagree	
	F (no)*	Percentage	F(nos)*	Percentage	F (no)*	Percentage
Existence of researchers motivation	34	75.5	3	6.7	8	17.8
Existance of researchers performance appraisal	27	60.0	5	11.1	13	28.9
Availability of well equipped infrastructure facilities for research	20	44.4	9	20.0	16	35.6
Availability of needful information system for researchers	27	60.0	8	17.8	10	22.2
Existing of incentives for the best performed researchers	13	28.9	12	26.4	20	44.4

* Multiple response; F = Frequency

Table 5 Distribution of researchers based on their perceived training needs (n=45)

A. Oilseeds Research Management	F (No.)*	Percentage	Rank
Recent trends in production technology of oilseed crops	36	80.0	I
SWOT analysis of research projects	25	55.	IV
Dynamics of integrated pest management in oilseed crops	20	44.4	VI
Impact assessment of oilseeds research projects	24	53.3	V
Post harvest technology for oilseeds development	28	62.2	III
Application of molecular technology in oilseeds development	13	28.9	VII
Use of statistics in oilseeds research	30	66.7	II
Research trends in weed management	10	22.2	VIII
B. Communication management			
Information technology and computer application in oilseeds development	41	91.1	I
Use of multimedia in out reach of oilseeds technology	32	71.1	II
Writting to media and journal for effective presentation	12	26.7	III
Others			
Upgradation of skills in handling of subject related equipment	20	44.4	IV
Assessment and refinement of traditional heritage system	27	60.0	III
Participatory technology development in oilseed crops	33	73.3	II
Participatory rural appraisal techniques	17	37.8	V
Administrative and financial procedures for scientific management	34	75.5	I

* Multiple response

Table 6 Distribution of researchers based on their general suggestion for effective training (n=45)

Particulars	F (No.)*	Rank
Emphasis laid more on practicals	34	II
Encourage in use of multi media for effective presentation	17	VIII
More number of visits to research and development organizations	36	I
Involvement of more experienced personnel as trainers	20	VI
Supply of information kit well in advance	30	III
Training should be conducted preferably during slack period	28	IV
Training should be arranged in the premier organizations	15	IX
Trained personnel need to be retained in the same working place at least three years after training	14	X
Encouragement of abroad training at least twice in the service	26	V
Encourage of incentives for the best performance in the research	18	VII
Encourage more discussions during training course	14	X

* Multiple response

Acknowledgements: The author is grateful to the Project Director for constant and technical support. The author is also thankful to Dr. S.V. Ramana Rao, G.V. Ramanjaneyulu and G. Keshauloo, who have helped in data collection and analysis. The service rendered by Sri B. Hari Kumar, PA in typing the manuscript is acknowledged.

References

Jerry, D. Gibson and John Hillison, 1994. Training needs of Area Specialized Extension Agents, *Journal of Extension*, **32** (3): 1-5.

Ramanjaneyulu, G.V., Ramana Rao, S.V. and Hegde, D.M. 1986-87 to 1997-98. A decade of Frontline Demonstrations in oilseeds: An over view, Directorate of Oilseeds Research (ICAR), Rajendranagar, Hyderabad-500 030, India.

J. Oilseeds Res., **22**(1) : 159-161 (2005)

Relationship of farmers' traits with knowledge of rapeseed-mustard production technology

R.S. Malik, P.S. Shehrawat, Sube Singh and Loveraj Singh

Department of Extension Education, CCS Haryana Agricultural University, Hisar-125 004, Haryana

(Received: February, 2000; Revised: August, 2004; Accepted: September, 2004)

Abstract

Knowledge about the production technology emerged as the single most important factor in the transfer and adoption of technology and was dependent up on various background variables of farmers. In planning a technology transfer programmes, extensionists and scientists should consider these factors in relation to their relative influence as indicated in the study. Among all the traits education of the farmers emerged important factor influencing knowledge which can be enhanced by means of training, motivating for participation in field days, *kisan melas*, farm darshan, dramas, etc. Mass media exposure and extension contact of farmers with extension agencies were found to be important variables affecting the knowledge of the farmers. Maximum efforts should be made to provide relevant and new information through radio and television by scientists who generate the information in different disciplines.

Key words: Trait, production technology, rapeseed-mustard

Introduction

Oilseed crops play an important role in Indian agriculture, industry and trade. Oilseed is the second largest commodity after cereals in India sharing 13% of the country's gross cropped area and about 5% of the gross national product and 10% of the value of all agricultural products. It occupies an area of 5070 thousand ha and production of 5080 thousand tones with productivity of 1002 kg/ha during 2001-02 (Hegde, 2004). Haryana is a major rapeseed-mustard growing state in India and ranks third after Rajasthan and Uttar Pradesh, both in area (535 thousand ha) and production (796 thousands tones) during 2001-02. The average yield of crop in the country as well as in the state is very poor as compared to the developed countries, where the average yield is two to four times higher than in India. For increasing the production and productivity of oilseed crop in the country requires a concerted extension thrust with special emphasis for successful transfer of technology to the farmer's fields. For this, it became imperative to study the relationship between farmers' background variables with their knowledge level pre-and post-exposure about rapeseed-mustard production technology.

Materials and methods

The study was conducted in Bhiwani district of Haryana state selected purposively because of its maximum area and production under rapeseed-mustard crop in the year 2000. This district comprises of eight blocks out of which Dadri-I and Tosham were selected randomly. A list of villages growing rapeseed-mustard crop was prepared for each block. From both the blocks two villages, namely, Mehrana and Kheri-Sanwal from Dadri-I and Sangwan and Dhani-Mahu from Tosham were selected randomly. Hence, total numbers of 100 rapeseed-mustard growers (25 from each village) were selected randomly. Data was collected on interview schedule at farmers' fields. Pearson's coefficient of correlation was worked out to determine the relationship between the farmer's background variables, namely, age, caste, family education, occupation, education, house, extension contact, material possession, farm power, mass-media exposure, source of irrigation, source of income, economic motivation, scientific orientation and risk preference and their knowledge level (pre- and post-exposure training) about rapeseed-mustard production technology.

Results and discussion

The findings indicated that at pre-training stage, no variable was found to be significantly correlated with the knowledge level of farmers about essential production practices (EPP) while respondent's education, family education, mass media exposure, extension contact and scientific orientation were found positively and significantly correlated with the motivational production practices (MPP) an given in Table 1. In case of other agricultural practices (OAP), the respondent's education, material possession, family education, mass media exposure, extension contact and scientific orientation were positively and significantly correlated. The respondent's education, mass media exposure, extension contact, economic motivation and scientific orientation were also positively and significantly correlated with the overall knowledge level of rapeseed-mustard production technology. It means that these variables play an important role in enhancing the knowledge level of farmers.

At post training, no variable was found to be significant or correlated with knowledge level of farmers in case of EPP. The correlation coefficients of respondent's education, family education, mass media exposure, extension contact and scientific orientation were positively and significantly correlated with the knowledge level about MPP, while in case of OAP, respondent's education, material possession, family education, mass media exposure, extension contact, economic motivation and scientific orientation were significantly correlated and also found to have positive relationship with overall knowledge of farmers. It indicated that farmer's education, material possession, family education, mass media exposure, extension contact, economic motivation and scientific orientation did positively affected the farmers gain in knowledge while the remaining variables did not effect.

Table 1 ***Correlation coefficients of farmers' background variables of their knowledge for pre-and post-training stages about rapeseed-mustard production technology in four villages (N=100)***

Variable	Pre-training				Post-training			
	EPP	MPP	OAP	Total	EPP	MPP	OAP	Total
Age	0.260	-0.220	0.142	0.004	0.158	-0.017	0.140	-0.044
Caste	0.069	0.077	-0.121	0.002	0.144	-0.109	-0.056	-0.089
Occupation	0.072	0.014	-0.140	-0.079	0.045	0.036	-0.064	-0.003
House	0.069	0.139	-0.049	-0.117	0.133	-0.192	0.107	-0.228
Social Participation	0.015	0.006	-0.085	-0.035	0.005	-0.072	-0.098	-0.228
Education	0.031	0.385	0.536*	0.826*	0.252	0.472*	0.475*	0.620*
Land Holding	0.154	0.126	0.003	0.177	0.172	0.119	0.089	0.184
Family type	0.159	0.183	-0.173	0.083	0.105	0.132	-0.145	0.047
Family size	0.155	0.010	-0.068	0.007	0.097	-0.027	-0.049	-0.020
Material possession	0.264	0.288	0.475*	0.699*	0.234	0.297	0.388*	0.416*
Farm power	0.100	0.026	0.008	0.038	-0.004	-0.029	0.055	0.036
Source of income	0.093	0.045	0.134	-0.092	0.080	-0.012	-0.104	-0.053
Family education	0.229	0.395*	0.539*	0.836*	0.300	0.497*	0.458*	0.630*
Source of irrigation	0.064	0.093	0.020	0.143	0.141	0.066	0.086	0.127
Mass-media exposure	0.262	0.423*	0.497*	0.854*	0.276	0.537*	0.437*	0.658*
Extension contact	0.252	0.382*	0.543*	0.839	0.218	0.437*	0.449*	0.588*
Economic motivation	0.334	0.373	0.296	0.700	0.257	0.319	0.319	0.439*
Scientific orientation	0.258	0.457*	0.408*	0.811*	0.324	0.457*	0.399*	0.582*
Risk preference	0.191	0.140	0.111	0.312	0.007	-0.006	0.058	0.024

* Significant at 0.05 level of significance EPP= Essential Production practices MPP= Motivational Production practices;

OAP= Other Agricultural Practices OARPT (Total)= Overall Rapeseed-mustard Production Technology

At pre-training, respondent education, material possession, family education, mass-media exposure, extension contact, economic motivation and scientific orientation were significantly and positively correlated and the same trends were observed in case of post-training stage also. It means that respondent education and family education were the crucial factors in all the villages. It shows the importance of education in the transfer of rapeseed-mustard production technology. Material possession, mass media exposure, extens[illegible] contact, economic motivation and scientific orientation were also found to be important factors in all the villages. Age, caste, occupation, social participation, house, land holding, family type, family size, farm power, income, irrigation and risk preference were not found significantly correlated with the knowledge level of farmers in all the four selected villages.

Table 2 Multiple regression analysis of farmers' background variables of their knowledge for pre-and post-exposure about rapeseed-mustard production technology (N=100)

Variable	Pre-training				Post-training			
	EPP	MPP	OAP	Total	EPP	MPP	OAP	Total
Age	--	--	--	--	--	--	--	--
Caste	--	--	--	--	--	--	--	--
Occupation	--	--	--	--	--	--	--	--
House	--	--	--	--	--	--	--	--
Social Participation	--	--	--	--	--	--	--	--
Education	--	--	--	0.262 (2.29)*	--	--	--	0.446 (2.86)*
Land Holding	--	--	--	--	--	--	--	--
Family type	--	1.196 (2.45)*	0.980 (2.47)*	--	--	1.123 (2.53)*	1.000 (2.81)*	--
Family size	--	--	--	--	--	--	--	--
Material possession	--	0.438 (2.63)*	--	0.500 (3.53)*	--	0.001 (2.81)*	--	1.119 (4.13)*
Farm power	--	--	--	--	--	--	--	--
Source of income	--	--	--	--	--	--	--	--
Family education	--	--	--	---	--	--	--	--
Source of irrigation	--	--	--	--	--	--	--	--
Mass-media exposure	--	--	--	0.378 (2.70)*	--	--	--	1.047 (3.84)*
Extension contact	--	--	--	0.405 (2.85)*	--	--	--	--
Economic motivation	--	--	0.152 (2.59)*	--	--	--	0.800 (2.25)*	--
Scientific orientation	--	0.202 (2.57)*	--	0.145 (3.03)*	--	0.102 (2.63)*	--	0.109 (2.58)*
Risk preference	--	--	--	*0.815 (2.66)**	--	--	--	0.113 (2.57)*

* Significant at 0.05 level of significance; Figures in the parenthesis are "t" value for the above shown "b" values
EPP= Essential Production practices; MPP= Motivational Production practices;
OAP= Other Agricultural Practices; *OARPT (Total)= Overall Rapeseed-mustard Production Technology*

The background variables of the farmers were also fitted into multiple regression equation to know the relative importance of each variable with their knowledge level. The total *variance explained by all the variables and the* net contribution of each variable reveals that when one of the *variables was increased*, the value of the dependent variable changed accordingly to their sign (positive/negative) with the amount of b value of each variable. It is evident from the Table 2 that in all the four selected villages, at pre-training stage, no variable was found significant in case of EPP. While in case of MPP, three variables. *viz., family type, material possession and* scientific orientation were found positively significant. Family type and economic motivation were found significant and positively correlated with the knowledge level of farmers about OAP, whereas in case of overall rapeseed-mustard production technology, six variables, namely, respondent education, material possession, mass media exposure, extension contact, scientific orientation and risk *preference were significantly and positively* correlated with the knowledge level of farmers. As discussed above, the same trend were found in post-training. Out of the variables included here, six variables jointly contributed to the extent of 85.36% and *79.96% of variation at the pre- and post-training stages*, respectively in the knowledge level of farmers towards the overall rapeseed-mustard production technology while the other variables held constant.

Findings suggest that farmers be supplied enough reading *material free of cost or at nominal rates. Efficient water* management through sprinklers schemes and need based irrigation must be recommended along with special emphasis on plant protection practices. Trainings on different aspects of crop production be imparted on the *farmers' field itself and should coincide with the cropping* season or crop growth stages.

References

Hegde, D.M. 2004. Becoming self reliant. *The Hindu : Survey of Indian Agriculture*,. pp.45-47.

J. Oilseeds Res., **22(1) : 162-163 (2005)**

Short communication

Genetics of iron-chlorosis related characters in groundnut, *Arachis hypogaea* L.

M.Y. Samdur, P. Manivel[1] and R.K. Mathur[2]

IARI Regional Station, Indore, MP

(Received: July, 2004; Revised: October, 2004; **Accepted: November, 2004**)

Groundnut, an important oilseeds crop, often suffers from lime induced iron-deficiency chlorosis particularly in areas having calcareous soils resulting in yield losses. The best way to deal with such problem is evolving high yielding varieties possessing tolerance to iron chlorosis suitable for cultivation in calcareous soils. The variation in groundnut germplasm for response to iron chlorosis has been reported (Singh and Chaudhari, 1991; Samdur *et al.*, 1999; Samdur *et al.*, 2000). Development of resistant varieties requires the knowledge on genetics and inheritance of chlorosis related parameters. Hence, the present investigation was carried out to study the genetics of iron chlorosis in groundnut.

For the study two parents, ICGV 86031 (resistant) and ICGV 86030 were selected and used in developing six generation breeding materials *viz.*, P_1, P_2, F_1, F_2, BC_1 and BC_2. All the generation materials were grown in Randomized Block Design with four replications during *rabi*-summer 2000 at National Research Centre for Groundnut (ICAR), Junagadh. Each net plot had one row for non-segregating generations (P_1, P_2, F_1), four rows for back cross generations and six rows for F_2 generation. Each row was of 2 m length with a spacing of 45 cm between rows and 10 cm between plants The experimental field had pH of 7.9, 29.6% calcium carbonate, 0.08% organic carbon, 0.06% total nitrogen, 6 ppm available P (Olsen's) and 1.35 ppm available Fe. On this soil plants showed iron deficiency chlorosis symptoms. The data were recorded on ten, forty and sixty randomly taken plants from each plot of non-segregating, back crosses and F_2 generation, respectively. Observations were recorded on Chlorophyll 'a', Chlorophyll 'b', Carotenoids, and total Chlorophyll contents at 35 and 50 days after emergence (DAE).

The scaling tests A, B, C and D were performed for all the four characters (Chlorophyll a, Chlorophyll b, total chlorophyll and carotenoids) to test the adequacy of three parameter model (Mather and Jinks, 1977). The estimates of gene effects and interactions were obtained using the digenic epistatic model (Hayman, 1958).

The ANOVA for all the characters i.e. Chlorophyll a, Chlorophyll b, total chlorophyll and carotenoids exhibited significant differences among the means of six generations (Table 1).

Table 1 Generation mean values of iron chlorosis deficiency related characters in groundnut cross ICGV 86031 x ICGV 86030

Character/ Generation	Chlorophyll content 35 DAE				Chlorophyll content 50 DAE			
	Chl 'a'	Chl 'b'	Total Chl	Carotenoids	Chl 'a'	Chl 'b'	Total Chl	Carotenoids
P_1	4.64	1.08	5.76	0.88	4.03	1.08	5.11	0.81
P_2	8.19	3.00	11.19	0.27	8.19	3.02	11.21	0.23
F_1	6.36	1.38	7.75	0.96	5.50	1.38	6.88	0.89
F_2	3.86	0.86	4.72	0.91	4.19	0.86	5.05	0.92
BC_1	4.55	1.10	5.65	0.95	4.79	1.10	5.89	0.93
BC_2	5.14	1.09	6.23	0.88	4.99	1.09	6.08	0.90
SEm (±)	0.94	0.27	1.24	0.02	0.82	0.23	1.02	0.03

Chl : Chlorophyll

[1] Senior Scientist, Crop Improvement Division, CPRI, Shimla-171 001, Himachal Pradesh.

[2] Senior Scientist, NRC for Oil Palm, Eluru, Andhra Pradesh.

The F_1 mean was significantly higher than mid parental and better parental values for carotenoids indicating the presence of dominance for this character. Out of four scaling tests, at least two were found significant for Chlorophyll a, Chlorophyll b, total chlorophyll and carotenoids (Table 2). This indicated the presence of non-allelic interactions for the inheritance of these traits. Six-parameter model indicated presence of additive x dominance epistatic interaction (j) significant for chlorophyll 'a', chlorophyll 'b' and total chlorophyll at both 35 DAE and 50 DAE. For carotenoids dominance gene effect (h), (j) and (l) type of interactions were found significant. In the present study only non-additive type of gene effects were observed for all the characters except for carotenoid content under study and hence these characters could possibly be improved by adopting reciprocal recurrent selection or bi-parental mating in the present material of groundnut.

Table 2 **Estimates of scaling tests and gene effects for different characters in a cross ICGV 86031 x ICGV 86030 in groundnut**

Character/ Generation	Chlorphyll content 35 DAE				Chlorophyll content 50 DAE			
	Chl 'a'	Chl 'b'	Total Chl	Carotenoids	Chl 'a'	Chl 'b'	Total Chl	Carotenoids
A	(-) 1.89±1.28	(-) 0.27 ±0.51	(-) 2.20±1.76	(+) 0.06±0.05	(+) 0.05 ±1.43	(-) 0.27 ±0.51	(-) 0.21±1.93	(+) 0.065±0.05
B	(-) 4.27±0.77*	(-) 2.21 ±0.47*	(-) 6.48±0.91*	(+) 0.53±0.08*	(-) 3.70 ±0.91*	(-) 2.23 ±0.48*	(-) 5.93±1.26*	(+) 0.53±0.08*
C	(-) 10.09±1.89*	(-) 3.42 ±0.68*	(-) 13.55±0.24*	(+) 0.55±0.17*	(-) 6.44 ±1.88*	(-) 3.43 ±0.68*	(-) 9.88±2.51*	(+) 0.55±0.17*
D	(-) 1.96±0.97	(-) 0.47 ±0.97	(-) 2.43±1.19*	(-) 0.02±0.08	(-) 1.40 ±0.93	(-) 0.47 ±0.31	(-) 1.86±1.19	(-) 0.02 ± 0.08
Gene effects								
m	(+) 3.86 ±0.39	(+) 0.85 ±0.08	(+) 4.72±0.47	(+) 0.90±0.03	(+) 4.19 ±0.31	(+) 0.85 ±0.08	(+) 5.05 ±0.39	(+) 0.90±0.39
(d)	(-) 0.58±0.56	(+) 0.11±0.26	(-) 0.58±0.71	(+) 0.07±0.03	(-) 0.20 ±0.68	(-) 0.01±0.26	(-) 0.19±0.89	(+) 0.07±0.02*
(h)	(+) 3.87 ±2.01	(+) 0.28 ±0.69	(+) 4.13±2.49	(+) 0.42±0.17**	(+) 2.18 ±1.99	(+) 0.27 ±0.69	(+) 2.45 ±2.58	(+) 0.42±0.16
(i)	(+) 3.92 ±1.94	(+) 0.94 ±0.62	(+) 4.86±2.38	(+) 0.04±0.15	(+) 2.79 ±1.87	(+) 0.94 ±0.62	(+) 3.73 ±2.39	(+) 0.04±0.16
(j)	(+) 1.18 ±0.73	(+) 0.97 ±0.30*	(+) 2.13 ±0.96**	(-) 0.23±0.05*	(+) 1.87 ±0.71	(+) 0.98 ±0.30*	(+) 2.85 ±0.96*	(-) 0.23±0.05**
(l)	(+) 2.24 ±2.93	(+) 1.53 ±1.24	(+) 3.82±3.73	(-) 0.64±0.21**	(+) 0.85 ±3.32	(+) 1.55 ±1.25	(+) 2.41 ±4.36	(-) 0.64±0.21*

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

References

Hayman, B.I. 1958. The separation of epistasis from additive and dominance variation in generation means. *Heredity*, **12**: 371-390.

Mather, K. and Jinks, J.L. 1977. *Introduction to Biometrical Genetics.* Chapman and Hall, London.

Singh, A. L. and Chaudhari, V. 1991. Screening of groundnut (*Arachis hypogaea*) varieties tolerant to iron chlorosis. *Indian Journal of Agricultural Sciences*, **61**: 925-27.

Samdur, M.Y., Mathur, R.K., Manivel, P., Singh, A.L., Bandyopadhyay, A., and Chikani, B.M. 1999. Screening of advance breeding lines for tolerance to lime-induced iron deficiency chlorosis. *Indian Journal of Agricultural Sciences*, **69**: 31-35.

Samdur, M.Y., Singh, A.L., Mathur, R.K., Manivel, P., Chikani, B.M., Gor, H.K. and Khan, M.A. 2000. Field evaluation of chlorophyll meter for screening groundnut genotypes (*Arachis hypogaea* L.) tolerant to iron-induced chlorosis. *Current Science*, **79 (2)**: 211-214.

J. Oilseeds Res., **22(1) : 164-167 (2005)**

Short communication

Potential crosses for development of hybrid varieties in Indian mustard, *Brassica juncea* (L.) Czern & Coss.

P.C. Gupta and Shiv Narayan

Agricultural Research Station, Rajasthan Agricultural University, Bikaner-334 006, Rajasthan

(Received: May, 2004; Revised: October, 2004; Accepted: December, 2004)

Indian mustard [*Brassica juncea* (L.) Czern & Coss.] is an important oilseed crop in the Indian sub-continent. So far, the agronomic improvement was sought by developing pure lines through pedigree method of breeding. Breeding methods for crop improvement depend upon the nature and magnitude of genetic variance controlling inheritance of the quantitative characters. Combining ability is frequently utilized to understand the nature of genetic variation, which in turn helps in selection of desirable parents for hybridization programme or identification of superior crosses for commercial exploitation of heterosis. Recently, the availability of stable cytoplasmic male sterile (cm) lines (Prakash and Chopra, 1990) and their restorer counter part (Kirti *et al.*, 1997) has stimulated the interest of plant breeders to explore the possibility of producing productive commercial hybrids. The present investigation was, therefore, undertaken to find superior cross combinations on the basis of combining ability and heterosis for their future use in development of superior hybrids.

Three well adapted commercial varieties *viz.*, Varuna, Bio 902 and Pusa Bold were used as testers and eleven elite lines i.e., JM 1, RGN 11, RGN 13, SPS 3, SPS 11, SPS 13, RN 505, RSM 256, RSM 250, RSM 243 and TM 1 were selected on the basis of desirable agronomic characters. These three commercial varieties and 11 lines of Indian mustard were crossed in line x tester mating design during *rabi*, 2001-02. The resulting 33 crosses along with 14 parents were evaluated in Randomized Block Design with 2 replications at Agricultural Research Station, Rajasthan Agricultural University, Bikaner during *rabi*, 2002-03. Each genotype was sown in two rows of 3 m length with a spacing of 30 cm between rows and 15 cm between plants. In all the plots, within and between replications, uniform plant population was maintained by proper thinning. Observations were recorded on five randomly selected competitive plants for plant height (cm), primary branches/plant, secondary branches/plant, length of main raceme (cm), siliquae on main raceme, siliquae/ plant, siliqua length (cm) and test weight (g). While observations for days to 50 % flowering, days to maturity and seed yield (kg/ha) were recorded on the plot basis. The estimates of combining ability effects were estimated according to the method suggested by Kempthorne, 1957. The standard heterosis for seed yield and it's components was estimated over the best check variety Pusa Bold.

Significant mean squares for parents vs crosses indicated the presence of heterosis in the crosses for all the traits except for plant height. Higher magnitude of variances due to lines in comparison to testers were observed for days to 50% flowering, days to maturity, plant height, length of main raceme, siliquae/ plant and test weight. However, the magnitude of variances due to *gca* (testers) were higher than those due to *gca* (lines) for primary branches/plant, secondary branches/plant, siliquae on main raceme and siliqua length indicating greater diversity among the testers as compared to lines for their combining ability. The variances due to *sca* were found to be higher in magnitude than *gca* (average) for all the characters except days to 50% flowering and days to maturity, suggesting preponderance of non-additive type of gene action in the inheritance of these traits and, therefore, hold promise for exploitation of heterosis in Indian mustard. These results are in agreement with those of Anand and Reddy (1987) and Patel *et al.* (1993).

Among the three tester parents, Bio-902 was good general combiner for seed yield (Table 1). It was also good general combiner for siliquae/plant, secondary branches/plant, siliquae on main raceme, length of main raceme, primary branches/plant and siliqua length. Varuna was found good general combiner for test weight only. Among the lines, only RSM 243 was good general combiner for seed yield. It was also good general combiner for siliquae/plant, secondary branches/plant, primary branches/plant, test weight and siliqua length. However, lines SPS 3 and RSM 256 for plant height, SPS 3 and RSM 250 for primary branches/plant, RN 505, RSM 256 and RSM 250 for secondary branches/plant, RN 505, SPS 3, RSM 256 and RSM 250 for length of main raceme, SPS 3 for siliquae on main raceme, RGN 13, RSM 250 and TM 1 for siliquae/plant, RSM 250 for siliqua length and JM 1, RGN 13, SPS 11, RSM 256 and RSM 250 for test weight were found good general combiners. As regards to earliness, JM 1, RGN 11, and TM 1 were found good general combiners. Since, the *gca* effects are attributed to fixable components i.e. additive and additive x additive gene effects, the above mentioned parents may be used in hybridization programme for the improvement of respective traits through transgressive segregants (Griffing, 1956; Sprague, 1966).

Sca effects are attributed to dominance and its interactions. Based on significant positive *sca* effects, only five crosses were considered desirable for seed yield. All these crosses except RN 505 x Varuna exhibited significant standard heterosis over the best check variety Pusa Bold for seed yield (Table 2). The cross RSM 250 x Bio 902 exhibited highest per se performance (4139 kg/ha) and *sca* effect (0.13) for seed yield. The *sca* effect of this cross was in desirable direction for most of the yield contributing traits also. Further, this cross exhibited 37% superiority over the Pusa Bold in terms of seed yield. This cross was followed by SPS 3 x Pusa Bold exhibiting 15% superiority over the best check. Nevertheless, the *sca* effect of this cross was desirable for earliness. Other crosses like RSM 256 x Pusa Bold and SPS 13 x Pusa Bold exhibited 17 and 10 per cent superiority over the best check Pusa Bold. All these crosses also had potential for components of seed yield.

Potential heterotic crosses involving atleast one parent of good general combining ability but non-significant *sca* effects were identified for handling segregating generations of these crosses to obtain transgressive segregants (Arunachalam and Katiyar, 1982). Based on this criterion, six crosses were found for seed yield (Table 3). These crosses were RSM 243 x Varuna, JM 1 x Bio 902, RGN 11 x Bio 902, RGN 13 x Bio 902, SPS11 x Bio 902 and RSM 243 x Bio 902. All these crosses except RGN 11 x Bio 902, exhibited standard heterosis over the Pusa bold for seed yield, siliqua length and test weight. The superiority of these crosses over best check variety Pusa Bold for seed yield was 5, 19, 14, 19 and 23% respectively. Beside this, heterotic crosses with significant *sca* effects may also give transgressive segregants provided the *gca* effects of parents are of greater magnitude (Goyal and Kumar, 1988). No such crosses could be identified in the present study for seed yield. However, for some component characters, a few crosses were identified as promising namely, RN 505 x Pusa Bold for length of main raceme, TM 1 x Varuna and TM1 x Bio 902 for siliquae/plant and RSM 256 x Varuna and RSM 250 x Varuna for test weight.

Table 1 Combining ability effects of lines, testers and crosses in Indian mustard

	Days to 50% flowering	Days to maturity	Plant height	Primary branches/ plant	Secondary Branches/ plant	Length of main raceme	Silquae on main raceme	Siliquae /plant	Siliqua length	Test weight	Seed yield
Lines											
JM 1	**-0.86***	**-0.89***	**-16.24****	-0.28	-1.29	**-7.8****	-2.12	**-163.67****	0.13	**0.61****	0.01
RGN 11	**-1.53****	**-1.56****	-7.08	**-1.37****	**-11.62****	0.54	-3.95	**-224.42****	-0.33	**-0.43****	-0.06
RGN 13	-0.03	-0.06	10.47	-0.24	0.21	-0.71	4.3	**174.58****	0.05	**0.26****	-0.02
RN 505	0.30	0.27	2.01	-0.03	**3.88****	**5.12****	**-6.79***	-24.26	-0.2	**-0.83****	**-0.07***
SPS3	**1.97****	**2.11****	**15.42****	**0.8****	-0.04	**6.7****	**5.55***	-73.76	**-0.53****	**-1.11****	0.02
SPS 11	-0.03	-0.06	1.26	-0.45	-0.62	-1.13	1.46	**-143.84****	0.01	**0.27****	0.02
SPS 13	0.14	0.11	6.26	0.09	0.05	**-7.71****	-3.2	**-132.01****	0.13	-0.03	0.02
RSM 256	0.80	0.77	**11.26**	-0.24	**3.3***	**4.7****	2.3	-35.01	0.22	**0.57****	0.03
RSM 250	**1.3****	**1.27****	3.34	**1.3****	**4.63****	**4.7****	4.13	**246.16****	**0.51***	**0.71****	0.05
RSM 243	0.30	0.27	-2.08	**0.8****	**6.63****	2.95	1.3	**135.33****	**0.42***	**0.5****	**0.07***
TM 1	**-2.36****	**-2.23****	**-24.58****	-0.37	**-5.12****	**-7.38****	-2.95	**240.91****	**-0.41***	**-0.54****	**-0.07***
SE	0.42	0.41	5.53	0.24	1.24	1.62	2.57	36.36	0.19	0.07	0.03
Testers											
Varuna	0.11	0.08	3.86	0.03	-2.55**	-3.02**	-2.2	4.16	-0.33**	0.24**	-0.03**
Bio-902	0.11	0.17	-2.78	**0.6****	**4.05****	**2.18****	**2.96***	**95.95****	**0.31****	**-0.14****	**0.06****
Pusa Bold	-0.21	-0.24	-1.08	**-0.64****	**-1.5***	0.84	-0.77	**-100.11****	0.02	**-0.09****	**-0.03****
SE	0.19	0.18	2.47	0.11	0.55	0.73	1.15	16.26	0.08	0.03	0.01
Crosses											
RSM250 x Bio 902			**16.11***	**0.81***	**7.12****		**10.37****	**304.3****	**0.78****	**0.21***	**0.13****
SPS3 x Pusa Bold	**-1.21***	**-1.42***			**9.83****			**304.28****	**1.1****	**1.46****	**0.12****
RN505 x Varuna								**248.26****	**0.87****		**0.12****
RSM256 x Pusa Bold				**0.97****	**4.5***		**10.43****	**348.53****		**0.82****	**0.11****
SPS13 x Pusa Bold					**4.25***	**11.83****	**10.43****	**173.53****		**0.4****	**0.09***

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

Table 2 Significant standard heterosis over Pusa Bold for different traits in Indian mustard

Crosses	Primary Branches/Plant	Siliquae/ plant	Siliqua length	Test weight	Seed yield
RSM 243 x Varuna			41.33 (7.25)	59.21 (6.83)	5.48 (3194)
JM 1 x Bio 902			51.07 (7.75)	27.04 (5.45)	19.25 (3611)
RGN 13 x Bio 902			55.95 (8.0)	31.24 (5.63)	13.74 (3444)
SPS 11x Bio 902			43.86 (7.38)	32.87 (5.70)	19.25 (3611)
RSM 256 x Bio 902			48.73 (7.63)		4.59 (3167)
RSM 250 x Bio 902	21.06 (10.75)	115.18 (1375)	68.23 (8.63)	38.00 (5.92)	36.69 (4139)
RSM 243 x Bio 902	21.06 (10.75)	96.4 (1255)	58.48 (8.13)	28.90 (5.53)	22.92 (3722)
SPS 3 x Pusa Bold		34.43 (859)	48.73 (7.63)	25.87 (5.4)	14.66 (3472)
SPS 13 x Pusa Bold			48.73 (7.63)	26.34 (5.42)	10.07 (3333)
RSM 256 x Pusa Bold		47.42 (942)	51.07 (7.75)	50.12 (6.44)	16.51 (3528)
RSM 250 x Pusa Bold			41.33 (7.25)	18.88 (5.10)	1.82 (3083)

Value in parenthesis indicate per se performance

Table 3 Heterotic crosses with their combining ability effects for different characters in Indian mustard

Crosses	g_i	g_j	S_{ij}	Characters
RSM 243 x Varuna	-0.03**	0.07*	0.01	Seed yield
JM 1 x Bio 902	0.06**	0.01	0.07	Seed yield
RGN 11 x Bio 902	0.06**	-0.06	0.01	Seed yield
RGN 13 x Bio 902	0.06**	-0.02	0.07	Seed yield
SPS 11 x Bio 902	0.06**	0.02	0.06	Seed yield
RSM 243 x Bio 902	0.06**	0.07*	0.02	Seed yield
RN505 x Pusa Bold	0.84	5.12**	4.99**	Length of main raceme
TM1 x Varuna	4.16	240.91**	114.09*	Siliquae/plant
TM1x Bio 902	95.95**	240.91**	207.8**	Siliquae/plant
RSM 256 x Varuna	0.24**	0.57**	0.45**	Test weight
RSM 250 x Varuna	0.24**	0.71**	0.45**	Test weight

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

On the basis of heterosis and combing ability effects, selection of parents may be done for hybridization while crosses may be selected both for handling of segregating generations with an aim to obtain transgressive segregants or commercial exploitation of heterosis. Bio 902 and RSM 243 were identified as good general combiner for seed yield and its contributing characters. Crosses, RSM 250 x Bio 902, RSM 243 x Bio 902, JM1 x Bio 902, SPS 11 x Bio 902, RSM 256 x Pusa Bold, SPS 3 x Pusa Bold, RGN 13 x Bio 902 and SPS13 x Pusa Bold were identified as potential for commercial exploitation of heterosis for yield. These crosses exhibited 37, 23, 19, 19, 17, 15, 14 and 10%, respectively superiority in terms of seed yield over the best check Pusa Bold. In these cross combinations, male sterility in one parent and its complete fertility restoration by other parent would make commercial exploitation of heterosis feasible.

References

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

Arunachalam, V. and Katiyar, R.K. 1982. A viable short term strategy for breeding composite populations. *Indian Journal of Genetics*, **42**:32-37.

Goyal, S.N. and Kumar, Sudhir. 1988. Heterosis in relation to general and specific combining ability in sesame. *Indian Journal of Genetics*, **48** (2): 251-253.

Griffing, B. 1956. The concept of general and specific combing ability in relation to diallel crossing system. *Australian Journal of Biological Sciences*, **9**: 463-493.

Kirti, P.B., Baldev, A., Gaikwad, K., Bhat, S.K., Kumar, Dinesh., Prakash, S. and Chopra, V.L.1997. Introgression of gene restoring fertility of CMS (Trachystma) *B. juncea* and genetics of restoration. *Plant Breeding*, **116**: 257 -262.

Kempthorne, O. 1957. *An introduction of genetic statistics*. John Wiley and Sons, New York., pp. 458-471.

Patel, K.M., Prazapati, K.P. Fattah, U.G. and Patel, I.D. 1993. Combining ability and heterosis in Indian mustard. *Journal of Oilseeds Research*, **10** (1): 129-131.

Prakash, S. and Chopra. V.L. 1990. Male sterility caused by cytoplasm of *Brassica oxyrrhina* in *B. campestris* and *B. juncea*. *Theoritical Applied Genetics*, **79**: 285 -287.

Sprague, G.F. 1966. Quantitative genetics in plant improvement. In: *Plant Breeding* (Ed. K.J. Frey), Iowa State Univ., Press, Ames, Iowa: pp. 315-347.

J. Oilseeds Res., **22**(1) : **168-171 (2005)**

Short communication

Assessment of genetic divergence in genepool inbreds and elite lines of sunflower, *Helianthus annuus* L.

V. Thirumala Rao, A.R.G. Ranganatha[1], M. Ganesh, K. Srinivasulu and P.V.R. Rao

Dept. of Genetics & Plant Breeding, College of Agriculture, ANGRAU, Rajendranagar, Hyderabad-500 030, AP

(Received: September, 2003; Revised: July, 2004; Accepted: September, 2004)

Sunflower (*Helianthus annuus* L.) is one of the most important oilseed crops, which can fit very well in to various cropping systems. The genetic variability may be utilized to further enhance the yield level and oil content of the cultivars by following appropriate breeding strategies. Nevertheless, before launching any such venture, proper assessment of existing variability and identification of genetically diverse genotypes is utmost important. Multivariate analysis is one of the important biometrical tools for quantifying the degree of divergence among different genotypes. Mahalanobis D^2 technique (Rao, 1952) has been successfully used by the plant breeders in different crops for isolating genetically diverse genotypes. In the present study, an attempt has been made to understand the nature and magnitude of genetic divergence and to select the divergent parents for future breeding programme for the exploitation of heterosis and population improvement programmes.

The experimental material consisted of 94 genotypes including three checks were sown in Randomized Block Design with two replications at college farm, College of Agriculture Hyderabad during *kharif* 2001. Each genotype was raised in two rows of 5 m length with a spacing of 60 x 30 cm. Recommended agronomic practices were followed to raise a good crop. In each treatment the data were recorded on five randomly selected plants for various characters *viz.,* number of leaves/plant, days to 50%flowering, days to maturity, plant height, head diameter, number of filled seeds and unfilled seeds/plant, test weight, seed yield and oil content in each replication. The Mahalanobis D^2 statistics were used to measure the divergence and grouping in to various clusters.

The genotypes differed significantly for all the characters studied i.e. number of leaves/plant, days to 50%flowering, days to maturity, plant height, head diameter, number of filled seeds/plant, number of unfilled seeds/plant, test weight, seed yield and oil content. Through multivariate analysis, 94 genotypes were grouped into ten clusters based on D values. The composition of different clusters varied from four to 15 genotypes. Among the ten clusters formed, cluster IV is the largest group comprising of 15 genotypes followed by cluster II and III with 12 genotypes, cluster I,V and VI with ten genotypes , cluster IX with eight genotypes , cluster VII with seven genotypes, cluster VIII with six genotypes and cluster X comprised of only four genotypes. Among inbreds Gene Pool (GP) lines are distributed in all most all the clusters except cluster X, which comprises of hybrids. Cluster III comprising of GP lines only. DRM lines are distributed in cluster I, II and V where as ARM lines are in cluster IV and V. Populations are distributed in cluster V, VI, VII and VIII. Hybrids are distributed in cluster IX and X. The inbreds GP-2150-1, GP9-290-1-2, GP9-846-1-4, GP9-152-5-4, GP1-1 and hybrids Jwalamukhi and MSFH –17 were included in the same cluster. It indicates that these lines are genetically almost similar with hybrids. Among inbreds, the lines GP9-290-5-3, GP1-890 and GP9-414-5-4 in cluster III and GP9-290-1-2 and GP-2150-1 in cluster IX showed high oil content, whereas GP-517-1, GP-1080-2 and ARM-250 in cluster IV, GP-2150-1 in cluster IX showed high autogamy.

