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Review Article

Quality and composition of niger, *Guizotia abyssinica* (L.) Cass - A review

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Abstract

Niger, *Guizotia abyssinica* (L.) Coss is a lesser known oilseed crop of the world grown mainly in India and Ethiopia. The seeds contain around 40% oil, 20% protein and 12% sugars. The niger oil is highly nutritious with around 70% linoleic acid, an essential fatty acid. The oil also contains around 8% stearic acid which is less harmful and more healthier. The protein is more balanced with respect to the essential amino acids. Though presently the cake is utilized as an animal feed, it has a potential for good food uses. The seed and oil, however, have many food uses. With no known antinutrients, niger and its products need more attention and exploitation.

Key words: *Niger (Noug), seed, oil and cake quality,* fatty acids, amino acids, utilization

Introduction

Niger [*Guizotia abyssinica* (L.) Cass. compositae] or *noug* is an oilseed crop cultivated mainly in India and Ethiopia. It is a major oilseed of Ethiopia accounting for 50% of its total oilseeds production and a minor oilseed of India accounting for 5% of its total oilseed production. India produces around 115,000 tonnes and Ethiopia 7000 tonnes annually. India earns around Rs.30 crores through export of niger seed (Damodaram and Hegde, 2003). Niger being a minor crop of the world has received very limited research efforts. It is cultivated as a sole or mixed crop by poor farmers and also by tribal farmers in soils with poor fertility. However, the seed is edible with no known anti-nutrients. It's oil is rich in linoleic acid, the essential fatty acid, (up to 70%) and its cake is balanced in most of the essential amino acids. It is the endeavor of this paper to review the available literature on the quality, composition and utility of niger seeds and their products.

Seed and oil quality

Niger seed is an achene 3-5 mm in length and 1.5 mm in width and lanceolate in shape. The testa is hard, glossy and normally black. One thousand seed weight ranges from 1.6 to 6.0 g with a mean value of 3.8 g.

The information on niger seed and oil quality characteristics have been compiled and reviewed by Hilditch *et al.* (1994), Maiti *et al.*, (1988) and Nagaraj, (1990a). In general the composition is as follows: the seed oil 30-43% (mean 40%), protein 10-30% (20%), and soluble sugars, 7-18% (12%). The seed also contains 10% crude fibre and 4% ash. On the higher side, the seeds may contain up to 60% oil.

Sahasrabuddhe (1925) found the oil content of 10 niger samples to range from 40.9 to 45.6% and their moisture content was 2.2 to 3.9%. Sahasrabuddhe and Kale (1933b) later analysed and reported oil quality values such as specific gravity (0.92) , melting point (8°C), acidity (4), saponification value (195), Reichert Meissel value (0.85), and iodine value (126). Sahasrabuddhe and Kale (1933a) studied oil synthesis in niger and reported that sugars got converted to low molecular weight fatty acids, higher molecular weight saturated fatty acids, unsaturated fatty acids and later glycerides were formed. Enzymes in the seed were responsible for the transformations. Higher activity of the enzyme resulted in higher oil accumulation in the seeds.

The triglyceride composition of the niger oil was determined by Vidyarthi and Mallya (1940). They reported the following composition : trilinolein 2%, oleo-dilinolein 40%, dioleolinolein 30%, myristo dilinolein 2%, myristo oleo-linolein 3%, palmito dilinolein 6%, palmito oleo linolein 11%, stearo-dilinolein 2% and stearo-oleo-linolein 4%.

Dunn and Hilditch (1950) furnished information on niger seed oil and its quality. It is a pale yellow oil. A yield of 35% was obtained, when clean niger seed from Southern Rhodesia was extracted with light petroleum ether. The other characteristics of the oil were saponification value = 193, iodine value = 135, free fatty acids = 1%, unsaponifiables = less than 1%, refractive index at 25°C = 1.4723 and at 40°C=1.4679. They also reported the fatty acid composition of niger oil. They used lead salt - alcohol fractionion, iodine number and also spectro photometric methods to study the fatty acid composition. The results were as follows: palmitic = 7.9-8.7, stearic = 10.6-10.4, arachidic = 1.0-0.9, oleic = 7.0-6.9, linoleic = 72.6 - 72.8 and linolenic acid - 0.9 - 0.8%.

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Nasirullah, *et al.*, (1982) analysed eight niger samples from Maharashtra and Gujarat states of India and reported the following composition: oil content – 30-33.4%, protein = 26-30.6% and moisture = 1.7 to 3.0%. The fatty acid composition of the oil was oleic acid = 13.4 – 39.3%, linoleic acid = 45.4 – 65.8%, palmitic acid = 5.8-13%, stearic 5.0 -7.5% and arachidic acid = 0.2-1.1%. They have reported some more oil quality characteristics.

Table 1 Niger seed composition and oil quality

Constituent	Composition	
	1	2
1000 seed weight (g)	1.6-6.0	-
Oil %	30-43.2	32-32.4
Protein %	10-30	26-30
Soluble sugars %	6.9-18	-
I.V.	138.2	112.8-129.0
Refractive index 25°C.	1.4715	1.4695-1.4722
Unsaponifiables	-	0.2-1.7
Colour of the oil	2.97 + 0.5 R	2.9 Y + 0.6R

(1) Nasirullah *et al.*, (1987); (2) Nagaraj (1995)

Mechanical extraction and solvent extraction of niger seed gave oils, differing in fatty acid composition (Ahmed, 1989). The former had 83% linoleic and 3.5% oleic acid, while the latter had 71% linoleic acid 12% oleic acids. The difference might be due to higher temperatures (steam) used during solvent extraction which might have oxidized and reduced the linoleic acid.

Oil content in niger has been shown to be affected by locational altitude and/or temperature which would make selections for higher oil content difficult (Westphal and Kelber, 1973). Oil content is also influenced by hull thickness. The hull content of 25 accessions varied from 13.5 to 36.6%. Low hull varieties had higher oil, protein and low crude fibre (Getinet and Belayneh, 1989).

Riley and Belayneh (1989) have furnished information on oil quality. The niger oil was pale yellow in colour with a sweet o dour and pleasant "nutty" sweet taste. However, on storage at moderate room temperatures for more than six months, the oil thickened and became rancid. The fatty acid composition of the oil is similar to that of safflower and sunflower, with high content of up to 75% linoleic acid, except that it may contain a small amount of (2%) lignoceric acid. Indian and Ethiopian oils are reported to differ markedly in linoleic acid content, with the Ethiopian oil averaging 70% and extending upto 85 % under cool conditions. Indian oil, ranged from 52 to 74 % linoleic, with the difference being made up by oleic acid. It is believed that the temperature under which the seed matures is the major determinant of this variation.

Nagaraj (1990b) studied the fatty acid and amino acid composition of some niger varieties *viz.*, No-71, Ootacamund, -5, RCR-18 and IGP-76. Oil content was highest in No. -71 (39.4%) followed by RCR-18 (37.2%). The other three varieties had oil content in the range of 30.9 to 33.4 %. The refractive index of the oil was around 1.4715 and the oils had bright yellow colour (mean value 2.9Y + 0.5R). Oleic and linoleic acids were the main fatty acids of niger varieties which together accounted for about 85% of the total fatty acids. No-71 and IGP-76 contained around 58% of linoleic acid with an oleic acid content of around 25%. However, ootacamund and N-5 varieties had a higher level of oleic acid (29 %) and a lower level of linoleic acid content (52 %). The linoleic acid content of these Indian varieties is lower than that observed in varieties from other countries which is around 75%. The differences are mainly because of the higher temperatures prevailing in India.

Fourteen niger genotypes were analysed for seed oil, protein, iodine value and fatty acid composition (Dasthagiriah and Nagaraj, 1993). The oil content was 37-38%, protein 21-30%, iodine value 137-141, and the linoleic acid ranged from 75-78%. The nutritional quality index (linoleic acid/saturated fatty acid ratio) of the oil was 4.5-5.3. The niger was grown at Chintapally, Andhra Pradesh a hilly tract in *Rabi* season with cooler climate. Hence, higher linoleic acid was observed in those samples. It is thus evident that niger is very good nutritionally.

Dutta *et al.* (1994) collected niger seed samples from different regions in Ethiopia for determination of oil content, fatty acids, tocopherols and sterol composition in the seed oil and analysed them by gas-liquid chromatography and high performance liquid chromatography methods. There was a large variation in oil content, ranging from 29 to 39%. More than 70% of the fatty acids was linoleic acid (18:2) in all the samples analysed. The other predominant fatty acids were palmitic (16:0), stearic (18:0) and oleic (18:1) at a range of 6 to 11% each. Total polar lipids recovered after preparative thin layer chromatography comprised a small fraction of the total lipids. They had higher 16:0 and lower 18:2 contents than the triacylglycerols. Alpha tocopherol was the predominant tocopherol in all samples, 94 – 96% of the total amounting to 630 - 800 µg/g oil. More than 40% of the total sterols was â sitosterol, at 2000 µg/g oil. The other major sterols were campesterol and stigmasterol, ranging from 11 to 14% . The 5 and 7 avenasterols were in the range of 4 to 7% each.

Nagaraj (1994) analysed niger samples from eight locations in India for their fatty acid composition. Oleic to linoleic acid ratio showed wide variation with respect to location. Linoleic acid was higher (60-70%) when the mean maximum temperature was less than 30°C and mean minimum temperatures (less then 20°C) were lower. At higher temperatures, oleic acid levels were higher (around 40%).

The importance of niger germplasm as source for breeding better quality niger varieties has been stressed by Balayneh (1991). Nagaraj *et al.*, (1994) and Sharma *et al.*, (1994) have evaluated 417 niger genetic resources for their yield, morphological and biochemical characteristics. The days to 50% flowering ranged from 40-70 days (mean

62.5) while the days to maturity ranged from 90-111 days (mean 106). The plant height varied from 100-197 cm with a mean of 142 cm. The number of branches were from 3-17 with an average of 11. While the capsules ranged from 30-110 /plant (average 63/plant). The thousand seed weight ranged from 1.6 to 6.0 g with an average of 3.8 g. The per plant yield varied from 0.7 to 7.3 g with an average of 2.6 g. The mean oil was 40.2% ranging from 30-43.2% while for protein the values were 20.1 and 10-30% and for sugars, they were 11.9 and 6.9 – 18.1%. The information furnished provides wide variation in the characters examined. It revealed the scope for breeding varieties with high yield as well as better seed quality.

Getinet and Teklewold, (1995) studied the genetic, agronomic and seed quality characteristics of 241 *noug* germplasm collections from different parts of Ethiopia. The maturity of the noug accessions ranged from 132 to 168 days. Seed oil content ranged from 39.8 to 46.9% with linoleic acid being major fatty acid (76.6% of total fatty acids). The results indicated that genetic differences for maturity existed among the *noug* accessions. Oil content variation was continuous, without clear separation of accessions into oil content groups. It was concluded that the genetic variation observed among these accessions could be utilized in breeding programmes to develop high yielding, well adapted, high oil content noug cultivars for production in Ethiopia.

Nagaraj (1999) analysed 78 specialty germplasm accessions of niger for their fatty acid profile along with some plant and seed quality characters. Nineteen lines matured earlier than 105 days, while 4 had more than 4.8 g 1000 seed weight. Seed yield per plant was more than 4 g in 21 accessions. 70 had more than 40 % oil, 42 had more than 20% protein and 10 had more than 14 % sugars. The average fatty acid composition of the 78 germplasm lines was 16:0 =9.2 , 18:0 =6.5, 18:1=10.9 and 18:2=72.9 (Table 2). It was concluded that there was scope for breeding niger varieties with higher linoleic (more nutritious) acid content. It was also observed that since niger oil contained higher stearic acid which is less harmful than palmitic and myristic acids, niger oil could be considered as more nutritious and healthier oil.

Table 2 Fatty acid composition of niger oil

Fatty acid	Composition	
	1	2
Palmitic (16:0)	9.2	6.-9.4
Stearic (18:0)	6.5	5.75
Oleic (18:1)	10.9	13.4-39.3
Linoleic (18:2)	72.9	45.4-65.8
Arachic (20:0)	0.5	0.2-1.0

(1) Nasirullah *et al.*, (1992); (2) Nagaraj (1999)

Seed weight and days to maturity were negatively correlated indicating that late maturing varieties produced seed with less weight (Nagaraj, 1999). Sugars were negatively related to seed weight. Seed yield did not have any correlation with the characters studied. Sugars were positively related to linoleic acid which was negatively linked to 18:0 and 18:1. These relations revealed the involvement of sugar and the other fatty acids as precursors of 18:2 in its biosynthesis.

Nine niger genotypes developed at Semiliguda (Orissa) have been evaluated. (Venkat Rao *et al.*, 1996) for plant and seed characteristics. Genotype ONS -8 and CNS -123 gave highest yields while Pittaguda local gave the lowest yields. Genotype, ONS-1 and Pitaguda local had higher oil content of 39%. The seed protein content of the genotypes varied from 20-23%. The main fatty acid linoleic acid ranged from 74-76%. Among the genotypes evaluated GA 11 and ONS-124 were considered better from the point of view of yield and oil quality.

The studies by various workers on Indian and Ethiopian niger samples revealed that, the latter contained higher oil and linoleic acid contents. However, some Indian genotypes grown under cool climate also had higher linoleic acid (up to 76%). The quality of such oil becomes equal to safflower oil. In addition, the less harmful stearic acid is present at higher level in niger oil making it healthier than safflower oil.

Niger cake

Chavan (1961) reported the information on niger cake and its importance as cattle feed. Some of its characteristics are as follows: digestible fats, 5.2%, digestible proteins 29.8%, digestible soluble carbohydrates 21.7%. digestible fibres 3.9%, nutritive ratio 1.3% and starch equivalent 51. Niger cake appears to have a fairly high percentage of soluble carbohydrates in addition to its high protein content. The starch equivalent provides a measure of relative values of feeding stuffs for the production of growth, fat, milk or work, and is also useful for comparing the relative prices of various food stuffs; the price per ton divided by the starch equivalent gives a fair measure of the relative cost of the cakes. Niger cake as a feed has a fairly high nutritive value. It is very much relished by the cattle in the Deccan and Konkan regions of India.

Daji (1943) who evaluated eleven types of cakes for their chemical composition furnished information on niger cake composition. Moisture 7.6 %, fat 6.4 %, protein 37.0 %, soluble carbohydrates 25.8 %, fibre 14.3 %, ash 8.9 % and phosphoric acid 0.88 %. The higher percentage of inorganic constituents in the niger cake provides it an advantage. A better idea of the nutritive value of oilcake can be obtained by computing their actual digestible nutrients.

Ethiopian niger protein quality was evaluated using chemical score and essential amino acid score (Haile, 1972). It was observed that niger protein was somewhat deficient in methionine, lysine, cystine, isoleucine and leucine. But over all, only lysine was observed really deficient.

Nagaraj (1990b) analysed the deoiled cakes for protein content and amino acid composition. The crude protein content of the cake was higher in Ootacamund variety (43.44 %) followed by No-71 (40.25%). The other three varieties had protein content ranging between 37 – 39%. The sulfur containing amino acid, methionine was higher in No-71 and RCR-18 (2.3%) while cystine was higher in Ootacamund (2.4%). The total lysine content of the varieties ranged between 3 and 3.7%. Glutamine was the major amino acid (19%) followed by arginine (8%), asparatic acid (8 %) and leucine (6 %). Niger protein appears to be deficient in leucine and lysine (Table 3).

Table 3 Amino acid composition of niger protein

Amino acid	Range (g/100 g protein)	Amino acid	Range (g/100 g protein
Alanine	3.3-3.4	Arginine	7.8-8.0
Aspartic acid	7.6-7.9	Cystine	2.0-2.4
Glutamic acid	18.5-18.8	Glycine	4.3-4.4
Histidine	2.4-2.9	Isoleucine	3.6-4.0
Laucine	5.2-5.7	Lysine (total)	3.1-3.7
Methionine	1.9-2.3	Phenylalamine	4.1-4.7
Proline	3.5-4.0	Serine	4.2-4.4
Threonine	2.6-2.7	Tyrosine	2.6-3.1
Valine	4.0-4.5		

Source: Nagaraj (1990 b)

Nagaraj (1995) has furnished information on niger cake. Niger cake is dark in colour. It contains 24 to 34% proteins, 4 to 14 percent oil, 8 to 24% crude fiber, 20 to 28% sugars and 8 to 12% ash. Niger cake is mostly utilized as animal feed. The cake contains 5% N, 2% P_2O_5 and 1.5% K_2O and the low grade cake can be used as manure. Protein concentrates can be prepared from niger meal. The protein seems to be more or less balanced in its amino acid composition. It is deficient in leucine, lysine and threonine. Blending of niger cake is suggested for improving the nutritional quality of other oilseed cakes.

A lipoprotein concentrate was prepared by extracting niger seed with hot water/ethanol, NaCl solution. (Eklund, 1971a; 1971b). The lipoprotein had 4% moisture, 12% ash, 46% protein, 20% fat, 7% crude fibre and 11% soluble sugars. The energy content was 400 Kcal/100g. They also gave a conversion ratio of 5.9 to calculate protein content of niger from its nitrogen content.

Niger expeller cake is normally used as a fuel, and in India it is sometimes used as a fertilizer. In general, Ethiopian cake was found to be higher in fiber (24%), lower in protein (24%) and total digestible nutrients than other oilseed cakes. Indian niger cake was found to be lower in fiber (14%) and higher in protein (30%) (Seegler, 1983).

Utilisation

Niger seeds are edible. Their seeds fried in *ghee* can accompany other foods to improve their palatability. They are parched and mixed with pulses as snack food. A spicy preparation called chutney, prepared by mixing red chilli powder with roasted and pounded niger seeds is a common preparation in some parts of rural India (Nagaraj, 2002). Niger seeds are parched and ground with water to make a drink. The seeds can be sprinkled on bread (Riley and Belayneh, 1989). The seeds have good market values in the export market. It is utilized as bird feed in some countries (Subramanian, 2003).

Niger cake is a very useful cattle feed. In performance it was similar to groundnut and linseed cakes (Sinha *et al.*, 1983; Roy Choudhury and Mandal, 1984). Niger cake in addition to being rich in proteins, is also rich in soluble sugars. Niger cake and its protein are balanced with respect to essential amino acids. Its quality is similar to that of sesame cake. Hence, attempts are needed for wider utilization of niger cake as a food ingredient (Nagaraj, 2002). Low grade cake can be utilized as manure or fuel (Vaughan, 1970).

Better grade niger seed oil is used for edible purposes. It is also used as adulterant, particularly for sesame and mustard oils. Niger oil is used for cooking, lighting, anointing, painting and cleaning of machinery (Chavan, 1961, Patil and Joshi, 1978., Patil and Patil, 1981). Low quality oil is used as an illuminant, lubricant and for preparation of soaps and detergents (Vaughan, 1970). It is also used as a body oil for smooth skin and supple joints (Nagaraj, 1995). Niger oil is useful in birth control and treatment of syphilis (Belayneh, 1991).

Riley and Belayneh (1989) have given information on utilization of niger seed and oil. Ethiopian niger is extracted in small mechanical village expeller mills. Such oil is highly prized for edible purposes which usually commands a premium over the other available oils. Some oil is extracted in the home by parching the seed, grinding it in to a fine powder, adding hot water and stirring. This process allows the oil to float to the surface and be skimmed off. Water may also be added to the parched, ground seed to make a drink. Other minor uses include mixing the parched seed with pulses as a snack food, and making a stew or "wot" with ground seed and spices (Seegler, 1983). Niger flour is also baked into a bread or sprinkled on bread prior to consumption. In India the oil is extracted by bullock-powered "ghanies" or in mechanized mills. Usually the oil is sold for edible purposes in the local market in its pure form, but may also be mixed with other oils. Occasionally it is used as an illuminant or in the manufacture of soap or paint.

Vles and Gottenbos (1989) reported that dietary fats, rich in linoleic acid prevent cardiovascular disorders

such as coronary heart disease, atherosclerosis and high blood pressure. Also linoleic acid derivatives serve as structural components of the plasma membrane and as precursors of some metabolic regulatory compounds. The high linoleic acid content makes the niger oil nutritionally valuable and safe for human consumption. A niger based agar medium can be used to distinguish a fungus that causes a serious brain ailment from other fungi (Paliwal and Randhawa, 1978).

Conclusion

It is thus evident that niger seed, its oil and cake have very good composition and quality. They are free from antinutrients. Oil is rich in essential fatty acids, while the cake and its protein are balanced in essential amino acids. Till date no anti nutrients have been reported in niger. All of them have varied and multiple edible uses. Niger needs more attention in view of its healthier composition .

References

Ahmed, I.O. 1989. Studies on niger seed oil. *Oil crop News letter*, No.6.

Balayneh, H. 1991. Oil crop germplasm, a vital resource for the plant breeder. Pp. 344-354 in *Plant Genetic Resources of Ethiopia* eds. (J.M.M.Angeles, J.G. Hawkes and M.Woredo Cambridge University Press, Cambridge.

Chavan, V.M. 1961. In *Niger and Safflower.* Published by the Secretary, Indian Central Oilseeds Committee, Gandhi Bhavan, Hyderabad-1, pp. 30-39.

Daji, J.A. 1943. Oil cake and their uses. *Indian Farming*, **4**(11): 553-558.

Damodaram, T. and Hegde, D.M. 2003. *Oilseed Situation – A Statistical Compendium*, Directorate of Oilseeds Research, Hyderabad-30, pp-471.

Dasthagiriah, P. and Nagaraj, G. 1993. Seed and oil quality characteristics of some niger genotypes, *Journal of Oil Technologists Association in India*, **25**(2): 42-44.

Dunn, H.C. and Hilditch, T.P. 1950. African Drying Oils. II. Component of linoleic rich oils: *Niger Seed Oil Journal Society Chemistry Industry* (London), **69**:13-15.

Dutta, P.C., Helmersson, S., Kebedu, E., Getinet, A. and Appelqvist, L.A. 1994. Variation in lipid composition of niger seed (*Guizotia abyssinica Cass*) samples collected from different regions in Ethiopia. *Journal American Oil Chemist Society*, **71**(8): 839-843.

Eklund, A. 1971a. Preparation and chemical analysis of a lipoprotein concentrate from niger seed (*Guizotia abyssinica* Cass). *Acta Chemistry Scandinania*, **25** : 2225-2231.

Eklund, A. 1971b. Biological evaluation of protein quality and safety of a lipoprotein from niger seed (*G. abyssinica* Cass). Acta Physiology Scandinania, **82**: 229-235.

Getinet, A. and Belayneh. 1989. Association of hull and embryo weight with oil content in niger (*Guizotia abyssinica* Cass). *Ethiopian Journal of Agricultural . Science*, **11**: 41-43.

Getinet, A. and Teklewold. 1995. An agronomic and seed quality evaluation of niger (*Guizotia abyssinica* Cass) germplasm grown in Ethiopia: *Plant Breeding*, **114**:375-376.

Haile, M. 1972. Protein evaluation of niger meal. M.Sc. thesis submitted to the University of Arizona, U.S.A.

Hilditch, T.P., Sime, I.E., Zaky, Y.A.H. and Meara, M.L. 1944. The component acids of various vegetable fats, *Journal of the Society Chemistry and Industry* (London), **63**(4): 112-114.

Maiti, S., Hegde, M.R. and Chattupadhyay, S.B. 1988. Niger (*Guizotia abyssinica* Cass). In Handbook of Annual Oilseed Crops ed. S. Maiti, M. R. Hegde, and S. B. Chattopadhyay. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, pp. 213-227.

Nagaraj, G. 1990a. Biochemical quality analysis of oilseeds. *Journal Oilseeds Research*, **7**(1): 47-62.

Nagaraj, G. 1990b. Fatty acids and amino acid composition of niger varieties. *Journal Oil Technologists Association of India*, **22**(4): 88-89.

Nagaraj, G. 1994. Effect of location on the fatty acid composition of niger seed oil. *Journal Oil Technologists Association of India*, **26**(3): 75-76.

Nagaraj, G. 1995. *Quality and utility of oilseeds*, Directorate of Oilseeds Research, Hyderabad, pp. 28-30

Nagaraj, G, 1999. Quality and production characteristics of some specialty genotypes accession of niger : *Journal of Oil Technologists Association of India*, **31**(4): 187-188.

Nagaraj, G. 2002. Value addition for improving utility and profitability of sesame and niger in Integrated Crop *Management of Sesame and Niger.* eds. S.S. Duhoon, A.K. Tripathi and H.K. Jharia, PC Unit (S&N), JNKVV, Jabalpur pp 26-31.

Nagaraj, G., Sharma, S.M. and Balakrishnan, R. 1994. Studies on yield and some physico-chemical characteristics of niger germplasm accessions. In *"Sustainability in Oilseeds"* eds. M.V.R. Prasad, R. Kalpana Sastry. C.V. Raghavaiah and T. Damodaram. Indian Society of Oilseeds Research, Hyderabad-500 030, India pp. 523-524.

Nasirullah, K., Mallika, T., Rajalaxmi, S., Pasupathi, K.S., Ankiah, N.N., Vibhakav, S., Krishna Murthy, M.N., Nagaraja, K.V. and Kapur, O.P. 1982. Studies on niger (*Guizodia abyssinica)* seed oil. *Journal of Food Science and Technology*, (India) **19**: 147-149.

Paliwal, D.K. and Randhawa, H.S. 1978. Evaluation of simplified (*Guizotia abyssinica*) seed medium for differentiation of Cryptococcus neoformans. *Journal of Clinical Microbiology*, 7:346-348.

Patil, C.B. and Joshi, B.P. 1978. *Niger yields can be doubled. Indian Farming*, 27:9.

Patil, C.B. and Patil, B.B. 1981. Niger cultivation in Maharashtra. *Indian Farming,* Feb. 1981, **30**:13-14.

Riley, K.W. and Belayneh, H. 1989. Niger. In (eds. G. Robbbelen, R.K. Downey and A. Ashri) *"Oil crops of the world"* McGraw Hill, New York, U.S.A. pp. 394-403.

Roy Choudhury, A. and Mandal, L. 1984. Utilisation of deoiled niger (*Guizotia abyssinica*) cake in the rations of growing pigs. *Indian Veterinary Journal,* **61**:608-611.

Sahasrabuddhe, D.L. 1925. The chemical composition of the *food grains, vegetables and fruits of western India. Bulletin, Department of Agriculture,* Bombay 124-125.

Sahasrabuddhe, D.L. and Kale, N.P. 1933. A biochemical study of the formation of the oil in niger seed (*Guizotia abyssinica* Cass). *Indian Journal of Agricultural Sciences,* **3** (1): 57-88.

Sahasrabuddhe, D.L. and Kale, N.P. 1933b. A study of the oil from niger seed (*Guizotia abyssinica*). *Indian Journal of Agricultural Sciences,* **3**(3): 57-58.

Seegler, C.J.P. 1983. *Oil plants in Ethiopia. Their Taxonomy and Agricultural Significance* Centre for Agricultural Publication and Documentation, PUDOC, Wageringen.

Sharma, S.M., Nagaraj, G. and Balakrishnan, R. 1994. *Niger genetic resources: Evaluation and analysis.* Directorate of Oilseeds Research (ICAR), Rajendranagar, Hyderabad pp 1-31.

Sinha, T.N., Srivastava, J.P., Verma, A.K. and Gupta, B.S. 1983. Utilization of Niger Cake (*Guizotia abyssinica*) as a nitrogen supplement in growing calf rations. *Indian Journal of Animal Sciences, 53: 887-889.*

Subramanian, A.N. 2003. Export of Oilseeds – Potential Constraints and Memorial Measures In Souvenir. National Seminar on *"Stress Management in Oilseeds for Attaining Self Reliance in Vegetable Oils"* eds. Harvir Singh and D.M. Hegde, Indian Society of Oilseeds Research, Hyderabad, pp.128-138.

Vaughan, J.G. 1970. *The structure and utilization of oilseeds.* Chapman and Hall, London, UK. pp. 41-43.

Venkat Rao, S., Nagaraj, G., Misra, R.C. and Halder, J. 1996. Yield and quality characteristics of nine niger genotypes developed in Orissa. *Journal of Oil Technologists Association of India,* **28**(2): 57-59.

Vidyarthi, N.L. and Mallya, M.V. 1940. Component glycerides of Niger Seed Oil *Journal of Indian Chemical Society*, **17**:87, 22.

Vles, R.O. and Gottenbos, J.J. 1989. Nutritional characteristics and food use of vegetable oils. In Robbelen, G; R.K. Downey and A. Ahsri edited *"Oil Crops of the World,* Mc.Graw Hill, New pp. 63-66.

Westphal, A. and Kelber, E. 1973. Performance, oil content and quality of niger and sunflower, pp. 40-76 in *Proceeding .of Annual Agricultural Seminar, Addis Ababa.*

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Stability analysis for biochemical traits in confectionery groundnut, *Arachis hypogaea* (L.)

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Abstract

Stability analysis of confectionery groundnut genotypes was carried out over the seasons to know the existence of genotype x environmental (G x E) interactions and stability of genotypes for biochemical traits like protein content, total sugar content, O/L (oleic/linoleic) ratio and oil content. Analysis of variance revealed significant differences among genotypes for all the characters indicating diversity in the material. Presence of significant G x E interactions were noticed for protein, total sugars, oil content and O/L ratio. Pooled deviations were significant for all the characters except total sugars indicating the predominance of unpredictable portion of environment. None of the genotypes were stable across the seasons in expression of all the biochemical traits. The genotypes, in general, were more stable in expression of total sugar content and O/L ratio despite the varying environment. Summer season found favourable for expression of low oil content indicating specificity of the seasons in confectionery groundnut. Whereas, both *kharif*, 2000 and summer, 2001 seasons were suitable for increasing protein content. Among the genotypes, TGLPS 7 exhibited stability for oil content and protein content, while M 13 and TKG 19A for total sugar content and ICGV 86564 for O/L ratio.

Key words: G x E interactions, confectionery, large seeded groundnut protein, total sugars, oil content, O/L ratio

Introduction

As cultivation of groundnut in India is predominantly under rainfed conditions during *kharif* season, both biotic and abiotic factors determine the expression of crop and in turn biochemical traits, especially in confectionery/large seeded groundnut. In addition use of variety, suitable agronomic practices, seasons and plant protection measures also influence the quality of produce. In confectionery groundnut several quality parameters such as kernel weight (>70 gm), shape, size, uniformity (depends on consumer preference) and blanching property of kernels (ease in removal of testa after roasting), sensory traits, low oil content (preferably less than 40%), O/L ratio (more than 1.6), free sucrose content (more than 5% with lower levels of reducing sugars) are of paramount interest (Dwivedi and Nigam, 1995). Therefore, identification of genotypes suitable for favourable locations as well as seasons assumes importance for potential expression o characters under interest. Since there is limited information available in literature pertaining to stability of performance of confectionery groundnut genotypes in respect of biochemical traits like protein, total sugars, O/L ratio and oil content, the present investigation was carried out using 13 elite genotypes for evaluation over different seasons.

Material and methods

Experimental material for the present study consisted of 13 elite large seeded genotypes from different habit groups of groundnut. Out of these, two genotypes M 13 and HPS-II-9701 were Virginia runner maturing in 130-140 days, seven Virginia bunch types *viz.*, Somanath, ICGV 86564, ICGV 94217, TKG 19A, TGLPS 1, TGLPS 3 and BAU 13 maturing in 115-120 days and four Spanish bunch types *viz.*, TGLPS 4, TGLPS 7, JL 24 and TAG 24 maturing in 100-110 days. The latter two were commercial oil types used as checks in the absence of released confectionery variety for cultivation in Karnataka, since kernels of these being treated as bold after grading.

A field experiment comprising all the 13 genotypes was laid out in a Randomized Complete Block Design with three replications in a single location at the Oilseed Block of ain Agricultural Research Station, University of Agricultural Sciences, Dharwad during two consecutive *kharif* seasons of 1999 and 2000 and summer, 2001. A suitable spacing of 45 cm between rows with intra row spacing of 10 cm was followed with application of recommended dose of fertilizers to the experimental crop in all the growing seasons. However, gypsum at the rate of 250 kg/ha to summer irrigated crop was provided as an additional input. Biochemical analysis for all the traits was carried out drawing kernel samples from bulk produce of each replication and season. Oil content of the samples was analysed using NMR (Nuclear Magnetic Resonance) spectrometer installed at RARS, Raichur. Protein per cent was estimated by N content of the samples (multiplied by 5.3) and total sugars by following Anthrone method

(Sadasivam and Manickam, 1992). Fatty acid composition was analysed in a Shimadzu 9A model gas chromatograph equipped with a flame ionization detector at Crop Quality Laboratory CMBD, ICRISAT Asia centre and expressed as O/L ratio. A two-way analysis of variance was performed and the stability parameters were computed following the model proposed by Eberhart and Russell (1966) and Breese (1969). The type of stability is decided on regression coefficient (b_i) and mean values (Finlay and Wilkinson, 1963). If b_i is equal to unity, a genotype is considered to have average stability (same performance in all the environments). If b_i is more than unity, it is suggested to have less than average stability (good performance in favourable environments) and if b_i is less than unity, it is reported to have more than average stability (good performance in poor environments).

Results and discussion

Mean squares due to genotypes were significant for protein content, total sugars, O/L ratio and oil content indicating genotypic differences for these attributes (Table 1). The mean squares due to genotype x environment interactions were significant for all the biochemical traits indicating that genotypes behaved differently in different seasons in expression of these characters. Existence of G x E interactions in non-confectionery groundnut has also been reported for protein content (Nagaraj and Sheela, 1987; Dwivedi *et al.*, 1990) for total sugars (Nagaraj and Sheela, 1987) for O/L ratio (Dwivedi *et al.*, 1993) and for oil content (Kumar *et al.*, 1984; Raut *et al.*, 1993; Dwivedi *et al.*, 1993; Moinuddin *et al.*, 1998). Pooled deviations were highly significant for all the traits except for total sugar content indicating that unpredictable environment formed the major portion of G x E interactions. The variance due to G x E (linear) and pooled deviations (non-linear) observed to be significant for oil content and O/L ratio indicating the prevalence of both predictable and unpredictable portion of environments influencing these traits.

Table 1 Pooled analysis of variance for stability in respect of different biochemical traits

Source of variance	d.f.	Mean sum of squares			
		Protein content (%)	Total sugars (%)	O/L ratio	Oil content (%)
Genotypes	12	25.50**	11.36**	0.1068**	2.73*
Environments	2	25.01**	11.32**	0.0023	30.77**
G x E	24	3.50**	0.46**	0.0033**	1.19**
Environment (linear)	1	50.02**	22.64**	0.0048	61.55**
G x E (linear)	12	4.32	0.60*	0.0043*	1.77**
Pooled deviation	13	2.46**	0.30	0.0021**	0.55**
Pooled error	72	0.29	1.03	0.0007	0.35

* and ** indicate significance at 5% and 1% probability levels, respectively.

The mean performance of genotypes in individual environments for all the traits and stability parameters is presented in Table 2 and 3, respectively. Analysis of genotypes with respect to their performance in individual environment revealed that *kharif*, 2000 and summer, 2001, in general, were favourable from the point of view of assured moisture while *kharif*, 1999 was an unfavourable season due to low and erratic distribution of rainfall.

Table 2 Performance of confectionery genotypes for different biochemical traits over seasons

Genotype	Protein content (%)			Total sugars (%)			O/L ratio			Oil content (%)		
	Kharif 1999	*Kharif* 2000	Summer 2001	*Kharif* 1999	*Kharif* 2000	Summer 2001	*Kharif* 1999	*Kharif* 2000	Summer 2001	*Kharif* 1999	*Kharif* 2000	Summer 2001
M 13	18.7	22.8	20.7	16.1	18.5	16.5	1.5	1.5	1.5	44.1	45.7	42.7
ICGV 86564	17.3	19.9	21.5	15.4	16.1	14.7	1.7	1.5	1.6	46.8	48.5	43.9
JL 24	15.6	27.0	23.5	15.5	16.6	12.7	1.0	1.0	1.2	44.8	44.7	42.7
ICGV 94217	22.9	23.8	21.4	14.0	15.1	11.2	1.5	1.5	1.3	45.0	45.5	41.7
TGLPS 1	15.4	16.7	15.2	16.6	17.5	14.6	1.4	1.4	1.4	45.2	45.5	44.7
TGLPS 3	14.8	17.3	16.4	15.4	16.4	15.4	1.4	1.5	1.4	44.9	44.3	42.6
TGLPS 4	14.2	15.9	14.8	11.5	12.6	10.2	1.4	1.4	1.3	45.3	45.4	45.7
TGLPS 7	16.3	18.7	16.4	17.5	18.5	18.1	1.4	1.4	1.4	44.3	45.9	43.1
TKG 19A	21.7	21.1	18.5	16.7	18.1	16.4	1.3	1.4	1.3	44.7	45.5	40.5
BAU 13	15.7	19.4	17.8	13.1	12.8	11.6	1.7	1.7	1.7	46.1	46.0	44.7
Somnath	18.7	18.4	17.4	13.0	13.9	12.7	1.3	1.3	1.2	45.5	48.5	42.7
HPS-II-9701	20.4	20.0	17.9	16.0	16.5	15.4	1.5	1.5	1.5	46.2	45.2	40.4
TAG 24	22.1	28.2	23.9	14.9	15.5	14.2	1.0	1.0	1.2	45.7	45.5	43.1
Env. Index	-1.2	1.52	-0.31	0.00	0.94	-0.93	0.10	0.001	-0.01	0.57	1.17	-1.74
CD (P=0.05)	0.86	1.02	0.89	1.86	1.43	1.82	0.06	0.05	0.03	0.83	0.97	0.74

Table 3 Stability parameters of confectionery groundnut genotypes for different biochemical traits

Genotype	Protein content (%)			Total sugars (%)			O/L ratio			Oil content (%)		
	Mean	b_i	S^2di	Mean	b_i	S^2di	Mean	b_i	S^2di	Mean	b_i	S^2di
M 13	20.75	1.44	0.15	17.06	1.10	0.91	1.49	1.91	0.00	44.20	0.90	0.53
ICGV 86564	19.56	0.70	6.93**	15.42	0.74	-0.34	1.61	1.06	0.01	46.37	1.49	0.24
JL 24	22.05	3.84**	10.76**	14.91	2.09	0.15	1.08	-1.53	0.01	44.08	0.76	0.05
ICGV 94217	22.70	0.49	1.88*	13.45	2.06	0.14	1.44	1.31	0.00	44.07	1.36	-0.06
TGLPS 1	15.77	0.51	0.15	16.22	1.53	-0.10	1.41	1.40	0.00	45.13	0.25*	-0.10
TGLPS 3	16.16	0.86	0.31	15.74	0.52	-0.17	1.44	1.50	0.00	43.93	0.71	0.39
TGLPS 4	14.95	0.64	-0.10	11.43	1.25	-0.33	1.37	2.77	0.00	45.50	-0.11*	-0.10
TGLPS 7	17.13	0.93	0.16	18.01	0.21	0.10	1.38	0.77	0.00	44.42	0.94	0.59
TKG 19A	20.41	0.04	5.79**	17.08	0.95	-0.17	1.33	2.97	0.00	43.56	1.74	-0.10
BAU 13	17.65	1.26	0.41	12.49	0.63	0.23	1.72	2.37	0.00	45.60	0.51	-0.01
Somnath	18.18	0.00	0.74	13.19	0.64	-0.27	1.26	0.66	0.00	45.54	1.78*	1.81*
HPS-II-9701	19.45	0.04	3.69**	15.97	0.59	-0.34	1.52	-1.07	0.00	43.94	1.87*	2.27
TAG 24	24.75	2.24	-0.08	14.88	0.69	-0.34	1.04	-3.26	0.00	44.76	0.91	0.16

* and ** indicate significance at 5% and 1% probability levels, respectively.

Eight out of 13 genotypes *viz.*, TGLPS 1, TGLPS 3, TGLPS 4, TGLPS 7, TAG 24, Somanath, BAU 13 and M 13 remained stable for protein content over the seasons as seen from the least deviations from their regression coefficients. Considering high mean protein content and b_i values nearer to unity, the genotypes TGLPS 7 and TGLPS 3 expressed average stability, therefore, these genotypes found suitable for cultivation in any seasons of the year. The genotypes M 13, BAU 13 and TAG 24 expressed higher protein content only during favourable seasons and, therefore, considered to be having below average stability (b_i value > unity).

Total sugar content of the genotypes observed to vary least from season to season indicating its stable expression. Among the genotypes, TGLPS 7 had the highest total sugar content (18.0%) followed by TKG 19A and M 13 (both recording 17.0%). While the genotypes TGLPS 4 and BAU 13 had the least total sugar content and were on par with non-confectionery checks like JL 24 and TAG 24. Highly stable performance of genotypes for sugar content over the environments had also been supported by the least deviations from their regression coefficients. In general, the character exhibited the least interactions with the surrounding environment and selection could be practiced for achieving higher sugar content. Considering all the three stability parameters the genotypes M 13 and TKG 19A were highly stable for this character.

All the genotypes appeared to be fairly stable even under varying environments in expression of O/L ratio, however, exhibiting genotypic differences where BAU 13 was superior for O/L ratio (1.68) followed by ICGV 86564 (1.6) and HPS-II-9701 (1.5). Due to non-significant deviations from regression coefficients these genotypes can be considered as stable in view of the least influence by environments. Considering high mean and unit regression, ICGV 86564 exhibited greater stability despite varying environments. The genotypes BAU 13, M 13, TGLPS 3 and ICGV 94217 found to have adaptation only to favourable environments due to high mean with b_i values greater than unity.

Kharif season was found favourable for the genotypes in expression of higher oil content and in the present case summer is desired for cultivation of confectionery types to exploit seasonal environment to achieve low oil content. The mean oil content of the genotypes across the environments varied from 43.5 to 46.3, a narrow difference but almost all the genotypes were stable in expression of oil content as noticed by non-significant deviations from their regression coefficients. Only two genotypes *viz.*, Somanath and HPS-II-9701 exhibited significant deviations and considered to be highly sensitive to changing environment. Considering high mean oil content and unit regression non-confectionery genotypes JL-24 and TAG 24 were highly stable in their performance and were unaffected by the seasonal cultivation. Among the confectionery genotypes TGLPS 3 and TKG 19A were specifically adapted to summer season and can be exploited to achieve lower oil content.

Although the study did not reveal genotypes exhibiting stability for more than one biochemical trait, it si highly relevant in identifying genotypes with wider adaptation over seasons or suitability to specific season for a particular character. Thus, it needs more number of genotypes to be involved in future evaluations over both locations and seasons to identify genotypes possessing stability for host of biochemical traits.

References

Breese, E.L. 1969. The measurement and significance of genotype environment interactions in grasses. *Heredity*, **24**:181-200.

Dwivedi, S.L., Jambunathan, R., Nigam, S.N., Raghunath, K., Ravishankar, K. and Nagabhushanam, G.V.S. 1990.

Relationship of seed mass to oil and protein contents in peanut (*Arachis hypogaea* L.). *Peanut Science*, **17**:48-52.

Dwivedi, S.L. and Nigam, S.N. 1995. Breeding for the improved seed quality in groundnut (*Arachis hypogaea* L.) with special reference to export promotion, issues and opportunities. Paper presented at the Workshop on *"Status of Confectionery Groundnut Research in India and Strategies for Export Promotion"*, BARC, Trombay, April, 1995, p.10.

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

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

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

Kumar, P., Yadava, T.P. and Gupta, S.C. 1984. Stability analysis in bunch group of groundnut. *Journal of Research Haryana Agricultural University*, **14**:180-183.

Moinuddin, H.H., Reddy, B.G.S., Lohitashwa, H.C., Sheriff, R.A., Kulkarni, R.S. and Patil, B.R. 1998. Stability for yield and its components in groundnut (*Arachis hypogaea* L.). *Journal of Oilseeds Research*, **15**:238-241.

Nagaraj, G. and Sheela, C. 1987. Seasonal variation in the oil quality of groundnut. *Indian Journal of Agricultural Sciences*, **57**:522-524.

Raut, S.S., Birari, S.P. and Jamadgni, B.M. 1993. Genotype x Environment interaction in bunch erect group of groundnut (*Arachis hypogaea* L.). *Indian Journal of Agricultural Sciences*, **63**:23-26.

Sadasivam, S. and Manickam, A. 1992. *Biochemical methods for Agricultural Sciences*. Wiley Eastern Limited, New Delhi, p.245.

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Effect of imposed drought conditions on genetic variation and association of physiological and yield traits in groundnut, *Arachis hypogaea* L.

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Abstract

A field experiment was conducted at ICRISAT centre, Patancheru, A.P. during rabi/summer season of 1999-2000 to evaluate twenty genotypes of groundnut for variability, heritability and genetic advance under normal growing environment, mid-season drought and end-of-season drought conditions. Selection for characters, crop growth rate (CGR), pod growth rate (PGR), no. of mature pods and oil percentage under normal conditions should be preferred. Similarly selection for harvest index and shelling percentage under mid-season drought, specific leaf nitrogen content (SLN), partitioning of dry matter to pods (PDM) and sound mature kernel percentage under end-of-season drought, relative leaf water content (RWC) under both the stress conditions and specific leaf area (SLA) under either normal or mid-season drought and hundred kernel weight under either normal or end-of season drought conditions should be preferred.

Under normal growing environment, CGR, PGR and SLN were positively correlated with pod yield and SLA negatively. Under mid-season drought, SLA was negatively correlated with pod yield and under the end-of–season drought, SLN, PGR, 100-kernel weight and sound mature kernel percentage positively. It would be useful to integrate SLA and SLN in a selection scheme for pod yield in a breeding program as they provide easily measurable indirect estimates for it.

Key words: Peanut, variability, heritability, genetic advance, correlation, moisture regimes

Introduction

Groundnut (*Arachis hypogaea* L) is a major leguminous oilseed crop in India. About 84% of groundnut in the country is grown in rainy season under rainfed conditions with little or no input. The crop often suffers from drought because of low and erratic rainfall during the season. The productivity of the crop under rainfed conditions remains low (997 kg/ha) as compared to irrigated post rainy season conditions (1512 kg/ha) (Anonymous, 2000). For any significant improvement in groundnut production in the country, its productivity under rainfed conditions will have to be improved substantially by growing drought-tolerant (including tolerance to other major stress factors), water-use efficient cultivars.

The past efforts, based on empirical approach, to develop drought tolerant genotypes have been inefficient and tardy. Recently, the focus in resistance breeding has shifted towards physiological traits associated with drought. Many physiological traits are associated with drought tolerance/increased water-use-efficiency in groundnut. These include, among others, relative leaf water content (Ravindra *et al.*, 1990), specific leaf area and radiation use efficiency (Wright *et al.*, 1994), leaf nitrogen content (Nageswara Rao *et al.*, 2001), crop and pod growth rates (Greenberg *et al.*, 1992; Nageswara Rao *et al.*, 1993) and partitioning and harvest index (Nageswara Rao *et al.*, 1993). Genotypic differences for these traits are also reported in literature.

Economic yield in groundnut, like any other crop species, is a complex character determined by various physiological processes through its components. There are several reports on genetic and phenotypic variation, heritability, expected genetic advance and correlation studies for yield and its components under normal or irrigated conditions (Chaudhary, 1993; Reddi *et al.*, 1991), but such reports are limited under imposed drought or limited moisture conditions (Reddy and Gupta, 1992; Chavan and Dhoble, 1994). For physiological traits, such information is very limited (Jayalakshmi *et al.*, 1999; Reddy and Gupta, 1992). Some of the physiological traits contributing to drought tolerance are reported to be associated with each other (Greenberg *et al.*, 1992; Wright *et al.*, 1994; Nageswara Rao *et al.*, 1995; Jayalakshmi *et al.*, 1999). But association of physiological and yield components with yield under moisture stress conditions are limited. So the present investigation was conducted to study phenotypic and genetic variability, heritability,

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expected genetic advance and correlation for physiological traits associated with drought and yield and its components in selected groundnut germplasm in three moisture regimes.

Material and methods

Twenty groundnut genotypes were included in the study (Table 1). The experiment was conducted at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) during the 1999/2000 *rabi*/Summer season (Dec-April) under three moisture regimes in a strip plot design with three replications. The moisture regime 'No drought' received full irrigation during the whole crop duration through the line source sprinkler irrigation system and served as the control. The mid-season and end-of-season droughts were imposed by withholding irrigation between 50-100 days after sowing (DAS) and 100 DAS to final harvest, respectively. For the remaining period, these treatments received full irrigation. A buffer area of 3.6 m width was left between the moisture regimes in the field to arrest the seepage across the treatments. There was no rain during the cropping period. The experiment was sown on 4th December 1999. The plot size was 4 m x 1.2 m with spacing of 30 cm x 10 cm. The experiment received 40 kg P_2O_5/ha as basal application and 400 kg gypsum/ha at the peak flowering stage. The crop was fully protected against diseases and insect pests. The observations on physiological traits were recorded before harvest. A net plot area of 2m x 1.2m (2.4 m^2) was harvested at maturity to record the observations on yield and its components. The following observations were recorded on the experimental material.

Relative leaf water content (RWC): From each plot, 2nd or 3rd healthy leaf from the apex of the main stem of each of eight randomly selected plants was sampled in the morning hours in plastic bags. The fresh weight of each leaf was recorded immediately in the laboratory. Turgid weight of leaves was recorded after floating them in water for 5-6 hrs. in plastic trays. Dry weight of leaves was recorded after oven drying them at 80° C for 48 hrs. The RWC was calculated as

RWC (%) = [(Fresh weight (g) – Dry weight (g))/Turgid weight (g) – Dry weight (g))] x 100

Specific leaf nitrogen (SLN) and specific leaf area (SLA): Either the 2nd or the 3rd healthy leaf from the apex on the main stem was collected in plastic bags from each of eight randomly selected plants in each plot. These leaves were brought to laboratory and on each leaf, eight SPAD Chlorophyll Meter readings were taken (two readings/leaflet) as a measure of leaf nitrogen content (Nageswara Rao *et al.*, 2001). The values for eight leaves were averaged. After measuring the SPAD values, leaf area of each leaf was measured by an automatic leaf area meter (LICOR 3100). Dry weight of leaves was recorded after oven drying them at 80° C for 48 hrs. The SLA was calculated as, SLA (cm^2/g) = Leaf area (cm^2)/ Oven dry weight (g).

Light interception (LI %): Canopy light interception (LI) was measured at mid-day by a Ceptometer (Degagon Instruments, Washington, USA). The readings were recorded in each plot by placing the sensor across the rows at two canopy levels (below and above the canopy). The fractional radiation intercepted by the canopy at a given time was calculated as follows:

LI (%) = $[(I_o-I)/I] \times 100$

Where,

I_o = Total incoming radiation (reading above the canopy)

I = Radiation transmitted to the ground (reading below the canopy)

Growth rates (CGR and PGR) and PDM: Growth analysis was conducted in each plot on plants harvested from a ground area of 0.6 m^2 [1.2m (4 rows width) x 0.5 m (length)] at 50 DAS, 100 DAS and at final harvest. Plants were separated into leaves, stems, and pods. Roots were discarded. These separated components were oven dried at 80° C for 48 hrs and their dry weight was recorded. Dry weights of all these were converted into dry weights per meter square area. Pod weight m^{-2} area was calculated and adjusted by multiplying it with a factor 1.65 (Duncan *et al.*, 1978). Crop growth rate (CGR) (g m^{-2} day^{-1}) and Pod growth rate (PGR) (g m^{-2}/day) were calculated by regressing adjusted biomass weight m^{-2} (oven dried leaf + stem+ adjusted pod weights per m^2 area) and adjusted pod weight m^{-2} with days after sowing respectively. Then partitioning of dry matter to pods (PDM) was worked out as PDM = PGR/CGR.

Yield and yield components: Observations on yield per plot and the yield contributing characters, i.e. number of mature pods per plant, shelling percentage, hundred kernel weight and sound mature kernel percentage were recorded. Oil content was estimated on a random seed sample (20 gm) from each plot. Genotypic and phenotypic coefficient of variability (GCV and PCV) and heritability percentage (broad sense) were worked out as per Singh and Chaudhary (1977). The expected genetic advance per cent over mean (GAM %) was worked out according to Johnson *et al.* (1955). Correlations were computed. All these parameters were worked out for each moisture regime treatments separately.

Results and discussion

The estimates of genetic parameters for physiological traits under three moisture regimes are presented in Table 2. As expected, the PCV (%) for all the traits in all the three moisture regimes was higher than the GCV (%) indicating that the environment had played a role in enlarging the phenotypic variability of these traits. Mid-season and end-of- season droughts operate at and influence different phenological stages of plant growth.

GCV for RWC, SLN, HI and PDM increased under moisture stress conditions. However, the reverse was true for CGR and PGR as their GCV was maximum under normal growing conditions. Full availability of moisture throughout the cropping season ensured maximum expression of these traits in each genotype. GCV for LI was maximum under mid-season droughts. Differential recovery of genotypes from mid-season drought creates variation in canopy affecting light interception (Williams *et al.*, 1986). The genetic variation in SLA was least affected by moisture regimes. It appeared a more stable trait at the genetic level. PCV for RWC and HI increased under moisture stress conditions. For traits, SLN, LI, PGR and PDM, it was maximum and for SLA minimum under mid-season drought conditions. PCV for CGR varied little across the three moisture regimes. Both GCV and PCV for RWC and HI were higher under moisture stress condition. Similarly, for LI, both of them were maximum at mid-season drought. For other traits, there was no agreement between GCV and PCV in their response to moisture regimes.

Table 1 Information on groundnut genotypes used in the study

Genotype	Botanical type	Pedigree	Year of release
JL 24	Spanish	Selection from EC 94943	1978
TMV 2	Spanish	Mass selection from 'Gudhiathum Bunch'	1940
S 206	Spanish	Selection from Manvi local	1969
KRG 1	Spanish	Selection from Argentina variety	1981
TAG 24	Spanish	TMS 1 x TGE 1	1978
D 39d	Spanish	VG 101 x KRG 1	*
KRG 2	Spanish	ICGS 11 x Chico	1994
KRG 3	Spanish	JLM 1 x TG 23	1996
R 9214	Spanish	(ICGS 7 x NC Ac 2214) X ICGV 86031	*
R 922s7	Spanish	(ICGS 7 x NC Ac 2214) ICGV 86031	*
K 134	Spanish	Kadiri 3 x JL 24	1993
ICGV 86031	Spanish	F 334A-B-14 x NC Ac 2214	1982
ICGV 86635	Spanish	NC Ac 2768 x NC Ac 17090	*
ICGV 92113	Spanish	ICG 1697 x ICG 4790	*
ICGV 92118	Spanish	ICGV 87340 x ICGS 11	*
ICGV 92120	Virginia	ICG 3736 x (TMV 10 X Chico)	*
ICGV 93260	Spanish	ICGS 11 x ICG 4728	*
ICGV 93261	Spanish	ICGS 11 x ICG 4728	*
ICGV 93269	Spanish	ICGS 11 x JL 24	*
ICGV 93277	Spanish	ICGV 87339 x Ah 7827	*

Spanish = *A. hypogaea* ssp. *fastigiata* var. *vulgaris*
Virginia = *A. hypogaea* ssp. *hypogaea* var. *hypogaea*
* = Genotypes which are improved germplasm or advanced breeding lines.

As broad sense heritability and expected GAM for CGR and PGR were highest under normal environment, the selection for these traits should be practiced in such an environment. Although the broad sense heritability for HI was the highest under normal growing environment, but its PCV and GCV were lowest. On the other hand, it had higher GCV and PCV under mid-season drought, but the heritability was lower than normal growing environment. Expected GAM for HI was the highest under mid-season drought followed by normal growing environment indicating a relatively greater progress in selection for this trait in the former environment. RWC was better selected under moisture stress as both heritability and expected GAM were higher under these environment; the end-of-season drought being the better. End-of-season drought was a good environment to select for SLN and PDM, as both heritability values and expected GAM were highest under this growing condition. For selection for SLA, both mid-season drought and normal growing environment were better than end-of-season drought.

The estimates of genetic parameters for yield and its components are presented in Table 3. GCV, PCV, heritability and GAM for pod yield were higher under mid-season drought and normal growing environment than end-of-season drought suggesting that the selection for pod yield should be carried out under the former conditions. Selection for shelling percentage under mid-season drought and for 100-kernel weight either under normal condition or end-of-season drought condition was preferred because of the higher values of the genetic parameters under such growing conditions. For number of mature pods per plant, GCV, heritability and GAM were highest under normal growing condition, the PCV was highest under mid-season drought conditions. For this trait also, selection under normal growing condition was preferred. End-of-season drought was the preferred environment for selection for sound mature kernel percentage because of the higher values of genetic parameters for this trait in that environment. Both normal growing and end-of-season drought conditions created more variability for oil content, but its heritability and GAM were highest under normal growing conditions. This suggested that preferred environment for selection for oil content should be normal growing conditions.

Correlations of pod yield with its components and physiological parameters did not present a consistent

picture under three moisture regimes (Table 4 and 5). CGR, PGR, and SLN correlated positively and SLA negatively with pod yield under normal growing conditions. However, except for SLA, these correlations disappeared under mid-season drought conditions. Under end-of-season drought condition, SLN, PGR, 100-kernel weight and sound mature kernel percentage correlated positively with pod yield. From these results, it is evident that SLN and SLA at harvest can provide easily measurable indirect estimates of pod yield for selection in segregating populations in a normal growing environment in a breeding program. SLN and SLA have shown stability across environments (Nageswara Rao and Wright, 1994; Nageswara Rao *et al.*, 2001). PGR can also serve the purpose, but it is not an easily measurable trait. It would be useful to integrate SLN and SLA in a selection scheme for high pod yield in groundnut.

Table 2 Estimates of variability parameters for physiological characters under three moisture regimes in groundnut

Character	Drought	GCV(%)	PCV(%)	Heritability	GAM (%)
Relative leaf water content at harvest	1	3.61	5.54	42.37	4.86
	2	6.16	8.53	52.15	9.17
	3	9.59	13.51	50.38	14.02
Specific leaf nitrogen content at harvest	1	7.90	11.87	44.27	10.83
	2	9.88	20.28	23.76	9.92
	3	9.90	11.51	74.02	17.54
Specific leaf area at harvest	1	7.66	14.63	27.40	8.25
	2	6.06	10.05	36.32	7.52
	3	6.76	17.90	14.27	5.26
Light interception at harvest	1	11.25	14.83	57.48	17.57
	2	25.86	34.00	57.85	40.53
	3	4.82	13.30	13.16	3.61
Crop growth rate	1	15.60	21.33	53.47	23.55
	2	13.86	22.11	39.29	17.96
	3	12.93	23.59	30.17	14.60
Pod growth rate	1	14.25	21.09	45.70	19.84
	2	8.87	29.10	9.15	5.64
	3	7.26	25.28	8.03	4.33
Partitioning of dry matter	1	7.35	12.17	37.03	9.30
	2	7.92	18.17	19.23	7.20
	3	9.82	13.33	52.94	14.59
Harvest index	1	12.80	14.24	80.73	25.49
	2	18.82	23.03	66.79	30.95
	3	17.10	26.59	41.36	21.46

1= *Normal condition;* 2= *Mid-season drought;* 3= *End-of-season drought*

Table 3 Estimates of variability parameters for yield and its components in groundnut

Character	Moisture regime	GCV (%)	PCV (%)	Heritability (%)	GAM (%)
No. of mature pods	1	25.57	40.64	39.61	33.11
	2	25.24	58.48	18.65	22.50
	3	9.87	48.38	4.18	4.17
Pod yield	1	18.17	25.58	50.47	26.59
	2	17.25	23.96	51.85	25.60
	3	13.65	21.51	40.29	17.85
Shelling percentage	1	3.70	5.15	51.59	5.47
	2	8.85	9.70	83.29	16.64
	3	5.79	6.81	72.24	10.14
100 kernel weight	1	15.79	17.77	78.98	28.90
	2	8.80	13.64	41.65	11.70
	3	17.84	19.98	79.77	32.83
Sound mature kernel percentage	1	4.16	8.67	22.96	4.10
	2	1.74	9.83	3.12	0.63
	3	7.92	13.35	35.20	9.69
Oil percentage	1	5.20	5.80	80.12	9.85
	2	3.66	4.57	64.04	6.21
	3	5.56	7.96	48.79	7.56

1= Normal condition 2 = Mid-season drought 3 = End-of-season drought

Table 4 Correlation of yield and yield components

Character	Moisture Regime	X_1	X_2	X_3	X_4	X_5	X_6
X_1	1	1.0	0.402	-0.283	-0.087	0.141	0.322
	2	1.0	0.361	-0.144	0.135	-0.049	0.224
	3	1.0	0.201	-0.125	0.006	-0.013	0.127
X_2	1		1.0	0.063	0.081	0.268	-0.333
	2		1.0	0.029	0.310	-0.005	-0.224
	3		1.0	-0.065	0.191	-0.047	0.017
X_3	1			1.0	0.327	0.439	0.381
	2			1.0	0.209	0.334	0.187
	3			1.0	0.423	**0.455***	**0.475***
X_4	1				1.0	0.250	-0.031
	2				1.0	0.109	-0.039
	3				1.0	**0.455***	**0.492***
X_5	1					1.0	0.011
	2					1.0	0.078
	3					1.0	0.426
X_6	1						1.0
	2						1.0
	3						1.0

* = significant at 0.05 P ** = significant at 0.01 P

1= Normal condition
2 = Mid-season drought
3 = End-of-season drought
X_1 - No. of mature pods
X_3-100 kernel weight
X_5- Oil percentage
X_2- *Shelling percentage*
X_4- *Sound mature kernel percentage*
X_6- *Pod yield (g/plot)*

Table 5 Correlation among physiological characters and with yield

Character	Moisture regime	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
X_1	1	1.0	-0.132	-0.075	0.326	-0.040	-0.152	-0.203	0.031	0.071
	2	1.0	-0.227	-0.137	-0.293	0.013	-0.123	-0.252	0.002	0.394
	3	1.0	0.137	-0.281	0.216	-0.066	-0.185	-0.214	0.126	-0.164
X_2	1		1.0	-0.282	0.109	0.301	**0.452***	0.225	-0.268	**0.588****
	2		1.0	-0.277	0.114	-0.053	0.076	0.230	0.067	0.105
	3		1.0	-0.208	-0.159	0.031	0.153	0.240	0.035	**0.444***
X_3	1			1.0	-0.178	-0.278	-0.271	-0.067	0.202	**-0.520***
	2			1.0	-0.054	-0.191	-0.143	0.007	0.154	**-0.494***
	3			1.0	0.040	-0.115	-0.021	0.172	0.073	-0.140
X_4	1				1.0	-0.063	-0.008	0.057	0.065	0.190
	2				1.0	0.348	0.199	-0.158	-0.412	-0.375
	3				1.0	0.134	-0.010	-0.301	-0.163	0.036
X_5	1					1.0	**0.847****	-0.333	**-0.979****	**0.622****
	2					1.0	**0.823****	-0.025	**-0.966****	0.280
	3					1.0	**0.854****	-0.158	**-0.964****	0.279
X_6	1						1.0	0.209	**-0.811****	**0.686****
	2						1.0	**0.568****	**-0.785****	0.360
	3						*1.0*	*0.371*	***-0.812****	***0.555****
X_7	1							1.0	0.370	0.026
	2							1.0	0.002	0.135
	3							1.0	0.182	0.298
X_8	1								1.0	0.039
	2								1.0	0.217
	3								1.0	0.094
X_9	1									1.0
	2									1.0
	3									1.0

* = significant at 0.05 P ** = significant at 0.01 P

1= Normal condition
2 = Mid-season drought
3 = End-of-season drought
X_1- Relative leaf water content at harvest
X_3- Specific leaf area at harvest
X_5- Crop growth rate
X_7 – Partitioning of dry matter to pods
X_2- Specific leaf nitrogen content at harvest
X_4- Light interception
X_6 –Pod growth rate
X_8 – Harvest index
X_9- pod yield

Among yield components, oil percentage was positively correlated with 100-kernel weight and sound mature kernel percentage only under end-of-season drought. Among physiological characters, crop growth rate was positively correlated with pod growth rate in all the three moisture conditions, similarly harvest index was negatively associated with crop and pod growth rate in all the three moisture conditions, indicating the stability of their association across the moisture regimes. Pod growth rate was positively associated with specific leaf nitrogen content only under normal condition and with partitioning of dry matter only under mid-season drought.

References

Anonymous 2000. *Area and production of principal crops in India 1997-98*. 79th issue, Publication Division, Directorate of Economics and Statistics, Department of Agriculture and Co-operation, Ministry of Agriculture, Government of India, Delhi.

Chaudhary, S.K. 1993. *Variability, heritability and genetic* advance in groundnut under mid altitude condition. *Indian Journal of Hill Farming*, **6**: 171-174.

Chavan, A.A. and Dhoble, M.V. 1994. Studies on genetic variation in (*Arachis hypogaea* L.) under water stress and natural conditions. *Journal of Oilseeds Research*, **11**: 9-14.

Duncan, W.G., Mc Cloud, D.E., Mc. Graw, R.L. and Boote, K.J. 1978. Physiological aspects of peanut yield improvement. *Crop Science*, **18**: 1015-1020.

Greenberg, D.C., Williams, J.H. and Ndunguru, B.J. 1992. differences in yield determining processes of groundnut (*Arachis hypogaea* L.) genotypes in varied drought environments. *Annals of Applied Biology*, **120**: 557-566.

Jayalakshmi, V., Rajareddy, C., Reddy, P.V. and Nageswara Rao, R.C. 1999. Genetic analysis of carbon isotope discrimination and specific leaf area in groundnut. (*Arachis hypogaea* L.). *Journal of Oilseeds Research*, **16**: 1-5.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. 1955. Estimates of genetic and environmental variability in soybeans. *Agronomy Journal*, **47**: 314-318.

Nageswara Rao, R.C., Talwar, H.S. and Wright, G.C. 2001. Rapid assessment of specific leaf area and leaf nitrogen in peanut (*Arachis hypogaea* L.) using a chlorophyll meter. *Journal of Agronomy and Crop Science*, **186**: 175-182.

Nageswara Rao, R.C., Udaykumar, M., Farquhar, G.D., Talwar, H.S. and Prasad T.G. 1995. Variation in carbon isotope discrimination and its relationship to specific leaf area and ribulose-1,5, biphosphate carboxylase content in groundnut genotypes. *Australian Journal of Plant Physiology*, **22**: 545-551.

Nageswara Rao, R.C., Williams, J.H., Wadia, K.D.R., Hubick, K.T. and Farquhar, G.D. 1993. Crop growth, water use efficiency and carbon isotope discrimination in groundnut (Arachis *hypogaea* L.) genotypes under end-of-season drought conditions. *Annals of Applied Biology*, **122**: 357-367.

Nageswara Rao and Wright G.C. 1994. *Stability* of the relationship between specific leaf area and carbon isotope discrimination across environments in peanut. *Crop Science*, **34**: 98-103.

Ravindra, V., Nautiyal, P.C. and Joshi, Y.C. 1990. Physiological *analysis of drought resistance and yield in groundnut* (*Arachis hypogaea* L.). *Tropical Agriculture* (*Trinidad and Tobago*), **67**: 290-296.

Reddi, M.V., Reddy, K.R., Reddy, K.H.P. and Rao, J.A. 1991. Heritability, genetic advance and character association in groundnut over three environments. *Journal of Maharashtra Agricultural Universities*, **16**: 383-385.

Reddy, K.R. and Gupta, R.V.S. 1992. Variability and inter relationship of yield and its component characters in groundnut. *Journal of Maharashtra Agricultural Universities*, **17**: 224-226.

Singh R.K. and Chaudhary, B. D. 1977. *Biometrical methods in quantitative genetic analysis.* Kalyani Publishers, New Delhi. pp. 53-54.

Williams, J.H., Nageswara Rao, R.C., Mathews, R. and Harris, D. 1986. *Responses of groundnut genotypes to* drought. pp. 99-106 (In) *Agrometeorology of Groundnut. Proceedings of an international symposium*, 21-26 August 1985, ICRISAT, Sahelian center, Niamey, Niger, Patancheru, A.P., India: ICRISAT

Wright, G.C., Nageshwara Rao, R.C. and Farquhar, G.D., 1994, Water use efficiency and carbon isotope discrimination *in peanut under water deficit conditions. Crop Science*, **34**: 92-97.

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Gene effects and genotypes x environment interaction at various growth stages for root characteristics, plant height and seed yield in Indian mustard, *Brassica juncea* (L.) Czern & Coss

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Abstract

***Thirty triple test cross families of Indian mustard, Brassica juncea* (L.) Czern & Coss., were raised in normal and moisture stress environment to detect and measure the interaction between the environments and the additive dominance and epistatic effects of the genes for root characteristics, plant height and seed yield at various growth stages. Additive as well as dominance gene effects and epistasis were observed for root characteristics, plant height and seed yield except root volume. Additive gene effects were more sensitive to environmental changes than the dominance gene effects. The additive x dominance 'j' and additive x additive 'l' type epistasis was relatively more sensitive to environmental differences than the additive 'i' type of epistasis. Thus, the hybrid Indian mustard would be more stable in varying environments corresponding to homozygous variety. Therefore, the commercial hybrids of such genetic make up need to be exploited on priority basis in stabilizing the unstable productivity.**

Key words: Gene effects, root characteristics, *epistasis*, *G x E interaction*, *Indian* mustard

Introduction

The estimates of additive and dominance components will show the same rate of change irrespective of the bias caused by epistasis provided all kinds of gene effects respond equally to the environmental differences. However, it does not generally happen and different kinds of gene effects usually respond differently to different environments. Therefore, under such a situation, detection and measurement of genotype x environment interaction becomes imperative. Perkins and Jinks (1971) suggested an extension of triple test cross design to account for macro-environmental factors. It allows independent detection and measurement of interaction between the additive, dominance and epistatic effects of the genes and macro-environmental differences. Scanty information is available in the literature for genotype interaction particularly for root characteristics in *Brassica* crops. Therefore, the present study was taken up to know the *Genotypes x Environment interaction* with estimates of genetic components using triple test cross families.