The maximum intra cluster distance was recorded in cluster IX (15.325) followed by cluster VIII (15.302) and this might be due to gene exchange (or) selection followed among the genotypes for different characters (Table 2). Cluster IV displayed the least intra cluster divergence (10.168) showing similarity of the genotypes. This may be explained on the basis that yield is being a complex character of polygenic inheritance, different combinations of genes could produce similar genotypes. Such combinations may have selective advantage when selection is practiced in the population. For inter cluster distance the maximum distance was observed between cluster I and IX followed by II and IX. Therefore it is suggested that if the diverse genotypes from these groups are used in breeding programme, it is expected to throw better segregants for high seed yield and oil content due to non allelic interaction (Muppidathi *et al.*, 1995; Sankara Pandian *et al.*, 1996). The minimum inter cluster distance between cluster III and IV indicates that the genotypes of

[1] Senior Scientist (Plant Breeding), Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, A.P.

these clusters are genetically less diverse and were almost with same genetic makeup. Such genotypes may also be specifically useful in breeding programme for developing biparental crosses between the most diverse and closed groups to break the undesirable linkage between yield and *oil content, so that genotypes with high seed yield coupled* with high oil content could be developed.

The mean values of clusters for seed yield and yield component characters were presented in Table 3. From the data it is concluded that considerable distance existed for all the characters in various genotypes studied. The data indicated that cluster X, VIII and VII recorded high mean values for majority of the important traits like seed yield, head diameter, filled seeds, test weight and oil content. The genotypes exhibited random pattern of distribution into various clusters revealing that genetic diversity and geographical diversity is not related. This suggests that those forces other than geographical origin such as genetic drift, natural and artificial selection, exchange of genetic material played an important role in the genetic diversity of the genotypes. Environmental variation is also partly responsible for this genetic diversity. Similar conclusions were drawn by earlier workers (Lee and Kaltiskies, 1973; Yadav *et al.*, 1988; Rao *et al.*, 2000). The contribution of various characters towards genetic divergence is presented in Table 4. The results revealed that number of filled seeds/head contributed maximum to genetic divergence (1146 times) followed by plant height (1075 times), oil content (884 times) and test weight (535 times). The overall perusal of research investigations indicated that the genotypes GP9-290-1-2, GP-2150-1, GP9-846-4-5, GP9-846-1-4, GP1-1, GP-1017-2, GP9-839-4-1 of GP lines, DRM-1-1, DRM-10-1, DRM-24-1, DRM-71-2, DRM-24-3, DRM-71-1, DRM-65-4 of DRM lines, R-378-AH, RHA-859, R-273, 3376R of R lines, 7-1B, 579B, X-15-NB-6, X-15-NB-3VND (NB)-5, VND (NB)-1O,VND (NB)-7 of germplasm are highly diverse and hence these may be utilized in the future breeding programmes for the commercial exploitation of heterosis and development of *synthetic populations. A high heterotic line can threw good* recombinants, so that gene pyramiding may also be followed by accumulating favourable genes.

Table 1 Distribution of sunflower genotypes in different clusters

Cluster	No. of genotypes	Genotypes
I	10	DRM-1-1, RR-1, DRM-10-1, DRM-24-1, DRM-71-2, GP9-839-4-1, R-378-AH, RHA-859, R-273, 400B
II	12	DRM-24-3, DRM-71-1, DRM-65-4, X-15-NB-6, X-15(NB)-3,7-1B, 579B, GP-1017-2, VND(NB)-5, VND(NB)-10, VND(NB)-7, 3376R
III	12	GP-247-1, GP 9-811-4-1, GP 1-2113, GP-2158-3, GP 9-846-5-3, GP 9-38C-2-2, GP 9-846-4-4, GP-152-1-2, GP-1334-4, GP1-890, GP 9-290-5-3, GP9-414-5-4
IV	15	GP-322-3, R-Sel-Spec, GP-1191-1, GP9-153-1-3, ARM-243, ARM-244, GP-517-1,GP-398-2, ARM-250, GP-1080-2, GP 9-195-5-3,ARM-245, GP1-121, ARM-247, RHA-6D-1
V	10	GP-517-2, GP-1618-5, GP 9-682-5-1, ARM-242, ARM-248, Rop-Sel, GP-824-2, GP9-515-7-4, DRM-7-2, Morden
VI	10	GPI-43, R-Sel-2-3-Seratov, GP9-55-1-5, GP-1618-1, GP9-183-1-2, GP9-195-5-3, R-Sel-Boardagen-1, Syn-Arm 89B, R-ARM-241
VII	7	GP-2158-5, R.Sel-Boradagen-2, GP9-217-4-4, R-Sel-2-3-Master GP1-934, GP9-279-7-5, GP9-709-7-4
VIII	6	GP9-472-1-2, DRSF-108, GP-1191-4, GP9-472-4-1, DRSF-110, DRSF-109
IX	8	GP-2150-1, GP9-290-1-2, DP9-846-1-4, GP9-846-4-5, GP1-1, MSFH-17, Jwalamukhi, GP9-152-5-4
X	4	PCSH-243, PCSH-245, KBSH-1, PAC-1091

Table 2 Average intra and inter cluster distance (*D values*) *of different clusters* in sunflower

	I	II	III	IV	V	VI	VII	VIII	IX	X
I	11.7 C	15.7 C	25.3 M	21.7 C	18.5 C	19.9 C	25.3 M	30.0 M	31.0 H	43.0 H
II		13.0 C	22.1 M	21.7 C	20.5 C	18.9 C	22.3 M	29.0 M	30.9 H	41.8 H
III			11.4 C	14.2 C	19.9 C	18.9 C	16.1 C	19.9 C	21.9 C	28.3 M
IV				10.6 C	15.2 C	16.4 C	17.8 C	18.1 C	18.2 C	28.0 M
V					12.9 C	18.1 C	18.5 C	21.5 C	20.1 M	30.6 H
VI						14.2 C	18.5 C	19.5 C	25.7 M	35.3 H
VII							11.7 C	18.0 C	23.1 M	27.0 M
VIII								15.3 C	22.2 M	26.2 M
IX									15.3 C	21.7 M
X										14.3 C

H:Highly divergent (above 30) M:Moderately divergent (23-30) C :Closely related (below 22)

Table 3 Cluster means of sunflower genotypes for various characters in sunflower

Cluster No.	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of leaves/ plant	Head diameter (cm)	Filled seeds/ plant	Unfilled seeds/plant	Test weight (g/pl)	*Seed yield* (g/pl)	Oil content (%)
I	59.0	83.3	90.1	23.3	9.2	410.1	111.1	2.6	12.0	28.2
II	52.5	81.6	86.2	21.7	10.9	339.5	154.7	3.7	13.1	33.3
III	60.3	90.0	132.5	26.0	12.6	392.2	118.8	4.6	18.1	40.1
IV	60.1	89.0	139.2	26.0	11.5	461.8	142.6	3.5	16.8	35.7
V	55.6	85.4	117.4	25.2	12.7	528.6	128.0	3.6	19.6	30.5
VI	57.8	86.8	129.1	26.8	11.9	328.3	187.4	4.3	14.5	31.6
VII	56.4	85.6	124.3	27.1	13.6	404.0	120.1	6.1	24.8	34.7
VIII	60.9	91.2	160.5	31.3	14.2	393.9	185.0	5.6	22.4	33.1
IX	60.1	88.5	140.9	28.2	14.0	637.2	168.3	3.6	23.9	37.1
X	58.7	88.1	172.4	29.8	15.5	679.0	122.6	5.6	37.4	40.6

Table 4 Contribution of different characters towards genetic divergence in sunflower genotypes

Character	No. of times ranked first	Per cent contribution towards divergence
Days to 50 % flowering	86	1.97
Days to maturity	18	0.41
Plant height (cm)	1075	24.59
Number of leaves/plant	30	0.69
Head diameter (cm)	9	0.21
Number of filled seeds/head	1146	26.22
Number of unfilled seeds/head	503	11.51
Test weight (g)	535	12.24
Seed yield/plant(g)	85	1.94
Oil content (%)	884	20.22

References

Lee, J. and Kaltiskies, P. J. 1973. The application of Mahalanobis's generalize distance to measure genetic divergence in durum wheat. *Euphytica*, **22**: 124-131.

Muppidathi, N., Sankara Pandian, R. and Rajarathinam, S. 1995. Genetic divergence, correlation and path analysis in sunflower(*Helianthus annuus* L.). *Crop Improvement*, **22**:221-224.

Rao, C. R. 1952. *Advanced Statistical Methods in Biometrical Research*. John Willey and Sons Inc., New York pp.357-363

Rao, N. V., Ranganatha, A..R.G., Kumar, M.V.N and Chandra Mohan, Y. 2000. Analysis of genetic divergence in sunflower inbred lines. *Indian Journal of Plant Genetic Resources*, **13**(1): 11-14.

Sankara Pandian, R., Muppidathi, N., Rajarathinam, S. and Chidambaram, S. 1996. Genetic divergence in sunflower(*Helianthus annuus* L.). *Madras Agricultural Journal*, **3**: 637-639.

Yadav, R. K., Behl, R. K. and Yadava, T. P. 1988. Assessment of diversity among sunflower collections. *Crop Improvement*, **15** : 160-162.

J. Oilseeds Res., **22**(1) : 172-173 (2005)

Short communication

Induced long narrow leaf mutant in sesame, *Sesamum indicum* L.

U.C. Kar and D. Swain

AICRP on Oilseeds (Sesamum), Orissa University of Agril. & Tech., Bhubaneshwar-751 003, Orissa

(Received: February, 2004; Revised: September, 2004; Accepted: October, 2004)

Sesame, one of the ancient oilseed crops of the Indian sub-continent is grown in *kharif* rainfed, *rabi* residual moisture/irrigated and summer irrigated conditions. But, sesame had failed to contribute its best to the Indian oilseed scenario in spite of its high yield potential, shorter life cycle, suitability to different cropping systems, land types and requirement of low input management. The potentiality of this crop can be explored if the crop improvement programme is concentrated on suitable plant ideotypes. The crop has limited morphological variations and needs enough variability for their use in hybridization programme for designing desired plant architecture. Induced mutation had proved in creating large spectrum of genetic variability in different crops in respect of qualitative, quantitative, morphological and physiological traits. This variability has been utilized in genetic improvement of crop plants directly or indirectly through hybridization programme. In this paper long narrow leaf mutant of sesame derived from induced mutation is discussed.

The seeds of cv. B 67 (Tilottama), were treated with different concentrations/ doses of ethylmethane sulphonate (EMS), nitroso-guanidine (NG) and gamma rays. The treatments of seeds were undertaken separately with above individual mutagens as well as in combination of mutagens. For treatment with chemical mutagens, dry seeds were pre-soaked in distilled water for 12 h followed by treatment with freshly prepared three different concentrations of EMS (0.25, 0.50 and 0.75%) and NG (0.01, 0.02 and 0.04%) aqueous solutions for 8 h, separately. For gamma rays treatments, dry seeds were irradiated with three doses of gamma rays (500 Gy, 700 Gy and 900 Gy) in Co^{60} gamma cell at the Division of Genetics, IARI, New Delhi. For combination mutagen treatments, dry seeds irradiated with 700 Gy gamma rays were pre-soaked in distilled water for 12 h and then treated separately with above-mentioned three concentrations of EMS and NG for 8 h. The chemical treatments were carried out at room temperature (22±1°C) with intermittent shaking. After the treatments, the treated seeds were thoroughly washed under tap water to leach out the excess residual chemicals adsorbed to the seeds and treated seeds were dried on blotting paper. The treated seeds of the above 15 treatments, along with the control, were sown immediately in the field to raise the M_1 generation and the seeds collected from the individual plants of M_1 were used to raise the M_2 generation in plant to row method.

In M_2 generation, 44,297 mutant plants were evaluated for different qualitative characters and 38 mutant plants were identified for long and narrow leaf mutations (Fig. 1). These long-narrow leaf mutants were derived from combination treatments only (700 Gy + 0.25% EMS; 700 Gy + 0.50% EMS; 700 Gy + 0.75% EMS; 700 G + 0.01 % NG) with an overall mean frequency of 0.086%. The comparative morphological characteristics of these mutants and the parent are presented in Table 1. The length of the leaf lamina from the base of the petiole of these mutants ranged from 25 to 30 cm (Fig. 2). With the lamina width at the middle of the leaf ranged from 1.5 to 2.0 cm, while the leaf of the parent ranged from 8.0 to 15.0 cm in length and 4.0 to 6.0 cm in width. These mutants were shorter in height, profusely branched and had small bold capsules (Table 1). Murthy and Oropeza (1989) had reported earlier the induction of narrow leaf lamina mutants in sesame.

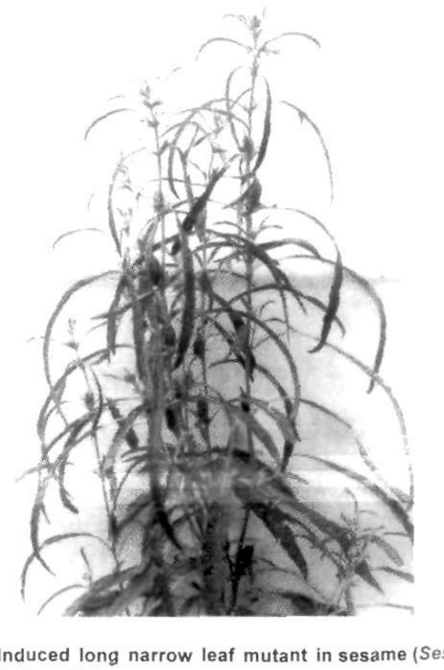


Fig. 1 Induced long narrow leaf mutant in sesame (*Sesamum indicum* L.)

Table 1 Comparison of morphological characters of induced long narrow leaf mutants with parental genotype, B-67

Characteristic	Long-narrow leaf mutant	Parent variety
Plant height (cm)	80-90 (83.4)*	110-135 (123.5)
No. of primary branches/plant	6-8 (7.2)	3-4 (3.2)
Internode's length (cm)	4-5 (4.2)	6-8 (6.8)
Leaf lamina length (cm)	25-30 (29.3)	8-15 (9.6)
Leaf lamina width (cm)	1.5-2.0 (1.5)	4-6 (4.7)
No. of productive capsules/plant	20-25 (22.4)	40-45 (42.3)
Capsule length (cm)	1.8-2.0 (1.9)	2.5-3.0 (2.6)

* Figures in parenthesis are the mean values.

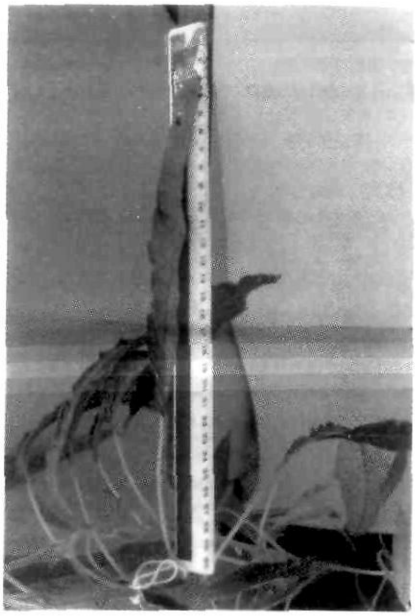


Fig. 2 **Induced long narrow leaf mutant in sesame (*Sesamum indicum* L.)**

These long-narrow leaf mutants of M_2 bred true in M_3 and its subsequent generations. This mutant was very easy to isolate and identify in the plant population for its distinct morphological features and thus, an useful trait for identification and certification of a sesame variety in seed multiplication programme. The low leaf area of the mutant facilitates better penetration of sunlight to the most of the lower leaves in the phyllotaxy borne in the stem and branch of the mutant plant. The dwarf plant habit and the morphological variation in the leaf of these mutants could form a useful breeding material for development of sesame plant ideotypes.

Reference

Murthy, B.R. and Oropeza, F. 1989. An induced leaf differentiation mutant in *Sesamum indicum* L. *Current Science*, **58**(8):464-466.

J. Oilseeds Res., **22**(1) : **174-175** (2005)

Short communication

D^2 analysis in sesame (*Sesamum indicum* L.)

T. Anuradha and G. Lakshmi Kantha Reddy[1]

Scientist & Head, Agricultural Research Station, Peddapuram, East Godavari District, AP

(Received: August, 2004; Revised: January, 2005; Accepted: January, 2005)

D^2 analysis is a vital tool for the evaluation of genetic diversity amongst germplasm lines and selection of parents for the breeding programme (Arunachalam, 1981). Conventional procedures of indiscriminate hybridization on a massive scale in any crop results in immense wastage of resources. Greater success can only be achieved through judicious choice of parents for hybridization based on D^2 analysis. Hence, an effort was made to assess the existing genetic diversity in sesame.

Seventy one diverse germplasm lines of sesame originating from different parts of the country were studied in a Randomized Block Design with 2 replications during *kharif*, 2001. Each line was sown in 2 rows of 5 m length spaced 30 cm apart. Data were recorded on 12 quantitative traits *viz.*, plant height, days to maturity, number of primary branches, capsules on main stem, capsules on primary branches, capsules/ plant, capsule length, seeds/capsule, 1000 seed weight, biological yield, harvest index and seed yield/plant and subjected to Mahalanobis (1936) D^2 statistic.

Analysis of variance showed highly significant differences among the genotypes for all the traits indicating the presence of considerable variability among the genotypes justifying the selection of the material for the study. Adopting Tocher's procedure, group constellation resulted in the distribution of 71 genotypes into six diverse clusters (Table 1). Clustering pattern was random and independent, and cluster II was largest with 22 genotypes followed by cluster I (17 genotypes) cluster VII was the smallest cluster comprised of only two genotypes (NAC 8414 and DCB 1874). It is observed that the distribution of the genotypes was random as was being observed from cluster II (largest cluster) comprising genotypes from Madhya Pradesh, Uttar Pradesh, Gujarat, Andhra Pradesh, Delhi and Orissa. The grouping pattern indicated that geographical distribution does not have relationship with the genetic divergence (Swain and Dikshit,1997, Solanki and Deepak Gupta, 2002).

The inter cluster distances were greater in magnitude than intra cluster distances suggesting the presence of diversity among the clusters indicating that the genotypes included in the same cluster are less divergent than those in different clusters. The inter cluster D^2 values were maximum between cluster 2(22) and 6(2) followed by cluster 1 and 4, since these clusters have more of inter cluster distance crossing between the genotypes of these clusters increase the chance of realization of higher heterosis, as such a good number of genotypes has been selected for crossing programme (Table 2).

The characters contributing maximum to the D^2 values are to be given greater emphasis for deciding on the cluster for the purpose of further selection and choice of parents for hybridization. Maximum contribution towards genetic divergence was by days to maturity (63) followed by 1000 seed weight (16), seed/capsule(15) and capsule length (5). The traits number of primary branches, capsules on primary branches and capsules/plant were the least contributors for divergence . Babu and Sivasubramanian (1992), reported that 1000 seed weight contributed maximum to divergence, while harvest index (Venkateswarlu, 1988), plant height (Manivannan and Nadarajan, 1996) and capsule/plant (Solanki and Deepak Gupta, 2002) were the factors contributing maximum to the divergence.

Considering inter cluster distance and characters with highest contribution to D^2 values, the logical choice for varietal improvement through hybridization programme involving genotypes of cluster 2 for the traits earliness, number of capsules per plant, seeds per capsule and seed yield per plant with the genotypes possessing desirable characters like seed yield/plant, capsules on primary branches and number primary branches under cluster 1.

[1] Associate Dean, Agricultural College, Bapatla, Guntur District.

Table 1 Cluster composition of 71 genotypes of sesame at Peddapuram

Cluster Number	Number of genotypes included in the cluster	Genotype	Origin
I	17	EC357313, Krishna, EC358039, DSR 1974, SI 3012, SO 2152, **EC358022**, K 5194, **Madhavi**, K 5163, K 5231, SI 75, K 5173, YLM 21, DCB 1857, **Tanuku brown**, JBT 9/29	NBPGR Delhi(3), A.P.(4), Bihar(4), UP(3), Guj(1), M.P.(2)
II	22	PS 201, SO 12-2172, **K 5177**, DCB 1826, DCB 1791, **Gowri**, YLM 11,K 5199, K 5170,NKD 1139, DCB 1824, **YLM 17**, K 5235, K 5203, K 5182, SO 12-2148, PSR 1943, EC 351882, DCB 1858, DCB 1862, DCB 60, **Vinayak**	A.P.(3), U.P(3), M.P(4), Guj(9), Orissa(1), Rajasthan(1), NBPGR Delhi(1)
III	14	**SI 320**,DCB 1855, K 5181, K 5220, NKD 1107, JBT 9/19, NKD 1093, DCB 1805, DCB 1844, **DCB 1799**, NKD 1160, DCB 1795, DCB 1836, DCB 1818	Guj(8), M.P.(1), Rajasthan(3), U.P.(1), Bihar(1)
IV	10	EC 357025, DCB 1802, JBT 9/39, NKD 1158, K 5201, SO 12-2171, EC 355653, **SO 12-2154**, K 5240, EC 357312	NBPGR Delhi(3), Guj(3), UP(1), M.P.(1), Rajasthan(1), Bihar(1),
V	6	DCB 1869, NKD 1070, K 5176, SI 1618, NKD 1151, **NKD 1110**	Rajasthan(4), U.P.(1), T.N.(1),
VI	2	NAC 8414, DCB 1874	Guj(1), Raj(1)

Bold genotypes were selected for combining ability analysis.

Table 2 Average intra and inter cluster D^2 values of 71 genotypes at Pedapuram

Cluster number	I	II	III	IV	V	VI
I	**20.70**	24.76	31.71	66.43	49.35	142.73
II		**14.87**	31.78	73.35	52.24	151.01
III			**16.17**	48.18	27.96	124.82
IV				**22.56**	29.34	81.83
V					**16.48**	102.13
VI						**16.77**

Bold figures intra-cluster distances; Normal figures inter-cluster distances

References

Arunachalam, V. 1981. Genetic distance in plant breeding. *Indian Journal of Genetics and Plant Breeding*, **41** : 226-236.

Babu, C. and Sivasubramanian, V. 1992. Studies on genetic divergence and association of characters in three maturity groups of sesame (*Sesamum indicum* L.), *Plant Breeding News Letter*, **2**(2) : 2.

Mahalanobis, P.C. 1936. On the generalized distance in statistics. *Proceeding National Academy of Science*, India, **2** : 49-55.

Manivannan and Nadarajan, N. 1996. Genetic divergence in sesame. *Madras Agricultural Journal*, **83**(12) :789 - 790.

Solanki, Z.S. and Deepak Gupta. 2002. Genetic divergence for seed yield and other characters in sesame (*Sesamum indicum* L.) *Journal of Oilseeds Research*, **19**(1): 35 - 37.

Swain, D. and Dikshit, U. N. 1997. Genetic divergence in *rabi* sesame (*Sesame indicum* L.), *Indian Journal of Genetics*, **57**(3) : 296-300.

Venkateswarlu, O. 1988. Genetic divergence in intra and inter sub-specific derivatives of groundnut (*Arachis hypogea* L.) M.Sc. (Ag.) Thesis Andhra Pradesh Agricultural University, Hyderabad.

J. Oilseeds Res., **22**(1) : 176-177 (2005)

Short communication

Variability studies in determinate type sesame, *Sesamum indicum* L. germplasm lines for yield and its component traits

K.N. Ganesan

Agricultural Research Station, Tamil Nadu Agricultural University, Bhavanisagar-638 451, TN

(Received: March, 2004; Revised: August, 2004; Accepted: September, 2004)

Sesame, *Sesamum indicum* L. is the oldest oilseed crop grown mostly in tropical to temperate zones of the World. In India, it is grown in an area of 1.67 million ha (37% of the World area) and the production is about 0.56 m.t. (27% of the World production). In Tamil Nadu, it is being cultivated in an area of 1.65 lakh ha, which is 4.7% of sesame growing area of India. Even though, sesame has considerable genetic diversity, the average productivity in India is around 332 kg/ha as against the potential yield of 1000 kg/ha. One of the reasons for low yield is non - synchronised maturity due to the indeterminate nature of the released varieties. The genetic variability exists in exotic sesame germplasm lines have been studied by many scientists (Padmavathi, 1997; Yingzhong, 1997). In order to generate information on natural variability of determinate sesame genetic stocks, about 136 determinate sesame germplasm lines were evaluated at Regional Research Station, Vriddhachalam, Tamil Nadu.

All the germplasm lines were sown in a single row of 3 m with a spacing of 30 x 20 cm and recommended package of practices were adopted. The determinate line Dt 9-3-1-35-8 was included as check and replicated thrice. The biometrical observations were recorded on five randomly selected and selfed plants in each accession. The data was recorded on days to 50% flowering, plant height, number of branches/plant, number of capsules/plant, number of seeds/capsule, 1000 seed weight and single plant yield. Variability parameters *viz.*, range, phenotypic co-efficient of variation (PCV), genotypic co-efficient of variation (GCV), heritability (h^2), genetic Advance (GA) and GA as percentage of mean were calculated by following the methods suggested by Singh and Chaudhary (1985).

The analysis of data revealed that there are significant differences among the genotypes for all the yield components studied. The mean seed yield/plant ranged from 1.061 g (Dt 9-20-2-38-7) to 12.670 g (Dt 9-10-1-20-29) (Table 1) showing a wide range of variability for seed yield, which is a pre-requisite for any breeding programme to select high yielding progenies. The genotypic co-efficient of variation was observed to be low (9.40%) since all the selected promising lines were more or less at par for yield. Days to 50% flowering exhibited a range from 29 days (Dt 9-2-1-4-32-31 and Dt 9-11-1-25-8) to 43 days (Dt 9-2-1-4-32-12 and Dt 9-10-1-20-28). This wide range will be useful in developing determinate sesame lines with wider range of duration groups. The genotypic co-efficient of variation was low (9.03%) as all the selected lines fall between 30 to 42 days category.

Regarding plant height, the range was observed to fall 23 cm (Dt 9-3-1-42-16, Dt 9-6-3-32-5 and Dt 9-12-2-20) to 93 cm (Dt 9-10-1-20-36). This trait exhibited a genotypic co-efficient of variation of 29.03%. This variability can be utilized by a breeder to decide the stature of variety to be developed. Though the range for number of branches/plant was observed to be very narrow (3 to 7), the genotypic co-efficient of variation was observed to be 20.82%. Another important economic trait *viz.*, number of capsules/plant was found to show very wide range of 10 capsules/plant in the accession Dt 9-6-3-30-20-1 and 186 capsules/plant in Dt 9-10-1-20-2. Among the traits studied, the highest co-efficient of variation (32.8%) was observed for this trait. The highest values of GCV and PCV are an indication of existence of excellent variability in the population under study. Hence, selection for sesame determinate lines possessing higher number of capsules/plant will be effective as this key trait contributes directly to the economic yield.

The range of 1000 seed weight was observed to fall between 3.6 (Dt 9-10-10-120-36) and 2.04 (Dt 9-20-9-3-1). The moderate level of 1000 seed weight holds good for the yield improvement. The genotypic co-efficient of variation of 1000 seed weight was 12.9%. The entry Dt 9-10-2-35-8 has recorded the highest number of seeds per capsules (80) while it was found to be the lowest in Dt 9-12-2-20 (32).

Broad sense heritability is an excellent index of transmission of traits. Similarly, genetic advance reveals the improvement in the genotypic value of the selected individuals over the parental population. Results revealed thee combination of high heritability (99.46%) (Table 1) coupled with high genetic advance as percentage of mean (67.55%) for number of capsule/plant as reported by Solanki and Gupta (2003). Further, plant height (99.51%

and 59.66%), number of seeds/capsule (91.95% and 25.73%) and 1000 seed weight (99.31% and 25.96%) also exhibited the high heritability estimates and moderate level of genetic advance as percentage of mean. It indicates that additive genes are governing these traits and phenotypic selection for these traits will be effective. Hence, whenever yield is the main objective of a breeding programme, the selection index should be constituted by including above important traits in order to improve the yield indirectly.

The study revealed sufficient genetic variability for most of the biometrical traits studied. The extent of variability present in the promising determinate sesame lines was depicted in Fig. 1. The available heritable variations in these germplasm lines can be exploited by using the promising germplasm lines as parents in a breeding programme formulated to develop an elite determinate sesame variety.

References

Padmavathi, N. 1997. Performance of exotic sesame germplasm lines. *Sesame and Safflower Newsletter*, **12**: 29 - 30.

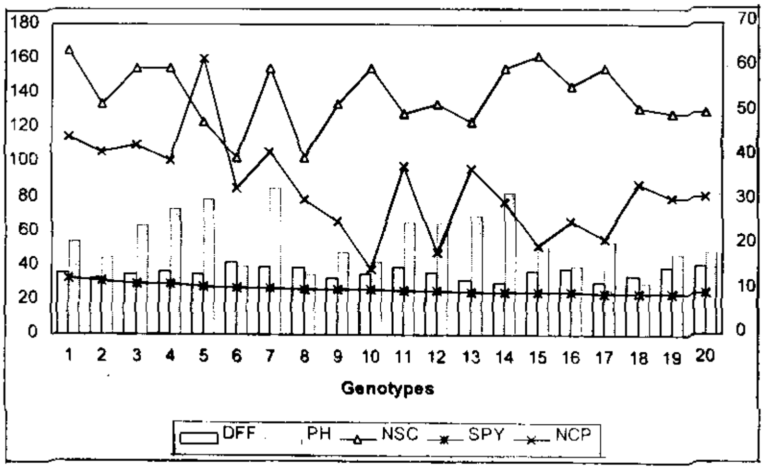
Singh, R. K. and Chaudhary, B. D. 1985. *Biometrical methods in quantitative genetic analysis.* Kalyani publishers, New Delhi. pp. 39-68.

Solanki, Z. S. and Gupta, D. 2003. Variability and character association among quantitative characters of sesame. *Journal of oilseeds Research*, **20**(2): 276-277.

Yingzhong, Z. 1997. A note on exotic sesame germplasm observations. *Sesame and Safflower Newsletter*, **12**: 31- 33.

Table 1 Variability parameters of different biometrical traits for determinate type sesame germplasm lines

Trait	Mean ±SE	Range	Vp	Ve	Vg	PCV	GCV	h^2 (%)	GA	GA as % of mean
Days to 50% flowering	35.90±0.72	29 - 43	13.02	2.50	10.52	10.05	9.03	80.79	6.00	16.73
Plant height (cm)	55.80±3.60	23 - 93	263.78	1.30	262.48	29.11	29.03	99.51	33.29	59.66
Branches/ plant	4.70±0.22	3 – 7	2.26	1.30	0.96	31.97	20.82	42.42	1.31	27.94
Capsules/ plant	85.35±6.27	10 - 186	791.91	4.30	787.61	32.97	32.88	99.46	57.66	67.55
Seeds/ capsule	53.80±1.61	32 - 80	53.42	4.30	49.12	13.58	13.03	91.95	13.84	25.73
1000 seed weight (g)	2.86±0.08	2.04 - 3.6	0.15	0.01	0.14	13.50	13.04	93.31	0.74	25.96
Seed yield/ plant (g)	10.27±0.22	1.06-12.67	0.93	0.007	0.92	9.40	9.36	99.26	1.97	19.21



DFF – Days to 50% flowering
PH – Plant Height
NCP – Number of capsules per plant
NSC – Number of seeds per capsule
SPY – Single plant yield

Fig.1 Variability among selected promising sesame germplasm lines for different traits

J. Oilseeds Res., **22**(1) : 178-179 (2005)

Short communication

Genetic variation and genotype x environment interaction in sesame, *Sesamum indicum* L.

G. Velu and N. Shunmugavalli

Agricultural College and Research Institute, Killikulam, Vallanad, Tuticorin-628 252, TN

(Received: August, 2004; Revised: October, 2004; Accepted: November, 2004)

Sesame (*Sesamum indicum* L.) is very sensitive to changes in environments compared to other crops. Average yield in sesame in India vary according to locations. Therefore the main targets of sesame researchers have usually focused on breeding new varieties with more stability under different environments. The present study was aimed to determine the extent of variability available in different genotypes as well as magnitude of Genotype Environment interactions over different environments.

A field experiment was conducted at Agricultural College and Research Institute, Killikulam, Tamil Nadu Agricultural University, with 40 sesame genotypes, raised in three seasons *viz., (i) Kharif,* 2001 *(ii) Rabi,* 2001 and (iii) summer, 2002. In each environment, the genotypes were raised in a Randomized Block Design with three replications. Data relating single plant yield, plant height, number of branches, number of capsules, number of seeds/capsule, capsule length, 1000 seed weight, oil content, days to 50% flowering and days to maturity were collected from five randomly selected plants in each replication. Individual and combined analysis of variance and the estimates of genetic variability under different environments were estimated adopting the procedure outlined by Johnson *et al.* (1956).

The variance estimated for all the characters under different environments brought out the differential response of characters to varied environmental effects. The estimates of phenotypic and genotypic variance, genotypic coefficient of variation, heritability and genetic advance as per cent mean are presented in Table 1. The phenotypic and genotypic variances were comparatively high for number of capsules, plant height and number of seeds per capsule indicating wide range of variability in these characters. The genotypic coefficient of variability was low for days to maturity (4.98 - 5.77), oil content (5.68 - 6.45), capsule length (6.62 - 6.81) and days to 50% flowering (8.06 - 8.77). The genotypic coefficient of variability for single plant yield was high and consistent at all environments (Table 1). Burton (1952) suggested that genotypic coefficient of variability together with heritability estimates gave picture on genetic advance to be expected from a selection. Johnson *et al.* (1956) stated that in predicting the resultant effects of selection, the genetic advance should be given weightage along with heritability. According to this yardstick, single plant yield, 1000 seed weight, number of capsules, number of seeds/capsule, plant height and number of branches have high values of heritability coupled with high genetic advance indicating additive gene effects in these traits (Panse, 1957). *Paramasivam and Prasad (1981) also observed high* heritability with high genetic advance for number of capsules, number of branches and single plant yield. Janardhanam *et al.* (1981) reported additive gene effect for number of capsules, number of branches and both additive and non additive gene effect for number of seeds/capsule. Other characters, which had low values for the two parameters may not respond favourably to selection.

For evolving high yielding strains, the plant breeder has to depend upon the economic characters which are quantitatively inherited and are considerably influenced by the environment. Johnson *et al.* (1956) pointed out that genotypic variance estimated on the basis of a single environment would include variance due to environment interactions and that conclusions based on the inflated estimates of genotypic variance might not hold true at other locations. In the present investigation, which was carried out under three different environments, the environment exerted significant effect in the expression of characters.

The pooled analysis (Table 2) revealed that there were significant environmental interaction effects on all characters except capsule length. This suggests that the effect of environment on the expression of genotypes was much pronounced on these characters. On the other hand influence of environment was the least on capsule length and single plant yield. This suggested that the least influenced characters could be improved to the extent expected on the basis of individual environment. The single plant yield showed almost similar estimates of coefficient of genetic variation, heritability and genetic advance based on the three individual environment average as well as on the basis of pooled analysis. It proved to be a stable character, least influenced by environment.

The results also indicate that, number of capsules, number of branches, number of seeds/capsule and single plant yield might be given due importance as indicated by additive gene effects, in selection programmes as considerable improvement can be obtained in these characters.

Table 1 **Estimates of genotypic variance, phenotypic variance, genotypic coefficient of variability, heritability and genetic advance as per cent of mean in sesame**

Character	Genotypic variance			Phenotypic variance			Genotypic coefficient of variation			Heritability			Genetic advance as per cent of mean		
	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3	E_1	E_2	E_3
Single plant yield	2.90	3.61	4.01	3.45	4.18	4.56	19.29	22.75	23.63	84.07	86.33	87.93	36.43	43.54	45.64
Plant height	158.70	150.69	195.84	161.19	174.86	197.51	13.08	12.63	14.34	98.45	86.18	99.15	26.74	24.15	29.41
No. of branches	1.60	2.11	1.24	2.12	2.52	1.70	13.93	18.21	11.73	78.45	83.96	73.04	25.42	34.37	20.66
No. of capsules	210.64	118.08	174.52	212.17	119.76	177.35	18.99	14.06	18.16	99.28	98.59	98.41	41.03	28.76	37.10
No. of seeds/capsule	69.46	63.89	63.31	70.20	65.52	65.83	14.25	18.21	13.76	98.94	83.96	96.17	29.13	34.37	27.80
Capsule length	0.03	0.03	0.03	0.03	0.03	0.03	6.81	6.81	6.62	99.19	92.08	95.71	13.96	13.45	13.33
1000 seed weight	0.29	0.35	0.18	0.38	0.36	0.19	18.05	17.25	14.34	75.40	98.04	92.58	36.82	48.46	32.12
Oil content	2.93	7.63	*8.24*	*6.30*	*8.24*	*8.74*	5.68	*6.32*	*6.45*	*94.13*	*92.57*	*94.35*	11.02	12.53	12.91
Days to 50% flowering	10.10	9.70	8.85	10.47	10.00	9.17	8.77	8.40	8.06	96.51	97.09	96.53	17.75	17.05	16.32
Days to maturity	22.98	25.02	16.37	24.25	25.80	17.58	5.77	6.03	4.98	94.73	96.96	93.15	11.58	12.23	9.89

Table 2 ***Pooled analysis of variance***

Source of variation	d.f.	Single plant yield	Plant height	No. of branches	No. of capsules	No. of seeds/capsule	Capsule length	1000 seed weight	Oil content	Days to 50% flowering	Days to maturity
Environment	2	2.41**	332.07**	26.51**	283.57**	35.38**	0.015*	0.119**	26.26**	7.87**	36.10**
Genotypes	39	9.77**	599.98**	4.30**	459.36**	194.40**	0.082*	0.402**	14.63**	25.04**	59.20**
G x E interaction	78	0.79**	35.96**	0.687**	23.45**	2.36**	0.237	0.237**	3.95**	2.05**	3.40**
Pooled error	117	0.279	3.669	0.220	1.006	0.814	0.001	0.019	0.246	0.162	0.544

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

References

Burton, G.W. 1952. *Quantitative inheritance in grasses. Proceedings 6th International Grassland Congress*, **1**: 277-283.

Janardhanam, V., B. Ratnakar, N. Sree Rama Reddy, G. Satyanarayana and D. Subramanyam. 1981. Genotypic, phenotypic, environmental variability, heritability estimates and genetic advance in Sesamum (*Sesamum indicum* L.). *The Andhra Agricultural Journal*, **28**(3&4): 105-108.

Johnson, H.W., H.F. Robinson and R.E. Comstock. 1956. Estimates of genetic and environment variability in soybean. *Agronomy Journal*, **47**: 314-318.

Panse, V. 1957. Genetics of quantitative characters in relation to plant breeding. *Indian Journal of Genetics*, **17**: 318-328.

Paramasivam, K and M.N. Prasad. 1981. Studies on variability and heritability in segregating populations of Sesamum (*Sesamum indicum* L.) crosses. *Madras Agricultural Journal*, **68**(1): 1-6.

J. Oilseeds Res., 22(1) : 180-182 (2005)

Short communication

Genetic variability and correlation studies in safflower, *Carthamus tinctorius* L.

Lakshyadeep, S.P. Sharma and S.S. Sinha

Department of Plant Breeding and Genetics, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur-334 003, Rajasthan

(Received: May, 2004; Revised: December, 2004; Accepted: January, 2005)

Safflower (*Carthamus tinctorius* L.) is an important multipurpose oilseed crops grown in Maharashtra and Karnataka. Its oil is important for health because of its very high polyunsaturated fatty acid content and believed to be ideal for tropical cooking conditions. The safflower oil has good drying properties and is therefore used in manufacturing paints, varnishes and linoleum. In Rajasthan, it has a vast scope since it thrives well in lighter soils and even under drought conditions. It can easily adapt to saline-alkaline conditions prevailing in some part of Rajasthan. The productivity of safflower is very low as compared to area covered by this crop, mainly due to lack of genetically improved cultivars with high oil content. Therefore, there is a need to develop improved cultivars to obtain break through in productivity potential of this crop through genetic manipulations. The assessment of genetic variability present in the crop helps for successful utilization of plant characters in developing suitable varieties for yield and oil content. Therefore, an attempt has been made to study the plant behaviour in terms of variability, heritability and genetic advance for safflower improvement through selection.