Material and methods

The experimental material comprised of 10 *genotypes/varieties viz.*, BIO 902, DHR 994, DHR 995, DHR 9, DHR 992, DHR 9401, DHR 9405, DYS-25-9, Laxmi and Rohini of Indian mustard which were selected on the basis of their phenotypic diversity for morphological, agronomical characteristics and on the basis of tolerance against moisture stress and seed yield. Five plants were randomly selected from each genotypes/varieties and crossed with three testers using RH 30, RH 819 and RH 30 x RH 819 (F_1) as pollen parents to develop 30 families as per triple test cross mating design in *rabi*, 1999-2000. Each of these plant was crossed, as male, to both of its parents (P_1 and P_2) and the F_1 (P_1 x P_2) to produce L_{1i}, L_{2i} and L_{3i} families, respectively. Thirty families each of the crosses thus produced were raised in Randomized Block Design with three replication in *rabi*, 2000-01 under two environments i.e., normal (with two irrigations at 45 DAS and 90 DAS) and moisture stress (with no irrigation). Observations were recorded on five plants from each family under both the environments for root length, root volume, root density, plant height and seed yield at various growth stages were subjected to the analysis of Perkins and Jinks (1971) to test and estimates the interaction between additive, dominance and epistatic gene effects and environment.

Results and discussion

Epistasis and its interaction with environments: Interaction of epistasis with environment for different root characters, plant height and seed yield revealed that the mean squares due to 'l' type epistasis was significant for root density and plant height at 90 DAS. The 'j' and 'l' type epistasis was significant for all the characters at this stage (Table 1). The interaction 'j' and 'l' type epistasis was observed significant for root volume only. At harvest, the mean squares due to 'l' type epistasis was significant for all the characters except root length. The 'j' and 'l' type

epistasis was significant for all the characters. The interaction 'j' and 'l' type epistasis with environment was significant for root length and plant height. Singh *et al.* (1989), Singh *et al.* (1990) and Pawar *et al.* (1996) also reported about the relative sensitivity of these sub-components of epistasis to environmental changes.

Interaction of additive and dominance gene effects with environments: Interaction of additive and dominance gene effects with environments at 90 DAS and harvest for root length, root volume, root density, plant height and seed yield are presented in Table 2. The mean squares due to sums and differences (type 'l' epistasis) was significant for all the characters at 90 DAS except root volume for which the item differences was non-significant. The interaction of sums and differences with environments was significant for root volume and root density. The interactions of differences with environment were also significant for root volume and root density. At harvest, the mean squares due to sums and differences were significant for all the characters except root length. The interaction of sums and differences with environments was also significant for all the characters except for root density. These findings suggested that additive gene effects were more sensitive to the change in environment than dominance gene effects. Similar results were also reported by Singh (1980); Singh and Dahiya (1984). However, Singh *et al.* (1990) noted equal sensitivity of additive and dominance gene effects to the change in environment for most of the traits.

Table 1 Mean squares from the pooled analysis for the test of epistasis for root length, root volume, root density, plant height and seed yield in different 30 TTC families of Indian mustard

Family	d.f.	Root length	Root volume	Root density	Plant height	Seed yield
At 45 DAS						
Epistasis ($\bar{L}1i + \bar{L}2i + \bar{L}3i$) 'l' type	1	100.28	17.78	0.0020*	261.81*	0.034
'J' & 'L' type Epistasis	9	356.53*	827.04*	0.0020*	268.88*	0.549*
'l' type epistasis environments	1	6.944	4.44	0.0005	9.67	0.085
'J' & 'L' type epistasis environments	9	55.80	538.70*	0.0011	45.60	0.369*
Rep. within environments x 'l' type epistasis	4	17.19	19.44	0.0011	8.66	0.203*
Rep. within environments x 'J' & 'L' type epistasis	36	16.06	30.55	0.0009	11.22	0.082
Within family error	720	73.34	177.05	0.0008	74.96	0.074
At harvest						
Epistasis ($\bar{L}_1 + \bar{L}_2 + \bar{L}_3$) 'l' type	1	0.80	605.80*	0.0060*	298.84*	0.029
'J' & 'L' type epistasis	9	165.94*	544.81*	0.0017*	133.69*	1.167*
'l' type epistasis environments	1	14.80	26.14	0.0010	0.40	0.507*
'J' & 'L' type epistasis environments	9	94.37*	334.78	0.0012	143.84*	1.714*
Rep. within environments x 'l' type epistasis	4	8.60	47.22	0.0013	8.47	0.110
Rep. within environments x 'J' & 'L' type epistasis	36	10.79	25.81	0.0006	9.24	0.243
Within family error	720	52.14	238.90	0.0010	42.53	0.320

* Significant at 0.05%

Table 2 Mean squares from the pooled analysis for the sums ($\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$) and difference ($\bar{L}_{1i} - \bar{L}_{2i}$) for root length, root volume, root density, plant height and seed yield in different 30 TTC families of Indian mustard

Family	d.f.	Root length	Root volume	Root density	Plant height	Seed yield
At 45 DAS						
Analysis of sum ($\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$)	9	419.08*	1438.52*	0.0015*	907.55*	0.59*
Sums x Environments	9	62.886	947.22*	0.0018*	116.77*	0.14*
Rep. within environments x sums	36	123.5	365.46*	0.0007	127.66	0.09
Within families error	720	78.58	213.63	0.0006	88.29	0.07
Analysis of difference ($\bar{L}_{1i} - \bar{L}_{2i}$)	9	237.57*	178.18	0.0028*	670.06*	0.45*
Difference x Environments	9	34.44	390.18*	0.0009*	109.37	0.25*
Rep. within environments x Differences	36	95.52	274.77	0.0007	116.03	0.05
Within families error	480	83.82	250.22	0.0005	101.63	0.075
At 90 DAS						
Analysis of sum ($\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$)	9	582.63*	1588.74*	0.0035*	1708.34*	14.47*
Sums x Environments	9	192.88*	950.15*	0.0014	423.11*	3.38*
Rep. within environments x Sums	36	99.77*	579.29*	0.0007	68.91	0.29
Within families error	720	59.26	257.06	0.0013	53.34	0.269
Analysis of difference ($\bar{L}$1i - $\bar{L}$2i)	9	46.78	2257.56*	0.0037*	597.42*	0.87
Difference x Environments	9	99.56*	534.81*	0.0015	610.42*	1.07
Rep. within environments x Differences	36	67.23	216.05	0.0005	81.37	0.262
Within families error	480	66.38	275.21	0.0016	64.16	0.218

* Significant at 0.05%

The estimates of G_{2D} (additive gene effects) and G_{2H} (dominance gene effects) revealed that the significance of these two components was similar to those of additive gene effects x environment and dominance gene effects x environment (Table 3). At both the stages, these two components were significant for root volume, root density, plant height and seed yield at 90 DAS, and at harvest. At harvest, the estimates of G_{2H} were greater than those of G_{2D} for root volume and plant height.

Hence, from the present study, it can be concluded that a higher sensitivity of the additive gene effects to environmental change than that of dominance gene effects would indicate that hybrid Indian mustard would be more stable in varying environments than a homozygous variety. Therefore, the exploitation of commercial hybrids with present genetic material needs to be done on a priority basis in stabilizing the unstable productivity of Indian mustard under varying environments.

Table 3 Estimation of additive gene effects x environment (G_{2D}) and dominance gene effects x environment (G_{2H}) for root length, root volume, root density, plant height and seed yield at various growth stages in 30 TTC families of Indian mustard

Effect	Root length	Root volume	Root density	Plant height	Seed yield
At 90 DAS					
G_{2D}	17.51*	258.56*	0.0005*	12.66*	0.148
G_{2H}	33.75*	93.31*	0.0003	5.23*	0.131
At harvest					
G_{2D}	41.38*	164.83*	0.0004*	164.34	1.383*
G_{2H}	21.55*	212.51*	0.0001	352.70*	0.537

* Significant at P=0.05; DAS = Days after sowing

References

Pawar, I.S., Yunus, M. and Singh, V.P. 1996. A study of interaction of additive, dominance and epistatic gene effects with environment in wheat. *Haryana Agricultural University Journal of Research*, **26** : 17-21.

Perkins, J.M. and Jinks, J.L. 1971. Analysis of genotype x environment interaction in triple test cross data. *Heredity*, **26** : 203-209.

Singh, I., Pawar, I.S. and Singh, S. 1989. Detection of genotype x environment interaction in spring wheat through triple test cross analysis. *Crop Improvement*, **16** : 34-37.

Singh, S. 1980. Detection of components of genetic variation and genotype x environment interaction in spring wheat. *Journal of Agriculture Science Cambridge*, **95** : 67-72.

Singh, S. and Dahiya, M.S. 1984. Detection and estimation of components of genetic variation and genotype x environment interaction in three what crosses. *Journal of Agriculture Science Cambridge*, **103** : 543-547.

Singh, S., Kumar, S., Singh, I. and Pawar, I.S. 1990. Interaction of gene effects with environment in wheat. *Haryana Agricultural University Journal of Research*, **20** : 201-205.

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Detection and estimation of components of genetic variation for different plant parts at various growth stages in Indian mustard, *Brassica juncea* (L.) Czern Coss

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Abstract

Thirty families from one triple test cross in Indian mustard, *Brassica juncea* (L.) Czern & Coss., were raised under two environments normal (with irrigation at 45 DAS and 90 DAS) and moisture stress (with no irrigation). Estimate of additive, dominance and epistatic components of genetic variation for different plant parts and seed yield at various growth stages were detected. The 'j' and 'l' type epistasis was more important than the 'i' type epistasis in the triple test cross analysis. Both the D (additive) and H (dominance) components were significant for biomass characters and seed yield under both the environments. The D component was relatively more important than the H component for biomass characters including seed yield at different growth stages. Therefore, the biparental mating in the advance generation of segregation would help to improve the biomass characters including seed yield. The selection of promising plants in early generation of selection is to be avoided due to the presence of epistasis.

Key words: Gene effects, epistasis, moisture stress, Indian mustard, growth stages

Introduction

The triple test cross method suggested by Kearsey and Jinks (1968) is a powerful tool to obtain precise estimates of genetic parameters of variation and epistasis. Since, this method not only provides unambiguous detection of epistasis and its partitioning, but, unbiased estimates of additive, additive gene effects x environments, dominance and dominance gene effects x environment components can also be obtained through this method if epistasis is absent. Further, the method is independent of allelic frequency, gene correlation and mating system. Keeping the above points in view, the triple test cross method was used in present investigation to detect epistasis and to know the bias caused by it in the estimation of additive and dominance and their interactions with environments for plant parts at different growth stages.

Material and methods

The experimental material comprised of ten genotypes/varieties of Indian mustard namely BIO 902, DHR 994, DHR 995, DHR 9, DHR 992, DHR 9401, DHR 9405, DYS-25-9, Laxmi and Rohini, which were selected on the basis of their phenotypic diversity for morphological, agronomical characteristics and on the basis of tolerance against moisture stress and seed yield. Five plants were randomly selected from each genotypes/varieties were crossed with three testers using RH 30. RH 819 and RH 30 x RH 819 (F_1) as pollen parent to develop 30 families as per triple test cross mating design were produced in the *rabi* season during 1999-2000. Each of these plants was crossed, as male, to both of its parents (P_1 and P_2) and the F_1 (P_1 x P_2) to produce L_{1i}, L_{2i} and L_{3i} families, respectively. Thirty families each of the crosses thus produced were raised in randomised block design with three replications in the *rabi* season during 2000-01 under two environments i.e., normal (with two irrigations at 45 DAS and 90 DAS) and moisture stress (with no irrigation). Observations were recorded on five plants from each family under both the environments for different plant parts at various growth stages.

Statistical analysis: The detection and estimation of additive (D), dominance (H) and epistatic components of genetic variation were carried out according to Jinks and Perkins (1970).

Test for epistasis: The mean due to the ($\bar{L}1i+\bar{L}2i - 2\bar{L}3i$) item were obtained for 10 d.f. This item was tested against within families error calculated for 360 d.f. except where replicate error (20 d.f.) was significant. If the replicate error was significant, this error was used to test the item epistasis. The item epistasis was further partitioned into 'I' type epistasis and 'J' and 'L' type epistasis for 1 and 9 d.f. respectively. The significance of this item was tested against 'I' type epistasis x replicate and 'J' and 'L' type epistasis x replicate items calculated for 2 and 18 d.f. respectively, if the latter two items were significant when tested against within families error. Detection and estimation of D and H component: The mean squares due

to sums ($\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$) and due to differences ($\bar{L}_{1i} - \bar{L}_{2i}$) were computed for 9 d.f. The significance of these items was tested against within families error. The estimation of D and H component were obtained according to Jinks and Perkins (1970).

Results and discussion

Ten genotypes/varieties *viz.*, BIO 902, DHR 994, DHR 995, DHR 9, DHR 992, DHR 9401, DHR 9405, DYS-25-9, Laxmi and Rohini of Indian mustard were selected on the basis of their phenotypic diversity for quantitative traits and on the basis of tolerance against moisture stress and seed yield. Randomly selected plants from each genotypes/ varieties were crossed with three testers using RH 30. RH 819 and their F_1 RH 30 x RH 819 (F_1) as pollen parent to develop 30 families as per triple test cross mating design during 1999-2000. Thirty families each of the crosses thus produced were evaluated in Randomised Block Design with three replication in the *rabi* 2000-01 under two environments i.e., normal (with two irrigations at 45 DAS and 90 DAS) and moisture stress (with no irrigation). Observations were recorded on five plants from each family under both the environments for root length, root volume, root density, plant height and seed yield at various growth stages were subjected to the analysis of Perkins and Jinks (1971) to test and estimate the interaction between additive, dominance and epistatic gene effects and environments.

Test of epistasis: The epistasis was significant for all the characters i.e., leaf, stem, root, siliquae, seed yield and total biomass under both the environments except siliquae dry weight under moisture stress environment. The item 'l' type epistasis were significant for leaf and stem dry weight under both the environments. Whereas, root and siliquae dry weight under normal environment and total biomass under normal environment item 'l' type epistasis was significant. The item 'j' and 'l' type epistasis was significant higher for all the biomass characters except for siliquae dry weight under normal environment. The presence of epistasis for all the biomass characters was observed at 45 DAS under normal environment. Whereas, at 90 DAS and harvest presence of epistasis for all the biomass characters under both the environments except siliquae dry weight under moisture stress environment. This indicated that epistasis played an important role in the control of these plant characters and hence, this component of genetic variation should not be ignored while deciding breeding plants. Therefore, the assumption of absence of epistasis may not be realistic in many plant materials for one or more characters. A number of investigators have noted the failure of this assumption of their studies (Pawar *et al.*, 2001).

Test and estimation of additive and dominance component: The estimates of additive and dominance components of variation were based on the comparisons due to sums ($\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$) and differences ($\bar{L}_{1i} - \bar{L}_{2i}$). The mean squares obtained from the analysis of sums and difference for dry weight at 45 and 90 DAS indicated that the mean squares due to the items sums and differences at 45 DAS were significant for all the biomass characters in normal environment indicating that both the additive and dominance gene-effects were important in control of these characters (Table 1). At 90 DAS, the mean squares due to sums were significant for all the biomass characters under normal environment. This item was significant for the leaf and root dry weight under moisture stress environment. The mean squares due to differences were significant for the leaf dry weight under both the environments. This item was significant for root and seed yield under moisture and normal environment, respectively.

The mean squares due to sums were significant for stem, root, siliquae, seed and total biomass under both the environments at harvest. This item was non-significant only for leaf dry weight under both the environments. The mean squares due to differences were significant for stem, root, seed yield and total biomass under both the environments. This item was also significant for siliquae dry weight under moisture stress environment.

Estimation of additive, dominance component and degree of dominance: Estimation of additive, dominance component and degree of dominance revealed that most of the characters at 45 DAS i.e., leaf, stem and total biomass showed over dominance (>1) (Table 2). The root dry weight indicated the presence of partial dominance (<1). At 90 DAS, all biomass characters under normal irrigation environment showed partial dominance (<1) except leaf dry weight, which indicated the presence of over dominance (>1). Under moisture stress environment leaf, root, siliquae and seed indicated the presence of over dominance (>1), whereas, stem and seed showed partial dominance (<1) for their genetic control at harvest. The low degree of dominance for siliquae, seed yield, stem and total biomass under both the environments indicated a considerably higher role played by the additive gene effects in the control of these characters than the dominance gene effects. The high value of degree of dominance was recorded for leaf and root dry weights (>1) under moisture stress environment indicating over dominance (>1). Similar findings were reported by Verma and Yunus, 1986 for total biomass. This also noted a greater importance of dominance component than the additive component for yield. Therefore, biparental mating in the advance generation of segregation would help to improve the biomass characters including seed yield. Selection of promising plants in early generations is to be avoided due to the presence of epistasis.

Table 1 Mean squares for the test of epistasis in different plant parts at 45 and 90 DAS and at harvest in 30 TTC families of Indian mustard under different environments

Family	d.f.	Environment	Leaf	Stem	Root	Siliquae	Seed yield	Total biomass
At 45 DAS								
Epistasis ($L_{1i} + L_{2i} + L_{3i}$)	10	N	3.874*	0.255*	0.327*	-	-	4.514*
I type Epistasis	1	N	3.417*	0.101*	0.131	-	-	2.108*
J&L type Epistasis	9	N	3.925*	0.283*	0.349*	-	-	4.781*
Replicate error	20	N	0.264	0.064	0.285	-	-	0.600
I type Epistasis x Replicates	2	N	0.185	0.033	0.086	-	-	0.103
J&L type Epistasis x Replicates	18	N	0.273	0.067	0.307*	-	-	0.654
Within family error	360	N	0.372	0.055	0.202	-	-	0.621
At 90 DAS								
Epistasis ($L_{1i} + L_{2i} + L_{3i}$)	10	N	1.605*	3.632*	4.182*	3.863*	0.424*	23.25*
	10	MS	3.565*	3.219*	4.276*	0.434*	0.414*	19.12*
I type Epistasis	1	N	7.442*	3.671*	0.910	2.091*	0.113	3.63
	1	MS	5.583*	0.105	1.901	0.139	0.055	2.74
J&L type Epistasis	9	N	0.957	3.628*	4.545*	4.061*	0.459*	25.43*
	9	MS	3.341*	3.571*	4.540*	0.467*	0.460*	20.94*
Replicate error	20	N	0.628	0.865	0.609	0.262	0.113*	2.79
	20	MS	0.444	0.708	2.042*	0.289	0.076	4.68
I type Epistasis x Replicates	2	N	0.280	1.081	0.272	0.719*	0.313*	2.40
	2	MS	0.360	1.006	1.172	0.594*	0.093	2.25
J&L type Epistasis x Replicates	18	N	0.666	0.841	0.646	0.212	0.091	2.84
	18	MS	0.454	0.675	2.139*	0.255	0.074	4.95
Within family error	360	N	0.716	0.968	0.707	0.263	0.071	2.47
	360	MS	0.541	1.092	1.295	0.240	0.078	4.41
At harvest								
Epistasis ($L_{1i} + L_{2i} + L_{3i}$)	10	N	0.790*	9.278*	2.232*	3.551	1.958*	34.45*
	10	MS	1.735*	3.958*	2.464*	3.344*	0.706*	16.67*
I type Epistasis	1	N	2.964*	29.521*	0.416	2.478	0.390	48.56*
	1	MS	2.278*	3.202*	7.770*	2.781*	0.146	8.05
J&L type Epistasis	9	N	0.548*	7.029*	2.424*	3.670	2.133*	32.92*
	9	MS	1.674*	4.042*	1.874*	3.409*	0.768*	17.63*
Replicate error	20	N	0.196	1.632	0.804	6.021*	0.267	4.56
	20	MS	0.255	2.558*	1.049	2.372	0.181	11.05*
I type Epistasis x Replicates	2	N	0.195	0.093	0.305	15.960*	0.038	12.24
	2	MS	0.036	10.654*	1.259	7.710*	0.072	42.70*
J&L type Epistasis x Replicates	18	N	0.196	1.803	0.861	4.917	0.292	3.70
	18	MS	0.280	1.659	1.026	1.778	0.193	7.54
Within family error	360	N	0.198	1.323	1.023	3.610	0.344	5.32
	360	MS	0.269	1.508	1.103	1.761	0.296	7.57

* Significant at 5%; N = Normal Environment; MS = Moisture stress Environment

Table 2 Estimation of additive component (D), dominance component (H) and degree of dominance $(H/D)^{½}$ in different plant part at various growth stages in 30 TTC families of Indian mustard under different environments

Genetic component	Environment	Leaf	Stem	Root	Siliquae	Seed yield	Total biomass
At 45 DAS							
D ($\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$)	N	0.32*	0.10*	0.55*	-	-	1.37*
H ($\bar{L}_{1i} - \bar{L}_{2i}$)	N	0.71*	0.19*	0.14*	-	-	1.51*
$(H/D)^{½}$	N	1.49	1.38	0.51	-	-	1.05
At 90 DAS							
D ($\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$)	N	0.25*	0.94*	1.37*	0.40*	0.10*	4.44*
	MS	0.51*	0.26	0.68	0.20	0.04	0.51
H ($\bar{L}_{1i} - \bar{L}_{2i}$)	M	0.74*	0.61*	0.70*	0.23	0.08	0.89*
	MS	1.73*	0.07	1.68*	0.28	0.08	0.09
$(H/D)^{½}$	N	1.73	0.80	0.72	0.75	0.92	0.45
	MS	1.85	0.53	1.57	1.18	1.32	0.43
At harvest							
D ($\bar{L}_{1i} + \bar{L}_{2i} + \bar{L}_{3i}$)	N	0.18	17.93*	1.14*	5.56*	3.91*	33.67*
	MS	0.04	5.14*	0.59*	5.32*	3.79*	8.65*
H ($\bar{L}_{1i} - \bar{L}_{2i}$)	N	0.08	2.21*	0.72*	0.65*	0.46*	2.89*
	MS	0.14	3.32*	1.58*	1.77*	0.53*	5.95*
$(H/D)^{½}$	N	0.68	0.35	0.79	0.34	0.35	0.29
	MS	1.94	0.80	1.64	0.58	0.38	0.86

References

Jinks, J.L. and Perkins, J.M. 1970. A general method for the detection of additive, dominance and epistatic components of variation. I II. F_2 and backcross populations. *Heredity*, **25** : 419-423.

Kearsey, M.J. and Jinks, J.L. 1968. A general method of detecting additive, dominance and epistatic variation for *metric traits*. 1. *Theory, Heredity*, **23** : 403-409.

Pawar, I.S., Singh, I. And Yunus, M. 2001. *Study of test of* failure of additive dominance model in wheat using triple-test cross methods. *Presented at Diamond Jubilee Symposium on Hundred Years of Post-Mendelian Genetics and Plant Breeding - Retrospects and Prospects* from Nov. 6-9, 2001, IARI, New Delhi-110 012.

Perkins, J.M. and Jinks, J.L. 1971. Analysis of genotype x environment interactions in triple test data. *Heridity*, **26** : 203-209.

Verma, S.S. and Yunus, M. 1986. Role of epistasis in the analysis of genetic component of variance in bread wheat. *Indian Journal of Agricultural Sciences*, **56**(10) : 687-689.

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Germplasm evaluation of Indian mustard, *Brassica juncea* (L.) Czern & Coss

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Abstract

Germplasm accessions of Indian mustard, *Brassica juncea* (L.) Czern & Coss. were evaluated for 16 agro-morphological and quality traits, with three checks (PCR-7, RH-30 and BIO-902) at the research farm of NRC Rapeseed-Mustard, Bharatpur during *rabi*, 1999-2000. Among the 16 traits studied, the maximum variability was observed for seed yield/plant (CV 73.9%) followed by secondary branches/plant (CV 61.8%). The least variability was observed for oil content (CV 3.6%) followed by protein content (CV 4.3%). Promising donors were identified for various economic traits, which can be further used for future breeding programme. Genotype EC 333596 found to be one of the useful donors for early initiation of flowering, 50 per cent flowering, days to maturity, siliqua on main shoot and oil content. Yield/plant and harvest index was maximum in the genotype, IC 148040, the highest 1000-seed weight and seeds/siliqua were recorded in genotype RBS Sel 3A and IC 394357, respectively. The positive and significant values of correlations were observed for harvest index, secondary branches/plant, main shoot length, primary branches/plant and siliqua on main shoot. Hence, selection for the highest values of these traits will be desirable to increase seed yield. Characterization of promising donors for high oil content and harvest index was also undertaken.

Key words: Indian mustard, agro-morphological characters, variability, donors

Introduction

Oilseed Brassica is a group of highly diverse crop plants and has great economic values. It comprises group of seven cultivated oilseed species of *Brassica* and its related genus. This group is the second important oilseed crop in India after groundnut. The oilseed Brassica, in 2002-03 covered 4.43 m.ha. of area, producing 4.54 m. tonnes of seed yield in the country. In spite of premier position occupied by India in the world oilseed scenario, per hectare yield are very low as compared to world average. Among the oilseed brassicae, Indian mustard [*Brassica juncea* (L.) Czern & Coss.] is an important *rabi* oilseed crop of the country. During 2002-03, the productivity in India was only 940 kg/ha as compared to the world level of 1632 kg/ha, this wide gap is an eye opener, keeping in view of intensive breeding programme at national level. This may be due to limited geographical distribution of *B. juncea*, confined to Indian sub-continent and inadequate utilization of available genetic diversity. The present study was undertaken to analyze the variability among the quantitative traits in Indian mustard germplasm. It also aimed to characterize the germplasm for certain useful agro-morphological traits. The identified accessions may prove to be an important gene pool for different traits.

Material and methods

Seeds of 176 elite germplasm accessions were procured from NBPGR, New Delhi and All India Coordinated Research Project on Rapeseed-Mustard (AICRP R-M) network which were grown in 380 sq. meter plot at 30 cm x 10 cm spacing under augmented design with three checks (PCR-7, RH-30 and BIO-902) at National Research Centre on Rapeseed-Mustard, Sewar, Bharatpur-321 303 during *rabi*, 1999-2000. These germplasm accessions were evaluated for 17 phyto-morphological and quality traits including initiation of flowering (days), 50% flowering (days), days to maturity (days), plant height (cm), primary branches, secondary branches, main shoot length (cm), siliquae on main shoot, siliqua length (cm), siliqua beak length (cm), seeds/siliqua, biological yield/plant (g), seed yield/plant (g), 1000-seed weight (g), harvest index (%), oil and protein content (%). The observations were recorded on five random plants for different traits at appropriate growth stages. 1000-seed was counted by electronic seed counter (The Old Mill Company, USA) and weighed by electronic balance. Further, protein and oil content were analyzed by NIR (Dickey - John, USA). Range, mean, coefficient of variation and simple correlation coefficients were computed using standard statistical methods (Gomez and Gomez, 1984).

Results and discussion

Perusal of Table 1 revealed sufficient genetic variability in the material under study as values of coefficient of variation for most of the traits were observed to be high.

Among the 16 traits studied, the maximum variability was observed for seed yield/plant (CV 73.9%) followed by secondary branches/plant (CV 61.8%). However, the least variability was observed for oil content (CV 3.6%) followed by protein content (CV 4.3%). Similar trend of genetic variation have also been reported by various other workers in oilseed *Brassica* (Yadav *et al.*, 1997; Kumar *et al.*, 2000; Meena *et al.*, 2000; Chauhan *et al.*, 2000). Promising donors identified for various economic traits (Table 2) can be further used for future breeding programme. Genotype EC-333596 was found to be one of the useful donors for early initiation of flowering, fifty per cent flowering, days to maturity, siliqua on main shoot and oil content. Genotypes IC 194732 and RK-9902 were observed earlier for initiation of flowering and 50 per cent flowering. Further, RK-9902 recorded as desirable donor for days to maturity and 1000-seed weight. However, siliqua on main shoot and oil content were recorded higher in genotype IC-148039. Genotype NIC-2234 was found superior for shorter plant height, more number of siliqua on main shoot and higher oil content. Yield/plant and harvest index were recorded maximum in the genotype, IC 148040, the highest 1000-seed weight and seeds/siliqua were recorded in genotype RBS Sel 3A and IC 394357, respectively.

Correlation of 15 metric traits presented in Table 3 revealed that seed yield had positive and significant correlations with plant height, primary branches/plant, secondary branches/plant, main shoot length, siliqua on main shoot, harvest index and 1000-seed weight. However, the positive and significant values of correlations were observed for harvest index, secondary branches/plant, main shoot length, primary branches/plant and siliqua on main shoot. These findings are in agreement with Reddy (1991) and Kachroo *et al.* (1997). Therefore, selection of these characters will be helpful in increasing seed yield. However, initiation of flowering, 50 % flowering and days to maturity had negative correlations with seed yield as their lower values are desirable because early maturing accessions escape certain biotic and abiotic stresses. Seed yield had negative correlation with protein content and positive but small with oil content. Hence, *Brassica* breeders must keep in mind the relationship between these traits at the time of selection and in formulation of breeding programme.

The oilseed *Brassica* is the major source of edible oil. Therefore, the plant breeders are looking for the high yielding donors coupled with the high oil content. In the present study, low variability (CV 3.3%), oil content *per se* was demonstrated. The maximum oil content i.e., 43.9% is recorded in EC 333596. The promising accessions with more than 41% oil content along with their agro-morphological traits are presented in Table 4. Similarly, there is a need for good donors having high harvest index especially when the target is to breed suitable ideotype for various agro-climate. Table 5 revealed that there are several good genotypes with high harvest (≥25). The genotypes having high oil content and harvest index can be further utilized in mustard crop improvement programme.

Table 1 Variability in some agro-morphological traits in Indian mustard

Character	Range of variation	CV (%)	Mean values of checks		
			PCR 7	RH 30	BIO 902
Initiation of flowering (days)	55.0-101.0	9.38	54.14	46.81	48.59
50% flowering (days)	70.0-107.0	8.90	66.43	56.11	59.26
Plant height (cm)	50.6-155.6	18.82	167.36	137.96	147.99
Primary branches/plant	2.0-8.2	19.28	5.56	5.55	5.63
Secondary branches/plant	0.0-18.2	46.88	7.96	9.97	9.81
Main shoot length (cm)	26.0-69.8	14.10	53.96	56.59	80.30
No. of siliqua on main shoot	11.2-58.2	19.99	38.89	36.22	38.70
Maturity (days)	126.0-153.0	3.12	144.57	141.30	145.44
Siliqua length (cm)	2.9-5.0	11.87	3.72	3.54	3.66
Siliqua beak length (cm)	0.6-1.7	16.49	0.70	0.72	0.71
Seed yield (g)	0.9-15.0	61.30	8.84	8.32	9.36
Harvest index (%)	7.1-33.8	30.22	22.30	22.94	23.11
Seeds/siliqua	6.6-22.5	16.67	14.61	13.86	14.59
1000-seed weight (g)	1.9-7.1	22.45	4.40	4.83	4.76
Protein content (%)	20.2-25.4	4.10	21.82	21.45	22.03
Oil content (%)	36.0-43.9	3.30	39.99	39.11	38.43

Table 2 Promising accessions of Indian mustard

Character	*Indian mustard accessions*
Initiation of flower days	≤ 59: EC-333596, IC-194732, RK-9902, JMM-97-1
50% flowering (days)	≤ 70: EC-333596, IC-94732, RK-9902, RN-514
Plant height (cm)	≤ 68.4: NIC-2234, PCR-9301, PR-9627, IC-147852
Primary branches/plant (No.)	≤ 6.6: IC-94090, IC-76645, NIC-8187-4
Maturity duration (DAS)	≤ 127: ORM-3-1, EC-333596, EC-333578, RK-9904
Main shoot length (cm)	≥ 65.2 VAR, NIC-313, IC-139225, IC-147867
Siliqua on main shoot (No.)	≥ 40.5 EC-333578, EC-333596, EC-367881, IC-148039
Siliqua length (cm)	≥ 5.0 Ahyco Shradha, MEB-3, BEC-201, DHR-9601
Seeds/siliqua (No.)	≥ 25.30 IC-147919, IC-148015, IC-394357, IC-57845, NIC-2234
1000-seed weight (g)	≥ 6.4 NIC-334, PSR-44, RBS SEL-3A, RK-9902
Harvest index (%)	≥28.5 IC-48040, IC-148046, IC-199727, IC-199730
Protein content (%)	≥ 24.3 ORM-3-1, RAURD-9701, HUM-3, RGN-14, TNM-1
Oil content (%)	≥ 41.8 RSM-9801, NIC-2234, NIC-7171, IC-148039, IC-199710, EC-333596

Table 3 Correlations among the different agro-morphological traits in Indian mustard germplasm

Character	Initiation of flowering	50% flowering	Days to maturity	Plant height	Primary branches/ plant	Secondary branches/ plant	Main shoot length	Siliqua on main shoot	Siliqua length	Siliqua beak length	Harvest index	Seeds/ siliqua	1000-seed weight	Protein content	Oil content
50% flowering	0.821*														
Days to maturity	0.044	0.103													
Plant height (cm)	0.252*	0.245*	0.073												
Primary branches/plant	0.091	0.110	-0.023	0.386*											
Secondary branches/plant	0.002	0.037	0.006	0.384*	0.722*										
Main shoot length (cm)	0.126	0.111	0.043	0.603*	0.157*	0.353*									
Siliqua on main shoot	0.019	-0.034	-0.106	0.242*	0.231*	0.329*	0.488*								
Siliqua length (cm)	0.342*	0.316*	0.107	0.356*	0.168*	-0.008	0.196*	-0.102							
Siliqua beak length (cm)	*0.154**	*0.115*	*-0.015*	*0.09*	*0.108*	*-0.092*	*-0.007*	*0.046*	*0.519**						
Harvest index (%)	-0.215	-0.284	-0.194	-0.165	-0.101	0.024	0.002	0.015	-0.099	0.133					
Seeds/siliqua	0.220	0.149*	0.125	0.177*	0.066	-0.02	0.089	-0.080	0.403*	0.267*	-0.159				
1000-seed weight (g)	-0.321	-0.294	0.049	-0.007	0.050	-0.053	0.029	-0.118	0.073	0.266*	0.359*	-0.085			
Protein content (%)	0.153*	0.051	-0.034	-0.030	-0.100	-0.082	-0.181	-0.056	0.050	-0.222	0.005	-0.041	-0.266		
Oil content (%)	-0.184	-0.165	-0.038	-0.119	0.051	0.079	-0.065	0.081	0.099	0.076	0.088	-0.052	-0.053	-0.318	
Yield/plant (g)	-0.120	-0.101	-0.135	0.226*	0.390*	0.443*	0.395*	0.302*	0.134	0.206*	0.520*	-0.005	0.280*	-0.193	0.018

Table 4 Characterization of promising accessions of Indian mustard having high oil content (> 41%)

Name of accession	Oil content	Initial flowering	50% flowering	Days to maturity	Plant height	Primary branches	Secondary branches	Main shoot length	Siliqua on main shoot	Siliqua length	Harvest index	Seeds/ siliqua	1000 seed weight	Protein content
EC 333596	43.9	55.0	70.0	126.0	84.0	4.6	6.2	48.8	46.4	4.0	23.8	6.6	4.6	20.7
NIC 7171	42.5	86.0	102.0	147.0	122.5	5.2	6.2	47.0	29.4	4.0	10.3	12.9	3.9	22.1
NIC 2234	41.9	74.0	86.0	147.0	68.4	3.8	0.0	33.6	25.0	4.6	17.9	17.3	6.3	20.2
IC 199710	41.8	73.0	86.0	148.0	92.0	3.6	5.0	50.4	36.0	3.1	21.4	9.8	4.4	21.6
RSM 9801	41.8	78.0	86.0	141.0	144.0	6.0	9.2	55.8	34.4	3.8	22.0	11.9	4.2	21.1
IC 148039	41.8	79.0	86.0	153.0	140.7	4.7	7.0	54.7	50.7	4.4	9.5	13.6	4.4	22.3
PRO 9901	41.4	86.0	101.0	149.0	101.6	4.6	3.4	41.2	26.8	4.3	19.0	12.0	3.5	23.7
DWRR 15-13	41.4	86.0		138.0	138.4	5.6	6.2	56.8	31.6	3.9	19.9	13.0	3.8	22.3
IC 199726	41.0	67.0	78.0	149.5	110.4	4.7	6.0	44.9	29.2	3.3	18.4	9.1	4.6	21.2

Table 5 Characterization of promising accessions of Indian mustard having high harvest index (> 25%)

Name of accession	Harvest index	Initial flowering	50% flowering	Days to maturity	Plant height	Primary branches	Secondary branches	Main shoot length	Siliqua on main shoot	Siliqua length	1000 seed weight	Seeds/ siliqua	Protein content	Oil content
JMM 951	33.8	79.0	86.0	147.0	117.6	3.6	3.4	47.4	30.4	4.2	12.1	4.0	21.9	39.5
IC 148046	33.1	79.0	86.0	151.0	133.4	4.4	5.8	51.0	27.4	4.2	10.2	3.1	23.0	40.0
IC 199730	28.6	63.0	78.0	142.0	100.2	4.3	5.5	50.6	32.0	3.7	9.6	5.3	22.9	39.8
IC 199727	28.5	76.0	86.0	144.5	112.0	3.9	5.1	56.3	31.9	3.6	10.4	5.0	21.0	39.3
ORM 3-1	27.8	70.0	78.0	127.0	87.4	3.6	3.6	45.2	32.4	3.4	10.3	4.1	24.3	39.5
RK 9902	27.6	59.0	70.0	148.0	101.8	5.4	8.4	40.0	26.8	3.4	10.4	6.4	22.0	39.3
BIO 129-97	26.6	78.0	86.0	138.0	133.6	4.4	5.8	60.2	33.0	3.4	10.9	5.1	21.5	38.0
IC 199708	26.3	79.0	86.0	141.0	115.4	5.6	8.0	56.6	38.4	4.0	13.9	4.4	22.0	38.1
DHR 9405	26.1	86.0	97.0	152.0	113.4	3.4	0.4	42.8	29.8	4.6	11.6	4.8	23.4	39.6

References

Chauhan, J.S., Yadav, S.K., Kumar, P.R., Pareek, S., Tyagi, M.K. and Meena, M.L. 2000. Evaluation of Indian mustard germplasm under rainfed condition. *Indian Journal of Plant Genetic Resources*, **13** : 177-182.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research*, Wiley Inter-Science Publication, New York, pp.416-422.

Kachroo, D., Kumar, A. and Bali, S.V. 1997. Correlation and regression studies between different yield attributes and seed yield in mustard. *Journal of Oilseed Research*, **14** : 202-206.

Kumar, P.R., Chauhan, J.S. and Singh, A.K. 2000. Rapeseed-mustard genetic resources : Status and Priorities. *Indian Journal of Plant Genetic Resources*, **13** : 207-218.

Meena, S.S., Chauhan, J.S. and Yadava, J.S. 2000. Genetic variability, correlation and path analysis in germplasm of Indian mustard. *Indian Journal of Plant Genetic Resources*, **13** : 171-176.

Reddy, B.N. 1991. Correlation studies in Indian mustard. *Journal of Oilseeds Research*, **8** : 248-250.

Yadav, S.K., Shukla, A.K., Chauhan, J.S., Singh, A.K. and Kumar, P.R. 1997. Characterization of genetic resources of Indian mustard. *Indian Journal of Plant Genetic Resources*, **10** : 41-48.

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Studies on genetic nature of yield and its components in sunflower, *Helianthus annuus* L.

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Abstract

Four CMS lines and 10 restorers were crossed in a L x T fashion to elucidate the information on the nature of gene action involved in the inheritance of important *quantitative traits and to select the parents with good gca* and crosses with good *sca* effects. The estimates of variance components revealed that *sca* variance was higher in magnitude compared to *gca* variance for all the characters studied indicating the predominance of non-additive gene action. The lines DCMS 5 and DCMS 16 were found to be good general combiners as they could contribute alleles with positive effect for improving all the important economic traits. Among the testers, DSI 81, DSI 82, RHA 298, RHA 271 and RHA 345 were proved to be good general combiners for majority of the yield contributing traits. Among the 40 cross combinations, the crosses, DCMS 36 x DSI 81, DCMS 5 x RHA 298, DCMS 16 x DSI 55, DCMS 5 x DSI 81 and DCMS 16 x RHA 341 were found to be good specific combiners since the *sca* effects of these crosses were in desirable direction for many of the yield contributing characters.

Key words: Combining ability, gene action, *gca*, *sca*, sunflower

Introduction

Development and commercialization of hybrids in sunflower started with the discovery of cytoplasmic male sterility (Leclercq, 1969) and the subsequent identification of restorers. From 1972, till today several hybrids have *been developed by using a single male sterile source*, PET1, which widens the scope for its vulnerability to any strain of disease or insect pests in epidemic form. Hence several new diverse cytoplasmic male sterile sources were identified but only few effective restorer lines were identified for these CMS sources. To develop sunflower hybrids with improved yield potential, the choice of parents through careful and critical evaluation is of paramount importance in order to raise yield ceiling and to improve productivity and total production. Combining ability studies elucidates the nature and magnitude of gene action involved in the inheritance of character by providing the information on the two components of variance *viz.*, additive genetic and dominance variance, which are important to decide upon the parents and crosses to be selected for eventual success. Such information is required to design efficient breeding program for rapid crop improvement. The selection of suitable outstanding parents with favourable alleles, which upon crossing would give heterotic hybrids. Accordingly, the present investigation was undertaken to have an idea on the *nature of gene action involved in the inheritance of* important quantitative traits and to select the parents with good *gca* and crosses with good *sca* effects through line x tester analysis in sunflower.

Material and methods

Four cytoplasmic male sterile lines (DCMS 5, DCMS 16, DCMS 36 and DCMS 41) and 10 restorers were planted during *kharif*, 2001 at Directorate of Oilseeds Research, Hyderabad. Four CMS lines were sown twice at an interval of 10 days, while the 10 inbred lines were planted three times at weekly intervals to facilitate synchronization of flowering. Each female line was sown in ten rows while, each restorer line was sown in two rows with 60 x 30 cm spacing. Crossing was performed in line x tester fashion among the CMS lines and restorers. Seed was collected to study the combining ability analysis in the next season.

During *rabi*, 2001-02 the 40 hybrids along with the 14 parents were sown in a Randomized Complete Block Design replicated thrice with a row length of 5 m. Spacing was adopted as 60 cm between rows and 30 cm between hills. Observations were recorded on five randomly selected plants in each replication to record the data on the following characters viz , days to 50% flowering, days to maturity, plant height, number of leaves per plant, head diameter, 100-seed weight, number of seeds plant, oil per cent and seed yield per plant. The data was analysed using the line x tester model suggested by Kempthorne (1957).

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Results and discussion

The analysis of variance for combining ability revealed the existence of significant differences among the parents, crosses, and parents vs crosses for all the characters (Table 1). This clearly indicates the existence of wider genetic differences among parents and crosses, while the significant variance due to parents vs crosses indicated the prevalence of heterosis for all the characters. But among the lines significant differences was observed for all the characters except days to maturity where as the testers showed significant difference for all the traits except number of leaves per plant. Interaction between lines and testers also exhibited significant differences for all the traits, showing the importance of non-additive gene action in the expression of the traits in the hybrids.

The comparative estimates of variances due to general combining ability (*gca*) and specific combining ability (*sca*) revealed the predominance of *sca* variance in relation to *gca* variance for all the traits which implied that all the characters were predominantly under the control of non-additive gene action. (Table 2). The result corroborates with the findings of Singh *et al.* (1999) and Krishna (2001). The degree of dominance was more than unity for all the traits studied confirming the earlier inference drawn.

The high magnitude of average degree of dominance (more than unity) revealed over-dominance for all the traits, confirming the earlier inference drawn about the preponderance of non-additive genetic variance in the material, which is in agreement with the reports of Kumar *et al.* (1997), Satyanarayana (2000) and Krishna (2001).

The parents with significant negative *gca* effects for days to 50% flowering and days to maturity are desirable. Therefore, the parents with significant negative *gca* estimates for days to 50% flowering and days to maturity and with significant positive *gca* effects for the remaining characters are considered as good general combiners. The parents with positive and non-significant or negative significant and non-significant *gca* estimates for number of leaves/plant, head diameter, 100 seed weight, number of seeds/plant, oil content and seed yield/plant are rated as poor general combiners. The character wise estimation of *gca* effects of lines and testers (Table 3) revealed that the lines DCMS 5 and DCMS 16 and the testers DSI 81 and DSI 82 were early in flowering indicating their usefulness in breeding for early maturing hybrids. The lines DCMS 5 and DCMS 16 were found to be good general combiners as evident by contributing positive alleles through expression of higher means for number of leaves/plant, head diameter, 100 seed weight, number of seeds/plant, oil content and seed yield/plant. Among the testers, DSI 81, RHA 298, RHA 271 and RHA 345 registered high *gca* effects for 100 seed weight, number of seeds/plant and seed yield/plant. The testers, DSI 81 and DSI 82 were found to be good general combiners for earliness, number of leaves, head diameter, number of seeds, oil content and seed yield/plant. From the overall observations among male parents, RHA 298, RHA 271, DSI 81, RHA 345 and DSI 82 proved to be best combiners for seed yield and its most of the related characters but none of them was proved to be a good general combiner for all the traits. The parents which are good general combiners for yield pocessed *gca* effects in the desired direction for yield components was also reported earlier by Radhika, 1994 and Prabhakar Rao (1996). Therefore, for improving a specific character, the parents showing high gca in positive direction can be used as good donors for improvement of that character (Haripriya, 1989).

Seventeen crosses were identified as good specific combinations for seed yield/ plant. (Table 4). The crosses DCMS 36 x DSI 81 (5.455), DCMS 16 x DSI 55 (5.420), DCMS 5 x RHA 298 (5.272), DCMS 16 x DSI 43 (4.991), DCMS 35 x RHA 345 (4.570), DCMS 36 x DSI 43 (4.991), DCMS 41 x RHA 345 and (4.570), were found to be best specific combiners for seed yield among the forty crosses studied. These cross combinations along with significant positive *sca* effect for seed yield also exhibited significant positive *sca* effects for other yield contributing traits. The cross DCMS 5 x RHA 298, is the best specific combination as it exhibited significant *sca* effects for all the traits in desirable direction. Moreover, it also exhibited negative significant *sca* effect for plant height indicating its suitability for commercial exploitation as the farmers prefer early maturing and dwarf hybrids. Like wise, the crosses showing good specific combinations for seed yield/plant was apparently due to its good specific combinations for other yield related characters.

Study of the relationships of *sca* effects of crosses and *gca* effects of parents revealed that the good specific combinations for various characters involved parents with high x low or low x low or low x high *gca* effects. If we consider single example of each case for the traits studied in high x low, low x low and low x high order, it was observed as, for number of leaves per plant (DCMS 5 x RHA 341, DCMS 36 x DSI 43, DCMS 41 x DSI 82), for head diameter (DCMS 5 x RHA 298, DCMS 36 x DSI 43, DCMS 41 x DSI 82), for 100 seed weight and number of seeds/plant (DCMS 5 x RHA 341, DCMS 36 x DSI 55, DCMS 41 x RHA 298) and for seed yield and oil content (DCMS 5 x DSI 55, DCMS 41 x DSI 66, DCMS 36 x RHA 298). In spite of the involvement of both poor general combiners or one of the parent as poor general combiners, these cross combinations expressed significant *sca* effects in desirable direction which might be due to concentration and interaction between favourable genes contributed by the parents. Singh *et al.* (1999) and Krishna (2001) also observed the involvement of high x low *gca* combinations of parents for crosses with high *sca* effects.

Therefore it can be concluded in the present investigation that almost all the characters were governed by non-additive gene action. The cross combinations showing

high *sca* effects for yield and its related traits, if found to be a combination of one or both parents having good general combining ability can be utilized in the hybrid development programme for exploitation of hybrid vigour through diversified restorer systems to raise the yield levels of sunflower.

Table 1 Analysis of variance for combining ability for the characters studied in Line x Tester (4x10) experiment in sunflower

Source of variation	d.f	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of leaves / plant	Head diameter (cm)	100 seed wt (g)	No. of seeds / plant	Oil (%)	Seed yield/plant (g)
Replications	2	1.12	5.19	0.09	6.12	4.13	0.02	204.16	0.28	5.82
Genotypes	53	40.95**	52.79**	777.05**	40.75**	13.4**	2.99**	79207.3**	32.61**	115.64**
Parents	13	20.59**	29.35**	416.76**	22.6**	8.503**	1.479**	44342.34**	30.21**	56.64*
Parents vs. crosses	1	782.99**	633.23**	6732.33**	161.65**	98.89**	2.743*	818329.6**	179.9**	199.35**
Crosses	39	28.71**	45.72**	744.45**	43.7**	12.84**	3.5**	71877.11**	29.64**	133.16**
Lines	3	76.2**	80.22	2051.56**	126.63*	55.89**	9.5**	136499*	52.56*	407.78**
Testers	9	53.26**	74.4*	1648.12**	49.87	20.87**	6.72**	129308.8*	60.2**	295.63**
Lines x Testers	27	15.25**	32.32**	297.99**	32.43**	5.38**	1.76**	45553**	16.94**	48.49**
Error	106	1.22	2.08	55.97	2.98	2.18	0.59	1353.79	2.37	8.4

* & ** Significant at 5% and 1%level respectively ; df- degree of freedom.

Table 2 Estimates of general and combining ability variances and degree of dominance for yield and yield components

Source	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of leaves	Head diameter (cm)	100 Seed Weight (g).	No. of seeds/ plant	Oil (%)	Seed yield/ plant (g)
σ^2 gca	0.2209	0.2199	7.3282	0.1850	0.1224	0.0286	432.0876	0.2085	1.3898
σ^2 sca	4.3900	10.0800	80.6733	9.8167	1.0667	0.3900	14733.070	4.8567	13.36330
σ^2 gca /σ^2 sca	0.0503	0.0218	0.0908	0.0188	0.11148	0.0732	0.0293	0.0429	.1040
Degree of dominance $\sqrt{\sigma^2 \text{ sca}}$ /2σ^2 gca	3.1522	4.7874	2.3461	5.1509	2.0874	2.6110	4.1290	3.4127	2.1926

Table 3 Estimates of general combining ability effects for fourteen parents for the characters studied in sunflower

Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of leaves	Head diameter (cm)	100 Seed Weight (g).	No. of seeds/ plant	Oil (%)	Seed yield/plant (g)
Lines									
DCMS 5	-1.100**	-0.925**	2.752*	0.952**	1.092**	0.275*	14.9*	0.928**	1.523**
DCMS16	-0.225**	-0.525*	-3.553**	3.125**	1.218**	0.365**	29.1**	1.205**	1.654**
DCMS 36	0.700**	0.375	7.851**	-2.482**	-0.836**	-0.338*	-2.8	-1.92**	0.615
DCMS 41	0.625**	1.075**	-7.050**	-1.595**	-1.472**	-0.299*	-41.2**	-0.211	-3.782**
SE(lines)	**0.201**	**0.263**	**1.365**	**0.315**	**0.269**	**0.140**	**6.717**	**0.281**	**0.529**
Testers									
DSI 81	-0.820*	-0.985*	-9.550**	1.575**	1.121**	0.930**	56.7**	1.709**	3.055**
DSI 82	-0.825*	-3.475**	6.450**	1.975**	1.973**	0.233	177.20**	1.702**	2.261**
DSI 83	-0.075	-0.225	9.700**	-2.525**	0.322	-0.095	-47.85**	-1.353**	-1.289
DSI 55	0.175	0.230	18.200**	-3.975**	-2.999**	-0.885**	7.55	-1.07*	-4.072**
RHA 341	0.170	0.225	-10.800**	-1.275*	0.64	0.082	-63.5**	0.555	-1.856**
RHA 271	-0.075	-0.225	5.700**	2.22**	1.408**	0.43*	48.25**	3.564**	3.162**
RHA 345	0.435	1.525**	4.200	2.495**	1.173**	1.26**	72.2**	-2.125**	2.312**
RHA 298	0.925*	2.412**	-17.300**	0.525	0.262	0.73**	43.05**	0.814	3.290**
DSI 43	0.175	0.925*	-0.550	1.975**	-1.785**	-1.228**	-71.05**	-0.885	-2.825**
DSI 66	-0.08-	0.410	-6.050**	-2.988**	-2.111**	-1.455**	-222.5**	-2.910**	-4.035**
SE(testers)	**0.320**	**0.416**	**2.159**	**0.498**	**0.426**	**0.221**	**10.621**	**0.444**	**0.836**

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

Table 4 Estimates of specific combining ability effects of forty hybrids for the characters studied in sunflower

Cross	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of leaves/ plant	Head diameter (cm)	100 seed weight (g)	No. of seeds/plant	Oil (%)	Seed yield/ plant (g)
DCMS 5 x DSI 81	-1.275 *	-1.835 *	18.250**	2.375 *	2.150 *	1.330 **	104.85 **	2.911***	4.052 *
DCMS 5 x DSI 82	4.375 **	1.375	-14.200**	2.925**	0.150	0.890 *	59.650 **	1.800 *	3.400 *
DCMS 5 x DSI 83	-0.450	1.875 *	4.250	-2.425 *	-0.450	-0.560	-89.650 **	-2.854 **	-4.321 **
DCMS 5 x DSI 55	2.250 **	1.125	16.500**	-2.425 *	-0.650	-0.790	-82.440 **	1.740 *	-1.945
DCMS 5 x RHA 341	1.125	1.625	-16.500**	2.325 *	2.350**	1.085 *	86.850 **	-2.950 **	3.570 *
DCMS 5 x RHA 271	-2.025 **	1.375	-2.700	-1.175	-2.250**	-0.290	39.155	-2.200 *	-3.235
DCMS 5 x RHA 345	-1.875 **	-2.555 **	9.250 *	0.825	1.750 *	-1.050 *	92.140 **	3.000 **	4.298 *
DCMS 5 x RHA 298	-1.625 *	-2.125 *	-16.250**	2.75**	4.350**	0.940 *	113.16 **	3.250 **	5.272 **
DCMS 5 x DSI 43	0.125	-0.125	8.900 *	-2.74 **	-4.540**	-1.555 **	-115.31 **	-2.000 *	-4.615 **
DCMS 5 x DSI 66	-0.625	-0.735	-7.500	-3.575	-2.850* *	0.010	-208.40 **	-2.697 **	-6.475 **
DCMS 16 x DSI 81	-0.325	3.555 **	3.400	-2.125 *	-2.750**	0.145	-34.055	-2.155 *	-6.190 **
DCMS 16 x DSI 82	-0.325	-0.325	-10.100 *	-2.903**	1.830 *	-0.575	-114.55 **	1.880 *	-6.370 **
DCMS 16 x DSI 83	-1.575 *	-1.825 *	0.150	-1.125	-2.450**	-0.655	-103.3 **	-3.917 **	0.052
DCMS 16 x DSI 55	-0.575	-2.055 *	18.500**	2.575**	2.250**	1.245 **	123.45 **	2.430 **	5.420 **
DCMS 16 x RHA 341	1.425 *	1.725 *	-9.850 *	2.875**	2.220**	0.905 *	116.95 **	1.860 *	5.050 **
DCMS 16 x RHA 271	3.175 **	1.635 *	1.900	-2.375 *	-1.040	-1.365 **	28.200	-1.195	0.187
DCMS 16 x RHA 345	1.425 *	-1.825 *	-8.850 *	2.035 *	1.710 *	0.870 *	56.200 **	0.630	3.537 *
DCMS 16 x RHA 298	-1.325 *	-0.633	5.050	-2.125 *	-0.350	-1.280 **	-79.800 **	1.015	-3.350 *
DCMS 16 x DSI 43	-1.575 *	-1.825 *	-5.850	1.195	0.690	0.975 *	48.300 *	2.420 **	4.991 **
DCMS 16 x DSI 66	-0.325	1.575	5.650	1.975	-2.120**	-0.265	-41.395	-2.967 **	-3.325 *
DCMS 36 x DSI 81	-2.725 **	-2.325 **	-3.450	3.175**	0.480	1.245 **	46.050 *	2.425 **	3.964 *
DCMS 36 x DSI 82	-2.725 **	-2.325 **	16.300**	2.975**	-2.610**	-0.840	-19.350	1.550	-0.285
DCMS 36 x DSI 83	1.005	-0.825	7.850 *	-2.475 *	-1.550	1.035 *	-64.950 **	-4.555 **	0.182
DCMS 36 x DSI 55	0.025	-1.975 *	-8.550 *	1.475	2.980**	0.965 *	126.35 **	0.366	5.455 **
DCMS 36 x RHA 341	0.025	-0.975	-9.250 *	-2.275 *	-2.350**	0.085	-140.40 **	-1.675	-4.99 **
DCMS 36 x RHA 271	-1.255 *	-0.975	-9.750 *	2.225 *	1.210	0.910 *	64.800 **	2.495 **	3.527 *
DCMS 36 x RHA 345	1.005	2.675 **	7.850	-2.455 *	-3.330**	-0.040	-45.200 *	-3.211 **	-6.20 **
DCMS 36 x RHA 298	2.270 **	2.175 **	-6.70	-3.525**	2.880**	0.565	44.200 *	2.810 **	4.364 **
DCMS 36 x DSI 43	2.025 **	2.175 **	13.65**	1.985 *	2.080 *	-1.695 **	54.700 *	-2.725 **	-1.902
DCMS 36 x DSI 66	0.350	2.375 **	-7.950	-1.105	0.210	-2.230 **	-66.200 **	2.520 **	-4.114
DCMS 41 x DSI 81	1.665 **	0.275	7.800	-2.575**	-1.110	-0.91 *	-59.35 **	-1.405	-3.650 *
DCMS 41 x DSI 82	-1.325 *	-1.735 *	-8.950 *	2.075 *	1.730 *	0.885 *	45.85 *	1.845 *	3.410 *
DCMS 41 x DSI 83	0.575	-0.225	-10.950 *	-3.275**	-3.580**	1.05 *	-166.05 **	-1.785 *	1.084
DCMS 41 x DSI 55	-0.465	0.025	22.55**	1.985 *	1.840 *	-2.325 **	79.4 **	1.810 *	-3.542 *
DCMS 41 x RHA 341	-1.575 *	-2.475 **	-14.700**	-3.175**	-3.680**	-0.445	-127.3 **	-1.975 *	-3.540 *
DCMS 41 x RHA 271	1.800 **	-1.725 *	0.800	-0.785	1.150	0.045	-88.85 **	-1.695 *	-2.475
DCMS 41 x RHA 345	-1.425 *	2.275 **	5.300	3.575**	2.780**	0.96 *	123.9 **	1.755 *	4.570 **
DCMS 41 x RHA 298	-0.350	1.775*	-1.200	1.575	1.870 *	0.895 *	92.1 **	1.430	3.958 *
DCMS 41 x DSI 43	-0.575	-0.225	1.050	-2.325 *	-3.730**	-1.095 *	-104.1 **	-2.050 *	-3.524 0
DCMS 41 x DSI 66	1.675 **	2.035 *	-1.700	2.925**	2.730**	0.94 *	204.4 **	2.070 *	3.710 *
SE	**0.637**	**0.832**	**4.319**	**0.996**	**0.852**	**0.443**	**21.242**	**0.888**	**1.673**

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

References

Haripriya, S. 1989. Combining ability analysis, heterosis and correlations in sesame (*Sesamum indicum* L.). M.Sc. (Ag) thesis, Andhra Pradesh Agricultural University, Hyderabad.

Kempthorne, O. 1957. *An introduction to genetic statistics*. John Wiley and Sons Inc., New York.

Krishna, 2001. Heterosis and combining ability studies in sunflower (*Helianthus annuus* L.). M.Sc (Ag.) Thesis, Acharya N. G. Ranga Agricultural University, Hyderabad.

Kumar, L. Singh, M. and Sheoran, R. K. 1997. Inheritance of achene yield and its components in a sunflower population. *Journal of Oilseeds Research*, **14**: 168-171.

Leclercq, P. 1969. Une sterilite male cytoplasmique chez le tournesol (A case of cytoplasmic male sterility in sunflower). *Ann Amelior Pl.*, **19**: 99-106

Prabhakar Rao, N. 1996. Studies on diverse sources of cytoplasmic male sterility for breeding new sunflower hybrids. M Sc (Ag.) Thesis, Acharya N G Ranga Agricultural University, Hyderabad.

Radhika, P. 1994. Genetic analysis of yield and certain physiological parameters in sunflower (*Helianthus annuus* L.). M.Sc (Ag.) Thesis, Acharya N.G. Ranga Agricultural University, Hyderabad.

Satyanarayana, K. V. 2000. Genetic analysis of elite inbred lines using L x T design and modified TTC model in sunflower (*Helianthus annuus* L.). M.Sc (Ag.) Thesis, Acharya N. G. Ranga Agricultural University, Hyderabad.

Singh, D. P. Singh, S. B. and Raheja, R. K. 1999. Combining ability analysis for seed yield, oil and oil quality in sunflower (*Helianthus annuus* L.). *Journal of Oilseeds Research* ,**16**: 38-42.

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Genetic divergence in sunflower, *Helianthus annuus* L.

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Abstract

In order to assess the divergence among 58 newly developed genotypes along with three checks in sunflower, Mahalanobis' D^2 statistics was applied. The analysis of variance revealed significant differences among the genotypes for all the traits. The 61 genotypes were grouped into 19 clusters, where cluster I was the largest containing 29 genotypes followed by cluster II with 7 genotypes and cluster III with 5 genotypes. The inter cluster distance was maximum between cluster XIV and XIX followed by cluster V and XIX and XVIII and XIX. Based on inter cluster distance and *per se* performance of genotypes, *the entries viz.*, EC 376211, EC 399318, RHA 344 and BLC-P_6 were selected which could be intercrossed to obtain high heterotic expression and also to recover desirable transgressive.

Key words: *Helianthus annuus*, genetic divergence, D^2 statistics

Introduction

Genetic diversity plays an important role in plant breeding because hybrids derived from diverse lines display greater heterosis than those from closely related strains. Assessment of genetic divergence also helps in downsizing the breeding lines to be maintained. In sunflower, several inbred lines have been recently developed from different source materials. The present investigation was carried out to know the magnitude of diversity present in newly developed inbreds and to select diverse parents to obtain heterotic crosses and wide array of recombinants.

Material and methods

The material for the present study comprised of 58 newly developed sunflower inbreds and three checks *viz.*, KBSH 1, MSFH 17 and Surya. The experiment was conducted at the Directorate of Oilseeds Research, Hyderabad during *kharif*, 1999. Each genotype was sown in paired row of 5 m length spaced at 60 cm with interplant distance of 30 cm. The experiment was laid out in Randomized Block Design with three replications. In each entry, five plants were randomly tagged and utilized to collect data on yield and its component characters *viz.*, days to 50% flowering, days to maturity, plant height (cm), head diameter(cm), 100-seed weight(g), seed yield/plant (g) and oil content. The data were subjected to statistical analysis using Mahalanobis' D^2 statistic (Mahalanobis, 1936) and Tocher's method as described by Rao *et al.*, (2000) was applied for determining the group constellation. Average intra and inter cluster distances were estimated as per Singh and Chaudhary (1977).

Results and discussion

The analysis of variance revealed significant differences among the genotypes for all the traits studied. Based on D^2 statistics, the 61 genotypes were grouped into 19 clusters with variable number of entries revealing the presence of considerable amount of genetic diversity in the material (Table 1). Cluster I had the maximum number of 29 genotypes followed by cluster II with 7 genotypes and cluster III with 5 genotypes. The three clusters I, II and III together included 41 of genotypes reflecting narrow genetic diversity among them. The intra and intercluster D^2 values among the three clusters ranged from 7.30 to 9.03 and 18.43 to 20.58 respectively indicating the narrow genetic diversity among the genotypes. The similarity in the base material from which they had been evolved might be the cause of genetic uniformity. Further, clusters IV, XIII and XV had two genotypes in each, while rest of the clusters V, VI, VII, VIII, IX, X, XI, XII, XIV, XVI, XVII, XVIII and XIX were solitary entry clusters. However, lines derived from the same source of parentage were grouped in different clusters demonstrating the impact of selection pressure in increasing genetic diversity. The checks Surya, KBSH 1 and MSFH 17 were included in cluster III, X and XI, indicating their distinctness from the inbreds with respect to traits considered. Similar results were reported by Teklewold *et al.* (2000).

Average intra and intercluster D^2 values among the 61 genotypes revealed that cluster I showed minimum intracluster value (7.30) indicating that the genotypes within this cluster were similar (Table 2). While cluster XV showed maximum intracluster D^2 value (36.44) followed by cluster XIII (31.34) revealing thereby the existence of diverse genotypes in these clusters. The intercluster D^2 values ranged from 18.43 to 322.26. Minimum intercluster D^2 values were observed between cluster I and III indicating the close relationship among the genotypes included in these clusters. Maximum intercluster value was

Table 1 Distribution of 61 newly developed sunflower genotypes in 19 clusters based on D^2 values

Cluster	Number of genotypes	Genotypes
I	29	852B, R341, R348, 345B, ACC1439-1, M924, ACC664-1, NDOL-2, ACC1149, ACC179, ACC916-1 ACC1228-1, ACC914-1, ACC136, ACC1149-1, ACC91[illegible], ACC1139-1, EC399453, ACC1142, ACC1485, ACC64, ACC914, M-1008, ACC1385
II	7	ACC1426, ACC1262, R298, 349B, M-1014, M-19-5, R34[illegible]
III	5	ACC1464, M-1001, ACC1439, EC376211, SURYA
IV	2	EC399464, HA341
V	1	343B
VI	1	R346
VII	1	ACC1254
VIII	1	350B
IX	1	ACC1168
X	1	KBSH-1
XI	1	MSFH-17
XII	1	M1026
XIII	2	378B,ACC1376
XIV	1	R344
XV	2	No.1874-1, ACC1174
XVI	1	RHA 6D-1
XVII	1	EC399318
XVIII	1	BLC-P_6
XIX	1	EC376211

Table 2 Average intra and inter cluster distances (D2 values) of 79 sunflower genotypes

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVII	XIX
I	**7.30**	19.49	18.43	73.32	272.26	126.58	32.73	31.83	54.23	46.50	119.78	143.27	134.45	100.30	114.78	192.76	282.56	96.56	186.22
II		**8.52**	20.58	102.0	33.83	86.96	253.69	52.38	121.25	48.32	86.69	69.35	121.65	111.33	92.65	158.97	204.45	44.58	104.27
III			**9.03**	117.56	212.45	44.82	125.43	182.25	216.98	86.61	111.25	171.75	188.98	143.67	102.86	40.99	116.96	159.63	222.67
IV				**10.08**	122.35	114.19	45.21	143.26	29.56	44.10	67.34	67.32	48.57	130.91	53.60	91.56	143.78	155.54	77.55
V					**0.00**	171.65	73.32	40.26	54.48	67.22	139.47	36.41	81.45	177.98	96.93	80.45	94.21	56.98	300.08
VI						**0.00**	96.26	122.38	96.26	131.87	70.54	100.15	57.26	93.57	63.69	292.34	159.32	160.57	197.48
VII							**0.00**	100.45	58.86	126.54	66.95	96.90	174.66	108.22	204.89	150.33	97.09	174.63	218.18
VIII								**0.00**	192.33	110.98	159.46	67.45	66.58	160.19	164.58	22.36	117.16	122.15	143.17
IX									**0.00**	93.41	91.82	156.59	118.87	120.51	115.47	84.56	59.22	172.45	165.43
X										**0.00**	63.54	136.47	150.26	139.41	121.69	96.01	30.78	78.98	276.22
XI											**0.00**	22.26	105.41	176.24	189.63	47.89	94.35	190.56	172.20
XII												**0.00**	76.96	103.67	48.32	74.68	175.26	71.45	122.54
XIII													**31.34**	93.89	153.78	79.82	53.60	202.31	91.56
XIV														**0.00**	210.51	49.37	116.48	32.26	322.26
XV															**36.44**	150.65	98.96	111.11	89.65
XVI																**0.00**	87.78	86.54	176.48
XVII																	**0.00**	159.86	153.54
XVIII																		**0.00**	296.86
XIX																			**0.00**

observed between cluster XIV and cluster XIX (322.26) followed by cluster V and cluster XIX (300.08) and cluster XVIII and cluster XIX (296.86) which indicated that the genotypes included in these clusters may give high heterotic response and thus better segregants.

The cluster means and contribution of each trait towards divergence are presented in Table 3. The data revealed considerable differences among the clusters for most of the characters studied. The cluster XVII (EC 399318) recorded highest seed yield/plant and days to maturity, whereas cluster X (KBSH 1) had highest oil content. However, cluster XIX (EC 376211) had maximum head diameter, days to 50% flowering and 100-seed weight, while cluster XIV (RHA 344) recorded minimum head diameter and 100-seed weight. Further, the cluster XVIII (BLC P_6) recorded lowest plant height and days to maturity. Among the seven characters studied, 100-seed weight contributed the most (35%) to divergence of genotypes, whereas the oil content contributed the least (0.05%) indicating narrow diversity for oil content among the genotypes under study.

Table 3 Cluster means and percent contribution of characters towards divergence

Cluster	Days to 50% flowering	Days to maturity	Plant height (cm)	Head diameter (cm)	100 seed weight (g)	Seed yield/ plant (g)	Oil content (%)
I	55	87	129	12.4	5.5	20	30.2
II	55	84	103	9.1	4.0	12	29.9
III	55	87	145	15.0	7.2	27	30
IV	58	91	132	17.8	7.7	13	29.3
V	54	87	162	12.0	3.8	13	29.2
VI	49	80	123	8.4	2.9	11	24
VII	49	85	135	11.9	6.3	19	32.1
VIII	54	85	105	13.8	7.1	14	29.1
IX	54	82	100	12.3	7.1	24	26
X	54	84	168	12.3	4.8	34	38.9
XI	58	89	140	16.5	7.0	45	31.2
XII	49	80	111	10.8	6.2	14	32.1
XIII	44	86	109	10.6	5.3	14	32.7
XIV	48	77	95	6.8	2.6	15	23.1
XV	49	82	136	11.8	3.9	19	30
XVI	58	87	130	8.7	2.4	15	34.3
XVII	59	93	115	15.5	5.3	46	28.1
XVIII	46	75	90	11.2	3.9	16	34.3
XIX	60	92	159	20.1	8.2	37	27
Per cent contribution	18.9	10.5	14.5	9.4	35	11.4	0.05

The data on inter-cluster distances and *per se* performance of genotypes were used to select genetically diverse and agronomically superior genotypes. The genotypes, exceptionally good with respect to one or more characters were deemed desirable. On this basis, four inbreds *viz.*, EC 376211, EC 399318, RHA 344 and BLC P_6 were selected. Intercrossing of divergent groups would lead to greater opportunity for crossing over, which releases hidden variability by breaking linkage (Thoday, 1960). Progenies derived from such diverse crosses are expected to show wide spectrum of genetic variability, providing a greater scope for isolating transgressive segregants in the advanced generations. Hence, these genotypes might be used in a multiple crossing programme to recover transgressive segregants.

References

Mahalanobis, P.C. 1936. On the generalized distance in statistics. Proceedings of National Academy of Sciences, **12**:49-55.

Rao, N.V., Ranganatha, A.R.G., Chandramohan, Y. and Kumar, M.V.N. 2000. Analysis of genetic divergence of sunflower (*Helianthus annuus* L.). *Indian Journal of Plant Genetic Resources,* **13**(1):11-14.

Singh, R.K. and Chaudhary, B.D. 1977. *Biometrical Methods in Quantitative Genetic Analysis.* Kalyani Publishers, New Delhi, pp. 304.

Teklewold, A., Jayaramaiah, H. and Jayarama Gowda. 2000. Genetic divergence study in sunflower. *Helia,* **23**(32):93-104.

Thoday, J.M. 1960. Effects of disruptive selection. III coupling and repulsion. *Heredity,* **14**:35-39.

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Studies on combining ability for yield and yield components in sesame, *Sesamum indicum* L.*

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Abstract

Combining ability analysis was carried out in sesame in a Line x Tester fashion for nine quantitative traits using four lines and three testers. The present study revealed the importance of non-additive gene action in the inheritance of traits *viz.*, days to 50% flowering, number of primaries/plant, number of capsules/plant, oil content (%) and seed yield/plant, while additive gene action was preponderant for days to maturity and 1000-seed weight. Both additive and non-additive gene action was found in plant height and number of seeds/capsule. Madhavi and Vinayak were best general combiners for majority of characters. Among crosses, Tanukubrown x Vinayak and Tanukubrown x DCB-1855 were most promising having good *sca* for seed yield/plant. Heterotic hybrids were more frequently observed in crosses involving high x low *gca* parents.

Key words: Combining ability, heterosis, line x tester, sesame

Introduction

The breeding method to be adopted for improvement of any crop depends primarily on the nature of gene action involved in the expression of quantitative traits of economic importance. Line x tester analysis is an efficient method for the study of combining ability so also the gene action involved. The present investigation has been undertaken in sesame to estimate combining abilities of parents and hybrids along with the magnitude of gene actions governing the expression of quantitative traits under study.

Material and methods

Four lines and three testers were crossed adopting line x tester mating scheme. The resulting 12 F_1 hybrids and their parents were grown in a Randomised Block Design with three replications at Agricultural College Farm, Bapatla during *rabi* 2002-03. Observations were recorded on 10 randomly chosen competitive plants for nine quantitative characters *viz.*, days to 50% flowering, plant height, days to maturity, number of primaries, number of capsules/plant, number of seeds per capsule, 1000-seed weight, oil content (%) and seed yield per plant. The oil content was estimated by NMR Spectrometer. The data was analysed according to the method given by Kempthorne (1957).

Results and discussion

The *sca* variance was significant and higher than *gca* for characters *viz.*, days to 50% flowering, number of primaries, number of capsules/plant, oil content (%) and seed yield/plant indicating non-additive gene action (Table 1). Similar gene action in case of days to 50% flowering, number of primaries and seed yield was reported by Jayalakshmi *et al.* (2000). While Kavitha *et al.* (1999) and Karuppaiyan *et al.* (2000) indicated the same gene action in case of number of capsules/plant and oil content (%). For the characters, days to maturity and 1000-seed weight *gca* variance was higher than *sca* variance indicating additive gene action. Similar gene action for days to maturity and 1000-seed weight was reported by Fatteh *et al.* (1995) and Sajjanar *et al.* (1995). Both additive and non-additive gene actions were observed for plant height and number of seeds/capsule. Devasena *et al.* (2001) and Dikshit and Swain (2001) reported similar results for plant height and number of seeds/capsule.

The estimates of *gca* effects indicated that line Madhavi exhibited significant effects for majority of characters *viz.*, days to 50% flowering, plant height, number of primaries, 1000-seed weight and seed yield/plant, while tester Vinayak exhibited significant *gca* for days to 50% flowering plant height, number of primaries, number of seeds/capsule and seed yield/plant (Table 2). Significant positive *gca* for seed yield/plant was recorded by Madhavi and Tanukubrown in lines while SO-12-2154 and Vinayak in case of testers. The estimates of *sca* effects indicated that cross Tanukubrown x DCB-1855 recorded significant sca in desirable direction for maximum number of characters *viz.*, days to 50% flowering, plant height,

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number of primaries, number of capsules/plant, number of seeds/capsule and seed yield/plant (Table 3). Crosses, Gowri x Vinayak and Rajeswari x DCB- 1855 recorded positive, significant *sca* for oil content (%). While crosses Madhavi x SO-12-2154, Madhavi x Vinayak, Gowri x Vinayak, Tanukubrown x Vinayak, Tanukubrown x DCB-1855, Rajeswari x SO-12-2154 and Rajeswari x DCB-1855 recorded positive, significant *sca* for seed yield/plant.

Majority of heterotic hybrids for important traits were resulted from the combination of parents, one with good and another with poor combining abilities (Table 4). Sarsar *et al.* (1986) indicated that this type of heterosis is due to non-allelic interaction of fixable and non-fixable genetic components for the characters involved.

Table 1 Analysis of variance for combining ability for different characters in sesame

Source	Df	Days to 50% flowering	Plant height (cm)	Days to maturity	No. of primaries	No. of capsules/ plant	No. of seeds/ capsule	1000-seed weight (g)	Oil content (%)	Seed yield/plant (g)
Replications	2	0.19	2.83	0.86	0.03	19.67	3.54	0.05	0.78	0.06
Lines	3	61.81	528.60	0.48	0.82	144.88	1167.01**	1.06**	5.85	24.08
Testers	2	12.02	119.25	1.69	0.08	54.82	46.95	0.04	2.45	9.72
Lines x Tester	6	52.95**	81.53**	0.95	0.63**	185.64**	56.39**	0.05	15.97**	25.65**
Error	22	0.43	2.58	0.55	0.01	11.54	2.12	0.02	1.25	0.04
σ^2 *gca*		3.47	30.60*	0.09	0.04	8.41	57.60**	0.05**	0.27	1.60
σ^2 *sca*		17.50**	26.31**	0.05	0.20**	58.03**	18.08**	0.01	4.90**	8.53**
$2s^2$ *gca* / $2\sigma^2$ *gca* + σ^2 *sca*		0.28	0.69	0.78	0.28	0.22	0.86	0.90	0.09	0.27

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

Table 2 Estimates of general combining ability (*gca*) effects of parents for different characters in sesame

Parent	Days to 50% flowering	Plant height (cm)	Days to maturity	No. of primaries	No. of capsules/ plant	No. of seeds/ capsule	1000-seed weight (g)	Oil content (%)	Seed yield/plant (g)
Lines									
Madhavi	-1.94**	9.99**	-0.27	0.37**	-2.41*	-1.44**	0.20**	0.71	0.25**
Gowri	0.94**	1.88**	0.05	-0.28**	-4.26**	7.97**	-0.50**	-0.45	-1.52**
Tanukubrown	-2.27**	-7.01**	-0.05	-0.20**	2.37*	9.02*	0.08	0.64	2.18**
Rajeswari	3.27**	-4.87**	0.27	0.10**	4.31**	-15.55**	0.21**	-0.90*	-0.91**
SEm±	0.22	0.53	0.24	0.03	1.13	0.48	0.04	0.37	0.06
CD (P=0.05)	0.45	1.11	0.51	0.07	2.34	1.00	0.09	0.77	0.13
Testers									
SO-12-2154	0.97**	-2.39**	-0.38	-0.02	0.42	1.02*	0.04	0.47	0.21**
Vinayak	-1.02**	3.57**	0.02	0.09**	1.89	1.25**	0.02	-0.05	0.77**
DCB-1855	0.05	-1.17*	0.36	-0.07*	-2.31*	-2.28**	-0.07	-0.42	-0.98**
SEm±	0.19	0.46	0.21	0.03	0.98	0.42	0.04	0.32	0.05
CD (P=0.05)	0.39	0.96	0.44	0.06	2.03	0.87	0.08	0.67	0.11

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

e 3 Estimates of specific combining ability (*sca*) effects of crosses for different characters in sesame

oss	Days to 50% flowering	Plant height (cm)	Days to maturity	No. of primaries	No. of capsules/ plant	No. of seeds/ capsule	1000-seed weight (g)	Oil content (%)	Seed yield/plant (g)
ıavi x S0-12-2154	3.36**	4.75**	-0.05	-0.26**	1.52	2.04*	0.03	1.04	1.05**
ıavi x Vinayak	-0.30	0.28	-0.13	0.70**	1.71	2.16*	0.10	-1.35*	1.22**
ıavi x DCB-1855	-3.05**	-5.04**	0.19	-0.43**	-3.24	-4.20**	-0.13	0.31	-2.27**
ri x SO-12-2154	-4.52**	-0.34	0.38	0.06	-0.85	-0.46	0.01	-1.96**	-0.65**
ri x Vinayak	-0.86*	1.45	-0.13	0.05	7.19**	1.84*	-0.02	2.90**	1.74**
ri x DCB-1855	5.38**	-1.10	0.52	-0.12	-6.34**	-1.38	0.01	-0.93	-1.09**
ıkubrown x SO-12-2154	-0.30	-7.13**	-0.27	0.17**	-6.82**	-4.73**	-0.11	-0.08	-2.88**
ıkubrown x Vinayak	3.69**	3.03**	0.63	-0.48**	2.34	1.48	0.10	1.30	1.18**
ıkubrown x DCB-1855	-3.38**	4.10**	-0.36	0.30**	4.47*	3.25**	0.01	-1.22	1.69**
swari x SO-12-2154	1.47**	2.72**	0.72	0.01	6.15**	3.15**	0.07	1.00	2.48**
swari x Vinayak	-2.52**	-4.77**	-0.36	-0.26**	-11.25**	-5.49**	-0.18*	-2.85**	-4.15**
swari x DCB-1855	1.05*	20.05*	-0.36	0.24**	5.10*	2.33*	0.11	1.84**	1.67**
±	0.38	0.92	0.43	0.06	1.96	0.84	0.08	0.64	0.11
P=0.05)	0.79	1.92	0.89	0.13	4.06	1.74	0.17	1.34	0.23

nificant at 5% level; ** Significant at 1% level

e 4 Frequency of parental combination for *gca* in 12 sesame hybrids for important yield related traits

acter	No. of significant heterotic hybrids over better parent for *gca* combinations			
	High x high	High x low	Low x low	Total
f primaries/plant	2	4	2	8
f capsules/plant	0	5	1	6
f seeds/capsule	1	1	1	3
ntent (%)	0	0	2	2
yield/plant	3	3	1	7
	6	13	7	26

traits involving significant and high *sca* with low *gca* controlled by non-additive gene action and can be oved by selection and intercropping mating the cted ones in early generation followed by re-selection, e characters having significant and high *gca* with low are controlled by additive gene action and can be oved by breeding methods involving simple selection pedigree method. And for the traits controlled by both itive and non-additive gene actions, improvement can brought about using breeding methods like diallel ctive mating or bi-parental mating followed by ction in advanced generation.

erences

asena, N., Muralidharan, V. and Punith, D. 2001. Studies on combining ability for yield related traits in sesame (*Sesamum indicum* L.). *Research on Crops,* **2**(3) : 409-413.

Dikshit, U.N. and Swain, D. 2001. Combining ability and heterosis for yield and yield components in sesame (*Sesamum indicum* L.). *Journal of Oilseeds Research,* **18**(1) : 28-31.

Fatteh, U.G., Patel, N.A., Chaudhari, F.P., Dangaria, C.J. and Patel, P.G. 1995. Heterosis and combining ability in sesame. *Journal of Oilseeds Research,* **12**(2) : 184-190.

Jayalakshmi, V., Raja, R.C. and Hariprasad, R.K. 2000. Combining ability analysis for yield and yield components in sesamum. *The Andhra Agricultural Journal,* **47**(3&4):197-200.

Karuppaiyan, R., Ramasamy, P., Arulmozhi, N., Santha, S. and Sundaresan, N. 2000. Heterosis and inbreeding depression in sesame. *Journal of Oilseeds Research,* **17**:260-264.

Kavitha, M., Ramalingam, S.R. and Raveendran, T.S. 1999. Combining ability in sesame (*Sesamum indicum* L.). *Journal of Oilseeds Research,* **16**(1) : 27-31.

Kempthorne, O. 1957. *An introduction of genetic statistics.* John Wiley and Sons Inc., New York, p.545.

Sajjanar, G.M., Giriraj, K. and Nadaf, H.L. 1995. Combining ability in sesame. *Crop Improvement,* **22**(2) : 250-254.

Sarsar, S.M., Patil, R.A. and Bhatola, S.S. 1986. Heterosis and combining ability in upland cotton. *Indian Journal of Agricultural Sciences,* **56**:567-573.

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Genetic variability created through biparental mating in sesame, *Sesamum indicum* L.

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Abstract

Biparental mating was attempted in the F_2 population of highest yielding (NKD 1110 x Gowri) and lowest yielding (DCB 1799 x Gowri) crosses of sesame in NC II mating model and compared with the F_3 bulk population of the respective crosses. BIP's recorded higher mean values compared to F_3 bulk in addition to that, it was observed that the lower and upper limits of range of variation in the BIP's was far below and above the limits in F_2 bulk populations. The coefficients of variations, heritability and genetic advance in the BIP's were improved in the BIP's compared to F_3 bulk population.

Key words: Biparental mating, sesame

Introduction

Sesame is one of the important oilseed crops of India. It is predominantly a self-pollinated crop. Autogamous species place a restriction on genetic recombination because of the fact selfing leads to rapid fixation of linked genes, precludes free exchange of favourable genes and also prevents emergence of desirable gene constellations, thereby limits variability. However, genetic variability is the most essential requirement for the success of any crop improvement programme. As such, biparental mating systems (Comstock and Robinson, 1948; 1952) are suggested to overcome the defects of conventional methods of breeding, and help to create new populations with higher frequencies of rare combinations which can not be realized in small segregating populations. Though there are studies on the biparental mating and its impact on various aspects on crop likes wheat and barley, reports on sesame are scanty and hence, the present work was undertaken in sesame with highest yielding (NKD 1110 x Gowri) and lowest yielding (DCB 1799 x Gowri) crosses and their F_3 bulk populations.

Material and methods

The F_2 generation of the highest yielding (NKD 1110 x Gowri) and lowest yielding (DCB 1799 x Gowri) crosses were used to generate biparental progenies by adopting North Carolina Design II (Comstock and Robinson, 1952). A random sample of six females and four males were crossed to constitute one set and in each cross two such sets were generated. The 24 biparental progenies and their corresponding F_3 bulk populations (selfs) were evaluated in a randomized block design with two replications along with the parents during summer, 2001. Healthy crop was raised using recommended agronomic practices and need based plant protection measures. Data were recorded on 10 random, competitive plants for 12 quantitative traits and subjected to analysis.

Results and discussion

Results on various variability parameters viz., mean, range coefficient of variation, heritability, genetic advance and genetic advance as per cent of mean for the biparental progenies of high yielding (NKD 1110 x Gowri), lowest yielding (DCB 1799 x Gowri) crosses B1PI and B1PII and corresponding F_3 bulk population (CI x CII) were furnished in Table 1 and Table 2, respectively. Comparison of the mean values indicated that the mean performance of biparental progenies are slightly more than the corresponding F_3 bulk of the traits like yield, number of capsules on primary branches, capsules per plant, seeds per capsule and biological yield. Such higher proportion of mean values were also reported by Sudharani *et al.* (1997) and Alarmelu *et al.* (1998) and Nagaraj Kampli *et al.* (2002). Higher mean values of the B1P generation could be attributed to the advantage of increased heterozygosity at many loci for the said characters compared to the F_3 bulk populations, so also the pushing of mean values towards positive side could be of immense value in throwing superior segregants in the advanced generations (Sudharani *et al.*, 1997).

Comparison of the range of variation in B1P's with that of F_3 bulk populations indicated that in both the biparental progenies, upper limit increased in recombination of latent variability that tends to remain locked under linkage.

Higher proportion of PCV and GCV for the traits plant height, number of primary branches, capsules on main stem, capsules on primary branches, capsules per plant, capsule length, seeds per capsule, biological yield and

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Table 1 Variability parameters in the biparental progenies (NKD 1110 x Gowri and DCB 1799 x Gowri) and F_3 bulk populations (CI & CII) for 12 quantitative traits in sesame

Character	Population	Mean	Range	Coefficient of variation
Plant height	B1PI	79.73	59.00 - 99.00	10.69
	CI	69.22	49.00 - 90.00	12.78
	B1PII	70.48	45.00 - 105.00	15.76
	CII	62.05	40.00 - 105.00	22.38
Days to maturity	B1PI	72.48	65.00 - 79.00	2.58
	CI	68.20	60.00 - 75.00	6.26
	B1PII	67.02	68.00 - 73.00	1.59
	CII	70.20	68.00 - 75.00	1.29
No. of primary branches	B1PI	2.15	0.00 - 4.00	39.52
	CI	2.07	1.00 - 4.00	35.17
	B1PII	2.03	0.00 - 5.00	40.70
	CII	2.30	0.00 - 5.00	40.83
Capsules on main stem	B1PI	55.82	29.00 - 99.00	21.42
	CI	44.04	27.00 - 70.00	23.89
	B1PII	35.21	7.00 - 72.00	39.02
	CII	36.77	11.00 - 62.00	30.00
Capsules on primary branches	B1PI	24.05	7.00 - 57.00	28.93
	CI	21.02	17.00 - 31.00	17.31
	B1PII	22.46	0.00 - 65.00	48.61
	CII	18.50	0.00 - 41.00	52.96
Capsules per plant	B1PI	81.25	41.00 - 138.00	18.89
	CI	66.02	47.00 - 105.00	19.81
	B1PII	47.71	0.00 - 121.00	66.76
	CII	57.27	21.00 - 97.00	32.56
Capsule length	B1PI	2.41	2.01 - 3.15	7.80
	CI	2.59	2.19 - 3.10	8.16
	B1PII	2.34	1.78 - 2.90	8.71
	CII	2.42	2.00 - 2.90	9.20
Seeds per capsule	B1PI	56.06	39.00 - 75.00	8.40
	CI	54.01	50.70 - 59.20	4.37
	B1PII	57.76	40.30 - 75.00	11.05
	CII	56.18	40.90 - 71.20	12.08
1000 seed weight	B1PI	2.74	1.50 - 3.95	15.59
	CI	2.79	2.18 - 3.22	9.42
	B1PII	2.80	1.80 - 4.10	14.85
	CII	2.89	2.37 - 4.10	15.89
Biological yield	B1PI	45.10	21.15 - 77.47	25.43
	CI	44.36	34.60 - 56.50	12.12
	B1PII	30.22	16.21 - 72.30	26.95
	CII	28.83	22.00 - 49.70	22.18
Harvest index	B1PI	20.81	11.58 - 56.63	25.43
	CI	20.99	14.41 - 28.87	12.81
	B1PII	19.94	13.74 - 30.38	13.35
	CII	20.62	17.73 - 24.81	9.06
Seed yield/plant	B1PI	10.11	4.04 - 17.20	23.96
	CI	9.25	7.75 - 12.72	14.23
	B1PII	6.00	3.19 - 9.90	30.59
	CII	5.90	4.10 - 9.70	20.34

B1PI = Biparental progeny of NKD 1110 x Gowri
CI = F_3 population of the cross NKD 1110 x Gowri
B1PII = Biparental progeny of DCB 1799 x Gowri
CII = F_3 population of cross DCB 1799 x Gowri

harvest index in the B1PII than that corresponding F_3 bulk may be due to breaking of linkages mostly in repulsion phase and uncovering of hidden genetic variability.

Estimates of heritability genetic advance and genetic advance as per cent of mean were high for all the traits except seeds per capsule suggesting that selection would be effective in improving yield.

Results on the variability heritability and genetic advance in biparental progenies revealed the observations useful to the breeder, that the biparental progenies served a good purpose when undesirable genes are linked. As such, it can be concluded that use of biparental mating in an early segregating generation of any appropriate cross could be of much use in widening variability and consequently in making the improvement in productivity.

Table 2 Genetic parameters in the biparental progenies (B1PI & B1PII) for 12 quantitative traits in sesame

Character	Population	Coefficient of variation		Heritability (h^2b)	Genetic advance (GA)	Genetic advance % of mean
		Phenotypic (PCV)	Genotypic (GCV)			
Plant height	B1PI	5.88	3.76	40.85	2.04	2.56
	B1PII	12.28	11.57	87.70	6.28	8.91
Days to maturity	B1PI	1.46	1.22	69.96	1.52	2.10
	B1PII	1.48	1.37	86.03	1.84	2.63
No. of primary branches	B1PI	17.66	15.25	74.57	6.40	297.2
	B1PII	19.98	18.39	73.41	6.72	331.2
Capsules on main stem	B1PI	15.85	14.85	87.89	7.13	12.77
	B1PII	37.36	36.48	75.34	11.96	33.97
Capsules on primary branches	B1PI	18.52	13.94	56.65	4.96	8.89
	B1PII	36.87	35.71	93.81	11.63	33.03
Capsules/plant	B1PI	13.08	11.92	83.05	6.18	7.61
	B1PII	43.72	41.64	90.71	12.25	25.69
Capsule length	B1PI	2.68	1.12	17.47	0.57	23.78
	B1PII	9.46	4.25	20.18	1.26	54.15
Seeds/capsule	B1PI	3.27	0.76	5.40	2.01	3.59
	B1PII	7.08	5.70	6.19	3.28	5.69
1000 seed weight	B1PI	12.05	11.21	86.54	6.14	178.77
	B1PII	12.02	11.53	92.01	6.57	234.6
Biological yield	B1PI	14.66	10.78	55.57	4.30	9.55
	B1PII	21.37	20.22	89.52	8.47	28.04
Harvest index	B1PI	9.66	5.06	43.69	2.75	13.22
	B1PII	11.79	11.06	88.00	6.22	31.93
Seed yield/plant	B1PI	14.48	12.37	73.21	5.72	56.00
	B1PII	21.46	20.38	90.18	6.58	122.57

B1PI = Biparental progeny of NKD 1110 x Gowri B1PII = Biparental progeny of DCB 1799 x Gowri

References

Alarmelu, S., Stephen Dorairaj, M. and Ramanathan, T. 1998. Population improvement in sesame. *Journal of Oilseeds Research*, 15(1) : 32-35.

Comstock, R.E. and Robinson, H.F. 1948. The components of genetic variation in population of biparental progenies and their use in estimating average degree of dominance. *Biometrics*, **4**:254-266.

Comstock, R.E. and Robinson, H.F. 1952. Estimation of average dominance of genes. In *Heterosis* (ed. J.W. Gowen) Iowa State College Press Ames, USA 494-516.

Nagaraj Kampli Salimath, P.M. and Kajjidoni, S.T. 2002. Genetic variability created through biparental mating in chickpea (*Cicer arietinum* L.). *Indian Journal of Genetics*, **62**(2) : 128-130.

Sudharani, M., Lakshmi Kantha Reddy, G. and Raja Reddy, C. 1997. Genetic analysis in the biparental progenies of two inter varietal crosses of sesame (*Sesamum indicum* L.). *Bulletin of Pure and Applied Sciences*, **16**:81-85.

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Genetic divergence in sesame, *Sesamum indicum* L. across three locations in Andhra Pradesh

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Abstract

Seventy one diverse germplasm lines of sesame, *Sesamum indicum* L. collected from different parts of the country were evaluated for genetic divergence at three locations of Andhra Pradesh *viz.*, Agricultural Research Station, Peddapuram; ARS, Elamanchili and Regional Agricultural Research Station, Jagtial during *kharif*, 1999. The study revealed that clustering was random and independent at the three locations and no parallelism observed between geographic origin and genetic diversity. The traits *viz.*, days to maturity, 1000 seed weight, seeds/capsule and 1000 seed weight contributed to maximum divergence at all locations.

Key words: Genetic divergence, sesame

Introduction

Conventional procedure of indiscriminate hybridization on massive scale in any crop results in an immense wastage of resources. 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 (Arunachalam, 1981). So, the present study was undertaken to measure genetic diversity among the germplasm lines of sesame to know the diverse nature and their relation with geographic diversity across locations.

Material and methods

Seventy one diverse germplasm lines of sesame originating from different parts of the country were studied under different locations of Andhra Pradesh *viz.*, Agricultural Research Station (ARS), Peddapuram (East Godavari District); Agricultural Research Station, Elamanchili (Vizag District) and Regional Agricultural Research Station, Jagtial (Karimnagar District) during *kharif*, 1999 in a randomized block design with two replications. 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 (1928) D^2 statistic.

Results and discussion

Seventy one genotypes were grouped into six clusters at ARS, Peddapuram while eight each were formed at Elamanchili and Jagtial (Table 1). Clustering pattern at the three locations of Andhra Pradesh was random and independent. Cluster II was the largest with 22 genotypes followed by cluster I (17 genotypes) and smallest being cluster VI (2 genotypes) at Peddapuram, while cluster VI (16 genotypes) and cluster VII (3 genotypes) and the cluster III (16 genotypes) and IV (4 genotypes) were the largest and smallest clusters at Elamanchili and Jagtial, respectively. The intra and inter D^2 values of the clusters at three locations are furnished in Table 2. The D^2 values among the various combination of germplasm lines ranged from 24.76 to 151.01 at Peddapuram while at Elamanchili and Jagtial, the intercluster D_2 values ranged from 11.88 - 41.61 and 13.07 to 44.59, respectively.

Magnitude of inter cluster distances were greater than intra cluster distances suggesting the presence of diversity among the clusters. The major clusters at the three locations included genotypes from different origin, as such can be concluded that there is no relationship between genetic and geographic diversity.

Study of cluster means indicated appreciable variation among the clusters for the traits like plant height, days to maturity, capsules on main stem, capsules on primary branches, capsules/plant, biological yield, harvest index and seed yield/plant (Table 3). Genotypes included in cluster IV are characterised by short stature coupled with earliness at Peddapuram while cluster V had similar expression at Jagtial. For the traits capsules on main stem, capsules on primary branches, capsules/plant and seed yield are characterized by cluster I and II (Peddapuram), V (Elamanchili) and III (Jagtial), respectively.

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The characters contributing maximum to the D^2 values have to be given greater emphasis for deciding on the clusters for the purpose of further selection and choice of parents for hybridization. Maximum contribution towards genetic divergence was by days to maturity (62.74), followed by 1000 seed weight (16.46), seeds/capsule (15.09) and capsule length (5.35) at Peddapuram while, the traits days to maturity (45.27), seeds/capsule (33.64), capsule length (5.35) and 1000 seed weight (5.27) at Elamanchili and 1000 seed weight (44.35), days to maturity (28.33), seeds/capsule (13.40) and capsule length (13.26) were the traits for divergence at Jagtial (Table 4). Comparison of the divergence pattern at the three locations indicated the importance of the traits *viz.*, days to maturity, 1000 seed weight, seeds/capsule and capsule length at the three locations. Review on genetic divergence indicated the importance of 1000 seed weight, capsule length and days to flowering (Swain and Dikshit, 1997), while, capsules/plant and seed yield/plant are the traits for divergence as per Solanki and Deepak Gupta (2002).

Table 1 Cluster composition of 71 genotypes of sesame

Cluster number	No. of genotypes included in the cluster	Genotype	Details of genotypes
Peddapuram			
I	17	5, 10, 7, 31, 8, 25, 6, 55, 18, 67, 26, 15, 42, 21, 37, 14, 46	EC 357313, Krishna, EC 358039, DSR 1974, SI 3012, SO 2152, **EC 358022**, K 5194, **Madhavi**, K 5163, K 5231, SI 75, K 5173, YLM 21, DCB 1857, **Tanuku brown**, JBT 9/29
II	22	16, 48, 44, 29, 33, 17, 19, 30, 40, 34, 68, 20, 28, 45, 36, 38, 41, 2, 39, 43, 63, 9	PS 201, SO 12-2172, **K 5177**, DCB 1828, 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 1860, **Vinayak**
III	14	12, 27, 23, 51, 32, 52, 54, 62, 53, 50, 47, 57, 58, 60	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
IV	10	3, 70, 56, 59, 49, 65, 1, 24, 71, 4	EC 357025, DCB 1802, JBT 9/39, NKD 1158, K 5201, SO 12-2171, EC 355653, **SO 12-2154**, K 5240, EC 357312
V	6	35, 64, 69, 11, 61, 66	DCB 1869, NKD 1070, K 5176, SI 1618, NKD 1151, **NKD 1110**
VI	2	13, 22	NAC 8414, DCB 1874
Elamanchili			
I	12	1, 58, 11, 69, 59, 61, 64, 54, 60, 62, 32, 52	EC 355653, ECB 1836, SI 1618, K 5176, NKD 1158, NKD 1151, NKD 1070, JBT 9/19, DCB 1818, DCB 1805, NKD 1107, NKD 1093
II	5	35, 66, 56, 47, 57	DCB 1869, NKD 1110, JBT 9/39, NKD 1160, DCB 1795
III	13	2, 18, 16, 17, 20, 21, 26, 45, 34, 38, 41, 68, 46	EC 351882, Madhavi, PS 201, Gowri, YLM 17, YLM 21, K 5231, K 5203, NKD 1139, SO 12-2148, PSR 1943, DCB 1824, JBT 9/29
IV	7	29, 30, 33, 31, 48, 40, 44	DCB 1828, K 5199, DCB 1791, DSR 1974, SO 12-2172, K 5170, K 5177
V	8	7, 9, 15, 42, 6, 5, 10, 14	EC 358039, Vinayak, SI-75, K 5172, EC 358022, EC 357313, Krishna, Tanuku Brown
VI	16	8, 19, 28, 63, 67, 43, 36, **39, 37,** 23, 25, 51, 27, 50, 53, 55	SI 3012, YLM 11, K 5235, DCB 1860, K 5163, DCB 1862, K 5182, DCB 1858, DCB 1857, K 5181, SO 2152, K 5220, DCB 1855, DCB 1799, 1844, K 5192
VII	3	12, 22, 13	SI 320, DCB 1874, NAC 8414
VIII	7	49, 70, 3, 65, 71, 24, 4	K 5201, DCB 1806, EC 357025, SO 12-2171, K 5240, SO 12-2154, EC 357312
Jagtial			
I	6	6, 13, 5, 7, 10, 1	EC 358022, NAC 8414, EC 357313, EC 358039, Krishna, EC 355653

II	4	22, 31, 65, 46	DCB 1874, DSR 1974, SO 12-2171, JBT 9/29
III	16	8, 12, 15, 21, 17, **19, 3, 20, 16,** 29, 4, 9, 14, 2, 11, 18	SI 3012, SI 320, SI 75, YLM 21, Gowri, YLM 11, EC 357025, YLM 17, PS 210, DCB 1828, EC 357312, Vinayak, Tanuku Brown, EC 351882, SI 1618, Madhavi
IV	9	23, 37, 59, 54, 24, 42, 25, 56, 41	K 5181, DCB 1857, NKD 1158, JBT 9/19, SO 12-2154, K 5173, SO 2152, JBT 9/39, PSR 1943
V	9	32, 51, 45, 43, 62, 34, 64, 47, 40	NKD 1107, K 5220, K 5203, DCB 1862, DCB 1805, NKD 1139, NKD 1070, NKD 1160, K 5170
VI	10	26, 67, 70, 27, 49, 35, 36, 55, 69, 30	K 5231, K 5163, DCB 1806, DCB 1855, K 5201, DCB 1869, K 5182, K 5194, K 5176, K 5199
VII	9	28, 38, 44, 53, 68, 33, 66, 48, 57	K 5235, SO 12-2148, K 5177, DCB 1844, DCB 1824, DCB 1791, NKD 1110, SO 12-2172, DCB 1799
VII	9	39, 71, 50, 52, 58, 61, 63, 60	DCB 1858, K 5240, DCB 1799, NKD 1093, DCB 1836, NKD 1151, DCB 1860, DCB 1818

Bold genotypes were selected for combining ability analysis.

Table 2 Average intra and inter cluster D^2 values of 71 sesame genotypes

Cluster number	I	II	III	IV	V	VI	VII	VIII
Peddapuram	**20.70**	24.76	31.71	66.43	49.35	142.73		
I		**14.87**	31.78	73.35	52.54	151.01		
II			**16.17**	48.18	27.96	124.82		
III				**22.56**	29.34	81.83		
IV					**16.48**	102.13		
V						**16.77**		
VI								
Elamanchili								
I	**9.26**	13.40	16.22	**17.78**	22.85	14.54	28.88	17.04
II		**9.82**	19.54	16.86	30.43	21.68	30.21	22.39
III			**10.38**	11.88	20.80	13.74	40.42	27.90
IV				**7.84**	26.26	18.51	41.10	30.52
V					**18.13**	16.91	41.61	28.40
VI						**9.99**	36.20	22.80
VII							**20.25**	22.12
VIII								**12.47**
Jagtial								
I	**14.20**	25.20	20.66	31.90	33.61	25.96	33.29	40.29
II		**19.94**	33.61	32.10	35.41	25.16	36.94	44.59
III			**14.63**	26.33	26.38	23.65	24.36	29.00
IV				**12.28**	13.15	15.36	17.59	18.99
V					**8.14**	15.40	13.07	16.28
VI						**9.99**	16.77	24.52
VII							**10.22**	15.71
VIII								**10.42**

Bold figures are intra-cluster distances; Normal figures are inter-cluster distances

Table 3 Contribution of different traits towards genetic divergence among 71 genotypes of sesame

Character	Peddapuram		Elamanchili		Jagtial	
	Times ranked first	% contribution towards divergence	Times ranked first	% contribution towards divergence	Times ranked first	% contribution towards divergence
Plant height	2	0.08	23	0.93	4	0.16
Days to maturity	1559	62.75	1125	45.27	704	28.33
No. of primary branches	0	0.00	9	0.36	3	0.12
Capsules on main stem	0	0.00	44	1.77	3	0.12
Capsules on primary branches	1	0.04	101	4.06	0	0.00
Capsules/plant	0	0.00	0	0.0	1	0.04
Capsule length	133	5.35	132	5.31	328	13.26
Seeds/capsule	375	15.09	836	33.64	333	13.40
1000 seed weight	409	16.46	131	5.27	1102	44.35
Biological yield	4	0.16	57	2.29	1	0.04
Harvest index	2	0.08	18	0.72	4	0.16
Seed yield/plant	0	0.00	9	0.36	2	0.08

Table 4 Cluster means for 12 quantitative traits in 71 sesame genotypes

Cluster	Plant height	Days to maturity	No. of primary branches	No. of capsules		No. of capsules/ plant	Capsule length	Seeds/ capsule	1000 seed weight	Biological yield	Harvest index	Seed yield/plant
				On main stem	On primary branches							
Peddapuram												
I	125.63	73.05	3.38	20.55	41.32	59.66	2.51	51.12	3.30	40.16	28.15	11.37
II	129.67	72.27	3.20	22.05	40.81	62.85	2.79	64.80	3.65	37.56	29.72	11.03
III	135.61	76.25	2.92	20.74	36.36	57.09	2.81	59.14	3.81	36.12	30.09	10.70
IV	123.54	72.70	3.30	15.53	32.42	47.95	2.69	52.55	3.49	35.67	19.93	7.12
V	137.03	79.92	2.85	24.58	29.78	54.36	2.87	62.00	3.72	37.08	23.94	8.57
VI	136.61	95.00	2.23	14.79	21.11	35.90	2.57	50.75	2.96	47.42	19.77	9.36
Elamanchili												
I	131.63	78.25	4.20	9.60	15.38	24.99	2.34	59.29	3.03	13.22	19.21	2.51
II	130.82	79.20	3.78	5.86	7.65	13.51	2.31	69.20	2.76	13.26	17.10	2.27
III	131.76	72.53	4.49	12.34	22.56	34.90	2.39	64.07	3.16	13.61	19.47	2.71
IV	118.81	72.31	4.04	10.75	13.68	21.44	2.26	72.28	3.16	14.44	17.59	2.56
V	130.53	72.62	5.07	17.24	36.84	54.08	2.16	47.06	3.26	20.93	20.60	3.71
VI	125.02	73.87	3.58	12.51	12.68	25.19	2.42	53.62	3.27	12.75	17.54	2.23
VII	122.91	88.66	2.48	16.51	14.37	30.88	2.69	51.66	2.85	21.82	18.93	2.48
VIII	132.53	83.28	4.19	9.60	18.76	28.36	2.43	50.92	3.46	14.38	19.31	2.89
Jagtial												
I	71.01	99.75	3.43	15.60	29.18	52.66	2.36	56.50	3.12	20.80	30.40	6.42
II	77.32	86.25	2.80	10.44	22.12	32.56	2.22	49.37	2.73	16.45	20.81	4.11
III	90.31	98.46	3.37	18.16	40.39	58.56	2.70	58.71	3.57	19.85	26.97	5.17
IV	62.52	83.72	2.63	6.90	12.98	19.88	2.21	49.50	3.63	13.11	19.44	2.60
V	59.01	83.05	2.59	6.41	12.63	19.05	2.10	62.66	3.74	10.96	28.23	2.79
VI	63.39	84.10	2.42	6.73	14.70	21.43	2.40	59.85	3.38	13.10	19.89	2.51
VII	62.30	84.27	2.72	8.04	16.25	24.30	2.76	67.83	3.72	12.81	19.41	2.40
VIII	67.00	84.66	2.53	6.81	15.07	21.89	2.72	56.18	4.06	12.02	21.20	2.29

References

Arunachalam, V. 1981. Genetic distance in plant breeding. *Indian Journal of Genetics and Plant Breeding*, **41** : 226-236.

Mahalanobis, P.C. 1928. On the generalized distance in statistics. *Proceedings of National Institute of Science* (India). **2** : 49-55.

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

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 (*Sesamum indicum* L.). *Indian Journal of Genetics*, **57**(3) : 296-300.

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Gene effects, heterosis and inbreeding depression in castor, *Ricinus communis* L.

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Abstract

The P_1, P_2, F_1, F_2, B_1 and B_2 of three castor, *Ricinus communis* L. crosses were studied for eight metric traits. Individual scaling tests and joint scaling test indicated that an additive-dominance model was adequate in seven cases *viz.*, plant height, number of nodes and number of effective spikes/plant in SKP-4 x JI-266, number of capsules on primary raceme, number of effective spikes/plant and seed yield/plant in SKP-4 x JI-269 and 100 seed weight in JP-81 x JI-263. The results of the rest f the cases suggested the presence of additive, dominance and epistatic gene effects for the traits indicating the importance of both additive and non-additive gene actions in the expression of these characters. Duplicate type of epistasis was prevalent in most of the cases. A substantial amount of heterosis over better parent (HBP) was revealed in all the three crosses for seed yield/plant and most of its attributes. Inbreeding depression was also observed significant for total length of primary raceme, effective length of primary raceme, number of capsules on primary raceme, 100-seed weight and seed yield/plant in all the three crosses except in case of SKP-4 x JI-269 for seed yield/plant. Suitable breeding strategies were suggested for the improvement of seed yield in castor.

Key words: *Gene effects, castor*

Introduction

Castor, *Ricinus communis* L. is an important oilseed crop of arid and semi-arid regions. Studies on nature of gene action governing complex quantitative traits are of great value to the plant breeders in selecting appropriate breeding methodology for the improvement of yield contributing traits. Such studied have been also reported by Bhatt and Reddy (1986), Pathak *et al.* (1988) and Gondaliya (1998) in castor. Information on the presence of type of epistatic gene effects in the inheritance of various quantitative traits is important for adopting suitable breeding procedures to improve the traits. In the present study, an attempt has been made to know the nature and magnitude of additive, dominance and epistatic gene effects for eight quantitative traits in three crosses of castor.

Material and methods

Six basic generations *viz.*, P_1, P_2, F_1, F_2, B_1 and B_2 derived from three crosses *viz.*, JP-81 x JI-263, SKP-4 x JI-266, SKP-4 x JI-269 were produced (F_1 produced during *kharif*, 1998-99 and rest of the generations were planted during *kharif*, 1999-2000) and evaluated in a Randomized Block Design with three replications during *kharif*, 2000-01 at Oilseeds Research Station, Gujarat Agricultural University, Junagadh. JP-81 and SKP-4 are good combiner and wilt resistant pistillate lines while all the three inbred lines are stable pollinator lines. Each plot consists of a single row of parents and F_1s each, two rows of B_1 and B_2 each and three rows of F_2 generation. Recommended package of practices were followed timely throughout the crop season. The observations were recorded on individual plant basis in each replication on randomly selected five plants in each parent and F_1, ten plants in each of B_1 and B_2 and 20 plants in F_2 generation for eight characters in each cross (Table 1). The scaling test (Mather, 1949; Hayman, 1958) and joint scaling test (Cavalli, 1952) were applied simultaneously for the detection of epistasis. Heterosis over better parent (Fonseca and Patterson, 1968) and inbreeding depression (Singh, 1990) were also worked out.

Results and discussion

The analysis of variance revealed significant differences among six basic generation means in all the three crosses for all the eight characters. The estimates of genetic parameters, heterosis over better parent and inbreeding depression for different characters recorded in three crosses are presented in Table 1. Out of 24 cases (3 crosses and 8 characters) adequacy of additive-dominance model assuming no epistasis was established in only seven cases when both individual scaling test (A, B and C) and joint scaling tests were applied simultaneously; in the remaining cases epistasis was evident. The joint scaling test was found to be more efficient in detection of epistasis compared to individual scaling tests; Ketata *et al.* (1976) in wheat had also concluded superiority of joint scaling test over the simple scaling tests.

The seven cases showing adequacy of scale were SKP-4 x JI-266 for plant height up to primary raceme, number of nodes upto primary raceme and number of effective spikes/plant, SKP-4 x JI-269 for number of capsules on primary raceme, number of effective spikes/plant and seed yield/plant and JP-81 x JI-263 for 100-seed weight. Both additive (d) and dominance (h) gene effects in these non-interacting crosses were important in the inheritance of plant height and number of effective spikes/plant. The additive gene effect (d) contributed towards inheritance of number of nodes upto primary raceme, while only dominance gene effect (h) were important for number of capsules on primary raceme and 100-seed weight in these non-interacting crosses. The additive gene effects could be exploited by pedigree method of breeding while dominance gene effects could be exploited by heterosis breeding.

Among interacting crosses, both additive (d) and dominance (h) gene effects contributed significantly towards the inheritance of number of nodes upto primary raceme and effective length of primary raceme in cross of SKP-4 x JI-269, total length of primary raceme, effective length of primary raceme and number of capsules on primary raceme in cross of SKP-4 x JI-266 and seed yield/plant in cross of JP-81 x JI-263. Only additive (d) was significant for number of nodes upto primary raceme in JP-81 x JI-263 and SKP-4 x JI-266, 100 seed weight in cross of SKP-4 x JI-266 and total length of primary raceme in SKP-4 x JI-269. While only dominance (h) was significant for plant height, total length of primary raceme, effective length of primary raceme, number of capsules on primary raceme, 100-seed weight in JP-81 x JI-263, for seed yield/plant in SKP-4 x JI-266 and SKP-4 x JI-269. Neither additive (d) nor dominance (h) was significant for plant height and 100-seed weight in the cross of SKP-4 x JI-269. Several workers have earlier reported importance of additive and dominance gene effects in the inheritance of seed yield and its components by Singh and Yadava (1981). Alba and Greco (1983), Thakkar (1987) and Pathak *et al.* (1988). Importance of only additive effects for seed yield was reported by Giriraj *et al.* (1973) and Kandaswamy (1977), while non-additive gene effects for seed yield/plant was reported by Singh and Srivastava (1982), Swarna *et al.* (1984), Patel (1985), Patel *et al.* (1986), Dangaria *et al.* (1987) and Thakkar (1987).

In addition to main effects, the digenic additive x additive interaction effect was significant for plant height in JP-81 x JI-263, (i) and (j) were significant for total and effective length of primary raceme, number of capsules on primary raceme and seed yield/plant in JP-81 x JI-263 and SKP-4 x JI-266. The fixable gene effect (d) and (i) in these crosses could be helpful in isolation for superior inbred lines of castor. The additive x dominance (j) and dominance x dominance (l) gene effects were involved in the inheritance of plant height, number of nodes upto primary raceme and 100-seed weight in SKP-4 x JI-269, number of capsules on primary raceme in JP-81 x JI-263 and 100-seed weight in SKP-4 x JI-266. While only additive x dominance (j) gene effects were significant for number of nodes upto primary raceme and number of effective spikes/plant in JP-81 x JI-263, effective length of primary raceme in SKP-4 x JI-269.

A perusal of gene action revealed that both additive and non-additive gene effects governing seed yield and its related traits were observed in three crosses of castor (Table 1). Further duplicate type of epistasis was observed for all the cases except total and effective length of primary raceme in SKP-4 x JI-266 and SKP-4 x JI-269 and number of capsules on primary raceme in SKP-4 x JI-266, where complimentary epistasis were observed. The presence of duplicate epistasis for most of the cases would be restricting rapid progress, making it difficult to fix genotypes with increased level of character manifestation. It is suggested that for the characters showing influence of digenic interaction in addition to main effects (d) and (h), population improvement approach in the form of biparental mating coupled with recurrent selection may be adopted. Such programme shall allow mild inbreeding in the population and enhance the possibilities of transgressive segregation and the span of selection over generations.

A substantial amount of heterosis over better parent was observed in cross JP-81 x JI-263 and SKP-4 x JI-269 for seed yield/plant and most of its attributes. High and significant heterosis for seed yield/plant in cross JP-81 x JI-263 and SKP-4 x JI-269 might be due to moderate and significant heterosis for 100-seed weight and number of capsules on primary raceme, respectively. The heterosis in above cases could be due to presence of dominance (h) and dominance x dominance (l) gene effects. Joint action of favourable gene combinations at different loci could be responsible for observed heterosis in these crosses for most of the traits. Inbreeding depression was also observed significant for total length of primary raceme, effective length of primary raceme, number of capsules on primary raceme, 100-seed weight and seed yield/plant in all the three crosses except in case of SKP-4 x JI-269 for seed yield/plant. High inbreeding depression in F_2 population for seed yield/plant ranged from 36.88 % (SKP-4 x JI-269) to 85.50% (JP-81 x JI-263) which might be due to wide base of genetic materials. All the crosses in most of the traits showed positive inbreeding depression indicated the presence of dominance effects for most of the traits. Association of high heterosis with high inbreeding depression for seed yield/plant and some of its component traits was observed by Kabaria and Gopani (1971), Pathak *et al.* (1988) and Patel (1996) suggesting importance of non-additive gene effects.

In the present study, involvements of both additive as well as non-additive gene effects were observed in most of the cases. Therefore, heterosis breeding, synthetic variety and population improvement adopting *inter se* mating among promising divergent genotypes and effecting simultaneous selection for seed yield, number of capsules/raceme and other components of yield is recognized as the ideal breeding approach for castor improvement programme.

Table 1 Estimates of gene effects, heterobeltiosis (HB) and inbreeding depression (ID) for eight characters in three crosses of castor

Crosses	m	d	h	i	j	l	HB	ID
Plant height upto primary raceme (cm)								
JP-81 x JI-263	49.62*±1.80	5.50±3.36	47.25*±10.57	33.50*±9.86	3.25±3.63	-15.00±17.05	16.00*±4.11	19.88*±3.97
SKP-4 x JI-266	33.54*±11.38	-8.38*±1.11	11.91*±2.73	-	-	-	20.00*±4.29	3.88±4.08
SKP-4 x JI-269	48.50*±2.78	-1.75±3.83	-13.50±14.22	-14.50±13.49	20.25*±4.10	43.00±20.95	23.00*±4.42	4.00±5.07
Number of nodes upto primary raceme								
JP-81 x JI-263	16.85*±0.44	3.30*±0.77	3.75±2.49	3.60±2.35	2.15*±0.85	-0.50±3.91	1.30±0.89	1.75*±0.85
SKP-4 x JI-266	15.84*±0.37	5.50*±1.07	0.60±0.79	-	-	-	3.30*±0.90	0.57±0.90
SKP-4 x JI-269	17.32*±0.64	2.32*±0.37	-8.95*±3.61	-6.50±3.35	4.85*±1.21	17.40*±5.67	-1.80±1.47	-0.12±1.37
Total length of primary raceme (cm)								
JP-81 x JI-263	36.38*±1.40	-1.75±1.68	19.50*±6.84	17.00*±6.55	5.75*±2.01	-6.50±9.63	-5.00*±2.34	8.12*±2.17
SKP-4 x JI-266	27.62*±1.38	10.25*±3.33	38.75*±9.48	26.00*±8.65	12.00*±3.80	6.00±16.37	11.00*±4.46	20.88*±3.68
SKP-4 x JI-269	31.88*±1.91	7.75*±3.07	20.50±10.68	14.00±9.79	9.75*±3.90	13.50±16.79	4.50±4.94	13.62*±4.02
Effective length of primary raceme (cm)								
JP-81 x JI-263	36.25*±1.43	-2.75±1.86	18.50*±7.09	15.50*±6.82	4.25*±2.14	-4.00±10.17	-4.00±2.24	8.25*±2.19
SKP-4 x JI-266	27.50*±1.41	10.25*±3.33	41.00*±9.58	26.50*±8.73	13.75*±3.86	2.00±16.47	11.00±4.46	21.00*±3.69
SKP-4 x JI-269	31.00*±2.02	8.75*±3.09	25.25*±11.05	15.50±10.16	14.00*±3.98	7.50±17.11	4.50±4.94	14.50*±4.07
Number of capsules on primary raceme								
JP-81 x JI-263	56.98*±3.75	5.25±6.03	92.90*±19.96	75.60*±19.29	26.05*±6.86	-102.90*±30.28	-3.50±6.49	20.72*±5.54
SKP-4 x JI-266	20.85*±2.39	15.00*±6.27	85.05*±17.92	53.00*±15.78	22.55*±7.29	0.10±31.76	24.50*±10.16	42.55*±8.00
SKP-4 x JI-269	19.98*±2.53	0.47±2.37	20.69*±5.30	-	-	-	27.70*±6.89	23.30*±6.48
Number of effective spikes/plant								
JP-81 x JI-263	8.55*±0.57	-1.70±1.13	-3.85±3.30	-2.40±3.21	-4.95*±1.21	7.90±5.27	-4.70*±0.88	0.05±0.81
SKP-4 x JI-266	8.16*±0.41	-1.48*±0.43	-1.78*±0.69	-	-	-	-2.50*±0.95	-0.65±0.67
SKP-4 x JI-269	5.19*±0.40	1.04*±0.37	3.03*±0.76	-	-	-	0.90±1.13	-0.10±1.02
100 seed weight (g)								
JP-81 x JI-263	24.64*±0.28	0.41±0.26	2.01*±0.65	-	-	-	3.19*±0.84	3.59*±0.92
SKP-4 x JI-266	30.61*±0.59	4.63*±0.87	-1.83±3.00	-4.36±2.92	2.65*±1.05	10.92*±4.40	0.55*±0.10	1.81*±0.66
SKP-4 x JI-269	33.09*±0.64	-0.07±1.10	-1.21±3.49	0.34±3.39	3.26*±1.28	13.63*±5.36	-4.89*±1.22	2.80*±0.81
Seed yield/plant (g)								
JP-81 x JI-263	157.00*±11.21	-94.50*±29.35	269.25*±76.68	180.00*±73.87	-60.75*±30.68	-196.50±132.22	55.50*±23.43	85.50*±21.64
SKP-4 x JI-266	108.12*±7.84	9.25±22.11	206.50*±59.06	144.00*±54.21	69.75*±24.58	-77.50±104.92	2.00±28.40	83.88*±22.28
SKP-4 x JI-269	90.25*±5.73	-4.91±5.70	81.15*±18.40	-	-	-	84.00*±30.58	36.88±32.59

* Significant at 0.05%

References

Alba, E. and Greco, I. 1983. Inheritance of seed production per plant components of genetic variability in F1 generation of castor bean. *Genetica Agraria*, 37 : 133.

Bhatt, D. and Reddy, T.P. 1986. Genetics of yield and its components in castor (*Ricinus communis* L.). *Genetica Agraria*, **40**(2) : 193-204.

Cavalli, L.L. 1952. *An analysis of linkage in quantitative* inheritance. *In* : *Quantitative Inheritance* (Ed. E.C.R. Rievs and C.H. Waddington), HMSO, London, pp.135-144.

Dangaria, C.J., Dobaria, K.L., Fatteh, U.G. and Patel, V.J. 1987. Heterosis and combining ability analysis in castor. *Journal of Oilseeds Research*, **4**(1) : 46-53.

Fonseca, S. and Patterson, F.L. 1968. Hybrid vigour in a seven parental diallel cross in common winter wheat (*Triticum aestivum* L.). *Crop Science.*, **8** : 85-86.

Giriraj, K., Mensinkai, S.W. and Sindagi, S.S. 1973. Co-relation and genetic studies in diallel crosses of castor. *Mysore Journal of Agricultural Sciences*, **7**(3) : 385-388.

Gondaliya, A.B. 1998. Study of gene action, heterosis and *inbreeding depression in castor* (*Ricinus communis* L.). M.Sc. Thesis submitted to Gujarat Agricultural University, S.K. Nagar, Gujarat.

Hayman, B.I. 1958. The separation of epistatis from additive and *dominance variation in generation. Heredity*, **12** : 371-390.

Kabaria, M.M. and Gopani, D.D. 1971. Note on heterosis and F2 performance in castor. *Indian Journal of Agricultural Sciences*, **41**(3) : 271.

Kandaswamy, M. 1977. Line x tester analysis of combining *ability in castor. Madras Agricultural Journal*, **64**(8) : 537-541.

Ketata, H., Smith, E.L., Edwards, L.H. and Mc New, R.W. 1976. Detection of epistasis, additive and dominance variation in winter wheat (*Triticum aestivum* L. em Thell.). *Crop Science*, **16** : 1-4.

Mather, K. 1949. *Biometrical Genetics.* Mathuen and Company Ltd., London.

Patel, A.A. 1996. Genetic analysis in castor (*Ricinus communis* L.). M.Sc. Thesis, Gujarat Agricultural University, S.K. Nagar, Gujarat.

Patel, K.M. 1985. Heterosis, combining ability and gene action in castor (*Ricinus communis* L.). M.Sc. Thesis submitted *to Gujarat Agricultural University, S.K. Nagar, Gujarat.*

Patel, V.J., Dangaria, C.J., Fatteh, U.G. and Patel, P.S. 1986. Line x tester analysis of combining ability in castor. *Journal of Oilseeds Research*, **3**(2) : 178-183.

Pathak, H.C., Dixit, S.K. and Patel, P.G. 1988. Gene effects and heterosis in castor. *Indian Journal of Agricultural Sciences*, **58**(6) : 476-478.

Singh, A. and Srivastava, A.N. 1982. Line x tester analysis in castor. *Indian Journal of Agricultural Sciences*, **52**(9) : 610-612.

Singh, B.D. 1990. *Plant Breeding.* Kalyani Publishers, New Delhi.

Singh, H. and Yadava, T.P. 1981. Genetic analysis of days to flowering, maturity and yield in castor. *Haryana Agricultural University Journal of Research*, **11**(1) : 54-59.

Swarna Lata, Prasad, M.V.R. and Rana, B.S. 1984. Inheritance of yield and its components in castor. *Indian Journal of Genetics*, **44** : 538-543.

Thakkar, D.A. 1987. *Heterosis and combining ability in castor* (*Ricinus communis* L.). M.Sc. Thesis, Gujarat Agricultural University, S.K. Nagar, Gujarat.

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Combining ability of new castor, *Ricinus communis* L. pistillate line : MCP-1-1

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Abstract

To study combining ability of new pistillate line MCP-1-1 along with the most popular line VP-1 was crossed with 16 testers (male combiners) in line x tester design. The analysis of variance indicated genetic differences among genotypes. The estimated variance of *gca* and *sca* indicated preponderance of non-additive gene action for seed yield, days to 50% maturity of primary raceme and effective length of primary raceme and additive gene action for 100 seed weight, number of nodes up to primary raceme and plant height up to primary raceme. The new pistillate line MCP-1-1 was a good general combiner for seed yield and 100-seed weight. It differed from VP-1 with respect to seed yield, 100 seed weight and effective length of primary raceme. Amongst testers MP-17-01 was identified as a good general combiner for seed yield, effective length of primary raceme and number of primary branches per plant. MCP-1-1 x MP-17-01 was identified as the best cross combination for seed yield, it can be directly used as F_1 hybrid. Selection in segregating generation of MCP-1-1 x MP-17-01, MCP-1-1 x MP 6-01 and MCP-1-1 x MP-7-01 would be effective for development of superior varieties/inbreds.

Key words: Combining ability, additive and non-additive gene effects, castor

Introduction

Castor (*Ricinus communis* L.) Is a cross pollinated crop. The availability of pistillate lines, such as VP-1, Geeta, JP-65, LRES-17 and DPC-9 facilitated the commercial exploitation of hybrid vigour in castor. To achieve quantum jump in castor heterosis breeding requires more diverse pistillate sources as well as testers. Present investigation was taken up to generate information on combining ability analysis and economic heterosis in hybrid combinations developed involving the new pistillate line MCP-1-1. Line x tester analysis was used to study combining ability.

Material and methods

The material for present study comprised of 32 F_1s, two genetically diverse pistillate lines MCP-1-1 and VP-1 and sixteen male combiners used as testers. Pistillate line MCP-1-1 and VP-1 were crossed with sixteen testers in line x tester mating design. The eighteen parents (line and testers) and F_1 were randomised among themselves and grown in contiguous blocks in randomised block design in two replications. Each treatment was sown in 4.5 m long two row plots spaced 90 cm apart, seeds were dibbled at a space of 45 cm with in row. Observations on seed yield per plant, days to 50% maturity of primary raceme, 100 seed weight, number of nodes to nodes to primary raceme, effective length of primary raceme, plant height up to primary raceme and number of primary branches per plant were recorded. In each plot observations on 10 randomly selected plants were recorded. The mean values were subjected to combining ability analysis as per methods suggested by Kempthorne (1957). Economic heterosis for seed yield was computed as per standard methods.

Results and discussion

The analysis of variance revealed that sufficient genetic variability existed in the experimental material for all the characters studied. The mean square due to parents v/s hybrids was significant for all the characters indicating manifestation of substantial heterosis amongst crosses. The partitioning of mean squares due to hybrid revealed that variances due to lines (pistillate) were significant for 100-seed weight, number of nodes up to primary raceme and plant height up to primary raceme. The testers (male combiners) differed significantly for days to 50% maturity of primary raceme, 100 seed weight, number of nodes up to primary raceme, effective length of primary raceme and plant height up to primary raceme. The line x tester interactions were significant for days to 50% maturity of primary raceme, 100-seed weight, number of nodes up to primary raceme and seed yield per plant. The contribution of lines, testers and line x tester to total variance for seed yield indicated that monoecious lines (testers) contributed maximum (66.6%) followed by line x tester interaction (31.7%) similar trend was obtained for other characters. The estimates of variance components (*gca/sca*) indicated that non additive components predominantly governed the inheritance of days to 50% maturity of primary raceme, effective length of primary raceme and seed yield per

plant. Patel *et al.*, (1986), Dangaria *et al.*, (1987), Dobariya *et al.*, (1992), Fatteh *et al.*,(1998) and Kavani *et al.*, (2001) also reported preponderance of non-additive gene action for inheritance of these traits. Higher estimates of *gca* variances than *sca* variances for 100-seed weight, number of nodes up to primary raceme and inheritance of these characters. Present results obtained were in agreement with those reported by Solanki and Joshi (2000). Estimates of genetic variances were negative for some traits it might be due to sampling error or presence of genotype x environment interaction in the expression of these traits.

The estimates of *gca* effects (Table 1) showed that among lines the new pistillate line MCP-1-1 exhibited positive and significant *gca* effects for seed yield per plant and 100-seed weight. It recorded higher mean values for seed yield, 100-seed weight and effective length of primary raceme as compared to pistillate line VP-1, indicating diversity for these traits. The estimates of *gca* effects for tester revealed that MP-17-01 was a good general combiner for seed yield per plant, effective length of primary raceme, number of nodes up to primary raceme and primary branches per plant. The male MP-7-01 was also a good general combiner for seed yield, earliness (days to 50% maturity of primary raceme and number of nodes up to primary raceme) and plant height up to primary raceme. Parents possessing additive gene effects for seed yield and other yield contributing characters are highly desirable for breeding programme. Among testers MP-6-01, MP-8-01 and MP-15-01 were the good general combiners for yield. Tester namely, MP-14-01, MP-1-01 and MP-18-01 were identified as good general combiners for 100-seed weight. In general *per se* performance for seed yield and other traits of parents were in agreement with their *gca* effects.

The specific combining ability effects were positive and significant for seed yield in five crosses out of 32 crosses. The magnitude of *sca* effects was maximum in cross MCP-1-1 x MP-17-01 followed by VP-1 x MP-15-01 and MCP-1-1 x MP-7-01 (Table 2). The magnitude of economic heterosis over hybrid GAUCH-1 was maximum in cross MCP-1-1 x MP 10-01 (82.7%) followed by cross VP-1 x MP-15-01 (47.6%), MCP-1-1 xMP-7-01 (45.3%) and MCP-1-1 x MP-6-01 (39.8%). Besides the utility of superior crosses as F_1 hybrids segregating generation of these crosses could be handled to develop superior varieties / inbreds. In best cross MCP-1-1 x MP-17-01 and other superior crosses MCP-1-1 x MP -101 and MCP-1-1 x MP-6-01 both parents involved were of good general combining ability nature for seed yield.

Table 1 Estimates of general combining ability effects

Line/Tester	Days to 50% maturity of primary raceme	100-seed weight	Number of nodes up to primary raceme	Effective length of primary raceme	Plant height up to primary raceme	No. of primary branches/plant	Seed yield plant
Lines							
MCP-1-1	0.3	1.24**	0.8**	0.9	5.5**	0.02	5.1*
VP-1	-0.3	-1.24**	-0.8**	-0.9	-5.5**	-0.02	-5.1*
SE ± gi	0.9	0.15	0.1	1.0	1.5	0.13	2.1
Testers							
MP1-01	-3.0	4.17**	-1.5**	1.0	-10.7*	-0.43	-23.8*
GAUC-1	-8.2**	-2.88**	-1.4**	-9.5**	-11.7*	-0.29	7.1
MP-4-01	-4.0	2.26**	0.3	-3.9	10.3*	-0.69	-30.8**
MP-5-01	-2.5	-2.68**	1.1**	8.3**	8.3	-0.06	-26.9*
MP-6-01	3.9	-5.13**	0.9*	5.1	4.9	0.28	37.1**
MP-7.01	-12.5**	0.04	-2.1**	-2.1	-11.7*	0.19	34.8**
MP-8-01	-4.5	0.17	0.0	6.5*	11.1*	0.46	19.6*
MP-9-01	-5.2*	-1.13*	-3.5**	-23.1**	-29.1**	0.31	5.7
MP-10-01	3.4	0.02	2.1**	-4.7	16.9**	0.49	-2.4
MP-12-01	-5.5*	3.87**	-0.5	0.4	-3.1	-0.69	-20.0
MP-13-01	17.2**	-1.78**	1.3**	-1.0	1.6	-0.11	-54.9**
MP-14-01	-5.7*	4.79**	-0.9*	-5.3	-5.8	-0.11	-6.1
MP-15-01	-2.0	2.89**	-0.6	0.9	-3.9	0.14	30.1**
MP-16-01	8.4**	-4.00**	1.8**	0.4	-7.1	0.31	-27.2**
MP-17-01	1.9	-5.45**	2.1**	28.5**	19.3**	0.86*	76.5**
MP-18-01	18.2**	4.76**	0.9*	-1.6	10.9*	-0.64	-18.1**
SE±gi	2.5	0.43	0.3	2.9	4.3	0.39	5.8

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

Table 2 Estimates of specific combining ability effects and economic heterosis of important crosses for seed yield

Cross	*sca* effects	Economic heterosis over GAUCH-1 (%)	Seed yield/plant (g)
MCP-1-1 x GAUC-1	5.0	12.4	184.1
MCP-1-1 x MP-5-01	6.4	-7.6	151.3
MCP-1-1 x MP-6-01	20.0*	39.8	229.0
MCP-1-1 x MP-7-01	31.2**	45.3	238.0
MCP-1-1 x MP-17-01	50.9**	82.7	299.3
MCP-1-1 x MP-18-01	2.7	-4.8	155.9
VP-1 x GAUC-1	-5.0	-	163.8
VP-1 x MP-8-01	29.8**	28.9	211.2
VP-1 x MP-9-01	1.7	3.3	169.2
VP-1 x MP-10-01	13.6	5.5	172.9
VP-1 x MP-15-01	50.0**	47.5	241.8
VP-1 x MP-16-01	3.9	-15.5	138.4
SE±sij	8.3		

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

The present study suggested the use of new pistillate line MCP-1-1 in heterosis breeding as it was identified as a good general combiner for seed yield and 100 seed weight. The tasters MP-17-01 and MP-7-01 were identified as good general combiners for seed yield and other important characters, to use future breeding programmes. MCP-1-1 x MP-17-01 can be directly used as a hybrid. Selection in segregating generations of crosses MCP-1-1 x MP 17-01, MCP-1-1 x MP 7-01 and MCP-1-1 x MP 6-01 can be effective to isolate superior castor varieties and inbreds.

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References

Dangaria, C.J., Dobariya, K.L., Fatteh, U.G. and Patel, V.J.1987. Heterosis and combining ability analysis in castor. *Journal of Oilseeds Research, 4(1) : 46-53.*

Dobariya, K.L., Dangaria, C.J. and Patel, V. J. 1992. Combining ability analysis in castor diallel. *Journal of Maharashtra Agricultural Universities,* **17**(2): 233-238.

Fatteh, U.G., Dangaria, C.J., Dobariya, K.L. and Patel, V.J.1998. Combining ability by line x tester analysis in castor (*Ricinus communis* L.). *Indian Journal of Agricultural Sciences,* **58**(1): 7-10.

Kavani, R.H., Golakia, P.R. and Dhaduk, H.L. 2001. Combining ability analysis in castor (*Ricinus communis L.). Journal of Oilseeds Research,* **18**(1): 24-27.

Kempthorne, O. 1957. *An Introduction to Genetical Statistics.* John Wiley and Sons., Inc. New York.

Patel, V.J., Dangaria, C.J., Fateh, U.G. and Patel, P.S. 1986. Line x tester analysis of combining ability in castor. *Journal of Oilseeds Research,* **3**(2): 178-183.

Solanki, S.S. and Joshi, P. 2000. Combining ability analysis over environments of diverse pistillate and male parents for seed yield and other traits in castor (*Ricinus communis* L.).*Indian Journal of Genetics & Plant Breeding* . **60**(2): 201-212.