One hundred fifty germplasm lines (GMU-1811 to GMU 1961) obtained from Solapur, were planted in Augmented Randomised Complete Block Design in five blocks along with five check varieties (Bhima, Manjira, A-1, JSF-1 and HUS-305) which were common for all the five blocks. The 35 entries were randomised in each block. Each entry was sown in two row plot of 5 m length. Spacing between rows was 45 cm and between plants was 20 cm. The observations were recorded on five randomly selected plants in each plot except for days to flowering and days to maturity wherein observations were recorded on complete plot basis.

The phenotypic and genotypic variance, phenotypic and genotypic coefficient of variation, heritability, genetic advance and correlation coefficient were worked out as per the formulae.

The mean performance of different germplasm lines and their genotypic and phenotypic coefficient of variation, heritability and genetic gain; and correlation coefficient are presented in Table 1 to 3, respectively. Analysis of variance indicated that mean square due to germplasm were significant for all the traits except number of leaves on main axis before branching, 100-seed weight and oil content suggesting that experimental material possessed considerable variability. Similar findings reported by Ghorpade *et al.* (1993).

For all the characters phenotypic coefficient of variation (PCV) was greater than genotypic coefficient of variation (GCV) indicating effect of environment on the expression of characters. However, trend of GCV and PCV was same. Higher GCV and PCV were recorded for number of capitula/plant and seed yield/plant. Moderate values of GCV and PCV were observed for plant height, number of seeds/capitulum and number of primary branches/plant. Similar results were reported by Gupta *et al.* (1996). High heritability was recorded for seed yield/plant, number of seeds/capitula, days to maturity, number of capitula/plant and number of primary branches/plant while relatively lower heritability was observed for days to flowering and plant height. Results were in accordance to Senapati *et al.* (1999). High genetic gain was recorded for number of capitula/plant and seed yield/plant. Medium magnitude of genetic gain was recorded in character *viz.*, number of seeds/capitulum, plant height and number of primary branches/plant. Similar results were reported by Kavani *et al.* (2000).

Estimates of correlation coefficients presented in Table 3 revealed that seed yield/plant exhibited significant positive correlation with number of capitula/plant, weight/capitulum and number of primary branches/plant at both genotypic and phenotypic level, number of seeds/capitulum and number of leaves on main axis after branching were correlated with seed yield/plant significantly at genotypic level only. Among the component traits directly correlated with seed yield/plant, number of primary branches/plant is significantly and positively correlated with number of capitula/plant.

Table 1 Performance of safflower germplasm lines in comparison with checks

Character	Germplasm lines		Checks		CV (%)
	Range	GM	Range	GM	
Days to flowering	80.76-124.76	102.12	103.00-107.60	104.96	3.46
Days to maturity	111.60-173.00	140.39	135.00-145.00	139.00	1.50
Plant height (cm)	32.87-152.07	88.67	85.16-97.84	89.19	13.66
No. of primary branches/plant	2.49-13.81	6.83	6.80-9.44	8.05	6.74
No. of leaves on main axis before branching	6.58-20.66	14.29	13.38-14.28	13.90	16.61
No. of leaves on main axis after branching	8.62-23.82	14.55	13.02-14.22	13.40	12.06
No. of capitula/plant	4.37-74.89	18.32	18.58-25.28	21.93	9.63
Weight/capitulum (g)	0.93-3.83	2.50	2.29-2.98	2.63	15.82
No. of seeds/capitulum	6.02-43.32	23.18	18.48-23.76	20.84	4.11
100-seed weight (g)	2.65-7.39	4.89	4.91-6.07	5.60	11.90
Seed yield/plant (g)	5.58-44.25	17.56	15.67-25.27	20.43	4.09
Oil content (%)	20.99-42.41	32.73	26.93-33.40	30.95	10.41

Table 2 Variability parameters*

Character	Phenotypic coefficient of variation	Genotypic coefficient of variation	Heritability	Genetic gain
Days to flowering	9.95	9.29	87.24	17.87
Days to maturity	9.54	9.43	97.56	19.18
Plant height (cm)	35.37	32.59	84.90	61.86
No. of primary branches/plant	28.67	27.55	92.34	54.54
No. of leaves on main axis after branching	17.44	13.45	59.48	21.37
No. of capitulum/plant	51.73	50.43	95.04	101.28
Weight/capitulum (g)	51.80	16.23	55.38	24.88
No. of seeds/capitulum	31.85	31.64	98.65	64.73
Seed yield/plant (g)	49.15	48.92	99.06	100.31

* The traits which were not having significant genotypic difference were excluded from further study.

Table 3 Genotypic (R_g) and phenotypic (R_p) correlation coefficients between different characters studied in safflower

Character		Days to flower	Days to maturity	Plant height (cm)	No. of primary branches/ plant	No. of leaves on main axis after branching	No. of capitula/ plant	Weight/ capitulum (g)	No. of seeds/ capitulum	Seed yield/plant (g)
Days to flowering	R_g	1.000	0.958**	0.930**	0.016	0.749**	0.189	0.722**	0.228	0.157
	R_p	1.000**	0.898**	0.813**	0.010	0.504**	0.176	0.487**	0.207	0.160
Days to maturity	R_g		1.000	0.886**	-0.035	0.711**	0.144	0.680**	0.170	0.132
	R_p		1.000	0.788**	-0.042	0.544**	0.135	0.472**	0.160	0.131
Plant height (cm)	R_g			1.000	0.122	0.869**	0.300	0.662**	0.202	0.310
	R_p			1.000	0.105	0.569**	0.285	0.529**	0.200	0.292
No. of primary branches/plant	R_g				1.000	-0.057	0.848**	0.273	0.064	0.482**
	R_p				1.000	-0.004	0.784**	0.140	0.060	0.463**
No. of leaves on main axis after branching	R_g					1.000	0.412*	1.006	0.112	0.358*
	R_p					1.000	0.242	0.398*	0.078	0.274
No. of capitulum/plant	R_g						1.000	0.290	0.138	0.683**
	R_p						1.000	0.253	0.131	0.663**
Weight/capitulum (g)	R_g							1.000	0.816**	0.674**
	R_p							1.000	0.633**	0.484**
No. of seeds/capitulum	R_g								1.000	0.320*
	R_p								1.000	0.323
Seed yield/plant (g)	R_g									1.000
	R_p									1.000

Number of leaves on main axis after branching exhibited significant positive correlation with number of *capitulum/plant and weight/capitulum at genotypic and* phenotypic level, respectively. Weight/capitulum showed significant and positive association with number of seeds/capitulum. Other characters having significant positive correlation with these yield correlated characters were days to flowering, days to maturity and plant height that correlated with number of leaves on main axis after branches and weight/capitulum. Similar positive association was reported by Patil (1997).

The germplasm lines showed high GCV and PCV, heritability and genetic gain for number of capitulum/plant and seed yield/plant. Correlation coefficients revealed that seed yield/plant had significant positive correlation with number of capitulum/plant, weight/capitulum and number of capitulum/plant, weight/capitulum and number of *primary branches/plant at both genotypic and phenotypic* level.

Germplasm lines that were superior in terms of yield and oil content included GMU-1878 (43.94% oil, 37.55g yield/plant), GMU 1929 (44.10%, 36.49g) and GMU 1869 (44.25%, 35.33g). Some other lines that were showing high oil content included GMU 1924 (38.15%), GMU 1925 (36.81%), GMU 1675 (36.74%), GMU 1932 (34.55%) and GMU 1933 (34.05%). Similarly, lines that were showing high yield included GMU 1871 (40.33g), GMU 1826 (39.51g), GMU 1879 (39.45g), GMU 1903 (38.95g) and GMU 1939 (38.83g).

Therefore, it can be concluded that direct selection is most effective for number of capitula/plant and seed yield/plant for safflower germplasm. However, to improve yield indirect selection for weight/capitulum and number of leaves on main axis after branching can also be utilized, as these characters had positive correlation with seed yield and between them.

References

Ghorpade, D.S., Tambe, S.I., Shinde, P.B. and Zope, R.E. 1993. Variability pattern in agromorphological characters in safflower. *Indian Journal of Genetics and Plant Breeding,* **53** :264-268.

Gupta, S.C., Nagda, A.K. and Pandya, N.K. 1996. Variability, interrelationship and path analysis in some morphological traits of safflower. *Transdactions* ISDT. 21.

Kavani, R.H., Shukla, P.T. and Madariya, R.B. 2000. Analysis of variability for seed yield and related characters in safflower. *Madras Agricultural Journal,* **87**(7/9):449-452.

Patil, H.P. 1997. Yield component analysis in safflower. *Annals of Agricultural Research,* **18**(3):332-336.

Senapati, N., Samalm, K.M., Mohanta, I.C. and Dhal, A. 1999. Performance, variability and character association in safflower. *Indian Journal of Agricultural Research,* **33**(4):254-258.

J. Oilseeds Res., **22**(1) : 183-187 (2005)

Short communication

Performance of groundnut, *Arachis hypogaea* L. as influenced by soil salinity and saline water irrigation in black clay soils

I.K. Girdhar, P.K. Bhalodia, J.B. Misra, Veena Girdhar and Devi Dayal

National Research Centre for Groundnut, P.B. No.5, Ivnagar Road, Junagadh-362 001, Gujarat

(Received: June, 2004; Revised: August, 2004; Accepted: September, 2004)

India has 60 m ha area under irrigation, of which 51.2 % is irrigated by wells. Hence, ground water is an important source of irrigation. Most of the ground water in the arid, semi-arid and coastal region in the country is of poor quality and availability of good quality water for irrigation is a limiting factor and the farmers have no option but to use such saline water for irrigation. Soil salinisation has seriously affected the productivity of over 1.2 m ha of land in Gujarat state. Groundnut, being an important oilseed and food crop in Gujarat, is fading out of cultivation particularly in coastal areas where soil and water salinity is a serious problem. It is therefore, important to generate information on the management of soil and water salinity for groundnut production. Hence a field study was conducted to evaluate the relative tolerance of different cultivars of groundnut to saline water irrigation and root zone salinity in saline black clay soils representing Saurashtra region of Gujarat.

Field experiment was conducted in *kharif* 2003 at National Research Centre for Groundnut, Research Farm, Junagadh to study the tolerance of groundnut to saline water irrigation in saline black clay soils. These soils are shallow (25-50 cm soil depth), clayey in texture, moderately well drained and calcareous in nature. Initial ECe (Electrical Conductivity of saturation extract) of 0 - 45 cm soil depth was 2.0, 4.7, 9.5 and 13.4 and pH is 7.9, 8.0, 7.9 and 7.9 respectively. This salinity and pH values in different treated plots were attained as a result of saline water irrigation to previous wheat crop. Four levels of ECiw (Electrical Conductivity of irrigation water) namely 0.5 (Control), 2, 4 and 6 dS/m and five genotypes (Gangapuri, GG 2, ICGS 44, JL 24 and MH 2) were tested in a Split Plot Design with three replications. Each salinity treated plot was separated from another plot by putting a 250 micron poly- carbonate sheet at 60 cm soil depth in different channels surrounding the various treated plot (5×4 m^2 plot size). Bunds of each plot were raised to the height of 30 cm and width of 30cm with the objective to absorb maximum rain water in the plot. The recommended doses of fertilizer i.e. 12.5 kg N and 25 kg P_2O_5/ha were applied. The groundnut crop was sown on 20-6-03 and harvested on 29-9-03 and on 8-10-03 in control and highly salinized plots. Four Sintex drums of 1000 litres capacity each were used for different saline water irrigation. Only one irrigation with saline water was given on 22-9-03 during the dry spell, as this year received well distributed rainfall (1275 mm) during the crop growth period. Soil samples were taken at 0-15, 15-30 and 30-45 cm soil depth periodically during the crop cycle and were analyzed for pH and ECe (Richards, 1954). Yield and yield contributing characters were recorded at the harvest of the crop besides the germination count at different DAS (Days after sowing). The oil content in different genotypes under varying salinity stress was also estimated by Arachilipometer (Misra and Yadav, 1997).

Germination: As the irrigation with saline water was not given at the germination stage, therefore data on germination was interpreted at differential root zone salinity build up as a result of saline water irrigation to previous wheat crop and monsoon rainfall thereafter. Decrease in germination with increase in soil salinity from 3.0 to 5.9 was significant over the control (ECe 1.7) at 8 to 11 DAS where as the adverse effect of increasing salinity from 1.7 to 3 was non-significant. Further, it was noticed that the germination at 1.7 on 6 DAS was almost the same (54%) as incase of germination at 5.9 salinity (52%) on 9 DAS (Table 1). Similarly the germination at soil salinity of 1.7 on 7 DAS was almost same (62%) as in case of salinity at 5.9 (64%) on 11 DAS indicating that the high salinity delayed the germination by 4-5 days. Difference in germination among various genotypes of groundnut was significant in saline environment (Table 1). Though MH 2 cultivar showed more tolerance at germination stage, but is poor yielder in comparison with ICGS 44 and JL 24 (Fig. 1).

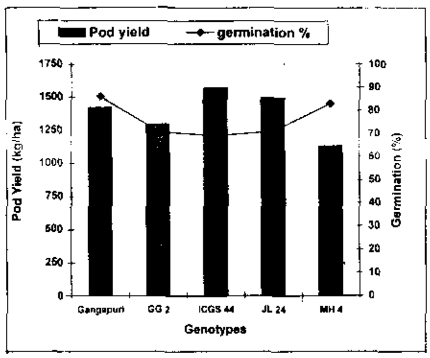


Fig. 1 Effect of soil and water salinity on germination and pod yield in different genotypes of groundnut

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

ECe (dS/m)	Days after sowing				
	6	7	8	9	11
			Germination (%)		
1.7	54	71	78	78	83
3.0	31	62	74	75	80
3.6	24	48	65	69	77
5.9	15	27	43	52	64
CD (P=0.05)	9	8	8	7	9
			Genotypes		
Gangapuri	45	65	77	79	86
GG 2	30	49	62	65	71
ICGS 44	24	49	59	64	69
JL 24	23	43	58	63	71
MH 2	32	56	69	73	83
CD (P=0.05)	10	10	9	8	10

Plant growth: Plant height both at 60 DAS and at maturity decreased significantly with an increase in the salinity from 1.2 to 2.8 in black clay soil (Table 2) the percent decrease being greater at 60 DAS than at maturity. This indicates that the adverse effect of increasing salinity on plant growth was more at the early stage than at the later stage of the crop growth period. Similarly root length is also significantly affected by the increasing salinity. Mature pod and pod weight/plant was unaffected by the additive affect of ECiw (2 dS/m) and ECe (2.1 dS/m) where as significantly adverse effect was noticed at ECiw of 4 and 6 and soil salinity of 2.5 and 2.8 respectively.

Yield and yield attribute: Pod yield at ECiw of 4 and 6 dS/m and at soil salinity 2.5 and 2.8 dS/m was significantly lower over the control (ECiw 0.5 and ECe 1.2 dS/m) and at soil and water salinity of 2 dS/m. Lower pod yield in control over the soil and water salinity of 2dS/m was mainly because of the severe infestation of major foliar fungal diseases in groundnut but the spread of these diseases is almost negligible at high soil and water salinity treated plots (Table 3). Possible reason/mechanism for inducing tolerance of major foliar fungal diseases in groundnut in saline environment is under investigations. Ghewande et al. (2004) have reported from the same investigation that increasing salinity induced tolerance to foliar fungal disease in groundnut. On the other hand Porter and Adamsen (1993) reported that the severity and incidence of early leaf spot (*Circospora arachidicola*) was usually greater in plants irrigated with sodic water. It was also reported that the presence of Na imbalance may cause disease suppression (Lyda and Kissel, 1974; Russell, 1978) or enhancement (Standaert *et al.*, 1973). In order to resolve this diverse opinion more systematic field studies need to be conducted in this direction. Further, data presented in Table 3 also indicate that the haulm yield, 100-pod weight and 100-seed mass is significantly affected by the high soil and water salinity. Low pod/haulm yield ratio at highest salinity showed that the adverse effect of salinity stress is more on pod yield than at haulm yield. According to Padole et. al. (1993), kernel, pod, dry matter yield, protein content and oil content of groundnut (JL 24) decreased with saline conditions. Patel et al (1993) found that saline water irrigation (4.4 to 5.9 dS/m) of 6 cm depth with 25 Mg/ha FYM at 8 days irrigation not only produced the maximum yield of wheat and maize fodder crops but also sustained the productivity of the succeeding *kharif* crops of groundnut.

Build-up of soil salinity and soil pH: Soil salinity (ECe) status in differently salinized plots was 2.0, 4.7, 9.5 and 13.4 dS/m respectively, well before the monsoon rains. The initial salinity (2.0 to 13.4 dS/m) was significantly reduced to 1.7 to 5.9 dS/m as a result of leaching of salts from the root zone by 175 mm of rainfall received in the month of June, 2003. The salinity which was 1.7 to 5.9 dS/m at the time of sowing, was further reduced to ECe ranging from 0.8 to 2.0 dS/m on 2-8-03 (Fig. 2) as a result of copious rains received in the month of July, 2003. Near maturity, crop showed moisture stress and was irrigated with different saline waters having salinity of 0.5 (control), 2, 4 and 6 dS/m. This supplemental saline water irrigation increased the root zone salinity from 0.8 to 2. to 1.2 to 2.8 dS/m. ECe varied between 1.4 to 3.0 dS/m during the crop growth period when irrigated with ECiw of 2 dS/m gave significantly greater yield than ECiw of 6 dS/m when root zone salinity was ranging from 2.0 to 5.9 dS/m.

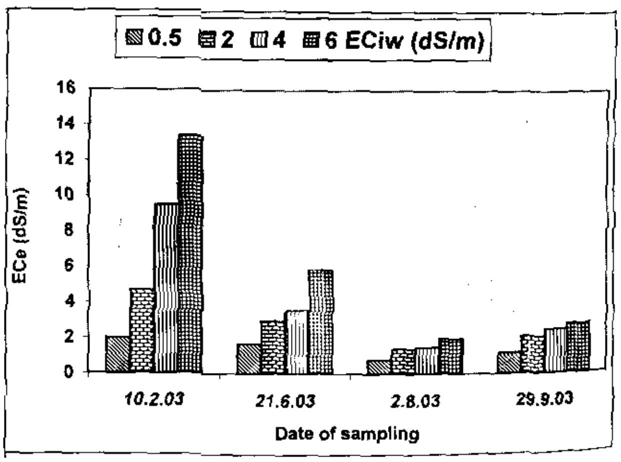


Fig. 2 Periodic changes in root zone salinity as result of rainfall and saline water irrigation

Significant increase in soil pH as a result of increasing soil and water salinity over the control was observed (Table 4). Though this small increase in pH was significant, but this increase in pH did not affect groundnut yield mainly because soil acts as a strong buffer and resists small changes in soil pH. Soil pH also increased due to leaching of soluble salts (NaCl dominated salts) as a result of monsoon rains.

Table 4 **Effect of rainfall and soil and water salinity on periodic changes in soil pH**

ECiw (dS/m)	*ECe (dS/m)*		*Soil pH*			
	Before rainfall	At maturity	10.02.03	21.06.03	02.08.03	29.09.03
0.5	2.0	1.2	7.9	8.0	8.1	8.0
2	4.7	2.1	8.0	8.2	8.5	8.3
4	9.5	2.5	7.9	8.3	8.6	8.5
6	13.4	2.8	7.9	8.2	8.4	8.4
CD (P=0.05)			NS	0.1	0.1	0.1

Oil content: Though the effect of soil and water salinity on the oil content was not significant in different genotypes of groundnut (Table 5) grown in *kharif*, 2003, but the adverse effect of these salinity treatments on oil yield was significant because of poor pod yield in highly salinized plot as a result of saline water irrigation having EC of 4 or 6 dS/m (Fig. 3). Oil content of different genotypes at a given salinity is also affected significantly and MH 2 showed the lowest oil content (Table 5). Aljibury and Talabany (1982) reported that salinity ranging from 2 to 11.3 dS/m decreased the seed production with increasing salinity, while oil percentage was little affected. Girdhar (1989) also reported that sunflower can be grown in sandy loam soil with saline water irrigation of 6 dS/m salinity without much reduction in yield but the oil content was decreased from 36.8 to 30.0 % with an increase in the weighted mean salinity from 1.5 to 11.3 dS/m. Further, according to Girdhar (1988); Girdhar *et al.* (1994) and Girdhar (1999), the tolerance of crops to saline water irrigation through different studies shows the following sequence in the decreasing order of tolerance to salinity.

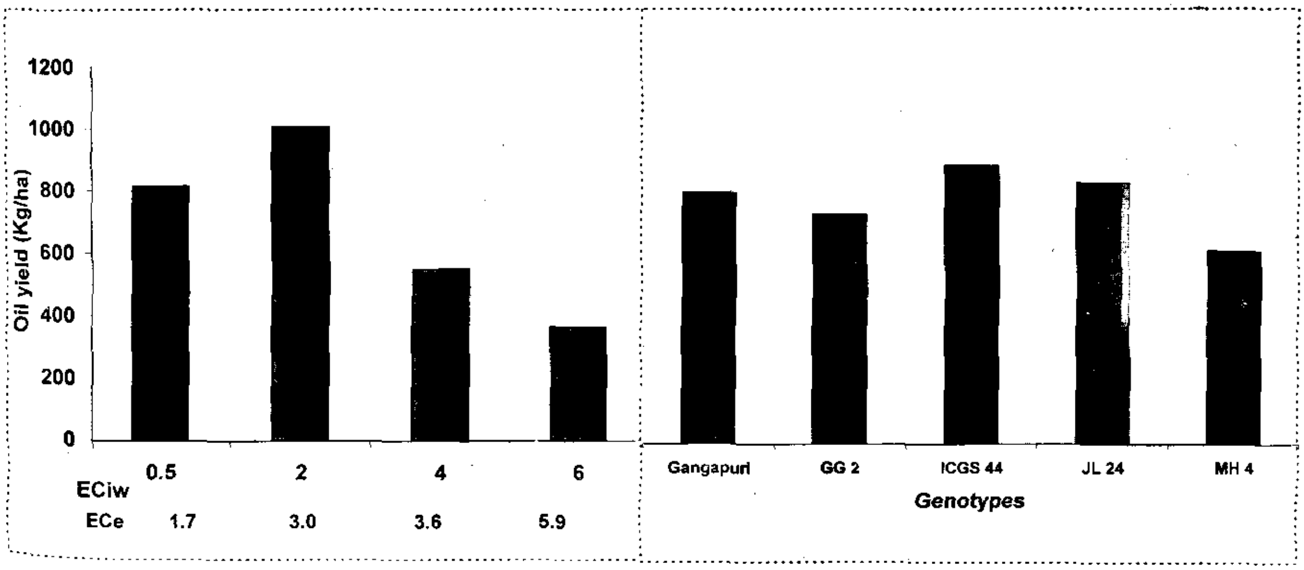


Fig. 3 Effect of soil and water salinity on oil yield of groundnut

Table 2 Effect of soil and water salinity on plant growth and other plant characters of groundnut

*ECiw (dS/m)	**ECe (dS/m)		Plant height (cm)		Per cent decrease in plant height over control		Root length (cm)	Mature pod/plant	Pod weight/ plant (g)
	At sowing	At maturity	60 DAS	Maturity	60 DAS	Maturity			
0.5	1.7	1.2	41	54	0	0	10.1	12	11.3
2	3.0	2.1	34	49	17	9	9.8	12	11.4
4	3.6	2.5	27	41	34	24	8.4	10	7.4
6	5.9	2.8	25	36	39	33	8.1	8	5.4
CD(P=0.05)			2	3			0.2	2	2.2

*ECiw = Electrical Conductivity of irrigation water; **ECe = Electrical Conductivity of soil saturation extract

Table 3 Effect of soil and water salinity on yield and yield contributing characters of groundnut

ECiw (dS/m)	ECe (dS/m)		Pod yield (kg/ha)	Haulm yield (kg/ha)	Pod/Haulm ratio	100-pod weight (g)	100-seed weight (g)	Shelling (%)
	At sowing	At maturity						
0.5	1.7	1.2	1652	3064	0.54	110	37	70
2	3.0	2.1	2039	3569	0.57	118	40	70
4	3.6	2.5	1105	3000	0.37	102	34	70
6	5.9	2.8	733	2429	0.30	88	32	66
CD(P=0.05)			333	594		8	2	1

Table 5 Effect of soil and water salinity on the oil content of different cultivar of groundnut

ECiw (dS/m)	ECe (dS/m)	Oil content (%)					
		Gangapuri	GG 2	ICGS 44	JL 24	MH 2	Mean
0.5	1.2	50.4	49.4	50.1	48.6	47.6	49.2
2	2.1	49.4	49.8	49.5	49.7	48.0	49.3
4	2.5	49.6	50.7	50.9	48.7	48.4	49.7
6	2.8	50.6	50.3	50.1	50.1	48.0	49.8
Mean		*50.0*	*50.1*	*50.2*	49.3	48.0	NS

CD (P= 0.05) for cultivar = 1.0, CD(P = 0.05) for ECiw and ECe : **NS**

Sunflower > Mustard > Dhancha > Wheat > Pearl millet > Rice > Guar > Sorghum > Maize.

In conclusions, supplemental saline irrigation water of 2 dS/m salinity, in addition to the rainfall, can be given safely in optimizing the pod and oil yield of groundnut in shallow calcareous, well drained saline black clay soils representing Saurashtra region of Gujarat.

References

Aljibury, L.K. and Talabany, D. 1982. Effect of different saline levels on yield and oil content of peanut seeds. *Journal of Research for Agriculture and Water Resources,* 1:121-127.

Ghewande, M.P., Girdhar, I.K., Vinod Kumar, Savalia, S.D., Bhalodia, P.K., Hingrajia, H.M. and Padavi, R.D.

2004. Role of soil and water salinity in inducing tolerance to major foliar fungal diseases of groundnut (*Arachis hypogaea* L.). *National Symposium on Enhancing Productivity of Groundnut for Sustaining Food and Nutrition Security* to be held on 11-13 October, 2004 at NRCG, Junagadh (In press).

Girdhar, I.K. 1988. Effect of saline irrigation water on growth, yield and chemical composition of rice crop grown in saline soil. *Journal of Indian Society Soil Science*, **6**:324-329.

Girdhar, I.K. 1989. Response of sunflower (*Helianthus annuus* L.) to saline water irrigation and changing root zone salinity. *Indian Journal of Agriculture Science*, **59**: 500-503.

Girdhar, I.K. 1999. Use of poor quality water in coastal agriculture. *Journal of Indian Society of Coastal Agriculture Research*, **7**:18-2, 247-254.

Girdhar, I.K., Compwell, W.F. and Dudley, L.M. 1994. Response of wheat and mustard to varying root zone salinity. *Symposium Managing Saline Water in Agriculture*, Logan, USA.

Lyda, S.D. and Kissel, D.E. 1974. Sodium influence on disease development and sclerotial formation by Phymatotrichum omnivorum. *Proceeding American Phytopathological Society*, **1**:163-164.

Misra, J.B. and Yadav, S.K. 1997. Arachilipometer - A simple device to determine oil content of groundnut seeds. *International Arachis Newsletter*, 17:73.

Padole, V.R., Bhalkar, D.V. and Kale, V.B. 1993. Performance of groundnut under different saline sodic soil conditions. *PKV Research Journal*, **17**: 108-110

Patel, M.S., Gundalia. J.D., Polara, K.B. and Patel, A.G. 1993. Effect of depth and frequency of saline well water irrigation and FYM on yield of wheat - maize - *groundnut/ Paddy cropping sequence on two* calcareous sodic soils of coastal belt. *Gujarat Agricultural University Research Journal*, **18**: 40-48.

Porter, D.M. and Adamsen, F.J. 1993. Effect of sodic water and irrigation on sodium levels and the development of early leaf spot in peanuts. *Plant Disease*, **77**: 480-483.

Richards, L.A. 1954. "Diagnosis and improvement of saline and alkali soils". *USDA HB No. 60* pp.89 & 102.

Russell, G.E. 1978. Some effects of applied sodium and potassium choloride on yellow rust in wheat. *Annals of Applied Biology*, **90**:163-168.

Standaert, J.Y., Myttenaere, C. and Meyer, J.A. 1973. Influence of sodium/calcium ratios and ionic strength of the nutrient solution on Fusarium wilt of tomato. *Plant Science Lett.*, **1**:413-420

J. Oilseeds Res., **22**(1) : 188-189 (2005)

Short communication

Effect of land treatments and dates of sowing on growth parameters of mustard, *Brassica juncea* (L.) Czern and Coss

C. Radha Kumari and D.S. Koteswara Rao

Department of Agronomy, S.V. Agricultural College, Tirupati-517 502, AP

(Received: January, 2003; Revised: October, 2004; Accepted: November, 2004)

Mustard, *Brassica juncea* (L.) Czern & Coss. is highly sensitive to soil moisture regime especially during initial crop growing period, thus, deciding the plant stand and establishment. Proper layout of seedbed would obviate this situation and ensure required level of moisture supply for germination and growth of mustard. Identification of optimum time of sowing is most important to realize the best productivity of any crop under a given environment. To realize the possible yield potential of mustard crop, right time of sowing and proper land treatment assume significance. Keeping this in view, the present investigation was taken up to find out suitable land treatments and optimum time of sowing for mustard in the southern agro climatic condition of Andhra Pradesh (a non-traditional area), since such information on these aspects is meager.

A field experiment was conducted during *rabi* season of 1999-2000 at the S.V. Agricultural College Farm, Tirupati, A.P. The soil of the experimental field was sandy clay loam with pH 7.7, low in available nitrogen (185 kg/ha), medium in available phosphorus (21 kg/ha) and low in available potassium (128 kg/ha). The treatments consisting of 3 land treatments (flat bed, ridge and furrow and broad bed and furrow method) and 4 dates of sowing (September 15, October 1, October 15 and November 1) were tested in a Randomised Block Design with factorial concept and replicated thrice. Mustard variety 'Sweetha' was sown at a spacing of 30 x 10 cm in flat bed and ridge and furrow method and at 30 x 7.5 cm in broad bed and furrow method to maintain the same plant population. Urea, SSP and MOP were used as the sources of N, P and K, respectively. A uniform basal dose of 50 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha was applied by opening the furrows adjacent to the seed rows. The crop was top dressed with 50 kg N at the time of flowering. A total of four irrigations were given during the entire crop growth period. The other cultural operations were taken up as per recommendations. The weekly mean temperatures ranged from 36.9 to 17.6, 32.4 to 17.2, 31.8 to 17.2 and 31.8 to 17.2 and 31.8 to 16.4°C during crop growth period of September 15, October 1, October 15 and November 1 sowings, respectively. Total number of rainy days was 23 during the crop growth period.

Drymatter production at different stages of crop growth period were higher with broad bed and furrow and ridge and furrow method compared to flat bed method of sowing (Table 1). Higher leaf area index coupled with more number of primary branches have resulted in higher drymatter production in broad bed and furrow method and ridge and furrow method of sowing, which might be due to better aeration, deep root system and better utilization of nutrients (Khan and Agarwal, 1985). Dates of sowing exerted substantial influence on LAI and drymatter production. At different stages of crop growth period crop sown on October 1 accumulated maximum quantity of drymatter, which was however, comparable to that of October 15 sowing but superior to other dates of sowing. This might be due to more number of primary branches (Dudhade *et al.*, 1996), higher leaf area index and better crop growth rate (Ghosh and Chatterjee, 1988).

CGR (Crop Growth Rate), RGR (Relative Growth Rate), NAR (Net Assimilation Rate) were maximum between 30 and 60 days after sowing and decreased later. Among the land treatments broad bed and furrow method of sowing resulted in maximum CGR, RGR and NAR followed by ridge and furrow method and flat bed method. At 30 days after sowing, the difference in LAI among the land treatments were not significant. At 50 days after sowing and harvest, the maximum leaf area index was observed in broad bed and furrow method which was on par with ridge and furrow method and both of them were significantly superior to flat bed method. CGR, RCR, NAR and LAI were higher in broad bed and furrow method and furrow method of sowing compared to flat bed method of sowing, which might be due to better aeration, deep root system and better utilization of nutrients (Khan and Agarwal, 1985). Number of days for 50% flowering and maturity is genetically controlled and mainly influenced by climate. In the present experiment the numb-- of days taken for 50% flowering and maturity was not influenced by land treatments since these are largely varietal dependent. Superior yield with broad bed and furrow method compared to sowing on flat bed was mainly due to increased number of siliquae/plant.

Table 1 Growth parameters and seed yield of mustard as influenced by different land treatments and dates of sowing

Treatment	DMP (g/m^2)			CGR (gm/day)		RGR (g/g/day)*		NAR (g/m^2/day)*		LAI			Days to 50% flowering	Days to maturity	Seed yield (kg/ha)
	30 DAS	60 DAS	At harvest	30-60 DAS	60 DAS harvest	30-60 DAS	60 DAS harvest	30-60 DAS	60 DAS harvest	30 DAS	60 DAS	At harvest			
Land treatment															
Flat bed	10.3	124.2	187.7	3.8	2.5	0.08	0.01	0.02	0.01	0.48	1.10	0.26	36	87	419
Ridge and furrow	11.3	151.1	220.3	4.5	2.6	0.08	0.01	0.02	0.01	0.50	1.23	0.29	35	86	509
Broad bed and furrow	11.6	160.1	231.4	5.0	2.7	0.09	0.02	0.03	0.02	0.52	1.27	0.30	34	85	515
SEm±	0.26	3.95	4.30	-	-	-	-	-	-	0.05	0.024	0.007	0.65	2.12	10
CD (P=0.05)	0.80	11.80	12.67	-	-	-	-	-	-	NS	0.072	0.024	NS	NS	32
Dates of sowing															
September 15	9.3	101.6	160.8	3.1	1.7	0.08	0.01	0.02	0.01	0.35	0.96	0.22	31	94	331
October 1	12.6	170.2	252.5	5.2	3.0	0.09	0.01	0.02	0.01	0.64	1.43	0.34	33	87	602
October 15	12.3	170.0	242.5	5.2	2.7	0.09	0.01	0.02	0.01	0.58	1.30	0.32	35	85	559
November 1	10.1	138.8	195.8	4.3	2.9	0.09	0.02	0.02	0.02	0.43	1.10	0.26	40	79	432
SEm±	0.31	4.54	4.88	-	-	-	-	-	-	0.06	0.028	0.003	0.76	2.27	12
CD (P=0.05)	0.93	13.6	14.6	-	-	-	-	-	-	0.18	0.084	0.01	2.26	6.80	37

* Data were not analysed statistically; DMP = Drymatter production; CGR = Crop Growth Rate;
NAR = Net Assimilation Rate; LAI = Leaf Area Index; RGR = Relative Growth Rate

Delay in sowing beyond October 1 resulted in gradual decrease in leaf area index resulting in poor crop growth rate. Crop sown earlier than October 1 resulted in lowest LAI, CGR, RGR and NAR, which might be due to higher than optimum temperatures prevailed during earlier stages of crop growth. Number of days takes for 50% flowering increased with delay in sowing from September 15 onwards. Higher temperature during the reproductive period thus reducing the duration of the late sown crop. Higher seed yield of 602 kg/ha was obtained with October 1 sowing and decreased gradually with delay in sowing. Higher seed yield with October 1 sowing was mainly due to better partitioning of photosynthates which increased the number of siliquae/plant and seed weight/plant. Poor yields of mustard under late sowing due to shorter reproductive period was reported by Shaoo *et al.* (2000). Increased seed yield with October 1 sowing due to better environmental conditions was also reported by Shastry and Kumar (1981). Lowest seed yield in September 15 sowing might be due to reduced leaf area index and decreased physiological activities of the plant as a result of higher temperature during the vegetative period. Though the reproductive period was longer, the seed yield was lowest due to reduced source.

Based on these findings, it may be concluded that sowing of mustard with broad bed and furrow and ridge and furrow method of land treatment during first fortnight of October is optimum to realise better growth and yield of mustard in non-traditional areas like Tirupati.

References

Dudhade, D.D., Gare, B.N., Khade, K.K. and Ramshe, D.G. 1996. Effect of sowing date on growth, yield attributes and yield of Indian mustard (*Brassica juncea*). *Indian Journal of Agronomy*, **41**(3) : 445-447.

Ghosh, R.K. and Chatterjee, B.N. 1998. Effect of dates of sowing on the productivity of Indian mustard in the short and mild winter of the Gangetic plains of West Bengal. *Indian Journal of Agricultural Sciences*, **58**(8) : 589-596.

Khan, G.M. and Agarwal, S.K. 1985. Water use efficiency and soil moisture extraction pattern of mustard in relation to water stress and sowing methods. *Indian Journal of Agronomy*, **30**(2) : 235-243.

Shaoo, J., Pati. and Panigrahi, R. 2000. Effect of sowing dates and row spacing on yield of Toria. *The Andhra Agricultural Journal*, **47** (3&4) : 179-180.

Shastry, A.B. and Kumar, A. 1981. Variation in yield, its attributes and quality of Indian mustard in relation to planting time and level of plant population. *Indian Journal of Agricultural Sciences*, **51**(1) : 27-32.

J. Oilseeds Res., **22**(1) : 190-191 (2005)

Short communication

Effect of mode of pond and fly ash application on yield and nutrient content of crops under yellow sarson, *Brassica napus* var. *glauca* and rice, *Oryza sativa* in rotation

S.K. Rautaray

Senior Scientist, RRL, Regional Research Station, Gerua, Hajo, Kamrup-781 102, Assam

(Received: April, 2003; Revised: July, 2004; Accepted: September, 2004)

Fly ash is collected in emission control devices after coal combustion in thermal power plants. Residues remaining at the bottom of the furnaces are called bottom ash. Often, both bottom and fly ash are disposed off to the settling ponds in wet form where it weathers with the leaching down of soluble salts and the resultant product is pond ash. Carlson and Adriano, 1993 reported beneficial effect of fly and pond ash as soil amendment and source of nutrients for crops. Meagre information is available on mode of pond and fly ash application and their impact on performance of crops in a sequence. Since the ash contained low levels of N and organic carbon, organic and chemical fertilizers were integrated to supply a desired level of nutrients to the crop.

A field experiment was conducted during 1996-98 on an acid lateritic (Haplustalf) soil (pH 5.4, total N 400 mg/kg, available P 4.4 mg/kg and available K 42 mg/kg). Yellow sarson and rice were grown in 3 seasons in sequence (i e) yellow sarson during dry season (November - March 1996-97), rice during wet season (June - October 1997) and yellow sarson during dry season (November – March 1997-98). The available N, P and K for pond ash were 18,30 and 60 mg/kg, respectively compared with 15, 57 and 61 mg/kg for fly ash. Available Ca, Mg, S and Zn content in pond ash were 324, 263, 129 and 3.5 mg/kg while in fly ash 401, 219, 105 and 2.8 mg/kg, respectively. Thirty tonnes/ha of either ash was applied in 3 modes in a 3 season cropping programme. The modes of application were 30-0-0 (First season yellow sarson crop received 30 tonnes/ha and no application to the following crops), 20-10-0 (First season yellow sarson crop received 20 tonnes/ha and 10 tonnes/ha to rice and no application to second season yellow sarson crop) and 10-10-10 (each crop received 10 tonnes/ha). Besides application of ash, a uniform fertilizer dose of 90, 26 and 33; 60, 17 and 33 kg/ha N, P and K was applied in rice and yellow sarson crops, respectively through 5 tonnes farmyard manure and complementary dose of chemical fertilizers or chemical fertilizers alone. The nutrient content of ash was not considered while calculating the fertilizer dose. Seventeen treatments were arranged in Randomized Block Design with three replications.