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Selection response for important quantitative traits in the early generation progenies of safflower, *Carthamus tinctorius* L.

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Abstract

The progenies *viz.*, 296 F_3, 189 F_4 and 40 F_5 of safflower, *Carthamus tinctorius* L. obtained through hybridization of diverse genotypes, mutagenesis of homozygous parental lines and their hybrids were tested for seed yield and its components during 1998, 1999 and 2000 *rabi* at Main Research Station, University of Agricultural Sciences, Dharwad. Inter-generation correlations indicated high positive correlation between F_3- F_4 and F_4- F_5 generation for important traits *viz.*, capitula number, test weight, capitulum diameter and oil content. However, narrow sense heritability estimates were low for all the characters studied indicating low response to selection in the early generations. The broad sense heritability estimates were high for seed yield, 100 seed weight, number of seeds per capitulum and plant height in all the generations suggesting the role of non-additive gene action for the expression of these traits. The progenies, which recorded significantly higher values than national check A-1 for seed yield and oil content are being tested in large-scale trials.

Key words: Safflower, intergeneration correlation, heritability and selection response

Introduction

The success of safflower, *Carthamus tinctorius* L. as a commercial crop in traditional areas and its expansion into new areas largely depends on the extent of improvement made in yield and oil content. The genetic up-gradation of ultimate product in safflower unlike in major oilseed crops involves simultaneous improvement of seed yield and oil content. The studies on interrelations among principal components suggested that the number of capitula per plant, number of seeds per capitulum, test weight and capitulum diameter are the principal components of oil yield per unit area. The strong negative association between these desirable traits is the major problem in safflower improvement (*Parameshwarappa et al.*, 1984; Ramachandram, 1985). Therefore, it is essential to generate wide variability to allow recombination between such strongly associated characters. In view of this, attempts were made to generate wide variability through mutagenesis of homozygous parental lines and heterozygous hybrids of diverse crosses involving high seed yielding and high oil genotypes (Veena and Ravikumar, 2003). Several promising progenies with high seed yield and oil content were selected in F_2/M_2 population and to F_5/M_5 generations and an attempt has been made to study the response to selection in these progenies.

Material and methods

The high oil genotypes A-2 (32-33%) and 19-185 (33-34%) were crossed with national check A-1 producing two hybrids *viz.*, A-1 x A-2 and A-1 x 19-185. About 100 seeds from each hybrid and 250 seeds of each parental lines *viz.*, A-2 and 19-185 were treated with chemical mutagen EMS (0.3%). Similarly, another set of hybrids and parental lines were exposed to 10 KR gamma rays treatment. Following mutagen treatment the F_1's, M_1's and F_1M_1's were advanced to F_2, M_2 and F_2M_2 generations respectively. From all the 10 segregating populations, 296 plants showing higher seed yield and/or oil content were advanced to F_3/ M_3/ F_3 M_3 generation. The selected 296 progenies were grown in two replications along with the check A-1 during 1998. Each progeny was grown in a single row of 4 m. Based on seed yield per plant, 189 promising progenies were advanced to next generation. The selected 189 $F_4/M_4/F_4M_4$ progenies were tested in two replications by growing each progeny in a single row of 5 m during *rabi* 1999. Forty progenies showing significantly superior seed yield over the check A-1 were identified. The selected progenies were tested along with national check A-1 in a randomized block design with 2 replications during *rabi* 2000. Each entry was grown in a plot size of 3m x 2.25m.

The observations on important yield components *viz.*, number of capitula, capitulum diameter, number of seeds per capitulum, 100 seed weight, oil content and seed yield were recorded on five randomly selected plants per replication in F_3, F_4 and F_5 generations. Intergeneration correlation between F_2-F_3, F_3-F4, F_4-F_5 and heritability estimates by parents-progeny regression method using the mean of the selected plants were carriedout for seed yield, oil content and other important quantitative characters.

Results and discussion

Early generation selection in self-pollinated crops is desired for rapid progress. However, the response to selection in the early generations depends on the genetic architecture of seed yield and important yield components. There are no reports available on response to selection in the early segregating populations of safflower. An attempt has been made to select individual plants in F_2 / M_2/ F_2M_2 generations of ten segregating populations which were advanced to succeeding generations. The progenies were derived by different breeding methods. Analysis of variance indicated that the progenies recorded significant variability for all the traits studied in all the generations except number of branches per plant in F_5 generation (Table 1). It was evident from F_2 to F_5 generation that the number of progenies exhibiting higher seed yield were reduced as the generations advanced. The mean seed yield per plant and important yield components such as number of capitula per plant and number of seeds per capitulum were high in F_2 generation and decreased in subsequent generations. This could be due to non-additive gene action and influence of environmental conditions. It is evident from Table 1 that the broad sense heritability values observed were high for seed yield and majority of yield components in F_3, F_4 and F_5 generations and narrow sense heritability values were low for all the traits in all the generations (Table 2). The F_2, F_3, F_4 and F_5 generations were raised in different years. The F_2 generation was grown in highly fertile soils with protective irrigation. Therefore, the general yield levels were very high in the F_2 generation. The F_5 generation had higher mean values for oil content, capitulum diameter and 100 seed weight (Table 1). Although the selections were made based on seed yield per plant the improvement in selected characters like capitulum diameter and 100 seed weight could be due to their high correlation with seed yield (Ramachandram and Goud, 1982).

Table 1 Analysis of variance, mean performance and braod sense heritability in different generations for important quantitative characters in safflower

Character	Mean sum of squares			Mean				Broad sense heritability		
	F_3	F_4	F_5	F_2	F_3	F_4	F_5	F_3	F_4	F_5
Number of progenies	296	189	40	296	296	189	40	296	189	40
Plant height (cm)	*39.58***	*189.02***	*58.02***	*67.2*	*68.4*	*53.9*	*61.2*	*61.1*	*78.0*	*55.3*
No. of branches/plant	5.08**	9.60**	3.91	15.1	9.8	11.8	12.1	44.5	54.2	24.2
No. of capitula/plant	40.96**	49.00**	23.70*	40.1	24.5	23.5	22.7	53.2	60.7	26.0
Capitulum diameter (cm)	0.092**	0.128**	0.299	2.3	2.1	2.2	2.8	69.9	27.2	13.6
No. of seeds / capitulum	96.57**	165.93**	103.6**	36.1	33.1	29.4	29.6	67.7	60.1	58.3
100 seed weight (g)	1.56**	1.88**	1.34**	1.6	4.4	5.6	6.0	85.7	52.3	94.7
Oil content (%)	5.93**	4.85**	1.25*	30.8	26.0	25.2	28.3	73.0	33.3	32.6
Seed yield/plant (g)	54.63**	89.48**	19.38**	65.3	21.9	26.3	20.4	67.8	74.7	61.4

* Significant at 0.05; ** Significant at 0.01

Table 2 Inter generation correlation between parent and progeny and heritability (narrow sense) estimates for important quantitative characters in safflower

Character	F_2-F_3		F_3-F_4		F_4-F_5	
	Correlation coefficient (*r*)	Heritability (h^2)	Correlation coefficient (*r*)	Heritability (h^2)	Correlation coefficient (*r*)	Heritability (h^2)
Plant height (cm)	0.273**	15.55	-0.019	-2.21	0.138	3.70
No. of branches/plant	0.331**	11.85	0.178*	14.91	0.223	8.61
No. of capitula/plant	0.081	2.54	0.045	2.80	0.233	8.20
Capitulum diameter (cm)	*0.469***	*19.86*	*0.356***	*24.11*	*0.086*	*5.90*
No. of seeds/capitulum	0.549**	22.14	0.369**	29.42	0.337*	11.30
100 seed weight (g)	0.684**	49.87	0.293**	18.34	0.533**	26.90
Oil content (%)	0.144*	10.41	0.173	7.14	0.252	8.12
Seed yield/plant (g)	*0.039*	*0.02*	*-0.062*	*-5.08*	*0.178*	*4.61*

* Significant at 0.05%; ** Significant at 0.01%

Inter generation correlation co-efficient gives an idea about the effectiveness of single plant selection and to some extent nature of gene action. The heritability was calculated by regression method, which is the ratio between additive variance and phenotypic variance (Smith and Kinman, 1965, Cahancer and Hillet, 1980). Higher the heritability more will be the additive component, consequently the observed mean value will be reliable.

In general, narrow sense heritability observed was low for all the character in all the generations (Table 2). However, the values were comparatively higher in F_3 than F_4 and F_5. Such differences between generations could be due to environmental factors as these generations were grown in different years. Low narrow sense heritability for yield and important yield components has been reported in safflower (Ramachandram and Goud, 1981). Relatively, 100 seed weight, number of seeds per capitulum and capitulum diameter had significant correlation between F_2-F_3 and F_3-F_4 and higher narrow sense heritability values. Amongst these, capitulum diameter and number of seeds per capitulum were the important oil components and additive gene action also plays an important role for the expression of these two traits. Their response to selection can be attributed to this factor. Hence oil content can be improved indirectly through its components by direct selection in the early generations. Such response to selection for oil content has been observed in sunflower (Vranceanu, 1970). The number of seeds per capitulum and 100 seed weight showed significant correlation between F_4-F_5 generation also, confirming the results reported in earlier studies (Deokar and Patil, 1980, Ramachandram and Goud, 1982). Seed yield and number of capitula per plant showed the least narrow sense heritability confirming the earlier results that it is controlled by non-additive gene action (Ramachandram and Goud, 1982; Rao, 1982; Parameshwarappa *et al.*, 1990). Hence, improvement through simple selection is not responsive.

The results indicated that important components of oil content are governed by additive gene action, while seed yield and its components are governed by non-additive gene action (Ramachandram and Goud, 1981). Therefore, it is suggested that development of hybrids may be useful in combining traits for both yield and oil content. In sunflower, hybrids with high oil content and seed yield have been developed. Similar strategy can be applied in safflower also and in this direction intensive efforts are being made (Anon., 1997). Apart from this it is also suggested to practice bi-parental mating for improvement of both in the pure lines (Parameshwarappa *et al.*, 1997).

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References

Anonymous, 1997. *Vision 2020 Perspective Plan.* Directorate of Oil seeds Research, Rajendranagar, Hyderabad. pp-81.

Cahancer, A. and Hillet, J. 1980. Estimating heritability and genetic correlation between traits from generations F_2 and F_3 of self fertilising species; a comparison of three methods. *Theoretical and Applied Genetics*, **58**: 33-38.

Deokar, A.B. and Patil, F.B. 1980. Combining ability analysis in a diallel cross of safflower. *Journal of Maharashtra Agricultural Universities*, **5**: 2114-216.

Parameshwarappa, K.G., Aradhya, K.M. and Prakash, K. S. 1984. Inheritance of seed yield, hull and oil content in safflower. *SABRAO Journal*, **16**: 129-134.

Parameshwarappa, K.G., Kullarni, N.S., Gulaganji, G.G., Kubsad, V.S. and Mullapur, C.P. 1997. An assessment of genetic variability created through biparental mating in safflower (*Carthamus tinctorius L.*). *IV International Safflower Conference, Bari (Italy)*, 2-7 June 1997, pp. 238-239.

Parameshwarappa, K.G., Srinivaschar, D and Ninganur, B. T. 1990. Genetic analysis of seed yield and yield components in safflower (*Carthamus tinctorius L.*). *Karnataka Journal of Agricultural Sciences*, **3 (3&4)**: 171-176.

Ramachandram, M. 1985. Genetic improvement of oil yield in safflower; Problems and Prospects. *Journal of Oilseed Research*, **2**: 1-9.

Ramachandram, M. and Goud, J.V. 1981. Genetic analysis of seed yield, oil contents and their components in safflower (*Carthamus tinctorius L.*). *Theoretical and Applied Genetics*, **60**: 191-195.

Ramachandram, M. and Goud, J.V. 1982. Components of seed yield in safflower (*Carthamus tinctorius L.*). *Genetica agraria*, **36**: 211-222.

Rao, V. R. 1982. Genetics of yield, per cent oil and their related components in Safflower. *SABRAO Journal*, **14** (2): 113-120.

Smith, J. D. and Kinman, M.L. 1965. The use of parent offspring regression as an estimator of heritability. *Crop Science*, **5**: 595-596.

Veena, K.R and Ravikumar, R.L., 2003. Comparative evaluation of hybridization, mutation and hybridization with mutation in evolving genetic variability in safflower. *Karnataka Journal of Agricultural Sciences.* **16** (3) : 397-402.

Vranceanu, A. V. 1970. Advances in sunflower breeding in Romania. *Proc. 4th International sunflower conference. Memphis*, pp. 136-148.

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Effect of organic and inorganic manures on yield and nutrient uptake of groundnut, *Arachis hypogaea* L. in Ultisols of Mizoram

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Abstract

A field experiment was conducted at ICAR Mizoram Centre, Kolasib in Ultisols during *kharif* 1999 and 2000 to study the effect of integrated use of organic and inorganic manures on yield attributes and nutrient uptake of groundnut. The results revealed that application of optimum dose of NPK in combination with FYM @ 15 t/ha recorded highest pod yield, haulm yield and other yield attributes. Graded doses of NPK application significantly increased the pod yields over control, but the yield response was quite high with the optimum doses of NPK. Integrated application of organic and inorganic manures showed higher uptake of NPK rather than sole application of organic manures might be due to increased nutrient availability and improvement in the physical condition of the soil. The available nutrient status of the soil significantly improved with the combined application of organic and inorganic manures. Conjunctive use of organic manures and optimum dose of NPK produced highest and sustainable crop yields and improved the fertility status of the soil.

Key words: Groundnut, organic manures, pod yield, nutrient uptake

Introduction

The area under oilseeds in Mizoram accounted to be 0.079 lakh ha with a production of 0.055 lakh tonnes and groundnut occupied around 60 and 65 % area and production, respectively during 2001-2002 (Anonymous, 2002). In fact the area and production of different oilseed crops has increased 4 to 5 folds in this state during the last 15 years. But the crop productivity is very low due to steep sloppy undulating hilly terrain, uneven distribution of torrential rainfall followed by severe soil erosion, soil acidity and other associated problems and non adoption of modern technologies (Laxminarayana and Azad Thakur, 1999). Total fertilizer consumption in this state accounted to be 1.44 thousand tonnes with a NPK ratio of 4.7:2.7:1.0 according to the estimates of 2000-2001 (FAI, 2001). The consumption of nutrients per unit area is 12.7 kg N, P_2O_5 and K_2O/ha, which is very low in comparison to the national average consumption of nutrients (88 kg/ha). The consumption of nutrients in oilseeds cultivation is very meagre, resulted into poor crop yields. In view of the above, an attempt has been made to study the effect of integrated use of organic and inorganic manures on yield and nutrient uptake of groundnut and their effects on soil properties.

Material and methods

A field experiment was conducted during *kharif* seasons of 1999 and 2000 on a Typic Hapludult at ICAR Mizoram Centre, Kolasib, Mizoram. The experimental soil was sandy loam in texture, acidic (pH 5.16), non saline (EC 0.74 dS/m), medium in organic carbon (0.62 %), low in available N (226 kg/ha), P (7.82 kg/ha) and high in available K (218 kg/ha). The experiment was laid out in a Randomized Block Design comprising 10 treatments and replicated thrice (Table 1). Farmyard manure, poultry manure and pig manure contains 0.44, 0.26 and 0.51 %; 2.18, 1.46 and 1.89%; 1.86, 1.22 and 1.45 % N, P_2O_5 and K_2O, respectively. Nitrogen was applied in 3 split doses (half at basal, each one fourth at 30 and 45 days after sowing) in the form of urea while entire doses of P and K were applied as basal in the form of single super phosphate and muriate of potash, respectively. Groundnut (cv ICGS-5) seeds were dibbled at a spacing of 30 x 20 cm. All the cultural practices were followed as per the schedule. The crop was harvested at maturity and the yield parameters were recorded. The soil samples were collected after harvest of the second crop, processed and analysed for physico-chemical properties by following suitable procedures (Jackson, 1973). The plant samples were collected at mid flowering and at harvest (kernels, shells and haulms), thoroughly washed, oven dried and dry matter yield (DMY) was recorded. The plant samples were ground, digested and analysed for N by microkjeldahl method, P by vanadomolybdophosphoric acid yellow colour method and K by flame photometric method (Jackson, 1973). The uptake of N, P and K at different growth stages was determined by multiplying nutrient concentration with yield of kernels, shells and haulms.

Results and discussion

Effect of graded doses of NPK: The results revealed that the DMY at mid flowering, pod yield and haulm yields were

significantly increased with the increased doses of NPK application over control (Table 1). An increase of 28, 70 and 78 % of mean pod yield was observed with the application of 50, 100 and 150 % NPK, respectively over control. The effect of graded doses of NPK application on DMY at mid flowering was substantial with an increase of 29-103 % over control during 1999, while it was 35-81 % during the year 2000. Similar increase of haulm yield and other yield attributes was observed with the application of different doses of NPK. Low haulm yield during 1999 was due to unfavourable climatic conditions coinciding with the harvest of the crop. Positive response in respect of all the yield parameters even to higher doses of NPK application was observed despite the crop has ability to fix atmospheric N. Crude protein content did not vary significantly to higher doses of NPK application, but it was significantly higher than control. The yields and yield responses obtained with graded doses of NPK have suggested that application of optimum dose of NPK will be beneficial to realize higher crop yields under these agro-climatic conditions.

Effect of organic manures: The pod and haulm yields have increased significantly with the application of different organic manures either sole or in combination with optimum dose of NPK over control (Table 1). An increase of 11-85 % of pod yield over control was observed with the application of organic manures alone for both the years and their effect on pod yield is higher than the application of half of the recommended dose of NPK. Highest mean pod yield for two years (2133 kg/ha) was recorded with the integrated application of 100 % NPK + FYM @ 15 t/ha followed by 100 % NPK + poultry manure @ 5 t/ha (1993 kg/ha) and 100 % NPK + pig manure @ 5 t/ha (1896 kg/ha). These results corroborate with the findings of Kathmale *et al.* (2000). Combined application of organic manures (FYM and poultry manure) along with recommended doses of NPK produced more than double the pod yields in comparison to control plots, which could be attributed due to better root growth, more biomass production as a result of direct addition of organic matter through FYM, poultry manure and pig manure along with recommended doses of NPK. These results are in conformity with the findings of Bharadwaj *et al.* (1994).

Integrated application of organic manures and optimum dose of NPK showed 40-54 % higher pod yield in comparison to sole application of organic manures, and 15-29 % higher than 100 % NPK. It was noticed that the DMY at mid flowering and harvest stages and shelling percentage was significantly higher with the combined application of optimum dose of NPK and FYM @ 15 t/ha in comparison to other treatments. Significant increase in yield attributes with the addition of organic manures could be attributed to the supply of nutrients through mineralization and improvement of physico-chemical properties of the soil (Dosani *et al.*, 1999; Rao and Shaktawat, 2002).

Nutrient uptake: The uptake of NPK at various growth stages was significantly increased with the application of graded doses of NPK and organic manures either alone or in combination with NPK over control (Table 2). The trend of the uptake of nutrients was lowest in the plots receiving no fertilizer/manure, indicating that continuous cropping without fertilization caused the lowest uptake of nutrients resulted into lower crop yields. Not only nutrient contents but also the improved physical condition of the soil as a result of application of organic manures led to higher pod and haulm yields and uptake of different plant nutrients (Bharadwaj and Omanwar, 1994). It was found that the uptake of NPK at mid flowering, kernels, shells and haulms showed an increase of 92, 92, 76; 125, 136, 132; 49, 64, 41 and 79, 88, 67 % with the application of optimum dose of NPK over control. These results indicated that the balanced fertilization significantly improved the nutrient content as well as uptake of nutrients by different plant parts. Addition of organic manures along with 100 % NPK increased the uptake of nutrients to a greater extent, might be due to the extra amount of nutrients supplied by organic manures which caused an increase in the yield and ultimately showed higher uptake of nutrients. Application of FYM @ 15 t/ha along with 100 % NPK showed higher uptake of N, P and K followed by 100 % NPK + poultry manure @ 5 t/ha and 100 % NPK + pig manure @ 5 t/ha. The highest nutrient uptake in different plant parts of groundnut with the integrated application of optimum dose of NPK and FYM may be due to higher biomass production and improvement in the physico-chemical properties of the soil.

The magnitude of increase in mean uptake of NPK at mid flowering and kernel selfing stages due to FYM application was 43, 29, 29 and 78, 82, 75 % over control. The corresponding increase with poultry manure was 35, 35, 30 and 68, 66, 65 %, while it was 36, 30, 27 and 67, 67, 68 % with the application of pig manure. The net effect of combined application of organic manures and NPK on nutrient uptake would be tantamount to their sole effect. The over all effect of poultry manure and pig manure is not better than FYM in increasing pod yield as well as nutrient uptake at various growth stages despite their high nutrient content than FYM. This may be due to variations in nutrient composition as well as quantity of their application and rate of decomposition of organic manures and differences in their release behaviour of nutrients into soil, similar to the findings of Rao and Shaktawat (2002). Sims (1986) reported that addition of poultry manure raised the pH of loamy sand soil from 6.5 to 7.5 immediately after its application, but the final pH after 20 weeks was about 5.5. The initial high pH could reduce micronutrient availability and finally more acidic pH caused phytotoxicity.

Table 1 Effect of integrated use of organic and inorganic manures on pod and haulm yields (kg/ha) of groundnut

Treatment	DMY at mid flowering		Pod yield		Haulm yield		Shelling (%)	Crude protein (%)
	1999	2000	1999	2000	1999	2000		
Control	1754	1946	720	1219	674	2092	49.1	19.0
50 % NPK	2361	2504	1055	1428	897	2661	60.1	19.3
100% NPK	3082	3093	1445	1853	1073	3325	63.5	19.6
150 % NPK	3552	3523	1548	1909	1150	3483	69.0	19.7
FYM @ 15 t/ha	2561	2208	1331	1447	908	2692	60.7	19.2
100 % NPK + FYM @ 15 t/ha	4249	4055	2040	2225	1367	3367	72.5	20.4
Poultry manure @ 5 t/ha	2565	2237	1284	1353	948	2589	61.2	18.9
100 % NPK + poultry manure @ 5 t/ha	4023	3944	1927	2059	1463	3002	71.2	19.8
Pig manure @ 5 t/ha	2475	2283	1280	1431	826	2486	58.8	19.0
100 % NPK + pig manure @ 5 t/ha	4067	3745	1790	2002	1230	2997	72.8	19.9
CD (P = 0.05)	124.0	343.7	76.4	142.2	79.5	282.8	1.57	0.22

N.B: Shelling percentage and crude protein values are average of 1999 and 2000; DYM = Dry matter yield.

Table 2 Effect of organic and inorganic manures on nutrient uptake (kg/ha) at different growth stages (mean values)

Treatment	Mid flowering			Kernel			Shell			Haulm		
	N	P	K	N	P	K	N	P	K	N	P	K
Control	33.8	6.4	35.7	14.6	2.1	4.0	3.7	0.6	4.4	13.3	3.1	23.2
50 % NPK	46.1	8.7	48.1	23.1	3.5	6.5	4.1	0.7	4.7	18.7	4.6	30.9
100% NPK	64.8	12.3	62.7	32.8	5.0	9.3	5.5	0.9	6.2	23.8	5.9	38.8
150 % NPK	75.8	14.6	74.5	37.5	5.9	10.7	5.1	1.0	5.9	27.0	6.6	42.5
FYM @ 15 t/ha	48.4	8.3	46.0	25.9	3.9	7.0	4.4	0.7	5.0	18.1	4.2	30.7
100 % NPK + FYM @ 15 t/ha	93.1	19.6	86.9	50.4	8.3	14.4	6.1	1.2	6.9	29.1	6.9	43.8
Poultry manure @ 5 t/ha	45.5	8.6	46.3	24.4	3.5	6.6	4.1	0.6	4.6	17.4	4.0	30.2
100 % NPK + poultry manure @ 5 t/ha	85.9	17.5	83.0	44.8	7.3	13.1	5.9	1.0	6.5	25.9	6.4	41.1
Pig manure @ 5 t/ha	45.8	8.3	45.3	24.2	3.6	6.7	4.5	0.6	5.1	16.0	3.7	28.5
100 % NPK + pig manure @ 5 t/ha	83.9	17.4	81.2	44.0	7.3	12.9	5.3	1.0	5.9	25.3	6.1	39.2
CD (P = 0.05)	4.02	0.90	3.51	1.47	0.25	0.44	0.39	0.08	0.38	1.72	0.36	2.73

Soil fertility status: It was observed that the fertility status of the soil decreased remarkably in the plots received no fertilizer/manures. The pH of the soil did not vary much with the graded doses of NPK application and decreased further with the sole application of organic manures (pH 5.12, 5.07 and 5.09 for FYM, poultry manure and pig manure, respectively). In general, the pH decreased with the application of organic manures over the initial value, which might be attributed to the formation of organic acids during decomposition of organic matter, similar to the findings of Das *et al.* (1991). However, the pH raised slightly with the integrated application of organic manures and inorganic chemical fertilizers. The decrease of pH with the addition of poultry manure (pH 5.07) was much pronounced than other organic manures (pig manure and FYM). These results are in agreement with the findings of Sims (1986).

It was noticed that the organic carbon and available N positively increased over the initial status with the application of different organic manures. The organic manures directly added organic matter into the soil, which has resulted into build up of high organic matter as well as available N status of the soil. The increase in available N was significantly higher with the integrated use of organic and inorganic manures (268, 265 and 259 kg/ha with 100 % NPK in combination with FYM, poultry manure and pig manure, respectively) over the sole application of either NPK or organic manures. The available P and K significantly improved over the initial status with the combined application of organic and inorganic manures. The relative effectiveness in fertility build up of the soils among the manures was followed the trend FYM > poultry manure > pig manure. Increase in available NPK with the integrated application of organic and inorganic manures

might be due to supply of plant nutrients directly through inorganic chemical fertilizers and released through decomposition of organic manures. Nambiar (1994) observed sustainable yields and enhanced fertility status of soil as well as efficiency of different nutrients after integrated application of organic/inorganic sources of plant nutrients.

It could be concluded that conjunctive use of organic manures and optimum doses of inorganic chemical fertilizers produced highest and sustainable crop yields of groundnut and improved the fertility status of the soil.

References

Anonymous. 2002. *Statistical Abstract, Department of* Agriculture and Minor Irrigation, Govt. of Mizoram, Aizawl, pp.18.

Bharadwaj, V. and Omanwar, P.K. 1994. Long term effects of continuous rotational cropping and fertilization on crop yields and soil properties-II. Effects on EC, pH, organic matter and available nutrients of soil. *Journal of the Indian Society of Soil Science,* **42**(3): 387-392.

Bharadwaj, V., Omanwar, P.K., Sharma, R.A. and Vishwanath. 1994. Long term effects of continuous rotational cropping and fertilization on crop yields and nutrient uptake. *Journal of the Indian Society of Soil Science,* **42**(2): 247-253.

Das, M., Singh, B.P., Ram, M., Dwivedi, B.S. and Prasad, R.N. 1991. Influence of organic manures on native plant nutrient availability in an acid Alfisol. *Journal of the Indian Society of Soil Science,* **39**: 286-291.

Dosani, A.A.K., Talashilkar, S.C. and Mehta, V.B. 1999. Effect of poultry manure applied in combination with fertilizers on the yield, quality and nutrient uptake of groundnut. *Journal of the Indian Society of Soil Science,* **47**(1): 166-169.

FAI. 2001. *Fertilizer Statistics.* The Fertilizer Association of India, New Delhi, pp. I-87.

Jackson, M.L. 1973. Soil Chemical Analysis. Prentice Hall of India Private Limited, New Delhi.

Kathmale, D.K., Khadtare, S.V., Kamble, M.S. and Patil, R.C. 2000. Integrated nutrient management in groundnut (*Arachis hypogaea*) – wheat (*Triticum aestivum*) cropping system on Vertisols of Western Maharashtra plains zone. *Indian Journal of Agronomy,* **45**(2): 248-252.

Laxminarayana, K. and Azad Thakur, N.S. 1999. Effect of phosphorus on yield performance of wheat in acidic soils of Mizoram. *Journal of Hill Research,* **12**(2): 138-140.

Nambiar, K.K.M. 1994. *Soil Fertility and Crop Productivity under Long-term Fertilizer Use in India.* ICAR, New Delhi.

Rao, S.S. and Shaktawat, M.S. 2002. Effect of organic manure, phosphorus and gypsum on groundnut (*Arachis hypogaea*) production under rainfed condition. *Indian Journal of Agronomy,* **47**(2): 234-241.

Sims, J.T. 1986. Phosphorus fractionation, adsorption and description studies with heavily manured and fertilized Atlantic coastal plain soils. *Agronomy Abstracts,* p. 172 (fide *Advances in Agronomy* **52**, 1994).

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Groundnut, *Arachis hypogaea* L. growth, yield and nutrient uptake as influenced by inoculation of plant growth promoting rhizobacteria

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Abstract

Out of a total of 233 plant growth promoting rhizobacterial (PGPR) isolates obtained from the groundnut rhizosphere, nine isolates identified as *Pseudomonas* sp. were found relatively effective. Three of these isolates, PGPR1, PGPR2, and PGPR4 were the best in PGPR attributes like production of *siderophore and* IAA, solubilization of tri-calcium phosphate and inhibition of *Aspergillus flavus* and *Aspergillus niger, in vitro*. *Pseudomonas fluorescens* isolates PGPR4 and PGPR5 also inhibited *Sclerotium rolfsii* strongly. In general, seed inoculation with the PGPR isolates resulted in increased root length, plant biomass, nodule number and dry weight and pod yield of groundnut (cv. JL24) in pots during the *kharif* season of 2000 with best performance recorded with PGPR1, PGPR2 and PGPR4. In a field trial during *kharif* 2000, seed bacterization of groundnut (cv. GG2) with PGPR isolates enhanced pod yield (13-32%), haulm yield, nodule number and dry weight, root length, 100 kernel weight etc., significantly. Uptake of N and P were also enhanced significantly due to *inoculation*, both in pot culture and field trial.

Key words: PGPR, fluorescent pseudomonads, groundnut, yield enhancement

Introduction

Plant growth promoting rhizobacteria (PGPR) have emerged as an important group of microorganisms with growth promotion and biocontrol capabilities. Beneficial free-living soil bacteria isolated from the rhizosphere, which have been shown to improve plant health or increase yield. While the potential of PGPR has been well studied, more attention is now focused on crop growth and yield enhancement capabilities.

The mechanisms of PGPR mediated enhancement of plant growth and yields of many crops are not yet fully understood. However, the possible explanations include: the ability to produce ACC-deaminase to reduce the level of ethylene in the roots of the developing plants thereby increasing the root length and growth (Jacobson *et al.*, 1994); production of plant hormones like IAA, gibberellic acid and cytokinins; asymbiotic nitrogen fixation; antagonism against phytopathogenic micro organisms by producing siderophores, β-1,3-glucanase, chitinases, antibiotics, fluorescent pigment, and cyanide (Pal *et al.*, 2001); and solubilization of mineral phosphates and mineralization of other nutrients.

To-date, a number of plant growth promoting rhizobacteria, e.g. *Pseudomonas putida* GR 12-2, *Enterobacter cloacae* UW4 and CAL2, *Bacillus subtilis* A 13 and others like *Pseudomonas fluorescens* Pf-5, *Pseudomonas fluorescens* 2-79, *Pseudomonas fluorescens* CHA0 etc. have been identified, the inoculation of which enhanced the growth and yield significantly in many crops including oilseed crop like canola (Kloepper *et al.*, 1988). However, in groundnut reports are scanty; therefore, we attempted to identify efficient PGPR for groundnut to enhance growth, yield and nutrient uptake.

Material and methods

Rhizobacteria were isolated from groundnut rhizosphere as per Jacobson *et al.*, (1994). Colonies of different morphologies were picked up and purified and maintained as stabs at 4°C in a refrigerator. For seedling bioassay, the isolates were grown in King's B medium agar plates at 28°C for 24 h. The inocula for treating seeds were prepared by suspending cells from agar plates in a standard nutrient broth (SNB) as described by Gerhardson *et al.*, (1985) in order to provide a concentration of live cells approximately 6 x 10^{10} colony forming units (CFU)/ml. Seedling bioassay was conducted as described earlier (Pal *et al.*, 1999). The length of the root of each seedling was measured after seven days and expressed in cm and compared with roots treated on day one with sterile SNB. A total of nine isolates enhanced the root length significantly. A separate bioassay was conducted with nine isolates to examine the consistency. The PGPR isolates were identified by morphological, physiological and biochemical characteristics following Bergeys' Manual of Systematic Bacteriology (8th Edition) and the taxonomy of pseudomonads (Bossis *et al.*, 2000).

All the nine isolates were further tested for siderophore production (Schwyn and Neilands, 1987) in CAS agar plates and in broth devoid of Fe, indole acetic acid production (Sarwar and Kremer, 1995) in L-tryptophan agar, solubilization of tri-calcium phosphate *in vitro* and ammonification in peptone water broth. *In vitro* antagonism of the nine selected rhizobacterial isolates against *Aspergillus flavus*, *Aspergillus niger* and *Sclerotium rolfsii* was studied as per Pal *et al.*, (2001). The radii of the inhibition zones were measured in mm in triplicates, with inhibition zone measuring scale, after 72 h of incubation at 28±2°C.

Based on the above-mentioned tests, a total of nine isolates were selected to evaluate their effects on the growth, yield and nutrient uptake of groundnut in pots. Pots had a size of 35 cm in diameter and capacity to hold 20 kg of soil under unsterile conditions. There were a total of 10 treatments, each having six replications. Three replications were used for determining nodule number and dry weight at 45 DAS. Groundnut, cv. JL24 a Virginia Bunch variety, was grown during the rainy season of 2000. Nitrogen @ 20 kg/ha as ammonium sulphate and P_2O_5 @ 40 kg/ha as single super phosphate were applied just before sowing. The seeds of each treatment were soaked in Phosphate Buffered Saline (PBS) containing the suspension of the PGPR isolates for one hour to maintain a population of 10^8 CFU/seed. In each pot, eight seeds (95% germination) were sown at a depth of 5 cm. After germination, five seedlings were maintained in each pot. Nodule number was recorded at 45 days after sowing (DAS) whereas shoot biomass, root length, and pod yield were evaluated after harvest.

A field trial was conducted during *kharif*, 2000 (average annual rainfall of 650 mm; day and night temperatures of 30-35°C and 25-30°C, respectively) in 5m x 4.5m plots in a randomized complete block design (RBD) keeping 10 treatments and four replications for each treatment. The field soil was black calcareous having pH of 7.9, organic carbon content of 0.52%, available P content of 10 kg/ha and available K of 240 kg/ha. In the field, normal doses of fertilizers (20 kg N/ha as ammonium sulphate and 40 kg P_2O_5/ha as single super phosphate) were applied. Groundnut cv. GG2, was sown for field trials. Seed bacterization was done using charcoal based PGPR cultures (10^9-10^{10} CFU/g carrier). Seeds (100 kg/ha) were sown at a depth of 5 cm, row spacing of 45 cm and plant to plant distance of 10 cm. A plant population of 440-450/plot was maintained by thinning, if required. Nodule dry weight and plant biomass were recorded at 45 DAS and other parameters like haulm yield, pod yield, pod number, shelling percentage, 100 seed mass etc. were recorded after harvest.

Total nitrogen in soil, haulm and kernel was determined following Kjeldahl method and total phosphorus in haulm and kernel was estimated following standard procedures.

Statistical analyses of the experimental data were done following SPSS package.

Results and discussion

A total of 233 rhizobacterial isolates having ACC deaminase activity were obtained from rhizosphere and rhizoplane of groundnut.

All the ACC deaminase positive isolates were evaluated, in a seedling bioassay, for the enhancement of root growth of the groundnut seedlings *in vitro*. Out of 233 isolates, only nine isolates enhanced the root length of groundnut significantly *in vitro*. The experiment was repeated three times with these nine isolates for evaluating the consistency (Table 1). Results indicated that PGPR1, PGPR2, PGPR4 and PGPR7 were the best among the isolates in increasing the root length of groundnut, cv. JL24. Again, PGPR1, PGPR2, and PGPR4 were the best in exhibiting the plant growth promoting attributes like siderophore production (5 mm, 7.6 mm and 12 mm of orange halos in CAS agar plates after 72 h of growth, respectively and produced catechol type of siderophore, 0.106, 0.121, and 0.137 mg/mg protein, respectively), IAA production (3.6, 7.8 and 9.3 mg/L, respectively) and solubilizing tri-calcium phosphate (48.52, 16.6 and 60 mg 100/ml broth, respectively). However, PGPR7, produced siderophore (9.5 mm orange halo in CAS agar and produced catechol siderophore, 0.109 mg/mg protein) and IAA (11.8 mg/L) appreciably (Table 1). Phosphate solubilization was also exhibited by PGPR5 (38.6 mg 100/ml broth) and PGPR9 (23.8 mg 100/ml broth). Five of these isolates, PGPR 1, PGPR2, PGPR4, PGPR5 and PGPR6, also showed strong inhibition (Table 1), *in vitro*, against *Aspergillus flavus*. While PGPR 1, PGPR2, PGPR4, and PGPR6 strongly inhibited *Aspergillus niger* (3.0-14.0 mm inhibition zones), PGPR4 and PGPR5 inhibited *Sclerotium rolfsii* (7.0-10.0 mm inhibition zones) strongly (Table 1). PGPR1, PGPR4, PGPR5, PGPR7 and PGPR9 exhibited ammonification character. All the nine isolates were identified as *Pseudomonas* at the National Research Centre for Groundnut, Junagadh, following morphological, physiological and biochemical tests according to Bergey's Manual of systematic Bacteriology. While PGPR1, PGPR2, PGPR4, PGPR5, PGPR6 and PGPR7 were *Pseudomonas fluorescens*, isolates like PGPR3, PGPR8 and PGPR9 were non-fluorescent type.

In general, seed inoculation with the PGPR isolates resulted in increased root length, plant biomass, nodule number, and pod yield in pots during *kharif*, 2000 (Table 2). However, best results were obtained with

PGPR1, PGPR2 and PGPR4. Maximum root length (28-33%), nodule number (27-28%), pod yield (23-25%), and plant biomass (24-47%) were obtained with PGPR1, PGPR2 and PGPR4. Inoculation with PGPR1, PGPR2 and PGPR4 gave significantly higher N content in soil, haulm and kernels and P content in haulm and kernels.

In a field trial, seed bacterization with six of the PGPR isolates enhanced pod yield significantly (13-32%). However, maximum yield increase was obtained with the inoculation of PGPR6. Plant biomass at 45 DAS was enhanced by PGPR1, PGPR2, PGPR4, PGPR8 and PGPR9 (Table 3). The nodule dry weight at 45 days after sowing was also enhanced due to seed inoculation of PGPR1, PGPR3, PGPR5, and PGPR6 (Table 3). However, seed mass and shelling percentage were not enhanced significantly. Nitrogen content in soil, plant and in kernels was enhanced significantly due to inoculation of PGPR1, PGPR2 and PGPR4. Available P uptake increased with PGPR1, PGPR2, PGPR4, PGPR5 and PGPR9 (Table 3).

In the present investigation, nine PGPR isolates which showed ACC deaminase activity and enhanced the root growth in a seedling bioassay, were evaluated for plant growth and yield enhancement in groundnut in pots as well as in field.

Table 1 **Seedling bioassay and quantification of plant growth promoting attributes of selected Plant Growth Promoting Rhizobacterial isolates**

Isolate	Siderophore		IAA like substance (mg/l)	Root length of seedling (cm)*	TCP solubilization (mg/100 ml broth)	Inhibition zones against (diameter in mm)			NH_4*	Identified as
	Orange halo (radii in mm)	Catechol (mg/mg protein)				*A. flavus*	*A. niger*	*S. rolfsii*		
Control	-	-	-	6.03	-	-	-	-	-	-
PGPR1	5.0 (±0.82)	0.106 (±0.005)	3.6 (±0.33)	8.40	48.52 (±5.29)	7.0 (±1.63)	7.0 (±0.81)	-	++	*Pseudomonas fluorescens*
PGPR2	7.6 (±0.33)	0.121 (± 0.007)	7.8 (±0.86)	9.10	16.6 (±2.78)	6.7 (±0.47)	3.0 (±0.41)	-	-	*Pseudomonas fluorescens*
PGPR3	-	-	-	7.90	-	-	-	-	-	*Pseudomonas* sp.
PGPR4	12 (±0.41)	0.137 (±0.002)	9.3 (±0.61)	8.87	60.0 (±4.08)	7.0 (±1.22)	14.0 (±1.63)	10.0 (±0.81)	++++	*Pseudomonas fluorescens*
PGPR5	4.4 (±0.49)	0.102 (±0.009)	-	8.03	38.6 (±2.77)	5.6 (±0.33)	-	7.0 (±0.41)	++	*Pseudomonas fluorescens*
PGPR6	4.6 (±0.33)	0.075 (±0.004)	3.9 (±0.08)	7.97	-	6.3 (±0.24)	5.0 (±0.81)	-	-	*Pseudomonas fluorescens*
PGPR7	9.5 (±1.47)	0.109 (±0.007)	11.8 (±1.29)	9.00	-	-	-	-	+	*Pseudomonas fluorescens*
PGPR8	4.3 (±0.57)	0.054 (±0.003)	-	8.07	-	-	-	-	-	*Pseudomonas* sp.
PGPR9	4.5 (±0.41)	0.072 (±0.010)	-	7.6	**23.8** (±0.98)	-	-	-	+	*Pseudomonas* sp.
CD (P=0.05)	-	-	-	0.58	-	-	-	-	-	-

* Mean of three replications repeated thrice and data in the parentheses represent standard deviation of means

Table 2 **Effect of plant growth promoting rhizobacteria on the nodulation, growth and yield of groundnut cultivar JL 24 in pots (rainy season 2000)***

Treatment	Nodule number/plant at 45 DAS	Root length/plant (cm) at 45 DAS	Biomass/ plant (g)	Pod yield/ plant (g)	Total N content (%)			Total phosphorus (%)	
					Soil	Shoot	Kernel	Shoot	Kernel
Control	89	33	13.1	3.6	0.06	1.70	3.97	0.21	0.41
PGPR 1	114	43	16.2	4.4	0.07	1.93	4.33	0.25	0.44
PGPR2	114	42	18.0	4.5	0.07	1.87	4.52	0.23	0.46
PGPR 3	103	39	15.9	3.7	0.05	1.70	4.07	0.21	0.40
PGPR4	113	42	19.2	4.4	0.07	1.86	4.45	0.25	0.45
PGPR 5	99	33	16.2	3.9	0.06	1.80	4.13	0.23	0.45
PGPR 6	89	38	15.9	3.7	0.06	1.73	4.07	0.22	0.42
PGPR 7	111	36	15.9	3.7	0.06	1.78	3.97	0.21	0.42
PGPR 8	108	35	16.1	4.1	0.06	1.68	3.98	0.20	0.39
PGPR 9	102	39	16.0	3.7	0.07	1.95	4.33	0.24	0.43
CD (P=0.05)	19.03	5.4	1.8	0.68	0.01	0.16	0.15	0.01	0.02

*Data are the mean of three replications

Table 3 **Effect of plant growth promoting rhizobacteria on the nodulation, growth, yield and nutrient uptake of groundnut cultivar GG2, in field (rainy season 2000)****

Isolate	NDW* (mg/plant) at 45 DAS	Plant biomass (g/plant) at 45 DAS	Pod yield (kg/ha)	Haulm yield (kg/ha)	Seed mass/100 seed (g)	Shelling (%)	Total N content (%)			Total phosphorus content (%)	
							Soil	Shoot	Kernel	Shoot	Kernel
Control	102.0	14.7	1938	2332	37.6	74.5	0.05	2.17	4.13	0.19	0.36
PGPR 1	119.5	16.8	1900	2932	36.4	74.8	0.08	2.36	4.68	0.23	0.38
PGPR2	116.8	17.0	1917	2830	36.4	74.2	0.07	2.32	4.53	0.23	0.37
PGPR3	137.3	15.7	2192	3252	38.4	73.8	0.04	2.13	4.03	0.19	0.36
PGPR4	114.3	19.6	2288	2950	36.8	73.1	0.07	2.39	4.53	0.23	0.39
PGPR5	127.0	16.2	2366	2722	37.7	74.5	0.06	2.18	4.05	0.22	0.37
PGPR6	121.0	16.0	2566	2550	36.7	73.8	0.06	2.24	4.10	0.21	0.36
PGPR7	115.5	15.5	2315	2640	36.9	74.7	0.06	2.19	4.15	0.22	0.36
PGPR8	113.3	19.6	2538	2775	37.2	73.8	0.04	2.18	4.20	0.21	0.36
PGPR9	103.8	18.6	1785	3037	37.5	74.3	0.05	2.27	4.05	0.23	0.40
CD (P=0.05)	15.4	1.7	193	261	NS	NS	0.02	0.14	0.24	0.03	0.01

**Mean of four replications; **NDW=Nodule dry weight*

PGPR isolates of groundnut, *viz.*, PGPR1, PGPR2 and PGPR4, exhibited IAA production, phosphate solubilization and siderophore production besides inhibiting *Aspergillus flavus* and *Aspergillus niger*. Seed bacterization of these three isolates significantly increased root length, nodulation, plant biomass and pod yield in pots. PGPR6 was the best in enhancing the pod yield of groundnut while PGPR1 and PGPR2 yielded at par with control under field conditions. The other parameters like plant biomass, nodule dry weight, N and P contents in plants and kernels were enhanced by the inoculation of PGPR 1, PGPR2, and PGPR4 isolates. Mobilization of iron by microbial siderophores and improved phosphorus uptake by phosphate solubilizing microorganisms were found to increase crop yield substantially (Glick, 1995). Fluorescent pseudomands having ACC deaminase activity, phosphate solubilizing ability, IAA and siderophore producing attributes have been found to enhance groundnut growth under pot cultures (Pal *et al.*, 1999). Despite all strains being positive for ACC deaminase, the differential effect in pots indicate the involvement of more than one attribute of the isolates in causing better plant growth and nutrient uptake. Moreover, synergistic effect was found between native *Bradyrhizobium* flora and PGPR as nodulation was enhanced due to inoculation of PGPR. Similar results were also obtained with dual inoculation of PGPR and *Rhizobium* in chickpea (Parmar and Dadarwal, 1999).

In view of the involvement of multiple plant growth promoting traits in the overall plant growth promotion of groundnut by these PGPR isolates, mutational analyses and subsequent evaluation only can unravel the exact mechanisms.

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References

Bossis, E., Lemanceau, P., Latour, P. and Gardan, L. 2000. The taxonomy of *Pseudomonas fluorescens* and *Pseudomonas putida*: current status and need for revision. *Agronomie*, **20**: 51-63.

Gerhardson, B., Alstrom, S. and Ramert, B. 1985. Plant reactions to inoculations of roots with fungi and bacteria. *Phytopathology Z.*, **60**: 1726-1733.

Glick, B.R. 1995. The enhancement of plant growth promotion by free living bacteria. *Canadian Journal of Microbiology*, **41**: 109-117.

Jacobson, C.B., Pasternak, J.J. and Glick, B.R. 1994. Partial purification and characterization of 1-aminocyclopropane-1-carboxylate deaminase from PGPR, *Pseudomonas putida* GR12-2. *Canadian Journal of Microbiology*, **40**:1019-1025.

Kloepper, J.W., Hume, D. J., Scher, F.M., Singleton, C., Tipping, B., Laliberte, M., Frawley ., K., Kutchaw, T., Simonson, C., Lifshitz, R., Zalesua, I. and Lee, L. 1988. Plant growth promoting bacteria on canola (rapeseed). *Plant Disease*, **72**: 42- 46.

Pal, K.K., Dey, R., Bhatt, D.M. and Chauhan, S.M. 1999. Enhancement of groundnut growth and yield by plant growth promoting rhizobacteria. *International Arachis Newsletter*, **19**:51-53.

Pal, K.K, Tilak, K.V.B.R, Saxena, A.K., Dey, R. and Singh, C. S. 2001. Suppression of maize root diseases caused by *Macrophomina phaseolina*, *Fusarium moniliforme* and *Fusarium graminearum* by plant growth promoting rhizobacteria. *Microbiological Research*, **156**(3): 209-223.

Parmar, N. and Dadarwal, K.R. 1999. Stimulation of nitrogen fixation and induction of flavonoid-like compounds by rhizobacteria. *Journal of Applied Microbiology*, **86**(1): 36-44.

Sarwar, M. and Kremer, R.J. 1995. Enhanced suppression of plant growth through production of L-tryptophan-derived compounds by deleterious rhizobacteria. *Plant and Soil*, **172**: 261-269.

Schwyn, B. and Neilands, J.B. 1987. Universal chemical assay for detection and determination of siderophores. *Analytical Biochemistry*, **160**: 47-56.

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Response of soybean, *Glycine max* (L.) Merril to application of inorganic fertilizers and their integration with farm yard manure in Satpura plateau zone of Madhya Pradesh

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Abstract

An investigation was carried out at Chhindwara (Madhya Pradesh) to find out the effect of macro and micro-nutrients, and organic manures on soybean cv JS-335 during *kharif* seasons of 1999, 2000 and 2001. Application of recommended dose of fertilizer + 10 tonnes FYM/ha resulted in 19% highest seed yield than control (1240 kg/ha). This may be due to superiority in growth parameters (plant height, branches/plant, number of grains/pod, 100-seed weight of seeds) and root characters (length of root, root weight, number of nodules/plant, root nodules/plant and nodule weight/plant). Combined application of sulphur and zinc with recommended dose of NPK recorded 14 and 18% higher seed yield over control.

Key words: *Macro and micro-nutrients, organic sources, productivity, soybean*

Introduction

Soybean, *Glycine max* (L.) *Merril* is one among important oilseed crops grown in India. In Madhya Pradesh, it is cultivated in 4.5 m ha with an average annual production of 5.2 m tonnes. Although, a number of production constraints have been reported (Joshi and Bhatia, 2003) the nutrient stress is considered as one of the most important factors for lowering the yield levels in this crop. Patel *et al.* (1981) reported response of micronutrients and FYM application on quality and yield in groundnut crop. The soybean crop is also reported to respond well to the application of zinc and sulphur integrated with major nutrients under Jabalpur conditions (Shinde and Soni 1981; Shinde *et al.* 1982). Since scanty information on performance of the soybean crop is available for Satpura plateau zone of Madhya Pradesh, the present investigation has been undertaken to assess the response of macro - micro nutrients and organic manures on the productivity of soybean in this region.

Material and methods

Field experiments were conducted on (same plot), soybean cv JS-335 at the research farm of ZARS, Chhindwara during *kharif* season of 1999, 2000 and 2001. Soils of the experimental site was Haplustart in sandy clay loam in texture with pH 7.2 and available N, P_2O_5 and K_2O to be 315, 18.2 and 400 kg/ha respectively. The soil analysed 9 ppm for S and 0.4 ppm for Zn. The seed rate @ 75 kg/ha of JS 335 was used with a spacing of 30 cm x 10 cm between rows and plants. The crop was sown on 23rd, 24th and 26th June and harvested on 5th, 7th and 8th October during the year of 1999, 2000 and 2001, respectively. The rainfall received during said years was 841, 952 and 960 mm, respectively. Seven treatments along with control were evaluated in a Randomized Block Design with three replications (Table 1). The entire quantity of NPK, FYM, sulphur and zinc was applied as basal dose as per treatments. The NPK fertilization was done by using IFFCO (12:32:16 grade), sulphur through gypsum and zinc through zinc sulphate. Recommended agronomic practices were followed for raising the crop.

Results and discussion

Growth/yield attributes: The treatments significantly influenced the growth/yield attributes of the variety JS-335 and the carried over effect was visible in seed yield (Table 1). The integrated incorporation of recommended NPK level coupled with FYM @ 10 t/ha was distinctly superior over other treatments and recorded maximum plant height (43 cm), branches/plant (5), pods/plant (32), seeds/pod (3) and 100-seed weight (15 g). The combinations of recommended levels of NPK with either Zn or S were superior than their sole applications as well as recommended application of NPK. This brings out the fact that balanced nutrition is essential for proper growth and performance of soybean and non application of plant nutrients through external carriers results in yield deterioration.

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Table 1 Effect of macro and micro-nutrients, organic and inorganic sources of nutrients on growth parameters, yield attributing characters, root characters and seed yield of soybean at Chhindwara (mean of 1999, 2000 and 2001)

Treatment	Growth parameters/yield attributing characters					Root characters				Seed yield (kg/ha)			
	Plant height (cm)	No. of branches/ plant	No.of pods/ plant	No. of seeds/ pod (range)	100-seed weight (g)	Root length (cm)	Root weight/ plant	Root nodules / plant	Nodule weight/ plant (g)	1999	2000	2001	Mean
Control	39	4	24	1-2	11.1	11.4	0.8	20	0.21	1149	1207	1363	1240
RDF (N:P:K @ 20:60:20 kg/ha)	39	4	27	2-3	12.3	12.4	1.0	45	0.26	1216	1291	1486	1331
Sulphur @ 20 kg/ha	39	4	25	1-2	10.2	11.8	0.8	42	0.23	1166	1291	1407	1265
Zinc @ 25 kg/ha	40	4	25	2-3	11.3	12.4	1.0	43	0.31	1191	1224	1461	1311
RDF + sulphur @ 20 kg/ha	41	4	27	2-3	12.8	12.6	1.1	47	0.32	1341	1282	1596	1423
RDF + Zinc @ 25 kg/ha	42	4	27	2-3	13.4	12.6	1.1	48	0.32	1352	1332	1610	1469
RDF + FYM @ 10 t/ha	43	5	32	2-3	14.9	13.1	1.2	67	0.34	1356	1444	1624	1479
CD (P=0.05)	1.52	0.17	3.15		0.90	0.43	0.38	2.12	0.05	189	1459	158	134

RDF = Recommended dose of fertilizer.

Root characters: Application of nutrients through any of the carriers resulted in superior root growth and nodulation over control. Among the treatments application of recommended NPK along with FYM @ 10 t/ha was influential in recording of maximum root length (13 cm), root weight (1.2 g), nodule number (67) and nodule weight (0.34 g). Root characters followed almost similar trend as that in case of growth attributes. The data suggested that integration of organic and inorganic carriers provided balanced nutrition but also helped the plant to perform better under water stress conditions and led to fertilizer economy by way of fixation of additional nitrogen from atmospheres.

Seed yield

Significant difference in yield in case of coupling of application of recommended levels of NPK with sulphur, zinc and farm yard manure were observed. This signifies the beneficial effects of balanced nutrition to the crop. The data also indirectly indicated that the experimental site was not capable of providing S and Zn to the crop requirement. Among the treatments evaluated, the integrated application of recommended NPK with farm yard manure out yielded (1479 kg/ha) the rest of the treatments and was at par with recommended NPK with Zn. The highest yield achieved by integrating recommended NPK with farm yard manure indicated that this treatment mitigates the deficiency of S as well as Zn. Similar effect in niger crop has been reported by Guggari *et al.* 1995; Jain *et al.* 1999.

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References

Guggari, A.K., Chandranth, H.T., Manjappa, K. and Pujari, B.T. 1995. Response of niger to application of macro and micro nutrients in Combination with farmyard manure. *Farming Systems,* **11** (3-4) : 51-53.

Jain, H.C., Deshmukh, M.R. and Hegde, D.M. 1999. Response of niger to macro and micro nutrients and organic manure in different soil types. *Journal of Maharashtra Agricultural Universities,* **24**(3) : 305-307.

Joshi, O.P. and Bhatia, V.S. 2003. Stress management in soybean In : National Seminar on *"Stress Management in Oilseeds for attaining Self reliance in Vegetable Oils"* January 28 - 30, 2003, Directorate of Oilseeds Research, Hyderabad, pp. 13-25.

Patel, J.D., Sinde, P.H., More, D.A. and Shende, G.K. 1981. Effect of the application of boron, sulphur and FYM on the yield and quality of groundnut. *Journal of Maharashtra Agricultural Universities,* **6**(1) : 17-18.

Shinde, D.A., Sawarkar, N.J., Sachidanand, B. and Soni, B.K. 1982. Major nutrient status of soybean of different stage of growth and affected by phosphorus and sulphur application. Contact and uptake of nutrient. *JNKVV Research Journal,* Jabalpur, **16**(1):33-37.

Shinde, D.A. and Soni, B.K. 1981. Effect of applied phosphorus and sulphur on the utilization of fertilizer sulphur by soybean (*Glycine max L.*) and A value of soil sulphur in black soil, *JNKVV Research Journal,* Jabalpur, **15** (3) : 98-101.

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Studies on the effect of seed rate, row spacing and sowing time on drymatter accumulation and nutrient uptake in soybean, *Glycine max* (L.) Merril.

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Abstract

Field trials conducted on soybean, *Glycine max* (L.) Merril. cultivar 'Hara Soya' during *kharif*, 2001 and 2002 with three seed rates (60, 75, 90 kg/ha), two row spacings (30, 45 cm) and two sowing dates (1st week of June, 3rd week of June) indicated that crop sown in 1st week of June, with a seed rate of 90 kg/ha and 30 cm row spacing resulted in significantly higher drymatter accumulation, nutrient uptake and seed and oil yield. Drymatter production decreased in order of 90 kg/ha>75 kg/ha > 60 kg/ha seed rate.

Key words: Drymatter accumulation, row spacing, sowing time, nutrient uptake

Introduction

Soybean is the third important oilseed crop after groundnut and rapeseed and mustard. In India, it is grown on about 5.6 million hectares with an average yield of 763 kg/ha, but average yield is much below the average yield of world i.e., 2250 kg/ha (Singhal, 2003). The manipulations of different agronomic inputs such as seed rate, row spacing and sowing time have resulted in various growth and yield responses. So, this investigation was initiated to study drymatter accumulation and nutrient uptake by the crop by manipulating different agronomic inputs.

Material and methods

This study was conducted during the *kharif* season of 2001 and 2002 at the Experimental Farm of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur (HP). Twelve treatments were laid out in Randomized Block Design with three replications comprised of three seed rates (60, 75 and 90 kg/ha), two row spacings (30 and 45 cm) and two sowing times (1st week of June, 1st June and 3rd week of June, 21st June). Taxonomically the soils of experimental site are classified as Typic Hapludalfs having silty clay loam texture (sand -19.8%, silt - 46.5% and clay -33.0%). *pH and organic carbon were 5.7 and 0.83% (high)*, respectively. The available N, P and K were 336 (medium), 18 (medium) and 276 (medium) kg/ha, respectively. Soybean variety, 'Hara Soya' was grown during both the years of experimentation. A fertilizer dose of 20 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha was applied at the time of sowing through urea, single super phosphate and muriate of potash, respectively. All recommended intercultural operations were carried out to raise a good crop of soybean.

The whole plant samples were collected at 30, 60 and 90 days after sowing and at harvest from a marked row length of 0.5 m from two different places/plot. The plant samples collected were dried in an electrical oven at 65°C and then their weight was recorded which was expressed in g/m^2 as drymatter accumulation. Seed and stover samples collected at maturity were also dried in oven at 65°C and were powdered with the help of grinding machines and then were analysed for N, P and K by adopting standard methods.

Nitrogen in plant samples was estimated by micro Kjeldahl method (AOAC, 1970). For phosphorus and potassium analysis the plant samples were digested with triacid mixture (HNO_3:H_2SO_4:$HClO_4$ in 9:4:1 ratio) as per Tandon (1993) and Flame Photometer method (Jackson, 1973), respectively. The uptake of N, P and K was calculated by multiplying nutrient content with drymatter yields and expressed as kg/ha. The N content (%) in grains was multiplied with 6.25 to calculate the protein content in grains. Oil content in grains was estimated by Soxhlet extraction method (AOAC, 1970) and oil yield was determined by multiplying oil content with grain yield. Statistical analysis of data was done as per the procedures given by Gomez and Gomez (1976).

Results and discussion

Effect of seed rate: The seed rates significantly influenced the drymatter accumulation at all the stages of observations. Soybean crop, in general, continued to accumulate drymatter upto the harvest stage of the crop. Similar results have also been reported by Weber *et al.* (1966) and Singh *et al.* (2000). The crop sown with 90 kg/ha seed rate recorded statistically highest drymatter accumulation as compared to 75 kg/ha and 60 kg/ha seed rates at all the stages of observations.

On an average for two years, crop sown with 90 kg/ha seed rate recorded 11.2 % and 31.9 % higher grain yield and 8.5 % and 32.9 % higher oil yield over 75 kg/ha and 60 kg/ha seed rates, respectively. Higher grain yields with higher seed rates have also been reported by Rajput and Shrivastava (1999) and Yadav *et al.* (1999). Similarly, 90 kg/ha seed rate also resulted in significantly higher N, P and K uptake because of higher drymatter production. Protein and oil content in grains were not significantly influenced by seed rates.

Effect of row spacing: Row spacing significantly influenced the drymatter accumulation. A closer row spacing of 30 cm resulted in significantly higher drymatter accumulation per unit area. It may be due to better utilization of available resources *viz.*, mineral nutrients, water, solar radiation, etc. No significant differences were recorded for seed yield due to different row spacings. Similar findings are corroborated with Dubey (1998).

N, P and K uptake by the crop was also not affected by different row spacing probably due to non-significant differences in grain yields. Seeds obtained from crop sown at 45 cm row spacing recorded significantly higher protein content than 30 cm row spacing, whereas no significant differences for oil content were recorded due to different row spacings. These results are in accordance with Singh and Sharma (1990) and Nimje (1996).

Effect of sowing time: Delay in sowing resulted in significant reduction in drymatter accumulation (Table 1). Crop sown in first week of June resulted in significantly higher drymatter accumulation than crop sown in third week of June. The benefits of early sowing on plant height and leaf area index might have been reflected in accumulation of higher drymatter in soybean plants.

Table 1 Effect of seed rate, row spacing and sowing time on drymatter accumulation and nutrient uptake of soybean (mean of two years)

Treatment	Drymatter accumulation (g/m^2)				Protein content (%)	Oil content (%)	Oil yield (kg/ha)	Grain yield (kg/ha)	Nutrient uptake (kg/ha) (both grain and stover)		
	30 DAS	60 DAS	90 DAS	Harvest					N	P	K
Seed rate (kg/ha)											
60	72.84	169.71	370.95	411.12	38.40	18.00	261	1480	148.3	9.9	36.3
75	83.32	242.74	436.69	514.68	38.50	18.68	356	1927	182.7	12.1	45.9
90	105.82	288.57	543.00	582.78	38.27	17.80	389	2170	204.2	14.6	52.1
CD (P=0.05)	10.17	31.07	44.76	40.38	NS	NS	36	174	14.9	1.2	3.6
Row spacing (cm)											
30	94.95	273.24	500.27	542.51	37.85	18.63	356	1915	182.0	12.6	45.4
45	79.71	194.04	418.15	463.91	38.92	17.69	316	1802	175.0	11.8	43.8
CD (P=0.05)	8.31	25.37	36.54	32.97	0.73	NS	29	NS	NS	NS	NS
Spacing time											
1st week of June	118.48	316.44	539.46	571.24	37.13	18.39	361	2088	191.5	13.5	49.3
3rd week of June	56.18	150.84	380.96	435.19	39.65	17.92	291	1629	165.4	10.9	39.9
CD (P=0.05)	8.31	25.37	36.54	32.97	0.73	NS	29	142	11.9	1.0	2.9

DAS = Days after sowing; NS = Non-significant

Crop sown in first week of June recorded statistically highest grain yield as compared to crop sown in third week of June. Reduction in seed yield due to delayed sowing can be attributed to shorter growth period of late sown crop. Reduction in yield with delay in sowing has also been reported by Billore *et al.* (2000). Higher oil yield was also recorded with early sown crop, because of higher grain yield. Significantly higher N, P and K uptake was also recorded with crop sown in 1st week of June, which might be due to higher grain yield.

Seeds obtained from crop sown in 3rd week of June recorded significantly higher protein content as compared to seeds obtained from crop sown in 1st week of June (Table 1). Increase in protein content with delay in sowing has also been reported by Benati *et al.* (1998). The per cent protein in grain is partly a function of grain yield and total uptake of nitrogen by seeds. In early sowing higher yields were obtained, so protein content was lower due to dilution effect. However, oil content in grain was not significantly influenced due to both the sowing dates.

These observations are in agreement with Nagre *et al.* (1991).

From the above study, it can be concluded that a seed rate of 90 kg/ha, row spacing of 30 cm and crop sown in 1st week of June resulted in significantly higher drymatter accumulation at all the stages of observations, higher grain yield and nutrient uptake by grains.

References

Association of Official Agricultural Chemists. 1970. *Official and tentative methods of analysis.* AOAC, Washington D.C.

Benati, R., Danusof, F., Amaducci, M.T. and Venturi, G. 1998. Effect of sowing date on seed oil and protein content in soybean (*Glycine max*). *Rivista di Agronomia*, **22**:279-287.

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

Dubey, M.P. 1998. Growth, yield and economics of soybean (*Glycine max*) as influenced by weed control methods and row spacing. *Indian Journal of Agronomy*, **43**:540-545.

Gomez, K.A. and Gomes, A.A. 1976. *Statistical procedures for agricultural research* (2nd ed.). John Wiley and Sons, New York.

Jackson, M.L. 1973. *Soil chemical analysis.* Prentice Hall of India Private Limited, New Delhi.

***Nagre, K.T., Deshmukh, S.B., Bhalerao, P.D. and Thorve, P.V.* 1991.** Effect of sowing dates and fertilizers on growth, yield and quality of soybean varieties. *PKV Research Journal*, **15**:82-84.

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

Rajput, R.L. and Shrivastava, U.K. 2000. Influence of varieties, sowing date and seed rate on physiological parameters and seed yield of soybean (*Glycine max*). *Legume Research*, **22**:117-120.

Singh, D. and Sharma, K.C. 1990. Effect of variety, row spacing and weed control treatments on yield and quality of soybean seed. *Annals of Agricultural Research*, **11**:211-214.

Singh, S., Singh, K. and Kaler, D.S. 2000. Influence of planting time and geometry/density on periodic drymatter accumulation and seed yield of soybean (*Glycine max* L. Merril.). *Crop Research*, **20**:76-80.

Singhal, V. 2003. *Indian Agriculture-2003.* Indian Economic Data Research Centre, New Delhi.

Tandon, H.L.S. 1993. *Methods of analysis of soils, plants, waters and fertilizers.* FDCO, New Delhi.

Weber, C.R., Shibles, R.M. and Byth, D.E. 1966. Effect of plant population and row spacing on soybean development and production. *Agronomy Journal*, **58**:99-102.

Yadav, R.P., Shrivastava, U.K. and Dwivedi, S.C. 1999. Effect of seed rate and weed control methods on yield of soybean (*Glycine max*) under rainfed conditions. *Indian Journal of Agronomy*, **44**:895-799.

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Evaluation of different post-emergence herbicides in soybean, *Glycine max* (L.) Merr., in Vertisols of Andhra Pradesh

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Abstract

A field experiment was conducted at the Regional Agricultural Research Station, Lam, Guntur, Andhra Pradesh on the black soils, during the rainy seasons of 1997-98 and 1998-99 to evaluate different weed control practices in soybean. Significantly higher mean seed yield of 1960 kg/ha was recorded with hand weeded treatment. Post-emergence application of imazethapyr 75 g and lectofen 90 g/ha were found promising alternative to hand weeding practices and each recorded 23 % higher yield over weedy check.

Key words: Soybean, herbicides, weed control efficiency

Introduction

Soybean, *Glycine max* (L.) Merr. is grown as a *kharif* crop, in the black clay soils of Andhra Pradesh under rainfed conditions. It has been reported that the yield loss in soybean due to crop weed competition at the most critical stages of crop growth can be as high as 53% (Muniyappa *et al.*, 1989). Farmers take up weeding in soybean, through inter cultivation and hand weeding. However, in black soils timely intercultivation and weeding may not always be possible due to unfavourable soil conditions and labour shortage at critical stages. Application of some pre-sowing and pre-emergence herbicide was effective in controlling the weeds upto 30-40 days stage (Pramila Rani and Kodanda Ramaiah, 1998). However, pre-sowing or pre-emergence herbicidal application is not widely adopted as it requires thorough field preparation before sowing. Some times, due to continuous rains, intercultivation may not be feasible. Under such conditions, an effective post-emergence herbicidal application may be useful. Hence, a trial was taken up to study the effect of some new post-emergence herbicides in controlling weeds in soybean.

Material and methods

A field experiment was conducted during the rainy season of 1997-98 and 1998-99 at the Regional Agricultural Research Station, Lam, Guntur on the black soils, under rainfed conditions. The soil of the experimental site was moderately alkaline in reaction (pH 8.3), with an available nitrogen, phosphorus and potassium of 185.0, 12.6 and 557.0 kg/ha, respectively. The weed control treatments included three post-emergence herbicides viz., propaquizafop at two levels (50 g and 75 g a.i/ha); imazethapyr at two levels (75 g and 100 g a.i/ha); lectofen @ 90 g a.i/ha; pre-planting incorporation of trifluralin @ 1.0 kg a.i./ha along with three checks (farmers practice, two hand weedings at 3rd and 6th week after sowing and unweeded). Preplanting herbicide was incorporated one day before sowing and the post-emergence herbicides were applied 20 days after sowing. The treatments were laid out in a Randomised Block Design and replicated thrice with a gross plot size of 3.6 m x 6.0 m. The soybean variety JS 335 was sown on 26.07.1977 and 09.07.1998 and harvested on 02.11.1997 and 22.10.1998, respectively during the years 1997-98 and 1998-99. The weed drymatter per square meter area and the seed yield from the net plot were recorded. The seed was inoculated with *Rhizobium japonicum* before sowing. A rainfall of 749 mm and 1217 mm was received during 1997 and 1998, respectively. During 1997, crop suffered due to severe moisture stress at vegetative stage, while during 1998 the rainfall was uniform and resulted in luxuriant crop growth. A uniform fertilizer dose of 30-60-40 kg/ha of nitrogen, phosphorus and potash was applied basally.

The weed flora of the experimental area included *Phyllanthus niruri, Abutilon indicum, Celosia argentea, Trianthema portulacastrum, Digera arvensis, Amaranthus tricolor, Cenchrus ciliaris* and *Cyanotis cucullate*. The weed intensity was comparatively less during the year 1998. Crop germination was not affected by weed control treatments.

Results and discussion

In both the years, plant height did not show significant difference due to weed control treatments. Plant height varied between 22.4 cm to 27.3 cm during 1997 and from 50.5 to 68.5 cm during 1998 (Table 1). Variation in plant height may be attributed to rainfall variation in both the years.

Number of pods/plant showed significant difference due to weed control treatments in the year 1997, where, highest pod number of 34.5 was recorded with two hand weedings and it was on par with post-emergence application of imazethapyr at both levels. The lowest number of pods/plant was recorded with unweeded treatment (18.1).

During 1998, pod number varied from 42.1 to 62.3 and the differences were not significant (Table 1).

The 100-seed weight did not vary significantly due to treatments in both the years and it ranged from 11.9 to 13.6 g during 1997 and from 13.4 to 14.3 g during 1998. More seed size during 1998 is mainly due to favourable weather conditions for crop growth.

During 1997, seed yield of soybean significantly increased due to the weed control treatments and the percentage increase over the unweeded check ranged from 16 to 105. Highest seed yield of 1411 kg/ha was recorded with two hand weedings treatment, which was at par with farmers practice (1400 kg/ha), imazethapyr at two doses *viz.*, 75 g and 100 g/ha (1233 and 1211 kg/ha) as post-emergence application. During 1998, imazethapyr application at 100 g/ha and propaquizafop at 75 g/ha did not show any yield increase over unweeded control, which is due to loss of some plant population at the higher doses. The yield reduction was 3% with proaquizafop 75 g/ha and 12% with imazethapyr 100 g/ha. Highest seed yield was recorded with two hand weedings treatment (2508 kg/ha) which was 25% higher than that of unweeded check (2010 kg/ha). Similar increase in seed yield due to hand weeding was reported by several workers (Ramamoorthy *et al.*, 1995). Pre-planting incorporation of trifluralin 1 kg/ha and farmers practice recorded comparable yields with that of hand weeded treatment.

Table 1 Soybean yield attributing characters, seed yield and weed control efficiency as influenced by different weed control practices

Treatment	Dose (g a.i./ha)	Time of application	Plant height		No. of pods/plant		100-seed weight (g)		Seed yield (kg/ha)	
			1997	1998	1997	1998	1997	1998	1997	1998
Trifluralin	1000	PPI*	27	65	24	56	12.7	13.4	800 (16)	2276 (13)
Propaquizafop	50	Post E**	25	60	22	54	12.6	13.5	844 (23)	2037 (1)
Propaquizafop	75	Post E**	27	63	24	49	12.6	13.7	978 (42)	1960 (-3)
Imazethapyr	75	Post E**	22	63	34	61	13.2	14.3	1233 (79)	2091 (4)
Imazethapyr	100	Post E**	24	60	33	52	13.1	14.1	1211 (76)	1775 (-12)
Lectofen	90	Post E**	24	51	23	42	11.9	13.7	1133 (64)	2176 (8)
Farmers practice			25	54	26	62	13.6	13.8	1400 (103)	2327 (16)
Two hand weedings			26	69	35	56	13.4	14.1	1411 (105)	2508 (25)
Unweeded			23.9	60.3	18.1	49.9	12.1	13.9	689	2010
CD (P=0.05)			NS	NS	2.5	NS	NS	NS	276	264

Figures in parenthesis are per cent increase or decrease over unweeded control
* PPI = Pre-Planting Incorporation; **Post E = Post-Emergence application

Table 2 Weed drymatter and weed control efficiency as influenced by different weed control practices in soybean

Treatment	Dose (g a.i./ha)	Time of application	Weed dry matter (g/m^2)		Weed control efficiency (%)	
			1997	1998	1997	1998
Trifluralin	1000	PPI	100	62	36	8
Propaquizafop	50	Post E	87	35	44	48
Propaquizafop	75	Post E	140	65	10	3
Imazethapyr	75	Post E	82	43	47	35
Imazethapyr	100	Post E	83	37	46	45
Lectofen	90	Post E	82	62	47	7
Farmers practice	-	-	39	8	75	89
Two hand weedings	-	-	40	4	69	95
Unweeded	-	-	155	67	-	-
CD (P=0.05)	-	-	41.6	25.1	-	-

PPI = Pre-Planting Incorporation; Post E = Post-Emergence application

The weed control efficiency (WCE) of different treatments ranged from 10-75% during 1997 and from 3-95% during 1998. Hand weeding and farmers practice showed higher WCE (Table 2). Among the weedicides, imazethapyr at both 75 g and 100 g, lectofen at 90 g and propaquizaop at 50 g/ha gave WCE upto 50%. Similar results were also reported by Patil *et al.* (1999) and Billore *et al.* (1999).

It is therefore concluded that two hand weedings was the best practice to control weeds and as an alternative, post-emergence herbicides like imazethapyr at 75 g and lectofen at 90 g/ha can also give effective weed control in soybean.

References

Billore, S.D., Joshi, O.P. and Ramesh, A. 1999. Herbicidal effects on nodulation, yield and weed control in soybean (*Glycine max*). *Indian Journal of Agricultural Sciences*, **69**(5):329-331.

Muniyappa, T.V., Ramachandra Prasad, T.V. and Krishnamurthy, K. 1989. Critical stages of crop weed competition and chemical weed control in soybean. *Indian Journal of Weed Science*, **18**:34-38.

Patil, B.M., Karmakar, A.P. and Sethi, H.N. 1999. Studies on femoxaprop (whip super 9 EC) and lactofen (Cobra 24 EC) for their bio-efficacy and phyto-toxicity in soybean. *Crop Research*, **17**(2):170-174.

Pramila Rani, B. and Kodanda Ramaiah, D. 1998. Evaluation of different weed control methods in soybean. *Annals of Agricultural Research*, **19**(3):282-284.

Ramamoorthy, K., Ramasamy, M. and Vairavan, K. 1995. Chemical and cultural weed control in irrigated soybean. *Indian Journal of Agronomy*, **40**(1):127-128.

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Effect of nitrogen, phosphorus and farm yard manure on growth, yield, quality and nutrient uptake of Indian mustard, *Brassica juncea* (L.) Czern and Coss.

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Abstract

A field experiment was conducted during *rabi* season of 1995-96, 1996-97 and 1997-98 at Integrated Oilseeds Research Station, Gujarat Agril. University, Navsari, Gujarat to study the effect of nitrogen, phosphorus and FYM on growth, yield, quality and nutrient uptake of Indian mustard, *Brassica juncea* (L.) Czern & Coss., var. GM-1. Seed and oil yield of mustard increased significantly with the application of FYM @ 10 t/ha over control, while the application of 75 kg N/ha and 50 kg P_2O_5/ha resulted in significantly higher growth, yield attributes, seed and oil yield as well as nutrient uptake by crop. The maximum net monetary return observed when crop was fertilized with 75 kg N + 50 kg P_2O_5 + 10 t FYM/ha.

Key words: Fertilizer, management, mustard

Introduction

Fertilizer management is one of the most important agronomic factors that affects the yield of oilseed crops. Farm yard manure (FYM) improves the soil properties and finally crop yield (Bhatiya and Shukla, 1982). Indian mustard responds to phosphorus remarkably depending on soil type (Patel and Shelke, 1998). Therefore, an attempt was made to study the effect of nitrogen, phosphorus and farm yard manure on growth, yield, quality and nutrient uptake of Indian mustard.

Material and methods

The experiment was carried out at Integrated Oilseed Research Station, Gujarat Agricultural University, Navsari during *rabi* seasons of 1995-96, 1996-97 and 1997-98. The soil was clayey in texture, low in organic carbon (0.38%), low in available N (236 kg/ha), medium in available P_2O_5 (36.5 kg/ha), fairly rich in available K_2O (577 kg/ha) with 7.8 pH. Mustard cultivar "Gujarat Mustard-1" was sown in the first fortnight of November with spacing of 45 cm x 10 cm. FYM was applied at 15 days prior to sowing. Half of the nitrogen and full of phosphorus was given at the time of sowing as basal and remaining nitrogen at 30 days after sowing as top dressing as per treatment. The crop received 6 number of irrigations in all. The experiment was laid out in factorial randomised block design with three replications (Table 1). The gross and net plot size of plots were 5.4 m x 5.0 m and 3.6 m x 5.0 m, respectively. Adequate plant protection measures were taken whenever required. The crop was harvested in second fortnight of February.

Results and discussion

Effect of nitrogen: Nitrogen had significant effect on seed yield of mustard. Application of 75 kg N/ha produced significantly the highest seed yield in pooled analysis. The yield increased to the tune of 23.3 and 39.8 % over application of 50 and 25 kg N/ha on pooled basis. The better response in seed yield recorded with higher nitrogen seemed to be due to significant more values of plant height, number of branches/plant, number of silique/plant and 1000-seed weight. Further, it is also due to significant higher uptake of nitrogen, phosphorus and potassium. Application of 25 and 50 kg N/ha recorded significantly the highest per cent of oil and remained at par with each other. Reverse trend was observed in the case of oil yield, 75 kg N/ha resulted in significantly the highest oil yield which might be due to more seed yield (Table 2). The maximum net returns of Rs. 16788/ha was noted in the application of 75 kg N/ha treatment. These results are in accordance with those of Patel *et al.* (1994) and Malvia *et al.* (1988).

Effect of phosphorus: Application of phosphorus affected significantly the seed yield of mustard. Seed yield was increased at each level from 0 to 25 and 50 kg P_2O_5/ha. *Significantly the highest seed yield was observed in 50 kg* P_2O_5/ha treatment in pooled analysis over control. This was attributed to better improvement in plant height, test weight and uptake of nitrogen, phosphorus and potassium. Though higher values of number of branches and silique/ plant along with silique length were recorded in 50 kg P_2O_5/ha treatment but failed to get the level of significance. Significantly the highest per cent of oil was obtained in 50 kg P_2O_5/ha treatment. The increase in oil content with phosphorus application could be due to the fact that phosphorus helps in synthesis of fatty acids and their esterification by acceleration biochemical reaction in glyoxalate cycle (Dwivedi and Bapat, 1998). The maximum net returns of Rs. 14592/ha was recorded in the application of 50 kg P_2O_5/ha treatment.

Table 1 Growth and yield attributes of Indian mustard as influenced by nitrogen, phosphorus and FYM (pooled over 3 years)

Treatment	Plant height (cm)	No. of branches/ plant	No. of siliqua/ plant	Siliqua length (cm)	1000-seed weight (g)	Seed yield (kg/ha)	Oil content (%)	Oil yield (kg/ha)	Net returns (Rs/ha)
Nitrogen levels (kg/ha)									
25	155	5.9	209	4.6	4.9	1116	32.0	380	10508
50	157	7.1	221	4.6	5.9	1265	31.8	411	12566
75	164	8.3	237	4.6	5.4	1560	30.9	494	16788
SEm±	1.5	0.4	6	0.05	0.1	23	0.1	40	-
CD (P=0.05)	4.3	1.3	17	NS	0.3	65	0.3	29	-
Phosphorus levels (kg/ha)									
0	154	6.8	215	4.4	4.9	1162	31.4	369	11466
25	154	6.7	224	4.5	5.0	1347	32.0	451	13803
50	161	7.9	228	4.6	5.4	1432	32.4	465	14592
SEm±	1.5	0.4	6	0.1	0.1	23	0.1	10	-
CD (P=0.05)	4.3	NS	NS	NS	0.3	65	0.3	29	-
FYM levels (kg/ha)									
0	153	6.6	222	4.6	4.9	1223	31.4	382	13133
10	164	7.6	223	4.6	5.3	1404	31.8	447	13141
SEm±	3.9	0.4	5	0.04	0.02	19	0.1	8	-
CD (P=0.05)	NS	NS	NS	NS	0.06	53	0.2	24	-
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	-

Table 2 Total uptake of N, P and K as influenced by nitrogen, phosphorus and FYM in Indian mustard (pooled over 3 years)

Treatment	Total uptake (kg/ha)		
	N	P	K
Nitrogen levels (kg/ha)			
25	39.1	8.3	34.8
50	46.9	9.7	36.9
75	61.2	11.9	41.9
SEm±	3.2	0.3	0.8
CD (P=0.05)	12.6	1.1	2.3
Phosphorus levels (kg/ha)			
0	40.5	7.9	32.8
25	50.9	10.4	39.3
50	55.7	11.7	41.6
SEm±	0.7	0.3	1.6
CD (P=0.05)	2.0	1.1	6.2
FYM levels (kg/ha)			
0	45.5	9.0	35.6
10	52.5	10.9	40.2
SEm±	1.4	0.1	0.7
CD (P=0.05)	4.1	0.4	1.9
Interaction	NS	NS	NS

Effect of FYM: Seed yield of mustard significantly influenced due to FYM application. An application of FYM @ 10 t/ha produced significantly higher seed yield of mustard. It might be due to more values of growth parameters as well as test weight of seeds along with more uptake of nutrients. The results corroborate the findings of Tomer *et al.* (1996). Oil content and oil yield of mustard were found enhanced due to application of FYM. An improvement of oil content was due to the fact that FYM promotes the synthesis of oil. Oil yield is the resultant of seed yield and oil content. Significant differences in oil yield is perhaps due to the significant differences in seed yield. An application of 10 t/ha FYM resulted in the maximum net returns of Rs. 13141/ha. The results are in conformity with the findings of Sinha *et al.* (1990).

References

Bhatiya, K.S. and Shukla, K.K. 1982. Effect of continuous application of fertilizer and manure on some physical properties of eroded alluvial soils. *Journal of the Indian Society of Soil Science*, **30**(1):33-36.

Dwivedi, A.K. and Bapat, P.N. 1988. Sulphur phosphorus interactions on the synthesis of nitrogenous fractions

and oil in soybean. *Journal of the Indian Society of Soil Science*, **46**:254-257.

Malvia, D.D., Patel, J.C. and Vyas, M.N. 1988. Studies on irrigation, nitrogen and phosphorus levels on growth and yield of mustard (Varuna). *Indian Journal of Agronomy*, **33**(3) : 245-248.

Patel, J.R. and Shelke, V.B. 1998. Effect of FYM, phosphorus and sulphur on growth, yield and quality of Indian mustard. *Indian Journal of Agronomy*, **43**(4):713-717.

Patel, P.M., Upadhyay, P.N. and Patel, J.B. 1994. Response of Indian mustard to irrigation schedules under varying levels of nitrogen and phosphorus. *Journal of Water Management*, **2**(1&2):63-65.

Sinha, A.C., Jana, P.K. and Mandal, B.B. 1990. Effect of micronutrients on rapeseed grown on acid soils of Eastern India. *Indian Journal of Agronomy*, **35**(1-2):126-130.

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

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Productivity and economics of Indian mustard, *Brassica juncea* L. Czern & Coss as influenced by foliar spray of agro-chemicals

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Abstract

A field experiment was conducted at National Research Centre on Rapeseed-mustard, Bharatpur during winter seasons of 2000-01, 2001-02 and 2002-03 to compare and assess the feasibility of foliar spray of agrochemicals in mustard. Basal application of 40 kg S/ha + thio-urea (0.1%) spray favourably influenced the growth, yield attributes and yield of mustard. Significantly higher seed yield was obtained with this treatment but it was at par with $ZnSO_4$ (0.5%), 40 kg S/ha + thio-urea (0.05%), thio-urea (0.1%) alone and basal application of 40 kg S/ha. The maximum net returns were recorded with spray of $ZnSO_4$ (0.5%) at 50% flowering remained at par with 40 kg S/ha + thio-urea (0.05/ 0.1%) spray. The higher IBCR (2.31) was also recorded with $ZnSO_4$ (0.5%) spray.

Key words: Sulphur, mustard, thio-urea, foliar spray, basal application

Introduction

Generally, in Rajasthan, Indian mustard, *Brassica juncea* (L.) Czern. & Coss is grown on light textured soils, which are low in organic carbon, medium in phosphorus and deficient in sulphur due to either by adoption of mono cropping (Fallow-mustard) or extensive use of sulphur free fertilizers. The sulphur requirement of rapeseed-mustard is the highest (16 kg S /tone of seed) among crop plants (Singh and Sahu, 1986). Application of plant nutrients (N, P and S) has been found to be highly profitable in deficient soils (Aulakh and Pasricha, 1977; Trivedi and Singh, 1999; Kumar *et al.*, 2002). Under such situations the foliar spray of agro-chemicals may also help to correct the nutrient deficiency and ultimately to increase the productivity of mustard. The present study was therefore conducted with different agro-chemicals containing nitrogen, sulphur, boron and zinc to economize the expenditure on nutrients for obtaining economic harvest of mustard.

Material and methods

An experiment comprising twelve treatments was conducted at National Research Centre on rapeseed-mustard, Sewar, Bharatpur, Rajasthan during *rabi* seasons of 2000-01, 2001-02 and 2002-03 (Table 1). The treatments were laid out in Randomized Block Design with four replications. The soil of the experimental plot was sandy loam in texture, low in organic carbon (0.31%), medium in available sulphur (19.2 kg/ha) and having pH 7.8. The net plot size was 30 m^2. The mustard variety 'PCR-7' was used for the study during all the three years. The inter and intra row spacing were maintained at 30 cm and 15 cm, respectively by thinning at 15 days after sowing. Full dose of phosphorus (40 kg P_2O_5/ha) and half of nitrogen (40 kg N/ha) were applied at the time of sowing. The remaining nitrogen was applied at first irrigation (35 DAS). The agro-chemicals (thio-urea, urea, zinc sulphate, sulphuric acid and boric acid) were sprayed at 50% flowering. Five plants were selected from each plot to record the yield attributes. The economics of different treatments were worked out by considering the present market price of inputs and produce. To draw valid conclusion, data on yield and its attributes were pooled from the experiment of three years.

Results and discussion

Growth and development: Significant impact of foliar spray of agro-chemicals was observed on growth and yield attributes, *viz.*, plant height, primary branches/plant, siliquae/plant, seeds/siliqua and 1000-seed weight (Table 1), barring the secondary branches/plant. The maximum values of these parameters were recorded where 40 kg S/ha + thio-urea (0.1%) was applied.

Seed yield and economics: In pooled analysis, the seed yield of mustard was highest in 40 kg S/ ha along with 0.1% spray of aqueous solution of thio-urea followed by $ZnSO_4$ (0.5%), 40 kg S/ha + thio-urea (0.05%) and basal application of 40 kg S/ha. About 35.4 % higher seed yield of mustard was recorded with basal application of 40 kg S/ha along with spray of thio-urea (0.1%) over control plots, which was the highest among different treatments. The contribution of thio-urea in this treatment was 8.5 % toward total productivity. The results corroborate the work of Khafi *et al.* (1997). The foliar spray of sulphydryl compound thio-urea might have helped in rapid cell multiplication and resulted in expansion of leaf area, thereby accelerating the photosynthetic rate and ultimately increased all the growth parameters. It also helped to overcome environmental stress in maize crop (Sahu and Solanki, 1991) and works as anti-stress in many crop

plants (Kumawat, 1996). This is further supported by the fact that soil of the experimental field was low in nitrogen and medium in sulphur the increased sulphur supplies from the soil and also from thio-urea spray, might have increased growth, yield attributes and finally increased the seed yield of mustard. The spray of $ZnSO_4$ (0.5%) also registered an increase of 33.3 % in seed yield over no spray. The increase in seed yield of mustard with 0.5% spray of zinc sulphate has been reported by Gupta *et al.*, 1996. Even single spray of water at 50% flowering helped to increase the mustard productivity under moisture stress condition. Benefit: cost ratio was almost similar in foliar spray of $ZnSO_4$ (0.5%), urea (2%), 40 kg S/ha + thio-urea, sulphuric acid (0.1%) and thio-urea (0.1%) spray alone.

Table 1 Effect of agrochemicals on growth, yield attributes, yield and economics of mustard

Treatment	Plant height (cm)	Primary branches/ plant	Secondary branches/ plant	Siliquae/ plant	Seeds/ siliqua	1000-seed weight (g)	Seed yield (kg/ha)	% increase over		B:C ratio
								Control	40 kg S/ha	
Control	173	5	5	161	13	3.9	1404	-	-	1.60
Water spray	174	5	5	176	13	4.0	1538	9.5	-	1.78
Thio-urea (0.05%)	192	6	5	243	14	4.0	1585	12.9	-	1.83
Thio-urea (0.1%)	196	6	6	238	15	4.2	1732	23.4	-	2.05
40 kg S/ha	194	6	7	248	14	4.4	1752	24.8	-	1.94
40 kg S/ha + Thio-urea (0.05%)	201	6	7	247	14	4.6	1814	29.2	3.5	1.94
40 kg S/ha + Thio-urea (0.1%)	206	7	8	286	15	4.8	1901	35.4	8.5	2.05
H_2SO_4 (0.1%)	197	7	7	249	14	4.3	1722	22.6	-	2.08
Urea (1%)	185	6	6	239	13	4.1	1676	19.4	-	1.98
Urea (2%)	203	7	7	263	14	4.4	1735	23.6	-	2.04
$ZnSO_4$ (0.5%)	199	7	6	278	14	4.5	1872	33.3	6.8	2.31
H_3BO_4 (0.2%)	187	6	6	207	13	4.1	1583	12.7	-	1.42
SEm ±	9	1	-	25	1	0.2	76	-	-	-
CD (P=0.05)	19	1	NS	51	2	0.5	155	-	-	-

It was concluded that spray of $ZnSO_4$ (0.5%), thio-urea (0.1%) alone, sulphuric acid (0.1%) and urea (2%) at 50% flowering or basal application of 40 kg S/ha along with thio-urea (0.1%), may be recommended wherever soils are deficient in sulphur for getting higher yield of mustard.

References

Aulakh, M.S. and Pasricha, N.S. 1997. Role of balanced fertilization in oilseed based cropping system. *Fertilizer News*, **42**: 101-111.

Gupta, S.P., Pradeep, Wali., Gupta, S.C., Bedi, A.S. and Khanna, Y.P. 1996. response of rapeseed-mustard to Zn, Bo and Sulphur. *Annals of Agri Bio Research.*, **1**(1-2):25-28.

Khafi, H.R., Porwal, B.L., Mathuria, R.K. and Malavia, D.D. 1997. Effect of nitrogen, phosphorus and foliar -applied agrochemicals on Indian mustard (*Brassica juncea*). *Indian Journal of Agronomy*, **42** (1): 152-154.

Kumar, Rajender, Singh, Dalip and Harmmet Singh. 2002. Growth and yield of Brassica species as influenced by sulphur application and sowing dates. *Indian Journal of Agronomy*, **47** (3):418-421.

Kumawat, B.L. 1996. Response of brassinosteroid in mitigating the effect of water stress in mustard (*Brassica juncea* L.). M.Sc. Thesis, Rajasthan Agricultural University, Bikaner.

Sahu, R.P. and Solanki, N.S. 1991. Role of sulphydryl in improving dry matter portioning and grain production of maize (*Zea mays* L.). *Journal of Agronomy and Crop Science*, **167**: 356-359.

Singh, H.G. and Sahu, M.P. 1986. Response of oilseeds to sulphur. *Fertiliser News*, **31** :23-30.

Trivedi, S.K. and Vijay Singh. 1999. *Response of blackgram (Phaseolus mungo)*- Indian mustard (*Brassica juncea*) cropping sequence to fertilizer application. *Indian Journal of Agricultural Sciences*, **69**(2) : 86-89.

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Effect of date of sowing, phosphorus and biofertilizer on growth, yield and quality of summer sesame, *Sesamum indicum* L.

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Abstract

A field experiment was conducted at Integrated Oilseeds Research Station, Gujarat Agricultural University, Navsari, Gujarat during summer seasons of 1999 and 2000 in a Split Plot Design with three replications. Three dates of sowing (10th February, 17th February and 24th February) as main plot and four levels of phosphorus (0, 15, 30 and 45 kg P_2O_5/ha) along with two treatments of biofertilizers (with and without phosphobacteria) were evaluated in the studies. Crop sown on 17th February resulted in significantly the highest seed yield of sesamum (1.29 t/ha) as compared to other dates of sowing. The highest (1350 kg/ha) seed yield of sesame was recorded when phosphorus was applied @ 45 kg/ha, but it was at par with 30 kg P_2O_5/ha (1260 kg/ha). Seed treatment with phosphobacteria gave significantly 8.4 % higher seed yield as compared to control.

Key words: Growth, yield, quality, sesame

Introduction

Sesame is one of the important oilseed crops. Mainly it is grown during *kharif* season but where the irrigation facility is available, its cultivation is rapidly extended during summer season. The average yield in summer season is remarkably higher than the yield of *kharif* season in Gujarat state. Phosphorus and biofertilizers play an important role in the ultimate productivity of a crop. Such type of work has not been done so far for this crop especially under the soil and climatic conditions of South Gujarat. Hence, the present investigation was planned.

Material and methods

A field experiment was conducted at Integrated Oilseed Research Station, Gujarat Agricultural University, Navsari, Gujarat during the summer seasons of 1999 and 2000. The soil was clayey containing 0.38% organic carbon, 236 kg/ha total nitrogen, 36.5 and 577 kg/ha available P2O5 and K2O, respectively. Soil had 7.8 pH and 0.19 dS/m electrical conductivity. In all, 24 treatments combinations consisting of three dates of sowing (10th February, 17th February and 24th February) as main plot treatment, four levels of phosphorus (0, 15, 30 and 45 kg P2O5/ha) and two levels of phosphobacteria seed treatment (with and without) as sub-plot treatment were tried and each treatment was replicated thrice. Sesame variety Gujarat Til-1 was sown in rows 45 cm apart and after 12 days thinned to keep one plant at 15 cm distance. Half dose of recommended nitrogen (20 kg N/ha) was applied at the time of sowing, while half dose (20 kg N/ha) was applied one month after sowing. Full dose of phosphorus was applied at the time of sowing as basal dose. Phosphobacteria (*Bacillus megateria* var. Phosphaticum) was used as seed treatment.

Results and discussion

Date of sowing: The data pertaining to seed yield revealed significant differences due to varying dates of sowing. Results were consistence during both the years. Sowing of sesame on 17th February gave significantly the highest seed yield than earlier sowing of 10th February and delayed sowing of 24th February during both the years as well as in pooled analysis. The later two dates were statistically at par. The magnitude of increase in seed yield under 17th February sowing was to the tune of 18.3% and 23.3 % over 10th and 24th February sowing, respectively. This might be due to cold spell in early sowing and more temperature in delayed sowing which affected the growth adversely. The crop sown on 17th February resulted significantly the tallest plant as compared to other dates, whereas other yield attributing characters under different dates of sowing were not significant, however, number of capsules/plant (19), number of branches/plant (4) and test weight (4.4 g) were the highest under 17th February sown crop. Cumulative effect of all these yield attributes might have reflected in the seed yield. Oil content (%) was not significantly influenced by different sowing dates. The results are in conformity with the findings of Asthana and Narain (1977), Ghosh and Bagdi (1986), Patil *et al.* (1992) and Sarma (1993).

Effect of phosphorus: Application of phosphorus was found significant during both the years and in pooled analysis. Successive increase in seed yield was noticed with increase in phosphorus levels. Application of 45 kg P_2O_5/ha produced the highest seed yield of summer sesamum but it remained at par with 30 kg P_2O_5/ha during both the years as well as in pooled analysis. The differences were significant for all the yield attributes studied except number of branches/plant. In

most of the characters, application of 45 kg P_2O_5/ha being at par with 30 kg P_2O_5/ha but found significantly superior over lower levels of phosphorus which ultimately reflected to nigher seed yield of sesamum at 45 kg P_2O_5/ha. Dwivedi and Namdeo (1992) and Deshmukh *et al.* (1990) reported almost similar results. Application of phosphorus significantly influenced the oil content. Application of 45 kg P_2O_5/ha resulted in significantly the higher oil content (%) over control and remained at par with 30 kg P_2O_5/ha level. The increase in oil content with phosphorus application might be due to the fact that phosphorus helps in synthesis of fatty acids and their esterification by accelerating biochemical reaction in glyoxalate cycle (Dwivedi and Bapat, 1998).

Table 1 Effect of different treatments on growth, yield attributes, yield and oil content of summer sesame (pooled over two years)

Treatment	Plant height (cm)	No. of capsules/ plant	No. of branches/ plant	Test weight (g)	Oil content (%)	Yield (kg/ha)		
						1997	1998	Pooled
Main plot								
Date of sowing								
D_1 - 10th February	95	83	3	4.2	45.7	1250	930	1090
D_2 - 17th February	104	92	4	4.4	45.2	1480	1100	1290
D_3 - 24th February	84	77	3	4.1	45.4	1200	890	1050
SEm±	1.2	5.4	0.4	0.1	0.3	60	40	30
CD (P=0.05)	3.8	NS	NS	NS	NS	220	160	100
Sub-plot								
P_2O_5 (kg/ha)								
P_0 - 0	89	71	3	3.9	43.7	1060	800	930
P_1 - 15	93	78	3	4.1	45.2	1190	880	1030
P_2 - 30	96	94	4	4.3	45.8	1450	1070	1260
P_3 - 45	99	93	4	4.6	47.0	1550	1150	1350
SEm±	1.8	3.9	0.4	0.1	0.4	60	40	30
CD (P=0.05)	4.9	11.0	NS	0.3	1.6	160	120	100
Biofertilizer								
B_0 - Control	94	82	3	4.2	45.0	1260	930	1100
B_1 - Biofertilizer	95	86	4	4.3	45.8	1360	1010	1190
SEm±	1.2	2.8	0.1	0.1	0.04	40	0.4	20
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	70
Interactions	NS	NS	NS	NS	NS	NS	NS	NS

Effect of biofertilizer: Seed treatment with phosphobacteria was found non-significant in individual year but in pooled analysis the effect found to be significant. Seed treatment with phosphobacteria resulted significantly highest seed yield of sesamum over control in pooled analysis. The effect of biofertilizer was found non-significant in case of all attributes recorded besides oil content (%), however, higher values were observed in all the cases with seed treatment with phosphobacteria. Almost similar observations were observed by Pawar and Raundha (2000) in groundnut crop.

References

Asthana, K.S. and Bhu Narain. 1977. Evaluation of sesame varieties in Bihar for summer. *Indian Journal of Agricultural Science,* **47**(12) : 611-613.

Deshmukh, V.A., Chavan, D.A. and Sugave, G.T. 1990. Response of sesamum (*Sesamum indicum* L.) to nitrogen and phosphate. *Indian Journal of Agronomy,* **35**(3):314.

Dwivedi, A.K. and Bapat, P.N. 1988. Sulphur phosphorus interactions on the synthesis of nitrogenous fractions and oil in soybean. *Journal of the Indian Society of Soil Science*, **46**:254-257.

Dwivedi, V.D. and Namdeo, K.N. 1992. Response of sesame (*Sesamum indicum*) to nitrogen and phosphorus. *Indian Journal of Agronomy,* **37**(3) : 606-607.

Ghosh, D.G. and Bagdi, P.R. 1986. Yield variations in sesamum sown at monthly intervals in subhumid lateritic acid tract of West Bengal. *Madras Agricultural Journal,* **73**(1):23-29.

Patil, B.V., Shishode, N.T. and Dahiphale, V.V. 1992. Effects of different sowing dates on growth and yield of sesamum. *Journal of Maharashtra Agricultural University,* **17**(2):350-351.

Pawar, V.S. and Raundha, D.P. 2000. Response of summer groundnut to levels of phosphate with 'P' solubilizer and foliar spray of phosphate. National Symposium on Agronomy : challenges and Strategies for the New Millennium, November 15-18, 2000, GAU, Junagadh, pp.83-84.

Sarma, N.N. 1993. Response of summer sesame (*Sesamum indicum* L.) to sowing dates in the hilly zones of Assam. *Annals of Agricultural Research,* **14**(3):363-365.

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Biology of painted bug, *Bagrada hilaris* (Burm.) on rapeseed mustard

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Abstract

The biology of painted bug, *Bagrada hilaris* (Burm.) was studied in the laboratory in BOD incubator at 28±2°C with 12 hr photo period of 60 Watt electric bulb on the leaves of 12 hosts i.e., *Brassica campestris* var. Toria, *B. campestris* var. Brown sarson, *B. juncea, B. napus, B. carinata, B. nigra, B. tournifortii, Eruca sativa, Sinapis alba, B. oleracea* var. *botrytis*, *B. oleracea* var. *capitata* and *Raphanus sativa*. The freshly laid eggs were oval and dirty white and bore reticulations on chorion visible under microscope. The colour changed from yellow to orange yellow and finally turned pink before hatching. At hatching the egg shell opened out at one end and remained attached to the egg shell at one point. The average incubation period varied between 5.1 to 5.6 days when reared on different hosts, lowest being on *B. campestris* var. Toria and highest on *E. sativa*. The average hatching varied from 94.40 (*B. campestris* var. Toria) to 85.6% (*E. sativa*). The painted bug passed through five nymphal instars to become adult. The newly emerged first nymphal instar was bright orange with red eyes, later the colour changed to reddish brown and just before moulting it turned to red on all hosts. Its duration varied from 3.1 days (*B. campestris* var. Toria) to 5.0 days (*S. alba*). The newly emerged second nymphal instar was bright orange with scarlet red eyes. Body colour changed to dirty red before moulting. Its period varied from 3.5 to 7.0 days on *B. campestris* var. Toria and *E. sativa*, respectively. The third nymphal instar was reddish with dark markings on abdomen. Its duration varied from 4.6 days (*B. campestris* var. Toria) to 6.8 days (*E. sativa*). The fourth nymphal instar was also reddish but the dark markings became prominent. Its duration varied from 4.9 days on *B. campestris* var. Toria to 6.9 days on *E. sativa*. The fifth nymphal instar assumed the colouration of adult with well developed markings backwardly elongated notum formed well developed wing pods. Its duration varied from 4.9 days on *B. campestris* var. Toria to 7.1 days on *E. sativa*. The average total nymphal period varied from 21.6 days on *B. campestris* var. Toria to 31.1 days on *E. sativa*. On the basis of biological studies, *B. carinata, B. nigra, B. tournifortii* and *E. sativa* were least preferred hosts. However, on *S. alba* none of the nymphal instars, except first, survived, thereby giving an indication that it is not a host of the painted bug.

Key words: Painted bug, *Bagrada hilaris*, rapeseed-mustard, biology

Introduction

Painted bug, *Bagrada hilaris* (Burm.) is an important pest of crucifer crops (Rai, 1976). It infests the crop at two stages of growth i.e., first at the seedling stage when it may result in the resowing of the crop (Singh *et al.*, 1993) and secondly at the maturity of the crop when it results into loss of seed weight, oil content and germination (Singh *et al.*, 1980). The biology of a pest provides an intimate information on the different stages, their appearance and changes and relative preference on different hosts. Hence, the efforts were made to visualise the changes that occur in the different stages on different 12 cultivars of rapeseed-mustard and their relative preference.

Material and methods

The studies were carried out in the laboratory, Department of Entomology, CCS Haryana Agricultural University, Hisar in a biological oxygen demand (B.O.D.) Incubator at 28±2°C with 12 hr photoperiod of 60 Watt electric bulb. The field collected adults were visually separated into males and females as per Rakshpal (1949). Single pair of adults was released separately on the leaves of different 12 hosts (Table 1). The eggs thus obtained from the adults, reared on different hosts, were utilized to obtain stock culture separately on each host. One hundred freshly laid eggs were kept separately in petridishes (10 cm dia) for hatching. Freshly emerged nymphs were provided with the fresh leaves of the same host on which their parents were fed. To ensure freshness and turgidity of the leaves, their petioles (singly) were wrapped in wet absorbent cotton swab. As and when the leaves appeared spoiled/consumed/ withered, they were replaced with the fresh one from the

same host. The freshly emerged adults from these cultures were paired for complete biological studies on the respective hosts.

Fecundity was studied in glass jar (20 x 15 cm) with five replicates for each host. Hatchability and incubation periods were studied with 100 eggs in five replicates in petridishes (10 cm, diameter) provided with dry filter paper at the top. Observations on the hatching of the eggs were recorded at 12 hr intervals. Per cent hatchability was calculated on the basis of numbers of eggs hatched successfully into first instar nymph. Other parameters such as number of nymphal instars and their durations were studied.

Results and discussion

The freshly laid eggs were oval and dirty white. The eggs showed reticulations on chorion under microscope. Their colour changed from yellow to orange yellow and finally pink before hatching. This is in conformity with Singh and Malik (1993) and Verma *et al.* (1993). At hatching, the egg shell opened out at one end, allowing a cap like flap of the shell to separate out but remained loosely attached to it at one place. The process of nymph emergence was completed in 20 to 30 minutes. After emergence the nymph rested for few minutes and then began to move about the started feeding.

The average incubation period varied between 5.1 to 5.6 days when reared on different crucifers hosts, lowest being on *B. campestris* var. Toria and highest on *E. sativa*. It was significantly lower on *B. campestris* var. Toria, *B. campestris* var. Brown Sarson, *B. juncea*, *B. napus*, *B. oleracea* var. *botrytis* and *B. oleracca* var. *capitata* as compared to other hosts (Table 1). Mukerji (1958) observed incubation period of 6 to 8 days on cabbage leaves under field conditions, where as under open laboratory conditions it varied from 8 to 10 days. On mustard (*B. juncea*) leaves under open laboratory conditions it was 3.8 days as per Rakshpal (1949). However, at controlled temperature of 24±4.2°C and RH of 44±8% it was 6.2 days on mustard seedlings (Verma *et al.*, 1993) and 6.27 days on soaked mustard seeds at 28±2°C (Singh and Malik, 1993).

The average hatchability varied from 94.4 (*B. campestris* var. Toria) to 85.6% (*E. sativa*). The hatchability on *B. campestris* var. Brown Sarson (94.0%) and *B. juncea* (93.4%) was at par with *B. campestris* var. Toria. Hatchability of 85.6% on *E. sativa* and 89.4% on *B. tournifortii* revealed their less preference by painted bug.

The painted bug passed through five nymphal instars to become an adult. The newly emerged first nymphal instar was bright orange with red eyes. As it developed, the colour changed to reddish brown and just before moulting it turned to red on all the hosts. This is in conformity with Rakshpal (1949), Atwal (1986), Singh and Malik (1993) and Verma *et al.* (1993). The average first instar nymphal period on various hosts differed significantly and varied from 3.1 days (*B. campestris* var. Toria) to 5.0 days (*Sinapis alba*) followed by 4.6 days on *E. sativa* (Table 2). The first instar nymphal duration of 2.3 to 3.3 days has been observed on mustard leaves under open and controlled laboratory conditions (24±4.2°C and 44±8% RH) by Rakshpal (1949) and Verma *et al.* (1993). However, on soaked mustard seeds higher duration of 6.2 days at 28±2°C was observed by Singh and Malik (1993).

Table 1 Incubation period and hatchability of painted bug, *Bagrada hilaris* eggs reared on different crucifer hosts

Host plant	Genotype	Incubation period (days)		Hatchability (%)
		Average ± S.E.	Range	average
Brassica campestris var. Toria	TH-68	5.1±0.06	4.0-6.0	94.4 (76.4)**
B. campestris var. Brown Sarson	BSH-1	5.1±0.05	4.0-6.0	94.0 (75.9)
B. juncea	RH-30	5.2±0.06	4.0-6.0	93.4 (75.3)
B. napus	GSH-1	5.2±0.07	4.0-6.0	92.8 (73.4)
B. carinata	HC-2	5.4±0.10	4.0-7.0	92.4 (73.3)
B. nigra	Local	5.4±0.08	4.0-7.0	91.0 (72.5)
B. tournifortii	Local	5.4±0.07	4.0-7.0	89.4 (71.1)
Eruca sativa	TMH-52	5.6±0.08	4.0-7.0	85.6 (67.8)
Sinapis alba	Local	*	*	*
B. oleracea var. *botrytis*	Snowball	5.2±0.07	4.0-6.0	92.8 (73.4)
B. oleracea var. *capitata*	Pride of India	5.2±0.08	4.0-6.0	92.0 (73.2)
Raphanus sativus	Pusa purple long	5.4±0.06	4.0-7.0	90.0 (71.5)
SEm±		0.11		(1.45)
CD (P=0.05)		0.22		(2.93)

* Did not complete second instar; Figures in parenthesis are angular transformed values

Table 2 Duration of nymphal instars of painted bug, *Bagrada hilaris* reared on different crucifer hosts

Host plant	Genotype	Average nymphal duration (days)					Total nymphal period ± S.E.
		1st instar± S.E.	2nd instar± S.E.	3rd instar± S.E.	4th instar± S.E.	5th instar± S.E.	
Brassica campestris var. Toria	TH-68	31.±0.12 (2.5-4.0)#	4.0±0.12 (3.5-5.0)	4.6±0.18 (3.5-5.5)	4.9±0.20 (3.5-6.0)	4.9±0.12 (4.0-6.5)	21.6±0.33 (20.0-25.5)
B. campestris var. Brown Sarson	BSH-1	3.3±0.14 (2.5-4.5)	4.5±0.10 (3.5-5.5)	4.9±0.14 (4.0-6.0)	5.2±0.17 (4.0-6.5)	5.5±0.17 (4.5-6.5)	23.5±0.32 (21.0-26.0)
B. juncea	RH-30	3.5±1.12 (2.5-4.5)	4.5±0.18 (3.5-5.5)	5.2±0.13 (4.5-6.5)	5.5±0.18 (4.0-6.5)	5.8±0.19 (5.0-7.0)	24.6±0.38 (21.0-26.5)
B. napus	GSH-1	4.0±0.08 (3.0-4.5)	4.8±0.14 (4.0-6.0)	5.3±0.14 (4.5-6.5)	5.7±0.14 (4.5-6.5)	5.9±0.17 (5.0-7.0)	25.8±0.38 (22.0-28.5)
B. carinata	HC-2	4.1±0.08 (3.5-4.5)	5.0±0.12 (4.0-6.0)	5.6±0.17 (5.0-6.5)	6.0±0.18 (5.0-7.0)	6.1±0.17 (5.5-7.0)	27.0±0.39 (26.0-29.5)
B. nigra	Local	4.1±0.09 (3.5-5.0)	5.1±0.13 (4.5-6.0)	6.12±0.17 (5.5-7.0)	6.4±0.17 (5.5-7.5)	6.6±0.19 (5.5-7.5)	28.4±0.36 (26.5-31.5)
B. tournifortii	Local	4.2±0.08 (3.5-5.0)	5.3±0.15 (4.5-6.0)	6.1±0.16 (5.5-7.0)	6.7±0.19 (5.5-7.5)	7.0±0.15 (6.0-7.5)	29.5±0.33 (27.0-32.5)
Eruca sativa	TMH-52	4.6±0.10 (4.0-5.0)	5.6±0.13 (5.0-7.0)	6.8±0.18 (6.0-7.5)	6.9±0.15 (5.5-8.0)	7.1±0.18 (6.5-8.5)	31.1±0.37 (28.5-33.5)
Sinapis alba	Local	5.07±0.09 (4.5-6.5)	*	*	*	*	*
B. oleracea var. *botrytis*	Snow ball	3.58±0.12 (3.0-4.5)	4.5±0.17 (3.5-5.0)	5.3±0.14 (4.5-6.5)	5.6±0.15 (4.5-6.5)	5.9±0.14 (5.0)	25.1±0.38 (21.5-26.5)
B. oleracea var. *capitata*	Pride of India	4.06±0.08 (3.5-4.5)	4.8±0.14 (4.0-5.5)	5.2±0.13 (4.5-6.5)	5.6±0.14 (4.5-6.5)	5.8±0.16 (5.0-7.0)	25.6±0.35 (22.0-28.5)
Raphanus sativus	Pusa purple long	4.08±0.08 (3.5-4.5)	4.9±0.11 (4.0-6.0)	5.4±0.10 (4.5-6.5)	5.8±0.13 (4.5-6.5)	6.0±0.17 (5.0-7.0)	26.3±0.36 (24.5-27.5)
SEm±		0.15	0.20	0.21	0.23	0.23	0.51
CD (P=0.05)		0.29	0.39	0.41	0.45	0.45	1.01

* Did not complete second instar; # Range

The newly emerged second instar nymph was bright orange with scarlet red eyes. Body colour changed to dirty red before moulting. The average second instar nymphal duration differed significantly on different hosts varying from 4.0 to 5.6 days with a range of 3.5 to 7.0 days on *B. campestris* var. Toria and *E. sativa*, respectively. In the present studies the second instar nymphal duration (4.0 days) on *B. campestris* var. Toria was quite close whereas, it was marginally higher on rest of the hosts than the previously observed duration of 4.0 days on mustard leaves under both open as well as controlled (24±4.2°C and 44±8% RH) laboratory conditions (Rakshpal, 1949; Verma *et al.*, 1993) and 4.1 days on soaked mustard seeds at 28±2°C (Singh and Malik, 1993).

The third instar nymph was reddish with a dark marking on abdomen. The average third instar nymphal period on *E. sativa* (6.8 days) was significantly more than on *B. campestris* var. Toria (4.6 days) and *B. campestris* var. Brown Sarson (4.9 days) (Table 2). Earlier a marginally lower third instar nymphal duration (4.0 to 4.3 days) was observed on mustard leaves under laboratory conditions (Rakshpal, 1949; Verma *et al.*, 1993). However, on soaked mustard seeds, it was 8.4 days at 28±2°C (Singh and Malik, 1993).

The fourth instar nymph was also reddish but the dark markings become more prominent. Its duration was significantly less on *B. campestris* var. Toria (4.9 days) and significantly more on *E. sativa* (6.9 days) followed on *B. tournifortii* (6.7 days). Presently observed fourth instar nymphal duration was higher than the previously reported i.e., 4.3 to 4.5 days on mustard leaves (Rakshpal, 1949; Verma *et al.*, 1993). However, the duration on *B. carinata, B. nigra, B. tournifortii* and *E. sativa* was comparable to the previously observed 6.5 days on soaked mustard seeds (Singh and Malik, 1993).

The fifth instar nymph assumed the colouration of adult and all the markings became well developed. Backwardly elongated notum formed well developed wing pads. Its average duration was significantly less (4.9 days) on *B. campestris* var. Toria and significantly more on *E. sativa* (7.1 days) followed by on *B. tournifortii* (7.0 days) (Table 2). Except on *B. tournifortii* and *E.*

sativa, its duration was within the earlier observed range of 4.4 to 6.8 days on mustard leaves (Rakshpal, 1949; Verma *et al.*, 1993). The durations on *B. tournifortii* and *E. sativa* are close to the previously observed duration of 8.2 days on soaked mustard seeds at 28±2°C (Singh and Malik, 1993). Earlier Rakshpal (1949), Bhai and Singh (1961), Batra and Sarup (1962), Atwal (1986), Verma *et al.* (1993) and Singh and Malik (1993) also observed five nymphal instars of painted bug.

The average total nymphal period varied from 21.6 days (*B. campestris* var. Toria) to 31.1 days (*E. sativa*). *B. carinata, B. nigra, B. tournifortii* and *E. sativa* were the least preferred hosts for nymphal development. However, on *S. alba* none of the nymphal instars, except first, survived. Therefore, it appears that *S. alba* is not the host of the painted bug.

References

Atwal, A.S. 1986. *Agricultural Pests of India and South-East Asia,* (Second Edition), Kalyani Publishers, New Delhi, pp.296-311.

Batra, H.N. and Sarup, S. 1962. Techniques of mass rearing of painted bug, *Bagrada cruciferarum* Kirk. (Heteroptera : Pentatomidae). *Indian Oilseeds Journal*, **6**(2) : 135-143.

Bhai, B.D. and Singh, S. 1961. On the biology of painted bug, *Bagrada cruciferarum* in Punjab. *Proceedings of 48th Indian Science Congress,* Part 3, 3-9 January, 1961, University of Roorkee, p.494.

Mukerji, G.P. 1958. Some aspects of biology of *Bagrada picta* Fab. *Agra University Research* (Science), **7**(2) : 143-156.

Rai, B.K. 1976. *Pests of Oilseed Crops in India and their Control.* Indian Council of Agricultural Research, New Delhi, p.121.

Rakshpal, R. 1949. Notes on the biology of *Bagrada cruciferarum* Kirk. *Indian Journal of Entomology*, **11**(1) : 11-16.

Singh, Harvir., Gupta, D.S., Yadava, T.P. and Dhawan, K. 1980. Post-harvest losses caused by painted bug, *Bagrada cruciferarum* Kirk. to mustard. *Haryana Agricultural University Journal of Research*, **1**(3) : 407-409.

Singh, Harvir and Malik, V.S. 1993. Biology of painted bug (*Bagrada cruciferarum*). *Indian Journal of Agriculture Sciences*, **63**(10):672-674.

Singh, Harvir., Rohilla, H.R., Ram, P. and Ahlawat, D.S. 1993. Out-break of painted bug, *Bagrada cruciferarum* (Kirk.) on oilseed *brassica* in Haryana. *International Journal of Tropical Agriculture*, **11**(2):153-154.

Verma, A.K., Patyal, S.K., Bhalla, O.P. and Sharma, K.C. 1993. Biology of painted bug (*Bagrada cruciferarum*) (*Hemiptera : Pentatomidae*) on seed crop of cauliflower (*Brassica oleracea* var. *botrytis* sub var. *cauliflora*). *Indian Journal of Agriculture Sciences*, **63 (10)** : 676-678.

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Management of green leaf hopper, *Amrasca biguttula biguttula* (Ishida) through seed treatment and foliar sprays with imidacloprid and its residue in sunflower seeds

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Abstract

Three doses of imidacloprid *viz.*, Gaucho 600 FS @ 6, 9 and 12 ml/kg of seed and Gaucho 70 WS @ 5, 7.5 and 10 g/kg seed along with Confidor 200 SL @ 100 and 200 ml/ha and monocrotophos 0.04 % as foliar spray were tested for the control of *Amrasca biguttula biguttula* (Ishida) on sunflower, *Helianthus annuus* L. at Hyderabad, Andhra Pradesh, India during 1999-2000. Gaucho 70 WS or 600 FS @ 5 g or 6 ml/kg of seed, respectively was found effective for the control of leaf hoppers. Seeds from the imidacloprid treated crop remained free of its residue. However, its toxic impact on natural occurring coccinellid population is yet to be ascertained.

Key words: Imidacloprid, *Amrasca biguttula biguttula*, sunflower, confidor

Introduction

Sunflower *Helianthus annuus* L. is bestowed with green canopy of leaves upto the maturity stage, thus becomes a reservoir of a number of insect-pests and natural enemies. Green leaf hopper *Amrasca biguttula biguttula* (Ishida) is one of the major sap sucking pests attacking the crop particularly when it is grown adjacent to cotton crop. Leaf hoppers devitalize the crop by sucking the cell sap from foliage of the plant. Yellow necrotic spots give the indication of leaf hoppers damage to the crop. Excessive feeding becomes major hurdle to yield potential.

Material and methods

Present studies were undertaken at the experimental farm of the Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, AP, to manage the leaf hoppers through seed treatment with imidacloprid (600 FS and 70 WS) as well as foliar spraying (Imidacloprid 200 SL) belonging to nitroguanidines group of the insecticide during *kharif*, 1999-2000. The experiment was carried out in Randomised Block Design with sunflower variety, Morden. In all, nine treatments in three replications were tried along with a control in a plot size of 2.4 x 3 m at a spacing of 60 cm between rows and 30 cm between plants. All agronomic practices i.e., 60 : 40 : 50 kg/ha N, P and K, respectively and irrigation at fortnightly interval were followed to raise a good crop of sunflower except plant protection measures. Observations on the nymphs of leaf hopper were taken after expiry of two sprays with imidacloprid i.e., 50 days after germination in all the treatments on 10 plants (three leaves representing; upper, lower and middle canopies). Other observations i.e., plant height, head diameter and necrosis disease incidence were taken a day before harvest.

Sunflower seed samples harvested treatment wise were collected and utilised for residue analysis. Sunflower seed powder (10 g) was extracted with acidified aqueous methanol. The extract filtered through a filter aid, filtrate concentrated and added to 50 ml 5% NaCl. The lipids extracted out using hexane thrice. The aqueous solution added to X AD-8 resin. The resin was washed with water and the pesticide residues if any were eluated using methanol (150 ml). The eluate was concentrated and dissolved in 10 ml acetonitrile : water (1:1). The final extract was utilised for HPLC analysis.

HPLC condition

- Liquid chromotograph	: Shimadzu LC 10 AT
- Column	: ODS-18
- Injection volume	: 20 micro litres
- Detection (wave length)	: 270 nm
- Mobile solvent	: Acetonitrile:water (35:65 v/v)
- Flow rate	: 1 ml/min
- Retention time	: 5.3 mm
- Sensitivity	: 2

Results and discussion

Population of leafhoppers remained below ETL (economic threshold level) i.e., 1 to 2 nymphs/plant in all the plots treated with both brands of Imidacloprid as against 6 to 9 nymphs/plant in control upto 35 days after sowing. Imidacloprid 200 SL had a quick knock down effect on leaf hoppers.

It is inferred that, Imidacloprid 70 WS or 600 FS @ 5 g and 6 ml/kg seed, respectively can be recommended for the management of leaf hoppers in sunflower upto 35 to 50 days after sowing. Foliar spraying with Imidacloprid @ 100 and 200 ml/ha at 35 days after germination was also equally effective. However, foliar spray impact on natural enemies is yet to be ascertained and confirmed as some of the dead predatory coccinellid beetles were observed in these treatments immediately after spraying. Necrosis disease incidence was significantly low in all the treatments except monocrotophos 0.04%. Some phytotonic effect of imidacloprid was also observed on plant height and head diameter, which resulted in higher yields. No residues could be detected in the seed samples of the crop grown with/under any of the above treatments with imidacloprid.

Present studies are in concurrence with Dewar and Read (1990) who reported imidacloprid effective for aphids control in sugar beet as seed treatment and Baraiya and Vyas (2002), who found Imidacloprid 0.006% as foliar spray, effective against *Emposca kerri* Pruthi in groundnut with moderate economics. Interestingly the plots treated with imidacloprid either seed treatment or through foliar spray had lower infection level of sunflower necrosis virus disease as compared to control. Deleterious effect of foliar spray on predatory coccinellid beetles with imidacloprid is yet to be confirmed. Imidacloprid can be safely used for the management of leaf hoppers in sunflower as the crop was residue free at harvest.

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Table 1 Efficacy of Imidacloprid (GAUCHO 70 WS, GAUCHO 600 FS and CONFIDOR 200 SL) against green leaf hoppers in sunflower

Treatment	Average leaf hopper/ plant (50 DAG)	Plant height (cm)	Head diameter (cm)	Necrosis infected plants (%)	Yield (Kg/ha)
Gaucho 600 FS 6 ml/Kg seed*	1.0	79	11	17.4	984
Gaucho 600 FS 9 ml/Kg seed*	0.7	92	10	18.7	1032
Gaucho 600 FS 12 ml/Kg seed*	1.0	96	12	18.5	1173
Gaucho 70 WS 5 g/Kg seed*	1.0	100	14	24.8	1051
Gaucho 70 WS 7.5 g/Kg seed*	1.0	95	13	18.8	1141
Gaucho 70 WS 10 g/Kg seed*	0.7	93	13	22.9	1065
Confidor 200 SL 100 ml/ha**	1.0	91	11	20.3	1030
Confidor 200 SL 200 ml/ha**	1.0	79	11	17.4	983
Monocrotophos 600 ml/ha	1.3	92	13	26.2	925
Control	4.3	84	12	29.8	891
CD (P=0.05)	0.4	NS	NS	8.0	NS
CV (%)	1.3	8.9	18.9	15.4	16.7

* Seed treatment
** *Foliar spray at 35 and 50 days after germination* (DAG)

Reference

Baraiya, K.P. and Vyas, H.J. 2002. Efficacy of different insecticides against leafhopper, *Empoasca kerri* Pruthi on groundnut. *Journal of Oilseeds Research*, **19**(1) : 135-137.

Dewar, A.M. and Read, L.A. 1990. Evaluation of an insecticidal seed treatment, imidacloprid, for controlling aphids on sugar beet. *Brighton Crop Protection Conference, Pests and Diseases*, **2** : 721-726.

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Bioefficacy of a native isolate of *Bacillus thuringiensis* against *Spodoptera litura* Fabricius and *Achaea janata* Linnaeus on castor[1]

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Abstract

Bioefficacy of native *Bacillus thuringiensis* against *Spodoptera litura* Fab. was studied under laboratory as well as pot conditions. Native *Bt* (GAU CT 2 isolate) was bioassayed against *Achaea janata* Linnaeus. Laboratory bioassays showed that the isolate GAU CT2 caused maximum mortality of *S. litura* (70.8%) and *A. janata* (66.4%) at 10^9 spore/ml after 7 days of treatment. The results of pot culture studies showed that *Bt* in combination with adjuvant (5% Tween 80 and Gum arabic) gave significantly good mortality (63.7%) after 7 days of treatment, which was at par with *Bt* alone (61.4%) treatment. However, a remarkable mortality of test insects was obtained in chemical insecticide endosulfan 0.07% treatment followed by *B.t.k.*

Key words: Bioefficacy, castor, *Bacillus thuringiensis*, *Spodoptera litura*, *Achaea janata*

Introduction

Castor, *Ricinus communis* L. is one of the major non-edible oilseed crop grown in tropical and sub-tropical regions of the world. A number of insect pest feed on castor at different stages of crop growth resulting in substantial yield losses. In Gujarat, yield losses in castor due to *Spodoptera litura* Fab., range from 12 to 23% (Thanki, 1999). Castor semilooper, *Achaea janata* Linnaeus causes extensive defoliation and also feeds on tender shoots and developing capsules leading to considerable reduction in the yield (Parthasarathy and Rao, 1989). Yield losses due to *A. janata* in GCH-4 and SH-41 cultivars were reported to be 21.8 and 27.7%, respectively in Gujarat. Insect pathogenic bacteria have been widely used against insects. *Bacillus thuringiensis* (*B.t.*) is now under extensive use for insect control in agriculture, horticulture and forestry and also for mosquito control over past three decades. Deshmukh and Deshpande (1989) observed that the endotoxin based *Bt* WP was found to be the most toxic followed by liquid and Biobit WP containing sub sp. *kurstaki* to 3rd instar larvae of *A. janata*. In view of this, the bioefficacy of a native *B. thuringiensis* (GAU CT2 isolate) was studied against *A. janata* in laboratory and against *S. litura* in laboratory as well as in the pots during the year, 2001.

Material and methods

Soil samples were collected from different crop fields located at various farms of GAU, Anand during the year, 2001. One hundred g composite soil sample of each crop was suspended in 100 ml sterile D/W in conical flask and mixed thoroughly on mechanical stirrer for 5 minutes. Each sample (0.1 ml) was taken with the help of sterile pipette into a test tube containing 9.9 ml of sterile distilled water to prepare 10^{-2} dilution and serially diluted further upto 10^{-6} dilutions. Finally, 0.1 ml 10^{-6} diluted sample of each crop was spread individually on the selective media. Yeast Extract Mannitol Agar with Polymixin-B for selective isolate of *B.t.* The procedure was carried out in laminar airflow chamber to avoid the contamination. A series of concentrations of *B.t.* (GAU CT2 isolate) *viz.*, 10^4, 10^5, 10^6, 10^7, 10^8 and 10^9 (spore-crystal mixture/ml) were prepared following serial dilution in sterile distilled water (D/W). Standard *Bt* var. *kurstaki* HD-1 (Ohio State University, USA) was used for comparison. Chemical insecticide (Endosulfan 35 EC) also kept as a treated check and an untreated check was also maintained. The number of *Bt* spores and crystals in suspension was pre-determined with an improved Neubauer's haemocytometer.

Laboratory bioassay: Bioassay was carried out in multicavity trays (13 cm L x 8.5 cm B x 2.3 cm H) having 24 wells with a well size, 1.7 cm D x 1.5 cm H using food contamination method. *Bt* treated leaves followed by drying of leaves at room temperature were cut into small pieces as per the size of the well and fed to previously starved second instar larvae of *S. litura* and *A. janata*. Trays were then kept in a B.O.D incubator at 28±2°C. After consumption of treated leaves, larvae were provided with fresh leaves during subsequent rearing procedure. Observations on larval mortality were recorded at 24 hrs intervals upto 7 days. Dead larvae of *S. litura* and *A. janata* were recovered from the bioassay trays followed by cutting the legs of the dead larvae and collects the haemocoal of the insect midgut and reisolate as *Bt* by observing the bacteria under phase contrast microscope to confirm the bacterial presence.

[1] Part of M.Sc. (Ag. Entomology) thesis submitted to Gujarat Agricultural University, S.K. Nagar, Gujarat.

Pod study: Thirty earthen pots (15 cm D) of 3.5 kg soil capacity were used for sowing of castor cv. GCH-4 seeds. The *Bt* suspensions prepared in the laboratory were sprayed using glass sprayer on castor leaves in respective pots during evening hours. The *S. litura* larvae were released @ 10/pot. Observations on larval mortality were recorded at 24 hrs interval upto 168 hrs (7 days). The data obtained on larval mortality were statistically analysed following arcsine transformation.

Table 1 Bioassay of *Bacillus thuringiensis* against *Spodoptera litura* Fab.

Treatments (spores/cm^2)	% mortality at indicated hours after treatment						
	24	48	72	96	120	144	168
10^9	21.7** (13.9)*	3.33 (30.5)	41.1 (41.6)	53.0 (63.8)	61.9 (77.7)	68.7 (86.1)	70.8 (88.9)
10^8	11.5 (5.6)	13.8 (8.3)	33.5 (30.5)	43.3 (47.2)	53.2 (63.8)	58.2 (72.2)	63.9 (80.6)
10^7	11.5 (5.6)	13.8 (8.3)	35.1 (33.3)	44.9 (50.0)	49.8 (58.3)	53.0 (63.8)	58.2 (72.2)
10^6	13.9 (8.3)	18.3 (13.9)	29.7 (23.0)	40.1 (41.6)	46.5 (52.7)	51.4 (61.1)	54.8 (66.7)
10^5	11.5 (5.6)	18.3 (13.9)	31.7 (27.7)	38.5 (38.8)	44.9 (50.0)	49.8 (58.3)	54.8 (66.7)
10^4	8.6 (5.6)	15.8 (11.1)	28.0 (22.2)	36.9 (36.1)	43.3 (47.2)	49.8 (58.3)	54.8 (66.7)
B.t.k. (Std.)	21.7 (13.9)	33.5 (30.5)	44.9 (50.0)	58.5 (72.2)	63.3 (86.1)	70.7 (88.8)	73.2 (91.7)
Endosulfan	63.9 (80.6)	89.1 (99.9)	89.1 (99.9)	89.1 (99.9)	89.1 (99.9)	89.1 (99.9)	89.1 (99.9)
Control	0.8 (0.02)	0.81 (0.02)	0.81 (0.02)	0.8 (0.02)	0.8 (0.02)	0.8 (0.02)	0.81 (0.02)
SEm±	4.81	6.14	2.23	2.32	2.53	2.35	2.08
CV (%)	45.48	40.35	10.42	8.91	8.59	7.44	6.23

* Figures in parenthesis are the retransformed values

** Figures indicating common letters do not differ significantly from each other at 5% level of significance according to DNMRT

Table 2 Bioassay of *B.t.* GAU CT-2 against *A. janata* L.

Treatments (spores/cm^2)	% mortality at indicated hours after treatment						
	24	48	72	96	120	144	168
10^9	13.9** (8.3)*	26.1 (19.5)	38.5 (38.9)	49.8 (58.3)	56.5 (69.5)	61.9 (77.8)	66.4 (83.3)
10^8	16.8 (8.3)	23.6 (16.7)	29.9 (25.0)	38.5 (38.9)	46.6 (52.8)	51.4 (61.1)	56.5 (69.4)
10^7	11.5 (5.6)	19.2 (11.1)	26.1 (19.5)	33.5 (30.6)	40.1 (41.7)	44.9 (50.0)	49.8 (58.3)
10^6	11.5 (5.6)	19.2 (11.1)	23.6 (16.7)	31.5 (27.8)	38.5 (38.9)	41.7 (44.4)	46.6 (52.8)
10^5	6.1 (2.8)	16.8 (8.3)	21.7 (13.9)	28.0 (22.2)	31.5 (27.8)	40.1 (41.7)	44.9 (50.0)
10^4	6.1 (2.8)	16.8 (8.3)	19.2 (11.1)	23.6 (16.7)	27.8 (22.2)	36.7 (36.1)	41.7 (44.4)
B.t.k. (Std.)	21.7 (13.9)	36.9 (36.1)	40.1 (41.7)	49.8 (58.3)	58.2 (72.2)	63.9 (80.5)	68.3 (86.1)
Endosulfan	62.2 (77.8)	89.2 (99.9)	89.2 (99.9)	89.2 (99.9)	89.2 (99.9)	89.2 (99.9)	89.2 (99.9)
Control	0.8 (0.02)	0.8 (0.02)	0.81 (0.02)	0.81 (0.02)	0.81 (0.02)	0.81 (0.02)	0.81 (0.02)
SEm±	4.48	1.92	2.13	2.45	2.28	2.49	2.74
CV (%)	46.37	12.03	11.5	11.06	9.15	9.01	9.20

* Figures in parenthesis are the retransformed values

** Figures indicating common letters do not differ significantly from each other at 5% level of significance according to DNMRT

Results and discussion

The results revealed that after 24 hrs of treatment insect larvae stop feeding and die due to the combined effect like starvation and tissue damage causing septicemia in the insect midgut. Except T_1 all the *B.t.* concentrations were found to be at par with each other and a similar trend was observed up to 168 hrs. of application (Table 1). The larval mortality was observed to increase time and concentration. However, treatment T_1 (10^9 spores/ml) gave significantly higher mortality (70.86%) with lower LC_{50} value 1.8×10^7 spores/ml (Table 3). The chemical insecticide endosulfan induced highest mortality (89.12%) in *S. litura* followed by *B.t.k.* standard and GAU *B.t.* isolate at highest dose (T_1), which were on par with each other. Puntambekar *et al.*, (1997) observed that laboratory evaluation of different *B.t.* subspecies showed that *B.t.k.* (NCIM 2514) at 10^8 spore/ml concentration caused more than 85% mortality of neonate larvae of *S. litura*. At higher *B.t.* concentrations, increased larval mortality was also observed by Jayanthi and Padmavathamma (1997) who reported maximum mortality at highest concentration tested. Laboratory evaluation of *B. t.* var *kurstaki* caused more than 85% mortality to the neonate larvae of *S. litura* and *Phthorimaea operculella* when tested @ 10^8 spores /ml at Maharashtra (Puntambekar *et al.*, 1997) and also gave maximum (87.5%) mortality of Ist instar *S. litura* larvae and 32.6% mortality in 6th instar larvae at higher concentrations in the laboratory. The mortality rate was observed to decrease with increasing larval age (Zaz and Kushwaha, 1993).

The results of bioassay with native *B.t.* isolate against *A. Janata* revealed that treatment T_1 (10^9 spore-crystal mixture/ml) gave significantly higher mortality (66.3%) as compared to other concentrations after 168 hrs of treatment with a LC_{50} value of 5.6×10^8 spores/ml (Table 2 and 3). The lowest mortality (41.8%) was obtained at 10^4 spores/ml and also found at par with 10^5, 10^6 and 10^7 concentrations. A similar trend was obtained at all the intervals at different concentrations. In untreated control larval mortality was not observed. However, the larval mortality increased with time and concentration. Overall the highest mortality of larvae was obtained in chemical insecticide endosulfan 0.07% treatment (89.1%) followed by *B.t.k.* (68.3%), which remained at par with *B.t.* GAU CT-2 at the highest concentration. A similar trend was also recorded at all the intervals. Similarly, a comparative bioassay of spore and endotoxin mixture and pre-dissolved endotoxin, showed that *B.t.* var *kurstaki* was highly pathogenic to the larvae of *A. Janata* L., followed by *B.t.* var *gallereae* and var *thuringiensis* (Deshpande and Ramakrishnan, 1982).