The first season yellow sarson crop responded up to 20 t/ha of fly ash or pond ash (Table 1). Similar yields under 20 or 30 t/ha of either ash might be due to the fulfilment of the nutritional requirement through 20 t ash. Also, at a higher dose (30 t/ha) of fly ash or pond ash, nutritional imbalance in soil might be possible. The increase in seed yield of first season yellow sarson was 17-41% under ash + chemical fertilizers compared with chemical fertilizers alone, while such increase in grain yield of rice was low (4-6%). All the three modes of ash application had similar effect on equivalent rice yield. Similarly, pond ash was at par with fly ash. However, the net return from the sequence were maximum under 20-10-10 followed by 30-0-0. Higher equivalent yield as well as yields of first and second season crops under ash+farmyard manure+ chemical fertilizers compared with ash+chemical fertilizers was not significant. However, this difference was significant for the third season crop indicating beneficial residual effect when ash, farmyard manure and chemical fertilizers were used in an integrated manner compared with the use of ash+chemical fertilizers. The beneficial effect of using ash, farmyard manure and chemical fertilizers over chemical fertilizers alone or farmyard manure+chemical fertilizers was significant on yields of individual crops and the equivalent yield of the cropping sequence. Application of fly ash alone did not increase the equivalent yield of the cropping sequence. Oil yield of yellow sarson followed a similar trend as seed yield.

Average nutrient content in yellow sarson seed over two seasons is presented in Table 2 as there is no variation due to mode of application. Content of P and K in yellow sarson seed was more in fly ash based treatments while Mg, S and Zn in pond ash based treatments. All other nutrient contents in seed were higher under ash+farmyard manure+chemical fertilizers followed by ash+chemical fertilizers and chemical fertilizers alone. Among the nutrients studied, S is especially beneficial for yellow sarson crop (Jaggi and Sharma, 1997) and Ca, particularly, under acidic conditions (Bora and Hazarika, 1997) leading to increased seed and oil yield of yellow sarson.

Table 1 Seed and oil yield of yellow sarson, rice grain and rice equivalent yield of yellow sarson-rice-yellow sarson cropping sequence and net return as influenced by fertilization sources

Fertilization source	Yield (kg/ha)						Net returns from S_1, S_2 and S_3 (Rs/ha)
	Yellow sarson seed, S_1	Rice grain, S_2	Yellow sarson seed, S_3	Rice equivalent	Yellow sarson oil, S_1	Yellow sarson oil, S_3	
Control	515	3123	433	5261	155	128	-12273
$FA_{10-10-10}$	832	3188	425	6020	351	132	-14478
CF	1383	3942	1260	9898	437	397	3942
$FA_{10-10-10}$+CF	1618	4105	1402	10910	529	461	3002
$FA_{20-10-0}$+CF	1919	4161	1385	11604	631	456	6472
FA_{30-0-0}+CF	1789	4190	1380	11307	587	453	4987
FYM_5+CF	1300	3937	1308	9804	412	425	1772
$FA_{10-10-10}$+FYM_5+CF	1669	4233	1602	11603	574	554	4767
$FA_{20-10-0}$+FYM_5+CF	1920	4307	1570	12171	557	542	7607
FA_{30-0-0}+FYM_5+CF	1894	4308	1583	12143	655	546	7467
$PA_{10-10-10}$	1013	3142	437	6408	316	136	-11938
$PA_{10-10-10}$+CF	1672	4090	1370	10943	548	464	3767
$PA_{20-10-0}$+CF	1952	4167	1365	11640	646	452	7252
PA_{30-0-0}+CF	1789	4145	1387	11300	592	459	5852
$PA_{10-10-10}$+FYM_5+CF	1653	4200	1592	11511	555	555	4907
$PA_{20-10-0}$+FYM_5+CF	1906	4312	1562	12125	655	544	7977
PA_{30-0-0}+FYM_5+CF	1836	4290	1557	11933	641	547	7017
LSD (P=0.05)	284.2	548.8	190.5	883.6	27.4	62.1	1190

The first, second and third value as subscript of PA (pond ash) and FA (fly ash) refers to the rate of application (tonnes/ha) to the first, second and third crop of yellow sarson-rice-yellow sarson cropping sequence.
CF = Chemical fertilizer; FYM = Farmyard manure;
S_1 = First season crop (yellow sarson, 1996-97),
S_2 = Second season crop (Rice, 1997) and
S_3 = Third season crop (yellow sarson, 1997-98)

Table 2 Nutrient content in yellow sarson seed as influenced by fertilization sources (Average of 1996-97 and 1997-98)

Fertilization sources	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	Zn (ppm)
Control	2.94	0.54	0.47	0.16	0.10	1.03	46.2
FA_{10}	3.09	0.62	0.79	0.17	0.12	1.04	52.0
CF	3.03	0.60	0.49	0.16	0.10	1.02	48.2
FA_{10}+CF	3.21	0.66	0.52	0.17	0.12	1.05	51.5
FA_{20}+CF	3.21	0.70	0.53	0.17	0.13	1.05	52.3
FA_{30}+CF	3.16	0.72	0.53	0.17	0.13	1.05	52.2
FYM_5+CF	3.10	0.65	0.50	0.16	0.12	1.04	50.9
FA_{10}+FYM_5+CF	3.32	0.74	0.58	0.17	0.14	1.06	54.1
FA_{20}+FYM_5+CF	3.30	0.77	0.58	0.17	0.15	1.07	54.2
FA_{30}+FYM_5+CF	3.23	0.77	0.58	0.17	0.15	1.06	54.2
PA_{10}	3.05	0.57	0.49	0.17	0.13	1.06	55.2
PA_{10}+CF	3.21	0.65	0.51	0.17	0.14	1.06	55.2
PA_{20}+CF	3.21	0.68	0.51	0.17	0.14	1.05	56.6
PA_{30}+CF	3.16	0.68	0.51	0.17	0.14	1.05	54.6
PA_{10}+FYM_5+CF	3.30	0.71	0.57	0.17	0.15	1.08	57.4
PA_{20}+FYM_5+CF	3.28	0.73	0.57	0.17	0.16	1.08	57.5
PA_{30}+FYM_5+CF	3.25	0.75	0.57	0.17	0.16	1.07	57.5
LSD (P=0.05)	0.06	0.02	0.01	0.01	0.02	0.01	1.8

References

Bora, P.C. and Hazarika, U. 1997. Effect of lime and boron on rainfed toria (*Brassica campestris* subsp. *oleifera* var. *toria*). *Indian Journal of Agronomy*, **42**(2): 361-4.

Carlson, C. L. and Adriano, D. C. 1993. Environmental Impacts of Coal Combustion Residues. *Journal of Environmental Quality*, **22**: 227-47.

Jaggi, R.C. and Sharma, D.K. 1997. Effect of sulphur and phosphorus on yield and their uptake by Indian mustard. *Indian Journal of Agronomy* **42**(2): 352-356.

J. Oilseeds Res., 22(1) : 192-193 (2005)

Short communication

Effect of sources and levels of sulphur on seed yield, quality and sulphur uptake by soybean, *Glycine max* (L.) Merrill.

D.N. Gokhale, A.G. Kanade, P.N. Karanjikar and V.D. Patil

College of Agriculture, Marathwada Agricultural University, Parbhani-431 402, MS

(Received: September, 2004; Revised: January, 2005; Accepted: January, 2005)

Soybean, *Glycine max* (L.) Merrill. is basically a leguminous crop and is gaining importance as an oilseed crops. Soybean is of paramount importance in human and animal nutrition, because it is a major source of edible vegetable oil and high protein. Sulphur is one of the essential plant nutrient, its importance in Indian agriculture is being increasingly emphasized. Role of sulphur in crop production particularly in oilseeds and pulses has been reported by several research workers. Sulphur deficiency causes 12-15% reduction in seed yield of soybean (Chandel *et al.*, 1989). Optimum dose of sulphur application with efficient source may be the remedial measure to improve the soybean yield and quality. With these considerations in view, the present study was undertaken to know the effect of sources and levels of sulphur on seed yield, quality and sulphur uptake by soybean on deep black soil of Marathwada region.

A field experiment was conducted at Agronomy Farm, College of Agriculture, Latur during *kharif*, 2003-04 in a deep black soil having pH 8.18. The available N, P and K were 181, 17 and 658 kg/ha, respectively. The soil was deficient in sulphur having available sulphur 8.6 mg/kg. The treatments comprised 3 levels of S (0, 20 and 40 kg/ha) and 3 sources of S (single super phosphate, elemental sulphur and gypsum). Nine treatments were tried in Factorial Randomised Block Design with 3 replications. The gross and net plot size were 6.0m x 4.5m and 5.0m x 3.6m, respectively. Gypsum and single super phosphate were given at the time of sowing, whereas, elemental sulphur was applied 15 days before sowing. The recommended dose of 30 kg N, 60 kg P_2O_5 and 30 kg K_2O/ha was given through urea, diammonium phosphate and murate of potash, respectively. The quantity of N and P were maintained as per recommended dose by adjusting N and P supplied through various sources of sulphur used in various treatment. Soybean cv. JS 335 was sown at a spacing of 30cm x 5 cm on 30.06.2003.

Increasing levels of sulphur from 0 to 40 kg/ha significantly increased the seed yield, oil content and sulphur uptake by soybean (Table 1). The maximum seed yield (2970 kg/ha) was recorded with the application of 40 kg/ha and which was found significantly superior over 20 kg S/ha (2704 kg/ha) and no sulphur application (2339 kg/ha). These results were in agreement with the results reported by Ramamoorthy *et al.* (1996). Significantly highest oil and protein content was recorded with 40 kg S/ha. Similar results have been also reported by Wasmatkar *et al.* (2002). The data further showed that the sulphur uptake by seed and straw were significantly increased due to application of 40 kg S/ha over application of 20 kg S/ha and no sulphur application.

Table 1 Effect of sources and levels of sulphur on quality, seed yield and sulphur uptake by soybean

Treatment	Seed yield (kg/ha)	Oil content (%)	Protein content (%)	Sulphur uptake (kg/ha)	
				Seed	Straw
Levels of sulphur					
0 kg S/ha	2339	18.76	39.37	3.38	2.66
20 kg S/ha	2704	19.58	40.38	6.03	5.16
40 kg S/ha	2970	20.69	42.20	7.52	9.39
SEm±	0.62	0.12	0.48	0.13	0.09
CD (P=0.05)	1.82	0.37	1.45	0.40	0.27
Sources of sulphur					
Single super phosphate	2707	19.74	40.97	5.80	5.21
Elemental S	2509	19.34	39.40	5.27	4.68
Gypsum	2798	19.95	41.20	5.87	5.29
SEm±	0.62	0.12	0.48	0.13	0.09
CD (P=0.05)	1.86	0.37	1.45	0.40	0.27

The higher amount of sulphur uptake by seed (7.52 kg/ha) and straw (7.39 kg/ha) were recorded with 40 kg S/ha. The results confirm to the findings of Sharma *et al.* (2002). This increase in oil content, protein content, seed yield and sulphur uptake by soybean may be due to favourable increase in yield attributes resulting ultimately in yield kg/ha as sulphur plays a specific key role in chlorophyll formation, synthesis of protein and oil in oilseed crop.

Significantly higher oil content, protein content, seed yield and sulphur uptake by soybean were observed due to application of gypsum and single super phosphate as compared to elemental sulphur. The higher seed yield (2798 and 2707 kg/ha) recorded due to application of gypsum and single super phosphate, respectively as compared to elemental sulphur (2509 kg/ha). However, higher oil and protein content were obtained from gypsum (19.95% and 41.20%, respectively) and single super phosphate (19.74% and 40.97%, respectively) which were at par with each other and found significantly superior over elemental sulphur (19.34% and 39.40%, respectively). In case of sulphur uptake, the higher sulphur uptake by seed and straw were observed due to gypsum (5.87 and 5.29 kg/ha, respectively) and single superphosphate (5.80 and 5.21 kg/ha, respectively) which was at par with each other and found significantly superior over elemental sulphur (5.27 and 4.68 kg/ha). The higher response of gypsum and single superphosphate in respect of quality character, seed yield and sulphur uptake by soybean might be due to readily availability of SO_4-S. Similar beneficial effect was also reported by Ramamoorthy *et al.* (1996).

It may be concluded from the study that application of 40 kg sulphur/ha either through gypsum or single super phosphate was found beneficial in improving growth characters, yield attributes, quality parameters and yield of soybean.

References

Chandel, A.S., Rao, G.P. and Saxena, S.C. 1989. Effect of sulphur nutrition to soybean. *World Soybean Research Conference*, **4**(1):363-386.

Ramamoorthy, K., Ramaswami, M. and Vairavan, K. 1996. Effect of sources and levels of sulphur on production of soybean (*Glycine max.*). *Indian Journal of Agronomy*, **41**(4):654-655.

Sharma, R.K., Shila, P.K., Sharma, R.A. and Gongarde, S.K. 2002. Effect of sulphur on seed yield and nutrient content and uptake by soybean. *2nd International Agronomy Congress*, November 26-30, New Delhi, India, pp.244-246.

Wasmatkar, R.P., Ingole, G.L. and Raut, P.D. 2002. Effect of different levels of sulphur and zinc on quality and uptake of nutrient by soybean. *Journal of Maharashtra Agricultural Universities*, **27**(3):244-246.

J. Oilseeds Res., **22**(1) : 194-196 (2005)

Short communication

Effect of spatial arrangement of soybean and sorghum in intercropping on productivity and energy use efficiency

S.D. Billore and O.P. Joshi

National Research Centre for Soybean, Indore-452 017, MP

(*Received: February, 2004; Revised: July, 2004; Accepted: September, 2004*)

Intercropping has been recognized as potentially beneficial system of crop production in semi-arid tropics. Evidences suggest that intercropping can provide substantial yield advantage compared to sole cropping (Trikha, 1985; Pal *et al.*, 1991, Balyan and Singh, 1987). Although, the soybean + sorghum intercropping is in practice in Madhya Pradesh, the present study was undertaken to identify suitable and economically more viable spatial arrangements for enhancing productivity from the system.

An intercropping experiment was conducted at Research Farm of National Research Centre for Soybean, Indore during *Kharif* 1999. The treatments consisted of interpolating one, two and four rows of sorghum between paired/ alternate rows of soybean (Table 1). The experiment involved eight treatments laid out in randomized block design with 3 replications. The soil of experimental site belonged to fine, montmorrillonitic, hypothermic family of typic chromusterts. The soil had pH 7.86, EC 0.14 dS/m, organic carbon 0.35 %, available phosphorus 11.0 kg/ha, and available potassium more than 213 kg/ha. The fertilizer N, P and K @ 20:26:16 kg/ha were applied to soybean only in the form of urea, single superphosphate and muriate of potash, respectively. Soybean (NRC 37) and sorghum (CSH 18) were planted in first week of July, 1999 and harvested in the first week of October, 1999. The gross plot size was 3.6 x 6 m. The total rainfall received during the crop season was 283.40 mm. The competitive ratio (Willey and Rao, 1980), the relative crowding coefficient (de Wit, 1960) and aggressivity (Mc Gilchrist 1965) were calculated. Energy inputs and outputs were computed using the conversion factors as suggested by Mittal and Dhawan (1988). Energy productivity and energy intensiveness were worked out as per Fluck (1979) and Burnett (1982), respectively. The energy use efficiency is the ratio between gross energy out put and gross energy input. Competition index and income equivalent ratio were also worked out.

Seed yield, soybean equivalent yield and mean seed yield index: Yield performance of both the crops was superior in their sole croppings than in intercropping (Table 1). The maximum yield of sole soybean in paired rows (22.5/90 cm) was 9% higher than that of 30 cm planting, but the differences were not significant. Planting of soybean and sorghum in intercropping system caused yield reduction to the tune of 17.7 to 34% in soybean and 46.5 to 67.8% in sorghum as compared to their sole crops. Among the intercropping systems, planting of one row of sorghum between paired rows of soybean (22.5/90 cm) produced maximum soybean yield than remaining treatments while sorghum yield was highest when sorghum and soybean planted in alternate paired rows (22.5/90 cm) and closely followed by 4:2 and 2:2 row ratio (30 cm). These differences might be on account of differential utilization of natural resources on account of varying planting geometry. Similar observations were also recorded by Tomar *et al.* (1987) and Joshi *et al.* (1994).

The system productivity as judged by the soybean equivalent yield from the intercropping treatments was superior to sole crops. The maximum soybean equivalent yield was recorded when two rows of sorghum planted between paired rows of soybean (22.5/90 cm) and remained at par with all the treatments except sole soybean. The lowest soybean equivalent yield was noted with sole soybean. These differences could be attributed to the differences in yield of soybean and sorghum (Table 1).

The mean seed yield index indicated that the soybean yield varied from 66.3 to 82.3% as compared to sole soybean while these values varied from 32.2 to 53.5% for sorghum.

Competition functions: The average land equivalent ratio ranged from 1.14 to 1.21 indicating that the planting pattern had a great impact on the productivity of the system. The planting of soybean and sorghum in alternate paired (30/30) rows showed the maximum biological efficiency (1.21) of the system and remained at par with rest of the intercropping treatments. These values suggest that intercropping system is more efficient in utilizing natural resources than sole cropping of component crops, resulting in higher productivity per unit space. The results are in agreement to those of Tomar *et al.* (1987). The highest competition ratio was noted when soybean and sorghum planted in 2:1 row ratio (22.5/90 cm) followed by

4:4 row ratio (30 cm). This means that component soybean produced 2.56 and 1.74 times higher as much as expected and it was competitive in same manner. Similar results were also reported by Billore *et al.* (1992).

Aggressivity values for soybean was positive for 2:1 (22.5/90 cm) and 4:4 row ratio (30 cm) representing the domination of soybean over sorghum. Remaining treatments showed dominance of sorghum. The maximum aggressivity value was noted in 2;1 row ratio (22.5/90 cm). These results are in close conformity with the observations made by Rai (1986) in *anjan* grass and Billore *et al.* (1992) in sorghum + pigeonpea intercropping. Data revealed that the products of relative crowding coefficient were more than one in all the planting patterns indicating more of non-competitive interference than the competitive ones. The planting of two rows of sorghum between four rows of soybean (30 cm) had the maximum value showing better compatibility between two crops.

Monetary advantage:. The additional monetary gain per hectare of land in intercropping ranged from Rs. 3264 to 4774; maximum being in the treatment where sorghum and soybean were sown in 4:2 row ratio (30 cm). Income equivalent ratio also followed a similar trend, however the values were lower when compared with sorghum. These differences may be accounted for wider differences in soybean and sorghum yield in respective planting pattern.

Energy budget: Working out the energy budget for the treatments revealed that the intercropping of sorghum with soybean consumed more energy inputs than sole soybean but lower than sorghum crop (Table 2). Among the treatments, intercropping of soybean and sorghum produced significantly higher gross and net energy output and proved better in energy use efficiency, and energy productivity as compared to sole soybean. Among the sole cropping systems, planting of soybean in paired rows (22.5/90 cm) being the maximum and remained at par with soybean planted at 30 cm and sole sorghum. The lowest energy output, energy use efficiency and energy productivity was recorded in sole soybean (30 cm). The differences in energy indices may be due to differences in their yield levels and energy inputs of the respective treatments. However, the sole cropping of either soybean or sorghum was more energy intensive than intercropping system. The variation in energy intensiveness might be due to variation in yield, price and energy inputs.

Table 1 Yield and biological efficiency of land as influenced by intercropping of soybean + sorghum

Treatment	Seed yield (kg/ha)		Mean yield index (%)		Soybean equivalent yield (kg/ha)	Land equivalent ratio	Compe-tition ratio	Aggre-ssivity	Relative crowding coefficient	Competition index
	Soybean	Sorghum	Soybean	Sorghum						
One row of sorghum (45 cm) between paired rows of soybean (22.5 / 90 cm)	2170	1648	82.26	32.20	3145	1.14	2.6	0.43	2.2	0.12
4 rows of soybean (30 cm) between paired rows of sorghum (30 cm)	1663	2690	68.70	52.56	3255	1.21	1.3	-0.03	2.4	0.15
Two rows of sorghum (30 cm) between paired rows of soybean (22.5 / 90 cm)	1740	2740	65.96	53.54	3361	1.19	1.2	-0.009	2.2	0.16
Alternate four rows of soybean and sorghum at 30 cm	1773	2148	73.23	41.98	3044	1.15	1.7	0.15	1.9	0.16
Alternate paired rows of soybean (30 cm) and sorghum (30 cm)	1606	2633	66.33	51.45	3164	1.17	1.3	-0.04	12.1	0.16
Paired rows of sole soybean (22.5 / 90 cm)	2638	-	-	-	2638	1.00				
Sole soybean (30 cm)	2421	-	-	-	2421	1.00				
Sole sorghum	-	5117	-	-	3028	1.00				
CD (P=0.05)	389.3	471.7	25.71	37.34	522	0.15	0.87	0.31	6.91	0.03

Sorghum @ 5 Rs/kg; Soybean @ 8.45 Rs/kg

Table 2 Economic and energy budgeting of soybean + sorghum intercropping

Treatment	Monetary advantage (Rs/ha)	Income equivalent ratio		Energy input (MJ/ha)	Energy output (MJ/ha)		Energy use efficiency	Energy productivity (g/MJ)	Energy intensiveness (MJ/Rs)
		Soybean	Sorghum		Gross	Net			
One row of sorghum (45 cm) between paired rows of soybean (22.5 / 90 cm)	3264	1.19	1.03	7607	46232	38625	6.08	413	0.29
4 rows of soybean (30 cm) between paired rows of sorghum (30 cm)	4774	1.34	1.07	7607	47249	39642	6.21	428	0.28
Two rows of sorghum (30 cm) between paired rows of soybean (22.5 / 90 cm)	4534	1.27	1.11	7607	49407	41800	6.50	442	0.27
Alternate four rows of soybean and sorghum at 30 cm	3355	1.26	1.00	7607	44747	37140	5.88	400	0.30
Alternate paired rows of soybean (30 cm) and sorghum (30 cm)	3885	1.31	1.05	7607	46511	38904	6.11	416	0.28
Paired rows of sole soybean (22.5 / 90 cm)	-			7504	38779	31275	5.17	352	0.34
Sole soybean (30 cm)	-			7504	35589	28085	4.74	323	0.37
Sole sorghum	-			*8967*	*44512*	*35545*	*4.96*	*338*	*0.35*
CD (P=0.05)	658	0.09	0.07	807	7569	7513	1.07	73	0.06

The results of this study revealed that the planting of soybean and sorghum either in 4:2 row ratio (30 cm) or two rows sorghum between paired rows of soybean (22.5/90 cm) proved to be better over other planting patterns with highest total productivity (3255/3361 kg/ha), monetary advantage (Rs 4774/4534) and land equivalent ratio (1.21/1.19) besides better companion indicating low competition interference, high energy output, energy use efficiency and energy productivity.

References

Balyan, J. S. and Singh, R. R. 1987. Nitrogen and weed control studies in sorghum-soybean intercropping systems. *Annals of Agricultural Research*, **8** (2): 243-251.

Billore S D, Upadhyay M S and Holkar S.1992. Effect of pigeonpea plant population on the productivity of sorghum in intercropping production complex. *Crop Research*, **5**:426-9.

Burnett, M. 1982. Energy analysis of three conserved agro-ecosystems. (In) *Basic Techniques in Ecological Farming*. pp. 183-195. Hill Stuart B (Ed.) Brikhauser Verlag, Boston.

de Wit, C. T. 1960. On competition. *Verslagen Van Land bow kundige onderzoekingen*, **66**(8): 1-82.

Fluck, R. C. 1979. Energy Productivity: A measure of energy utilization in agricultural systems. *Agricultural Systems*, **4**: 29-37.

Joshi O P, Bhatia V S and Bundela V P S. 1994. Performance of soybean-pigeonpea intercropping systems in Malwa plateau of Madhya Pradesh. *Journal of Oilseeds Research*, **11**:189-92.

Mc Gilchrist D A.1965. Analysis of competition experiments. *Biometrics*, **21**: 975-85.

Mittal, J. P. and Dhawan, K. C. 1988. *Research Manual on Energy Requirements in Agricultural Sector*, pp. 20-23.

Pal, M. S., Gupta, P.C. and Singh, O.P. 1991. Effect of sorghum based intercropping systems on productivity, land equivalent ratio and economics in Mollisols of U. P. *Indian Journal of Agronomy*, **36** (1): 12-16.

Rai, P. 1986. Effect of intercropping of annual grain legumes on the productivity of anjan grass. *Indian Journal of Agronomy*, **31**:147-53.

Tomar, R. S. S., Upadhyay, M. S. and Sharma, R. A. 1987. Effect of planting patterns in pigeonpea+soybean intercropping systems. *Indian Journal of Agronomy*, **32**:322-5.

Trikha, R. N. 1985. The potential of soybean in Indian cropping systems. In: *Soybean in Tropical and Sub-tropical Systems, Proceedings of Symposium*, Taukuba, Japan, The Asian Vegetable Research and Development Centre, Shanua, Taiwan, China, pp 77-80.

Willey R W and Rao M R. 1980. A competition ratio for quantifying competition between intercrops. *Experimental Agriculture*, **16**:105-17.

J. Oilseeds Res., **22**(1) : 197-198 (2005)

Short communication

Relative performance of sesame, *Sesame indicum* L. varieties in Kymore plateau zone of Madhya Pradesh (India)

M.R. Deshmukh, H.C. Jain and S.S. Duhoon

Project Coordinating Unit (Sesame & Niger), J.N. Krishi Vishwa Vidyalaya Campus, Jabalpur, MP

(Received: June, 2001; Revised: July, 2004; Accepted: September, 2004)

Sesame (*Sesamum indicum* L.) is an important oilseed crop in Kymore plateau zone of Madhya Pradesh. Its productivity is quite low (174 kg/ha) in the region in comparison to average production of the state (247 kg/ha) and the nation (325 kg/ha) due to its cultivation in marginal and sub-marginal lands under poor management and input starved rainfed conditions. Recently high yielding varieties *viz.* TKG-21, TKG-22, TKG-55, JTS-8, Tapi, VRI-1, TC-25, Uma, RT-46, RT-54, RT-103 and RT-125 have been evolved by the breeders which may be suitable for this zone. Hence, the present study was undertaken to evaluate suitable high yielding varieties for cultivation in the region.

An experiment was conducted at Research farm of the Project Coordinating Unit (Sesame and Niger) J.N.K.V.V. Jabalpur, Madhya Pradesh. The soil was clay loam in texture, neutral in reaction (pH) and low in organic carbon (0.19%), available N (220 kg/ha), available P_2O_5 (7.85 kg/ha) and available K_2O (345 kg/ha). The rainfall was 839, 1738 and 1060 mm during the crop seasons in 1998, 1999 and 2000, respectively. Ten varieties (Table 1) were tested for their relative performance in Randomized Block Design with three replications. Sowing was done with 5kg seeds/ha in rows 30 cm apart on July 4, 14 and 7 in 1998, 1999 and 2000 respectively and then plant spacing 10 cm was maintained by thinning. A uniform dose of 40 kg N, 30 kg P_2O_5 and 20 kg K_2O/ha was applied. Observations on various growth parameters, yield attributes, and seed yields were recorded. Pooled analysis of 3 years data was carried out as per method suggested by Panse and Sukhatme (1957).

Based on pooled data of three years, variety RT -54 outyielded amongst all but the differences were significant only with RT-46 and VRI-1 (Table 1). Although plant population and maturity periods were similar for all the varieties, they differed significantly in their growth parameters (plant height, branches/plant) and yield attributes (capsules/plant and test weight of seeds) due to their genetic ability. Plant height did not contribute much to seed yield. Variety TKG-21 had the tallest plants (132 cm) while RT -103 had the shortest plants (98 cm). The seed yields were 956 and 924 kg/ha from the respective varieties. The branches per plant, capsule/plant and test weight of seeds mainly contributed to increased seed yields (Mondal *et al.* 1992; Venkatakrishnan and Ravichandran, 1998).

Table 1 Yield attributes, seed yield and oil yield of sesame varieties

Variety	Plant population (000/ha)	Days to Maturity	Plant height (cm)	Branches/ plant	Capsules / plant	Test weight (g)	Seed yield (kg/ha)	Oil (%)	Oil yield (kg/ha)
TC-25	307	83	106	3.6	61	3.1	864	48.6	420
VRI-1	304	87	117	5.6	72	2.8	434	49.0	213
Tapi	306	85	125	3.2	53	3.2	872	48.8	425
TKG-21	316	85	132	3.7	65	2.9	956	47.9	458
TKG-22	325	84	119	3.4	62	3.2	1021	49.2	502
RT-125	333	79	109	3.5	57	2.9	847	48.7	412
RT-46	331	82	111	3.9	62	3.1	791	48.9	387
RT-103	328	80	98	3.5	55	2.9	924	48.8	451
RT-54	342	84	99	3.8	67	3.1	1026	46.1	473
Uma	341	85	111	3.8	63	2.8	948	46.5	441
SEm ±	28.1	0.7	5	0.6	2.1	0.05	064	0.6	0.65
CD (P=0.05)	NS	NS	17	1.8	6.3	0.14	189	NS	1.94

Oil yield is a product of seed yield and oil content of seeds. The oil content of seeds varied from 46.1 to 49.2% among the varieties, which was not significant. But the varieties producing higher seed yields produced significantly higher oil yields. The varieties were almost in the same order for oil yield as they were in order for seed yield with little variations. Oil content in seeds did not differ much. Hence, seed yields of different varieties attributed to oil yield of varieties. The results are in close conformity with the findings of Shinde *et al.* (1994) and Gangakishan *et al.* (1998).

References

Gangakishan., A., Rao, V.S.N. and Vijayabhinandana, B. 1998. Swetha Thil- A high yielding and high oil white seeded new sesame variety. *Journal of Oilseeds Research*, **15** (1): 177-179.

Mondal, S.S., Verma, D. and Kulia, S. 1992. Effect of organic and inorganic sources of nutrients on growth and seed yield of sesame (*Sesamum indicum*). *Indian Journal of Agricultural Sciences*, **62** (4) : 258-262.

Panse, V.G and Sukhatme, P.V. 1957. *Statistical Methods for Agricultural Worker.* ICAR, New Delhi, pp., 307-322.

Shinde, Y.M, Chaudhari, P.N, Deokar, A.B and Badhe, P.L. 1994. Padma-4 New early variety of sesame for a Part of Maharashtra. *Journal of Maharashtra Agricultural Universities*, **19**(2): 190-191.

Venkatakrishnan, A.S. and Ravichandran, V.K. 1998. Effect of dryland technologies on the yield of sesame under rainfed condition. *Madras Agricultural Journal*, **83(1)** : 51-53.

J. Oilseeds Res., 22(1) : 199-200 (2005)

Short communication

Effect of sources and levels of sulphur on seed and oil yield of sesame, *Sesamum indicum* L. under different agro-climatic situations of India

S.S. Duhoon, M.R. Deshmukh, A. Jyotishi and H.C. Jain

All India Coordinated Research Project on Sesame and Niger, J.N. Krishi Vishwa Vidyalaya, Jabalpur-482 004, MP

(Received: August, 2002; Revised: July, 2004; Accepted: September, 2004)

Sesame, *Sesamum indicum* L. is an ancient and important oil crop of India. The average productivity of sesame is very low, (335 kg/ha), which is mainly due to its cultivation on marginal and sub-marginal lands with poor fertility under rainfed conditions without any nutrient management. The role of sulphur in yield and quality improvement of sesame is well established, as sulphur is the key constituent of oilseeds and directly involved in the formation of oleic, lnoleic, palmitic, stearic acids in oil compounds. Continuous cropping of sesame with use of sulphur-free fertilizers like di-ammonium phosphate and urea under intensive crop sequences and removal of sulphur from soils is causing sulphur-deficiency in the soils. Consequently the deficiency of sulphur is widely spread in sesame growing areas of the country resulting in reduction of productivity levels. Sharma and Kakate (1993) reported increase of 25 to 30 % in yield with application of sulphur. Sulphur application with efficient source may be the remedial measure to improve the sesame yield. Keeping this in view, the present investigations were undertaken to evaluate the efficiency of sulphur-sources and determine the suitable sulphur-requirement in sesame for different agroclimatic regions of India under rainfed conditions.

The studies were carried out during *kharif* season under rainfed conditions at four locations i.e. for four years during 1998 to 2001 at Amreli on Vertisol, for three years during 1998 to 2000 at Jalgaon on Vertisol and Vriddhachalam on Alfisol and for two years during 2000 to 2001 at Tikamgarh on Inceptisol, under All India Coordinated Sesame Improvement Project. Initial status of the sulphur in the experimental plot was 9.54 kg/ha, 18 kg/ha and 11.8 kg/ha at Amreli, Vriddhachalam and Tikamgarh respectively whereas it was very low at Jalgaon. Ten treatments consisting of three sources of sulphur *viz.* elemental sulphur (ELS), gypsum (GY) and single super phosphate (SSP) and three levels of sulphur *viz.* 15, 30 and 45 kg S/ha and control (no sulphur application) were tested in randomized block design with three replications. The crop was sown in lines with a planting geometry of 30 cm x 10 cm at Jalgaon, Tikamgarh, Vriddhachalam and 45 cm x 15 cm at Amreli in the month of July. Recommended doses of fertilizers as 50:25:00, 50:00:00, 60:40:20 and 35:23:23 kg NPK/ha, were applied at Amreli, Jalgaon, Tikamgarh and Vriddhachalam, respectively along with sulphur through appropriate sources and rates as per treatments. Recommended varieties i.e. Gujarat Til-2 at Amreli, Padma at Jalgaon, JTS-8 at Tikamgarh and VRI-1 at Vriddhachalam were grown with recommended agronomic practices. Data on seed and oil yield were recorded in the respective years and economics of the treatments as benefit cost ratio was worked out on the basis of the pooled mean for seed yield over the years.

Sesame responded to application of S in terms of seed and oil yield as compared to control (no sulphur) at all the centres except Vriddhachalam where differences were not significant. Similar results were also reported by Sharma and Kakate (1993).

No remarkable difference was observed on seed and oil yield of sesame under different levels of sulphur application at all the centres except Tikamgarh, where higher mean seed yield of 854 kg/ha was recorded with 45 kg S/ha and closely followed by 824 kg/ha recorded with 30 kg S/ha and 777 kg/ha with 15 kg S/ha (Table 1). Similar trend was also observed in oil yield. These results are in close conformity with the findings of Nagavani *et.al.* (2001). The study on economics worked on B:C ratio indicated that application of different levels of sulphur was found profitable over control (no sulphur application) at all the centres. As regard to the different doses of sulphur, application of 15 kg S/ha was found profitable over 30 and 45 kg S/ha at all the locations except at Tikamgarh where increasing trend in yield was noted with increasing levels of sulphur. With regard to effect of different sources of sulphur, the seed yield of sesame was found almost equal. However, B:C ratio was numerically higher, when sulphur was applied through gypsum. The lowest response was observed with the application of sulphur through elemental sulphur at all the centres. Similar results are also reported by Mandal *et al.* (1993), Nageshwar Lal *et al.* (1995) and Sarawagi *et al.* (1995) in sesame.

Table 1 **Effect of different levels and sources of sulphur on seed yield, oil yield and economics of sesame (Pooled mean of 1998 to 2001)**

Treatment Sulphur (kg/ha)	Seed yield (kg/ha)					Oil yield (kg/ha)					Benefit : Cost ratio				
	Amreli	Jalgaon	Tikam garh	Vriddha chalam	Mean	Amreli	Jalgaon	Tikam garh	Vriddha chalam	Mean	Amreli	Jalgaon	Tikam garh	Vriddha chalam	Mean
Control	745	392	707	650	623	312	190	329	262	273	1.17	0.19	1.35	0.85	0.89
15 – SSP	966	645	773	741	781	404	317	359	313	348	1.71	0.74	1.21	0.88	1.13
15 – ELS	933	591	795	749	767	393	290	370	316	342	1.56	0.52	1.14	0.82	1.01
15 – Gypsum	1034	589	764	750	784	429	294	356	325	351	1.93	0.65	1.30	0.97	1.21
Mean	998	606	777	747	782	409	300	362	318	347	1.73	0.64	1.22	0.89	1.12
30 – SSP	984	652	805	749	797	415	323	376	316	357	1.61	0.68	1.17	0.82	1.07
30 – ELS	982	612	852	760	801	410	302	398	321	358	1.58	0.44	1.06	0.70	0.94
30 – Gypsum	921	555	816	759	763	387	271	381	316	339	1.58	0.55	1.43	0.99	1.13
Mean	962	606	824	756	787	404	299	385	318	351	1.59	0.56	1.22	0.84	1.05
45 – SSP	991	545	836	769	785	409	269	390	356	356	1.58	0.34	1.14	0.79	0.96
45 – ELS	996	680	884	779	835	410	332	395	368	376	1.52	0.48	0.95	0.61	0.89
45 – Gypsum	1008	595	842	788	808	424	291	393	373	370	1.79	0.65	1.49	1.05	1.24
Mean	998	607	854	778	809	414	297	392	365	367	1.63	0.49	1.19	0.81	1.03
SSP	980	614	805	753	788	409	303	375	328	354	1.63	0.58	1.17	0.83	1.05
ELS	960	628	830	763	795	404	308	388	335	359	1.55	0.48	1.05	0.71	0.94
Gypsum	987	580	807	765	785	413	285	377	338	353	1.76	0.62	1.40	1.00	1.19
SEm±	29	21	22	74	-	-	-	-	-	-					
CD (P=0.05)	81	62	65	NS	-	-	-	-	-	-					

It may be concluded from the results of the study that, application of 15 kg S/ha through Gypsum or single superphosphate gave remarkably higher seed as well as oil yields with higher B:C ratio on Vertisol of Amerli and Jalgaon, and Inceptisol of Tikamgarh. However, on Alfisol of Vriddhachalam response of sulphur was not found positive, which may be due to required availability of S in soil.

References

Mandal, S., Sengupta, K., Maity, D. and Jana, P.K. 1993. Sulphur boosts the yield of summer sesamum. *Indian Farming*, **43** (5): 17-18.

Nagavani, A.V., Sumathi, V., Chandrika V. and Muneendra Babu, 2001. Effect of nitrogen, sulphur on yield and oil content of sesame (*Sesamum indicum* L.). *Journal of Oilseeds Research*, **18** (1): 73-74.

Nageshwar Lal, Sarawagi, Tripathi, R.S. and Bhambri, M.C., 1995. Effect of nitrogen, potassium and sulphur on seed yield, nutrient uptake, quality and economics of summer sesame (*Sesamum indicum* L.). *Indian Journal of Agronomy*, **40** (2): 333-335.

Sarawagi, S.K., Lal, N; Tripathi, R.S. and Purohit, K. 1995. Effect of nitrogen, potassium, sulphur on growth and yield of sesame (*Sesamum indicum* L) in summer season. *Annals of Agricultural Research*, **16**(1): 101-103.

Sharma, N. N. and Kakate, N.N. 1993. Response of summer sesame (Sesamum indicum L.) to levels of N and spacing. *Indian Journal of Agronomy*, **38**(4): 659-661.

J. Oilseeds Res., **22**(1) : 201-203 (2005)

Short communication

Studies on intercropping greengram in summer sesame, *Sesamum indicum* L.

M. Hari Krishna and A. Pratap Kumar Reddy

Department of Agronomy, S.V. Agricultural College, Tirupati-517 502, AP

(Received: September, 2003; Revised: July, 2004; Accepted: September, 2004)

Intercropping, an important feature of traditional dryland farming has been successfully employed to increase productivity per unit of land and water in semi-arid tropics (Willey, 1977). Inclusion of pulse crop in oilseed based intercropping system is considered to be economically viable to give sustained profitable production (Gangwar and Kumar, 1989; Anon., 1991). Hence, present investigation was carried out to study the effect of plant geometry and introduction of a short season greengram as an intercrop without sacrificing the base crop (summer sesame) population to obtain additional yield advantage under irrigated condition.

An experiment was conducted during summer, 1998 at Agricultural College, Wetland Farm, Tirupati in Randomized Block Design with 12 treatments which were replicated thrice (Table 1). The soil of experimental site was sandy loam, slightly alkaline in reaction, low in organic carbon and available nitrogen, medium in available P and K. Recommended dose of fertilizer of 60 kg N, 40 kg P_2O_5 and 40 kg K_2O/ha was applied through urea, single super phosphate and murate of potash, respectively. 30 kg N/ha was applied as basal and 30 kg N/ha at 25 DAS as top dress. The varieties used for sesame and greengram were Gowri and LGG 450, respectively. Recommended seed rate for sesame and greengram was 5 and 12-15 kg/ha, respectively. Pre-harvest and post-harvest observations of sesame and greengram *viz.*, plant height, leaf area index (LAI), drymatter production (DMP), capsules/plant, seeds/capsule, test weight, seed yield and stalk yield were recorded.