The results of the experiment conducted in pots showed significant differences in *S. litura* mortality. After 168 hrs of treatment *B.t.* with adjuvant (5% Tween 80 and Gum arabic) gave significantly good mortality (63.7%) and was at par with *B.t.* alone (61.4%) treatment (Table 4). However, the chemical insecticide, endosulfan gave highest total larval mortality (89.1%) followed by the commercial *B.t.* formulation Delfm (80.3%). The results also established that mixing of spreaders and stickers marginally increased effectiveness of *B.t.* against *S. litura* than *B.t.* alone. Similar results were observed by Zaz and Kushwaha (1984; 1993) on efficacy of *B.t.* against *S. litura* in pots and reported that indigenous *B. cereus* and *B. thuringiensis* isolates gave 56.3 and 61.3 % mortality at 7.0×10^8 and 6.4×10^7 spores/ml respectively against second instar larvae of *S. litura* on cabbage.

Acknowledgements: We are grateful to IMTCC, Chandigarh for identification of our native *Bacillus thuringiensis* isolates.

Table 3 Probit analysis of GAU *Bacillus* isolates bioassay against *S. litura* Fab. And *A. janata* L.

Isolates	Chi^{2*}	Slope	LC_{50} value	Fiducial limits (95%)		Regression *equation*
				Lower	Upper	
GAU CT-2 (*S. litura*)	0.39	0.12	$1.8 \times 10^{7**}$	4.717	9.783	Y = 4.09 + 0.12x
GAU CT-2 (*A. Janata*)	0.44	0.22	$5.6 \times 10^{8**}$	6.495	11.015	Y = 3.11 + 0.22x

* Table value of Chi^2 [$P_{(0.05)}$ = 11.1]
** *Observations of 96 hrs when 50% and above mortality was achieved*

Table 4 Bioefficacy of *Bacillus thuringiensis* against *S. litura* Fab. on castor in pots

Treatment	% mortality at indicated hours after treatment						
	24	48	72	96	120	144	168
B.t. (GAU CT2)	15.5 (8.3)	23.8 (16.7)	34.1 (31.7)	44.0 (48.3)	53.9 (65.0)	56.9 (70.0)	61.4 (76.7)
B.t. +Adjuvant	16.9 (10.0)	27.7 (21.7)	36.2 (35.0)	48.8 (56.7)	59.1 (73.3)	61.2 (76.7)	63.7 (80.0)
Delfin (Marketed ***B.t.k.***)	25.2 (18.3)	33.0 (30.0)	43.1 (46.7)	54.8 (66.7)	66.1 (83.3)	71.8 (88.3)	80.3 (95.0)
Endosulfan	51.9 (61.7)	77.4 (93.3)	86.2 (98.3)	89.2 (100.0)	89.2 (100.0)	89.2 (100.0)	89.2 (100.0)
Control	0.8 (0.1)	0.8 (0.02)	0.8 (0.02)	0.8 (0.02)	0.8 (0.02)	0.8 (0.02)	0.8 (0.02)
SEm±	2.40	2.20	1.77	1.12	1.69	1.97	2.24
CV (%)	26.61	16.25	10.81	5.75	7.71	5.74	9.27

* Figures in parenthesis are the retransformed values

** Figures indicating common letters do not differ significantly from each other at 5% level of significance according to DNMRT

References

Deshmukh, A.D.D. and Deshpande, A.D. 1989. Bio-efficacy of *Bacillus thuringiensis* Berliner against *Achoea janata* L. and *Bombyx mori. L. Entomon.*, **14**(12):91-94.

Deshpande, A.D. and Ramakrishnan, N. 1982. Pathogenicity of certain serotypes of *B. thuringiensis* Berliner against *A. janata. L. Entomon.*, **7**(2):239-245.

Jayanthi, P.D.K. and Padmavathamma, K. 1997. Response of tobacco caterpillar *Spodoptera litura* (Fab.) to various concentrations of *Bacillus thuringiensis* sub sp., *kurstaki. Pesticide Research Journal*, **9**(1):20-24.

Parthasarathy, S. and Rao, A.P. 1989. Chemical control of castor semilooper, *Achaea janata* Linn. *Journal of Oilseeds Research*, **6**:158-161.

Puntambekar, U.S., Mukherjee, S.N. and Ranjekar, P.K. 1997. Laboratory screening of different *Bacillus thuringiensis* strains against certain lepidopteron pests and subsequent field evaluation on the pod boring pest complex of pigeonpea (*Cajanus cajan*). Antonie-Van-Leeuwenhoek **71**(4):319-323.

Thanki, K.V. 1999. Ph.D. Thesis (Agril. Entomology), Gujarat Agricultural University, S.K. Nagar.

Zaz, G.M. and Kushwaha, K.S. 1984. Efficacy of *B. cereus* Frankland and Frankland against different instars of *S. litura* (Fab.) fed on treated cabbage leaves. *Journal of Entomological Research*, **8**(2):216-219.

Zaz, G.M. and Kushwaha, K.S. 1993. Effectiveness of *Bacillus thuringiensis* Berliner against different instars of *Spodoptera litura* (Fabricius). *Indian Journal of Entomology*, **55**(1):62-66.

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Comparative economics of seed production *vis-a-vis* commercial production of sunflower in Andhra Pradesh

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Abstract

Seed plays a crucial role in increasing the productivity potential and thus determines the sustainability at relatively little cost, for equitable income growth of the farmers. The cost of seed production was higher (Rs. 33498/ha) over commercial production (Rs. 19525/ha) in sunflower due to additional labour involvement in operations like roguing, pollination, etc. However, the net benefit cost ratio was high in seed production (0.70:1.00) over commercial production (-0.33-1.00), as the price paid per quintal of seed (Rs. 8867/q) was almost eight times to that of commercial produce (Rs. 1012/q). The results of discrimination function analysis revealed the higher contribution of owned and hired labour in sunflower seed production. All the inputs considered together contributed to 7.0% change in gross returns while the seed production technology alone contributed to 45.3% change in sunflower.

Key words: Seed production, commercial production, cost of cultivation and income measures

Introduction

In a developing country like India, where agriculture is contributing more than 65 % of Gross Domestic Product, vertical growth in productivity of different crops seems to be the only way. Agriculture of any country is as strong as its seed programmes. Seed, a living capsule, embodies the genetic potential of plants, which determines the productivity potential and sustainability at relatively little cost, for equitable income growth of the farmers and the society as a whole.

Andhra Pradesh is considered as the 'Seed Capital' of the country, producing about 20 lakh q. of seed of various crops in one lakh ha. area annually. However, the cost of seed production is higher compared to commercial crop production, as it involves some specific cultural operations, such as sowing of male and female parents in separate rows, pollination, roguing, harvesting male and female rows separately, threshing and packing, etc. There are several studies pertaining to cost of cultivation of various crops under commercial production, but only few studies related to cost of seed production. Sunflower is an important oilseed crop, for which seed production in the state is being taken up in an area of about 6,000 ha annually. Hence, the present study was taken to analyse the economics of seed production *vis - a - vis* commercial production in sunflower.

Material and methods

Sample selection: Though Nizamabad district of Andhra Pradesh ranks first in acreage under sunflower certified seed production, with 744 ha., Cuddapah district was selected, because of the larger area under sunflower seed production offered by most of the private seed companies without offering for certification, which was revealed during primary survey of the districts. Later, a sample of 30 farmers were selected purposively from unregistered private seed growers of Cuddapah district, along with a random sample of 30 farmers taking up commercial cultivation of sunflower, for the present study. Thus, a final sample of 30 each of seed and commercial farmers were selected randomly for further study.

Data collection: Primary data on cost of cultivation of both hybrid seed production and commercial production of sunflower were collected from the sampled farmers of 30 each, for the year 1998-99, through a pre-tested schedule.

Data Analysis: Conventional tabular analysis was used to estimate the various costs according to cost concepts and income measures as given below.

Cost concepts:

Cost A_1 = All the variable costs excluding family labour cost and including interest on working capital

Cost B_1 = Cost A_1 + interest on value of owned fixed capital (other than land)

Cost B_2 = Cost B_1+rental value of owned land+rent paid for leased-in land

Cost C_1 = Cost B_1+ imputed value of family labour

Cost C_2 = Cost B_2 + imputed value of family labour

Cost C_3 = Cost C_2 +10% of Cost C_2 to account for the value of management input of the farmer

Income measures:

Net income	=	Gross income – Cost C_3
Family labour income	=	Gross income – Cost B_2
Farm business income	=	Gross income – Cost A_1 / Cost A_2
Farm investment income	=	Farm business income – Imputed value of family labour
Net benefit – cost ratio	=	Net income / Cost C_3

Discriminate function analysis

Linear discriminate function of the following form was employed to know the relative importance of different variables in discriminating between two groups of farms of equal size, *viz.*, seed production and commercial production of sunflower.

$$Z = \sum_{i=1}^{n} Li\ Xi$$

where,

Z = Total discriminate score for seed production and *commercial production*

X_i = Variables selected to discriminate the two groups (i.e., i = 1,2, ...,7, which include

X_1 = owned labour, X_2 = hired labour, X_3 = seed, X_4 = manures and fertilizers,

X_5 = plant protection chemicals, X_6 = miscellaneous expenses and X_7 = gross returns)

L_i = Linear discriminate coefficients of the variables estimated from the data

Mahalanobis D^2 statistic was used to measure the discriminating distance between the two groups.

$$D^2ab = (n-g) \sum_{i=1}^{n} \sum_{j=1}^{p} W_{ij} (X_{ia} - X_{ib} (X_{ja} - X_{jb})$$

$$= \sum_{i=1}^{n} L_i d_i$$

where,

n = total number of cases
g = number of groups
p = number of variables
X_{ia} = mean of i^{th} variable in group 'a'
W_{ij} = element from the inverse of the within groups covariance matrix
L_i = inverted matrix of the coefficients of the discriminant function.
d_i = mean difference of the variables
a = commercial farm group
b = seed farm group

The significance of D^2 was tested by applying the following F test.

$$\frac{(n-1-p)\ (n_1 n_2)}{p(n-2)\ (n)} D^2 \sim F\propto (p, n-p-1)$$

Where

n_1 = number of individuals in the commercial farm group

n_2 = number of individuals in the seed farm group

$n = n_1 + n_2$

The Z scores for each group may be calculated as:

$$Z_1 = \sum_{i=1}^{P} L_i X_{1i} \text{ (for commercial farm)}$$

$$Z_2 = \sum_{i=1}^{P} L_i X_{2i} \text{ (for seed farm)}$$

The critical mean discriminant score was obtained as:

$$Z = [Z_1 + Z_2]/2$$

For each individual Zi value was calculated as:

$$Z_i = \sum_{i=1}^{P} L_i X_i$$

If the individual Zi value is **more than Z, the individual** belongs to commercial farm, **other wise to seed farm.**

Decomposition model

The total change in gross returns can be decomposed into programme component that refers to change in the farming situation i.e., from general commercial crop production to seed production and input component that refers to changes in the quantities of independent variables. For measuring these two types of changes, 'the decomposition model' as adopted by Bisalaiah (1977), was adopted.

The model involves Cobb-Douglass type of production function, by decomposing the natural logarithm of the ratio of 'new' output to 'old' output.

Thus, the per ha. production function for sunflower commercial production can be written as:

$$\text{Log } Y_{1i} = \text{Log } b_o + bi \sum_{i=1}^{n} \text{Log } X_{1i} + U_{1i} \quad \ldots\ldots\ldots (1)$$

Where

Y_{1i} = gross returns in Rs/ha.
X_i = independent variable (i.e., i = 1,2,.....4 , which include X_1 = human labour, X_2 = seed, X_3 = manures and fertilizers and X_4 = plant protection chemicals)

b_o = scale parameter

b_i = input coefficient

Likewise, the per ha. production function for sunflower seed production can be written as:

$$\text{Log } Y_{2i} = \text{Log } b_o^1 + b_i^1 \sum_{i=1}^{n} \text{Log } X_{2i} + U_{2i} \quad \ldots\ldots\ldots \quad (2)$$

By taking the difference between two production equations, adding some terms, subtracting the same terms and rearranging them, the equation can be written as:

$$\text{Log}\frac{Y_{2i}}{Y_{1i}} = \left[\text{Log}\frac{bo^1}{bo}\right] + \left[\sum_{i=1}^{n}(b_i 1 - b_i)\,\text{Log}\,x1_i\right] + \left[b_i^1 \sum \text{Log}\frac{X2i}{X1i}\right] + (U_{2i} - U_{1i}) \ldots (3)$$

From the decomposition equation (3), it could be inferred that the first bracketed expression is a measure of percentage change in output due to shift in scale parameter (bo) of the production function; the second bracketed expression gives the sum of the arithmetic changes in output elasticities, each weighed by the logarithm of the volume of that input used, is a measure of change in output due to shifts in slope parameters (output elasticities) of the production function; and the third bracketed expression is the sum of the logarithms of the ratio, for each input of 'new' to 'old' input, each weighed by the output elasticity of the input. Thus, this gives a measure of change in output due to changes in per ha. quantities of labour, fertilizer, capital, etc. used, given the output elasticities of these inputs, under new production technology.

Results and discussion

Cost of cultivation: The item – wise cost of seed production as well as commercial production of sunflower revealed that both operational (51.2%) and fixed costs (48.7%) were almost equally contributing to the total cost of Rs.33498/ha. in seed production. But, the operational costs were higher (53.7%) than fixed costs (46.2%) in commercial production. Interest on fixed capital was high in commercial production over seed production. This might be due to the fact that most of the seed producers in the study area were usually settlers from Prakasam, Guntur and other South Coastal districts of Andhra Pradesh, in which case they do not own any fixed assets of high value. But, the rental value of owned land was high in seed production (Rs.12855/ha.) over commercial production (Rs.2875/ha.), because the gross returns were high in seed production over commercial production and the rental value of owned land was taken as one fifth of the gross returns (Table 1).

Table 1 Itemwise comparison of costs in sunflower

Item	Seed production	Commercial production
Operational cost		
Human labour	6648	2783
	(19.8)	(14.3)
Mechanical labour	3090	2512
	(9.2)	(12.8)
Seed	1267	855
	(3.8)	(4.4)
Manure and fertilizers	3530	2082
	(10.5)	(10.6)
Plant protection chemicals	403	265
	(1.2)	(1.4)
Irrigation	65	82
	(0.2)	(0.4)
Miscellaneous expenses	1852	1720
	(5.5)	(8.8)
Interest on working capital	308	193
	(0.9)	(0.9)
Sub-total	17162	10492
	(51.2)	(53.7)
Fixed cost		
Depreciation on implements and farm buildings	1275	1703
	(3.8)	(8.7)
Cess	200	350
	(0.6)	(1.8)
Rent for leased - in land	1293	3082
	(3.8)	(15.8)
Rental value of owned land	12855	2875
	(38.4)	(14.7)
Interest on owned fixed capital (excluding land)	713	1022
	(2.1)	(5.2)
Sub-total	16335	9033
	(48.7)	(46.2)
Total cost	33498	19525
	(100.0)	(100.0)

Figures in parenthesis indicate per cent to total cost.

Table 2 **Comparative study of sunflower seed production and commercial production according to cost concepts and income measures**

(Rs/ha)

Item	Seed production	Commercial production
Cost concept		
Cost A1	*16498*	*114.58*
Cost A2	17790	14540
Cost B1	17210	12480
Cost B2	31357	18437
Cost C1	19350	13567
Cost C2	33498	19525
Cost C3	36845	21478
Income measures		
Yield (q/ha)	7.0	14.2
Price (Rs/q)	8867	1012.50
Value of male seed and discards/byproducts	2218	-
Gross income	64280	14378
Net income	27435	-7100
Family labour income	32922	-4060
Farm business income	46490	-163
Farm investment income	44350	925
Net benefit-cost ratio	0.75:1.00	-0.33:1.00

Thus, the total cost of cultivation including the operational and fixed costs was extremely high in seed production than in commercial production of sunflower. This might be due to (i) additional labour costs of Rs.3865/ha. involved in intensive operations like land preparation (Rs.500/ha.), supplementary pollination (Rs.750/ha.), extensive weeding (Rs.590/ha.), roguing (Rs.625/ha.), post harvest operations (Rs.1350/ha.) like cleaning, grading, etc. (ii) higher expenditure on material inputs like seed, fertilizer, manures and plant protection chemicals. Thus, the expenditure on different items was higher in seed production than in commercial production of sunflower.

Cost concepts and income measures: The costs and returns according to various cost concepts and income measures of sunflower are given in Table 2. The results reveal that all the costs were higher in seed production over commercial production. Though the costs according to different cost concepts were high, the benefit-cost ratio was high and positive (0.75:1.00) in seed production, while it was reverse (-0.33:1.00) in commercial production. Even though the physical yields were high in commercial production (14.2 q/ha.) over seed production (7.0 q/ha.), the price paid per quintal of seed (Rs.8867/q) was almost eight times to that of commercial produce (Rs.1012 /q). Thus, all the income measures, except that of farm investment income (Rs.925 /ha.), were negative in sunflower commercial production.

Discriminating characteristics between seed farms and commercial farms of sunflower: Results of analysis of the linear discriminate function of sunflower are presented in Table 3. It is observed that all the seven variables *viz.*, owned (X_1), hired labour (X_2), seed (X_3), manures and fertilizers (X_4), plant protection chemicals (X_5), miscellaneous expenditure (X_6) and gross returns (X_7) were found to have negative mean difference of -1.05, -2.81, -0.41, -1.44, -0.13, -0.13 and -49.90, respectively, representing higher expenditure on all items in seed production farms over commercial production farms.

$D^2 = 53.1387^{**}$, $T^2 = 798.8398$

F statistic = 102.3144

$Z_1 = -45.8444$, $Z2 = -99.1012$ *and* $Z = -72.4728$

** indicate significance at 5% level of probability

The magnitude of the coefficients of the individual discriminators reveal negative contribution by all the seven variables under study and thus the linear discriminate *function for sunflower is as follows*:

$Z = -10.0028\ X_1 - 4.8788\ X_2 - 11.2896\ X_3 - 3.4240$

$X_4 - 0.0011\ X_5 - 2.4631\ X_6 - 0.3817\ X7$

It is observed that the discriminating distance D^2 of 53.1387 was found to be statistically significant in discriminating commercial and seed growers. The gross returns with 36.16% followed by hired labour (26.03%), owned labour (19.94%), manures and fertilizers (9.36%) and seed (8.78%) contributed mostly to discriminate between commercial and seed farms of sunflower. However, all the variables contributed positively to the total distance measured by the discriminate function. The higher contribution of owned and hired labour components indicates the higher labour utilization in seed production over commercial production.

Change in gross returns: By substituting the values of production parameters and the input levels in the decomposition equation, the details of total change in per hectare gross returns of sunflower production are given in Table 4.

It could be observed from Table 4 that the total change in the measured output was 16.5%. However, total technical change was 45.3%. When the change in the gross returns due to different inputs was worked out, it was high with the human labour as 5.1% followed by seed with 2.0% indicating their prominent influence to change the per hectare gross returns in sunflower. However, all the inputs together explained 7.0% change in gross returns.

Table 3 Particulars of discriminate variables in sunflower

Item	Mean ('000 Rs/ha)		Mean difference di('000 Rs/ha)	Discriminate coefficient (Li)	(Li) (di)	% contribution to the total distance
	Group I (Commercial production)	Group II (Seed production)				
X_1 - Owned labour	1.0862	2.1405	-1.0543	-10.0028	10.5029	19.9429
X_2 - Hired labour	1.6962	4.5067	-2.8105	-4.8788	13.7094	26.0314
X_3 - Seed	0.8542	1.2680	-0.4138	-11.2896	4.6287	8.7889
X_4 - Manure and fertilizer	2.0832	3.5295	-1.4463	-3.4240	4.9306	9.3622
X_5 - Plant protection chemicals	0.2667	0.4017	-0.1350	-0.0011	0.0001	0.0002
X_6 - Miscellaneous expenses	1.8020	1.9350	-0.1330	-2.4631	0.3202	0.6079
X_7 - Gross returns	14.3775	64.2792	-49.9017	-0.3817	19.0468	36.1660

Conclusions and policy implications: As the net benefit from sunflower seed production is encouraging, area under seed production can be increased to ensure timely supply of quality seed to the farmers. Farmers should also be encouraged to take up seed production by providing the required quantity of breeder/foundation seed along with proper technical guidance in production of quality seed, which are the main factors hindering the farmers to take up seed production on large scale in the state. The seed production in private seed firms should also be offered for certification to have quality assurance.

Table 4 Decomposition analysis of total change in per hectare gross returns between seed production and commercial production of sunflower

Item	Per cent change attributable
Total change in measured output	16.5
Technical change	45.3
Change in inputs:	
Human labour	5.1
Seed	2.0
Manures and fertilizers	-0.4
Plant protection	0.3
Total due to input change	7.0
Total due to all sources	52.3

Reference

Bisalaiah, S. 1977. Decomposition analysis of output change under new production technology to wheat farming : Some implications to returns on research investment. *Indian Journal of Agricultural Economics*, **32**(2) : 193.

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Effect of moisture addition and steaming on hardness, rupture energy and oil recovery of karanj seed, *Pongamia glabra*

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Abstract

Three types of pre-treatments namely instant addition of moisture, conditioned addition of moisture and steaming were applied to 45% size reduced karanj seeds, *Pongamia glabra* (7.6 mm geometric mean diameter) and their effect on hardness, rupture energy and oil recovery were observed. The reduction in hardness and rupture energy and increase in oil recovery was observed in moisture addition treatment. But, in steam treatment, the reduction in hardness and rupture energy and increase in oil recovery were observed upto 51.72kPa for 10 min. and then there was reverse trend. The maximum oil recovery of 55.9% was obtained in 51.72kPa, 10 min. steam treatment followed by 40.8% in 75 g conditioned addition of moisture treatment.

Key words: Texture analyzer, table oil expeller, moisture content, instant addition, conditioned addition

Introduction

Karanj is one of the potential forest based non-edible oil seed of India. The theoretical potential of Karanj oil is estimated to be 1,35,000 tonnes, whereas the actual production is stagnant around 4000 to 6500 tonnes. The oil content of kernel is reported to vary from 27-39% (Bringi and Mukerjee, 1987). In India, the oil is extracted commercially by *ghanis*, expellers and solvent extractors. The oil yield in *ghani* and expeller is reported as 18-22% and 24-27%, respectively (Bringi and Mukerjee, 1987). Karanj oil is mainly used as a raw material for soap and leather industry. It is also best known for its curative effect for skin problems such as leucoderma, psoriasis, scabies and skin itches. The deoiled cake is also used as manure (Achaya, 1990; Axtell and Fairman, 1992). Pre-treatment of oilseeds prior to expression plays a pivotal role for getting more oil yield using mechanical expeller. Moisture addition and steaming of oilseeds prior to oil extraction leads to softening of tough membranes, which surrounds the oil globules. Dehulling, size reduction, moisture addition, steaming, cooking, flaking etc., are some of the normal pre- treatments recommended for oil extraction from oil bearing seeds. This process leads to the reduction of hardness and energy for rupturing oilseeds, which facilitates more oil recovery from the seeds than the normal course of practice.

Although there has been published work on numerous chemical investigations of oil compounds and their isolation, a systematic study on post harvest processing of karanj oil seeds has not been reported. The objective of present work is to study the effect of different pre-treatments like moisture addition and steaming on hardness, rupture energy and oil recovery of karanj seed to get optimised condition for more oil yield from mechanical oil expeller.

Material and methods

The test material was procured from M.P. State Minor Forest Produce Co-operative Federation Limited, Bhopal. The actual oil content was determined by solvent extraction method using soxhlet apparatus. Moisture content in wet basis was estimated using hot-air oven at 105°C to a constant weight. The three types of pre-treatments instant addition of moisture, conditioned addition of moisture and steaming were selected for this study. The effect of these pre-treatments on hardness, rupture energy and oil recovery was observed on Texture Analyser (Fig.1) and Table Oil Expeller (Fig.2), respectively.

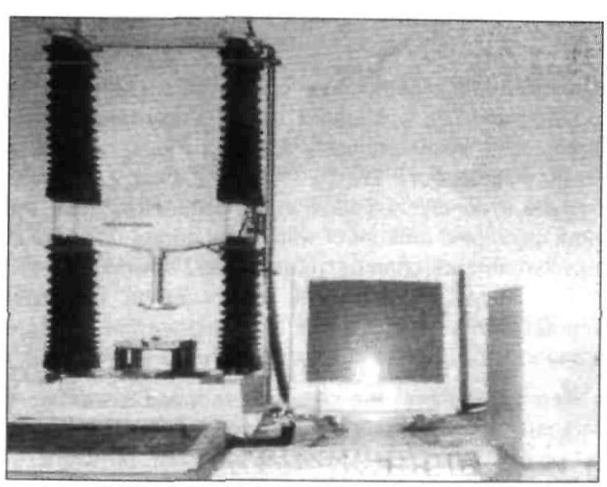

Fig.1 TEXTURE ANALYSER

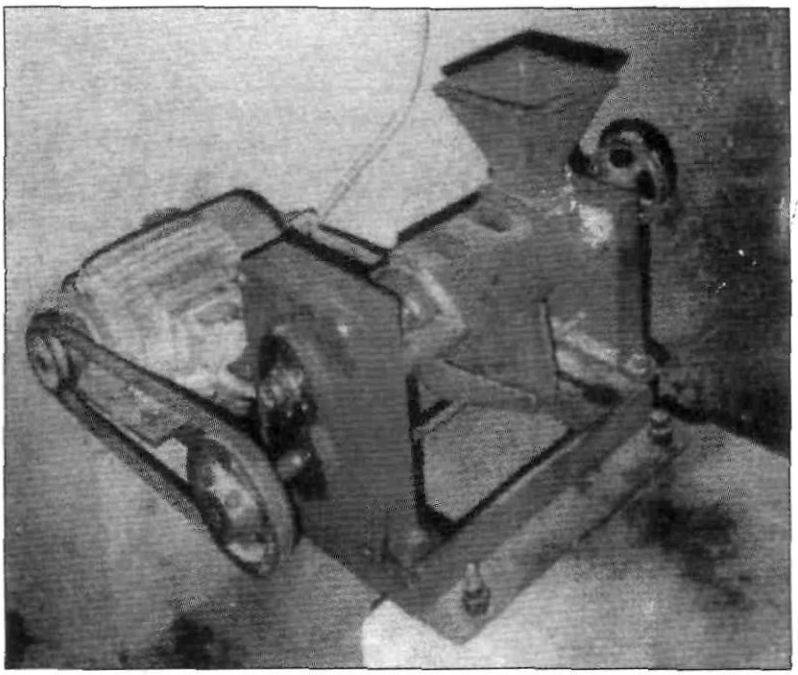

Fig.2 TABLE OIL EXPELLER

The seeds were cleaned manually for foreign matter, broken and immature seeds. The sample of 1000 g cleaned karanj having the geometric mean diameter of 13.6 mm was taken for the study. Since the geometric mean diameter of karanj seed was more than the annular crushing space of oil expeller, the size reduction was required prior to oil expelling. Hence, the size of seeds was reduced to 7.6 mm geometric mean diameter (45% size reduction) in CIAE model low cost multipurpose grain mill.

In instant addition of moisture, calculated amount of water 25g, 50g and 75g was added to 1000g size reduced raw karanj seed instantaneously to bring the sample at a moisture content of 8.1%, 10.3% and 12.4%, respectively. Similarly, in conditioned addition of moisture treatment, the same calculated amount of water was added and kept in the environmental chamber (Macro scientific works, Model: MSW-127) at 25°C and 55% RH for 24 hr. The main purpose of this treatment was to equilibrate the moisture throughout the surface of the seed (Shukla *et al.*, 1992).

In steam treatment, the raw size reduced seeds were steamed in laboratory autoclave (M/S Bells India Instrumentation, New Delhi) at different pressure of 17.24kPa (2.5 psi), 34.48kPa (5.0 psi), 51.72kPa (7.5 psi) and 68.96kPa (10.0 psi) for the duration of 10 minutes.

For measuring the hardness and rupture energy of raw and pre-treated karanj seeds, Stable Micro-System Texture Analyser (Model: TA-XT2i, 1997) (Fig.1) was used. The karanj seed was placed in natural rest position under 75 mm compression plate probes in 50 kg load cell. The pre-test speed, test speed and post-test speed were fixed as 1.5 mm/s, 0.3 mm/s and 10 mm/s, respectively. Since the mean thickness of size reduced karanj seed was 4 mm, the testing distance was fixed as 50% of mean thickness i.e., 2 mm. The results of hardness and rupture energy were reported as mean of three non significant (5% level) replications. The graph was drawn between hardness force (N) and test distance (mm) during the test with the help of software (Texture Expert Exceed™, MS Windows) attached with the texture analyzer. The maximum force resisted by the seed against the probe was considered as hardness. From the graph, the maximum value of the force was considered as hardness force and the area falling under this maximum hardness value was considered as rupture energy (N-m). The typical graph of the texture analyzer showing the relationship between the force and the test distance is given in the Fig.3.

The karanj oil was extracted using 15 kg/h capacity commercial table oil expeller (M/S Lakshmi Industries, Ludhiana) (Fig.2). This expeller is having screw, crushing chamber, feed trough and oil outlet. It is operated by one HP electric motor. The oil recovery was calculated using the following expression (Shukla *et al.*, 1992).

Results and discussion

The oil content of test material was found as 34% using soxhlet apparatus for six hours with hexane as solvent. The effect of moisture content and steaming on hardness, rupture energy and oil recovery is shown in Table1.

Effect of moisture addition and steaming on hardness and rupture energy: The instant addition of 25g, 50g and 75g moisture to 1000g raw size reduced karanj seed, corresponding moisture content of the seed was 8.1, 10.3 and 12.4%(wb), and the hardness reduced significantly by 10.6%, 29.1% and 34.6%, respectively (Table 1). In conditioned addition of moisture, the significant reduction in hardness was 18.4%, 30.1% and 40.2%, respectively. Maximum reduction in karanj seed hardness was 40.2% from 5.8% to 12.4% m.c. (wb). No significant reduction of rupture energy between raw seed and 25g, 50g,and 75g instant moisture addition treatments was observed. In steam treated karanj seed for 10 min, 8.5%, 49.1%, 48.6% and 46.7% hardness reduction was observed in steam pressure of 17.24kPa, 34.48kPa, 51.72kPa and 68.96kPa, respectively. The hardness reduced upto 34.48kPa, and then increased non-significantly. Similar trend was observed for rupture energy. This may be due to the cooking effect of steam treatment and hardening of fat material inside the seed after steam treatment. The lowest hardness value of 155.95N was observed in steam

pressure of 34.48kPa. The lowest rupture energy (9.96N-m) was observed in 75 g conditioned moisture addition treatment. Reduction in rupture energy of 3.2%, 40.1% and 44.5% was observed in 25g, 50g and 75g instant moisture addition, respectively. Maximum reduction (44.5%) was observed from 5.8% to 12.4% moisture content (wb). Similarly, reduction in rupture energy was observed to be 14.4%, 40.3% and 52.1% in 25g, 50g and 75g conditioned addition of moisture treatment, respectively. Maximum reduction in rupture energy (52.1%) was observed from 5.8% to 12.4% moisture content (wb). In steam treatment, 17.2%, 47.2%, 45% and 43.2% reduction in rupture energy was observed in 17.24kPa, 34.48kPa, 51.72kPa and 68.96kPa steam treated karanj seed for 10 min, respectively. In general, it was observed that rupture energy was in decreasing trend with the reduction in hardness for all the treatments.

Effect of moisture addition and steaming on oil recovery: It is apparent from the Table1 that there was no oil recovery from size reduced raw karanj seed. It may be due to more hardness and rupture energy of the raw seeds. However on moisture addition or steaming, there was oil recovery from the seed. The maximum oil yield of 40.9% was obtained in the seed having 12.4% moisture content (wb) in conditioned treatment followed by 28.2% in instant moisture addition treatment. Among the moisture addition treatments, conditioned addition of moisture registered higher oil yield than instant addition treatment. This may be due to the uniform and equal distribution of moisture inside the seed, which leads more reduction in hardness and rupture energy, resulting in more oil yield. There was a high negative correlation coefficient (0.79 at 1% level) between hardness and oil recovery and between rupture energy and oil yield (0.8 at 1% level).

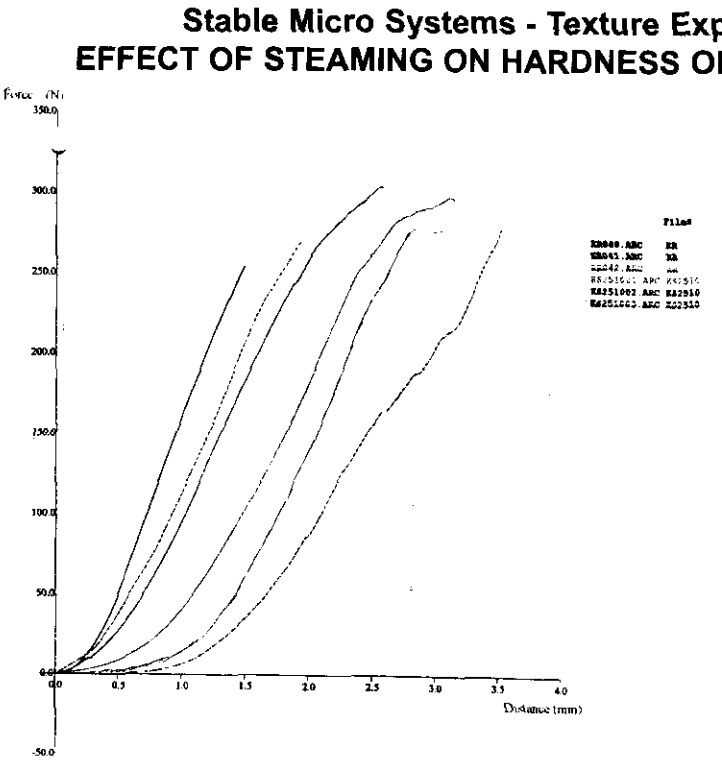

Fig.3 TYPICAL GRAPH (ORIGINAL) OF TEXTURE ANALYSER

Table 1 Effect of pre-treatment on hardness, rupture energy and oil recovery of the karanj seed oil content of test material=34%

Treatment	Condition	Moisture content,%(wb)	Mean hardness (N) ± SE	Mean rupture energy (N-m) ± SE	Mean Oil recovery (%) ± SE
No treatment	Raw seed	5.8	306.07 ± 1.87	20.77 ± 1.24	Nil
Moisture addition	Instant addition				
	25 g	8.1	273.68 ± 2.54	20.10 ± 1.46	16.8 ± 0.57
	50 g	10.3	217.03 ± 3.02	12.44 ± 0.33	21.5 ± 0.89
	75 g	12.4	200.08 ± 2.46	11.54 ± 0.50	28.2 ± 0.51
	Conditioned addition				
	25 g	8.1	249.89 ± 1.79	17.79 ± 1.52	19.2 ± 0.36
	50 g	10.3	214.05 ± 0.99	12.40 ± 0.34	26.9 ± 0.57
	75 g	12.4	183.20 ± 2.00	9.96 ± 0.43	40.8 ± 0.56
Steaming	17.24kPa, 10 min.	14.1	279.95 ± 1.09	17.20 ± 0.50	30.2 ± 0.95
	34.48kPa, 10 min.	14.3	155.95 ± 1.30	10.96 ± 0.26	55.8 ± 0.43
	51.72kPa, 10 min.	14.9	157.46 ± 2.07	11.43 ± 0.93	36.5 ± 0.46
	68.96kPa, 10 min.	16.0	163.10 ± 1.85	11.79 ± 0.58	29.1 ± 0.37
SEm±			15.89	1.19	4.32
CD (P=0.05)			5.86	2.52	1.67

Maximum oil recovery of 55.8% was obtained from 34.48kPa, steam treated karanj seed. The oil recovery increased significantly upto 34.48kPa and then a decreasing trend was observed. This is attributed to the cooking of seed under increased steam pressure. In general, increase in oil yield was observed on addition of moisture and steam treatment prior to expression. However, reduction in hardness and rupture energy was observed on addition of moisture and steam treatment. The high positive correlation coefficient (0.92 at 1% level) between hardness and rupture energy confirms the results.

It was also noticed that the oil yield was highest in steam treatment followed by conditioned addition of moisture and instant addition. This is due to the fact that when moisture is added to the karanj seed, it reacts with the outer cell and thereby the moisture ingress into each cell and oil globules of the karanj seed to facilitate the loosening of seed and expansion of oil globules. Hence, the hardness and rupture energy is reduced and leads to more oil recovery. Steaming might have exerted pressure on karanj seeds and this results the tough membrane surrounding the oil droplet exposed and burst under pressure, enabling the oil to ooze out. This phenomenon might be responsible for reduction in hardness and rupture energy and increase in the oil recovery during mechanical expression.

Reference

Achaya, K.T. 1990. Processing of un-conventional oil bearing material. In: *oilseeds and oil milling in India- A cultural and Historical survey.* Oxford & IBH Publishing Co. Pvt. Ltd. p.264.

Axtell, B.L. and Fairman, R.M. 1992. *Minor oil crops.* FAO Agricultural Service Bulletin, No.94. pp; 153-156.

Bringi, N.V and Mukerjee, S.K. 1987. Karanja seed (*Pongamia glabra*) oil. In: *Non traditional oilseeds and oils of India. (ed.)* Bringi, N.V. *(ed.)* Oxford & IBH Publishing Co. Pvt. Ltd. pp; 143-166.

Shukla, B.D., Srivastava P.K. and Gupta R.K. 1992. *Oilseeds Processing Technology.* Published by CIAE, Bhopal, pp; 9-23.

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Production potential of different oilseed crops - on farm evaluation

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Abstract

On farm field trials were conducted to study the profitability of different oilseed crops in *Kharif* season for delayed onset of rainfall The seed equivalents, monetary returns, B:C ratio, production efficiency (kg/ha/day, Rs/ha/day) were highest in sunflower, followed by groundnut The yield and monetary returns were highest during third year of study (2003). Sunflower recorded highest net returns of Rs 6740/ha over groundnut, castor and sorghum.

Key words: Sunflower, production efficiency, economics

Introduction

The major challenge in rainfed agriculture is to minimize year-to-year variations in crop yields due to aberrant weather conditions (Hegde and Havangi, 1989) The Mahabunagar district of AP. is in Southern Telangana region; the average annual rainfall of the region is 760 mm. The soils of this region are predominantly Alfisols. Castor, sorghum + pigeon pea and groundnut are the traditional crops of the region. They are generally sown with the onset of rains during last week of May to first week of June. Usually, the onset of rains is uncertain. There are more chances of occurrence of droughts and consequently the crop experience moisture stress at various stage of crop growth. Farmer is a confident decision maker and he is generally averse to take up cultivation of non traditional crops without success stories Hence to demonstrate the profitability of growing sunflower as a contingent crop during periods of late onset of monsoon, to build up confidence in the farmers and to encourage them to take up cultivation of new crop, on farm experiments were conducted.

Material and methods

The field experiments were conducted during *kharif* seasons of 2000-01, 2001-02, and 2002-03 on farmers' field at Wanaparthy mandal in Mahabubnagar district The experimental site was sandy loam in texture. The soils were low in available N (215 kg/ha) and P (10 kg/ha $P2O_5$) and medium to high in available potassium (280 kg/ha K_2O). Castor (Kranti), sorghum (local) + pigeon pea (LRG 30) and groundnut (TMV-2) crops were sown in June with the onset of monsoon, and sunflower (Morden) was sown in August as contingent crop. The crops were raised with recommended agro-techniques. Total rainfall received during three consequent years was 872.2, 639.4 and 582.1 mm respectively. For comparison among the crops, yields of all the crops were converted into sunflower equivalents on price basis (Verma and Mudgal, 1993). Economic analysis was made considering market price of crops, yield and equivalent yields. Production efficiency values in terms of Kg/ha/day and Rs/ha/day were calculated as suggested by Singh and Verma (1998).

Results and discussion

The data presented in the Table 1 indicated that, the yields of all the crops expect castor were higher in 2002-03 compared to 2000-01 and 2001-02. The crop did not experience any dry spell during third year where as, in first year, the castor experienced two dry spells, one during vegetative phase and the other during formation of secondaries. Similarly sorghum experienced a dry spell of 16 and 13 days at flowering and early grain formation stage as a result, the yield of sorghum was reduced The rains ceased from October which adversely affected the yields of tertiaries, the yield of pigeon pea was also reduced in sorghum + pigeon pea intercropping system. Where as in the second year, there was severe moisture stress during vegetative phase for all the crops. There was excess moisture during reproductive stage (September and October), which increased the pest (semilooper) and disease (gray mould) attack in castor, and grain mould formation in sorghum. Hence, the yields of the crops were reduced to a great extent in the second year. The dry spell during vegetative phase, at the time of formation of primaries and secondaries was very critical in influencing the growth and yield of castor (Subba Reddy *et al.*, 1998).

The Groundnut yields were low during first year compared to other two years. There was excess moisture during vegetative phase in the first year, this has increased the vegetative growth and it reduced the flowering. Where as in the second year there was severe stress during vegetative phase and flowering. These two had conditions reduced the yields. Where as in third year there was moderate stress during vegetative stage. Often the stress at vegetative stage promotes better partitioning of dry matter into reproductive parts.

Table 1 Yield and equivalent yields and production efficiency of different oilseed crops

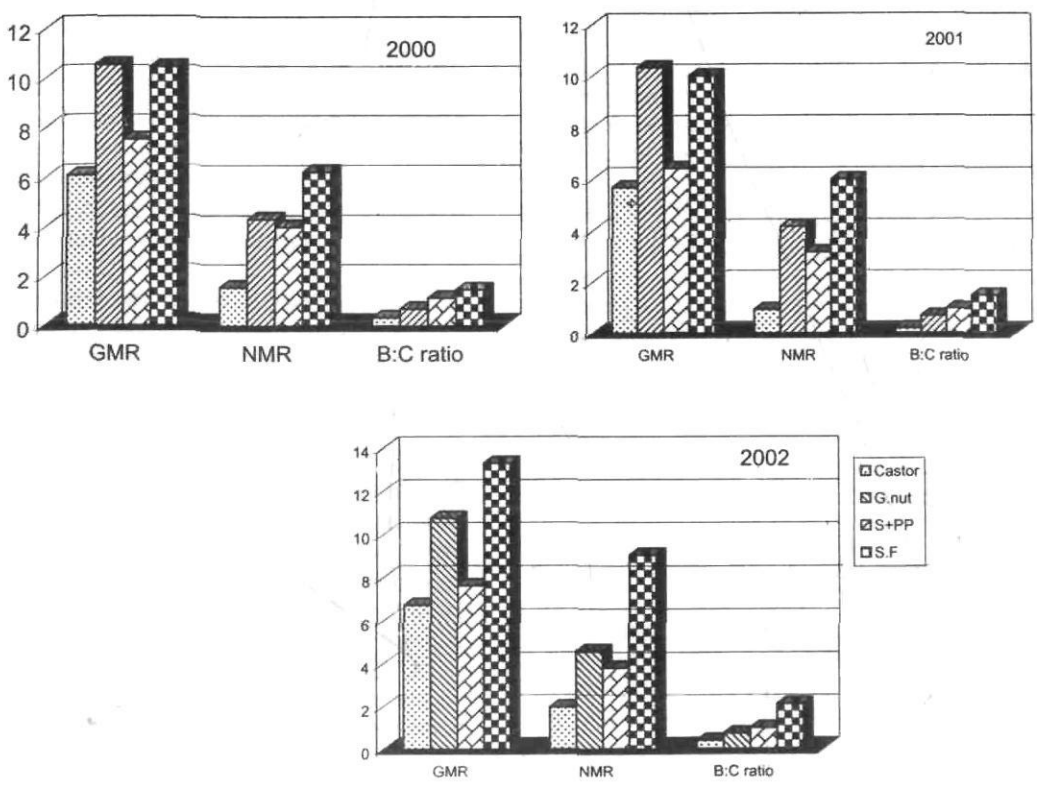
Treatment	Seed yield (kg/ha)			Sunflower equivalent yield (kg/ha)			Production efficiency (kg/ha/day)			Production efficiency (Rs/ha/day)		
	2000	2001	2002	2000	2001	2002	2000	2001	2002	2000	2001	2002
Castor	506	355	449	404.8	378	481	2.69	2.52	3.2	10.45	6.2	13.23
Groundnut	613	652	675	701	650	763	6.68	6.19	7.25	41.26	39.79	43.8
Sorghum + Pigeon pea	800+ 250	668+ 200	850+ 200	502	405	541	3.34	2.7	3.6	26.8	21.13	25.56
Sunflower	698	558	950	697	604	950	7.3	7.0	10	65.68	63.13	95.26
SEm±				47.07	72.9	102.68	-	-	-			
CD (P=0.05)				106.48	165	232.26	-	-	-			

Sunflower recorded higher yields during 2002-03 as compared to 2000-01. There were two dry spells in the crop period one in the vegetative stage (16 days period) and another after flowering (13 days period). Therefore the crop matured earlier than the normal duration. In second year, the crop experienced severe stress during vegetative phase, late flowering and grain formation stage. The moisture stress during late flowering and seed filling stage is considered to be most critical and reduced the yield drastically (Hegde and Havangi, 1989). Hence the yield of the crop was low in second year compared to other years.

Among the crops tested, sunflower recorded significantly highest seed equivalents (747 kg/ha) as compared with other crops. This was followed by groundnut, sorghum + pigeon pea and castor respectively.

The highest mean net monetary returns of Rs. 6740/ha was recorded in Sunflower followed by sorghum + pigeon pea, groundnut and castor. This was due to the fact that cost of cultivation of groundnut was higher than that of sorghum + pigeon pea. Higher benefit cost ratio (1.62) was recorded in sunflower. This was closely followed by sorghum + pigeon pea, groundnut and castor respectively (Fig 1).

Fig. 1 Economics of different crops



Figure

The mean production efficiency over three years was higher in sunflower (7.87 kg/ha/day, 70.94 Rs/ha/day), which was closely followed by groundnut, this showed that the per day productivity of sunflower is higher than long duration crops like castor and sorghum + pigeon pea system. The study revealed that, sunflower is a remunerative contingent crop for productive effective and economic use of available resources during the delayed onset of rains for Alfisols of semi arid tropics.

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References

Hegde, M.R. and Havangi, G.V. 1989. Effect of moisture stress at different phases on seed setting and yield of sunflower. *Karnataka Journal of Agricultural Sciences*, **2**(3): 147-150.

Singh, N.B. and Verma, K. K. 1998. Production Potential and economic analysis of rice based cropping system. *Indian Journal of Agronomy*, **43** (2): 199-203.

Subba Reddy, G., Sailasree, P.S. and Reddy B. M. K. 1998. Contribution of Production factors in rainfed castor. *Journal of Oilseed Research*, **14**:102-104.

Verma, S. P. and Mudgal, S.C. 1983. Production potential and economics of fertilizer application as a resource constraint in Maize wheat crop sequence. *Himachal Journal of Agricultural Research*, **9**(2): 89-92.

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Short communication

Heterosis for yield and its components in Indian mustard, *Brassica juncea* (L.) Czern & Coss

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Exploitation of hybrid vigour is an important tool for making genetical improvement of yield and its attributing characters in Indian mustard. The magnitude of heterosis provides a basis for genetical diversity and a guide for the choice of desirable parents for developing superior F_1 hybrids to exploit hybrid vigour and for building gene pools to be employed in breeding programme. Keeping this in view, the present investigation was carried out to know magnitude of heterosis for seed yield and its components in mustard.

Twenty eight F_1s along with parents were sown in a randomized complete block design with three replications during *rabi* 2000-2001at Main Castor-Mustard Research Station, GAU, S.K. Nagar. Each genotype was sown in a single row of three meter length with spacing of 45 x 10 cm. The recommended fertilizer dose (50:50:00 NPK kg/ha) and four irrigations were given for raising the crop. Observations were recorded on 10 characters from five competitive plants taken randomly from the plot. The heterosis as percentage deviation from mid parent (relative heterosis), the better parent (Heterobeltiosis) and the standard check variety GM 2 (standard heterosis) for each character was computed.

The analysis of variance revealed highly significant differences among the genotypes for all the characters. Further, partitioning of means sum of square for genotype *viz.*, parents, hybrids suggested significant differences among the parents and the hybrids for most of the characters indicating the existence of considerable genetic variability in the experimental materials. The mean squares for parents vs. hybrids was highly significant for all the characters except for days to maturity, 1000-seed weight and oil content, implying that performance of hybrids was significantly different than that of the parents.

Significant negative heterosis was recorded for days to 50 % flowering which is desirable for the development of early type. None of the hybrids showed significant negative standard heterosis. It was, however, observed that crosses showing negative heterosis for 50 % flowering did not always exhibit negative heterosis for days to maturity revealing complex nature of gene action. Thirteen hybrids expressed consistent significant and negative heterosis for plant height. The cross RSK 28 x Pamaru showed the highest standard heterosis (-19.9%). It was observed that crosses involving RSK 28 as one of the parents showed dwarfness suggesting its use as a potential donor for the development of dwarf varieties. Significant heterosis was recorded for various yield contributing characters. For seed yield, 18 crosses depicted significant relative heterosis, 14 exhibited heterobeltiosis while standard heterosis was exhibited by 9 crosses (Table 1). However, heterosis for seed yield and its components revealed that the hybrid SKM 9033 x GM 2 expressing the highest standard heterosis for seed yield/plant also manifested high standard heterotic effects for harvest index, siliquae/plant, branches/plant, 1000-seed weight and oil content. Similar trend was observed in other high standard heterotic hybrids *viz.*, BIO 902 x SKM 9033 and RSK 28 x Lalpur 12. These finding are in agreement with the report of Sheikh and Singh (2001) and Singh *et al.* (2003). High association among these attributes as well as seed yield have been reported as in the case of combinational heterosis (Joshi and Patil, 2003). The range of standard heterosis, for number of branches/plant was -27.2 % (PM 67 x GM 1) to 47.7 % (RSK 28 x Lalpur 12). For siliquae/plant and oil content heterosis in the desired direction was quite low even though the parents exhibited wide diversity for these characters. A standard heterosis of 7.0 was recorded in the cross BIO 902 x SKM 9033 for oil content. Standard heterosis for harvest index was exhibited by SKM 9033 x GM 2 (46.5 %). An interesting feature of the study was the performance of parent RSK 28 with the results of high heterotic crosses in a series, suggesting that the potential of parent to be used in a breeding programme for developing suitable cross combination. The superior F_1 hybrids are expected to produce transgressive segregants.

Table 1 Standard heterotic crosses for seed yield and its component characters

Best heterotic crosses	Seed yield/plant	Harvest Index	No. of branches/plant	No. of siliquae/plant	Plant height	1000 seed weight	Oil content
SKM 9033 x GM 2	34.1**	46.5**	18.5**	15.0**	9.1	19.0**	7.0**
BIO 902 x SKM 9033	33.1**	46.3**	33.2**	18.7**	11.7	13.3**	7.0**
RSK 28 x Lalpur 12	31.9**	42.1**	47.7**	20.0**	-19.0**	8.7	-7.5**

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

References

Joshi, S. and Patil, S. 2003. Exploitation of heterosis breeding in Indian mustard, *Brassica juncea* (L.) Czern & Coss. *Journal of Oilseeds Research*, **20**(1): 31-34.

Sheikh, I.A. and Singh, J.N. 2001. Heterosis in Indian mustard hybrids derived using male sterile lines for yield and components characters. *Crop Research*, **21**(2) :198-203.

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

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Short communication

Genetic divergence of seed yield and its components in Indian mustard, *Brassica juncea* (L.) Czern & Coss under sodic conditions

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A meaningful classification of genotypes that enables to distinguish genetically close and divergent types is a pre-requisite for plant breeding programme. The success of any crop improvement programme through hybridization followed by selection depends primarily on the selection of parents having high genetic variability for different characters (Rao, 1952; Murty and Arunachalam, 1966). The Mahalanobis D^2 statistics helps the breeder to estimate the genetic divergence and classify the genetic stocks into distinct groups so as to enable them to efficiently plan the hybridization programme for evolving salt tolerant genotypes. Genetic divergence has been reported under normal conditions but available information in sodic soils conditions is meager on the clustering of genotypes on the basis of morphological parameters along with yield under sodic conditions. Hence, the present investigation was carried out to find out the genetic distance among 19 genotypes and also identify the promising genotypes under sodic soil conditions. This may help in taking up further breeding programme based on morphological traits for crop improvement under sodic conditions.

Nineteen genetically diverse genotypes (CS 33-4-24G, CS33-4-19, Kranti, CS 506-1-P1, Varuna, CS 617-4-1-32, CS 604-4-5-1P, CS 328-2, CS 330-1-1, CS 513-2-1-P2, CS 611-1-3-5, CS 126-2, CS 614-4-1-4, CS 609B13, CS 609B10, CS506-B1-P1, CS 52 and CS 245-2) of Indian mustard [*Brassica juncea* (L.) Czern & Coss.] were sown in a Randomized Block Design in single row of 3 m length and 30 x 15 cm spacing under sodic conditions (Average pH_2 9.6; 0-30 cm soil depth) during *rabi*, 2000-01 in micro plots at Central Soil Salinity Research Institute, Karnal (Haryana). Observations on nine characters *viz.*, plant height, primary branches/plant, secondary branches/plant, main shoot length (cm), pod/main shoot, pod length (cm), seed/siliqua and 1000-seed weight (g) and seed yield/plant (g) were recorded from 5 randomly selected plants from each replication of each genotypes. The analysis of divergence using Mahalanobis (1936) D^2 statistics and subsequent grouping of genotypes following Tocher's method were carried out. The percentage contribution of a character toward genetic divergence was calculated according to Singh and Chaudhary (1977).

In the present investigation, ANOVA for all characters under study of 19 genotypes of mustard exhibited significant differences for all the characters, indicating existence of genetic diversity among the genotypes under sodic soil conditions. Selection, which is the basis of pre-requisite breeding programme, operates only on variation which is of genetic nature and wide range of variability present in any crop always provides the better chances of selecting desired types. Mahalanobis D^2 statistics grouped 19 genotypes into five clusters (Table 1). Cluster I was the largest with 11 genotypes followed by cluster II with 5 genotypes. Cluster III, IV and V contained one genotype each and were unique in having the zero intra-cluster distance (Table 2).

Table 1 Composition of clusters based on D^2 values under sodic stress conditions

Cluster	No. of genotypes	Genotypes
I	11	33-4-24G, 33-4-19, Kranti, 506-1-P1, 211-1, Varuna, 617-4-1-32, 604-4-5-1P, 328-2, 330-1-1 and 513-2-1-P2
II	5	611-1-3-5, 126-2-614-4-1-4, 609B13 and 609B10
III	1	506-B1-P1
IV	1	CS-52
V	1	245-2

Table 2 Intra and inter-cluster distances under sodic conditions

Cluster	I	II	III	IV	V
I	7.18	10.27	8.60	10.32	16.19
II		7.20	12.55	11.02	20.54
III			0.00	14.08	12.11
IV				0.00	23.80
V					0.00

The intra-cluster distance was maximum in cluster II (7.20) followed by cluster I (7.18). The minimum inter-cluster distance between I and III (8.60) indicated that the genotypes of these clusters were genetically least diverse. Such genotypes can also be useful in particularly breeding programme for developing biparental crosses between the most diverse and closest groups. The highest inter-cluster divergence was observed between genotypes of cluster IV and V (23.80). This indicated that the genotypes included in these clusters had maximum genetic divergence for the characters under sodic soil conditions. Hence, intermating between the clusters may give high heterotic response and some better segregants for sodic situations.

The average clusters mean for eight characters indicated that genotypes included in cluster IV had maximum main shoot length, pods/main shoot and seed yield/plant and genotypes included in cluster V had maximum plant height. The contribution of various characters towards the expression of genetic divergence indicated that seeds/siliqua, pods/main shoot, plant height and secondary branches/plant contributed more than 60% to the total divergence in the 19 genotypes of Indian Mustard and these are the basic attributes of plant architecture, which need greater attention in breeding programme under sodic soil conditions.

In the present study, the highest inter-cluster distance between cluster IV and V was noted and as such these two clusters can be effectively utilized as donors for improving the salt tolerance. Further, the genotypes CS 52 of cluster IV and CS 245-2 of cluster V were genetically most diverse. These could be used as parents in hybridization programme to obtain high heterotic combinations and desirable transgressive segregants under sodic conditions to enhance productivity of Indian Mustard crop in salt affected soils.

References

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

Murty, B.R. and Arunachalam, V. 1966. The nature of genetic divergence in relation to breeding system in crop plants. *Indian Journal of Genetics*, **26**:188-198.

Rao, C.R. 1952. *Advanced Statistical Methods in Biometrical Research*, Wiley & Sons, New York, pp.357-364.

Singh, R.K. and Chaudhary, B.D. 1977. *Biometrical methods in quantitative genetic analysis.* Kalyani Publishers, New Delhi.

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Short communication

Stability for seed and oil yield in promising sunflower, *Helianthus annuus* L. hybrids under irrigated conditions in Northern parts of Karnataka

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Varietal adaptability to environmental fluctuations is important for the stabilization of crop production both over regions and years. Adaptability is measured in terms of stability, which is one of the most desirable properties of genotypes to be released as a variety/hybrid for wide cultivation. Successfully developed new genotypes should have sustained stable performance and broad adoption over a wide range of environments in addition to high yield potential. Evaluating stability performance and range of adoption is becoming increasingly important for breeding programmers. Sunflower is an important oilseed crop, fluctuations in the production of sunflower are owing to the sensitivity of the crop to changing environments and therefore, there is a need to identify genotypes with stable performance over different environments. Hybrid sunflowers ensure homogeneity and production stability (Seetharam *et al.*, 1977). In the present study an attempt was made to identify more stable hybrids among the promising hybrids, with good performance in the northern parts of Karnataka under irrigated conditions during *Kharif* season over the years.

Fourteen promising hybrids (Private as well as newly bred hybrids) were grown under irrigated conditions at four different Agricultural Research Stations of UAS, Dharwad *viz.*, Bailhongal, Bagalkot, Bheemarayanagudi and Belavatagi, in a Completely Randomized Block design during *Kharif* 2001 and 2002.

The plot size was 3 m x 4.5 m (5 rows of 4.5 m length) with spacing of 60 cm between the rows and 30 cm within the rows. Recommend dose of fertilizer was applied. The net plot yield (1.8 x3.9 m) was converted into kg/ha and the same was considered for statistical analysis. Stability parameters for seed yield and yield components were worked out according to the methods suggested by Eberhart and Russell (1966).

The pooled analysis of variance due to genotypes and environments observed highly significant differences indicating the presence of substantial genetic variability (Table 1). The highly significant mean sum of square due to environment (linear) indicated the differences across environments. The linear component of environment was higher in magnitude. Both linear and non-linear component of genotype-environment interactions were significant for all traits. On partition of genotype-environment, the linear component was larger in magnitude for all character studied indicating the possibility of prediction across the environments. Significant mean sum of squares observed for all the characters under irrigated conditions indicated the predictability of the genotypes. Significant pooled deviations observed for the characters indicate the greater role of unpredictable components in genotype-environment interactions. (Kumar, 1988; Madhey and Bakheit, 1988; Verma and Mahto, 1994).

Table 1 Analysis of variance for yield and other characters in sunflower hybrids

Source	d.f	Mean sum of squares	
		Seed yield	Oil yield
Genotypes	13	220713**	42677**
Environments	07	3032985**	482645**
Genotype x Environment	*91*	*77002***	*12551***
Environment+ (genotype* environment)	98	288143**	46129**
Environments (linear)	1	21230898**	3378520**
Genotype x Environment (linear)	13	176906**	26462**
Pooled deviations	84	56040**	9502**

** Significant at 5%

The estimates of stability are based on first order statistics and therefore are statistically more robust and reliable. All the stability parameters (mean, bi, S^2d) are presented in Table 2. The hybrids *viz.*, RSFH-1, CG-41, CG-177, MSFH-17 and DK-3849 recorded yield levels above the average mean performance (group 'a'). However, the hybrids GK-2002, PAC-8699, Kaveri-6186, PAC-304, MSFH-51, KBSH-1 and RSFH-213 recorded yield levels on par with the average mean values (group 'b'). According to Eberhart and Rusell (1966) model, regression

co-efficient is considered as parameter of response and mean square deviation as parameter of stability. Hence, only the hybrids RSFH-1 and CG-177 were stable under group 'a' and hybrids GK-2002, PAC-304 and KBSH-1 were stable under group 'b' (on par with average) having regression co-efficient close to unity. In the present study high yielding hybrids were found less stable. Similar results of inverse relationship between seed yield and stability parameters have been reported by Kallennavar *et al.*, 2003. However, the genotypes RSFH-1 and CG-177 were found stable and superior.

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Table 2 Stability parameters for seed and oil yield in fourteen sunflower hybrids under irrigated conditions

Genotype	Irrigated (*Kharif* 2001 and 2002 at 4 locations)					
	Seed yield (kg/ha)			Oil yield (kg/ha)		
	Mean	bi	S^2d	Mean	bi	S^2d
CG-41	2239 a	1.75**	160102.03**	864 a	1.57**	29078.19**
CG-177	2196 a	1.05	-3299.64	860 a	1.08	894.51
GK-2002	2074 b	1.02	-7418.97	788 b	1.08	-33.15
PAC-8699	2067 b	0.99	47903.08**	749 b	0.97	11142.81**
KAV-6186	2070 b	1.05	10870.25	769 b	1.26	5946.64**
PAC-304	2067 b	0.98	2960.67	775 b	0.90	1408.97
MSFH-51	2012 c	0.59*	1698805.67**	743 b	0.58*	2615.36**
MSFH-17	2204 a	1.15	54352.44**	748 b	1.19	7511.86**
DK-38	2216 a	1.15	29514.97*	829 a	1.05	5592.49**
KBSH-1	2022 b	1.07	10839.57	793 b	1.16	2120.73
DSH-1	1607 c	0.73	13326.43	613 c	0.79	1111.92
RSFH-1	2139 a	0.83	-7682.70	787 b	0.88	-435.02
RSFH-27	1711 c	0.38**	62340.99**	637 c	0.40**	6295.82**
RSFH-213	2008 b	1.16	27347.97*	721 b	1.09	3676.52**
SE(b)		0.19			0.19	
Mean	2045			761		
SEm±	189.47			36.84		

*, ** Significant at 5% and 1% respectively.
a = Above average mean; b = On par with average mean; c = Below average mean

References

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

Kallennavar, K., Giriraj, K. and Mohan G. Bentur. 2003. Stability analysis of sunflower hybrids for seed yield over environments. Published in the extended summaries of the National Seminar on *Stress Management in Oilseeds for Attaining Self-Reliance in Vegetable Oils*, Hyderabad, January 28-30, 2003.

Kumar, D. 1988. Phenotypic stability for quantitative traits of sesame under rainfed conditions of arid environments. *Journal of Oilseeds Research*, **5** : 8-12.

Madhey, E.F. and Bakheit, B.R. 1988. Environmental effect on genetic components of some morphological traits in sesame. *Australian Journal of Agricultural Sciences*, **19**(2) : 72-88.

Seetharam, A., Kusuma Kumari, P., Patil, N.M. and Sindagi, S.S. 1977. Performance of hybrid sunflowers produced by means of cytoplasmic male sterility. *SABRO Journal*, **9** : 51-55.

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

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Short communication

NDSH-1 : A high yielding, early maturing and downy mildew resistant sunflower, *Helianthus annuus* L. hybrid for Andhra Pradesh

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Sunflower is one of the important oilseed crops grown in India. It occupies 5th rank in area as well in production. In Sunflower, hybrids are superior over open pollinated cultivars in terms of higher yield, increased self-fertility and resistance to diseases (Miller, 1987). Although there are many hybrids that are released both by public and private sectors, majority of them are highly susceptible to downy mildew disease, which is highly destructive in nature and are longer in crop duration. To over come these bottle necks, the hybrid *viz.*, Nandyala Sunflower Hybrid-1 (NDSH-1) was developed and identified as highly resistant to downy mildew and early in maturity through NATP-MM project on "The development of Hybrid crops-Sunflower" at Regional Agricultural Research Station, Nandyal.

Though NDSH-1 was developed for general cultivation in Andhra Pradesh, it can be grown through out India. Based on its performance in All India coordinated trial, NDSH-1 has recorded an average yield of 1183 kg/ha as against 1036 kg/ha of KBSH-1, a national check. Thus, this hybrid exhibited an overall improvement of 12.4% in seed yield over different years and locations. With reference to Oil yield, NDSH-1 recorded an overall oil yield of 393 kg/ha against 338 kg/ha of KBSH-1 (Table 1).

In Network trial also, it was tested in different locations through out India (Table 2). In this trial it recorded an average yield of 2060 kg/ha with a highest yield of 2688 kg/ha at Ludhiana where as KBSH-1 recorded 1919 kg/ha indicating the ability of NDSH-1 to adapt to different agro-climatic situations.

Table 1 Performance of NDSH-1 in all India coordinated trials (AHT-M)

Hybrid	1997-1998			1998-1999			2000-2001			Overall mean		
	Seed yield (kg/ha)	Oil yield (kg/ha)	100 Seed Wt. (g)	Seed yield (kg/ha)	Oil yield (kg/ha)	100 Seed Wt. (g)	Seed yield (kg/ha)	Oil yield (kg/ha)	100 Seed Wt. (g)	Seed yield (kg/ha)	Oil yield (kg/ha)	100 Seed Wt. (g)
NDSH-1	1401	543	4.4	1172	351	5.4	979	435	4.7	1184	393	4.8
KBSH-1 (c)	1240	569	4.3	1066	264	4.8	805	413	3.8	1037	338	4.3

Table 2 Reaction of NDSH-1 to different diseases in all India coordinated trials (AHT-M)

Entry	Alternaria severity		Rust severity (%)			Downy mildew severity		
	97-98	98-99	97-98	98-99	2000-01	97-98	98-99	2000-01
NDSH-1	14.1	11.4	6.0	4.9	33.9	0.0	31.3	3.2
KBSH-1 (c)	14.7	13.7	7.0	5.0	33.9	25.9	48.5	82.5

NDSH-1 is characterised by non-branching habit with a plant height of 120-150 cm with 20-23 greenish leaves. It matures in 80-85 days. It is 7-10 days early in maturity when compared to most of the private sector hybrids.

Due to this earliness in maturity, it can fit in any cropping system like relay and contingency cropping systems. It also reduces the cost of cultivation i.e., one irrigation and plant protection measures and birds damage.

Its 100-seed weight is 4.8 g, which is the main reason for its high yield. It contained 37-42% oil because of which it is fetching higher rate in the market. During 2002, it had fetched Rs.1700-2100/q at Nandyal due to its high oil percentage.

When compared to the national check, this hybrids is highly tolerant to downy mildew. The overall mean over three years for downy mildew incidence in case of NDSH-1 was only 11.5% where as in case of the national check, KBSH-1, it was 52.3% (Table 2).

Due to its consistent superior performance State Varietal Release committee had released this hybrid as NDSH-1 for Andhra Pradesh during July 2002.

References

Miller, J.F. 1987. Sunflower. *Principles of cultivar development.* Vo1.2 In: W.R.F ehr (ed). Mac Millian Publ. Co., York, pp. 626-668.

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Short communication

Genetic divergence, heritability and genetic advance in sesame, *Sesamum indicum* L.

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For an efficient breeding programme, selection of genetically divergent parents and superior genotypes is very important which ensures the exploitation of heterosis and development of transgressive segregants (Moll and Stuber, 1971). An assessment of the nature and magnitude of diversity between genotypes will help to choose better parent for hybridization. Since much work has not been undertaken in sesame on this aspect, hence, efforts were made to assess the existing genetic diversity, coefficient of variability, heritability and genetic divergence in 48 genotypes.

Forty eight accessions including two indigenous released varieties (RT-46 and TC-25) representing 10 countries *viz.*, Mexico, Russian, Nepal, Italy, Chile, Pakistan, Angola, Bangladesh, Afghanistan and India were grown in Randomized Block Design with two replications at the Agricultural Research Station, Mandor during *kharif*, 1997. The plant to plant distance of 15 cm was maintained within rows which were spaced at 30 cm. Observations were recorded on various yield parameters on five randomly selected plant per accession. The genetic divergence was estimated using Mahalanobis D^2 statistics and the population were grouped into cluster by following the Tocher's method described by Rao (1952). Coefficient of variation was estimated as per Burton (1952). Heritability in broad sense and genetic advance were calculated as per Johonson *et al.* (1955).

Based on relative magnitude of D^2 values, the 48 accessions were grouped into ten clusters (Table 1). As many as 26 accessions were accommodated in cluster I, 12 in cluster II, 3 in cluster VII, one each in III, IV, V, VI, VIII, IX and X. The 14 accessions from Pakistan were spread over four clusters likewise, eight accessions of Russia origin fall in five different clusters. Further, 26 accessions originating from Mexico, Russia, Nepal, Italy, Chile, Pakistan, Angola, Bangladesh and Afghanistan were grouped into one cluster. These results showed that geographic diversity is not necessarily a direct cause of genetic diversity (Trehan *et al.*, 1974). Genetic drift and selection in different environments could cause the greater diversity among genotypes than their geographic distances. Frequent exchange of breeding materials from one place to other (Verma and Mehta, 1976) and further selection may also be responsible for distribution of gene complexes over distant geographical location. Thus, it is more appropriate to select accessions for hybridization based on genetic diversity rather than geographic distances.