Sesame

Growth parameters *viz.*, plant height, drymatter production (DMP) and leaf area index (LAI) varied significantly in sesame due to different spatial arrangements (Table 1). More plant height at closer intra row spacings as reported by Ashok *et al.* (1992), were in agreement with present findings where, 100% greengram intercropped under sesame at 60 cm x 5 cm single row single skip system recorded highest plant height, drymatter production/plant due to more leaf area index and branches/plant. Plant grew taller whenever the intra-raw spacings were reduced from normal spacings of 10 cm to either 6 or 5 inspite of having wider row spacing of 60 cm. This additional growth of plant in closer intra-row spacings can be attributed to competition for light factor and the natural habit of growing in search of light.

Significantly higher number of capsules/plant, seeds/capsule, 1000 seed weight, seed yield, stalk yield and HI were recorded when sole sesame (30 cm x 6.6 cm) was planted in double row single skip arrangement. This might be due to better canopy development at this geometry, border effect and prolonged photosynthetic activity upto maturity than in other crop geometrical arrangements. These results are also in conformity with the findings of Thakur and Borulkar (1980) and Tiwari and Namdeo (1997). Inferior performance of sesame double row double skip + 100 % greengram in skip rows with respect to yield attributes may be due to competition from component crop as its critical stages of input requirement. Reduction in yield parameters observed irrespective of plant geometry in all intercropping treatments with sesame as compared to sole cropping was responsible for lower seed yields. The reduction in yield in intercropping might be due to the competition offered by greengram for nutrients, moisture and solar radiation in the vegetative phase. The seed yield also varied due to planting geometry. Intercropping of greengram at 50% population recorded higher yield than that at 100 % population because of reduced competition.

Greengram

Plant height and LAI were higher at higher plant densities. Sole greengram (T_2) and sesame double row single skip + 100% greengram in skip row (T_7) recorded taller plants due to competition for light by virtue of higher canopy growth. The yield attributes like pods/plant, seed per pod and test weight were higher at sesame single row single skip + 50% greengram single skip row (T_9), sesame double row single skip + 50% greengram in skip row (T_{10}), sesame double row double skip + 50% greengram in skip row (T_{11}) and sesame 50% population + greengram 50% population in alternate rows (T_{12}). However, the highest greengram yield was obtained at sole greengram (T_2) treatment. Sole crop of greengram in (T_2) recorded higher grain yield than intercropping. Introduction of greengram in single row single skip (T_6) and double row double skip recorded almost equal and was superior to double row single skip (T_7) at which intra row spacing was reduced (Table 2).

Sesame equivalent yield

Greengram yield when converted into sesame equivalent yields, the highest combined yield of 1062 kg/ha with sesame 100% in single row single skip + 100% greengram, followed by sesame double row single skip + 100% greengram in skip row (T_7) and sesame double row double skip + 100% greengram in skip row (T_8) which were at par (Table 3). The better combined yield with this treatment might be due to better growth and development of plants facilitated by a more suitable plant geometry with adjustments in intra row spacing without much competition for growth factors. Compared to sole crops, intercropping resulted in the highest yield advantage and land equivalent ratio (LER). The highest yield equivalent and LER in sesame + greengram (1:) intercropping system followed by sesame + greengram in 2:1 and 3:1 ratios were also reported by Anon. (1996).

Table 1 Yield attributes and yield of sesame at different crop geometries intercropped with greengram

Treatment	Plant height (cm)	No. of branches/ plant	LAI	DMP (g/plant)	Capsules/ plant	Seeds/ capsule	Test weight (g)	Seed yield (kg/ha)	Stalk yield (kg/ha)	HI (%)
T_1 Sesame (30 cm x 10 cm) sole	93	8	2.5	9.9	38	40	2.3	720	999	41.1
T_2 Greengram (30 cm x 10 cm) sole	-	-	-	-	-	-	-	-	-	-
T_3 Sesame (60 cm x 5 cm) sole single row single skip	90	9	2.6	10.8	34	36	2.2	613	924	37.9
T_4 Sesame (30 cm x 6.6 cm) sole double row single skip	93	9	3.0	11.7	40	42	2.4	769	1019	42.0
T_5 Sesame (60 cm x 5 cm) sole double row double skip	90	9	2.6	10.6	37	38	2.3	663	955	40.2
T_6 Greengram (100%) in single row single skip	103	9	3.6	15.4	32	32	2.1	430	768	35.3
T_7 Greengram (100%) in double row single skip	99	9	3.1	14.8	33	33	2.1	461	793	36.8
T_8 Greengram (100%) in double row double skip	97	9	3.1	14.1	32	31	2.0	406	755	35.3
T_9 Greengram (50%) in single row single skip	99	9	3.1	13.5	35	34	2.2	504	822	37.1
T_{10} Greengram (50%) in double row single skip	95	9	2.6	14.1	37	35	2.2	536	838	39.4
T_{11} Greengram (50%) in double row double skip	93	9	2.5	12.1	33	33	2.1	460	785	36.1
T_{12} Sesame (50%) + greengram (50%) in alternate rows	92	9	2.4	10.4	33	41	2.4	367	587	37.8
SEm±	1.22	0.0	0.17	0.17	0.44	0.41	0.04	13.4	23.1	0.3
CD (P=0.05)	3.61	0.2	0.49	0.57	1.30	1.2	0.12	39.5	68.3	1.1

Table 2 Yield attributes and yield of greengram at different crop geometries intercropped with sesame

Treatment	Plant height (cm)	LAI	DMP (g/plant)	Pods/ plant (No.)	Seeds/ pod (No.)	Test weight (g)	Seed yield (kg/ha)	Stalk yield (kg/ha)	HI (%)
T_1 Sesame (30 cm x 10 cm) sole	-	-	-	-	-	-	-	-	-
T_2 Greengram (30 cm x 10 cm) sole	41	1.0	9.4	14	6	37.8	1075	1951	35.6
T_3 Sesame (60 cm x 5 cm) sole single row single skip	-	-	-	-	-	-	-	-	-
T_4 Sesame (30 cm x 6.6 cm) sole double row single skip	-	-	-	-	-	-	-	-	-
T_5 Sesame (60 cm x 5 cm) sole double row double skip	-	-	-	-	-	-	-	-	-
T_6 Greengram (100%) in single row single skip	38	1.0	8.5	13	6	36.3	898	1817	33.0
T_7 Greengram (100%) in double row single skip	42	0.8	7.5	12	5	33.9	775	1500	34.0
T_8 Greengram (100%) in double row double skip	36	1.0	8.2	12	6	34.7	848	1800	32.0
T_9 Greengram (50%) in single row single skip	35	0.5	13.6	16	6	39.3	682	1682	28.8
T_{10} Greengram (50%) in double row single skip	39	0.4	12.9	15	6	36.8	608	1402	30.2
T_{11} Greengram (50%) in double row double skip	35	0.5	13.2	15	6	38.2	652	1673	28.0
T_{12} Sesame (50%) + greengram (50%) in alternate rows	39	0.5	13.9	16	6	37.5	703	1712	29.1
SEm±	0.7	0.01	0.18	0.23	0.08	1.22	2.2	22.3	0.30
CD (P=0.05)	1.96	0.03	0.54	0.70	0.25	3.7	67.8	73.2	0.93

Table 3 Sesame yield, greengram yield as sesame equivalent yield, total yield advantage, LER, gross returns, net returns and B:C ratio of the intercropping system

	Treatment	Sesame yield (kg/ha)	Greengram as sesame yield equivalent (kg/ha)	Sesame equivalent yield (kg/ha)	*LER*	Gross *returns* (Rs/ha)	Net *returns* (Rs/ha)	*BCR*
T_1	Sesame (30 cm x 10 cm) sole	720	-	720	1.0	12531.5	6946.5	1.02
T_2	Greengram (30 cm x 10 cm) sole	-	763	763	1.0	15905.2	10045.2	1.71
T_3	Sesame (60 cm x 5 cm) sole single row single skip	614	-	613	0.85	10709.4	5724.4	1.14
T_4	Sesame (30 cm x 6.6 cm) sole double row single skip	769	-	769	1.06	13379.0	8164.0	1.56
T_5	Sesame (60 cm x 5 cm) sole double row double skip	663	-	663	0.92	11551.7	6566.7	1.31
T_6	Greengram (100%) in single row single skip	429	634	1063	1.43	21021.3	14356.3	2.15
T_7	Greengram (100%) in double row single skip	463	547	1009	1.36	19645.8	12980.8	1.94
T_8	*Greengram (100%) in double row double skip*	406	589	1004	1.35	19994.8	13329.8	1.99
T_9	Greengram (50%) in single row single skip	504	482	985	1.33	19514.6	13369.6	2.17
T_{10}	Greengram (50%) in double row single skip	536	429	966	1.31	18771.5	12626.5	2.05
T_{11}	Greengram (50%) in double row double skip	460	460	920	1.24	18392.8	11647.8	1.89
T_{12}	Sesame (50%) + greengram (50%) in alternate rows	367	496	863	1.16	17418.3	11696.3	2.04
	SEm±	13.4	-	13.2	-	-	-	-
	CD (P=0.05)	39.5	-	40.7	0.06	-	-	-

Economic viability

The highest gross returns, net returns and B:C ratio were obtained at sesame single row single skip + 100% greengram in skip row (T_6) treatment which was proved to be the best treatment. Thus, the highest monetary advantage was obtained in intercropping compared to sole cropping and growing crop in single skip was found to be better. The skip rows can be efficiently utilized for introduction of greengram as an intercrop. These findings are in accordance with the results of Tiwari *et al.* (1994).

Thus, it can be concluded from the study, that among the crop geometries sole sesame can be successfully grown with double row single skip. While the highest yield advantage can be obtained by introducing greengram as an intercrop with 100% population than 50% population which in turn was superior to sole crop of sesame.

References

Anonymous. 1991. Intercropping of sesame and greengram in summer. Seasonal Report, RARS, Tirupati, January - June. Pp.85.

Anonymous. 1996. Oilseeds scenario in India - Strategies and potentials for maximizing production. Annual Oilseed Research Workers' Group Meeting (Sesame and Niger), pp.1-4.

Ashok, S., Jadhav, G., Chavan, V. and Ghungarde, S.R. 1992. Geometry of sesame (*Sesamum indicum*) cultivars under rainfed conditions. *Indian Journal of Agronomy*, **37**(4):857-858.

Gangwar, B. and Kumar, V. 1989. Study on sesame + pulse intercropping in rice fallows of Bay Islands. *Indian Journal of Agronomy*, **34**(4):421-428.

Thakur, B.D. and Borulkar, D.N. 1980. Effect of spacing and nitrogen levels on growth, yield and quality of different varieties of sesame (*Sesamum indicum* L.). *Oilseeds Journal*, **10**:85-87.

Tiwari, K.P. and Namdeo, K.N. 1997. Response of sesame (*Sesamum indicum*) to planting geometry and nitrogen. *Indian Journal of Agronomy*, **42**(2):365-369.

Tiwari, K.P., Namdeo, K.N., Tomar, R.K.S. and Raghu, J.S. 1994. Intercropping in sesame with soybean, greengram and kodomillet. *Indian Journal of Agronomy*, **39**(4):455-457.

Willey, R.W. 1977. Some priorities problems and possible approaches in intercropping research paper presented at the workshop held at the Patrolina NF, Brazil, May 30-31.

J. Oilseeds Res., **22**(1) : 204-205 (2005)

Short communication

Seed yield of castor, *Ricinus communis* L. hybrids as influenced by different dates of sowing

K.S. Patel, G.N. Patel, M.K. Patel, H.C. Pathak and B.S. Patel[1]

Main Castor and Mustard Research Station, Gujarat Agricultural University, **Sardarkrushinagar-385 506, Gujarat**

(Received: August, 2002; Revised: August, 2004; Accepted: October, 2004)

Early sowing of castor crop was most efficient with regard to productivity under normal rainfall situations (Dhoble, 1990). The optimum sowing time for irrigated castor has been found to be around middle of July to middle of August under North Gujarat agro-climatic conditions (Patel *et al.*, 1991). The yielding ability of different castor hybrids may differ with respect to different dates of sowing. Therefore, an experiment was conducted to find out high yielding hybrid, optimum time of sowing and interaction effect between castor hybrids and sowing dates.

A field experiment was conducted at Main Castor-Mustard Research Station, Gujarat Agricultural University, Sardar Krishinagar during *kharif* 1998-99 and 1999-2000 on loamy sand soil. The soil of experimental plot was slightly alkaline (pH 7.9), low in available nitrogen (172 kg/ha), high in available phosphorus (45 kg/ha) and available potassium (333 kg/ha). Four dates of sowing (15th day of July, August, September and October) and three hybrids (GCH-2, GCH-4 and GCH-5) were tested in split plot design, with dates of sowing in main plot and hybrids in sub-plot, with three replications. A uniform dose of fertilizer (120 kg N and 50 kg P_2O_5/ha) was applied to all the plots. The crop was dibbled keeping 120 cm x 60 cm spacing. The entire dose of P_2O_5 was applied as basal. Nitrogen was applied in three equal splits at basal, 40 DAS and 100 DAS. Weeding was done at 30 and 45 DAS. Irrigations were applied at 15-20 days interval after cessation of monsoon. In 15th September and 15th October sowings, irrigations were applied just after sowing for better germination and establishment of the crop. The spike of the crop was harvested at physiological maturity.

The maximum temperature at sowing was 30.1, 33.7, 36.0 and 33.4°C in the year 1998-99 and 34.5, 33.8, 35.4 and 32.0°C in the year 1999-2000 and minimum temperature was 25.9, 24.5, 24.7 and 22.0 °C in the year 1998-99 and 27.3, 25.4, 25.0 and 19.9°C in the year 1999-2000 on 15th day of July, August, September and October, respectively.

Effect of dates of sowing: The number of nodes counted upto primary spikes were significantly higher in 15th August sowing compared to 15th September and 15th October sowings and was at par with 15th July sowing in 1998-99 and the values was highest during 1999-2000.

Individual year effect was significant with respect to length of primary spike and number of capsules per primary spike. Sowing done on 15th August recorded higher length of primary spike and number of capsules per primary spike. The seed yield in different years was at par in 15th July and 15th August sowing but higher than later two dates. Delayed in sowings reduced the period of maturity and number of pickings. Similar finding was reported by Baby and Reddy (1998) in rainfed situation. In March and April months, the temperature was higher which affected seed setting and male to female ratio (reduced) resulting in low seed yield in late sowing.

Response of hybrids: The data recorded on seed yield from different hybrids indicated that in individual year, castor hybrid GCH-5 recorded significantly higher seed yield during 1998-99 and 1999-2000 and was at par with GCH-4 during 1998-99. In pooled analysis, castor hybrid GCH-5 gave the significantly highest seed yield than GCH-4 and GCH-2. This may be due to longer primary spike and higher number of capsules per main spike in GCH-5 resulting higher seed yields.

Interaction effect between dates of sowing and hybrids: Significant interaction effect between dates of sowing and hybrids on seed yield (Table 2) showed that castor sown at 15th July the hybrid GCH-5 gave significantly higher seed yield than GCH-2 and GCH-4. In 15th August sowing, GCH-5 and GCH-4 were at par with each other and gave significantly higher seed yield than GCH-2. Similar trend was observed in 15th September and 15th October sowing. In different hybrids, sowing GCH-2 on 15th July gave significantly higher yield than later dates of sowing while the castor hybrid GCH-4 gave the highest yield at 15th August sowing which was at par with 15th July sowing but gave significantly higher seed yield than later dates of sowing. Hybrid GCH-5 sown on 15th July recorded higher seed yield and was at par with 15th August sowing and gave significantly higher seed yield than later dates of sowing.

[1] Associate Professor (Agronomy), C.P., College of Agriculture, Gujarat Agricultural University, Sardarkrishinagar-385 506, Gujarat.

Table 1 The yield and yield attributors of castor hybrids as influenced by different dates of sowing

Treatment	Length of primary spike (cm)			No. of capsules/ main spike			No. of nodes upto primary spike			Seed yield (kg/ha)		
	1998-99	1999-00	Pooled	1998-99	1999-00	Pooled	1998-99	1999-00	Pooled	1998-99	1999-00	Pooled
Sowing date												
15th July	21.9	50.5	36.2	59	53	56	18	16	17	2719	2326	2478
15th August	64.7	62.7	63.7	71	72	71	19	18	18	2537	2091	2314
15th September	60.0	59.7	59.9	59	64	62	16	14	15	1526	1499	1513
15th October	62.4	54.8	58.6	60	74	67	14	14	14	1218	1382	1300
SEm±	1.2	1.6	8.1	1.6	2.1	4.3	0.5	0.2	0.6	125	81	143
CD (P=0.05)	4.2	5.6	NS	5.5	7.4	NS	1.6	0.8	2.5	305	281	297
Hybrid												
GCH-2	51.3	54.6	52.9	58	59	59	16	16	16	1371	1660	1516
GCH-4	4706	53.6	50.6	53	55	54	16	15	15	2237	1644	1941
GCH-5	5709	62.6	60.3	79	84	79	18	17	17	2391	2103	2247
SEm±	1.2	1.6	0.9	1.5	1.3	2.4	0.4	0.3	0.2	73	36	30
CD (P=0.05)	3.6	5.6	2.5	4.4	4.0	14.9	1.1	0.9	0.7	155	108	131
Interaction	Sig.	NS	NS	8.7	8.0	NS	NS	NS	NS	Sig.	Sig.	Sig.
Between dates of sowing with same hybrids										310	215	293
Between hybrids at same date of sowing										395	331	363

Table 2 The seed yield of castor as influenced by interaction effect between castor hybrids and dates of sowing (pooled data of 1998-99 and 1999-2000)

Hybrid	Dates of sowing				Mean
	15th July	15th August	15th September	15th October	
GCH-2	2350	1784	1007	922	1516
GCH-4	2204	2515	1659	1385	1941
GCH-5	2878	2644	1873	1593	2247
Mean	2477	2314	1513	1300	
					CD (P=0.05)
Between dates of sowing with same hybrids					293
Between hybrids at same date of sowing					363

It can be concluded that hybrid GCH-5 can be sown at any time from 15th July to 15th October (the best for timely and late sown condition) for realizing higher yield under North-Gujarat agro-climatic condition. Hybrid GCH-4 can be preferred for sowing between 15th August to 15th October over others.

References

Baby Akula and Bapi Reddy, T. 1998. Effect of dates of sowing on yields of castor cultivars. *Journal of Oilseeds Research*, **15**(2):375-376.

Dhoble, M.V., Thet, M.R. and Kating, E.A. 1990. Productivity of some *kharif* crops as influenced by varying dates of planting under rainfed conditions. *Indian Journal of Agronomy*, **35**(2):190-198.

Patel, M.K., Fatteh, U.G. and Patel, V.J. 1991. Effect of spacing and sowing time on the yield of irrigated castor under North Gujarat conditions. *GAU Research Journal*, **17**(1):119-121.

J. Oilseeds Res., 22(1) : 206-208 (2005)

Short communication

Seeding date and irrigation effects on the productivity and oil quality of post-monsoon grown castor, *Ricinus communis* L. in Alfisols

U. Nagabhushanam and C.V. Raghavaiah[1]

Department of Agronomy, College of Agriculture, Rajendranagar, Hyderabad-500 030, AP

(Received: August, 2003; Revised: July, 2004; Accepted: September, 2004)

Globally India occupies a premier position in the area, production and productivity of castor where 7.1 lakh ha was put to castor cultivation with a production and a productivity of 8.5 lakh tonnes and 1197 kg/ha, respectively during 2001. In Andhra Pradesh castor occupies an estimated area of 3.92 lakh ha with 130.7 metric tonnes production and a productivity of 333 Kg/ha, which is very low because castor is grown in marginal and sub-marginal lands under rainfed conditions. As a consequence, cultivation of castor during *kharif* has become less remunerative. Of late, some progressive farmers and seed production agencies are raising this crop during post-monsoon (*rabi*) season under irrigated conditions reaping better yields. However, the information on some of the production technological components like optimum date of seeding and scheduling of irrigation is lacking, implying the need for generation of production technology under non-traditional season and crop growing niches in Andhra Pradesh. Hence, the present field study was conducted.

A field experiment was conducted at the research farm of the Directorate of Oilseeds Research, Hyderabad. The soil was sandy loam in texture, neutral in reaction, low in available nitrogen (208Kg/ha), medium in available phosphorus(23.6Kg/ha) and high potassium contents (313.5Kg/ha).

The experiment was laid out in Split-Plot Design with four irrigation regimes as main-plot treatments and three seeding dates as sub-plot treatments and replicated thrice (Table1). The gross and net plot size was 5.4m x 6.0m and 3.6m x 4.8m, respectively. The castor hybrid DCH-177 (Deepak) was sown at the recommended spacing of 90x60 cm as per the seeding dates. Recommended dose of fertilizer *viz.*, 80-40-30 kg/ha of N, P_2O_5, K_2O was applied. Half of the nitrogen along with the entire dose of phosphorus and potassium was applied as basal dose and 20 kg N each at 40 DAS and after first picking was top-dressed.

A common post-sowing irrigation was applied to all the experimental plots to facilitate germination and another irrigation was given 10 DAS for better establishment of seedlings. Subsequent irrigations were imposed as per the irrigation treatments. The amount of water to be discharged to each plot was measured by a parshall flume of 7.5 cm throat width. The depth of irrigation was 50mm. Need based intercultural operations and plant protection measures were taken up. The crop was harvested in 3 pickings based on the physiological maturity of the primary spikes and spikes that are formed on secondaries and tertiaries. The first, second and third pickings were done at 100-110 DAS, 130-140 DAS and 160-170 DAS, respectively. During the crop growth period, biometric observations on growth parameters such as plant height, leaf area index, and dry matter was recorded. Yield attributes such as number of spikes/plant, length of primary spike, number of capsules in primary spike, 100 seed weight and castor bean yield were recorded. Oil content was estimated by NMR technique and oil yield and harvest index were computed.

Effect of Seeding date

Growth and yield components: Seeding the crop on 15 October resulted in taller plants in comparison with that sown on 1 November and 15 November which in turn were comparable. The present findings corroborate with the reports of Raghavaiah and Sudhakar Babu (2000) and Sreedhar Chauhan (2001). The crop sown on 15 October offered higher dry matter at harvest (2.7t/ha)which decreased with delayed sowing in November (2.3t/ha).

There was enhancement in number of spikes per plant due to 15 October sowing by 17 and 40 percent., number of capsules per primary spike by 26 and 82 percent, and test weight of seed in comparison with late sowings on 1[st] November and 15[th] November . Sudharani (2001) also made similar observations.

Castor bean yield: Seeding on 15 October offered substantially greater castor bean yield over the later dates. Almost similar trend was noticed with respect to yields from primary, secondary and tertiary order spikes. The percent increase in castor bean yield with 15 October

[1] Principal Scientist (Agronomy), Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, AP.

seeding over 1 November and 15 November sowing was 28 and 99, respectively. Synergistic effect of temperature, relative humidity and less evaporation coupled with rainfall and optimum sunshine hours during 15 October sowing have contributed to better growth and development, ultimately culminating in enhanced bean yield. Delayed seeding provided lower yield due to poor synchronization of flowering or capsule development with lower temperatures in December and January coupled with relative increase in evaporation which might have effected fertilization and seed set adversely. Diminution of bean yield with delayed sowings under Hyderabad climatic conditions was reported by Raghavaiah and Sudhakara Babu (2000) and Sreedhar Chauhan (2001). Akin to seed yield, the percent increment in harvest index due to 15 October sowing was 8.2 and 36.6 over that of 1 November and 15 November sowings, respectively.

Oil content and oil yield: In oilseeds, the synthesis of oil in the seeds is governed by genetic makeup of a genotype and is not usually altered by environmental conditions. However, seeding the crop on 15 October induced significantly higher oil content in seeds to the tune of 9.6% as compared to that sown on 15 November . This observation is in variance with that of Sreedhar Chauhan (2001). The decline in oil content in seeds with late sowing could be due to high temperatures prevailing at the time of seed filling and forced maturity of the crop. The oil yield registered a significant decline with every successive delay in seeding date beyond 15 October. As there was decline in castor bean yield as also oil content with delay in sowing, it has resulted in a concomitant diminution in oil yield. Reduction in oil yield with delayed sowing in *rabi* season was also reported by Sreedhar Chauhan (2001).

Effect of Irrigation regimes

Growth: Scheduling irrigation to the crop at 0.8 IW/CPE registered 32.7, 25.5 and 24.5% increase in plant height over 0.4, 0.6 IW/CPE ratios and irrigation at 15 days interval, respectively. Increase in plant height with soil wetness was also reported by Sudhakar and Praveen Rao (1998). Irrigation at 0.8 IW/CPE being comparable with farmers practice exhibited greater assimilatory efficiency vis-à-vis irrigation at 0.4 and 0.6 IW/CPE ratios at all the stages of crop growth. The percent enhancement in LAI with 0.8 IW/CPE over 0.4 and 0.6 IW/CPE ratios was to the level of 75.2 and 32.9, respectively. In the present context, as the wet regimes (0.8 IW/CPE) could maintain higher LAI than dry regimes (0.4, 0.6 IW/CPE), their assimilatory efficiency could have been great resulting in better branching and biomass production. The observations of Sudhakar and Praveen Rao (1998) and Sudha Rani (2001) lend support to these findings. The dry matter at harvest with 0.8 IW/CPE was greater by 32, 20 and 15% over 0.4 and 0.6 IW/CPE ratios and irrigation at 15 days interval, respectively. Decrease in dry matter due to moisture stress was reported by Kudinova (1973), and enhanced biomass with ample moisture supply was reported by Sudhakar and Praveen Rao (1998).

Yield components: The wet regime of 0.8 IW/CPE produced 38.7, 29.3 and 7.1% more spikes than 0.4, 0.6 IW/CPE ratios and irrigation at 15 days interval, respectively. Firake *et al.* (1998) also made similar observation. Provision of supplemental irrigation at 0.8 IW/CPE induced the crop to bear 78.8 percent more number of capsules in primary spike as compared to 0.4 IW/CPE which produced least number of capsules in primary spike.

Castor bean yield: Irrigation applied based on climatological approach at 0.8 IW/CPE out yielded those at 0.4, 0.6 IW/CPE ratios and farmers practice of irrigation at 15 days interval to a tune of 70.7, 55.8 and 51.7%, respectively. Akin to the total productivity, the yield obtained from different spike orders too followed similar trend in relation to irrigation regimes.

Although the farmers practice of irrigation at 15 days interval received almost similar quantity of water as that of 0.8 IW/CPE, the yield obtained was distinctly less than that of the later. This could probably be due to non-synchronization of water supply with the physiological demands of crop growth and development, unlike the 0.8 IW/CPE, which was based on climatological approach where the crop received water in consonance with the physiological demands. The beneficial effects of irrigation based on climatological approach were also reported by Sudhakar and Praveen Rao (1998). Irrigation at 20-day interval was reported to give higher castor yield (Ishwar Singh and Ganapath Singh, 1992) and increase in yield due to irrigation was reported by Vijaya Kumar and Shiv Shankar (1992).

Interaction effect between seeding date and irrigation regime indicated that seeding on 15 October with irrigation at 0.8 IW/CPE offered discernible increase in seed yield (3125 kg/ha) over the rest of the combinations. (Table 2).

Oil content and oil yield: Application of irrigation water did not induce perceptible variation in oil content of castor (47.5 to 49.3%). The findings of Firake *et al.* (1998) corroborate with our observations. Unlike the oil content, irrigating the crop at 0.8 IW/CPE ratio recorded significantly higher oil yield(1116Kg/ha.) in comparison with drier regimes of 0.4, 0.6 IW/CPE ratios and irrigation at 15 days interval. Seedling on 15 October and irrigation at 0.8 IW/CPE produced the highest oil yield.

Table 1 Growth parameters, yield components, castor bean yield (kg/ha), harvest index (%) and oil content as influenced by seeding time and irrigation regimes in *rabi* (post-monsoon) season

Treatment	Plant height (cm)	LAI at 90 DAS	Drymatter (kg/ha) at harvest	No. of capsules/ primary spike	100 seed weight (g)	Spikes/ plant	Primary spike length (cm)	Castor bean yield (kg/ha)	Harvest index (%)	Oil content (%)	Oil yield (kg/ha)
Seeding dates											
October 15	41.5	1.36	2728	58	35.4	5	41	2115	42.8	50.2	1067
November 1	36.7	1.25	2464	46	33.9	4	38	1651	39.6	49.1	811
November 15	33.3	0.90	2317	32	32.2	3	34	1063	31.4	45.8	492
SEm±	1.7	0.07	73.7	1.4	0.7	0.2	1.8	83.6	1.37	0.9	42.6
CD (P=0.05)	5.3	0.20	220.9	4.2	2.1	0.5	5.4	250.8	4.10	2.7	127.8
Irrigation regimes											
Irrigation at 15 days interval	35.6	1.42	2520	49	34.7	5	40	1469	35.9	47.8	717
Irrigation at IW/CPE 0.4	33.4	0.81	2188	32	32.8	3	32	1309	36.9	47.6	628
Irrigation at IW/CPE 0.6	35.3	1.06	2412	42	33.0	4	34	1431	36.6	48.7	698
Irrigation at IW/CPE 0.8	44.3	1.40	2892	58	35.0	5	45	2230	42.0	49.4	1116
SEm±	2.1	0.07	83.0	2.4	0.3	0.2	3.6	107.7	1.94	1.1	56.6
CD (P=0.05)	7.2	0.24	287.3	8.5	1.3	0.7	NS	372.7	NS	NS	196.1
Seeding date x Irrigation regime (CD (P=0.05)	NS	NS	NS	Sig.	NS	NS	NS	Sig.	NS	NS	Sig.

Table 2 Interaction between irrigation regimes and seeding dates on castor bean yield (kg/ha) in *rabi* (post-monsoon) season

Seeding date / Irrigation regime	October 15	November 1	November 15
Irrigation at 15 days interval	1895	1458	1055
Irrigation at IW/CPE 0.4	1633	1340	953
Irrigation at IW/CPE 0.6	1806	1474	1013
Irrigation at IW/CPE 0.8	3125	2332	1234
		SEm±	CD (P=0.05)
Sowing date at same level of irrigation		167.2	501.3
Irrigation regime at same or different sowing date		173.9	552.2

From the foregoing ,it can be inferred that seeding on 15 October resulted in distinctly superior growth parameters; yield attributes, bean yield, oil content and oil yield than delayed sowing on 1 November and 15 November. There was a favourable interaction of seeding date and irrigation regimes on number of capsules per primary spike, castor bean yield from secondary spike order, total bean yield and oil yield of castor. Scheduling irrigation at 0.8 IW/CPE ratio (wet regime) resulted in significantly higher castor bean yield over irrigation at 15 days interval and irrigation at 0.4 and 0.6 IW/CPE ratios (dry regime). Similar trend was also noticed in growth parameters and yield attributes. Oil content was not significantly influenced by irrigation regimes; while early seeding on 15 October distinctly improved oil content over delayed sowings in November.

Acknowledgement: The authors thank Dr. D.M. Hegde, Project Director, DOR for providing field facilities.

References

Firake, N.N., Shinde, S.H and Magar, S.S. 1998. Drip irrigation scheduling for castor in sandy clay loam. *Journal of Maharashtra Agricultural Universities*, **23**(3): 280-282.

Ishwar Singh and Ganpat Singh. 1992. Schedule of irrigation for Aruna castor. *Indian Journal of Agricultural Sciences*, **62**(9): 614-615.

Kudinova, I.M. 1973. Effect of drought, trace elements and Phosphorous on some physiological processes in castor. *Referativny Zhurnal*, **2**:555-644.

Raghavaiah, C.V. and Sudhakara Babu, S.N. 2000. Effect of seeding date, female : male row proportion and nitrogen on certified seed production of GCH-4 (VP-1x 48-1) castor hybrid. *Journal of Oilseeds Research*, **17** (1):100-106.

Sreedhar Chauhan. 2001. Influence of seeding time on castor genotypes under *irrigated conditions. M.Sc. (Ag) thesis* submitted to Acharya N.G. Ranga Agricultural University, Hyderabad.

Sudhakar, C. and Praveen Rao, V. 1998. Water use and yield response of pigeonpea, castor, wheat and soybean under different irrigation schedules. *Journal of Research, Acharya N.G. Ranga Agricultural University*, **26** (1): 1-8.

Vijaya Kumar, B. and Shiva Shankar, M. 1992. Response of castor varieties to irrigation, nitrogen and plant density. *Journal of Research, Acharya N.G. Ranga Agricultural University*, **20** (1): 25-26.

J. Oilseeds Res., 22(1) : 209-210 (2005)

Short communication

Nitrogen requirement of *rabi* castor, *Ricinus communis* L. under different crop sequences

K.S. Patel, G.N. Patel, M.K. Patel, H.C. Pathak and J.K. Patel

Main Castor and Mustard Research Station, Gujarat Agricultural University, Sardarkrushinagar-385 506, Gujarat

(Received: November, 2003; Revised: September, 2004; Accepted: September, 2004)

Castor is one of the important non-edible oilseed and industrial crops of India and has prestigious place in Indian sub-continent from time immemorial. In Gujarat and Rajasthan castor is grown under irrigated conditions whereas in Andhra Pradesh, Karnataka and Tamil Nadu it is grown under rainfed conditions. It is mostly grown in *kharif* under fallow-castor crop sequence. The productivity of castor, following *kharif* short duration crop is lower. However, it can be enhanced through suitable agronomic practices. Among the various agronomic practices, application of nitrogen plays an important role in improving the yield levels. Further, the nutrient requirements of castor in fallow-castor is entirely different from that grown after *kharif* crops. The information available on nutrient requirement of castor in sequential system is meager. Hence, in the present study, an attempt has been made to assess the effect of different levels of N on growth and yield of *rabi* castor following *kharif* crops.

A field experiment was conducted during *kharif* and *rabi* season of 1998-99 to 2000-01 at Main Castor-Mustard Research Station, Gujarat Agricultural University, Sardarkrushinagar. The soil of the experimental plot was sandy loam, alkaline (pH 8.0), and low in available nitrogen (172 kg/ha), medium in available phosphorus (35 to 51 kg/ha) and high in available potassium (333 kg/ha). The experiment was laid out in Split Plot Design with 3 replications. The main plots consisted of 4 crop sequences, *viz.*, fodder sorghum-castor, green manure-castor, greengram-castor and fallow-castor and sub-plots comprised of 4 levels of nitrogen application to *rabi* castor (0, 40, 80 and 120 kg/ha). In N_2, 40 kg N/ha was applied as basal; in N_3 out of 80 kg N/ha, 40 kg N/ha was applied as basal whereas 40 kg N/ha at 40 DAS and in N_4 (120 kg N/ha), nitrogen was applied in three splits 40 kg each as basal, 40 and 75 DAS. A common dose of 50 kg P_2O_5/ha was applied to castor at the time of sowing. Plot size was 6.0 m x 4.5 m. Sorghum fodder (GSF-4), sunhemp (local), as green manure and greengram (K 851) crops were raised in 1st week of July under rainfed conditions and castor (GCH-5) in *rabi* season (1st week of October) was raised as irrigated crop following recommended package of practices. The greengram and fodder sorghum were raised with 20-40 and 80-40, N and P_2O_5 kg/ha, respectively. Whereas sunhemp was raised without application of any fertilizer. The sunhemp was incorporated into the soil at the time of flowering. The analysis of nutrient content (%) of sunhemp as green manure are N-1.76, P-0.20, K-1.66, Zn-0.005 and Fe-0.05 and added N-87, P-10, K-83, Zn-0.25 and Fe-2.50 kg/ha. The *kharif* crops received 621,143 and 400 mm rains in 18, 8 and 13 rainy days during the years of 1998, 1999 and 2000, respectively. Treatments were evaluated in terms of growth and yield attributes characters; quality parameters, seed yield, castor equivalent yield and economics.

Performance of crop in crop sequence: Significantly the highest seed yield of *rabi* castor was obtained in green manure-castor sequence, recording 19.6, 21.4 and 45.2 % increase over fallow-castor, sorghum (fodder)-castor and greengram-castor sequences, respectively (Table 1). Bheemaiah *et al.* (1994) reported similar results. Crop sequence, green manure-castor gave significantly higher seed yields than other sequences mainly due to significant superiority in growth parameters *viz.*, plant height and branches/plant and yield attributes *viz.*, primary spike length and capsules/main spike. Bheemaiah *et al.* (1998) also reported similar findings. Crop sequences fallow-castor, fodder sorghum-castor and greengram-castor were similar in their performance.

Effect of nitrogen: Length of primary spike, number of capsules/primary spike and number of branches/plant were significantly superior with application of 80 and 120 kg N/ha over 40 kg N/ha and control. Application of 80 and 120 kg N/ha did not show any significant variation in seed yields. Application of 80 or 120 kg N/ha recorded significantly higher seed yields over that of 40 kg N/ha and control. Further, significant lower seed yield was recorded in control as compared to 40 kg N/ha (Table 1). These findings are in agreement with the findings of Paida and Parmar (1980), Wali *et al.* (1991) and Mathukiya and Modhawadia (1992). The nitrogen application at flower initiation in third split might not have been utilized by the crop for seed development. Thus, effective utilization of only 80 kg N/ha in two splits, basal and at 40 Das was observed. Plant height also increased significantly by successive increments of N up to 80 kg/ha beyond which no further significant increase was observed. Yield attributing characters *viz.*, length of primary spike, number of capsules/primary spike and number of branches/plant were at their maximum with application of 80 kg N/ha (Table 1).

Castor equivalent yield: Castor sown in *rabi* after greengram or fodder sorghum or green manure gave significantly higher castor equivalent yields than fallow-castor (Table 1). Significantly, lower castor equivalent yield was recorded in fallow-castor (control) sequence as compared to *all* other crop sequences. Application of 80 or 120 kg N/ha did not show any significant variation in castor equivalent yield. Application of 80 or 120 kg N/ha recorded significantly higher castor equivalent yield over that of 40 kg N/ha and control. Further, significantly lower equivalent yield was recorded in control as compared to 40 kg N/ha.

Table 1 Seed yield and yield attributing characters of castor as influenced by different crop sequences and levels of nitrogen

Treatment	Plant height (cm)	Primary spike length (cm)	Capsules/ primary spike	Branches /plant	*Rabi* castor yield (kg/ha)				Castor equivalent yield (kg/ha)	Net returns (Rs/ha)	B:C ratio
					1998	1999	2000	Pooled			
Crop sequence											
S_1-Fodder sorghum-castor	48	51	43	5	1648	1503	2192	1781	2294	11080	1.78
S_2-*Green manure-castor*	*55*	*57*	*53*	*6*	*1898*	*2011*	*2576*	*2162*	*2162*	*11980*	*2.02*
S_3-Greengram-castor	45	49	44	4	1425	1387	1655	1489	2424	12146	1.83
S_4-Fallow-castor	49	53	48	6	1522	1491	2410	1808	1807	10775	2.18
SEm±	1.3	2.8	1.1	0.2	85	50	136	95	98		
CD (P=0.05)	4.3	9.2	3.8	0.8	294	172	470	327	341		
N levels of *rabi* castor (kg/ha)											
N_1 - 00	41	41	40	4	1340	918	1800	1353	1714	7562	1.67
N_2 - 40	50	54	47	5	1634	1462	2142	1746	2107	10785	1.87
N_3 - 80	55	59	52	6	1798	2102	2438	2113	2474	14452	2.13
N_4 - 120	55	56	48	6	1722	1910	2453	2028	2390	13159	2.00
SEm±	1.5	1.4	1.2	0.2	47	29	98	100	100		
CD (P=0.05)	4.4	4.1	3.5	0.5	137	84	285	345	345		
S x N interaction CD (P=0.05)	NS	NS	5.8	NS	NS	451	NS	NS	NS		

The highest net monetary returns with B:C ratio of 1:1.83 was obtained in greengram-castor crop sequence followed by green manure-castor with B:C ratio of 1:2.02. Among the N levels, a progressive increase in yield, net returns and benefit cost ratio was observed with the increasing levels of nitrogen upto 80 kg/ha. The maximum net returns and benefit cost ratio of 2.13 was obtained with the application of 80 kg N/ha.

Interaction effect of crop sequences and nitrogen levels were found to be non-significant in pooled analysis however, it was significant in the year 1999-2000. It can be concluded that the farmers of North Gujarat agro-climatic zone growing *rabi* castor after short duration *kharif* crops (greengram or fodder sorghum) are advised to fertilize the *rabi* castor crop with kg N/ha to obtain higher castor equivalent yield and higher monetary return.

References

Bheemaiah, G., Madhusudan, T., Subrahmanyam, M.V.R. and Ismail, Syed. 1998. Effect of green leaf manuring and nitrogen application on growth and yield of x rainfed castor (*Ricinus communis* L.) alley cropped with white popinac (*Leucaena leucocephala*). *Indian Journal of Agricultural Sciences*, **68**(11) : 722-725.

Bheemaiah, G., Subrahmanyam, M.V.R. and Ismail, Syed. 1994. Studies on compatibility of oilseed crops intercropped with *Faidherbia albida* under different alley widths in drylands. *Journal of Oilseeds Research*, **11**(1) : 94-98.

Mathukiya, R.K. and Modhawadiya, M.M. 1992. Response of castor (*Ricinus communis* L.) to nitrogen and phosphorus. *Indian Journal of Agronomy*, **38(10)**: 152.

Paida, V.J. and Parmar, M.T. 1980. A note on effect of different levels of nitrogen and phosphorus on yield and yield attributes of castor. *Gujarat Agricultural University Research Journal*, **5**(2):48-51.

Wali, B.M., Palled, Y.B., Kalaghatagi, S.B., Babalad, H.B. and Megeri, S.N. 1991. Response of castor genotypes to irrigation and nitrogen. *Journal of Maharashtra Agricultural Universities*, **16**(2):262-263.

J. Oilseeds Res., **22**(1) : 211-212 (2005)

Short communication

Optimization of production technology of safflower, *Carthamus tinctorius* L. under resource constraints

O.R. Misra, S.L. Deshpande, A.M. Rajput, A.K. Sharma, K.K. Tripathi and K.K. Saxena

Jawaharlal Nehru Krishi Vishwa Vidyalaya, College of Agriculture, Indore-452 001, MP

(Received: February, 2000; Revised: August, 2004; Accepted: October, 2004)

Safflower (*Carthamus tinctorius* L.) is an important crop for dryland agriculture. Safflower is extensively grown in *Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu.* Constraints of growth and yield of safflower keeping factors in view the study of "Optimization of production technology under resource constraints" was under taken and highest cost benefit *ratio (1:3.95) was obtained from* full package of practices adopted for safflower.

Safflower is an important oilseed crop for dryland agriculture, but has low productivity. Hence, efforts are to be made to boost up the yield/ha of safflower. There are many constraints of growth and yield of safflower. There was response of safflower to nitrogen and phosphorus under rainfed conditions (Ahmad *et al.*, 1985). Infestation/damage by weeds should be checked in the early stages of crop growth (Bailly, 1997). Among various constraints heavy infestation of aphids plays significant *role in reducing the yield of safflower (Dhoble et al., 1985).* Very little work has been done to evaluate the management practices for getting higher yield of safflower and determining the constraints of safflower production in Madhya Pradesh. The present investigation was carried out to assess the effect of different constraints on growth and yield of safflower and to quantify the economics of different treatments under study.

A field experiment was carried out during *rabi* season of 1998-99 at Jawaharlal Nehru Krishi Vishwa Vidyalaya, College of Agriculture, Indore to assess the performance of T_1 *(full package of practices) with* T_2 *(T_1 - fertilizers)*, T_3 (T_1 - thinning), T_4 (T_1 - plant protection), T_5 (T_1 - weed control), T_6 (T_1 - fertilizers + plant protection), T_7 (T_1 - weed control + thinning), T_8 (T_1 - weed control + fertilizers + plant protection + thinning). The soil of the experimental field was clay in texture (53.6% clay, 36% silt and 10.4% sand), low in available N and P_2O_5 (108 and 8 kg/ha) and high in K (600 kg/ha). The pH and electrical conductivity of the soil was 7.6 and 0.4 dS/m respectively. The experiment was laid out in Randomized Block Design having three replications. Variety used was JSF-1, sown at row to row distance of 45 cm and plant to plant distance of 20 cm.

Table 1 Yield, yield trials and economics of different treatments in safflower

Treatment	Mean No. of capitula/ plant	Mean No. of seeds/ capitulum	Weight of seeds/ capitulum (g)	Seed yield/ha (kg)	Biological yield/ha (kg)	Gross return (Rs/ha)	Net return (Rs/ha)	Cost benefit ratio
T_1 : Full package	21	53	3.6	1898	13154	17087	12765	1:3.94
T_2 : T_1 - fertilizer	18	43	2.9	1271	11076	11435	7885	1:3.22
T_3 : T_1 - thinning	16	45	3.0	1447	13695	13022	8988	1:3.22
T_4 : T_1 - plant protection	19	45	3.1	1295	11079	11652	7893	1:3.04
T_5 : T_1 - weed control	18	50	3.5	1463	13081	13174	9127	1:3.25
T_6 : T_1 - fertilizer + plant protection	17	42	2.9	909	11479	8174	5124	1:2.68
T_7 : T_1 - weed control + thinning	15	42	2.9	1415	14700	12739	8880	1:3.30
T_8 : T_1 - weed control + fertilizer + plant protection + thinning	15	40	2.9	1040	14699	9360	6420	1:3.18
CD (P=0.05)	2.94	7.6	0.52	429.8	1191.68	3868.2	-	-

Yield contributing characters *viz.*, mean number of capitula per plant, number of seeds per capitulum, weight of seeds per capitulum were numerically highest under T_1 (full package of practices without any constraints). Highest seed yield of safflower (1898 kg/ha) was recorded under T_1 (full package of practices), which was 100% higher than treatment T_6 having the constraints of fertilizers and plant protection. This might be due to the fact T_1 (full package of practices) increased the yield contributing characters *viz.*, number of capitula/plant, number of seeds/capitulum, seed weight/capitulum and ultimately the seed yield/hectare. These findings corroborate the findings reported by Bhilegaonkar *et al.* (1998) and Dhambare (1998).

Highest profit of Rs.12765/ha was obtained from full package of practices, which was 149% higher than T_6. Likewise highest cost benefit ratio (1:3.95) was found under full package of practices. This might be due to the reason that both the constraints *viz.*, fertilizers and plant protection affected the growth and development of crop adversely, which ultimately resulted into reduced seed yield per hectare. These findings are similar to the results obtained by Dange *et al.* (1996) and Bailly (1997).

References

Ahmad, A.S.S., Modekhar and Mohammed, S. 1985. Response of safflower to nitrogen and phosphorus. *Indian Journal Agronomy*, **30**(1): 126-130.

Bailly, M.E., 1993. Integrated weed management in oilseed crops in India. Integrated weed management for sustainable agriculture. Proceedings of Indian Society of Weed Science. International Symposium, Hisar, India, 18-20 Nov., 1993, Vol. I, 317-323.

Bhilegaonkar, M.W., Ekshinge, B.S. and Karle, B.G.,1995. Effect of phosphorus, sulphur and boron levels on dry matter and grain yield of safflower. *Journal of Maharashtra Agricultural Universities*, **20**(1):132.

Dange, N.M., Suryawanshi, D.S. and Tanwar, P.R., 1996. Efficiency of insecticide against safflower aphids. *Journal of Maharashtra Agricultural Universities*, **21**(1): 149-150.

Dhambare, A.J.,1998. Evaluation of safflower entries and insecticides against safflower aphids. *Journal of Maharashtra Agricultural Universities*, **23**(2): 190-192.

Dhoble, S.Y., Jagdal, G.B. and Deokar, A.B., 1985. insecticidal control of safflower aphids with dust application. *Pesticides*, **19**(5):53-54.

J. Oilseeds Res., **22**(1) : 213-214 (2005)

Short communication

Studies on N and P fertilization of niger, *Guizotia abyssinica* (L.f.) Cass in Satpura Plateau Zone of Madhya Pradesh

N.S. Thakur, M.R. Deshmukh and R.S. Sharma

Zonal Agricultural Research Station, Chhindwara-480 001, Madhya Pradesh

(Received: December, 2003; Revised: September, 2004; Accepted: October, 2004)

Niger [*Guizotia abyssinica* (L.f.) Cass] is most important oilseed crop grown by resource poor farmers in tribal belt of Satpura Plateau Zone of Madhya Pradesh. Mostly it is grown without or with a little quantity of fertilizers in marginal lands of hill tops with a low productivity of 165 kg/ha (Sharma and Kewat, 1998). But it is responsive to application of N and P fertilizers depending on the agro-climatic conditions. Such information is meager for this zone and hence, the present investigations have been carried out to find out the effect of N and P fertilization on the productivity of niger.

Field experiments were carried out on niger cv. Ootacmund, M.P., in sandy loam soil of Chhindwara during 1999-2000 to 2001-2002. The soil of the experimental field was alkaline in reaction (pH 8.1) with shallow depth analyzing low in available N (220 kg/ha) and P (8.1 kg/ha) and high in available K (520 kg/ha) contents. The rainfall was 1379, 610 and 579 mm during the crop season in three consecutive years. Twelve treatments (Table 1) consisting of 20 and 40 kg N/ha with 20 and 40 kg P_2O_5 all along with PSB and sources P as single super phosphate (SSP) and Diammonium phosphate (DAP) were tested in Randomized Block Design with three replications. Sowing was done in rows 30 cm apart on July 15,27 and 29 in 1999, 2000 and 2001, respectively. Nitrogen (N) fertilizer was given as urea, while P through single super phosphate and DAP. All N and P fertilizers as per treatments were given as basal along with phosphorus solubilizing bacteria (PSB). Data on plant population, plant height, branches/plant, capitulum/plant, test weight, harvest index, seed yield/ha were recorded. Mean data of three years were used for interpretation of the results.

Based on three years mean data, increasing levels of N or N and P combination significantly increased the plant height, branches/plant and capitulae/plant but harvest index, however, 1000-seed weight did not differ due to various treatments (Table 1). All treated plots showed superiority in these parameters over untreated control (T_1). Significant increase in seed yield with 40 kg N/ha + PSB (503 kg/ha) over 20 kg N/ha (455 kg/ha) indicated the response of niger up to 40 kg N/ha confirming the views of Deshmukh *et al.* (2002a).

Table 1 Yield attributes of niger under varying N and P levels (Mean data of 3 years, 1999 to 2001)

Treatment		Plant height (cm)	Branches/ plant	Capitulum/ plant	100 seed weight (g)	Harvest index (%)
T_1 :	Control	82	8	30.9	4.7	10.2
T_2 :	20 kg N/ha	91	9	36.2	4.9	9.7
T_3 :	20 kg N/ha + PSB	93	9	38.0	5.0	9.6
T_4 :	20 kg N + 20 kg P_2O_5 (DAP)/ha	94	9	39.8	5.2	9.6
T_5 :	20 kg N + 20 kg P_2O_5 (SSP)/ha	94	10	40.3	5.2	9.1
T_6 :	20 kg N + 20 kg P_2O_5 (DAP/ha+PSB	95	10	42.9	5.3	9.7
T_7 :	20 kg N + 20 kg P_2O_5 (SSP/ha+PSB	96	10	44.3	5.4	9.7
T_8 :	40 kg N/ha + PSB	98	9	44.0	5.4	9.0
T_9 :	40 kg N + 20 kg P_2O_5 (DAP/ha+PSB	98	10	48.1	5.5	9.4
T_{10} :	40 kg N + 20 kg P_2O_5 (SSP)/ha	101	11	49.3	5.6	9.7
T_{11} :	40 kg N + 40 kg P_2O_5 (DAP/ha+PSB	104	10	51.6	5.7	9.5
T_{12} :	40 kg N + 40 kg P_2O_5 (SSP/ha+PSB	103	11	54.0	5.9	9.6
	CD (P=0.05)	7.7	1.2	6.2	0.6	NS

The seed yield was slightly lesser with 20 kg N/ha than 20 kg N/ha + PSB, which indicated that inoculation of PSB in conjunction with N fertilizer further improved the efficiency of N fertilizer due to enhanced availability of native P. Beneficial effect of PSB on fertilizer use efficiency has also been reported by Deshmukh *et al.* (2002b). Seed yield was maximum with 40 kg N + 40 kg P_2O_5 (SSP)/ha + PSB which was comparable to 40 kg + 20 kg P_2O_5 (SSP)/ha + PSB, 40 kg N + 40 kg P_2O_5 (DAP)/ha + PSB and 40 kg N + 20 kg P_2O_5 (DAP)./ha+PSB. All combination of higher dose of N and P (40 kg/ha each) produced significantly more seed yields than their combination with lower doses (Table 2). Efficiency of P was numerically more when it was applied through SSP compared to DAP at both higher and lower levels of P application. Oil content did not deviate much due to different treatments, thus oil yields followed the same trend to seed yields under various treatments.

Economics : Application of 20 kg N/ha gave higher net monetary returns than control emphasizing the monetary advantage of N application to niger crop. Application of 40 kg N + 40 kg P_2O_5 (SSP)ha + PSB accrued net returns closely followed by (40 kg N + 20 kg P_2O_5 (SSP) +PSB, 40 kg N + 40 kg P_2O_5 (DAP)/ha + PSB, 40 kg N + 20 kg P_2O_5 (DAP)/ha + PSB and 20 kg N + 20 kg P_2O_5 (SSP)/ha + PSB. Application of 40 kg N/ha + PSB led to register lesser net monetary returns than above mentioned treatments including where lesser N was applied with P (Table 2), which indicated that application of P was quite remunerative to this crop. The superiority of (T_3) over (T_2) indicated the advantage of PSB. Treatments T_5, T_7, T_{10} and T_{12} receiving P by SSP were more remunerative than T_4, T_6, T_9 and T_{11}, respectively receiving P through DAP at the same levels was indicative for the higher P use efficiency through SSP. These results are in close conformity with the finding of Mishra *et al.* (1999).

Table 2 Seed yield and net monetary returns (NMR) of niger under varying N and P levels

Treatment	Seed yield (kg/ha)				NMR (Rs./ha)	Oil content (%)	Oil yield (kg/ha)
	1999	2000	2001	Mean			
T_1 : Control	395	345	436	392	2490	46.1	180
T_2 : 20 kg N/ha	465	385	515	455	3058	46.3	211
T_3 : 20 kg N/ha + PSB	480	410	538	476	3073	46.4	221
T_4 : 20 kg N + 20 kg P_2O_5 (DAP)/ha	501	427	466	498	3135	46.2	230
T_5 : 20 kg N + 20 kg P_2O_5 (SSP)/ha	490	435	546	490	3094	46.3	227
T_6 : 20 kg N + 20 kg P_2O_5 (DAP/ha+PSB	503	445	562	503	3104	46.1	232
T_7 : 20 kg N + 20 kg P_2O_5 (SSP/ha+PSB	540	466	587	531	3479	46.2	245
T_8 : 40 kg N/ha + PSB	513	440	556	503	3219	46.3	233
T_9 : 40 kg N + 20 kg P_2O_5 (DAP/ha+PSB	560	485	620	555	3571	46.4	258
T_{10} : 40 kg N + 20 kg P_2O_5 (SSP)/ha	590	524	645	586	3990	46.3	271
T_{11} : 40 kg N + 40 kg P_2O_5 (DAP/ha+PSB	590	510	640	580	3586	46.3	269
T_{12} : 40 kg N + 40 kg P_2O_5 (SSP/ha+PSB	620	544	670	611	4010	46.2	282
CD (P=0.05)	61	46	62	56	450	-	-

References

Deshmukh, M.R., Jain, H.C., Duhoon, S.S. and Goswami, U. 2002a. Performance of niger [*Guizotia abyssinica* (L.f.) Cass] influenced by inorganic fertilizers, FYM and biofertilizers in different soil types. *Journal of Oilseeds Research*, **19** (1) : 79-81.

Deshmukh, M.R., Jain, H.C., Duhoon, S.S. and Goswami, U. 2002b. Integrated nutrient management in sesame (*Sesamum indicum* L.) for Kymore Plateau Zone of Madhya Pradesh. *Journal of Oilseeds Research*, **19 (1)** : 73-75.

Mishra, P.J., Haldar, J. and Panda, S. 1999. Efficiency of different sources of phosphatic fertilizer and FYM in niger under red acidic soils. *Environment and Ecology*, **17** (3): 754-756.

Sharma, R.S. and Kewat, M.L. 1998. Niger does well under farming situation constraints. *Indian Farming*, **47**:(11) : 15-16.

J. Oilseeds Res., **22**(1) : 215-217 (2005)

Short communication

Mechanism of transmission of tobacco streak virus by *Scirtothrips dorsalis*, *Frankliniella schultzei* and *Megalurothrips usitatus* in groundnut, *Arachis hypogaea* L.

Sonali Shukla, G. Kalyani, N. Kulkarni, F. Waliyar and S.N. Nigam

International Crops Research Institute for The Semi-Arid Tropics (ICRISAT), Patancheru-502 324, AP

(Received: August, 2004; Revised: December, 2004; Accepted: January, 2005)

Peanut stem necrosis disease (PSND) was first reported in groundnut in the 2000 rainy season in Anantapur district of Andhra Pradesh. The disease affected nearly 225,000 ha and the crop losses were estimated to exceed Rs. 3 billion (Reddy *et al.*, 2002). Tobacco streak virus (TSV) was identified as the causal agent of PSND. The pollen-assisted TSV transmission process has been studied in detail in other host plants, *Nicotiana clevelandii, Chenopodium amaranticolor, Lycopersicon esculentum* and *Cucumis sativus* by Sdoodee and Teakle, 1987 and Greber *et al.*, 1991. The TSV transmission occurs when thrips carrying pollen from TSV infected plants on their bodies, land on host-plants and cause them to dislodge on leaves and while feeding on host plants wound both leaf tissue and infected pollen to facilitate virus infection of the plants. After identification of the causal agent of PSND in India, TSV transmission studies were initiated. Adults of all the three thrips species [(*Frankliniella schultzei* (Trybom), *Scirtothrips dorsalis* Hood and *Megalurothrips usitatus* (Bagnall)] were experimentally proved to transmit TSV in groundnut, sunflower and cowpea in the presence of pollen from TSV infected parthenium, sunflower or marigold plants (Prasada Rao *et al.*, 2003). Further studies were needed to study the role of nymphs of thrips in virus transmission and possibility of disease spread from the infected plants in the field. This paper summarises the results obtained from experiments designed to further study virus-vector-pollen-host relationships in groundnut.

Thrips from sunflower heads (*F. schultzei*), groundnut flowers (*M. usitatus*), and young folded leaflets of groundnut (*S. dorsalis*) were collected in homeopathic vials and were identified as per Amin and Palmer, 1985. After identification, *S. dorsalis* and *F. schultzei* were reared separately on groundnut plants (cv. JL 24) in the glasshouse at 23-25°C. Thrips from healthy colonies were frequently released onto test plants (cowpea) to confirm their virus free status. *M. usitatus* did not survive on young groundnut plants in the absence of flowers for more than a week, so they were used directly in the transmission tests. The sunflower plants were sap inoculated with TSV and tested by ELISA for the presence of the virus. Pollen from these TSV infected sunflower plants was dislodged by gently brushing the flower heads over an open petridish. Pollens were then picked up on a camel's hair brush and dusted onto the test plant leaves. Cowpea cv. C 152 and groundnut cv. JL 4 plants were raised in 10 cm plastic pots in the glasshouse at temperatures ranging from 25 to 30°C. All the plants used in the experiments were one week old.

Transmission tests

Virus acquisition by nymphs and adults: For acquisition feeding tests with nymphs, groundnut plants were sap inoculated with TSV. After 5-6 days of sap inoculation, young groundnut leaflets showing clear PSND symptoms were detached and placed on water in petridishes. Twelve petridishes were used and each petridish contained three leaflets. Usually 10-15 nymphs of *S. dorsalis* and *F. schultzei* were released separately on each leaflet with the help of a fine brush and allowed to feed for 24 h. These nymphs were then transferred separately onto nine healthy plants each of groundnut and cowpea covered by polystyrene cylindrical cages (75 mm high x 33 mm diameter) and allowed to feed for 2 days. A similar procedure was followed for the control except that the nymphs fed on healthy groundnut leaves. After the inoculation access period of 2 days, the groundnut and cowpea plants were sprayed with 0.4% dimethoate to kill the feeding nymphs. Nymphs of *M. usitatus* could not be included in the study, as they were not easily found. For acquisition feeding tests with adults, adults of *S. dorsalis, F. schultzei* and *M. usitatus* were released separately for 24 h on TSV infected groundnut plants covered individually by polystyrene cylindrical cages and maintained in the glass house. After 24 h, the thrips were collected from these infected plants and 10-15 adults of each thrips species were released separately onto nine healthy plants each of groundnut and cowpea covered by polystyrene cylindrical cages and allowed to feed for 2 days. A similar procedure was followed for the control except that the adult thrips were exposed to healthy groundnut plants. After the inoculation access period of 2 days, the groundnut and cowpea plants were sprayed with 0.4% dimethoate to kill the feeding thrips. The exposed plants in both the cases were maintained in a glasshouse at 28 to 32°C for two weeks and later tested for TSV presence by ELISA.

The results of the virus acquisition and transmission tests are presented in Table 1. In virus acquisition experiments with nymphs of *S. dorsalis* and *F. schultzei* and adults of *S. dorsalis, F. schultzei* and *M. usitatus*, none of the plants showed positive reaction in ELISA indicating that these failed to directly acquire and transmit the virus. Similar observations on the failure of nymphs and adults of thrips to directly acquire TSV were reported in *C. amaranticolor* (Sdoodee and Teakle, 1987).

Table 1 **Results of TSV acquisition and transmission tests with *Scirtothrips dorsalis, Frankliniella schultzei* and *Megalurothrips usitatus* on groundnut (cv. JL 24) and cowpea (cv. C 152) at ICRISAT**

Treatment*	Test plant	Test plants infected** (No.)	
		Symptoms	ELISA
Virus acquisition with nymphs of *S. dorsalis*	Groundnut	0/9	0/9
	Cowpea	0/9	0/9
Virus acquisition with adults of *S. dorsalis*	Groundnut	0/9	0/9
	Cowpea	0/9	0/9
Virus acquisition with nymphs of *F. schultzei*	Groundnut	0/9	0/9
	Cowpea	0/9	0/9
Virus acquisition with adults of *F. schultzei*	Groundnut	0/9	0/9
	Cowpea	0/9	0/9
Virus acquisition with adults of *M. usitatus*	Groundnut	0/9	0/9
	Cowpea	0/9	0/9
Infective pollen and adults of *S. dorsalis*	Groundnut	10/10	10/10
	Cowpea	10/10	10/10
Infective pollen and adults of *F. schultzei*	Groundnut	10/10	10/10
	Cowpea	10/10	10/10
Infective pollen and adults of *M. usitatus*	Groundnut	10/10	10/10
	Cowpea	10/10	10/10
Infective pollen and adults of *S. dorsalis*	Groundnut	10/10	10/10
	Cowpea	10/10	10/10
Infective pollen and adults of *F. schultzei*	Groundnut	10/10	10/10
	Cowpea	10/10	10/10
Infective pollen and *S. dorsalis* feeding wound	Groundnut	0/9	0/9
Carborundum and infective pollen	Groundnut	9/15	9/15

* In the corresponding control of the above treatments no infection was observed.

** *Number of infected test plants over total number of test plants used.*

Virus transmission using pollen from TSV infected sunflower plants: Ten adults of *S. dorsalis, F. schultzei* and *M. usitatus* and ten nymphs of *S. dorsalis* and *F. schultzei* were released separately onto ten healthy plants each of cowpea and groundnut prior to dusting with pollen from TSV infected sunflower plants. Thrips were retained on the plants by covering the plants individually with polystyrene cylindrical cages. Control plants were dusted with infected pollen only, or infected by adult thrips only or infested by nymphs only. After the inoculation access period of 2 days, the cowpea and groundnut plants were sprayed with 0.4% dimethoate to kill the feeding thrips. The exposed plants were maintained in a glasshouse at 28 to 32°C for two weeks and later tested for TSV presence by ELISA.

Cowpea plants showed clear vienal necrosis and groundnut plants showed stem necrosis symptoms. All plants were found positive for virus in ELISA test (Table 1). Sdoodee and Teakle (1987) also observed regular TSV transmission in *C. amaranticolor* when virus carrying pollen was placed on leaves of its test seedlings before introducing thrips.

Transmission of TSV by dusting infective sunflower pollen on thrips feeding wounds on groundnut leaves: Ten adults of *S. dorsalis* were allowed to feed on nine healthy groundnut plants for 24 h. Thrips were retained on the plants by covering the plants individually with polystyrene cylindrical cages. After 24 h, the thrips were removed with a soft brush and the plants were sprayed with 0.4% dimethoate to kill any escaped thrips. The wounds caused on groundnut leaves by thrips feeding were then dusted with pollen from TSV infected sunflower plants. For control, the feeding wounds were dusted with pollen from healthy sunflower plants. The plants were maintained in a glasshouse at 28 to 32°C for three weeks and later tested for TSV presence by ELISA.

Neither control nor the test plants showed positive reaction in ELISA. A possible reason for this could be that the virus is contained inside the pollen and it can not enter leaf cells by itself unless there is a mechanical damage to both pollen and leaf tissue. In this case, thrips were not present to damage the infected pollen, therefore, no TSV infection was observed. Klose *et al.* (1992) also reported that the success of TSV transmission depended on sufficient virus being released by pollen close to a thrips-induced wound that was susceptible to infection.

Transmission of TSV by rubbing infective sunflower pollen on carborundum dusted groundnut plants: Fifteen groundnut plants were dusted with carborundum and their young leaves were rubbed with pollen from TSV-infected sunflower plant using a camel hair brush. Similar procedure was followed for control except that the young leaves of the plants were rubbed with pollen from TSV infected sunflower plants without dusting carborundum on them. The plants were maintained in a glasshouse at 28 to 32°C for three weeks and later tested for the presence of TSV by ELISA.

Groundnut plants showed 60% infection, whereas in the control no infection was observed. The infection may be due to the mechanical damage caused to the leaf tissue as well as to the pollen by carborundum while rubbing.

Summary: The mechanism of TSV transmission in groundnut and other host crops is different from that of other viruses in plants. There is no leaf-to-leaf transmission of TSV by adults of all the three thrips species, *S. dorsalis*, *F. schultzei* and *M. usitatus* and nymphs of *S. dorsali* and *F. schultzei* in groundnut and cowpea, as they do not acquire virus from infected plants. However, they assist in transmission of TSV in groundnut and cowpea in the presence of pollen from TSV infected sunflower plants by causing injury to both leaf tissue of host plants and pollen.

Acknowledgements: This work was supported by the Indian Council of Agricultural Research - National Agricultural Technology Project - ROPS:18. The first author expresses her gratitude to Dr. S.N. Nigam, Principal Investigator, NATP-ROPS-18 for his technical guidance and support.

References

Amin, P.W. and Palmer, J.M. 1985. Identification of groundnut Thysanoptera. *Tropical Pest Management*, **31**:286-291.

Greber, R.S., Klose, M.J., Teakle, D.S. and Milne, J.R. 1991. High incidence of tobacco streak virus in tobacco and its transmission by *Microcephalothrips abdominalis* and pollen from *Ageratum houstonianum*. *Plant Disease*, **75**: 450-452.

Klose, M.J., Webb, R.I. and Teakle, D.S. 1992. Studies on the association of tobacco streak virus and pollen using an environmental scanning electron microscope and molecular distillation drying techniques. *Journal of Computer-Assisted Microscopy*, **4**:213-220.

Prasada Rao, R.D.V.J., Reddy, A.S., Reddy, S.V., Thirumala Devi, K., Chander Rao, S., Manoj Kumar, V., Subramaniam, K., Yellamanda Reddy, T., Nigam, S.N. and Reddy, D.V.R. 2003. The host range of *Tobacco streak virus* in India and transmission by thrips. *Annals of Applied Biology*, **142**:365-368.

Reddy, A.S., Prasada Rao, R.D.V.J., Thirumala Devi, K., Reddy, S.V., Mayo, M.A., Roberts, I., Satyanarayana, T., Subramaniam, K. and Reddy, D.V.R. 2002. Occurrence of Tobacco streak virus on peanut (*Arachis hypogaea*) in India. *Plant Disease*, **86**:173-178.

Sdoodee, R. and Teakle, D.S. 1987. Transmission of tobacco streak virus by *Thrips tabaci* : A new method of plant virus transmission. *Plant Pathology*, **36**:377-380.

J. Oilseeds Res., **22**(1) : 218-219 (2005)

Short communication

Application of Dyar's Law in the development of *Bagrada hilaris* (Burm.)

H.R. Rohilla, Harvir Singh, Hoshiar Singh and B.S. Chhillar

Department of Entomology, C.C.S. Haryana Agricultural University, Hisar-125 004, Haryana

(Received: December, 2003; Revised: July, 2004; Accepted: September, 2004)

The painted bug, *Bagrada hilaris* (Burm.) is one of the serious insect-pests of all crucifer oilseeds and vegetable crops. In case of severe incidence, in the early stage of the crop, it may necessitate resowing of the crop (Bakhetia, 1986; Singh *et al.*, 1993) and it has been found to be responsible for 26.84 to 70.43 % loss in seed weight (Joshi *et al.*, 1989) and 4.5 % in oil content (Batra 1958) in crucifer oilseeds. Its biology was studied in detail on various oilseed crucifer crops and the article is in press (Rohilla *et al.*, 2003). During these studies the measurement of the width of the head capsule were recorded and the data were subjected to find out the calculated head width of different instars as per Dyar, 1890. This helps in ascertaining the correct nymphal instar, if the Dyar's Law is applicable. Therefore, with this objective in mind the current studies were initiated on different crucifer oilseeds.

The observed and calculated head widths of various nymphal instars of *B. hilaris* are presented in Table 1. It is evident that the head width of all the nymphal instars, except that of second instar, was influenced by the host plant. In first, second, third, fourth and fifth instars, it varied from 0.540 to 0.563, 0.718 to 0.701, 0.917 to 0.882, 1.255 to 1.218 and 1.629 to 1.590 mm, respectively, depending on the host.

The order of head width on various hosts of all the nymphal instars was *Brassica campestris* var. toria > *B. campestris* var. brown sarson > *B. juncea* > *B. napus* > *B. carinata* > *B. nigra* > *B. tournifortii* > *Eruca sativa*. The calculated head widths of second, third, fourth and fifth nymphal instars fell with in the range of the observed head widths. Hence the progression of head width in nymphal instars of *B. hilaris* followed the Dyar's Law, irrespective of the host plant. Rakshpal, (1949) also observed that the *application of Dyar's Law holds good for the* post-embryonic development of the painted bug.

Table 1 Observed and calculated nymphal head width of painted bug, *Bagrada hilaris* reared on different crucifer hosts

Host plant	Genotype	Head width (mm)								
		1st instar	2nd instar		3rd instar		4th instar		5th instar	
		Observed	Observed	Calculated	Observed	Calculated	Observed	Calculated	Observed	Calculated
Brassica compestris var. toria	TH-68	0.563 (0.54-0.58)*	0.718 (0.70-0.74)	0.732	0.917 (0.90-0.96)	0.933	1.255 (1.19-1.28)	1.192	1.629 (1.56-1.68)	1.631
B. campestris var. brown *sarson*	BSH-1	0.562 (0.54-0.58)	0.714 (0.70-0.74)	0.730	0.916 (0.90-0.96)	0.928	1.251 (1.19-1.28)	1.191	1.626 (1.56-1.68)	1.628
B. juncea	RH-30	0.560 (0.54-0.58)	0.713 (0.70-0.74)	0.728	0.911 (0.90-0.95)	0.927	1.243 (1.19-1.27)	1.184	1.618 (1.57-1.67)	1.615
B. napus	GSH-1	0.554 (0.53-0.57)	0.710 (0.70-0.73)	0.720	0.905 (0.89-0.95)	0.923	1.238 (1.18-1.26)	1.176	1.610 (1.55-1.67)	1.609
B. carinata	HC-2	0.550 (0.53-0.57)	0.709 (0.70-0.73)	0.720	0.898 (0.88-0.95)	0.922	1.233 (1.18-1.26)	1.176	1.609 (1.55-1.67)	1.616
B. nigra	Local	0.546 (0.52-0.56)	0.706 (0.69-0.72)	0.715	0.894 (0.88-0.94)	0.924	1.231 (1.19-1.28)	1.171	1.605 (1.54-1.65)	1.612
B. tournifortti	Local	0.543 (0.52-0.56)	0.705 (0.69-0.72)	0.711	0.887 (0.87-0.94)	0.923	1.224 (1.18-1.24)	1.162	1.598 (1.54-1.65)	1.603
Eruca sativa	TMH-52	0.540 (0.52-0.55)	0.701 (0.69-0.72)	0.707	0.882 (0.87-0.94)	0.918	1.213 (1.17-1.24)	1.155	1.590 (1.54-1.64)	1.589
SEM±		0.007	0.012		0.015		0.014		0.017	
CD (P=0.05)		0.013	N. S.		0.029		0.028		0.033	

*Range

Calculated head width for first four hosts = Observed head width x 1.31

Calculated head width for remaining four hosts = Observed head width x 1.30

Summary: Applicability of Dyar's law was observed on development stages of painted bug, *Bagrada hilaris* (Burm.) when reared on various crucifer hosts. It was observed that progression of head widths of second, third, fourth and fifth nymphal instars of *B. hilaris* fell within the range of observed head widths, thus confirmed the applicability of Dyar's law.

References

Bakhetia, D.R.C. 1986. Pest management in rapeseed-mustard. *Pesticides*, **20**(5): 32-38.

Batra, H.N. 1958. Bionomics of *Bagrada cruciferarum* Kirk. (Heteroptera: Pentatomidae) and its occurance as a pest of mustard seeds. *Indian Journal of Entomology*, **20**(2): 130-135.

Dyar, H.G. 1890. The number of moults of lepidopterous larvae *Psyche* (Cambridge, M95), **5**:420-422.

Joshi, M.L., Ahuja, D.B. and Mathur, B.N. 1989. Loss in seed yield by insect pests and their occurrence on different dates of sowing in Indian mustard (Brassica juncea sub sp. juncea). *Indian Journal of Agricultural Sciences*, **59** (3): 166-168.

Rakshpal, R.1949. Notes on the biology of *Bagrada cruciferarum* Kirk. *Indian Journal of Entomology*, **11**(1): 11-16.

Rohilla, H.R., Hoshiar Singh, Harvir Singh and Chhillar, B.S. 2003. Biology of painted bug *Bagrada hilaris* (Burm.) on different rapeseed-mustard plants. *Journal of Oilseeds Research*, in Press.

Singh, H., Rohilla, H.R., Pala Ram and Ahlawat; D.S. 1993. Outbreak of painted bug, *Bagrada cruciferarum* Kirk. on oilseed *Brassica* in India. *International Journal of Tropical Agriculture*, **11**(2):153-154.

J. Oilseeds Res., **22**(1) : 220-221 (2005)

Short communication

Screening of *Brassica* lines against mustard aphid, *Lipaphis erysimi* (Kalt.) infestation

R.K. Verma, Neeraja Agarwal and S.K. Rajak

Department of Entomology, C.S. Azad University of Agriculture and Technology, Kanpur-208 002, UP

(Received: April, 2003; Revised: August, 2004; Accepted: September, 2004)

Lipaphis erysimi (Kalt) is the most destructive aphid pest and causes heavy damage to rapeseed and mustard crops. Host plant resistance is one of the important components of integrated pest management (IPM). On this aspect by Malviya and Lal (2000) reported 15 Brassica germplasms as promising against mustard aphid but according to Prasad (2001) none of the germplasm tested was found resistant against mustard aphid. The present investigation was undertaken to screen 16 mustard entries against mustard aphid, *L. erysimi*.

Field experiment was conducted at C.S. Azad University of Agriculture and Technology, Kanpur during *rabi* 2001-02 and 2002-03. Selected varieties/cultivars of *Brassica juncea* and *B. nigra* were sown in paired rows of 3 m length in Randomized Block Design (RBD) with 3 replications. Three plants of each entry from a replication were randomly selected for observations on aphid population (Bakhetia and Sandhu, 1973) and population count of mustard aphid was scored accordingly. Mustard aphid infestation on test germplasm was recorded as aphid infestation index (AII) categorized into six categories on 0-5 scale depending upon level of aphid infestation as suggested by Prasad (1996). The data on the incidence of mustard aphid was utilized to find out the resistance/ susceptibility of the various varieties on the basis of mean AII. Weekly observation of population count starting from 8 weeks after sowing (WAS) till 17 WAS during 2001-02 and 2002-03 were recorded. The population of mustard aphid was counted visually. Thus the population was recorded on these selected germplasms from initial incidence of mustard aphid till its disappearance during crop season. Variety Varuna was taken as a check.

Response of 16 selected germplasm to aphid was observed based on aphid infestation index (AII) at flowering and pod formation stages. AII of *Brassica* germplasms ranged from 0.12 to 3.3 and 0.15-3.2 at flowering stage during the year 2001-02 and 2002-03, respectively. The lowest (AII) was recorded on Banarsi Rai and Rohini having AII of 0.12 and 0.18 during 2001-02 and 0.15 and 0.19 during 2002-03, respectively. Varuna, Vaibhav, Vardan and UPN-9 having 3.3-3.2, 2.9-2.8, 2.9-2.8 and 2.3-2.6 AII during 2001-02 and 2002-03, respectively, were found most susceptible to aphid, as shown in Table 1.

Table 1 Screening of *Brassica* species/genotypes based on aphid infestation index of *Lipaphis erysimi* (Kalt.)

Genotype	Average aphid infestation/plant (10 cm top central twig)		Aphid infestation index (0-5 scale): At full flowering stage		At full pod formation stage		Overall		Reaction
	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	2001-02	2002-03	
Vardan (*B. juncea*)	72.95	56.1	2.9	2.8	3.4	3.2	3.15	3.00	S
Rohini (*B. juncea*)	16.01	13.0	0.18	0.19	1.4	1.2	0.79	0.69	HR
Vaibhav (*B. juncea*)	86.53	65.7	2.9	2.8	3.8	3.2	3.35	3.00	S
RK-819 (*B. juncea*)	61.51	46.4	1.8	1.8	3.5	3.4	2.65	2.60	MR
Krishna (*B. juncea*)	52.24	44.2	1.6	1.3	3.4	3.2	2.50	2.25	MR
RK-9304 (*B. juncea*)	65.80	48.9	1.3	1.2	2.8	3.0	2.10	2.10	MR
RGN-19 (*B. juncea*)	60.20	44.2	1.7	1.4	3.7	3.4	2.70	2.40	MR
RK-9801 (*B. juncea*)	69.54	52.1	2.5	1.9	3.4	3.0	2.95	2.45	MR
RK-30 (*B. juncea*)	49.62	40.4	2.9	1.7	3.0	2.9	2.65	2.30	MR
Basanti (*B. juncea*)	39.66	32.3	2.4	2.1	3.5	3.1	2.95	2.60	MR
Banarsi Rai (*B. nigra*)	2.87	24.31	0.12	0.15	1.0	1.2	0.56	0.67	MR
UPN-9 (*B. juncea*)	81.45	59.30	2.3	2.6	3.8	3.4	3.30	3.00	S
SBG-51 (*B. juncea*)	77.13	57.72	2.5	2.1	3.3	3.1	2.90	2.60	MR
Urvashi (*B. juncea*)	48.29	36.7	1.9	1.7	2.8	2.6	2.35	2.15	MR
MLN-157 (*B. juncea*)	43.38	33.6	1.5	0.3	2.6	2.8	2.10	2.10	MR
Varuna (*B. juncea*)	91.85	72.9	3.3	3.2	3.8	3.4	3.55	3.30	S

S = Susceptible; HR = Highly resistance; MR = Moderate resistance

At full pod formation stage, (AII) of Banarsi Rai and Rohini was recorded as 1.0-1.4 and 1.2 each during 2001-02 and 2002-03, respectively. Highest (AII) was recorded on 11 germplasms with 3.0-3.8 and remaining germplasms were recorded 2.6-2.8 during 2001-02. In the year 2002-03, 11 germplasms had upto 3.0-3.4 (AII) while remaining germplasms were found having AII of 2.6 - 2.9.