The intracluster distance ranged from 12.9 (cluster II) to 13.5 (cluster VII), while the intercluster distance was maximum (70.8) between I and VII (Table 2). The minimum intercluster distance value (8.6) was found between cluster III and cluster IV, indicating that the genotypes of these two cluster were genetically close.

Cluster means for different yield characters indicated that seed yield/plant (7.87 g), plant height (135.1 cm), branches/plant (7.0) and capsules/plant (153.1) were highest in cluster VII. Cluster X showed early flowering (37) and high 1000-seed weight (2.31), whereas, cluster V also early flowering (37) as well as high capsules bearing plant height (82). Hybridization between accessions falling in the most distant clusters I and VII may result in maximum hybrid vigour and eventually desirable segregants. Also based on mean performance, genetic distance and clustering pattern, hybridization involving EC-370867, EC-370929, EC-370823 and ES-100 may result in desirable combinations leading to development of useful genetic stocks and varieties.

The genetic components for different characters (Table 3) indicated a wide range of variation for all the characters. The maximum range of variation was recorded for capsules/plant and the minimum for 1000-seed weight. High phenotypic and genotypic coefficient of variation (PCV, GCV) were recorded for branches/plant, seed yield/plant and capsules/plant. This indicates the higher magnitude of variability present in germplasm and selection may therefore be effective for the improvement of these characters (Gupta, 1975). Low PCV and GCV were recorded by days to flowering and maturity.

High heritability in broad sense was recorded for seed yield/plant, plant height, branches/plant, capsules bearing plant height, capsules/plant and 1000-seed weight while moderate heritability were recorded for days to flowering

and maturity. High heritability coupled with high genetic advance were observed for seed yield/plant, branches/plant, capsules bearing plant height and capsules/plant indicating the influence of additive gene action and consequently a possibility of improving these traits through selection (Malik and Singh, 1995).

The high heritability estimated for plant height and 1000-seed weight was not coupled with high genetic advance, thus, the expression of these characters can be modified through hybridization followed by selection.

Table 1 Distribution of sesame genotypes into different clusters

Cluster	Number of genotypes	Genotype	Origin
I	26	ES-210, EC-370847, ES-222-1-84, ES-205, ES-230(A), ES-341-1-84	Miexico
		EC-370802, EC-370528, EC-370803, EC-370808, EC-359002	*Russia*
		EC-359002	Nepal
		EC-343406, EC-343404, 343402	Italy
		ES-113-2-84	Chile
		ES-107(A), ES-103-1-84, ES-102, ES-99, ES-108-1-84, ES-104	Pakistan
		EC-370935	Angola
		EC-358048	Bangladesh
		ES-41-4-84, ES-41-3-84	Afghanistan
II	12	ES-111-1-84	Chile
		TC-25, RT-46	India
		ES-106, EC-370933, ES-109, EC-370938	Pakistan
		ES-233-1-84, ES-207, ES-279-3-84(B)	Mexico
		EC-370800	Russia
		EC-358021	Bangladesh
III	I	ES-297	Mexico
IV	1	EC-377186	Russia
V	1	ES-100	Pakistan
VI	1	EC-370816	Russia
VII	3	EC-370867	Nepal
		EC-370929,EC-370939	Pakistan
VIII	1	ES-111	Chile
IX	1	EC-377187	Russia
X	1	EC-370823	Angola

Table 2 Intracluster (in bold) and intercluster distance among 8 characters in sesame

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X
I	**13.4**	21.5	31.5	30.5	20.1	31.8	70.8	34.3	18.6	42.6
II		**12.9**	17.0	19.1	16.5	16.5	54.4	19.1	20.5	26.8
III			**0.00**	8.6	23.5	9.3	42.3	11.3	27.0	12.2
IV				**0.00**	22.2	15.4	48.3	19.0	28.5	16.7
V					**0.00**	22.8	62.8	28.4	27.4	33.0
VI						**0.00**	42.3	12.7	28.5	13.7
VII							**13.5**	38.5	62.4	32.9
VIII								**0.00**	26.8	16.5
IX									**0.00**	37.9
X										**0.00**

Table 3 Mean, range, coefficient of variation, heritability and genetic advance for eight characters in sesame

Character	Range	Mean ± SE	PCV	GCV	Heritability	GA as per cent of mean
Seed yield/plant	0.6-9.3	2.6±0.2	82.9	82.1	98.1	167.6
Days to flowering	37.0-47.0	39.4±1.10	7.6	6.3	71.4	11.1
Days to maturity	77.0-86.0	83.9±1.30	3.1	2.2	50.1	3.2
Plant height	46.8-146.0	92.1±4.20	25.4	24.6	93.6	48.9
Branches/plant	1.0-8.6	3.7±0.30	46.0	44.5	93.4	88.6
Capsule bearing plant height	14.0-85.6	51.4±2.00	31.7	31.2	96.9	63.4
Capsules/plant	13.2-159.8	47.8±2.00	70.6	70.4	99.5	144.3
1000-seed weight	1.10-2.88	1.91±0.10	23.1	21.7	88.3	42.0

References

Burton, G.W. 1952. *Quantitative inheritance in grasses.* Proceedings of sixth International Grassland Congress, 1:277-283.

Gupta, T.R. 1975. Estimates of genotype and environmental variability in *Sesamum*. *Oilseeds Journal*, **5**:31-32.

Johonson, H.W., Robinson, H.F. and Comstock, R.E. 1955. Estimates genetic and environmental variability in soybean. *Agronomy Journal*, **47**:314-318.

Malik, B.P.S. and Singh, S. 1995. Genetic variability, correlation and path analysis in linseed. *Journal of Oilseeds Research*, **12**(1):1-4.

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 Sciences*, **11**:706-711.

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

Trehan, K.B., Rao, A.V., Mehto, S.K., Chand, H., Sharma, H.N. and Brijal, S.K. 1974. Genetic divergence in sesame. *Indian Journal of Agricultural Sciences*, **44**:208-212.

Verma, V.S. and Mehta, R.K. 1976. Genetic divergence in lucerne. *Maharashtra Agricultural University Journal*, 1:23-28.

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Short communication

Genetic divergence in sesame, *Sesamum indicum* L.

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Sesame, *Sesamum indicum* L. is one of the important ancient oilseed crops grown in India. The development of new varieties is important to increase the productivity in the crop for which variability of the desired character in the base material is required. Genetic diversity between the parents plays an important role in producing heterotic effect and desirable segregants. The multivariate D^2 statistic is a powerful tool in quantifying the degree of divergence among the populations. Thus, the present study with 72 genotypes was undertaken to ascertain the nature and magnitude of genetic diversity in sesame and also to identify genetically diverse parents for hybridization programme.

Seventy two sesame genotypes were evaluated at Agricultural Research Station, Yellamanchili, ANGRAU, Visakhapatnam District, Andhra Pradesh during *kharif*, 2002. The trial was laid out in randomized block design replicated twice. Each entry was sown in a single row of 6 m length adopting a spacing of 30 x 15 cm.

Recommended cultural practices were followed. Observations were recorded on five randomly chosen plants for seven characters relating to yield. Multivariate analysis was done as per Mahalanobis (1936) method, genotypes were grouped to 10 different clusters based on weighted average linkage group method.

The analysis of variance showed significant differences among all seven characters studied. The D^2 values ranged from 0.00 to 548.79 and the seventy two genotypes were grouped into 10 clusters (Table 1). Among the clusters, cluster X had 14 genotypes. Other clusters IV and VIII had 6 each, I and IX had 4 each, and VII had one genotype. The cluster distances were given in Table 2. The intra cluster distance was maximum in cluster V (88.91) and minimum in cluster III (19.04). Inter cluster distance was recorded maximum (548.79) between V and VII clusters followed by VII and X (411.23), VII and X (340.40) III and VII (338.04) I and VII (331.98) and II and VII (321.96). Hence, genotypes of these divergent clusters when crossed among them may produce high heterosis and recombinants.

Table 1 Cluster composition of seventy two sesame genotypes

Cluster	No. of genotypes	Genotypes
I	4	SI-75, EC-355653, EC-357304, EC-358039
II	12	SI-1618, Tanuku Brown, SI-5354, G-2, Vinayak, R 2001-IVT-8, PS-201, Madhavi, SI-3012, YLM-11, EC-357309, G-46
III	11	DCR-1974, G-7, G-18, G-33, G-36, G-43, G-4, EC-357313, EC-358069, G-19, G-45
IV	6	DCB-1799, G-9, G-17, G-32, YLM-17, EC-351886
V	2	RT-332, JLT-201
VI	11	EC-357308, EC-357322, EC-358046, EC-358025, G-13, G-35, G-16, G-8, G-15, G-3, G-12
VII	1	NAD-1156
VIII	6	SI-320, K-5235, K-5170, VS-9701, RT-103, SD-12-2154
IX	5	Krishna, VS-9516, OS-5, OS-15, K-5231
X	14	TNAU-165, RT-331, TNAU-142, Rama, JL-203, K-5794, TKG-21, RT-54, YLM-11, JCS-9439m, PKDS-10, TC-25, MT-101, AT-86

Table 2 Inter and intra cluster distances of seventy two sesame genotypes

	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI	Cluster VII	Cluster VIII	Cluster IX	Cluster X
Cluster I	56.68	80.00	134.04	171.27	278.82	126.18	331.98	253.69	189.18	302.74
Cluster II		38.48	56.04	78.39	157.18	84.08	321.96	142.35	101.97	149.32
Cluster III			19.04	56.72	108.48	5.67	338.03	87.39	93.84	120.27
Cluster IV				39.63	143.70	79.87	228.35	117.62	114.89	102.97
Cluster V					88.91	176.10	548.79	188.85	280.45	129.94
Cluster VI						39.59	276.98	127.90	119.41	169.47
Cluster VII							0.00	349.90	340.40	411.23
Cluster VIII								38.18	110.62	104.54
Cluster IX									53.67	165.27
Cluster X										52.75

Among the clusters, Cluster I recorded highest mean value for capsules/plant (78.55) and Cluster VII showed highest mean value for seed yield/plant (11.17). Cluster VIII (80.5) and X (80.11) recorded low mean values for days to maturity indicating earliness. The following genotypes are selected as parents for hybridization based on their mean and genetic divergence.

Cluster	Best genotype
I	EC 358039, EC 357304
II	EC 357309, PS 201
III	G 18, G 43
IV	YLM 17, EC 351886
V	R 2001, IVT 10
VI	EC 358046, EC 358025
VII	NAD 1158
VIII	RT 2001, IVT 14, SD 122154
IX	K 5231
X	R 2001, IVT 1, R 2001, IVT 3

The highest contributor towards total divergence was capsules/plant (24.18%) followed by days to maturity (23.2%), 1000 seed weight (16.04%) and seed yield (14.01%). Solanki and Deepak Gupta (2002) and Dhamu *et al.* (1983) also reported similar results. However, Manivannan and Ganesan (2000) observed plant height as highest contributor followed by number of branches/plant and 1000 seed weight.

Grouping of genotypes into different clusters was not related to their geographic origin. Genotypes from different geographical origin were grouped into same cluster and vice-versa. For example, RT 330, RT 103 and RT 54 from Mandor (Rajasthan) were distributed into different clusters *viz.*, cluster II, VI and X, respectively. Similarly, YLM-11 and YLM-17 from Yellamanchili (A.P) were grouped into clusters II and IV, respectively. At the same time, SI 1618 (Vridhachalam, T.N.), Tanuku Brown (Tanuku, A.P), SI 5354 and PS 201 (Jabalpur, M.P), G-2 and G-46 (A.P), Vinayak (Bhubaneswar), RT 330 (Mandor, Rajasthan), Madhavi and YLM-11 (Yellamanchili, A.P) and EC 357309 an exotic collection were grouped into cluster II, indicating that there was no relation between grouping and geographic origin.

To conclude cluster VII is more divergent from cluster I, II, III and IX, hence, crosses between the varieties of these clusters may give rise to better hybrid vigour and segregating population.

References

Dhamu, K.P., Ayyaswamy, M.K. and Shanmugasubramanian, A. 1983. Genetic diversity in sesamum. *Madras Agricultural Journal*, **70** (8) : 495-498.

Mahalanobis, P.C. 1936. On the generalised distance in statistic. *Proceedings of National Institute of Sciences*, India, **2** : 49-55.

Manivannan, N. and Ganesan, J. 2000. D2 Statistic in sesame (*Sesamum indicum* L.). *Madras Agricultural Journal*, **87** (4-6) : 278-280.

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.

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Short communication

Identification of specific cross combinations in sesame, *Sesamum indicum* L.

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Sesame, *Sesamum indicum* L. is an ancient oil crop grown throughout India having tremendous potential for export. It offers several advantages by virtue of its faster growth and short duration. However, it has not contributed enormously to the total oilseed production mainly because of average low yield level (323 kg/ha). Therefore, there is an urgent need to augment its productivity through the incorporation of wide adaptability and high yield potential. The performance and adaptation of parents are not always a true indicator of superior combining ability as it depends upon complex interaction system among genes. Thus, critical choice of parents is the most crucial step in any breeding programme particularly in heterosis breeding. Hence, the present investigation was carried out to identify the best general combiners and specific cross combinations for seed yield and yield components in sesame.

Seven genetically diverse genotypes of sesame *viz.*, T 4, MT 2, TRS 9, RT 274, RT 264, AT 09 and DSS 133 were crossed in all possible combinations excluding reciprocals. The parents along with their 21 F_1s were grown in a Randomized Block Design with three replications during *kharif*, 1998 at Crop Research Farm, Mauranipur. Each entry was sown in single row of 5 m length having 30 x 15 cm crop geometry. A single non-experimental row was grown all around the experimental area to neutralize the border effect. Recommended agronomic practices were adopted to raise good crop of sesame. Data were recorded on five randomly selected plants in each row for seven yield and yield attributes. Combining ability analysis was done following Griffing (1956) Method 2 and Model 1.

The analysis of variance for combining ability showed that variances due to general (*gca*) and specific combining ability (*sca*) were highly significant for all the traits. *Sca* variance was higher than *gca* for primary branches, number of capsules and seed yield/plant indicating the preponderance of non-additive gene effects in the expression of these traits. Similar results were reported by Ramalingam *et al.* (1990) and Manivannan and Ganeshan (2000). *Gca* variance was higher than *sca* variance for plant height, days to maturity, number of capsules on main stem and 1000-seed weight. These findings revealed the preponderance of additive gene action in the inheritance of these traits as reported earlier by Devasena *et al.* (2001). The results clearly reflected that heterosis breeding would be rewarding for the commercial exploitation of yield heterosis in the present set of materials. Whereas, for the improvements in the traits like plant height, maturity, seed weight and number of capsules on main stem, simple selection of progenies in segregating generations would be highly effective.

A perusal of *gca* effects revealed that the parent RT 264 was good general combiner for seed yield, 1000 seed weight, earliness and dwarfness, whereas, DSS 13 for seed yield and its components except primary branches/plant. The *per se* performance of the parents was good indication of *gca* effects for seed yield/plant. High *gca* effects were related to additive and/or additive x additive gene effects which are the only fixable part. Hence, RT 264 and DSS 13 may be extensively used in the hybridization programme for the improvement of these traits. The best specific cross combinations for the seven traits revealed that none of them was desirable for all the characters (Table 1). The best specific cross combination for seed yield/plant was TRS 9 x DSS 13 coupled with the highest *per se* performance and significant *sca* effects for plant height, primary branches and number of capsules/plant. Similarly, the best specific cross combination for the other traits have been presented in Table 1. It was also observed that most of the best crosses for different traits involved at least one high general combiner. This may be of immense interest to the sesame breeder, because such specific crosses may result in to desirable transgressive segregants, if the additive effects of one parent and complementary epistatic effects in the other act undirectionally to maximize the expression of the character under selections as also observed by Goyal and Sudhir Kumar (1988) and Ramesh *et al.* (1998).

The best specific combiner for seed yield (TRS 9 x DSS 13) involved the parents having low and high *gca* effects indicating the presence of additive x dominance type of gene interaction (Table 2). The other specific combinations for seed yield were having high x low and low x low general combiners. It is evident that parents with highest

gca effects will not necessarily generate best specific cross combinations as also reported earlier by Fatteh *et al.* (1995). However, few crosses between low x low general combiners produced high *sca* effects, suggesting the prevalence of overdominance and epistatic gene action arised due to the genetic diversity in the form of heterozygous loci.

The present investigations suggested that three crosses i.e., TRS 9 x DSS 13, TRS 9 x RT 264 and T4 x RT 264 may be selected both for the commercial exploitation of heterosis and obtaining transgressive segregants in later generations whereas TRS 9 x AT 09 exclusively for the commercial exploitation of yield heterosis in sesame.

Table 1 Best specific cross combinations for seven characters in sesame

Character	Cross	Mean	*sca* effect	*gca* status of the parent	
				P_1	P_2
Plant height (cm)	T 4 x AT 09	161.0	10.85**	Low	Low
Days to maturity#	RT 274 x DSS 13	71.3	-8.42**	Low	High
Primary branches/plant	RT 274 x DSS 13	4.3	0.98*	Low	High
Capsules/plant	T 4 x MT 2	106.6	45.52**	Low	Low
Capsules on main stem	T 4 x DSS 13	35.3	8.22**	Low	High
1000-seed weight (g)	RT 274 x AT 09	4.0	0.62**	Low	Low
Seed yield/plant (g)	TRS 9 x DSS 13	25.0	7.00**	Low	High

*,** Significant at P=0.05 and P=0.01 level, respectively # *Sca* effects in negative direction was considered
Low : Non-significant *gca*; High : Significant *gca*

Table 2 Top ranking six specific cross combinations for seed yield in sesame

Character	Mean seed yield/ plant (g)	*sca*	*gca* status of the parent	
			P_1	P_2
TRS 9 x DSS 13	25.0	7.00**	Low	High
TRS 9 x RT 264	25.3	6.81**	Low	High
TRS 9 x AT 09	21.3	5.19**	Low	Low
T 4 x RT 264	22.7	4.48**	Low	High
T 4 x DSS 13	21.3	3.67**	Low	High
MT 2 x RT 264	21.7	3.44**	Low	High

*,** Significant at P=0.05 and P=0.01 level, respectively # *Sca* effects in negative direction was considered
Low : Non-significant *gca*; High : Significant *gca*

References

Devasena, N., Muralidharan, V. and Punitha, D. 2001. Combining ability for yield related traits in sesame (*Sesamum indicum* L.). *Journal of Oilseeds Research*, **18**(1):115-117.

Fatteh, U.G., Patel, N.A., Chaudhari, F.P., Dangaria, C.I. and Patel, P.G. 1995. Heterosis and combining ability in sesame. *Journal of Oilseeds Research*, **12**:184-190.

Goyal, S.N. and Sudhir Kumar. 1988. Heterosis in relation to general and specific combining ability in sesame. *Indian Journal of Genetics and Plant Breeding*, **48**:251-253.

Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel crossing system. *Australian Journal of Biological Sciences*, **9**:463-494.

Manivannan, N. and Ganeshan, J. 2000. Combining ability in sesame through diallel analysis. *Journal of Oilseeds Research*, **17**(2):249-254.

Ramalingam, A., Muralidharan, V. and Mohammad Shrief, N. 1990. Combining ability studies in sesame. *Journal of Oilseeds Research*, **7**:75-77.

Ramesh, S., Sheriff, R.A., Rao, A.M. and Gangappa, E. 1998. Combining ability in sesame (*Sesamum indicum* L.). *Crop Research*, **15**:238-244.

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Short communication

Magnitude of genetic diversity for some metric and quality attributes in sesame, *Sesamum indicum* L.

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Sesame, *Sesamum indicum* L. is an important oilseed crop with 40-64% oil and 20-25% protein. It is rich in minerals too, as it contains good amount of calcium and phosphorus, etc. The productivity of the sesame in Uttar Pradesh is very low i.e., 190 kg/ha and the similar situation is witnessed at the country level. The success of any crop improvement/breeding programme essentially depends on the nature and magnitude of genetic variability present in the crop. Therefore, it was endeavoured to conserve more genetic variability and have detailed knowledge of genetic diversity among the diverse genotypes in sesame, on the basis of which superior and desirable genotypes could be selected and utilized in the breeding programme.

Fifty diverse genotypes of sesame were grown at Kanpur in a Randomized Block Design with three replications in *kharif*, 2001-02 (Table 1). Each strain was sown in single row of 5 m length at a distance of 45 cm between the rows and 15 cm between the plants within the rows. Recommended dose of fertilizers and normal agricultural practices were applied for successful conduction of the experiment.

Five plants were chosen randomly in each strain replicationwise to record observations on nine characters such as, plant height, days to 50% flowering, number of branches/plant, number of capsules/plant, days to maturity, 1000-seed weight, harvest index, oil content and seed yield/plant. Genetic divergence in relation to these attributes was worked out using D^2 analysis as suggested by Mahalanobis (1978).

On the basis of D^2 values, 50 genotypes/strains were grouped in 8 clusters (Table 2). Clusters indicated that the genotypes under study were genetically different. Genotypes showing the values equal or near to cluster mean were placed in the same cluster while genotypes showing different D^2 values were grouped in different clusters. Cluster V retained maximum number of genotypes i.e., thirteen. Thus, it is quite obvious that the genotypes falling in this group have almost the same or equal values. However, cluster I, II, VI and VIII have retained less number of strains, showing greater diversity from one genotype to another. Comparison between clusters revealed high to low divergence among the group of genotypes. These results were in agreement with those of Anitha and Dorairaj (1990), Mahapatra *et al.* (1993) and Verma and Mahto (1995).

Table 1 Name of the sesame accessions studied under the investigation

S.No.	Accession	S.No.	Accession	S.No.	Accession	S.No.	Accession	S.No.	Accession
1.	IS-148-1-84	11.	IS-199-2-84	21.	ES-104	31.	ES-102	41.	ES-98-3-84A
2.	IS-158-3-84	12.	IS-143	22.	ES-46	32.	ES-68	42.	ES-56
3.	IS-165-B	13.	IS-221-1-84	23.	ES-52-1-84C	33.	ES-64	43.	ES-5
4.	IS-221-A	14.	IS-1414-1A	24.	ES-46-1-84	34.	ES-71	44.	ES-445
5.	IS-186-1-84	15.	IS-222-2-84	25.	ES-83B	35.	ES-79	45.	ES-105
6.	IS-186-2-84	16.	IS-225-1-84	26.	ES-34A	36.	ES-53	46.	ES-108-3-84
7.	IS-196-3-84	17.	IS-225-2-84	27.	ES-55-1-84	37.	ES-14-4-84	47.	ES-176
8.	IS-189-1-84B	18.	IS-225-3-84	28.	ES-72A	38.	ES-10-1-84	48.	ES-58B
9.	IS-189-1-84B	19.	IS-122-1	29.	ES-81	39.	ES-73B	49.	ES-83A
10.	IS-195-1-84B	20.	IS-14B	30.	ES-98-3-84B	40.	ES-89-1-84	50.	ES-72-1-84

Table 2 Composition of clusters based on D^2 statistics in sesame

Cluster	Serial number of genotypes	Total number of genotypes
I	20, 38	2
II	9	1
III	10, 29, 33, 34, 37, 49, 50	1
IV	15, 19, 22, 25, 26, 27, 28, 35, 42	9
V	1, 2, 3, 4, 5, 6, 8, 18, 23, 24, 40, **41, 44**	13
VI	12, 21, 30, 31	4
VII	7, 11, 16, 32, 36, 39, 45, 47, 48	9
VIII	13, 14, 17, 43, 46	5

Comparison of cluster means for nine characters showed considerable genetic differences between the groups (Table 3). The minimum cluster mean was observed in cluster I for harvest index, plant height, number of branches, number of capsules and 1000-seed weight. Cluster II showed minimum mean values for oil content and days to 50% flowering. Cluster III marked minimum mean value for seed yield/plant. Cluster VI exhibited maximum group mean values for seed yield/plant while cluster VII reflected maximum mean value for plant height. Cluster II showed highest mean values for number of branches/plant and number of capsules/plant while, cluster IV reflected highest mean values for harvest index, 1000-seed weight and oil content. These results indicated that the selection of genotype having high/low values for one or more characters should be based on a particular group so as to have a better genotype of wider genetic background. Inter and intra cluster distances indicated that the highest magnitude of genetic divergence was observed in cluster V (D^2=166.21) which showed that the strains included in this cluster were having maximum base of genetic diversity in comparison to other clusters (Table 4). Inter cluster distance was recorded highest between cluster II and VII (D^2=149.54) followed cluster II and IV (D^2=134.22), cluster II and V (D^2=117.46) and II and III (D^2=112.76). It clearly indicated that the strains included in these clusters are having wide base of genetic diversity. It is, therefore, envisaged that the inter cluster distance must be considered and diversed lines/strains may be used in hybridization for obtaining desirable recombinants for developing high yielding varieties in this crop. However, the yield potential of the individual genotype, should not be over looked. Certain economic attributes viz., harvest index, number of capsules/plant and number of branches/plant could be strongly recommended for improvement in the present material. Selection of strains in sesame having early flowering and early maturity will give better dividend towards yield as these characters had shown negative and non-significant relationship with seed yield. Selection and recombination breeding may be helpful for improvement in the characters.

Table 3 Inter cluster group mean for nine characters in sesame

Cluster	Harvest index (%)	Plant height (cm)	Days to 50% flowering	Number of branches/ plant	Number of capsules/ plant	Days to maturity	1000-seed weight (g)	Oil content (%)	Grain yield/ plant (g)
I	4.2*	116.8*	39.7	3.1*	29.9*	83.2	1.7*	38.5	3.8
II	4.4	118.0	35.7*	4.3**	42.0**	82.7	2.3	36.1*	4.3
III	4.2	127.9	38.1	3.7	30.0	83.3	2.3	41.2	3.5*
IV	7.3*	118.2	37.6	3.6	30.7	81.4*	2.5**	41.4**	4.3
V	4.3	116.8	42.7**	3.4	31.2	83.7**	2.4	40.7	4.5
VI	5.7	117.3	38.7	3.6	39.9	82.0	2.5	41.1	5.7**
VII	4.3	130.0**	39.7	3.3	31.1	83.0	1.8	40.8	3.6
VIII	5.3	127.3	39.9	3.7	34.5	82.9	1.8	41.3	4.4

* Lowest mean value for the characters
** Highest mean value for the character

Table 4 Average intra and inter cluster D^2 and d values in 50 genotypes of sesame

Cluster	I	II	III	IV	V	VI	VII	VIII
I	**7.46** (2.73)	122.53 (11.06)	81.82 (9.05)	85.27 (0.23)	60.16 (7.75)	91.15 (9.56)	68.96 (8.30)	89.29 (9.44)
II		**0.00** (0.00)	112.76 (11.08)	124.22 (11.58)	17.46 (10.83)	67.82 (8.23)	149.54 (12.22)	102.81 (10.14)
III			**63.56** (7.97)	13.91 (3.73)	44.82 (6.70)	83.43 (9.13)	39.00 (6.24)	40.55 (6.36)
IV				**107.50** (10.30)	42.46 (6.52)	75.86 (8.70)	45.54 (6.74)	58.54 (7.65)
V					**166.21** (12.89)	64.14 (8.01)	41.09 (6.14)	54.83 (7.40)
VI						**37.80** (6.14)	85.30 (9.23)	61.48 (7.84)
VII							**121.65** (11.02)	40.19 (6.34)
VIII								**57.53** (7.58)

Values in parenthesis are square root of D^2 values

References

Anitha, N. and Dorairaj, M.S. 1990. Genetic divergence and hybrid performance in sesame. *Journal of Oilseeds Research*, **7** : 63-71.

Mahalanobis, P.C. 1978. A statistical study of Chinese head measurement. *Journal of Asiatic Society of Bengal*, **25**:301-377.

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**:372-380.

Verma, A.K. and Mahto, J. 1995. D^2 *analysis in sesame under* rainfed environments. *Journal of Research Birsa Agriculture University*, **7**:83-84.

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Short communication

Combining ability analysis for seed yield and its components in linseed, *Linum usitatissimum* L.

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Relative importance of general and specific combining abilities in crops are helpful in the analysis and interpretation of the genetic basis for important traits. Thus, the present study has been taken up to assess the genetic parameters through a diallel set in linseed.

Ten homozygous and genetically diverse parents of linseed were crossed in all possible combinations excluding reciprocals. Half of the F_0 seeds were advanced to get F_1s. A complete set of material consisting 10 parents, 45 F_1s and 45 F_2s were sown during rabi, 1997-98 in a complete randomized block design with three replications at Oilseed Research Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. Each plot consisted of two rows of 3 m long and spaced 45 cm apart. All recommended cultural practices were followed to raise a healthy crop. The observations were recorded on 10 randomly selected plants in parents and F_1s and 20 plants from F_2s in each plot per replication for seed yield and its components. The oil content in seed was determined by NMR method. Statistical analysis was carried out as usual procedure while, combing ability was done according to the Method-2, Model-1 of Griffing (1956).

The analysis of variance for combining ability revealed that both the general and specific combining ability variances were found to be significant for all characters in both the generations (Table 1). The estimates of variance indicated that magnitude to σ^2s (*sca*) were higher than σ^2g (*gca*) for all the characters in both the generations except 1000-seed weight in F_2 generation. The higher value of σ^2s indicated the pre-dominance role of non-additive gene action. For 1000-seed weight in F_2 generation, the value of σ^2g and σ^2s are almost equal, indicating the presence of both additive and non-additive gene action.

In the combining ability analysis if both *gca* and *sca* effects are significant it is useful to know how important the interactions are in determining the single cross progeny. The relative importance of *gca* and *sca* in determining the progeny performance is better assessed by the ratio $2\sigma^2g/2\sigma^2g + \sigma^2s$ (Baker, 1978). Lower value of the ratio for number of tillers, number of branches, days to maturity, number of capsules, seed yield and oil content in both the generations indicated the pre-dominant role of non-additive gene effects. 1000-seed weight in F_2 generation showed additive type of gene action whereas, days to flowering, plant height, seeds per capsule in both the generations and 1000-seed weight in F_1 generation showed almost equal importance of both additive and non-additive gene effects. Mahto and Rahman (1998) and Yadav *et al.* (2000) also reported similar findings.

A study of *gca* effects of parents revealed that none of the parents showed desirable *gca* effects simultaneously for all the characters (Table 2). However, Shubhra was observed to be good general combiners for eight characters whereas, T-397 was good general combiner for six characters. On the basis of *gca* effect the good general combiners common in both the generations were Shubhra, NL-93, T-397 for earliness, NL-93, Shubhra and Garima for plant height, Shubhra, RL-914 for tillers/plant, Shubhra for number of branches, T-397 for number of capsules, T-397 and Neelum for seeds/capsule, LCK-87132, T-397 and Shubhra for seed yield, Neelum, LCK-89512, NL-93 and LCK-87132 for 1000-seed weight and Shubhra and LCK-89512 for oil content.

The varieties like RL-914, T-397 and Neelum proved as good general combiners for those characters, which are direct components of seed yield. However, these parents were not the best general combiners for seed yield. It might be due to mutual cancellation of the contribution by other traits towards the total yield. Singh and Joshi (1966) and Swarnkar (2001) also observed the higher *gca* effects for yield did not necessary for yield component.

The result of specific combining ability indicated that none for the cross was best specific combiner for all the characters. However, for seed yield, 19 crosses in F_1 and 17 crosses in F_2 exhibited significant and desirable *sca* effects. A perusal of ten crosses (Table 3) showing desirable *sca* effects for seed yield/plant indicated all possible combinations between the parents of high and low *gca* effects. Cross combination Shubhra x LCK-87132 in both the generations showed high x high *gca* effects. This cross is valuable because of the presence of additive

x additive type of gene action and might be improved through the bi-parental mating system in the model of design-III of Comstock and Robinson (1948).

LCK-87132 x RL-914, T-397 x Neelum in F_1 and Shubhra x LCK-88062 in F_2 generation showed high x F_2 low *gca* effects. Garima x LCK-89512 in F_1 and LCK-89512 x NL-93 in F_2 generation showed low x low *gca* effect. A good cross combination does not always be as a result of crossing between high x high and high x low combiners. Low x low combiners may also give rise to best cross combination (Swarnkar, 2001). Low x low gene effect indicated the pre-ponderance role of non-additive gene action, which could not be exploited by any classical breeding programme. Most of these crosses exhibited high and desirable *sca* effect for number of tiller, number of branches, number of capsules, a direct yield contributing character. Therefore, *sca* of yield may be influenced by the *sca* of yield components and combining ability of the parents may serves as reliable guide in assessing the yield potential of cross. These results are in accordance with Yadav and Gupta (1999) and Kumar *et al.* (2000).

Table 1 ANOVA for combining ability for 10 different characters in linseed

Source	D.F.	Generation	Days to flowering	Days to maturity	Plant height	Tillers/ plant	Branches/ plant	Capsules/ plant	Seeds/ capsule	Yield/ plant	1000-seed weight	Oil content
gca	9	F_1	29.49**	18.27**	162.32**	1.32**	19.33**	890.31*	1.21**	1.65**	1.98**	3.97**
		F_2	21.63**	16.69**	165.54**	0.58**	12.62**	489.95**	0.98**	1.41**	1.63**	4.59
sca	45	F_1	3.10**	7.92**	23.31**	0.97**	20.44**	720.89**	0.26**	1.81**	0.24**	4.08**
		F_2	4.42**	7.76**	21.72**	0.94**	31.90**	1014.74**	0.20**	3.04**	0.15**	2.07**
Error	108	F_1	0.22	0.16	1.20	0.04	1.60	26.56	0.04	0.04	0.02	1.97
		F_2	0.25	0.16	0.97	0.03	0.78	20.14	0.06	0.04	0.03	0.20
σ^2g		F_1	2.43	1.51	13.43	0.11	1.48	71.98	0.10	0.13	0.16	0.17
		F_2	1.70	1.38	13.71	0.05	0.99	39.15	0.08	0.11	0.13	0.37
σ^2s		F_1	2.88	7.76	22.11	0.93	81.84	694.33	0.22	1.77	0.21	2.11
		F_2	4.17	7.61	20.75	0.91	31.12	994.59	0.14	3.01	0.12	1.87
$2\sigma^2g/2\sigma^2g+2\sigma^2s$		F_1	0.628	0.280	0.548	0.191	0.034	0.170	0.476	0.128	0.604	0.139
		F_2	0.449	0.266	0.570	0.109	0.060	0.08	0.533	0.068	0.684	0.284

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

Table 2 General combining ability effect of the parent for 10 characters in linseed

Parent	Days to flowering		Days to maturity		Plant height		Tillers/ plant		Branches/ plant		Capsules/ plant		Seeds/ capsule		Yield/ plant		1000-seed weight		Oil content	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
Garima	-0.34	-0.84**	-0.23	-0.10	-4.36**	-4.77**	-0.20*	0.10	-0.35	1.43**	-4.51**	11.26**	-0.51**	-0.23**	-0.48**	0.07	-0.19**	-0.35**	0.04	-0.17
T-397	-1.84**	-1.68**	-1.23**	-1.93**	0.47	-0.62	0.21*	0.05	0.26	-0.64	12.82**	4.30*	0.24**	0.39**	0.33**	0.23**	-0.50**	-0.31**	0.12	-0.34
Neelum	1.22**	1.21**	0.29	1.07**	3.27**	2.50**	-0.57**	-0.20**	-2.11**	-0.65	-13.64**	-1.15	0.27**	0.28**	-0.27**	0.51**	-0.79**	0.79**	-0.97	-0.64
LCK-89512	0.36	0.21	0.60**	0.59**	-1.14*	1.40**	-0.32**	-0.10	-1.98**	-1.00**	-10.61**	1.72	0.10	0.10	-0.37**	-0.08	0.30**	0.23**	0.16	0.25
Shubhra	-0.76**	-0.51*	-1.12**	-1.13**	-1.99**	-2.43**	0.25**	0.33**	0.88	1.07**	8.80**	1.59	0.05	0.15	0.31**	0.17	0.07	-0.17**	0.88**	1.46**
LCK-87132	1.77**	1.32**	1.49**	1.07**	3.51**	4.70**	-0.22**	-0.19**	-0.02	0.68	0.68	2.57	0.36**	0.10	0.39**	0.37**	0.13*	0.12	-0.30	-0.53**
RL-914	1.19**	1.79**	1.35**	1.59**	4.61**	3.56**	0.40**	0.18**	1.28**	0.08	5.00*	-9.14**	0.14	0.09	-0.09	-0.58**	-0.56**	-0.47**	0.82	-0.51**
LCK-88062	1.33**	1.04**	0.63**	-0.10	1.89**	0.81*	0.45**	0.02	1.87**	-0.21	5.17*	-9.97**	0.14	-0.03	0.31**	-0.39**	0.10	0.09	-0.57	-0.31
LCK-88312	0.24	-0.37	0.60**	0.40*	0.73	1.80**	0.04	-0.39**	0.17	-1.73**	3.04	-4.15*	-0.27**	-0.26**	0.32**	-0.29**	-0.26**	-0.12	0.16	-0.25
NL-93	-3.17**	-2.18**	-2.37**	-1.46**	-6.99**	-6.96**	-0.03	0.20**	0.01	0.97**	-6.75**	2.98	-0.52**	-0.56**	0.52**	-0.03	0.25**	0.18**	-0.35	0.02
SE(gi)±	0.13	0.14	0.11	0.11	0.30	0.27	0.06	0.05	0.35	0.24	1.41	1.23	0.05	0.06	0.05	0.05	0.04	0.05	0.38	0.12
SEgi-gi±	0.19	0.20	0.16	0.16	0.48	0.40	0.09	0.07	0.52	0.36	2.10	1.83	0.08	0.10	0.08	0.08	0.06	0.07	0.57	0.18

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

Table 3 Ten best specific crosses exhibiting *per se* performance of *sca* effect for seed yield/plant in F1 and F2 generation and their performance in other traits

Cross	*sca* effect	*Per se* performance	*gca* effect		Other characters with desirable significant *sca* effects
			P_1	P_2	
F_1					
Shubhra x LCK-88062	2.63**	7.31	0.31**	0.31**	Plant height, tillers/plant, branches/plant, days to maturity, capsules/plant
Shubhra x LCK-87132	2.15**	6.90	0.31**	0.39**	Days to flowering, plant height, tillers/plant, branches/plant, days to maturity, capsules/plant
LCK-87132 x RL-914	2.00**	6.35	0.39**	-	Plant height, tillers/plant, branches/plant, days to maturity, capsules/plant
LCK-89512 x NL-3	1.48**	4.65	-	0.52**	Tillers/plant, capsules/plant
LCK-87132 x LCK-88062	1.43**	6.18	0.39**	0.31**	Days to maturity, capsules/plant
T-397 x Neelum	1.40**	5.58	0.33**	-	Tillers/plant, capsules/plant
RL-914 x LCK-88312	1.39**	6.68	-	0.32**	Tillers/plant, branches/plant, days to maturity, capsules/plant and oil content
LCK-89512 x LCK-88312	1.31**	5.31	-	0.32**	Tillers/plant, branches/plant, days to maturity, capsules/plant
Garima x LCK-88312	1.24**	5.14	-	0.32**	Branches/plant, days to maturity, capsules/plant, 1000-seed weight
Garima x LCK-89512	1.13**	4.33	-	-	Tillers/plant, branches/plant, days to maturity, capsules/plant, 1000-seed weight
F_2					
LCK-89512 x NL-93	2.80**	7.26	-	-	Plant height, tillers/plant, branches/plant, days to maturity, capsules/plant, seeds/capsule
Shubhra x LCK-88062	2.57**	6.90	0.17*	-	Plant height, tillers/plant, branches/plant, capsules/plant
Shubhra x LCK-87132	2.16**	7.26	0.17*	0.37**	Days to flowering, tillers/plant, branches/plant, capsules/plant, oil content
T-397 x LCK-88062	2.14**	6.54	0.23*	-	Days to maturity, capsules/plant, seeds/capsule, oil content
T-397 x RL-914	2.10**	6.32	0.23*	-	Days to flowering, plant height, tillers/plant, branches/plant, days to maturity, capsules/plant
Garima x LCK-88312	1.98**	6.32	0.07	-	Tillers/plant, branches/plant, capsules/plant
RL-914 x LCK-88062	1.94**	5.54	-	-	Plant height, tillers/plant, branches/plant, capsules/plant, oil content
Garima x LCK-89512	1.80**	6.35	0.07	-	Tillers/plant, branches/plant, capsules/plant
Garima x NL-93	1.75**	6.36	0.07	-	Days to flowering, plant height, tillers/plant, branches/plant, days to maturity, capsules/plant, oil content
Neelum x LCK 89512	1.67**	6.67	0.51**	-	Tillers/plant, branches/plant, capsules/plant, oil content

References

Baker, R.J. 1978. Issues in diallel analysis. Crop Science, **18** : 533-536.

Comstock, R.E. and Robinson, H.F. 1948. The components of genetic variance in population of bi-parental progenies and their use in estimating degree of dominance. *Biometrics*, **4** : 254-266.

Griffing, B. 1956. Concept of general and specific combining ability in selection to diallel crossing system. *Australian Journal Biological Science*, **9**:463-493.

Kumar, M., Singh, P.K. and Singh, N.P. 2000. Line x tester analysis in linseed (*Linum usitatissimum* L.). *Annals Agriculture Research*, **21**(4) : 485-489.

Mahto, C. and Rahman, M.H. 1998. Line x tester analysis of seed yield and its components in linseed (*Linum usitatissimum* L.). *Journal of Oilseeds Research*, **15**(2) : 242-246.

Singh, S.P. and Joshi, A.B. 1966. Line x tester analysis in relation to breeding for yield in linseed. *Indian Journal of Genetics*, **6**:177-194.

Swarnkar, S.K. 2001. Genetics of yield, its components and quality attributes in linseed (*Linum usitatissimum* L.). Unpublished Ph.D. Thesis, Kanpur University, Kanpur.

Yadav, R.K. and Gupta, R.R. 1999. Genetics studies for some metric and quality characters in linseed under different environments. *Crop Research*, **18**(1) : 57-59.

Yadav, R.K., Gupta, R.R. and Krishna Ram. 2000. Heterosis and combining ability estimates in linseed (*Linum usitatissimum* L.). *National Seminar on Oilseeds and Oils Research and Development Needs in the Millennium*, Feb. 2-4, 2000, DOR, Hyderabad.

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Short communication

Genotypic association and path coefficient analysis in castor, *Ricinus communis* L.

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Castor (*Ricinus communis* L.) is an upcoming commercial crop in Haryana. Presently, it is cultivated over an area of 1500 ha in Haryana both under rainfed and irrigated conditions. Results of All India Coordinated Research Project trials on castor conducted in Haryana under both situations indicated significant yield differences (Anon., 2002). Castor seed yield is a complex quantitative character, which is highly influenced by environmental fluctuations. Path coefficient analysis is a plant breeder's technique used to study the partitioning of the correlation coefficient into component of direct effect (Li, 1956). Determination of the association of yield components has been useful to breeders in selecting suitable plant types. The simple correlations do not provide the exact basis of simultaneous improvement of the different traits (Niles, 1923; Turkey, 1954). The present study was therefore, undertaken to estimate the correlation among different characters and to determine the direct effect of component characters of yield in castor.

Sixteen improved genotypes *viz.*, PSC 137, DCH 519, DCH 531, JHB 880, JHB 882, JI 292, DCS 84, DCS 85, JI 266, DCH 171, DCH 200, JHB 832, JHB 876, DCS 9 (C), DCH 32 (C) and GCH 4 (C) of castor were selected from Advance Varietal Hybrid Trial and grown in Randomized Block Design with three replications under rainfed and irrigated conditions during *kharif* 2001 at CCS Haryana Agricultural University, Regional Research Station, Bawal, Rewari and Cotton Research Station, Sirsa respectively. Each plot consisted of 4 rows of 5 m length accommodating 32 plants in each plot. The distance between rows was 90 cm. Ten competitive plants, excluding terminal ones were randomly selected in all the replications and used for recording the observations on days to 50 % flowering, nodes to primary raceme, plant height (cm), effective spikes/plant, 100 seed weight (g), oil content (%) and seed yield (g/plot). The correlations were worked out by the method suggested by Al-Jibouri *et. al.* (1958) and path coefficients were calculated as per Dewey and Lu (1959).

Genotype PCS 137 (2755 kg/ha) and DCH 531 (2420 kg/ha) under rainfed conditions; DCH 171 (2263 kg/ha) and JI 266 (2238 kg/ha) under irrigated conditions were found best yielder (Anon., 2002). Well distributed rainfall at Bawal (rainfed) resulted in higher seed yield. Range of days to 50% flowering of primary spike was 54 - 68 for JHB 880 and DCS 9, respectively. The phenotypic and genotypic correlations of various components with seed yield and their direct effect contributing towards yield have been shown in Table 1. In general, the values of genotypic correlation coefficient were on higher side than those of phenotypic correlation coefficients indicating thereby less role of environment. Seed yield was positively and significantly correlated with only nodes to primary raceme under both the environments. Plant height showed a positive and significant correlation with seed yield under rainfed condition only, indicating the importance of tallness under rainfed condition. Similar results have been reported by Bhatt and Reddy (1981).

Among different characters (Table 2), nodes to primary raceme exhibited significant positive genotypic correlation with plant height and days to 50% flowering and significant negative correlation with oil content and 100 seed wt. under rainfed condition, whereas, it also showed positive genotypic correlation with effective spike/plant and 100 seed weight under irrigated condition.

Plant height exhibited significant positive correlation with nodes to primary raceme and days to 50% flowering under both the environments. The significant correlation of plant height with above characters should be taken into consideration for the improvement of yield components under both the conditions as reported earlier by Muthian *et al.* (1982).

Effective spikes exhibited a significant positive correlation with days to 50% flowering and negative correlation with nodes to primary raceme under rainfed condition only whereas under irrigated condition effective spikes exhibited a significant positive correlation with nodes to primary raceme and it also showed negative correlation with days to 50% flowering.

In the present study, six characters were considered as casual variables of seed yield under both the conditions. The critical analysis of the data in Table 1 revealed that plant height and days to 50% flowering had positive direct effect under rainfed condition whereas nodes to primary

Table 1 Estimates of phenotypic and genotypic correlation and direct effects of path coefficient on seed yield and mean values of characters in castor under rainfed and irrigated conditions

Character		Correlation coefficient with seed yield		Direct effect of path coefficient		Mean value	
		Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated
Days to 50% flowering	Phenotypic	-0.03	-0.33*	-	-	63	62
	Genotypic	0.32*	-0.12	0.46	0.22		
Nodes on primary raceme	Phenotypic	0.43*	0.55*	-	-	17.2	16.0
	Genotypic	0.32*	0.58*	0.03	0.73		
Plant height	Phenotypic	0.46*	0.23	-	-	200 cm	137 cm
	Genotypic	0.66*	-0.24	0.69	-0.34		
Effective spikes/plant	Phenotypic	-0.25	0.49*	-	-	8.0	6.8
	Genotypic	-0.14	-0.11	-0.01	0.07		
100-seed weight	Phenotypic	-0.03	0.40*	-	-	26.7 g	23.7 g
	Genotypic	-0.02	-0.40*	0.07	-0.35		
Oil content	Phenotypic	0.08	0.20	-	-	51.4%	51.4 %
	Genotypic	-0.03	-0.33*	-0.07	-0.41		
Seed yield		-	-	-	-	2179	1586

***Table 2 Correlation coefficient* between yield and yield components of castor under rainfed and irrigated conditions**

Character		Days to 50% flowering	Nodes to primary raceme	Plant height	Effective spikes/plant	100 seed weight	Oil content	Seed yield
Days to 50% flowering	Rainfed	1.00	0.32*	0.32*	0.66*	-0.14	-0.02	-0.03
	Irrigated	1.00	-0.12	0.58*	-0.24	-0.11	-0.40*	-0.33*
Nodes to primary raceme	Rainfed		1.00	0.41*	-0.15	-0.39*	-0.45*	0.43*
	Irrigated		1.00	0.21	0.88*	0.39*	-0.01	0.55*
Plant height	Rainfed			1.00	0.20	0.05	-0.16	0.46*
	Irrigated			00	0.20	0.15	0.15	0.23
Effective spikes/plant	Rainfed				1.00	0.03	0.19	-0.25
	Irrigated				1.00	0.55*	0.22	0.49*
100-seed weight	Rainfed					1.00	0.33*	-0.03
	Irrigated					1.00	0.07	0.40*
Oil content	Rainfed						1.00	0.08
	Irrigated						1.00	0.20
Seed yield	Rainfed							1.00
	Irrigated							1.00

raceme and days to 50% flowering had positive direct effects under irrigated condition. Nodes on primary raceme that also had significant positive correlation with seed yield manifested a large positive direct effect under irrigated condition. A large negative direct effect on seed yield was recorded by oil content and 100 seed weight under irrigated condition. Similar results in castor were also reported by Khorgade *et. al* (1994).

Based on the above findings it may be suggested that nodes to primary raceme and plant height had positive significant correlation and high positive direct effect on seed yield irrespective of management practices. Hence, these components are given importance in selection to improve the seed yield in castor under both conditions.

References

Al-Jibouri, H.A., Miller, A. and Robinson, H.F. 1958. Genotypic and environmental variances in an upland cotton cross of interspecific origin. *Agronomy Journal*, **50**: 633-37.

Anonymous, 2002. *Annual Progress Report Castor*, 2001-02. Directorate of Oilseeds Research, Hyderabad, pp.,75-79.

Bhatt, D. and Reddy, T.P. 1981. Correlation and path analysis in castor. *Canadian Journal of Genetics & Cytology*, **23:** 525-531.

Dewey, P.R. and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agronomy Journal*, **51** (9): 511-518.

Khorgade, P.W., Dhapke, S.K. and Narkhede, M.N. 1994. Path analysis in castor (*Ricinus communis* L.). *Agricultural Science Digest*, **14**: 60-62.

Li, C.C. 1956. The concept of path coefficient and its impact on population. *Genetics*, **22**: 190-210.

Muthian, A.R., Manivannan, M.I., Natarajan, C., Palaniswamy, G.A. and Jayaraj, S. 1982. Genetic variability in some quantitative characters of castor. *Madras Agricultural Journal*, **69** (4): 278-80.

Niles, H.E. 1923. The method of path coefficient. *Genetic*, **8**: 256-60.

Turkey, J.W. 1954. *Causation, Segregation and Path Analysis, Statistics and Mathematics in Biology*, Iowa State Coll. Press Ame. Iowa.

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Short communication

Combining ability and heterosis in seed yield of safflower, *Carthamus tinctorius* L.

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The choice of an appropriate breeding procedure for the improvement of economic productivity of a crop plant depends upon the nature and magnitude of genetic variation. The exploitation of genetically diverse stocks help to identify promising hybrid combinations and/or to develop superior lines from them. The combining ability analysis is frequently used by breeders to choose such hybrid combinations. The present study was therefore undertaken to study the combining ability and heterosis for seed yield in safflower to identify the superior crosses for varietal breeding programme.

Forty five crosses were produced by crossing 10 diverse parents *viz.*, Bhima, A-1, 86-2-2, JLSF-346, NARI-2, JSI-99, GMU-6401, GMU-6299, GMU-1530 and GMU-6812 in half diallel fashion during *rabi* 1999-2000. These crosses along with parents were evaluated during *rabi* season of 2000-2001 in Randomized Block Design with two replications at dry farming Research Station, Solapur. Recommended package of practices were adopted. Each entry was grown in a 4 m long single row with a spacing of 45 x 20 cm. From the net row of 3.6 m length, the seed yield was recorded and the combining ability analysis was carried out as per Grifing (1956) method-2.

The analysis of variance revealed that the parents and crosses differed significantly for seed yield. The mean sum of squares due to general combining ability (GCA) and specific combining ability (SCA) presented in table-1 were also observed to be highly significant indicating presence of both additive and non-additive gene actions for seed yield in the material studied. However, higher variance for specific combining ability indicated that non-additive gene action was more important. These results are in agreement with Ranga Rao (1982), Narkhede *et al* (1984), Ramchandra and Goud (1984), Narkhede *et al* (1990) and Patil *et al.* (2002).

The estimates of general combining ability effects (Table 2) were positive and significant for A-1 and GMU-6401 revealing thereby that they are best general combiners. Narkhede *et al.* (1984) and Patil *et al* (2002) reported A-1 as a good general combiner. GCA effects represents the fixable component of genetic variance thus, in the present investigation A-1 and GMU-6401 are expected to results in desirable segregants and may be very useful in varietal breeding programme.

Significant SCA effects (Table 3) were recorded in five crosses *viz.*, Bhima x JSI-99, GMU-6401 x GMU-6812, GMU-6299 x GMU-1530, NARI-2 x GMU-1530 and 86-2-2 x GMU-6812 (1% level of significance for first three and 5% level of significance for last two). The mid parent heterosis was also observed to be significant in these crosses except NARI-2 x GMU-1530. Bhima x JSI-99 got 1% level of significance while remaining at 5% level of significance. It was further to note that none of the crosses had exhibited significant heterosis over the standard variety Bhima. However, out of these, three crosses *viz.*, GMU-6401 x GMU-6812 (26.31%), Bhima x JSI-99 (25.26%) and GMU-6299 x GMU-1530 (22.10%) have exhibited good standard heterosis. The pedigree of these three crosses shows that only first cross has one parent (GMU-6401) with good combining ability. This suggests that only this cross is useful for varietal breeding and may yield segregants if handled by specific breeding programme like diallel selective mating or biparental mating.

Table 1 Analysis of variance for combining ability for seed yield

Source	df	MSS
GCA	9	5988.10 **
SCA	44	2671.28 **
Error	54	1226.02
S^2 GCA	-	396.8399
S^2 SCA	-	1445.2610

** Significant at 1% level of probability

Table 2 General combining ability effects for seed yield in safflower and parental

Parent	GCA effect	Mean seed yield (g/3.6 m row)
Bhima	-34.432	237.5
A-1	58.902 **	240.0
86-2-2	-31.932	167.5
JLSF-344	-27.765	217.5
NARI-2	12.652	237.5
JSI-99	-65.682	42.5
GMU-6401	45.152 **	222.5
GMU-6299	11.818	197.5
GMU-1530	-7.348	195.0
GMU-6812	-68.182	157.5
SE (gi)	9.589	

** Significant at 1% level of probability.

Table 3 SCA effects, mean and heterosis

Cross	SCA effects	Mean seed yield (g)	MP	BP	SH
Bhima x A-1	33.485	260.0	8.90	8.33	9.47
Bhima x 86-2-2	24.318	270.0	18.68	13.68	13.68
Bhima x JSI-99	107.443 **	297.5	112.50 **	25.26	25.26
86-2-2 x GMU-6812	59.943 *	272.5	67.69 *	62.69 *	14.73
NARI-2 x GMU-1530	66.402 *	280.0	29.48	17.89	17.89
GMU-6401 x GMU-6812	98.485 **	300.0	57.89 *	34.83	26.31
GMU-6299 x GMU-1530	95.985 **	290.0	47.77 *	46.84	22.10
SE (Sij)	32.253				
SE (Sij-Sik)	47.410				
SE (Sij-Skl)	45.204				
SE (Mid parent)			42.88		
SE (Better parent)				49.52	48.36
SE (Standard Variety Bhima)					

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

References

Grifing, B. 1956. *Concept of general and specific combining* ability in relation to diallel crossing systems. *Australian Journal of Biological Science*, **9**: 463-493.

Narkhede, B.N., Deokar, A.B. and Patil, J.V. 1984. Line x tester analysis in safflower. *Journal of Maharashtra Agricultural Universities*, **9**(3) : 334-336.

Narkhede, B.N., Patil, A.M. and Deokar, A.B. 1990. Combining ability for yield and its components in safflower. *Journal of Maharashtra Agricultural Universities*, **15**(1) : 122.

Patil, A.J., Murumkar, D.R. and Tambe, S.I. 2002. Line x Tester *studies in Safflower. Sesame and Safflower News Letter* **17** (2002), 17:88-91.

Ramchandra, M. and Goud, J.V. 1984. Combining ability and heterosis for some economic characters in safflower (*Carthamus tinctorius* L). *Mysore Journal of Agricultural Science*, **18** : 113-117.

Ranga Rao, V. 1982. Genetics of yield, per cent oil and their related components in safflower (*Carthamus tinctorius* L). *SABRAO Journal*, **14**(2) : 115-120.

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Short communication

Productivity of soybean, *Glycine max* L. Merril. as influenced by date of sowing in Satpura Plateau Zone of Madhya Pradesh

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In Satpura plateau of Madhya Pradesh soybean is cultivated under rainfed situation. At present due to scanty rainfall and cultivation on sandy clay loam soil which has low water holding capacity directly influence on soybean crop yield. In Madhya Pradesh soybean is grown on 4.5 m ha. with a production of 5.2 m tonnes. However, the productivity of soybean in the Madhya Pradesh is decreasing continuously as compared to 1980-1990 decade owing to scanty, erratic and uneven rainfall pattern (Dhoble *et al.*, 1990; Vishwakarma *et al.*, 2000). The time of sowing is one of the most important component of improved technology which plays a major role in gainful productivity of crop. Delayed sowing invite lot of diseases. Thus it is imperative to find out the suitable date of sowing in *kharif* season to assess the effect of date of sowing on yield potential of soybean.

The experiment was conducted at the research farm of Zonal Agricultural Research Station, Chhindwara, Madhya Pradesh during *kharif* season of 1999 and 2000 in Complete Randomized Design comprising five date of sowing with five replications (Table 1). The crop (variety: JS-335) was fertilized with 20 kg N, 60 kg P_2O_5 and 20 kg K_2O/ha. The entire quantity of chemical fertilizers was applied as basal. Spacing was adopted 30 x 10 cm between rows and plants. The soil of the experimental field was Haplustart in sandy clay loam texture having pH 7.4, 315 kg/ha available N, 18.2 kg/ha available P and 400 kg/ha available K. The total rainfall received during the crop growth period was 376 and 435 mm respectively in the reporting years.

Table 1 Effect of date of sowing on yield and yield attributing characters of soybean during *kharif* (mean of 1999 and 2000)

Treatment/ sowing date	Plant height (cm)	No. of branches/ plant	No. of pods/ plant	No. of seeds/ plant	100 seed weight (g)	Root length (cm)	Root weight (g)	Nodule number/ plant	Nodule dry weight/ plant (g)	Seed yield (kg/ha)	Straw yield (kg/ha)
22 June	48	4	34	2	14.6	14	1.1	46	0.3	1259	2303
29 June	45	4	31	2	12.9	11	1.0	34	0.2	1014	1899
6 July	39	3	28	2	12.1	10	0.9	29	0.2	995	1889
13 July	36	3	25	2	11.5	9	0.9	23	0.1	825	1645
20 July	32	2	18	1	9.7	6	0.7	18	0.1	377	793
CD (P=0.05)	6.2	0.5	4.2	0.2	1.2	3.1	0.18	6	0.07	189	315

Crop sown on 22 June recorded significantly more plant height (48 cm) which was at par with sowing on 29 June (Table 1). Early date of sowing i.e. 22 June was distinctly superior over other dates of sowing maximum number of branches/plant (4), pods/plant (34), seeds/pod (2) and higher 100-seeds weight (14.6 g). Likewise, significantly highest root length (14 cm), root weight (1.1 g), nodules/plant (46) and higher nodule dry weight/plant (0.3 g) was recorded with sowing on 22 June which was at par to sowing on 29 June except. Significantly higher seed and straw yield was recorded with 22 June sowing date in both the years over later sowing dates. This may be due to the favourable environment conditions available to the crop during the initial stage to crop growth period. The similar results have also been reported by Barik and Sahoo 1989.

References

Barik , T. and Sahoo K.C., 1989. Response of soybean to date of sowing and spacing. *Indian Journal of Agronomy*, **34** (4) : 464-466.

Dhoble, M.V., Thete, M.R. and Khating, E.A. 1990. Productivity of some *kharif* crops as influenced by varying date of planting under rainfed condition. *Indian Journal of Agronomy*, **35** (1 & 2) : 190-198.

Vishwakarma, S.V., Ranade, D.H., Paradkar, V.K., Jain, V.K. and Tomar, A.S. 2000. Productivity analysis of wet and dry spell for agricultural planning of Chhindwara. *Indian Journal of Agricultural Sciences*, **70** (10) :719-721.

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Short communication

Impact of frontline demonstrations on augmenting the soybean, *Glycine max* L. productivity

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Soybean, *Glycine max* L. is among first three oilseed crops in India. Even after three decades of its commercial adoption, the productivity still remains around 1 t/ha. Although, the average maturity duration of Indian soybean varieties is about 95 days, the fact repeatedly put forth that this productivity level is about half the world average and 2/3 of Asian average. The reasons normally stated for low yield are the slow rate of technology transfer, lack of awareness about production technologies in newer areas, non-availability of quality seed and that too of improved varieties, imbalanced nutrient applications, timely unavailability of agrochemicals, etc. In order to facilitate effective technology transfer to convince the farmers on the impact of available technology, the Government of India through ICAR launched a programme during 1989-90, called Frontline Demonstrations on Oilseeds and Pulses under the direct supervision of scientists. The demonstrations are directed to demonstrate the farm validated production technology including the improved varieties evolved for different agro-climatic regions under real farm situations.

These frontline demonstrations were organised under the aegis of the All India Coordinated Research Project on Soybean at 14 centres under this network on improved soybean production technology (Table 1). At each centre nearly 15 FLDs were carried out every year during 1989 to 1998 with each demonstration plot having 0.4 ha area and the same was compared with equal area under farmers' managed plot. The components of improved technology involved appropriate seed bed preparation, location specific improved recommended varieties, seed treatment with thiram and carbendazim, seed inoculation with Bradyrhizobium and phosphate solubilizing bacteria (PSB), balanced nutrition, application of recommended plant protection methods, cultural and chemical weed control, timely harvesting and proper threshing and storage techniques. The demonstrations were conducted under the direct supervision of scientists of each AICRP centres. The highest yield levels achieved under FLDs were considered as potential yield. The different yield gaps like yield gap I and II and national yield gap percentage and their ratio were determined as per the method followed by Radha *et al.* (1998).

Table 1 Impact of improved production technology on yield of soybean at farmers' fields

Year	No. of trials	Highest yield (kg/ha)		Mean yield (kg/ha)		National yield (kg/ha)	Yield gap (kg/ha)		National yield gap (%)		National yield ratio		ICBR
		IT	FP	IT	FP		IT	FP	IT	FP	IT	FP	
1989	167	2536	1776	1665	1110	801	1426	555	51.89	27.83	2.08	1.38	3.55
1990	153	2634	1803	1921	1283	1015	1351	638	47.16	20.89	1.89	1.26	3.21
1991	134	2686	1896	1991	1448	782	1238	543	60.72	45.99	2.55	1.85	4.60
1992	227	2705	1829	1925	1427	894	1278	498	53.55	37.35	2.15	1.60	3.61
1993	210	2650	1991	1854	1407	1086	1243	447	41.42	22.81	1.70	1.29	2.86
1994	218	2630	2080	1810	1360	911	1270	450	49.66	33.01	1.99	1.49	3.40
1995	220	2430	1890	1830	1380	1012	1050	450	44.70	26.67	1.80	1.36	2.95
1996	187	2565	1962	1890	1540	987	1025	350	47.78	35.90	1.91	1.56	3.06
1997	186	2423	1820	1852	1409	1126	1064	443	39.20	20.08	1.64	1.25	2.76
1998	229	2354	1703	1729	1233	905	1121	496	47.66	26.60	1.91	1.36	2.80
Mean		2566	1874	1847	1359	487	1207	487	48.37	29.71	1.96	1.44	3.28
SD		115.78	106.50	91.06	115.84	108	129	75	5.84	7.83	0.24	0.17	0.52
CV(%)		4.52	5.68	4.93	8.52	15.33	10.66	15.33	12.08	26.35	12.53	12.38	16.07

The average yield of soybean under IT ranged from 1665 to 1991 with mean average of 1847 kg/ha compared to 1110 to 1540 kg/ha (1359 kg/ha mean yield) under farmers' managed plots (Table 1). The overall yield increment was 43.05% over farmers' practice with the mean incremental cost benefit ratio of 3.28.

Further, yield gap analysis revealed that the yield gap I was three times greater than yield gap II, indicating that the yield potential of improved varieties is still to be capitalized. Under these FLDs, the yield gap I ranged from 1025 to 1426 with 1206.6 kg/ha mean, whereas the values for yield gap II varied from 350 to 638 with 487 kg/ha mean yield. Hence, the yield gap I was higher with lower variability than yield gap II. These results clearly brought out that the yield gap I and II, both revealed a decreasing trend. Similar results are also reported by Bhatnagar and Tiwari (1989) and Tiwari *et al.* (2001). This directs that the adoption of IT is capable of nearly doubling the productivity of soybean in the country.

Comparing the national yield gap, it was observed that the gap between FP v/s national productivity was lower with high variability (26.35% CV) than IT v/s national productivity. The national gap under IT varies from 39.20 to 60.72% (mean value 48.37%) and the ratio ranged from 1.64 to 2.55. While in case of FP, it ranged from 20.08 to 37.35% with 29.71% mean and the yield ratio was 1.25 to 1.85.

The results mentioned above clearly indicated that the frontline demonstrations which is an effective tool for dissemination of improved production technology were successful in narrowing the yield gap II and pave the way for doubling the production and productivity of soybean in the country.

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References

Bhatnagar, P.S. and Tiwari, S.P. 1989. Yield gap and constraints analysis for harnessing productivity potential of soybean in India. *Proceedings of WSRC-IV (5-9 March, 1989).* Buenos Aires, Argentina, Vol.II, pp.811-9.

Radha, Y., Prasad Eshwar, Y. and Rao, Satyanarayana, V. 1998. Analysis of yield gaps and constraints for low yield in rainfed groundnut in Karimnagar district of Andhra Pradesh. *Journal of Oilseeds Research*, **15**(1):170-174.

Tiwari, S.P., Joshi, O.P. and Billore, S.D. 2001. Realizable yield potential of soybean varieties at farm level in India. In: *India Soy Forum-2001*. Harnessing the soy potential for health and wealth held at SOPA, Indore on March 17-18, 2001, pp.108-112.

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Short communication

Screening of soybean, *Glycine max* L. varieties for their suitability for intercropping with pigeonpea, *Cajanus cajan*

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The central part of the country covering the regions of Madhya Pradesh, Maharashtra and Rajasthan accounts for almost 97% of total area under soybean. Crop diversification appears to be a major strategy to sustain the productivity of this region and intercropping with crops suitable for the area offers an excellent opportunity for the same. Traditionally, grown pigeonpea is documented to offer yield stability and improved total production when grown with soybean as a companion crop (Prasad *et al.*, 1997). Adoption of this system also ensures adequate yield of at least one of the crops even under aberrant weather conditions (Rao and Willey, 1980). In view of meager information available on biological efficiency and varietal compatibility, the present investigation was undertaken to evaluate the productivity. Competitive indices, monetary advantage and energy balance of soybean varieties in soybean-based intercropping with pigeonpea.

A field experiment was conducted at National Research Centre for Soybean, Indore during 1999-2000. The soil was clayey, having pH 7.86, EC 0.14 dS/m, organic carbon 0.3%, available P 4.86 kg/ha and available K >99 kg/ha. The experiment was laid out in Randomised Block Design with three replications. Treatment combinations comprised sole soybean (JS 335, PK 1024, PK 1029, NRC 37, PK 416 and JS 90 41), sole pigeonpea (ICPL 87119) and their combinations with soybean in 4:2 row arrangements were evaluated. The crops were sown in first week of July, 1999. A fertilizer dose of 20:26:17 kg NPK/ha to soybean and 20:22:0 kg NPK/ha to pigeonpea was applied as basal through urea, single super phosphate and muriate of potash in sole cropping systems. Intercropping treatments received only fertilizer levels recommended for soybean. The competitive ratio (Willey and Rao, 1980), the relative crowding coefficient (de Wit, 1960) and aggresivity (Mc Gilchrist, 1965) were calculated. The conversion factors as suggested by Mittal and Dhawan (1988) were utilized to compute energy inputs and outputs. Energy productivity and energy intensiveness were worked out as per Fluck (1979) and Burnett (1982), respectively.

Seed and soybean equivalent yield: Significant reduction in seed yield of soybean (11.25 to 30.94%) and pigeonpea (45.99 to 62.92 %) was noticed when planted in intercropping systems as compared to their sole plantings (Joshi *et al.*, 1999; Billore and Joshi, 2004). However, the highest yield reduction was recorded with JS 90-41 followed by PK 1024, while the pigeonpea yield reduction was the maximum with the combination with JS 335 and JS 90-41. Among the sole planted soybean genotypes, seed yield of NRC 37 (2070 kg/ha) was the maximum followed by JS 335 (1653 kg/ha). The lowest yield was associated with PK 416 (1315 kg/ha). The beneficial effect of intercropping could be judged by considering the total productivity in terms of soybean equivalent yield and comparing with sole soybean. The highest soybean equivalent yield was recorded in *NRC 37 + ICPL 87119* (4:2) which was at par with rest of the intercropping combinations. These results are in agreement with the earlier findings of Joshi *et al.* (1999) and Billore and Joshi (2004). It may be noted that the intercropping systems reduced the quantum of fertilizer input.