Based on over all (AII), Banarsi Rai and Rohini were grouped as highly resistant, showing (AII) of 0.56-0.67 and 0.79-0.69, during the year 2001-02 and 2002-03, respectively. Four cultivars *viz.*, Varuna, Vaibhav, Vardan and UPN-9 were found to be susceptible to mustard aphid and (AII) of these germplasms was 3.8-3.3, 3.8-3.0, 3.4-3.0 and 3.3-3.0 during the year 2001-02 and 2002-03, respectively. Ten-germplasms *viz.*, RK-819, Krishna, RK-9304, RGN-19, RK-9801, RK-90, Basanti, SBG-51, Urvashi and MLN-157 were found moderately resistant, as their (AII) ranged between 2.1-2.95 during two experimental years. The reaction of Varuna was susceptible to aphids in the present study but it was found resistant at Shillongoni (Anonymous, 1987) and at Hisar (Anonymous, 1988). In agreement with present findings, Prasad and Phadke (1980) reported that Banarsi Rai was least preferred by aphids. Saxena *et al.* (1995) found lowest yield losses in Rohini, which supports the present findings. Srivastava, *et al.* (1996) and Ashwani, *et al.* (1996) screened out mustard germplasm against aphids and observed nil susceptibility on Vaibhav variety. However, Lal *et al.* (1997) observed Vaibhav variety as susceptible to aphids, which is in agreement to the present work.

References

Anonymous. 1987. Annual Progress Report, Rapeseed-Mustard, 1986-87. All India Co-ordinated Research Project on Oilseeds. Directorate of Oilseeds Research, Hyderabad, India, p.29.

Anonymous, 1988. Annual Progress Report, Rapeseed-Mustard, 1987-88. All India Co-ordinated Research Project on Oilseeds. Directorate of Oilseeds Research, Hyderabad, India.

Ashwani, K., Sharma, S.D. and Singh, N.N. 1996. Screening of different germplasm entries of mustard against *Lipaphis erysimi* Kalt. *Advances in Agricultural Research*, **5**: 42-46.

Bakhetia, D.R.C. and Sandhu, R.S. 1973. Differential response of Brassica species/varieties to the aphid. *L. erysimi* Kalt. infestation. Journal of Research Punjab Agricultural University, **10** (3) : 272-279.

Lal, M.N., Singh, S.S. and Singh, V.P. 1997. Relative susceptibility of Brassica germplasms to mustard aphid, *L. erysimi* Kalt. *Indian Journal of Entomology*, **59** (4):369-373.

Malviya, J.K. and Lal, M.N. 2000. Screening of Brassica germplasms against mustard aphid, *L. erysimi* Kalt. *Annals of Plant Protection Sciences*, **8**(2):150-153.

Prasad, S.K. 1996. Management of insect tests of rape seed and mustard crop In: *Recent Advances in Indian Entomology* (ed.) O.P. Lal, APL publication Pvt. Ltd., New Delhi; **7**, 343-345.

Prasad, S.K. 2001. Screening of rapeseed and mustard against mustard aphid, *L. erysimi* Kalt. *Annals of Agricultural Research*, **22** (1):120-122.

Prasad, Y.K. and Phadke, K.G. 1980. Population dynamics of *L. erysimi* Kalt on different varieties of *Brassica* species. *Indian Journal of Entomology*, **42**(1):54-63.

Saxena, A.K., Bhadauria, S.S., Gadlwadikar, P.N., Bartaria, A.M., Tomar, S.S. and Dixit, S.C. 1995. Yield loss in some improved varieties of mustard by the aphid, *L. erysimi* Kalt. *Agricultural Sciences Digest*, **75** (4): 235-237.

Srivastava, A., Singh, H. and Thakur, H.L. 1996. Assessment of avoidable yield loss caused by green peach, *Myzus persicae* Sulzer and mustard aphid, *L. erysimi* Kalt. in *Brassica*. *Indian Journal of Plant Protection*, **24** (1-2):115-116.

J. Oilseeds Res., **21**(2) : 222-223 (2004)

Short communication

Bio-efficacy of some newer insecticides against *Spodoptera litura* (Fab.) infesting sunflower, *Helianthus annuus* L.

K. Sudhakara Reddy, G. Ramachandrarao, P. Arjuna Rao and P. Rajasekhar

Department of Entomology, Agriculture College, Bapatla-522 101, A.P

(Received: November, 2003; Revised: February, 2004; Accepted: July, 2004)

Sunflower (*Helianthus annuus* L.) is now one of the world's important oilseed crops. In India, it occupies an area of 1.71 m.ha with a production of 0.94 m.t.. In Andhra Pradesh it is grown in 0.27 m. ha with a production of 0.16 m.t. Sunflower crop is damaged by lepidopteran pests, of which, tobacco caterpillar *Spodoptera litura* (Fab.) is most devastating, which has developed resistance to many of the conventional insecticides. Hence, the present study was designed to evaluate the efficacy of certain newer and safer insecticides belonging to different groups, alone and in combination with *B.t* at half of the normal concentrations against *S. litura* on sunflower.

The field study was carried out at Agricultural College Farm, Bapatla during *rabi* 2001-02. The experiment was laid out in a Randomised Block Design on hybrid, APSH-11 with 12 treatments including untreated control replicated thrice. The size of each plot was 15m^2 (5 m x 3 m). Recommended doses of NPK (80-60-40 kg/ha) were applied in the form of urea, single super phosphate and muriate of potash respectively. During the crop period, the treatments were given as foliar sprays. The first spray was given at 50 days after sowing.

Observations on larvae on the 10 tagged plants were counted a day prior to spray as pre-treatment count and post treatment counts were taken at two, five, ten and fifteen days after imposition of treatments. The reduction of larval population over control was worked out as per (Flemming and Ratnakaran, 1985)

The data (Table 1) recorded at two days after application of treatments showed that indoxacarb 0.0145% was the most effective and significantly superior to all other treatments with 80.9% mean population reduction over untreated control. However, treatments lufenuron 0.005% + *B.t* 0.075% (21.2%) and neem 0.1% (16.0%) were less effective, while *B.t.* 0.15% (11.2%) and lufenuron 0.01% (12.3%) were on par and the least effective.

The observations recorded at five days after spraying revealed that the combination treatments and lufenuron, *B.t* and neem alone showed significant increase in their efficacy while there was slight increase in the efficacy of indoxacarb and acephate alone. Ravi Kumar (1993) reported that acephate 0.1% effectively reduced the damage due to *S. litura* and *H. armigera* in groundnut. Indoxacarb 0.00725% + lufenuron 0.005% was the most effective with 91.6% mean population reduction of *S. litura* over untreated control, but was on par with indoxacarb 0.00725% + *B.t* 0.075% (89.7%). Among the treatments neem 0.1% (43.7%) was the least effective.

The data recorded at ten days after the treatment showed that the combination treatments were better than their corresponding individual treatments against the larval population of *S. litura*. The combination treatment, spinosad 0.01% + lufenuron 0.005% was the most effective among all the treatments with 72.7% reduction in larval population but it was on par with indoxacarb 0.00725% + lufenuron 0.005% (72.4%). Spinosad 48 SC (Spinosyn A+D) was reported to be highly effective against *S. litura*, *Hellula undalis* (Fabricius) and *Plutella xylostella* of cabbage at a dosage level of 15-25 g a.i/ha (Dey and Somchaudhury, 2001).

Indoxacarb (0.024%) and spinosad (0.015%) showed 86.66% and 73.33% ovicidal activity against *S. litura* (Ahmed *et al.*, 2001). Among the treatments neem oil 0.1% (25.6%) was found to be the least effective.

At 15 days after treatment the combination treatments proved much better than their corresponding individual treatments, although there was slight build up of pest population in all the plots. Among the treatments the combination treatment, indoxacarb 0.00725% + lufenuron 0.005% was the most effective with 50.03% reduction in larval population of *S. litura* and was on par with indoxacarb 0.00725% + *B.t* 0.075%.

The overall mean efficacy showed that the combination treatments performed better over the corresponding individual treatments. The results showed that indoxacarb 0.00725% + lufenuron 0.005% (69.9%) and indoxacarb 0.00725% + *B.t* 0.075% (68.1%) recorded the highest reduction of larval population and were on par with each other and significantly superior to all the other treatments.

Table 1 Efficacy of the treatments after two sprayings against *S. litura* on sunflower during *rabi* 2001-02

Treatment	Concentration (%)	Mean larval population/ 10 plants before spray	Mean per cent reduction of larvae over control				Overall mean efficacy	Mean yield (kg/ha)	% increase in yield over control
			2 DAT	5 DAT	10 DAT	15 DAT			
T_1 Spinosad	0.0169	10.7	67.5^{b} (55.3)	82.4^{c} (65.3)	57.2^{e} (49.1)	43.4^{c} (41.2)	62.62^{c} (52.3)	1377	49.4
T_2 Indoxacarb	0.0145	9.5	80.9^{a} (64.2)	75.7^{d} (60.5)	60.0^{d} (50.8)	45.7^{bc} (42.5)	65.6^{b} (54.1)	1444	56.6
T_3 Lufenuron	0.01	11.0	12.3^{g} (20.4)	67.4^{e} (55.2)	36.4^{g} (37.1)	24.5^{e} (29.6)	35.2^{f} (36.3)	1155	25.3
T_4 *Bacillus thuringiensis*	0.15	11.5	11.2^{g} (19.2)	67.0^{e} (55.0)	30.1^{h} (33.2)	16.5^{f} (23.8)	31.2^{g} (33.9)	1089	18.1
T_5 Neem	0.1	10.3	16.0^{f} (23.5)	43.7^{g} (41.4)	25.6^{i} (30.4)	16.6^{f} (23.9)	25.5^{h} (30.3)	1056	14.5
T_6 Acephate	0.075	10.5	62.6^{c} (52.3)	59.1^{f} (50.2)	31.1^{h} (33.9)	25.4^{e} (30.2)	44.6^{d} (41.9)	1267	37.4
T_7 Spanosad + Lufenuron	0.01+0.005	12.5	55.2^{d} (49.0)	87.3^{b} (69.3)	72.7^{a} (58.6)	47.7^{ab} (43.5)	65.6^{b} (54.1)	1444	56.6
T_8 Spanosad + B.t	0.01+0.075	11.0	54.6^{d} (47.6)	85.1^{bc} (67.5)	69.1^{c} (56.4)	45.5^{bc} (42.4)	63.5^{bc} (52.9)	1422	54.2
T_9 Endoxacarb + lufenuron	0.00725 + 0.005	11.5	65.7^{b} (55.2)	91.6^{a} (73.5)	72.4^{ab} (58.3)	50.0^{a} (45.0)	69.9^{a} (56.8)	1656	79.5
T_{10} Indoxacarb + B.t	0.00725 + 0.075	11.0	64.0^{c} (53.1)	89.7^{a} (71.7)	70.3^{bc} (57.0)	48.3^{ab} (44.0)	68.1^{a} (55.6)	1600	73.5
T_{11} Lufenuron + B.t	0.005 + 0.075	10.5	21.2^{e} (27.3)	59.5^{f} (50.7)	44.4^{f} (41.8)	32.9^{d} (34.4)	39.5^{e} (38.9)	1244	34.4
T_{12} Untreated control		12.0	0.0^{h} (4.1)	0.0^{h} (4.1)	0.0^{j} (4.1)	0.0^{g} (4.1)	0.0^{i} (4.1)	922	-
F Test			Sig.	Sig.	Sig.	Sig.	Sig.		
SEm±		-	0.6	0.7	0.5	0.6	0.5	0.04	-
CD (P=0.05)		NS	1.4	1.8	1.5	1.8	1.5	0.10	-

DAT = Days after treatment; Figures in parentheses are angular transformed values;
(Figures followed by same letters in each column are not significantly different)

The next best treatments spinosad 0.01% + lufenuron 0.008% (65.6), indoxacarb 0.0145% (65.6%) and spinosad 0.01% + *B.t* 0.075% (63.5%) were on par with each other and recorded more than 63% reduction in larval population. Harikrishna (1996) indicated that lufenuron and profenofos were equally effective in reducing *S. litura* population on cabbage.

Among the treatments neem 0.1% (25.5%) was found to be the least effective. This is in accordance with Bhanukiran *et.al.* (1997) who reported that neem oil 0.5% was relatively less effective compared to other insecticides against *S. litura* on groundnut. However, all the treatments were significantly superior over untreated control in bringing down the larval population of *S. litura*.

Based on the results obtained in the study it is concluded that the use of toxic insecticides at lower doses in combination with *B.t* is more promising in controlling the pests when compared to the individual sprays at higher doses. It is also useful in reducing environmental pollution and other hazards to beneficial organisms and human beings caused by them. Hence, using insecticides in combinations with lufenuron and *B.t.* is advocated in present day IPM.

The data pertaining to the yield of sunflower revealed that indoxacarb 0.0075% + lufenuron 0.005% recorded the highest yield (1655 kg/ha), but it was on par with indoxacarb 0.00725% + *B.t.* 0.075% (1600 kg/ha). The other treatments indoxacarb 0.0145% (1444 kg/ha), spinosad 0.01% + lufenuron 0.005% (1444 kg/ha), spinosad 0.01% + *B.t.* 0.075% (1422 kg/ha) were on par with each other. Among the other treatments *B.t.* 0.15% (1088 kg/ha) and neem 0.1% (1055 kg/ha) were on par and recorded significantly the lowest yields. However, all the treatments recorded significantly higher yields than the untreated control (922 kg/ha).

References

Ahmed, K., Rao, V.H. and Rao, P.P. 2001. Promising new insecticides as potential ovicides against eggs of *Spodoptera litura* Fab. *Pestology,* **25** : 20-21.

Bhanukiran, Y., Rao, P.A. and Rao, K.T. 1997. Management of *Spodoptera litura* (Fabricius) on groundnut with combination of insecticides and eco-friendly chemicals. *Journal of Entomological Research,* **21** : 71-74.

Dey, P.K. and Somchaudhary, A.K. 2001. Evaluation of spinosyns A + D (Spinosad 48SC) against lepidopteran pest complex of cabbage and its effect on natural enemies of diamond back moth under field conditions of West Bengal. *Pestology,* **25**(1) : 54-58.

Flemming, R. and Ratnakaran, A. 1985. Evaluation of single treatment data using Abbott's formula with reference to insects. *Indian Journal of Economic Entomology,* **78** : 1179-1181.

Harikrishna, G. 1996. Management of cabbage pests with selected insecticides. M.Sc(Ag)thesis, Acharya N G Ranga Agricultural University, Hyderabad.

Ravi Kumar, Ch. 1993. Studies on the efficacy of certain newer insecticides against groundnut pest complex. M.Sc(Ag) thesis, Acharya N G Ranga Agricultural University, Hyderabad.

J. Oilseeds Res., **22**(1) : **224-225 (2005)**

Short communication

Field screening of soybean, *Glycine max* (L.) Merrill. lines for resistance to yellow mosaic virus

Rajkumar Ramteke and G.K. Gupta

National Research Centre for Soybean, Khandwa Road, Indore, MP

(Received: February, 2004; Revised: July, 2004; Accepted: September, 2004)

In India, soybean is grown in about 6 m ha area, largely in the tracts of Madhya Pradesh, Maharashtra, Rajasthan, Karnataka and other parts of India during the *kharif* as a rain fed crop. Soybean provides good quality protein, vegetable oil and other neutraceuticles. Initially the crop was relatively free of diseases but continuous cultivation of it led to emergence of new diseases and increase in intensity of existing ones. Yellow mosaic disease is one of them, which is posing serious challenge to this crop.

Mungbean yellow mosaic virus (Gemini virus group) causing yellow mosaic in soybean continues to affect the soybean in the endemic areas of the country. The disease flourishes under high temperature and high humidity and is transmitted by whitefly, *Bemisia tabaci* Genn. Yield reduction to the tune of 15-75% is reported in India (Gupta, 2003). Yield loss remains low if infection occurs at post-bloom stage. At Ludhiana yield loss of 36.6% was reported (Gill and Rataul, 1991). Earlier, a number of germplasm, breeding lines and varieties of soybean having resistance to yellow mosaic have been reported.

Chemical methods of controlling yellow mosaic virus indirectly by reducing whitefly population are available, but the cost-benefit ratio and chemical hazards involved, indicated that the most desirable approach would be to capitalise the genetic resistance. Therefore, development of high yielding yellow mosaic virus resistant lines and then screening them at the hot spots is the major approach to manage the disease. Promising genetic material of soybean developed at NRC for soybean, Indore was evaluated at Jabalpur, New Delhi and Ludhiana under field condition in *kharif*, 2002 and 2003. The scoring of the disease was done at pod-fill stage, using standard 0-9 scale based on the percent area of leaf and pods infected, where 0 denotes no disease and 9 denotes >90 % areas covered due to yellow mosaic.

Table 1 Reaction of the parents and segregating lines of soybean to yellow mosaic virus

Reaction	Score	Genotypes/Lines		
		At Ludhiana	At Delhi	At Jabalpur
No infection	*0*	*SL 603, SL 295, NRC 20, SL 459,* SL 525	*SL 603, SL 295*	*Nil*
Highly resistant	1	PK 416, SL 328, three lines of (F_3: PS 1024 x Ankur)	PK 416, NRC 20, UPSM 534, SL 525, SL 328, three lines of (F_3: PS 1024 x Ankur)	Nil
Resistant	3	UPSM 534, SL 428, (F_7: PK 472 x PK 416), one line of (F_3: PK 416 x Samrat), one line (F_4: Ankur x PS 1024)	PS 564, SL 459, SL 517, SL 428, three line of (F_3: PK 416 x Samrat), two lines (F_3: Ankur x PS 1024), one line (F_3: JS 335 x PK 1024), (PK 472 x PK 416), (JS 335 x PK 416)	Ankur, PS 1024, PS 1029, PK 416, PS 564, (F_2: PS 1024 x Ankur), (F_2: Ankur x PS 1024), (F_2: PK 416 x Samrat)
Moderately resistant	5	PS 564, SL 517, one line (F_4: Ankur x PS 1024)	One line (F_3: Ahilya 4 x PK 1024), (Bragg x PK 416), (F_7: PK 416 x G. 73)	Nil
Susceptible	7	Four lines of (F_3: PK 416 x Samrat), two lines (F_3: Ankur x PS 1024), (F_3: JS 335 x PK 1024), two lines (F_3: Ahilya 4 x PK 1024), three lines (F_4: Ahilya 4 x PS 1029),	Three lines (JS 335 x *Glycine soja*), One line (F_3: Ahilya 4 x PK 1024), two lines (F_3: PK 416 x Samrat),	JS 80-21, (F_2: PS 1029 x JS 80-21), (F_2: JS 335 x PS 1024), (F_2: Ankur x PK 416), (F_2: Ahilya 4 x PK 1024), Six lines of (F_3: Ahilya 4 x JS 80-21), 18 *lines of (F_3: Ankur x PS 1024)*, Fourteen lines of (F_3: Ahilya 4 x PS 1029), Four lines of (JS 335 x *Glycine soja*)
Highly susceptible	9	Ahilya 4, Samrat, JS 335, two lines (F_3: Ankur x PK 416), 2 lines (F_3: PK 1024 x JS 80-21), 2 lines (F_4: Ahilya 4 x PS *1029), 3 lines (F_7: JS 335 x G. soja)*, (PK 416 x Shilajeet), (F_7: NRC 2 x *G. soja*), (Bragg x PK 416), (PK 416 x Bragg), (JS 335 x PK 416), (F_7: PK 416 x G. 73)	JS 335, two lines (F_3: Ankur x PK 416), (PK 416 x Shilajeet), Ahilya 4, Samrat	Ahilya 4, JS 335, Samrat,

It was observed that the incidence and severity of yellow mosaic was more at Ludhiana followed by New Delhi and Jabalpur. The perusal of results revealed that the lines SL 603, SL 295 remained free of YMV, while PK 416, SL 328 and three lines of PS 1024 x Ankur (F_3) were found highly resistant and many other as resistant at both the locations (Delhi and Ludhiana). At Jabalpur, none of the evaluated lines were free or highly resistant to yellow mosaic, however, F_2 lines derived from crosses PS 1024 x Ankur, Ankur x PS 1024 and PK 416 x Samrat and genotypes Ankur, PS 1024, PS 1029, PK 416 and PS 564 were resistant. Ahilya 4, JS 335, and a popular unreleased variety Samrat were highly susceptible at all the three locations. The genotypes i.e. SL 603, SL 328, SL 428, three F_3 lines of PS 1024 x Ankur, (F7: PK 472 x PK 416), one F_3 line of PK 416 x Samrat and one F_4 line of Ankur x PS 1024 were observed as better source for further utilization in breeding YMV resistant high yielding soybean cultivars.

References

Gill, C.K. and Rataul, H.S. 1991. Varietal response in soybean to yellow mosaic virus transmitted by *Bemisia tabaci* (Genn). *Journal of Insect Science*, **4**: 1, 85-86.

Gupta, G.K. 2003. Integrated management strategies for soybean diseases in India. In: *On the spot diagnosis and identification of major seed-borne diseases of soybean.* Training manual No. DRS/02/2003, Department of Plant Breeding and Genetics, JN Krishi Vishwa Vidyalaya, Jabalpur. pp. 114-125.

J. Oilseeds Res., **22**(1) : 226-227 (2005)

Short communication

Selection for resistance to stem and pod rot in groundnut, *Arachis hypogaea* L.

A. Krishnakanth, G.K. Naidu and M.V.C. Gowda

Department of Genetics and Plant Breeding, University of Agricultural Sciences, Dharwad-580 005, Karnataka

(*Received: May, 2003; Revised: August, 2004; Accepted: September, 2004*)

Sclerotium rolfsii incited stem- and pod-rot is a major constraint in groundnut production (Mehan and McDonald, 1990; Bowen *et al.*, 1992). Most of the Spanish bunch cultivars are susceptible to stem and pod rots. Though, the non-genetic solutions are available, they are not economical and environment friendly. The available resistant genotypes suffer from one or the other defects like late maturity, poor adaptation and undesirable pod features. Under such circumstances, hybridization between popular Spanish bunch cultivars and available resistant sources is a welcome approach to develop high yielding resistant cultivars with desirable agronomic attributes. In such an effort, information on genetic control of the character would contribute greatly to the planning and logistics for assured results. In the absence of any information on genetic basis of resistance to stem and pod rots (Mehan *et al.*, 1995), an empirical effort to assess the scope for selection in two hybrid populations is envisaged in the present study.

A popular but susceptible Spanish bunch cultivar, JL 24 (52.6 % disease) and Dh 8, a partially resistant (14.7 % disease) but deficient in hundred seed weight (28.8 g as against 49.3 g in JL 24) and shelling percent (72.7% as against 79.8 % in JL 24) were used as ovule and pollen parents to generate two crosses. Owing to partial nature of resistance, it is difficult to assess individual plants especially in early generations. Hence, 50 F_2 derived F_5 lines from each cross were evaluated along with the parents during the rainy season, 1999. The material was raised in single rows of 2.25m length with four replications in Randomized Block Design under artificially inoculated condition. The recommended package of practices for groundnut cultivation in rainy season were adopted. *S. rolfsii* was isolated from diseased plants grown in Vertisols. Sand-corn meal medium (Abeygunawardena and Wood, 1957) was used to prepare the culture of *S. rolfsii* Inoculum containing mycelium and sclerotia along with corn meal and sand was applied to the soil surface around the base of groundnut plants at approximately 125g/2.5 m row, 50-60 days after sowing. Sorghum stubble (3-4 cm pieces) was also scattered along the rows to enhance the fungal growth. After two weeks the inoculation was repeated.

Plants showing stem and/or pod rot symptoms were counted and percentage incidence was computed from the total number of plants in each plot. Healthy pods from all the plants were collected from the whole plot and dried. As an index of yield potential, pod yield/plants was computed by total pod yield from healthy plants divided by number of plants and expressed in g/plant. Hundred seed weight and shelling percent was computed from a sample of pods.

The data was subjected to ANOVA and correlation analysis to compute genetic components of variance and correlation coefficients.

Significant variation existed among the lines in both the crosses for the characters. The magnitude of variation as revealed by phenotypic and genotypic coefficients of variation was high (>32) for disease incidence and yield/unit area, moderate (17.1 to 25.1) for yield potential and low (<13.7) for hundred seed weight and shelling percent (Table 1). Heritability was high (>50) for most of the characters. Genetic advance was high for productivity followed by disease incidence, yield potential and hundred seed mass indicating the scope for selection of resistance and productivity under epidemic conditions followed by yield potential and hundred seed mass. Significant negative correlation between disease incidence and yield/unit area (data not given) revealed the importance of resistance in obtaining higher yield under pathogen stress. The positive correlation of disease incidence with hundred seed mass and shelling percent in both the crosses and with pod yield/plant in JL 24 ´ Dh 8 revealed undesirable association of resistance with these characters.

Based on means and frequency of desirable (superior to JL 24) segregants, the direct cross (JL 24 x Dh 8) was superior over its reciprocal (Dh 8 x JL 24) for hundred seed mass and shelling per cent, while, reverse for disease incidence and yield/unit area. This indicates the possibility of cytoplasmic influence on the expression of these traits. This was evident as Dh 8 was partially resistant but deficient in hundred seed mass and shelling percent. Dwivedi *et al.*, (1989) reported significant genetic and maternal interaction effects for shelling percent. Reciprocal cross differences are know to affect expression of many characteristics in groundnut (Knauft and Wynne, 1995).

Table 1 Genetic components of variance of resistance, yield and yield related traits in two groundnut crosses

Source of variation	Disease incidence (%)		Yield/ha (q/ha)		Pod yield/plant (g)		100 seed weight (g)		Shelling per cent	
	JL 24 x Dh 8	Dh 8 x JL 24	JL 24 x Dh 8	Dh 8 x JL 24	JL 24 x Dh 8	Dh 8 x JL 24	JL 24 x Dh 8	Dh 8 x JL 24	JL 24 x Dh 8	Dh 8 x JL 24
PCV	32.0	34.4	45.8	40.1	25.1	20.5	11.7	13.7	4.3	3.8
GCV	24.5	32.1	40.0	32.9	20.6	17.1	9.8	13.0	2.7	3.1
H	58.4	87.0	76.2	80.5	67.4	69.5	70.7	90.6	37.6	67.4
GAM	38.5	61.6	72.0	66.4	34.8	29.4	17.	25.5	3.4	5.2
PNS	42.0	54.0	28.0	38.0	26.0	32.0	18.0	4.0	14.0	0.0
PSS	6.0	12.0	6.0	8.0	6.0	6.0	18.0	4.0	14.0	0.0
Mean	56.1	50.0	17.7	19.4	14.0	14.3	45.2	41.7	77.5	75.0
CD (5%)	22.8	12.2	7.5	6.1	4.0	3.1	5.6	3.3	5.2	3.1
CV (%)	20.6	16.5	22.2	19.0	14.3	12.8	6.3	5.3	3.4	2.8

PCV – Phenotypic coefficient of variation
H – Heritability in broad sense
PNS – Per cent segregants numerically superior over JL 24
PSS – Per cent segregants significantly superior over JL 24
GCV – Genotypic coefficient of variation
GAM – Genetic advance over mean

High frequency (48%) of lines was superior to JL 24 for disease resistance with much contribution from the reciprocal cross. The frequency was moderate for yield per unit area (33%), pod yield per plant (29%) but low for shelling per cent (7 %) and hundred seed mass (11%). Low recovery of desirable segregants for some characters led to drastic reduction in the proportion of superior segregants, when more than one character combination was considered simultaneously. Nine (9%) lines were significantly superior to JL 24 for resistance. Among them, five recorded higher yield. One of these lines, line no. 10 exhibited significant improvement over Dh 8 for pod yield per plant, shelling per cent and hundred seed mass. Other lines recorded improvement in at least one of these characters indicating scope for breaking the undesirable association. Thus, potential variability was evident among the crosses for resistance but they were less potential in generating resistant segregants combining other desirable traits, revealing a need for raising large segregating population or intermating among the selected segregants.

References

Abeygunawardena, D.V.W. and Wood, R.K.S. 1957. Factors affecting the germination of sclerotia and mycelial growth of *Sclerotium rolfsii* Sacc. *Transactions of British Mycological Society*, **40**:221-230.

Bowen, K.L., Hagan, A.K. and Weeks, R. 1992. Seven years of *Sclerotium rolfsii* in peanut fields: Yield losses and means of minimization. *Plant Diseases*, **76**: 982-985.

Dwivedi, S.L., Thendapani, K. and Nigam, S.N. 1989. Heterosis and c combining ability studies and relationship among fruit and seed characters in peanut. *Peanut Science*, **16**:14-20.

Knauft, D.A. and Wynne, J.C. 1995. Peanut breeding and genetics. *Advances in Agronomy*, **55**: 393-445.

Mehan, V.K., Mayee, C.D., Brenneman, T.B. and McDonald, D.1995. Stem and pod rots of groundnut. *ICRISAT Information Bulletin*, **44**:1-19.

Mehan, V.K. and McDonald, D. 1990. Some important diseases of groundnut - sources of resistance and their utilization in crop improvement. In: *Country Training Course on Legumes Production*, 9-17 July 1990, Sri Lanka.

J. Oilseeds Res., **22**(1) : 228-230 (2005)

Short communication

Growth and yield of sesame, *Sesamum indicum* L. as influenced by seasons

Lakshmi Prayaga and P. Lakshmamma

Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, AP

(Received: July, 2003; Revised: August, 2004; Accepted: September, 2004)

Photoperiodically sesame is a shortday plant with indeterminate growth habit. It is grown in monsoon, post monsoon (*rabi*) and summer seasons as sole crop or inter crop (Sharma, 1985). Though the crop can be taken up in all seasons, the growth and yield is highly influenced by environment. These seasons provide varying environments for the growth and development of this crop. Differential response of varieties to varied environments is also possible because of varied photoperiods and temperatures. Hence, an experiment was conducted to find out variation in growth and yield of varieties grown in different seasons, the extent of variability in seed filling in different environments and to identify the suitability of these varieties to different seasons.

An experiment was conducted with nine varieties at Directorate of Oilseeds Research, Rajendranagar, Hyderabad during *kharif* 1996, 97 and summer 1997, 98 on red sandy loam soil. The varieties studied include Pb til No.1, RT 46, RT 127, Tapi, TC 289, Co-1, Gowri, Madhavi and Pratap. The experiment was laid out in Randomized Block Design (RBD) with three replications. Seeds were sown at a distance of 10 cm in rows spaced at 30 cm in 3 x 3m plots. Crop was given 30-30-20 NPK kg/ha through urea, single super phosphate and muriate of potash. 50% N, total P and K were applied as basal and remaining N was applied at flowering. Irrigation and plant protection measures were provided as and when needed. Observations on weather parameters, total drymatter, capsule number, filled and unfilled seed weight were recorded.

In the two *kharif* seasons, more rainfall (673 mm in 36 rainy days) was received during 1996 compared to 1997 (331mm in 18 rainy days). Compared to *kharif* 1997, the crop grown in 1996 received 40 mm more rainfall from germination to flowering and 302 mm more rainfall from flowering to seed filling i.e., in total 1996 crop received 342 mm more rainfall. Summer crop did not experience any rain and received more sunshine hours (775 in 1997 and 806 in 1998) compared to *kharif* (469 in 1996 and 527 in 1997). Mean temperatures did not differ much between seasons.

Crop duration was extended by three days to one week for summer crop though the crop took less time from germination to flowering, the duration from flowering to maturity was extended by 7 to 14 days than *kharif* crop. Early flowering was associated not only with long seed filling periods but also with long delays between flowering and the beginning of seed fill (Nelson, 1987).

Dry matter production of different varieties during different seasons was presented in Table 1. Total drymatter (TDM) production was more during *kharif* 1997 (34 g/plant) than *kharif*, 1996 (16 g/plant), though the amount of rainfall received was less during this season. Less TDM during *kharif* 1996 could be due to prevalence of low light intensities and reduced day length with 36 rainy days in 90 days of crop duration. Of the two seasons, summer crop performed better by producing more dry matter. Kathiresan and Gnanamoorthy (2001) also reported more drymatter at harvest in summer crop compared to monsoon crop. Among genotypes, Pratap showed 35% increase in dry weight in summer over *kharif* followed by TC 289 (27%) and Pb Til No.1 (24%). Most of the dry matter was built up during reproductive phase indicating that the growth of the reproductive structures is based on current photosynthates rather than from the remobilized drymatter and this must compete for assimilates with other vegetative sinks (Narayanan and Reddy, 1982).

In sesame, approximately 40% of drymatter is diverted to the formation of the capsules. 30% of the capsules dry weight is contributed by seed and the remaining 70% by the capsule wall. This poor partitioning of assimilates into seeds appears to be a major limitation for achieving higher yield (Saha and Bhargava, 1980). Capsule number/ plant (Table 1) was more (76) during summer compared to *kharif* (51). In the two *kharif* seasons, 1997 crop was comparable to summer crop. Increase in number of capsules could be due to better growth during these seasons. Narayanan and Narayan (1987) also reported more capsule number in summer. Partitioning of assimilates during summer season was very high due to the powerful reproductive sink size as is evident from the number of capsules. Among varieties, Gowri and CO-1 produced more number of capsules during *kharif*.

Madhavi, RT 46 and Gowri produced more capsule number during summer. Compared to their capsule production during *kharif*, RT 46, Madhavi and Pratap produced 100, 73 and 76% more capsules during summer respectively. Gowri showed similar capsule number during both seasons which shows its suitability for both the seasons.

Influence of seasons on seed yield of different varieties is presented in Table 2. Yield was higher in summer season compared to *kharif* 1996 and 1997. Similar results were reported by Narayanan and Narayan (1987a). Short photoperiods prevailing during *kharif* were known to reduce the yield of sesame drastically. Nath *et al.* (2001) reported direct positive effect of PAR and temperature on seed yield. Seed yield during *kharif* 1997 was more compared to *kharif* 1996. This could be due to more number of sunny days which is represented by more number of sunshine hours (527) and less number of rainy days (18 rainy days in 87 days of crop duration) during *kharif* 1997 compared to *kharif* 1996 which experienced 36 rainy days in a total duration of 90 days.

Table 1 Variation for TDM and capsule number in sesame varieties as influenced by seasons

Variety	TDM (g/plant)						Capsule number/plant					
	Kharif			Summer			*Kharif*			Summer		
	1996	1997	Mean	1997	1998	Mean	1996	1997	Mean	1997	1998	Mean
Pb Til No.1	11.9	23.3	17.6	20.7	23.0	21.9	31	50	41	56	65	61
RT 46	12.2	36.5	24.4	24.4	26.8	25.6	24	68	46	79	105	92
RT 127	15.9	35.0	25.5	24.7	26.6	25.7	34	44	39	56	65	61
Tapi	14.5	40.6	27.6	24.7	27.5	26.1	17	52	35	58	75	67
TC 289	13.1	23.2	18.2	22.7	23.4	23.1	36	54	45	58	60	59
CO-1	26.1	31.9	29.0	34.3	36.7	35.5	61	77	69	78	83	81
Gowri	26.5	35.9	31.2	28.3	30.1	29.2	87	79	83	85	94	90
Madhavi	14.1	40.9	27.5	30.9	34.7	32.8	26	86	56	87	107	97
Pratap	7.0	40.4	23.7	29.6	34.4	32.0	14	77	46	81	81	81
Mean	16.0	34.0	25.0	27.0	29.0	28.0	37	65	51	71	82	77
SEm±	0.41	0.94		1.04	1.13		2.06	3.0		2.71	3.13	
C.D (P=0.01)	1.70	3.89		4.30	4.67		8.53	12.39		11.19	12.94	
C.V (%)	4.5	4.8		6.2	7.3		9.8	12.0		16.6	13.4	

Table 2 Variation for seed yield and unfilled seed weight in sesame varieties as influenced by seasons

Variety	Seed yield (g/plant)						Unfilled seed weight (g/plant)		
	Kharif			Summer			*Kharif*		
	1996	1997	Mean	1997	1998	Mean	1996	1997	Mean
Pb Til No.1	3.5	5.1	4.3	6.1	4.3	5.2	0.2	0.3	0.2
RT 46	6.4	7.7	7.1	4.4	10.5	7.5	0.4	0.4	0.4
RT 127	4.6	6.4	5.5	8.2	9.0	8.6	0.4	0.2	0.3
Tapi	3.4	10.7	7.1	7.6	9.0	8.3	0.4	0.1	0.2
TC 289	4.8	5.5	5.2	4.7	7.3	6.0	0.2	0.5	0.3
CO-1	5.8	8.4	7.1	7.8	9.5	8.7	1.1	0.6	0.8
Gowri	6.2	5.4	5.8	13.6	6.4	10.0	2.2	0.7	1.5
Madhavi	2.7	10.1	6.4	11.3	10.6	11.0	0.8	0.7	0.7
Pratap	1.1	6.2	3.7	9.3	8.4	8.9	0.3	0.5	0.4
Mean	4.0	7.0	5.5	8.0	8.0	8.0	0.7	0.4	0.6
SEm±	0.43	0.55		0.48	0.62		0.06	0.07	
C.D (P=0.01)	1.76	2.25		2.0	2.56		0.26	0.27	
C.V (%)	18.1	13.0		10.4	12.9		16.2	26.4	

Unfilled seed weight (Table 2) was also more in *kharif* crop, more so in *kharif* 1996 and negligible in summer crop. Seed filling was complete in summer crop, which also resulted in increased seed yields. Kathiresan and Gnanamoorthy (2001) also reported similar results. Among the varieties, RT 46, Gowri, CO-1, TC 289 and RT 127 recorded significantly higher seed yield during *kharif* 1996 whereas during *kharif*, 1997, Madhavi, Tapi, CO-1 and RT 46 performed well. RT 46 and CO-1 performed equally well during both the seasons, which shows that they can adapt well even to low light intensities and reduced day length. During summer, Madhavi and Gowri performed better than other varieties. Pratap showed very high % increase (141) in seed yield when grown in summer compared to *kharif* followed by Madhavi and Gowri which shows that these three varieties are sensitive to low light intensities and reduced day length and therefore not suitable for heavy rainfall seasons.

Significant variation among varieties was observed for seed yield and seed filling in different seasons. Seed filling was affected only in the *kharif* crop. Compared to *kharif*, summer crop yields were more due to the production of more number of capsules and better seed filling. Pratap, Gowri and Madhavi are sensitive to low light intensities and reduced day length whereas RT 46, TC 289 and Gowri were insensitive to low light intensities and therefore suitable for all seasons.

References

Kathiresan, G. and Gnanamoorthy, P. 2001. Performance of sesame genotypes during various seasons. *Madras Agricultural Journal*, **88**: 152-153

Narayanan, A. and Narayan, V. 1987. Yield variations caused by cultivar, season and population density of Sesamum (*Sesamum indicum* L). *Journal of Oilseeds Research*, **4**: 19-27.

Narayanan, A. and Narayan, V. 1987a. Yield response of sesame cultivars to growing season and population density. *Journal of Oilseeds Research*, **4**: 193-201.

Narayanan, A. and Reddy, K.B. 1982. Growth, development and yield of sesame (*Sesamum indicum* L.) cultivars. *Field Crops Research*, **5**: 217-224.

Nath, R., Chakraborty, P.K. and Chakraborty, A. 2001. Effect of climatic variation on yield of sesame (*Sesamum indicum* L.) at different dates of sowing. *Journal of Agronomy and Crop Science*, **186** :97-102

Nelson, R.L. 1987. The relationship between seed filling period and seed yield in selected soybean germplasm accessions. *Field Crops Research*, **15**: 245-250.

Saha, S.N. and Bhargava, S.C. 1980. Physiological analysis of the growth, development and yield of oilseed sesame. *Journal of Agricultural Sciences*, **95**: 733-736.

Sharma, S.M. 1985. *Sesame*. In: *Efficient management of Dryland Crops.* (Eds.) V. Balasubramanian and J. Venkateswarlu. CRIDA, Hyderabad, pp. 245-258.

J. Oilseeds Res., **22**(1) : 231-234 (2005)

Short communication

Effect of integrated nutrient management practices on productivity, nutrient uptake and economics of sunflower intercropped with *Azadirachta indica* and *Melia azadirach* trees

Panneer Selvam and G. Bheemaiah

Department of Forestry, College of Agriculture, Rajendranagar, Hyderabad-500 030, AP

(Received: February, 2004; Revised: November, 2004; Accepted: December, 2004)

The growing demands for food, fuel and fodder due to burgeoning human and animal population and shrinkage of available land resources necessitate to increase the production per unit area. Non-availability of input like fertilizers is a paradox leading to low yields and frequent failures of crops because of their frugal resources. Therefore it is not appropriate to depend completely on traditional agriculture which is uncertain and extremely risky but to develop alternate land use systems such as agroforestry which are more sustainable and stabilize the income besides help to protect the environment. Sunflower being an important oilseed crop has the potential to respond to production inputs. Application of chemical fertilizers to soil, being expensive, often results in imbalance in soil reserve and compelled to findout suitable alternative measures such as organic manures and biofertilizers to ensure the improved soil fertility in order to sustain high productivity of crop. Hence, the study was initiated.

A field experiment was conducted during *kharif* season of 2002 at students Farm, College of Agriculture, Hyderabad to evaluate the effect of INM practices on nutrient uptake, productivity and economics of sunflower intercropped with *Azadirachta indica* and *Melia azadirach* trees. The site of the experiment was under 5 years old neem and 6 years old Melia trees spaced at 4x3 m and 6x2 m respectively. The treatment comprised of three cropping systems *viz.*, intercropping of sunflower with neem (ICN), intercropping of sunflower with melia (ICM) and sole cropping of sunflower (SC) as main plots and INM practices like control (T_1), recommended dose of N 60 kg/ha (T_2), neem green leaf manure (GLM) 5t/ha + 30 kg N/ha (T_3), melia GLM 5t/ha + 30kgN/ha (T_4), subabul GLM 5t/ha + 30 kg N/ha (T_5) and FYM 10 t/ha+30 kg N/ha (T_6) as subplots and replicated thrice in Split Plot Design. The soil of the site was red sandy loam with medium in organic carbon (0.5%), available P (20.3kg/ha) and K (195 kg/ha). The plot size was 6x4 square meter. GLM was obtained by lopping neem (N content 2.5%), melia trees (N content 2.3%) *in situ* while subabul leaves (N content 3.6%) were obtained by lopping near by trees and required quantity of GLM i.e 5 t/ha and FYM 10 t/ha (N content 0.5%) incorporated into the soil 15 days before sowing of sunflower. Recommended dose of P 60 kg/ha applied to all the plots for better decomposition. Nitrogen was applied through urea at 30 DAS in all the plots excepts control and also at sowing in T_2 treatment. The sunflower variety Morden was sown in 25.7.2002 at a spacing of 45x20cm in all the cropping systems. All the package of practices were adopted for crop and which was harvested on 17.10.2002. Gross return were calculated by multiplying economic yield in each treatment and also returns from tree biomass. Net return was calculated by subtracting cost of cultivation from gross returns for each treatment and Benefit cost ratio obtained by dividing the present value of benefit (net returns) by present value of cost (cost of cultivation). Agronomic efficiency and apparent N recovery were calculated as fallows:

$$\text{Agronomic efficiency (kg seed/kg N applied)} = \frac{\text{Seed yield (kg/ha) in each treatment}}{\text{N applied (kg/ha) in each treatment}}$$

$$\text{Apparent N recovery (\%)} = \frac{\text{N uptake in treatment (kg/ha) - N uptake in control (kg/ha)}}{\text{N applied in treatment (kg/ha)}} \times 100$$

Perusal of data (Table 1) showed that the seed yield of sunflower was significantly influenced by cropping systems. Significantly higher seed yield was recorded under sole cropping (560 kg /ha) as compared to neem and melia intercropping system with values of 461 kg/ha and 317 kg /ha respectively. Seed yield of sunflower under sole cropping increased by 21.4 and 76.6% over neem and melia intercropping systems. More yield reduction under melia trees was observed due to competition for nutrients and moisture because of shallow root system of melia and shading effect . Sarada Devi (1999) found similar results from agroforestry system.

Application of nitrogen through organic and inorganic sources significantly influenced the seed yield of sunflower. Maximum seed yield (566 kg/ha) was obtained with subabul GLM 5t/ha + 30 kg N /ha (T_5) treatment. The reduction in yield under T_2, T_3, T_4, T_6 and T_1 was by 4, 10, 13.4, 19.4 and 81%, respectively compared to T_5

treatment. Higher nutrient uptake coupled with increased nutrient release might be the reason under T_5 treatment. Solomon Allemu and Bheemaiah (2002) corroborates with the results from agroforestry systems.

Interaction effects between cropping systems and INM practices were also found significant in respect to seed yield of sunflower. Perusal of data showed that higher seed yield of 710 and 688 kg/ha in T_5 and T_2 treatments respectively noticed over other treatments under sole cropping. Comparable yield was obtained with neem intercropping system at respective INM practices. However, reduction of yield under melia was higher indicating that melia trees had adverse effect on companion crops. Okorio *et al.* (1994) from melia based agroforestry systems reported such harmful effects of melia on yield of companion crops.

Nitrogen uptake of sunflower was significantly influenced by the cropping systems and INM practices (Table 2). Uptake of nitrogen by sunflower was higher in sole cropping (57.8kg/ha) which had increased the nitrogen uptake by 7.83 and 51.1% over neem intercropping (53.6 kg/ha) and melia intercropping (38.2 kg/ha) system respectively. Higher reduction of nitrogen uptake under melia trees might be due to less light interception ultimately affecting stomatal opening and dry matter production besides not trapping the soil layers due to shallow and lateral root spread of melia. Application of subabul GLM 5 t/ha + 30 kg N /ha increased the N uptake (63.1 kg/ha) of sunflower by 3.78, 11, 14.7,21.3 and 421%, respectively over the treatments of T_2 (60.8kg/ha) T_3 (56.8 kg/ha), T_4 (55.0 kg/ha), T_6 (52 kg/ha) and T_1 (12.1 kg/ha) treatments respectively .Higher N content coupled with less lignin and fibre content in subabul GLM might have increased mineralization under conjunctive use of organic and inorganic source of nitrogen and leads to more drymatter production and N uptake. Malleswara Rao (2002) also obtained high nutrient uptake under INM practices.

The interaction effects were found significant. Application of subabul GLM 5t/ha + 30kg N/ha (T_5) under sole cropping had significantly higher N uptake of 72.4 kg/ha *and found superior to N uptake obtained at T_5 under neem* intercropping system (68.1 kg/ha) and melia intercropping system (49 kg/ha). Efficient utilization of nutrients are the reason attributed.

Table 1 Seed yield, net returns and benefit cost ratio of sunflower as influenced by cropping systems and INM practices

Treatment	Seed yield (kg/ha)				Net returns (Rs/ha)				B:C ratio			
	ICN	ICM	SC	Mean	ICN	ICM	SC	Mean	ICN	ICM	SC	Mean
T_1	116	65	142	548	380	-223	-2478	-2321	0.22	-0.04	-0.59	-0.41
T_2	570	386	688	509	5170	2990	3402	3854	0.89	0.51	0.71	0.70
T_3	523	366	639	490	3908	2047	2117	2691	0.60	0.31	0.38	0.43
T_4	506	354	610	566	3707	1906	1773	2462	0.57	0.29	0.32	0.39
T_5	582	407	710	457	4606	2533	2958	3366	0.71	0.39	0.52	0.54
T_6	470	325	575		3743	2017	1813	2524	0.62	0.33	0.36	0.43
Mean	461	317	560		3585	1878	1597		0.60	0.29	0.28	
	SEm±		CD (0.05)		SEm±		CD (0.05)		SEm±		CD (0.05)	
Mean	10.2		28.4		105		291		0.03		0.08	
Sub	10.2		20.8		129		265		0.03		0.07	
M x S	24.0		54.0		252		553		0.07		0.16	

ICN : Intercrop of sunflower with neem; ICM : Intercrop of sunflower with melia; SC : Sole crop of sunflower

T_1 : Control; T_2 : Recommended dose of N (60 kg/ha)
T_3 : Neem green leaf manure (5 t/ha + 30 kg N/ha); T_4 : Melia green leaf manure (5 t/ha + 30 kg N/ha)
T_5 : Subabul green leaf manure (5 t/ha + 30 kg N/ha); T_6 : FYM 10 t/ha + 30 kg N/ha

Table 2 Nitrogen uptake, agronomic efficiency and apparent N recovery of sunflower as influenced by cropping systems and INM practices

Treatment	Nutrient uptake (kg/ha)				Agronomic efficiency (kg seed/kg N)				Apparent N recovery (%)			
	ICN	ICM	SC	Mean	ICN	ICM	SC	Mean	ICN	ICM	SC	Mean
T_1	14.1	8.10	14.2	12.1	-	-	-	-	-	-	-	-
T_2	65.6	46.5	70.3	60.8	9.49	6.43	11.4	9.12	85.8	63.9	93.5	81.0
T_3	60.0	44.0	66.4	56.8	8.68	6.10	10.6	8.46	76.5	59.9	87.0	74.4
T_4	58.9	42.6	63.5	55.0	8.43	5.89	10.1	8.16	74.6	57.5	82.1	71.4
T_5	68.1	49.0	72.4	63.1	9.67	6.78	11.8	9.42	90.0	68.1	97.0	85.0
T_6	56.7	339.1	60.2	52.0	7.81	5.40	9.56	7.59	71.0	52.3	76.6	66.6
Mean	53.6	38.2	57.8		7.35	5.10	8.93		66.3	50.3	72.7	
	SEm±		CD (0.05)		SEm±		CD (0.05)		SEm±		CD (0.05)	
Mean	1.19		3.32		0.15		0.43		2.57		7.15	
Sub	1.24		2.54		0.16		0.33		2.14		4.38	
M x S	2.82		6.31		0.37		0.82		5.95		13.76	

Agronomic efficiency and apparent N recovery were significantly influenced by cropping system and INM practices. Sole cropping produced higher agronomic efficiency (8.93 kg seed /kg N) and apparent N recovery (72.7%) over neem intercropping and melia intercropping systems with values of 7.35 and 5.1 kg seed/kg N respectively in terms of agronomic efficiency and 66.3% and 50.3%, respectively in terms of apparent N recovery. Higher dry matter production coupled with more nutrient uptake is the probable reasons ascribed. Agronomic efficiency and apparent N recovery of sunflower significantly influenced by INM practices. Subabul GLM 5 t/ha+30 kg N/ha (T_5) resulted in higher agronomic efficiency of 9.42 kg seed/kg N with an increase of 3.28, 11.3, 11.7 and 24.1% with T_2, T_3, T_4 and T_6 treatments respectively. Increased mineralization coupled with higher N uptake might have contributed to increased values. This was in conformity with findings of Malleswara Rao (2002).

Interaction effect also had the significant influence and higher agronomic efficiency was noticed at T_5 treatment (11.8 kg seed/kg N) under sole cropping compared to other INM practices and cropping systems. Similar trend was observed with apparent N recovery. However, neem intercropping system produced similar effects of sole cropping. The reason might be timely decomposition and timely release of nutrients coupled with higher seed yield both under the sole and neem intercropping systems. Similar results were reported by Subba Reddy *et al.* (1991).

Economic evaluation of different cropping systems showed that sunflower intercropped with neem recorded higher net returns (Rs 3585/ha) and BCR (0.6) followed by ICM with net returns of Rs 1878/ha and BCR of 0.29 when compared to sole cropping with net returns of Rs 1597/ha and BCR of 0.28. Maximum net returns and BCR under neem system could be due to increased yield, whereas reduction under melia system was more due to deleterious effect of trees on yield because of its constant shade effect and competition for water and nutrients. Net returns and BCR were differed significantly due to INM practices. Nitrogen application through subabul GLM 5t/ha + 30kg N/ha and recommended dose of N 60kg/ha had resulted in higher net returns of Rs 3366/ha and Rs 3854/ha respectively over control (Rs.-2321/ha). Similar trend was noticed under BCR. Higher net returns and BCR under INM practices were due to increased yield coupled with increased availability of nutrients. The results are in accordance with findings of Singh *et al.* (1989).

Interaction effects of cropping systems and INM practices influenced the net returns and BCR. Higher net returns were obtained under neem intercropping system with recommended dose of nitrogen (Rs 5170/ha) and with subabul GLM 5 t /ha+30kg N/ha (Rs 4606/ha) over other treatments. Similar trend was observed in the BCR. Higher net returns and BCR under neem system with INM practices could be due to advantage of intercropping and green leaf manuring besides improved soil health under rainfed conditions. From alley cropping studies, Singh *et* *al.* (1989) had obtained similar results with application of green leaf manure.

From the experimental results, it is clear that all integrated nutrient management practices significantly influenced the N uptake, agronomic efficiency, apparent N *recovery and* seed yield of sunflower crop. Where as net returns and BCR were higher with recommended dose. Hence, intercropping of sunflower with neem trees proved beneficial. Further study also revealed that conjunctive use of nitrogen with freely available tree leaves like neem, subabul was advantages in terms of enhancing crop yield and sustaining soil health.

References

Malleswara Rao, N. 2002. Response of sunflower to INM practices under guava based agri-horticulture system. M.Sc (Ag) Thesis submitted to Acharya N.G. Ranga Agricultural University, Hyderabad.

Okorio, J., Byenkya, S., Wajja, N. and Pedan, D. 1994. Comparative performance of seventeen upper storey tree species associated with crops in the highlands of Uganda. *Agroforestry System*, **26**:185-203

Sarada Devi, Y. 1999. Performance of rainfed castor intercropped with *Melia azaderach* L. under different cropping systems and nitrogen levels. M.Sc. Thesis submitted to Acharya N.G. Ranga Agricultural University, Hyderabad.

Singh, R. P., Ong, C. K. and Saharan, N. 1989. Above and ground interaction in alley cropping in semi-arid India. *Agroforestry Systems*, **9**(3): 259-274.

Solomon Allemu and Bheemaiah, G. 2002. Growth and yield of groundnut under different cropping systems and nutrient management practices. *Journal of Oilseeds Research*, **19**(1):67-70.

Subba Reddy, G., Venkateshwarlu, and Shanker, G.R.M. 1991. Green leaf manuring as an alternative nitrogen source for castor bean on marginal soil of India. *American Journal of Alternative Agriculture*, **6** (3): 132-138.

J. Oilseeds Res., **22**(1) : 235-237 (2005)

Short communication

Changes in the physiological and biochemical characters of mustard, *Brassica juncea* L. genotypes grown under irrigated and rainfed condition

Maharaj Singh and Arvind Kumar

National Research Centre on Rapeseed-Mustard, Sewar, Bharatpur-321 303, Rajasthan

(Received: September, 2003; Revised: October, 2004; Accepted: December, 2004)

Rapeseed and mustard is an important group of oilseed crops in India accounting for 20.5% and 25.2% of total oilseeds hectarage and production (Anon., 2003) respectively. It is commonly grown in poor agro-climatic situations ranging from semi-arid to arid tropical zones. Nearly 37% cropped area is under rainfed where soil moisture stress affects the crops at one or more phenological stage [(Germination, early seedling growth (Pandya et. al., 1972), number of branches seed yield (Richard and Thurling, 1978) were decreased by the drought)]. The activity of nitrate and nitrite reductase, the key enzyme involved in nitrogen assimilation is substrate inducible and it's substrate NO_3 uptake is adversely affected by the drought situation. The chlorophyll content, responsible for photosynthesis also adversely affected by the drought condition. The studies on nitrogen assimilatory enzyme and chlorophyll content need more attention, thus the emphasis was given on these biochemical characters and root characters in the present studies.

The experiment was conducted in the *rabi* season of 2001-2002 with eight different mustard genotypes namely, Varuna, PCR 7, RH 819, RL 1359, Seeta, GM 1, JM 1 and Laxmi. Each variety was sown in the plot size of 3 x 5m under irrigated and rainfed situation. The two irrigations were given at vegetative (40 days after sowing) and flowering stage (80 days after sowing) to the irrigated plots while no irrigation was given to the rainfed plots. The total of 131.6 mm rain was received during the crop season (Oct., 01 to March, 02). There were three replications for the each treatment and the whole experiment was planned under Randomized Complete Block Design. The recommended dose of fertilizer was given to the crop. The soil moisture content was measured at different depths and different intervals. For root studies, the roots were pulled out carefully from the soil and washed it carefully with running tap water and measured for root depth. The root volume was measured by water replacement method. The nitrate reductase activity in leaf was assayed by the method of Jaworski (1971) whereas the nitrite reductase activity was assayed by using the method of Ferari and Varner (1971). The chlorophyll content was estimated by the method of Arnon (1949). Five competitive plants were randomly taken for each genotype from each replication to record the observation on yield and yield components.

The mean soil moisture content declined steadily from 17.0% (0 to 30 cm soil depth) and 18.0% (30 to 60 cm) at the time of sowing to 5.2% (0 to 30 cm) and 6.8% (30 to 60 cm) at maturity under rainfed condition (Table 1). While under irrigated condition, the soil moisture content decreased from sowing to 35 days after sowing . The increase in soil moisture content under irrigated condition were noted at 45 and 85 days after sowing because of the two irrigation given at 40 and 80 days after sowing. Soil moisture content of irrigated plot was recorded 10.1% (0 to 30 cm) and 11.35 % (30 to 60 cm) at maturity stage.

Table 1 Soil moisture content of irrigated (IR) and rainfed (RF) plots recorded from 0 to 30 cm and 30 to 60 cm soil profile on dry weight basis

Treatment	Soil depth (cm)	At sowing	Days after sowing					At harvest
			35	45	65	75	85	
Irrigated	0 to 30	17.2	13.7	17.6	14.4	12.3	16.8	10.1
	30 to 60	18.3	14.9	19.2	15.7	13.7	18.7	11.3
Rainfed	0 to 30	17.0	13.0	10.1	8.6	7.3	6.0	5.2
	30 to 60	18.0	14.2	12.1	9.7	8.1	7.5	6.8

The relative water content was higher in the irrigated plots at flowering and pod filling stage. The significant decrease in relative water content was observed in all the genotypes at all the growth stage under rainfed condition. The maximum reduction was recorded at grain filling stage and the minimum was recorded at vegetable stage. The genotypes JM-1 showed maximum 47.8% reduction in RWC at grain filling stage, while the genotype Varuna showed minimum 4% decrease in RWC at vegetative stage. According to Singh *et. al.*, (1999) the higher yield recorded in *B. juncea* genotypes may be attributed to their higher RWC. The higher seed yield in Rajat, DHR 9204, DHR 9504 and DHR 9401 was because of the maintenance of their higher RWC along with LWR (Singh et. al., 1999).

Significant increase in root depth and decrease in root volume were observed in all the genotypes of Indian mustard under rainfed condition as shown in Table 2. The genotype RH 819 showed maximum 49% increase in root depth where as it showed minimum decrease in root volume. While on the other hand, the genotypes RL 1359 and PCR 7 showed minimum increase in root depth under rainfed condition. Deep rooting was positively correlated with seed yield, crop growth, low canopy temperature and soil water extraction in common bean (Sponchiado *et. al.*, 1989). Drought tolerant genotype could extent their root to more depth in drought environment (White and Castillo, 1988) as observed for RH 819.

The chlorophyll content of different mustard genotypes decreased significantly under rainfed situation as shown in Table 3. The genotype Seeta and Varuna showed maximum and minimum decrease in chlorophyll content, respectively. However, the genotype RH 819 showed maximum chlorophyll. content both under irrigated and rainfed condition. The reduction in chlorophyll content under rainfed condition was related to the enhanced activity of the chlorophyllase (Ready and Vora, 1986). The drought condition lead to disruption of the fine structure of chlorophyll and instability of the pigment protein complex, which may also be the cause of the reduced chlorophyll content under rain-fed conditions. The positive though non-significant correlation of chlorophyll content with seed yield was noted by Thakral (2003).

Table 2 Changes in the relative water content, root depth (cm) and root volume (cm^2) of mustard genotypes grown under irrigated and rainfed condition

Genotype	Relative water content (%)				Root characters			
	Flowering stage		Grain filling stage		Root depth (cm)		Roof volume (cm^2)	
	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
Varuna	76.2	52.3 (31.4)	70.5	46.4 (34.2)	11.8	14.6 (19.5)	8.8	3.18 (63.6)
PCR 7	74.5	47.5 (36.2)	69.5	41.4 (40.4)	16.3	22.6 (27.8)	14.4	5.98 (58.3)
RH 819	68.3	51.5 (24.6)	74.4	43.4 (41.7)	11.2	22.1 (49.0)	15.9	11.2 (29.6)
RL 1359	77.8	46.7 (40.0)	71.9	38.5 (46.6)	17.7	17.9 (11.2)	17.4	8.55 (51.1)
Seeta	78.5	45.5 (42.1)	73.3	40.1(45.2)	11.0	13.4 (17.3)	9.0	4.87 (45.5)
GM 1	84.7	53.4 (36.9)	78.4	44.5 (43.2)	13.2	15.4 (14.9)	22.6	13.0 (42.5)
JM 1	80.7	48.9 (39.0)	76.4	39.9 (47.8)	15.2	19.6 (22.4)	22.8	13.7 (40.0)
Laxmi	83.5	55.4 (34.0)	77.5	43.4 (44.0)	15.8	18.9 (15.9)	25.3	14.7 (41.9)
CV (%)	21.4	11.2	14.6	8.79	17.5	17.2	11.3	9.57
CD (P=0.05)	6.58	3.25	6.57	3.24	1.07	1.6	2.23	1.25

Table 3 Changes in chlorophyll content, nitrate and nitrite reductase activity and yield of mustard genotypes grown under irrigated and rainfed conditions

Genotype	Chlorophyll content		Nitrate reductase		Nitrite reductase		Seed weight/plant	
	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed
Varuna	1.94	1.61 (16.9)	205.1	125.2 (38.9)	263.3	166.5 (36.8)	19.96	7.02 (64.8)
PCR 7	2.76	1.76 (36.1)	204.3	123.6 (39.5)	261.8	211.4 (19.2)	18.25	7.81 (56.9)
RH 819	4.48	2.73 (39.0)	187.3	124.6 (33.5)	256.5	204.3 (20.3)	19.29	8.78 (54.5)
RL 1359	2.46	1.56 (36.5)	174	130.6 (24.9)	227.7	165.5 (20.3)	18.86	6.95 (63.1)
Seeta	3.16	1.77 (43.9)	145.1	111.9 (22.8)	213.1	136.6 (35.9)	13.88	3.82 (72.4)
GM 1	2.17	1.46 (32.5)	165.1	119.2 (27.6)	222.2	144.8 (34.8)	19.91	4.19 (78.9)
JM 1	1.96	1.45 (25.7)	153.5	107.5 (30.0)	230.2	146.7 (36.2)	17.7	7.32 (58.6)
Laxmi	1.75	1.35(22.6)	208.9	112.3 (46.2)	281.4	171.9 (38.9)	19.38	7.12 (63.3)
CV	5.27	11.65	19.4	7.76	2.14	9.56	9.79	10.53
CD (P= 0.05)*	0.24	0.36	9.79	11.5	9.19	8.98	3.27	1.01

The significant decrease in nitrate and nitrite reductase activity was measured in all the mustard genotypes under rainfed condition. The maximum percent decrease (46.2%) in nitrate reductase and 38.9% decrease in nitrite reductase was observed in Laxmi. While on the other hand, GM-1 and PCR-7 showed minimum decrease in nitrate and nitrite reductase respectively. However, the genotype RL 1359 and PCR 7 showed maximum activity of nitrate and nitrite reductase under rain-fed condition. The effect of drought on nitrate and nitrite reductase may be attributed to inhibition of enzyme induction. It has been reported that the stress caused a shift of ribosome from polymeric to the monomenic from in maize seedling (Hsiao, 1970). *The enhanced degradation of nitrate* reductase activity system which may lead to a decrease in enzyme activity (Plaut,1974) would be the other reason for decreasing nitrate and nitrite reductase activity under drought condition. The possibility for decreased enzymatic activities under drought may also be because of limited substrate availability in the leaves resulting from inhibition of NO_3 uptake.

The seed weight decreased significantly in all the genotypes under rainfed condition. The decrease in seed yield of different mustard genotypes earlier was also reported by Singh *et. al.* (2002). The genotype Varuna showed maximum seed yield under irrigated condition which is closely followed by the genotype Laxmi and RH 819. The genotype RH 819 performed well under rainfed condition because of its deep and well spread root system and better chlorophyll content under rainfed condition. Thus it gives better yield under rainfed situation than the other genotypes. While on the other hand genotype Varuna and GM-1 performed well under irrigated condition.

References

Anonymous. 2003. Agricultural statistics at a glance. *Agricultural Statistics Division. Directorate of Economics and Statistics. Department of Agriculture and Co- operation. Ministry of Agriculture. Government of India.*

Arnon, D.I. 1949. Copper enzyme in isolated chloroplast, *polyphenyl oxide in Delta Vulgaris. Plant Physiology,* **24** : 1-15.

Ferari, T.E. and Varner, J.E. 1971. Intact tissue assay for nitrite reductase in barley aleurone layer. *Plant Physiology*, **47** : 775-794.

Hsiao, T.C. 1970. Rapid changes in polyribosomes of *Zea mays* leaves in response to water stress. *Plant Physiology*, **46** : 281-285.

Jaworski, K. 1971. Nitrate reductase assay in intact plant tissues. *Biochemistry Biophysics Research Communication*, **43** : 1274-1279.

Pandya, R. B., Gupta, S.K., Khan, M.I. and Dhindsa, K.S. 1972. Effect of PEG induced stress on germination, moisture uptake, seedling growth and nitrogen metabolism of brown sarson. *Biochemic and Physioloie der Pfanzen*, **163** : 392-397.

Plaut, Z. 1974. Nitrate reductase activity of wheat seedlings during exposure to all recovery from water stress and salinity. *Plant Physiology*, **3** : 212- 222.

Reddy, M.P. and Vora, A.B. 1986. Salinity induced changes in pigment composition and chlorophyllase activity of wheat. *Indian Journal Plant Physiology*, **21** : 265-276.

Richard, R.A. and Thurling, N. 1978. Variation between and within species of rapeseed (*Brassica camperstris* and *Brassica napus*) in response to drought stress. I. Sensitivity at different stages of development. Australian *Journal of Agricultural Research*, **29** : 469-477.

Singh, D., Kumar, S., Pannu, R.K. and Singh, D.P. 1999. Genetic variability for plant water relation and seed yield in oilseed Brassicae. *Proceeding of IX^th^ International Rapeseed Congress*, Canberra, Australia.

Singh. Maharaj, Chauhan, J.S. and Kumar, P.R. 2002. Growth and yield performance of different released varieties of mustard under irrigated and rainfed condition. *New Agriculturist*, **13** (1-2) : 19-23.

Sponchiado, B.N., White, J.W., Castillo, J.A. and Jones, P.G. 1989. Root growth of common bean cultivars in relation to drought tolerance in environment with contracting solid type. *Experimental Agriculture*, **25** : 249-257.

Thakral, N.K. 2003. *Effect of salinity on some physio-biochemical* parameters and their correlation with seed yield and seedling vigour in Ethiopian mustard. *National Seminar on " Stress management in oilseeds for attaining self reliance in vegetable oils*, Directorate of Oilseed Research, Hyderabad, Jan., 28-30, 2003.

White, J.W. and Castillo, J.A. 1988. Studies at CIAT on *mechanism of drought tolerance in bean*, In : *Research on drought tolerance in common bean* (146-151), White, J.W., Hoongenboom, G., Barra, F.I. and Singh, S.P (eds.) CIAT, Cali, Colombia.

J. Oilseeds Res., **22**(1) : 238-239 (2005)

Short communication

Evaluation of frontline demonstrations on groundnut, *Arachis hypogaea* L. in Saurashtra region of Gujarat

P.M. Vaghasia, R.L. Savalia and G.R. Kelaiya

Oilseeds Research Station, Junagadh Agricultural University, Junagadh-362 001, Gujarat

(Received: August, 2004; Revised: January, 2005; Accepted: January, 2005)

Oilseeds occupy an important position in the Indian economy as they account for 10.10% of the gross cropped area and contribute more than 5% to the gross national product. Groundnut is the king of oilseeds grown in India. It accounts for 34% of the world area under cultivation and contributes 26.8 % of the total groundnut production. Its share in the total oilseeds production of 20.87 mt was 25.44% in 1999-2000. Its yield has been fluctuating in the country due to weather aberration and area under irrigation is limited to less than 20% (Singh and Chandra, 2004). The major states that grow the crop are Gujarat (26.64%), Andhra Pradesh (26.06%), Karnataka (16.16%), Tamil Nadu (12.08%), Maharashtra (7.57%), Rajasthan (3.93%), Madhya Pradesh (3.78%), Uttar Pradesh (1.5%) and Orissa. These states together cover more than 98.5% area. Out of which Gujarat ranks first in production and groundnut is grown in an area of 19.13 lakh ha with a productivity of 2687 kg/ha in 2002-03 (Anon., 2004). In Gujarat, the region of Saurashtra contributes to 85 and 81 % of area and production respectively and this region is considered to be the groundnut bowl of the country.

Keeping in view the significance of transfer of technology, the present investigation attempts to know the yield gaps between FLD trials and farmer's field, extent of technology adoption and additional benefit and cost ratios in the Saurashtra region of Gujarat during 1998-99 to 2002-03.

The cross-sectional data on output of groundnut and inputs used per hectare have been collected from the frontline demonstration trials. In addition to this, data on traditional practices followed by the farmers have also been collected.

To estimate the technology, extension gap and technology index, the following formula has been used:

Technology gap = (Potential yield) - (Demonstration yield)

Extension gap = (Demonstration yield) - (Farmers yield)

$$\text{Technology Index} = \left[\frac{Pi - Di}{Pi}\right] \times 100$$

Where, Pi = Potential yield of i^{th} crop
Di = Demonstration yield of the i^{th} crop

During 1998-99 to 2002-03, frontline demonstrations were conducted in farmer's fields revealed that there was 1.00 to 45% increased in yield over local check i.e., farmers own practiced in varieties GG-20, GG-13, GG-5 and GG-7. The average yield in demonstration (Table 1) varied from 906 to 2412 kg/ha during all five years. Highest yield (2412 kg/ha) in demonstration was recorded during 2001-02 followed by 1658 kg/ha during 1998-99. The lowest yield (906 kg/ha) was recorded during 2000-01. In local check maximum yield (2188 kg/ha) was obtained in 2001-02, while the minimum yield (867 kg/ha) during 2000-01. The lowest yield obtained from farmers as well as demonstrations plot during 2000-01 was due to severe moisture stress condition at growth stage of crop. However, the potential yield of variety GG-20, GG-13, GG-5 and GG-7 is 3500, 2800, 2600 and 2700 kg/ha, respectively.

In general, in all the years, yield of demonstration plots was higher than local check which was due to adoption of recommended practices in FLD trials. Such type of finding also reported by Suryawanshi and Mahendra Prakash (1993).

Yield gaps: A wide gap existed between potential yield and frontline demonstration yield. This was mainly due to variation in soil fertility, non-congenial weather and local specific management problems. Technological gap was higher (2250 kg/ha) in GG-20 than GG-13 (388 kg/ha) as indicated in Table 1. Prasad *et al.* (1993) observed that similar kind of trend in pulse crops. Technological gap remain higher than extension gap during all the five years, which indicate that there is scope to further exploit the potential yield of the crop. The extension gap varied from 39 to 515 kg/ha indicating the need to educate the farmers in adoption of improved technology.

Technology index: The adoption of technology in FLD was studied through technology index and recommended package of practices being followed by the farmers.

Technology index shows the feasibility of the evolved technology in farmer's field. The lower the value of technology index, higher is the feasibility of technology. Technology index varied from 14 to 67% during all the five years. This indicated the wide gap existed between technology evolved and technology adaptation at farmer's fields. Similar finding were also reported by Kadian *et al.* (1997) and Thakral and Bhatnagar (2002).

Table 1 Impact of groundnut varieties under frontline demonstration

Year	Variety	No. of FLDs	Area (ha)	Average yield (kg/ha)		Increase in yield (%)	Technological gap (kg/ha)	Extension gap (kg/ha)	Technology index (%)
				FLD	Local				
1998-99	GG-20	5	3.5	1658	1143	45	1842	515	52
	GG-13	3	1.2	1417	1196	18	1383	221	49
	GG-5	5	2.0	1525	1275	20	1075	250	41
1999-00	GG-20	4	1.6	1350	1150	17	2150	200	61
	GG-13	3	1.2	1085	891	22	1715	194	61
	GG-5	5	2.0	1120	950	18	1480	170	57
2000-01	GG-20	2	0.8	1250	1000	25	2250	250	64
	GG-13	5	2.0	906	867	1	1894	39	67
2001-02	GG-13	2	0.8	2412	2188	10	388	224	14
	GG-5	3	1.2	1879	1583	19	721	296	28
2002-03	GG-5	8	3.2	1431	1323	8	1169	108	45
	GG-7	12	4.8	1450	1300	11	1250	150	46

Economic analysis: Production cost of front line demonstration was higher than the local check plot in all the years. It was due to the fact that farmers are using self produced seed. The additional returns of Rs. 7871, 3738, 817, 5789 and 3877, respectively were obtained during the year 1998-99, 1999-00, 200-01, 2001-02 and 2002-03. The additional return of Rs. 817 was lowest in the year 2000-01 due to low yield. The gross return of Rs. 28817, 22409, 17310, 31038 and 32680 were obtained from FLD during the year 1998-99, 1999-00, 2000-01, 2001-02 and 2002-03, respectively. There were 47, 25, 5, 28 and 13% increase in net return over local check plot, recorded during the above referred years. These findings confirms the results obtained by Sharma and Kushwah (2001). B:C ratio were also computed for all the five years on the basis of benefit obtained over production cost involved in frontline demonstrations. Highest B:C ratio (9.23) was obtained in year 2001-02 followed by (7.10) year 1998-99. The lowest B:C ratio (1.58) was recorded during 2000-01, this may be due to increase in labour and input cost in the year 2000-01.

It was concluded that conduction of groundnut frontline demonstration trials by Oilseeds Research Station had remarkable influence on the farmers regarding use of improved farm practices. Hence, it suggested that frontline demonstration trials are to be used as transfer of technology tool for adaptation of improved groundnut production technology.

References

Anonymous. 2004. Margdarshika, Directorate of Agriculture, Gujarat State, Gandhinagar, India, p.1.

Kadian, K.S., Sharma, Ravinder And Sharma, A.K. 1997. Evaluation of frontline demonstration trial on oilseeds in Kangra Valley of Himachal Pradesh. *Annals of Agricultural Research*, **18**(1):40-43.

Prasad Eswara, Y., Rao Manohar, M. and Vijayabhinandana, B. 1993. Analysis of on-farm trials and level of technology on oilseeds and pulse crop in Northern Telangana zone of Andhra Pradesh. *Indian Journal of Agricultural Economics*, **48**:351-356.

Sharma, R.P. and Kushwah, S.S. 2001. Evaluation of frontline demonstration trials in Rajgadh district of Madhya Pradesh. *Agricultural Science Digest*, **21**(3):182-185.

Singh, G. and Chandra, H. 2004. Production and economic factors growth in cultivation of groundnut crop in India *Journal of Oilseeds Research*, **21**(1):121-124.

Suryawanshi, S.D. and Mahindra Prakash. 1993. Impact of viable technology for promoting oilseeds in Maharashtra. *Indian Journal of Agricultural Economics*, **28**:420.

Thakral, S.K. and Bhatnagar, P. 2002. Evaluation of frontline demonstration on chickpea in North Western Region of Haryana. *Agricultural Science Digest*, **22**(3):217-218.

Book Review

"Applied Genetics of Oilseed Crops".

T. Ramanathan, Editor. Published by Daya Publishing House, 1123/74, Deva Ram Park, Tri Nagar, Delhi-110 035, 2004, pp.xxiv + 424, Rs. 995/-, ISBN : 81-7035-320-3.

India, with an area of about 25 *million hectares* and production of 21-22 million tonnes of oilseeds, occupies a pre-eminent position in the world oilseeds scenario. However, *of-late*, India has become a major importer of edible oils by spending more than Rs. 9000 crores annually. By the end of present decade it is estimated that the demand for oils will be of the order of 17.7 million tonnes which means doubling the present level of production. In this context, any book that provides information on advanced research work carried out on crop improvement will be valuable to the oilseeds breeder. This critical need has been met by Dr. T. Ramanathan by bringing out the book under review: **"Applied Genetics of Oilseed Crops"**.

The foreword of the book is written by none other than Dr. M.V. Rao, Vice-President; NAAS; Ex-Spl. Secretary, DARE, GOI; Ex-Spl. DG, ICAR and Ex-Vice-Chancellor, A.N.G.R.A.U., Hyderabad.

The book, besides introduction, deals with the following oilseed crops in separate chapters: Groundnut, Sesame, Sunflower, Safflower, Niger, Castor, Linseed and the currently talked about biodiesel producing *Jatropha*. The subjects dealt under each crop are: Genetic Resources, Botanical description, different techniques employed for crop improvement and advancements through molecular breeding. After covering the crops, the last two chapters deal with transfer of technology and maintenance breeding respectively. All the topics have been discussed thoroughly and supported with large number of references from scientific literature given at the end of each chapter which would not only prove very useful for those researchers who are interested in details of some specific aspects but they also make this book an excellent up-to-date authentic source of literature reviewed. The author index, followed by a subject index at the end of the book, enhanced the utility of the book for quick reference to desired topics and subjects dealt in the book. The book is also well illustrated with relevant line drawings and black and white photographs. However, being printed in black and white, that too on ordinary maplitho paper, the quality and details of these otherwise good photographs have been lost considerably. Although the presentation style of the book is attractive, there are a large number of typographical mistakes and some other technical errors, which should be corrected before the second edition, if any, is published. The book is well prepared, attractively produced with perfect binding with an art paper wrapper having an attractive photograph.

There has, however, been one significant omission in this book which is striking. That is, the book does not deal with two of the major oilseed crops grown in India *viz.*, Rapeseed-Mustard and Soybean. Both these crops put together account for almost half the oilseeds area and production of the country.

Another important factor that would limit the book's reach to maximum users is its price of Rs. 995/- for a book of 424 pages.

Over all, the book contains useful and interesting information in a reader friendly format. In view of its excellent quality and quantity of scientific contents, the book will be a valuable addition to the libraries in all agricultural colleges, oilseed research stations and also will have a special place in the personal library of every oilseeds researcher.

Hyderabad
August 2, 2004

(P.S. REDDY)
Ex-Project Director, DOR

Flat No. 201, Block-C
Amrutha Enclave
Road No.14, Banjara Hills
Hyderabad-500 034

INFORMATION FOR CONTRIBUTORS

Contributions from the members only on any aspect of oilseeds research/extension will be considered for publication. Articles *for publication* (**in triplicate**) and *subject* reviews should be addressed to the Editor, Journal of Oilseeds Research, Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, A.P., India (**A Floppy Diskette containing the manuscript should also be sent along with the revised article**). Manuscript should be prepared strictly according to the pattern of Journal of Oilseeds Research 18(1) (June, 2001) and should not exceed **15 and 5 types pages** for articles and short communications, respectively (including tables and figures).

MEMBERSHIP TARIFF

(w.e.f. 01.01.2003)

Life Membership		**Annual Subscription**		**India**	**Abroad**
Individual :	Rs.1500/- + Admn. Fee Rs.20/-	Individual	:	Rs. 150/- + Admn. Fee Rs.20/-	US$ 70
		Institutions	:	Rs. 1000/-	US$ 130 + Postage
		Students	:	Rs. 75/- + Admn. Fee Rs.20/-	

For subscription, please contact ☛ The General Secretary, Indian Society of Oilseeds Research, Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, A.P., India

ADVERTISEMENT TARIFF

(w.e.f. 01.04.2001)

Location	Two issues (Rs)	One issue (Rs)
Back cover (in side)	8000/-	5000/-
Page facing back cover	3000/-	1500/-
Inside full page	2500/-	1500/-
Inside half page	1500/-	750/-

Overall size 23 cm height (max.) x 17 cm width (max.)

1. Back cover & Full page 23 x 17 cm
2. Half page 11 x 17 cm

Indian Society of Oilseeds Research thankfully acknowledges the financial assistance received from INDIAN COUNCIL OF AGRICULTURAL RESEARCH, New Delhi for printing this Journal