Land equivalent ratio and competition functions: Land equivalent ratio varied from 1.07 - 1.43 for different intercropping systems denoting their greater biological efficiency (Table 1). Planting of NRC 37 and PK 1029 with pigeonpea gave higher land equivalent ratio, while remaining soybean varieties showed greater biological efficiency. The higher value of land equivalent ratio indicated greater biological efficiency and lower competition between crops (Billore and Joshi, 2004). Soybean genotypes *viz.*, JS 335, PK 416 and JS 90-41 were found more competitive as these varieties showed faster vegetative growth during early stage (Rao and Willey, 1980). The lowest competition index was recorded with NRC 37 followed by PK 1029. Soybean varieties JS 335, PK 416 and JS 90-41 showed positive values of aggresivity in intercropping systems indicating its dominance over pigeonpea (Billore and Joshi, 2004). The product of relative crowding coefficient of component crops was more than unity in all the intercropping treatments revealing a non-competitive interference than the competitive one. The higher relative crowding coefficient values indicated better compatibility of pigeonpea varieties with soybean and resulted in higher yields (Prasad *et al.*, 1997; Billore and Joshi, 2004).

Table 1 Yield, yield attributes and competition functions of soybean with pigeonpea intercropping

Treatment	Seed yield (kg/ha)		Soybean equivalent yield (kg/ha)	Mean yield index (%)		LER	CR	Agressivity	RCC	CI	Monetary advantage (Rs/ha)	IER	
	Soybean	Pigeonpea		Soybean	Pigeonpea							Soybean	Pigeonpea
Sole JS 335	1653		1653			1.00						1.00	
Sole PK 1024	1198		1198			1.00						1.00	
Sole PK 1029	1199		1199			1.00						1.00	
Sle NRC 37	2070		2070			1.00						1.00	
PK 416	1315		1315			1.00						1.00	
Sole JS 90-41	1480		1480			1.00						1.00	
ICPL 87119		**2422**	3726			1.00							1.00
Intercropping													
JS 335+ICPL-97119	1366	898	2747	82.63	57.08	1.19	2.22	0.21	7.56	0.11	3706	1.66	0.73
PK 1024+ICPL-87119	927	1220	2804	77.37	50.37	1.27	1.54	-0.07	8.90	0.11	5037	2.34	0.75
PK 1029+ICPL-87119	1067	1250	2990	88.99	51.61	1.41	1.71	-0.03	18.77	0.05	7346	2.49	0.80
NRC-37+ICPL-87119	1837	1308	3338	88.74	54.00	1.43	1.65	-0.07	19.32	0.05	8609	1.64	0.90
PK 416+ICPL-87119	1046	1006	2797	79.54	41.54	1.20	1.93	0.06	8.36	0.12	3935	2.12	0.75
JS 90-41+ICPL-87119	1022	925	2445	69.05	38.19	1.07	1.81	0.10	5.23	0.19	1352	1.65	0.65
CD (P=0.05)	212	953	1390	11.60	11.33	0.26	0.37	0.17	9.36	0.08	4049	0.59	0.13

LER = Land equivalent ratio; CR = Competition ratio; RCC = Relative crowding coefficient; CI = Competition index; IER = Income equivalent ratio

Table 2 Energy budgeting as influenced by soybean varieties in intercropping with pigeonpea

Treatment	Energy input (MJ/ha)	Energy out (MJ/ha)		Energy use efficiency	Energy productivity (g/MJ)	Energy intensiveness (MJ/Rs)
		Gross	Net			
Sole JS 335	7504	24299	16795	3.24	220	0.54
Sole PK 1024	7504	17611	10107	2.35	160	0.74
Sole PK 1029	7504	17625	10121	2.35	160	0.74
Sle NRC 37	7504	30429	22925	4.06	276	0.43
PK 416	7504	19331	11827	2.58	175	0.66
Sole JS 90-41	7504	21756	14252	2.90	197	0.60
ICPL 87119	5426	54772	49346	10.09	687	0.18
Intercropping						
JS 335+ICPL-97119	9003	40381	31378	4.48	305	0.34
PK 1024+ICPL-87119	9003	41219	32216	4.58	311	0.38
PK 1029+ICPL-87119	9003	43953	34950	4.88	332	0.35
NRC-37+ICPL-87119	9003	49069	40066	5.45	370	0.31
PK 416+ICPL-87119	9003	41116	32113	4.57	311	0.38
JS 90-41+ICPL-87119	9003	35942	26939	3.99	272	0.43
CD (P=0.05)	1756	20438	20184	3.28	223	0.28

Monetary advantages and income equivalent ratio: Maximum monetary advantage was associated with NRC 37 + ICPL 871 19) (Rs. 8,690/ha) closely followed by PK 1029 and PK 1024. The highest income equivalent ratio was recorded with PK 1029, which was at par with PK 1024 and PK 416. Similarly, income equivalent ratio values for soybean were greater than one, revealing that intercropping of soybean with pigeonpea was beneficial than sole soybean (Billore and Joshi, 2004).

Energy budget: The intercropping of pigeonpea with soybean consumed more energy inputs than their sole crops (Table 2). Among the soybean varieties, NRC 37 followed by PK 1029 intercropping with pigeonpea produced highest energy output and proved better in energy use efficiency and energy productivity as compared to other varieties of soybean as well as their sole crops. However, the PK 1024 was found most energy intensive in both the cropping systems (Billore and Joshi, 2004).

Results showed that intercropping of all the soybean varieties with pigeonpea was beneficial than sole soybean. Among the soybean varieties, NRC 37 and PK 1029 emerged more compatible for intercropping with pigeonpea as evidenced from higher land equivalent ratio, relative crowding coefficient, monetary advantages, income equivalent ratio and lower values of competition ratio.

References

Billore, S.D. and Joshi, O.P. 2004. Screening of pigeonpea (*Cajanus cajan*) varieties for their suitability as intercrop in soybean (*Glycine max* L.). *Indian Journal of Oilseeds Research*, **21**(1):58-61.

Burnett, M. 1982. Energy analysis of three conserved agro-ecosystems. In: *Basic Techniques in Ecological Farming*, Hill Sturt, B. (Ed.) Brikhauser Verlag, Boston, pp.183-195.

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 system. *Agricultural Systems*, **4**:29-37.

Joshi, O.P., Billore, S.D. and Bhatia, V.S. 1999. Planting pattern of higher productivity of soybean and pigeonpea intercropping system. *Indian Journal of Agronomy*, **44**(2):271-274.

Mc Gilchrist, C.A. 1965. Analysis of competition experiments. *Biometrics*, **21**:975-985.

Mittal, J.P. and Dhawan, K.C. 1988. *Research manual on energy requirements in agricultural sector*, pp.20-23.

Prasad, S.N., Singh, R. and Singhal, A.K. 1997. Grain yield, competitive indices and water use in soybean based intercropping systems in South Eastern Rajasthan. *Indian Journal of Agricultural Sciences*, **67**(4):150-153.

Rao, M.R. and Willey, R.W. 1980. Preliminary studies of intercropping combinations based on pigeonpea or sorghum. *Experimental Agriculture*, **16**(1):29-40.

Willey, R.W. and Rao, M.R. 1980. A competitive ratio for quantifying competition between intercrops. *Experimental Agriculture*, **16**(2):117-125.

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Short communication

Effect of improved varieties on productivity of rapeseed-mustard under frontline demonstrations

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Rapeseed-mustard have 25.6% of the total 26.81 m ha oilseeds in India where as, in Uttar Pradesh the rapeseed - mustard acreage is about 17% of area, under nine oilseeds 27.8% of the total annual oilseed production and 32.3% of the total annual edible oil production is the second major group of oleiferous crops next to ground (Yadav *et al.*, 2002).

The rapeseed-mustard group of crops offers the best opportunity to meet the increasing oil requirement and chance for diversification in cereal producing states.

The Government of India launched Technology Mission Project during 1989-90 to meet growing deficit of oilseeds. The objective of mission was to accelerate self-reliance in edible oils to save valuable foreign exchange. To achieve this goal, much emphasis was put upon transfer of improved technologies for oilseed production at the farmers' level. Krishi Vigyan Kendras (KVKs) functioning in India were also included in this task to help the mission. Keeping this in view a study was conducted to analyze the yield gap in rapeseed-mustard under front line demonstrations.

Krishi Vigyan Kendras functioning in Zone IV (ICAR), Kanpur have conducted total 601 demonstrations in an area of 222.76 ha of rapeseed-mustard with improved varieties and other component technologies during 2002-03. These demonstrations were laid out on various types of soils and varied rainfall distributions. Twenty-one KVKs under 8 Agro Climatic Zones (Central Plain, Western Plain, South-Western Semi-Arid, North Eastern Plain, Bundelkhand, Eastern Plain, Bhabar & Tarai and Vindhyan) took up the front line demonstrations in Uttar Pradesh. These demonstrations were laid out at farmers' fields in selected villages by KVKs as cluster approach during *rabi* season. The KVK wise 12 varieties of mustard were included *viz.*, NDR - 8501, Varuna, Pusa Jaikisan, Pusa Bold, Pusa Gold, B - 9, T - 59, Pusa Agrani, Rohini. CS-52, Urvashi, Kiran and 3 varieties of rapeseed (toria) *viz*; PT-303, NDR-4 and Narendra Lahi. Seeds and fertilizers were made available to the farmers as critical inputs along with technical knowledge. Critical monitoring of FLDs was done by the scientists. The other agronomic practices were followed as per the recommendations of crop i.e. seed rate (5-6 kg/ha), appropriate time of sowing (mid September to mid October), NPK application (60:40:40 kg/ha). The yield data were collected and analyzed by using simple statistical techniques like weighted mean and percentage to find out the yield gaps.

Yield performance of rapeseed-mustard: Mustard cultivars Pusa Gold registered highest yield followed by Pusa Jaikisan, then the local check respectively at farmers' fields (Table 1). Similar findings were reported by Gurjar and Chauhan, 1997 that cultivars Pusa Bold and Kranti provided higher yield with recommended dose of N: 50 kg and P_2O_5 : 30 kg/ha with 30 cm row spacing.

There is yield gap of 347 kg/ha between local check and demonstrated condition. This yield gap could be bridged by demonstrations of improved varieties at farmers' level. Similar findings were also reported by Kokate *et al.*, 1996.

Under rapeseed cultivars PT-303 attained highest yield as compared to Narendra Lahi and NDR-4. Further, these cultivars provided 31.4, 103.9 and 92.1 % higher yield as compared to the local check. There was a yield gap of 421 kg/ha between improved technology and farmers' practices. There is greater chance for enhancing the productivity of rapeseed-mustard in the state.

Farmers opined that mustard cultivar NDR 8501 performed the best. They further reported that application of single super phosphate was better source of Phosphatic fertilizers and it provided sulphur, which resulted in enhanced yield. Timely sown mustard escaped the aphid infestation.

Table 1 FLD on different cultivars of rapeseed-mustard during 2002-03

Variety	Area (ha)	No of demons	No of places	yield (kg/ha	Farmers practice	Yield increase%
Mustard						
NDR 8501	53.00	133	8	1372	893	53.6
Varuna	25.00	87	4	1336	1061	25.9
Pusa Jaikisan	25.20	54	3	1645	1207	36.3
Pusa Bold	7.00	14	2	1372	990	38.6
Pusa Gold	10.80	21	2	17.05	1290	32.2
B-9	3.60	6	1	1148	1000	14.8
T-59	1.46	7	1	1326	1050	26.3
Pusa Agrani	4.40	10	1	1620	1200	35.0
Rohini	6.00	31	1	728	610	19.3
CS-52	5.00	16	1	770	440	75.0
Urvasi	5.00	11	1	1589	1050	51.3
Kiran	10.00	20	1	1150	800	43.7
Total/ Weighted mean	156.46	410	26	1313	966	14.1
Toria						
PT-303	49.00	149	9	1067	812	31.4
NDR-4	15.00	38	1	995	518	92.1
N. Lahi	2.00	4	1	1040	510	103.9
Toral/Weighted Mean	66.00	191	11	1034	613	66.8

References

Gurjar, B.S. and Chuauhan, D.V.S. 1997. Yield attributes and seed yield of Indian mustard (*Brassica juncea*) as influenced by varieties, fertility levels and spacing in Harsi command area. *Indian Journal of Agronomy*, **42** (1) : 142-144.

Kokate, K.D., Chauhan, K.N.K. and Venkateswarlu. 1996. Diffusion of mustard technology among farmers of arid region: An action research. *Indian Journal of Extension Education*, **32** (1&4) : 47-51.

Yadav, J.S., Singh, A.K. and Chauhan, J.S. 2002. *Rapeseed and mustard. Oilseed Based Cropping System : Issues And Technologies*. PDCSR, Meerut, pp.127-139.

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Short communication

Effect of waterlogging on growth and yield of sunflower, *Helianthus annuus* L.

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Excess moisture at any growth stage is detrimental to any crop. Waterlogging results in major yield loss in sunflower even when not accompanied by high salt levels. When wet, the heavy clay soils on which sunflower is mostly grown have poor aeration and poor internal drainage (Weiss, 2000). Sunflower is sensitive to poor soil aeration (Blamey *et al.*, 1997). The response of plants to waterlogging is usually considered to be dependent on genotype, environmental conditions, stage of development and the duration of waterlogging (Russel 1959; Cannell 1977). Leaf expansion and stem extension of sunflower decreased with waterlogging for nine days at the six leaf and bud visible stages (Orchard and Jessop, 1984; Orchard and So, 1985). Waterlogging at anthesis resulted in complete crop failure (Orchard and So, 1985). Therefore a pot culture experiment was conducted to quantify the effect of waterlogging at various growth stages on growth and development of sunflower.

A pot culture experiment was conducted during *rabi* 1999 at Directorate of Oilseeds Research, Hyderabad to study the effect of different durations of waterlogging at various growth stages of sunflower. Cement coated mud pots of 40 cm diameter and 50 cm height, filled with 15 kg black soil were used to grow sunflower plants (KBSH 1). Fertilizers at the recommended doses of N, P and K (60-30-30 kg/ha) were thoroughly mixed in the soil of each container. Crop was sown during first week of October and thinned to 3 plants /pot at 10 days after sowing. Drainage holes of pots were sealed with cement before imposing waterlogging. The treatments were released by breaking the cement seals and allowing free drainage in the later part of growth period. Waterlogging treatments were imposed by maintaining water level to 2-3 cm above soil surface. The plants were subjected to waterlogging at seedling stage (15-20 days after sowing), bud initiation stage (30-40 days after sowing), flowering (45-65 days after sowing) and maturity (55-90 days after sowing) stages for 2, 4 and 6 days. The experiment was conducted in CRD with three replications. In control treatment watering was done as and when required. Plants were harvested at physiological maturity stage and yield and yield components were quantified. Photosynthetic rate was measured in each plant with help of photosynthetic system during treatments imposition.

Waterlogging at seedling and budding stages, significantly reduced plant height while it was not affected with waterlogging at flowering and seed filling stages as maximum height was already attained by that stage. At flowering among 2, 4 and 6 days duration, waterlogging for 6 days considerably decreased plant height. Stem girth did not differ significantly with excess moisture at various stages of crop growth and with different durations of waterlogging. Head diameter was significantly affected due to waterlogging for 6 days at seedling, budding and flowering stages. Waterlogging at seedfilling did not affect the head diameter, which indicated that the head formation was completed well before imposition of waterlogging. Though leaf weight was significantly reduced due to waterlogging compared to control (no waterlogging) but differences for leaf weight with duration and stages were not significant. Stem weight was significantly reduced due to waterlogging at seedling and budding stages for 2, 4 and 6 days. As there will be maximum growth during these stages, stem growth was severely affected. Orchard and Jessop (1984) reported that leaf expansion and stem extension were inhibited by waterlogging at the 6 leaf and buds visible stages although these effects did not always persist until maturity. Imposition of waterlogging at seedling and budding stages for 2,4 and 6 days reduced the head weight significantly. Due to reduction in source, translocation of assimilates was affected which resulted in reduced head weight. But waterlogging at flowering and seed filling stages did not significantly affect the head weight. Total dry matter was considerably reduced when plants were exposed to waterlogging at seedling and budding stages due to reduced leaf, stem and head weight. But waterlogging at flowering and seed filling did not affect total drymatter significantly. Waterlogging at different stages affected the seed yield adversely. The reduction in yield was greater when imposed at seedling stage (34%) and this was followed by budding (25%), flowering (11%) and seed filling (11%) stages. The decrease was more conspicuous when waterlogging imposed at seedling than at budding stage. This could be due to reduced drymatter production and seed filling. With

respect to yield of sunflower stage of development seemed to be of greater importance than the duration of waterlogging (Orchard and Jessop, 1984). Irrespective of duration of waterlogging, seedling stage was found to be most susceptible to submergence followed by budding, flowering and seed filling stages indicating that the impact was less as the crop advanced towards maturity. The damage to the crop increased with increase in duration of waterlogging. Under conditions of waterlogging short term waterlogging (i.e., upto 10 days) numerous authors have shown that greater the duration of waterlogging the more the damaging effect (Gilbert and Chamblee, 1965; Hoveland and Donelly, 1966; Leyson and Sheard, 1978). Considerable reduction in photosynthetic rate was observed with waterlogging at different stages and duration of waterlogging compared to control. The affect was greater when plants were waterlogged at budding stage. Irrespective of stage of waterlogging photosynthetic rate was reduced with increase in duration of waterlogging.

Table 1 Effect of waterlogging on growth and yield of sunflower

Waterlogging		Plant height (cm)	Stem girth (cm)	Head diameter (cm)	Leaf weight (g/pl)	Stem weight (g/pl)	Head weight (g/pl)	Total drymatter (g/pl)	Seed weight (g/pl)	Photosynthesis (m moles CO_2/m_2/sec)	
Stage	**Days**									**Treatment**	**Control**
Control		145	4.5	12.5	7.0	22.5	42.6	72.1	26.4	-	-
Seedling	2	144	3.5	11.1	3.8	18.0	29.1	50.9	20.6	-	-
	4	135	3.1	10.8	3.7	18.0	26.8	48.5	16.2	-	-
	6	131	3.2	8.5	4.7	7.8	26.0	38.5	15.9	-	-
Budding	2	126	3.7	10.7	3.8	21.1	30.7	55.6	24.8	5.3	22.8
	4	126	3.5	10.0	3.4	16.9	30.9	51.2	20.6	4.2	25.3
	6	103	3.6	8.2	3.3	7.6	30.6	41.5	14.1	3.8	24.8
Flowering	2	144	2.6	11.8	4.1	24.1	39.5	67.7	24.9	23.0	33.3
	4	142	3.0	10.7	4.0	20.5	36.0	60.5	23.2	13.3	31.6
	6	135	3.2	9.9	3.8	19.9	35.2	58.9	22.2	7.6	34.4
Seed filling	2	139	3.8	11.0	3.6	24.1	40.9	68.6	24.6	15.6	16.9
	4	137	4.3	10.7	4.5	18.5	39.3	62.3	22.6	5.2	13.8
	6	136	4.3	10.7	4.4	19.5	37.8	61.7	23.3	5.1	12.4
SEm±		3.01	0.42	0.41	0.39	1.6	3.8	5.5	1.9		
CD (P = 0.05)		11.6	NS	1.18	1.12	4.6	10.9	16.0	6.0		
CV (%)		4.6	20	7.9	19.8	16.5	20.0	15.6	15.6		

References

Blamey, F.P.C., Richard, K. Z and Albert, A. S. 1997. *Production and Culture. A monograph on Sunflower Technology and Production* (Ed. A.S. Albert, A. S.) pp. 600.

Cannell, R. Q. 1977. Soil aeration and compaction in relation to root growth and soil management. *Applied Biology,* **2**: 1-86.

Gilbert, W.B and Chamblee, D.S. 1965. Effect of submersion of water in tall fescue, orchard grass and ladino clover. *Agronomy Journal,* **57**: 502-504.

Hoveland, C.S and Donelly, E.D. 1966. Response of *Vicia* genotypes to flooding. *Agronomy Journal,* **58**: 342-345.

Leyson, A.J. and Sheard, R.W. 1978. Growth and yield of barley in flooded soil. *Canadian journal of Soil Science,*. **58** : 346-355.

Orchard, P.W and Jessop, R. S. 1984. The response of sorghum and sunflower to short term waterlogging I. Effects of stage of development and duration of waterlogging on growth and yield. *Plant and Soil,* **81**: 119-132.

Orchard, P. W. and So, H.B. 1985. The response of sorghum and sunflower to short term waterlogging. II. Changes in the soil environment under waterlogged conditions. *Plant and Soil,* **82**: 407-419.

Russel, M. B. 1959. Water and its relation to soils and crops. *Advances in Agronomy,* **11**: 1-131.

Weiss, E. A. 2000. *Oilseed Crops.* World Agriculture Series. Longman, London.

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Short communication

Standardization of sieve size for grading the seeds of sunflower, *Helianthus annuus* L.

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Seed bulk, which comes from the field for processing, contains a wide range of seed sizes and foreign material. Farmers have always realized the necessity of using bold seeds of good viability to obtain high emergence and growth. Processing which involves drying, conditioning, cleaning, grading, treating and bagging of seeds, improves physical quality of seed lots. Grading is the most important step in processing channel during which under size seeds and foreign materials from the seed lot are removed in order to get high quality seed that give rise to optimum plant population and higher yield. Importance of seed size in relation to seedling vigour, which is positively correlated to population density, has been reported in cotton (Gelmond, 1972) and soybean (Tiwari *et al.*, 1978). The sieve sizes prescribed in the MSCS for certification purposes are based on crops only, while in a crop considerable variations among the varieties exist for seed size. The sieve size recommended for processing of crops may not be suitable for all the varieties of the same crop. The recommended sieve size for grading of sunflower varieties is 2.40 mm slot perforation (Tanwar and Singh, 1988), which may not be suitable for grading of bold seed sized sunflower genotypes. Considering in view, the present study was under taken to standardize the sieve sizes for grading of sunflower seeds, *Helianthus annuus* L.

The seed material of APSH-11 and PKVSF-9 was raised at Oilseeds Farm, Kalyanpur, Kanpur during *rabi*, 2001-02. The unprocessed seeds of each genotype were graded by sieves of 4.00, 3.50, 3.25 and 3.00 mm size (slot perforation). The seeds retained over each sieve were collected separately and analysed for seed quality i.e., processing recovery, 1000 seed weight, standard germination, seedling length and seed vigour index. The standard germination test was conducted as per the procedure outlined by ISTA (Anonymous, 1999). Normal seedlings were considered as germinated seeds. After termination of germination test, ten seedlings were selected randomly and seedling length was measured. The seedling vigour index was calculated as per Abdul-Baki and Anderson (1973). During *rabi*, 2002, a field trial replicated thrice was conducted to assess the yield of each grade. At maturity, the heads were harvested, threshed and cleaned and yield was reported as kg/ha. All the data were statistically analysed (Cochran and Cox, 1957). Processing recovery was also calculated.

It is discernible that the genotype showed significant effect for 1000 seed weight, seedling length, seedling vigour index, processing recovery and yield kg/ha while standard germination was not affected (Table 1). The highest germination (79.2 %), seedling length (19.8 cm) and vigour index (1584) was recorded in hybrid APSH 11. However, the genotype PKVSF 9 exhibited maximum 1000 seed weight (81.6 g) and processing recovery (84.8 %). Hybrid APSH 11 recorded significantly higher seed yield (1479 kg/ha) as compared to PKVSF 9 (1368 kg/ha). The genotypic differences with respect to processing recovery and others quality attributes have also been recorded by Raj and Khare (1996).

Significant differences among the grades were observed. The sieve size 3.25 and 3.00 mm did not exhibit any significant difference for seedling length however, rest of the parameters showed significant differences. Sieve size of 4.00 mm recorded significantly highest germination, seedling length, seed vigour index and 1000-seed weight while lowest was found in 3.00 mm sieve size. Significantly highest processing recovery (92.2%) was noticed in 3.00 mm sieve size, however lowest (63.1%) was found in 4.00 mm sieve size. The sieve aperture size of 3.50 mm recorded significantly highest yield (1524 kg/ha) followed by 3.25 mm (1519 kg/ha) while lowest was observed in 3.00 mm sieve size. Increase in germination percentage, seedling length, seedling vigour index and 1000 seed weight was observed as the sieve size was increased while seed recovery percentage exhibited the decreasing trend. These findings are in accordance with the results of Patil *et al.* (1987) and Waykar *et al.* (1994).

The interactions of genotype and sieve sizes showed significant differences for all the characters except seed yield. In case of standard germination, all the combination showed significant differences except PKVSF 9 x 4.00 mm and PKVSF 9 x 3.50 mm and PKVSF 9 x 3.25 mm and PKVSF 9 x 3.00 mm which expressed non-significantly with decrease with increase in the sieve size, which

retained greater number of bold seeds as indicated by higher 1000 seed weight. These results are in conformity with the findings of Raveendranath and Singh (1991) in sunflower.

Considering the appearance and uniformity of graded seed lot, germination percentage, processing recovery and yield, sieve size of 3.25 mm (S_3) can be recommended for grading of APSH-11 and PKVSF-9.

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Table 1 Effect of sieve sizes on yield and seed quality of sunflower genotypes

	Treatment	Yield (kg/ha)	Processing recovery (%)	1000-seed weight (g)	Germination (%)	Seedling length (cm)	Seedling vigour index
Genotype	APSH-11	1479	62.57 (82.90)	64.3	62.88 (79.22)	19.8	1584.04
	PKVSF-9	1368	67.06 (84.80)	81.6	62.37 (78.49)	19.2	1497.11
	CD (P=0.05)	60	0.55	0.4	NS	0.5	44.20
Sieve sizes	4.00 mm	1389	52.62 (63.14)	82.1	65.68 (83.04)	21.2	1743.33
	3.50 mm	1524	61.87 (77.77)	73.9	63.90 (80.65)	20.4	1644.85
	3.25 mm	1519	70.96 (89.36)	69.1	61.96 (77.90)	8.5	1436.50
	3.00 mm	1264	73.82 (92.24)	66.6	58.97 (73.43)	17.9	1337.65
	CD (P=0.05)	85	0.78	0.5	0.85	0.7	62.51
Interactions	APSH-11 x 4.00	1454	50.01 (58.70)	74.4	66.83 (84.52)	22.0	1858.05
	APSH-11 x 3.50	1596	62.17 (78.21)	65.7	64.54 (81.52)	21.2	1722.78
	APSH-11 x 3.25	1567	67.35 (85.17)	60.0	62.91 (79.26)	18.2	1440.63
	APSH-11 x 3.00	1300	70.76 (89.14)	56.9	57.26 (70.75)	17.9	1314.73
	PKVSF-9 x 4.00	1324	55.22 (67.46)	89.7	64.54 (81.52)	20.5	1628.60
	PKVSF-9 x 3.50	1452	61.57 (77.33)	82.3	63.26 (79.76)	19.7	1566.02
	PKVSF-9 x 3.25	1470	74.56 (92.91)	78.3	61.01 (76.51)	18.7	1432.38
	PKVSF-9 x 3.00	1228	76.88 (94.84)	76.2	60.67 (76.01)	17.9	1360.58
	CD (P=0.05)	NS	1.11	0.78	1.21	1.06	88.40

Figures in parenthesis are actual percentage.

References

Abdul-Baki, A.A. and Anderson, J.D. 1973. Vigour determination in soybean seeds by multiple criteria. *Crop Science*, **13**:630-633.

Anonymous. 1999. International Rules for Seed Testing. *Seed Science & Technology*, **27**:155-199.

Cochran, W.G. and Cox, G.M. 1957. Split plot design. *Experimental Design*, Published by Asia Published House, Lucknow, pp.293-315.

Gelmond, H. 1972. Relation between seed size and seedling vigour in cotton (*Gossypium hirsutum* L.). *Proceedings of International Seed Testing Association*, **37**:792-702.

Patil, V.N., Dighe, R.S. and Patil, M.R. 1987. Effect of sieve size on germination, vigour and yield of sunflower. *PKV Research Journal*, **11**(1):80-82.

Raj, R.S. and Khare, D. 1996. Effect of seed size on seed yield, seedling vigour and quality attributes of chickpea. *Indian Journal of Pulse Research*, **9**(1):66-67.

Raveendranath, V. and Singh, G.B. 1991. Effect of seed size on seedling vigour in sunflower. *Seed Research*, **19**(1):37-40.

Tanwar, N.S. and Singh, S.V. 1988. Screen aperture sizes for seed processing. In: *Indian Minimum Seed Certification Standard*, Published by CSCB, GOI, New Delhi, pp.362-365.

Tiwari, B.K., Tiwari, J.P. and Agrawal, V.K. 1978. Evaluation of soybean for high germinability and field emergence. *Seed Research*, **6**:125-128.

Waykar, S.K., Shinde, L.A., Solunke, B.R., Moore, P.R. and Borikar, S.T. 1994. Standardization of sieve size for sunflower seed. *Annals of Plant Physiology*, **8 (2)** : 161-164.

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Short communication

Effect of intercropping vegetables in castor, *Ricinus communis* L. under rainfed conditions

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Castor (*Ricinus communis* L.) is one of the most widely recognized non edible oilseed crop to withstand the vagaries of rainfall, constraints of soil physical properties and nutrient deficiencies owing to its inherent sturdy morphological growth with deep root system (Hegde and Sudharkar Babu, 2002). Castor is mainly cultivated in Nalgonda, Mahaboobnagar and Ranga Reddy districts of Telangana Zone of Andhra Pradesh state. Its long duration, slow growth during initial stages and wide spacing offer a scope to introduce short duration quick vegetables as intercrops to improve the total productivity and net returns per unit area and time. Earlier investigation documented that intercropping systems in castor facilitate insurance against aberrant weather conditions (Ofori and Stern, 1991). But information on vegetables as intercrops in castor under rainfed conditions is lacking. Keeping this in view, a field experiment was conducted during *kharif*, 2003 at the Agricultural College Farm, Rajendranagar, Hyderabad. The soil was clay loam in texture with pH 8.3. It was medium in available N (290 kg/ha), P or P_2O_5 (13 kg/ha) and K or K_2O (140 kg/ha). Castor (*cv. Kranti*) was sown with a spacing of 9 x 60 cm and intercrops were sown on 15 July. The experiment was conducted in Randomized Block Design with nine treatments and four replications (Table 1).

Intercrops were sown as additive series with two rows of french bean (*Phaseolus vulgaris* L.); dolichos bean (*Dolichos lablab* L.), carrot (*Daucus carota* L.) and three rows of cluster bean (*Cyamopsis teragonoloba* L.) between the castor rows.

Recommended dose of fertilizers 60: 40: 30 kg/ha of N-P_2O_5-K_2O was applied for sole and intercrops. Pest and diseases were controlled according to the requirement of crop. A total of 429.8 mm rainfall was received during the crop growth period. Castor and intercrops were harvested in three pickings except carrot, which was harvested at single stretch. Vegetables were sold fresh and castor produce was threshed, dried, cleaned and the seed yield was recorded in calculating a castor seed equivalent yield of vegetable crop is converted into yield equivalent of the castor by using the ratio of prices of the two crops. Yield attributing characters, seed yield and castor seed equivalent yield were influenced by intercropping with vegetables in contrast to sole cropping.

The performance of castor was severely affected by intercropping three rows of cluster bean or two rows of carrot. The number of spikes/plant and number of capsules/spike were significantly reduced compared to sole crop. The yield was reduced to 1246 kg/ha by intercropping three rows of cluster bean and 1383 kg/ha by intercropping two rows of carrot compared to the sole crop yield of 1640 kg/ha. Castor tolerated the competition by intercropping two rows of french bean or dolichos bean. There was no significant reduction in number if spikes per plant or number of capsules per spikes. Castor intercropped with two rows of french bean produced seed yield of 1500 kg/ha. It yielded 1600 kg/ha when intercropped with two rows of dolichos bean. The production due to these two intercropping treatments was on par with the yield of sole crop.

Intercropped cluster bean produced pod yield of 1590 kg/ha. This was 47 % of its sole crop yield. Intercropped french bean yielded 530 kg/ha pod yield, equivalent to 52% of its sole crop. Intercropped dolichos bean yielded 903 kg/ha pod yield, equivalent to 55 % of its sole production. The carrot root yield was 1700 kg/ha in intercropping system which accounted for 57 % of the sole crop. These results indicated that about half of the sole crop yield can be obtained by intercropping the vegetable crops in castor.

The overall evaluation of intercropping systems indicated castor equivalent yield was better than the sole crop of castor. These were also superior to the sole crop of cluster bean, french bean or dolichos bean. The best intercropping system was castor + carrot in 1: 2 row ratios. Maximum castor equivalent yield of 2517 kg/ha was realized by this treatment. This was significantly superior to sole castor or any vegetable crop.

The land equivalent ratio recorded better land use efficiency to obtain higher total productivity of intercropping systems than the land needed for the same yields of the two species grown as sole crop. Maximum LER of 1.61 was recorded by intercropping two rows of dolichos bean in castor. The LER was 1.43 by intercropping two rows of

french bean and 1.35 by two rows of carrot. Intercropping three rows of cluster bean was relatively less efficient. The LER was 1.23.

The gross returns were more by intercropping castor with vegetables. Maximum returns of Rs 30196/ha were obtained by intercropping two rows of carrot in castor compared to Rs 19680 from the sole crop. Carrot accrued more income than castor intercropped with two rows of french bean or three rows of cluster bean. Similarly, maximum net returns of Rs 20203/ha were realized by intercropping two rows of carrot in castor. The profitability was also more by intercropping cluster bean, french bean or dolichos bean than sole crop of castor. Intercropping of castor with carrot or cluster bean fetched Rs 0.67/Rs. This was equivalent to the sole crop of castor. The per rupee returns were 0.60 and 0.62 by intercropping french bean and dolichos bean. The maximum per rupee return of Rs 0.71 was realized from sole cluster bean.

The results indicated that intercropping two rows of either french bean or dolichos bean provided bonus yield with no significant reduction in the production of castor with increased LER and net returns per ha compared to castor. Intercropping of two rows of carrot significantly reduced the yield of castor, but overcompensated this loss by maximizing the castor equivalent yield, enhanced LER and maximum net return per hectare.

Table 1 Effect of intercropping vegetables in castor on yield, seed equivalent yield, LER, gross and net returns

Treatment	No. of spikes/ plant	No. of capsules/ spike	Castor yield (kg/ha)	Vegetable yield (kg/ha)	Castor equivalent yield (kg/ha)	LER	Gross returns (Rs/ha)	Net returns	
								Rs/ha	Rs/Re
Sole Castor	7	33	1640	-	1640	-	19680	13161	0.67
Castor + Cluster bean (1:3 row ratio)	6	26	1246	1590	2108	1.23	25287	16986	0.67
Castor + French bean (1:2 row ratio)	6	30	1500	530	2074	1.43	24890	15086	0.60
Castor + Dolichos bean (1:2 row ratio)	7	32	1600	903	2353	1.61	28230	17707	0.62
Castor + Carrot (1:2 row ratio)	6	27	1383	1700	2517	1.35	30196	20203	0.67
Sole Cluster bean	-	-	-	3350	1814	-	21768	15378	0.71
Sole French bean	-	-	-	1016	1101	-	13212	4241	0.32
Sole Dolichos bean	-	-	-	1643	1369	-	16428	6198	0.38
Sole Carrot	-	-	-	3316	2210	-	26520	17144	0.65
S.Em±	0.29	1.06	65	-	293	-	-	-	-
CD (P=0.05)	0.96	3.4	213	-	871	-	-	-	-

LER : Land Equivalent ratio;
The unit price considered were Rs.12.00, 6.50, 13.00, 10.00 and 8.00 per kg of produce for Castor, Cluster bean, French bean, Dolichos bean and Carrot respectively.

References

Hegde D. M. and Sudhakar Babu S. N. 2002 *A Text Book of Field Crops Production.* pp. 579-603.

Ofori F. and Stern W. R. 1991 Cereal-legume Intercropping Systems. *Advances in Agronomy,* 41 : 41-90.

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Short communication

Allelopathic effect of *Eucalyptus grandiflora* trees on growth and yield of castor, *Ricinus communis* L.

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In Agroforestry systems planting eucalyptus trees along with field crops, plantation crops and fruit trees is a common practice. Eucalyptus trees planted on field bunds was reported to decrease the plant stand, suppress growth, delayed flowering and maturity by 10-15 days in pigeonpea, groundnut, castor, sorghum and pearl millet upto a distance of 10 meter (Narwal , 1994). Allelopathy plays a major role in influencing the productivity of agro ecosystems through inhibitory or stimulatory interactions. The inhibitory effect of certain plants decreases the yield of field crops. Bund plantation of eucalyptus proved harmful to field crops (Craig and Saenalo , 1988).

A field study was conducted to assess the effects of bund plantation of eucalyptus on castor in Vertisols at Regional Agricultural Research Station , Nandyal during *kharif* 2000. The experiment was conducted in Randomised Block Design with three replications. Castor cv. Kranthi was sown at a spacing of 90 X 60 cm under rainfed conditions during July, 2000 and harvested in February, 2001. The Eucalyptus trees were of 20 years old planted at 3 m distance on either way in North-South direction. The girth of trees was one metre diameter at base and 30 m tall. First row of castor was sown at a distance of 2 m from eucalyptus trees. Observations were recorded on each row of castor crop representing one metre interval (Table 1). Castor crop was sown in East - West direction perpendicular to eucalyptus plantation. Soil pH, Ec, available nitrogen, phosphorous, potassium and micronutrients were estimated from 0-30 and 30-60 cm soil depths at every 2 m interval at harvest. Moisture percentage was estimated from 0-15, 15 - 30 , 30 - 45 and 45 - 60 cm soil depth on dry weight basis at every 2 m interval at harvest. A pit was dug upto 14 m distance with a depth of 60 cm to find out number of lateral roots of Eucalyptus trees. The number of lateral roots was counted at 2 m interval from 0-30 and 30-60 cm depth of soil. Observations on weed flora , weed density and weed dry weight were also recorded in one square metre area at 2 m interval at harvest.

Crop Growth: Plant height, dry weight per plant and root length of castor increased as the distance from Eucalyptus trees increased upto 19-20 m (Table 1). Adverse effect of Eucalyptus on growth of castor was more upto 15-16 m distance. Castor plants were not able to produce any yield attributes upto a distance of 4-5 m from Eucalyptus plants. Inhibitory effect of allelochemicals produced from Eucalyptus tree roots probably reduced the growth of castor plants. Primary spike length, capsules/ plant and seed yield / plant increased as the crop distance increased from 5-6 m to 20-21m.

Seed Yield: No seed yield from castor could be obtained upto a distance of 4-5 m (Table 1). Beyond 5-6 m distance the seed yield increased with increase in distance from eucalyptus plants. Castor seed yield / plant was reduced by 97,96, 95, 91,90,89,86,84, 83, 73, 69, 59, 36 and 18 % when sown at 5-6, 6-7, 7-8, 8-9, 9-10, 10-11, 11-12, 12-13, 13-14, 14-15, 15-16, 16-17, 17-18, 18-19 m respectively compared to 20-21 m distance from eucalyptus trees. The yield losses, came down as the distance increased from the eucalyptus trees. Although growth resources like sun light, temperature were adequate for proper crop growth, the growth of castor crop was inhibited due to allelopathic effect. The reduction in yield was primarily due to depletion of available nutrients (Table 2)and moisture (Table 3)in the crop rhizosphere through competition by roots of eucalyptus. Narwal and Sarmah (1992) reported that eucalyptus trees planted on field bunds suppressed growth and reduced the seed yield in castor upto a distance of 10 metre. Singh and Kohli (1992) reported that maximum phytotoxins was found at a distance of one metre from the tree line at all depths resulting in reduced crop growth and yield of chickpea , lentil, toria, wheat and cauliflower.

Nutrient Status: Soil pH and Ec was low in surface layers compared to sub surface layers. Available Nitrogen and phosphorous content in soils increased as the distance from Eucalyptus trees increased both in 0-30 and 30-60 cm soil depth (Table 2). There was 35 and 28 % reduction in available nitrogen at 0-2 m compared to 12–14 m distance in 0-30 and 30-60 cm depth of soil, respectively. The depletion of nutrients in upper layers (0-30 cm) was higher compared to lower layers (30-60 cm) due to presence of more number of eucalyptus lateral roots in

upper layers (Table 3). However, Potassium content was higher in upper layers compared to the lower layers. Micro nutrients content were low in upper layers compared to the lower layers.

Moisture Content: Moisture depletion was faster in surface soil (0-15 cm) compared to sub surface layers. Moisture content of surface soil (0-15 cm) increased as the distance increased from the Eucalyptus trees upto 12-14 m (Table 3). However in 15-30, 30-45 and 45-60 cm soil depths the moisture content decreased as the distance increased from eucalyptus upto 6-8 m and again increased from 8-10 m. This clearly indicates that moisture content was depleted due to the presence of more number of lateral roots of trees upto a distance of 6-8 m (Table 3).

Weed Growth: Weeds such as *Cynodon dactylon* (grass), *Chrozophora rotteleri* (broad leaved weed) and *Cyperus rotundus* (sedge) were predominantly observed in the field Weed growth behaved similar to that of crop growth. These weeds were not noticed upto a distance of 8-10 m from eucalyptus tree. Beyond 10-12 m distance the density of grasses, BLW's and sedges and dry weight increased as the distance increased upto 22-24 m (Table 4).

Table 1 Growth and yield of castor in relation to its distance from eucalyptus plants

Distance of crop from tree (m)	Plant height (cm)	Dry weight / plant (g)	Root length (cm)	Spikes / plant	Primary spike length (cm)	Capsules/ plant	Seed yield / plant (g)
0-1	16.5	1.2	3.2	0	0	0	0
1-2	27.6	2.6	3.3	0	0	0	0
2-3	28.8	4.0	4.2	0	0	0	0
3-4	34.0	4.6	5.1	0	0	0	0
4-5	35.0	6.0	5.6	0	0	0	0
5-6	42.2	6.6	7.2	1.2	5.3	7.4	3.2
6-7	44.8	8.0	9.1	1.4	5.3	7.6	3.8
7-8	52.8	9.3	10.2	1.6	5.3	7.8	5.8
8-9	58.8	11.3	16.2	1.8	10.4	11.2	10.5
9-10	62.6	12.6	19.1	2.4	13.6	12.6	11.9
10-11	67.8	14.0	25.4	2.8	14.8	14.6	12.7
11-12	71.2	16.6	30.1	3.2	14.8	15.4	16.9
12-13	74.8	27.3	40.2	3.6	14.8	17.4	19.1
13-14	87.2	33.2	45.6	3.8	14.8	17.6	20.1
14-15	87.8	35.4	60.2	3.8	15.6	18.7	31.4
15-16	99.2	42.3	65.2	3.8	15.6	19.8	36.5
16-17	109.4	80.6	70.1	3.8	15.6	20.4	48.4
17-18	112.3	85.4	72.6	3.8	16.8	23.5	75.0
18-19	120.0	87.2	73.3	3.8	16.8	25.5	95.2
19-20	128.0	87.6	75.2	4.4	17.4	32.6	116.4
20-21	128.0	88.0	75.2	4.4	17.4	32.6	116.8
SEm ±	2.4	2.0	1.3	0.5	0.9	1.0	1.7
CD (P=0.05)	6.72	5.7	3.70	1.39	2.66	2.70	4.87

Table 2 Available nutrients in soil after harvest of castor as influenced by distance from eucalyptus trees

Distance from tree (m)	0-2		2-4		4-6		6-8		8-10		10-12		12-14	
Depth (cm)	0-30	30-60	0-30	30-60	0-30	30-60	0-30	30-60	0-30	30-60	0-30	30-60	0-30	30-60
pH	8.63	8.87	8.76	9.00	8.72	9.10	8.80	9.12	8.98	9.04	8.54	9.10	8.65	8.95
Ec (dS^{-2})	0.40	0.58	0.34	0.51	0.42	0.49	0.49	0.81	0.48	0.51	0.42	0.47	0.44	0.53
Available N (kg/ha)	115	129	127	134	132	148	133	151	135	153	146	161	156	165
Available P_2O_5 (kg/ha)	3.0	3.4	3.2	4.3	3.2	4.3	5.4	6.9	7.5	7.9	8.7	10.9	8.6	9.1
Available K_2O (kg/ha)	404	330	404	330	330	257	293	404	367	367	514	330	404	367
Fe (ppm)	8.9	9.3	8.0	8.6	8.5	9.3	7.9	9.0	7.7	9.3	8.9	10.2	8.9	9.8
Mn (ppm)	11.0	23.8	16.0	19.7	15.4	16.6	18.0	20.0	15.2	17.1	16.0	17.2	16.6	17.3
Zn (ppm)	0.36	0.42	0.32	0.40	0.26	0.28	0.32	0.42	0.20	0.24	0.26	0.48	0.34	0.42
Cu (ppm)	0.80	0.88	0.80	0.86	0.78	0.82	0.74	0.84	0.70	0.82	0.78	0.88	0.82	0.92

Table 3 Soil moisture (%) at harvest and number of lateral roots of eucalyptus trees in relation to distance from trees and soil depth

Distance from tree (m)	Moisture (%)				Number of lateral roots of eucalyptus trees		
Soil depth (cm)	0-15	15-30	30-45	45-60	0-30	30-60	Total
0-2	1.29	8.65	10.76	10.72	34	16	50
2-4	2.59	8.77	8.56	10.06	23	10	33
4-6	5.38	7.47	7.81	8.13	20	9	29
6-8	6.44	6.38	8.29	8.50	13	9	22
8-10	8.83	7.24	8.55	9.51	7	7	14
10-12	9.96	8.34	9.20	9.86	4	6	10
12-14	10.72	9.30	10.46	10.58	0	4	4

Table 4 Weed density and dry weight of weeds in relation to distance from eucalyptus trees

Distance from tree (m)	Weed density (No/m^2)			Dry weight (g/m^2)
	Grasses	BLW	Sedges	
0-2	0 (1.0)	0 (1.0)	0 (1.0)	0(1.0)
2-4	0 (1.0)	0 (1.0)	0 (1.0)	0(1.0)
4-6	0 (1.0)	0 (1.0)	0 (1.0)	0(1.0)
6-8	0 (1.0)	0 (1.0)	0 (1.0)	0(1.0)
8-10	0 (1.0)	0 (1.0)	0 (1.0)	0(1.0)
10-12	24 (4.9)	0 (1.0)	0 (1.0)	6 (2.6)
12-14	39 (6.2)	1 (1.3)	0 (1.0)	12 (3.5)
14-16	109 (10.4)	3 (1.9)	1 (1.3)	68 (8.2)
16-18	164 (12.8)	4 (2.2)	2 (1.7)	74 (8.6)
18-20	168 (12.9)	4 (2.2)	3 (1.9)	86 (9.3)
20-22	172 (13.1)	5 (2.4)	4 (2.2)	92 (9.6)
22-24	172 (13.1)	5 (2.4)	4 (2.2)	94 (9.7)
SEm ±	0.24	0.13	0.10	0.19
CD (P=0.05)	0.73	0.39	0.30	0.58

BLW = Broad leaved weeds
Figures in the parenthesis denotes square root transformed values

References

Craig , I. A. and Saenalo, M.1988. Effects of paddy-bund planted Eucalyptus trees on the performance of field crops. Working paper No.1, Nearad Project, The Phar, Khon Kaen, Thailand.

Narwal,S.S.1994. *Alloepathy in crop production* .Jodhpur, India : Scientific Publishers, 288 pp.

Narwal, S.S. and Sarmah, M.K.1992. Suppression effect of *Eucalyptus tereticornis* on the field crops. In *Proceedings of First National Symposium on Allelopathy in Agro ecosystems*. eds. P.Tauro and S.S.Narwal , pp 111-113., Hisar, India: Indian Society of Allelopathy, Haryana Agricultural University, Hisar.

Singh, D. and Kohli, R.K.1992. Impact of *Eucalyptus tereticornis* shelter belts on crops . *Agroforestry system*, 20 :253-266.

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Short communication

Field efficacy of botanical preparations on late leaf spot, *Phaeosariopsis personata* (Berk. and A.M. Curt) Van Arx. of groundnut, *Arachis hypogaea* L.

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Late leaf spot of groundnut caused by *Phaeosariopsis personata* is endemic in groundnut growing transitional zone of Karnataka leading upto 50% yield loss (Subrahmanyam *et al.*, 1984). Severe epiphytotic also affects the shelling and fodder quality. Though the disease can be managed by chemical fungicides, but involves high input cost. Recently, many botanical preparations are reported to control the plant diseases caused by fungal pathogens (Natarajan and Lalithakumari, 1987; Dubey, 1991). Therefore, some of the botanical preparations which were found inhibitory to the late leaf spot pathogen *in vitro* were subjected to field evaluation.

Present studies were conducted following Randomised Block Design and replicated thrice in medium black soils at Main Research Station, University of Agricultural Sciences, Dharwad during *kharif*, 1999-2000 and 2000-01. The plot size of 3.0 x 5.0 m (gross) was maintained and susceptible groundnut variety JL-24 was sown adopting the spacing of 30 x 10 cm on 18.07.1999 and 16.07.2000 in respective seasons. The fertilizer at 25:50:25 kg NPK/ha was applied as basal dose two days prior to sowing. Other management practices such as interculture operations and weeding were attended on need basis. The crop was protected from defoliating pest (*Spodoptera litura*) by spraying quinolphos 0.05% twice during the crop growth (40 DAS and 50 DAS).

The plant leaf extracts of *Datura stramonium, Adhathoda vasica* and *Polyalthia longifolia* which were inhibitory to spore germination of *P. personata in vitro* were considered for field testing. Fresh leaves of above plants were collected, washed in tap water. The leaves of each plant were minced separately into small pieces with the help of knife, weighed and placed in container and distilled water was added in the ratio of 1:1 both small letters and boiled for 20 minutes. After cooling, it was strained through the double layered muslin cloth and filtrate was collected as 50% standard stock extract. It was further diluted in water in the ratio of 1:9 and 1:4 (v/v) to have 5 and 10% of spray extract respectively. The extracts were prepared fresh each time at treatment imposition. Carbendazim 0.05% and mancozeb 0.2% were sprayed to maintain them as protected control. Plots, which were not sprayed, served as unprotected control. The plant extracts and protected control treatment were applied at 30, 45 and 60 days after sowing (DAS).

Disease severity was recorded on 85 DAS from five randomly selected plants in each treatment, collected by hand plucking and brought to laboratory. They were sorted out assigning a severity grade to individual leaflet on 1-9 scale and PDI was calculated (Subrahmanyam *et al.*, 1982). Yield per treatment and shelling per cent were also recorded.

Late leaf spot was moderately severe in *kharif* 1999-2000 while it was severe during 2000-01. In both the years the botanical preparations at 5 and 10% were found significantly superior over the unsprayed control and recorded low PDI (Table 1). The disease control was on par with fungicidal treatment and botanical preparations. Pooled data indicated that *Polyalthia longifolia* at 10% recorded significantly least PDI (26.8%) followed by *Adhathoda vasica* (27.4%).

Dry pod yield of groundnut was high in 1999-2000 as compared to 2000-01. Distribution of rainfall during the flowering partly affected the yields in *kharif*, 2000. Pod yield was significantly superior in protected control and botanical sprayed plots during 1999-2000 while it was on par with the extracts treatments (both at 5 and 10%) during 2000-01. Mean yield over years indicated that it was on par in all the botanical sprayed plots while significantly highest (2575 kg/ha) and least (1697 kg/ha) in protected and unprotected control respectively. The range of yield increase in botanical extracts was to the extent of 17.5 to 31.2%. The cost effectiveness of the treatments indicated that the higher concentration of botanical found to be much more remunerative (4.5-6.1) than fungicide treatment (3.4).

The shelling per cent of groundnut was ranged from 3.3 to 5.2 in various treatments. Significantly higher shelling was recorded in higher concentration (10%) of plant extract over control.

Table 1 Efficacy and economics of botanical preparations on late leaf spot of groundnut

Treatment	Mean disease (LLS)		Mean yield		Mean disease shelling		B:C ratio
	PDI	Reduction (%)	kg/ha	Increase (%)	Shelling (%)	Increase (%)	
Datura stramonium (5%)	32.8	37.7	2062	21.5	73.0	3.3	2.7
Adhathoda vasica (5%)	31.3	31.1	1994	17.5	73.5	4.0	2.0
Polyalthia longifolia (5%)	29.2	35.7	2018	18.9	73.0	3.3	2.2
Datura stramonium (10%)	29.4	35.3	2106	24.1	74.0	4.7	4.5
Adhathoda vasica (10%)	27.4	39.8	2200	29.6	74.4	5.2	5.7
Polyalthia longifolia (10%)	26.8	40.9	2227	31.2	74.4	5.2	6.1
Protected control (Carbendazim 0.05% + Mancozeb 0.2%)	23.1	49.2	2575	51.1	74.5	5.4	3.4
Unprotected control	45.4	-	1697	-	70.7	-	-
SEm±	0.7	-	85	-	0.5	-	-
CD (P=0.05)	2.3	-	259	-	1.4	-	-

Botanicals tested were found equally effective as chemical fungicides in controlling the late leaf spot disease of groundnut. Extract of *Polyalthia longifolia* was best to reduce the disease intensity but its availability is limited. However, *Adhathoda vasica* and *Datura stramonium* are available abundantly as weed and could be used.

References

Dubey, R.C. 1991. Fungicidal effect of essential oils of three higher plants on sclerotia of *Macrophomina phaseolina*. *Indian Phytopathology*, **44**:241-244.

Natarajan, M.R. and Lalithakumari, D. 1987. Antifungal activity of the leaf extract of *Lowsonia inermis* on *Drechslera oryzae*. *Indian Phytopathology*, **40**:390-395.

Subrahmanyam, P., Mc Donald, D., Gibbons, R.W., Nigam, S.N. and Nevill, D.J. 1982. Resistance to rust and late leaf spot disease in some genotypes of *Arachis hypogaea*. *Peanut Science*, **9**:6-10.

Subrahmanyam, P., williams, J.H., Mc Donald, D. and Gibbons, R.W. 1984. The influence of foliar disease and their control by selective fungicides on a range of groundnut (*Arachis hypogaea* L.) genotypes. *Annals of Applied Biology*, **104**:467-476.

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Short communication

Effect of stem tunnelling by the maggots of stem fly, *Melanagromyza sojae* (Zehntner) on yield and yield attributes of soybean, *Glycine max* (L.) Murrell.

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Stemfly *Melanagromyza sojae* (Zehntner) has been reported as serious pest of soybean in India (Singh and Singh 1990 a). The maggots of the pest have been found infesting over 90% of soybean plants in Madhya Pradesh. Due to stem tunnelling, the conducting tissues are damaged resulting in the loss of plant vigour (Singh *et. al.*, 1989 and Singh and Singh 1990a) and the infested plants gave 32.43% less yield than the healthy plants (Singh and Singh 1990b). In Satpura plateau of Madhya Pradesh, soybean variety JS-335 has become popular among the cultivators, since last five years the yield of soybean is being effected by the stem fly damage but the information about effect of stem tunnelling on yield and yield attributes is lacking. In the present study, attempts were made to determine the effect of stem tunnelling by stemfly on yield and yield attributes of soybean.

The field experiments were conducted during *kharif* 2000 and 2001 at Farm of Zonal Agricultural Research Station Chandangaon, Chhindwara with soybean variety JS-335. The sowing was done on 3rd July during both the years in an area of 40 × 20 m. Fertilizer was applied @ 20 kg N, 80 kg P_2O_5 and 40 kg K_2O/ha. Soybean crop was protected by defoliator, by spraying with Endosulfan 25 EC @ 2 ml/lit of water at 40 and 60 days crop stage. At harvest 500 plants were picked up randomly and cleaved vertically for recording the extent of tunnel damage caused by the maggots of stemfly. Before cleaving the plants observations on plant height, number of branches and weight of pods and grains of individual plants were also recorded. These plants were divided into ten groups as healthy (zero infestation), plants having 1-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61-70, 71-80 and 81-90% damaged tunnel length. Correlation and regression coefficient was worked out between stem tunnelling and yield attributes. Grain yield/ha was calculated on the basis of an optimum plant population of 4 lakh/ha.

The stemfly infestation started in the last week of July and continued up to last week of September. Data recorded after assessment of 500 plants it is revealed that, the stemfly infested 94.80% of plants and stem tunnel length ranged from 1.8 to 92% (mean 42.42%) in different plants. Earlier Bhattacharya and Rathore (1977) reported 92 to 100% soybean plant infestation and 29% stem tunnelling by the maggots of stemfly at Pantnager however Singh and Singh (1992) reported that the stemfly infested 93.5% of soybean plants and the maggots tunnelled 2.6 to 90% of stem length at harvest in Madhya Pradesh.

The highest number of damaged plants (22.2%) were observed in the tunnelled length of 31-40% category followed by 21-30 and 41-50% category. Only 2.6% infested plants recorded the highest stem tunneling of 81-90% (Table 1).

Effect on number of branches: Number of branches were more in the healthy plants in comparison to infested plants (Table 1). A gradual reduction was observed in number of branching up to 61-70% damaged plants category and thereafter severe reduction was observed. Similarly Talekar (1980) and Singh and Singh (1992) also reported that a significant reduction in branching/plant in soybean infested plants by *M.sojae*.

The number of branches/plant were significantly and negatively correlated with percent tunnel length ($r = 0.895$). The regression equation ($Y_1 = 4.98 - 0.055\ x$) showed that with an increase of one per cent stem tunnelling, there was a reduction of 0.06 branches/plant.

Effect on pod and grain weight: The healthy plants recorded the highest pod weight. However, a decreasing trend observed in pod weight/plant with increase in stem tunnel length. The lowest pod weight was recorded from the plants having 81-90% stem tunneling. Earlier Ipe and Bhatti (1977) reported that in soybean flowers withered and pod setting reduced due to heavy infestation of *M.sojae*. Whereas Singh and Singh (1989) reported that due to higher stem tunnelling a large number of pods remained unfilled.

A gradual decrease in grain weight/plant was recorded up to 61-70% stem tunnelling group, but thereafter an abrupt decrease was found in the case of 71-80 and 81-90% stem tunnelling. The stem tunnelling (X) was negatively correlated with pod and grain weight respectively

(r_2 = -0.0943 and r_3 = -0.889). The regression equations being Y_2 = 4.70 – 0.041 ' and Y_3 = 5.47-0.057 ' showed that with an increase of every one per cent tunnelling, there were reduction in 0.04 g pod and 0.057 g grain weight/plant respectively. Similarly Singh and Singh (1992) also reported that significant correlation between stem tunnel length and number of branches and pod and grain weight in soybean.

Effect on calculated yield: Highest yield of soybean was observed in plants having no stem tunneling. Stem tunnelling to the tune of 1-10% caused a reduction of 6.1% over healthy plants. There was a an abrupt decrease in yield i.e., 11-20% stem tunnelling but there after gradual reduction in yield was observed upto 41-50% stem tunnelling. A severe yield reduction of 61.2 and 75.5% was observed in 51-60 to 81-90% stem tunnelling respectively. Thus a linear relationship with negative correlation (r-0.921) was observed between yield and stem tunnelling. The regression equation was found Y_4 = 22.33-0.252 thus, indicated that yield decreased by 0.25 kg by every percent increase in stem tunnelling (Fig.1). In contrast to present observations, Bhattacharya and Rathore (1977) did not find any significant relationship between the stem tunnelling and yield, however Singh and Singh (1992) reported 30.2% yield reduction with 46% stem tunnelling in Madhya Pradesh.

Table 1 Effect of stem tunnelling by *Melanagromyza sojae* on various attributes of soybean yield (average of 2 years)

Stem tunnel length (% range)	Average stem tunneling (%)	Infested plants (%)	Yield attributes			Grain yield (kg/ha)	Grain yield loss	
			No. of branches/ plant	Pod weight/ plant (g)	Grains weight/plant (g)		q/ha	%
0.00	0.0	6.8	3.5	8.6	4.9	19.60	-	-
1-10	6.2	12.6	3.4	8.3	4.6	18.40	1.2	6.12
11-20	17.2	15.0	3.2	7.5	3.8	1520	4.4	22.44
21-30	26.3	22.2	3.0	6.8	3.5	1400	5.6	28.57
31-40	38.8	13.0	2.9	6.6	3.1	1240	7.2	36.73
41-50	48.8	11.2	2.7	6.3	2.9	1160	8.0	40.81
51-60	55.9	7.4	2.1	6.0	1.9	760	12.0	61.22
61-70	67.9	4.0	2.0	5.9	1.7	680	12.8	65.30
71-80	76.2	2.6	1.9	3.8	1.5	600	13.6	69.38
81-90	86.6	-	1.8	3.4	1.2	480	14.8	75.51
Mean	42.4	-	2.65	6.3	2.9	1164	8.84	45.10

References

Bhattacharya, A.K. and Rathore, V.S. 1977. Survey and study of bionomics of major soybean insects and their chemical control. Final Technical Report of Project. Department of Entomology. College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnager, India.

Ipe, I.M and Bhatti, Y.A.S. 1977. Studies on the biology of *M.sojae* (Zehntner) (Diptera: Agromyzidae) and its incidence of infestation on five cultivated pulse crop in and around Agra, India. *Ang. Schadlingskde*, **50**: 104-105.

Singh, O.P. and Singh, K.J. 1989. Efficacy and economics of granular insecticides in the management of the stem borers of soybean in M.P., India. *Pestology*, **14** : 29-34.

Singh, O.P. and Singh, K.J. 1990a. Seasonal incidence and damage of *Melanagromyza sojae* (Zehntner) on soybean. *Indian Journal of Plant Protection*, **18**(2): 271-275.

Singh, O.P. and Singh, K.J. 1990b. Efficacy and economics of some emulsifiable concentrate insecticides against *M. sojae and C.accuta on* soybean. *Journal of Insect Science*, **3** (1): 77-82.

Singh, O.P. and Singh, K.J.1992. Influence of stem tunnelling by stemfly on yield of soybean. *Journal of Insect Science*, **5**(2): 198-200.

Singh, O.P., Verma, S.N. and Nema, K.K. 1989. *Insect pests of soybean in India.* International Book Distributors. Dehradun.

Talekar, N.S. 1980. *Search for bean fly resistance in soybean,* mung bean and snapbean pp., 293-295. In proceeding of Legumes in the Tropics, Faculty of Agriculture, University Pertanian, Malaysia, Serdang, Malaysia.

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Short communication

Evaluation of sunflower, *Helianthus annuus* L. hybrids against insect pests in semi-arid tropics

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Sunflower, *Helianthus annuus* L. being one among top five number of oilseed crops contributes about 6.5 % to the total Indian oilseeds production. The productivity of this crop in India is affected by a of reasons. Many insecticides are being used to control the ravaging population of insect-pests on this crop which pose health hazards in the form of accumulation in the food chain and leave toxic residues in oil. Keeping these aspects in view an effort has been made to evaluate the popularly grown sunflower hybrids against insect pests.

Four sunflower hybrids *viz.*, Jwalamukhi, HSFH-848, KBSH-1 and Krishidhan-13 were planted in the month of February during two consecutive crop seasons (Spring, 2001 and 2000) after following recommended package of practices for *rabi* crops of North-Western plain region. The crop was monitored from sowing till harvest for all the insect pests appearing on it. The experiment was planted in a Randomized Block Design with five replications for ease of statistical analysis. Ten plants/replication were initially selected and tagged for recording weekly observations. The observations on leaf hopper and whitefly were recorded by counting number of nymphs/leaf (5 leaves randomly selected on each plant). Afterwards, defoliators (comprising of grasshopper, lepidopteron defoliators, sunflower beetles) were recorded together in the form of leaf damage/plant. The observations on head boring insects were recorded from the selected plants which comprised of *Helicoverpa armigera*.

During initial stages of germination, sucking pests mainly, whitefly, *Bemisia tabaci* and leaf hopper, *Amrasca biguttula biguttula* were abundant (Table 1). Leaf hoppers/plant were ranging from a minimum of 2 on HSFH-848 to a maximum of 4 on KBSH-1, Jwalamukhi and Krishidhan-13. Whitefly population was present till late in the season and its population varied from minimum of 3 on HSFH-848 to a maximum of 4 (nymphs + adults)/plant on Jwalamukhi and KBSH-1. Krishidhan-13 was carrying slightly less population of whiteflies. The population was significantly less on HSFH-848 than the other hybrids. Later on defoliator population was recorded which was ranging from 2 larvae/plant being minimum on Jwalamukhi followed by 3 larvae/plant on KBSH-1 and being maximum 5/plant on Krishidhan-13. The population of insects on Jwalamukhi and HSFH-848 was significantly lower than other two hybrids. Population of head borer when monitored revealed that a minimum of 1 larvae/head was recorded on HSFH-848 followed by Jwalamukhi, KBSH-1 and Krishidhan-13.

Leaf hopper, *A. biguttula biguttula* was observed to be the most serious sucking pest during the crop growth stage in both the years. These results are substantiated by the reports of crop losses by this pest upto 46% (Rajamohan, 1976; Anonymous, 1979). Some hybrids have been reported to show less damage due to leaf hopper like KBSH-8 and KBSH-1 (Bhat and Virupakshappa, 1993).

Major defoliators present in the crop were *Spilosoma obliqua*, *Diacrisia casignethin* Kollar, *Spodoptera litura*, *S. exigua* Hub. *Plusia orchalsia* and Grasshoppers were also present. The losses in yield have been reported to the tune of 268 kg/ha at Bangalore (Anonymous, 1979). Defoliation has been reported to result in heavy loss in the assimilate supply to capitulum thereby upsetting floral population and its survival (Conner and Sadras, 1992).

Table 1 Reaction of different sunflower hybrids against various insect-pests

Hybrid	Insect pests							
	Leaf hoppers/plant		Defoliators/plant		Whitefly/plant		Head borer/plant	
	2001	*2002*	*2001*	*2002*	*2001*	*2002*	*2001*	*2002*
Jwalamukhi	*3*	*4*	*2*	*2*	*3*	*4*	*2*	*1*
HSFH-848	2	3	1	3	2	3	1	1
KBSH-1	4	4	2	3	2	4	2	2
Krishidhan-13	4	4	2	5	3	4	2	2
CD (P=0.05)	0.8	0.7	0.6	0.6	0.4	0.9	0.6	0.7
CV (%)	16.8	15.2	25.0	12.0	10.5	18.3	25.0	29.3

References

Anonymous, 1979. Annual Progress Report (Sunflower): All India Coordinated Research Project on Oilseeds. Directorate of Oilseeds Research, Hyderabad, pp.109.

Bhat, N.S. and Virupakshappa, K. 1993. Integrated pest management in sunflower. Group Discussion on IPM Strategies in Oilseeds in India. Dec. 23-24, 1993. Punjab Agricultural University, Ludhiana.

Conner, J.J. and Sadras, V.O. 1992. Physiology of yield expression in sunflower. *Field Crop Research*, 30 : 333-391.

Rajamohan, N. 1976. Pest complex of sunflower - a bibliography. *PANS*, **22** : 546-563.

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Short communication

Validation of eco-friendly IPM module for safflower, *Carthamus tinctorius* L.

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Safflower (*Carthamus tinctorius* L.) is one of the most important rainfed and drought resistant oilseed crops in India. Of the various factors responsible for low productivity, the attack of insect pests and diseases is the major one. Safflower is attacked by about 22 insect pests (Rai, 1976), of which the aphid, *Uroleucon compositae* (Theobald) and *Helicoverpa armigera* Hubner are the most destructive and dreaded pests. This crop is also attacked by many diseases *viz.*, Fusarium wilt (*Fusarium oxysporum* f.sp. *carthami*), Alternaria blight (*Alternaria carthami*), Verticillium wilt (*Verticillium alboatrum*), *Cercospora* leaf spot (*Cercospora carthami)* and Brown leaf spot (*Ramularia carthami)* of which fusarium wilt is the major one (Sastry *et al.*, 1993). There is scanty of information on IPM in safflower crop in India. Therefore, an attempt has been made to develop IPM technology for this crop for the Marathwada region.

The experiments were carried out on farmers' fields in three watershed villages *viz.*, Takli (K), Kinhola and Zari in Parbhani Taluka (State Maharashtra: India) during *rabi* 2002-03. Experiments were conducted in paired plot design with 2 treatments and 15 replications. The two treatments *viz.*, T_1 (IPM module–I) and T_2 (control/farmers' practices/non-IPM) were tested at farmers' fields. The IPM module was synthesized for safflower crop (Table 1) and validated against farmers' practices (which included use of Sharda variety - BSF 168-4, late sowing *i.e.*, on 25.10.2002 and no plant protection measures for the control of pests). However, under IPM module, sowing was done on 5.10.2002 and the area under each treatment was 0.4 ha.

Observations on pests (no. of aphids/5cm apical shoot length, no. of *Helicoverpa* larvae/m row length), natural enemies (no. of coccinellids/plant, no. of chrysopids/plant, parasitization of aphid by *Endaphis aphidimyza* Shiv.) and diseases wilt incidence (%), intensity of *Alternaria* leaf blight), plant characters (plant height, number of capitula/plant, number of grains/capitulum, weight of 1000 grains) and the for the calculation of cost benefit ratio (seed yield, production cost, market price of the produce) had been recorded.

The results indicated that the IPM module was significantly effective over farmers' practices (non-IPM). The mean aphid population was significantly less in IPM module (10.12 aphids/5 cm apical shoot length), where timely sowing (during 1st week of October), border spraying with dimethoate @ 0.05% on four rows on each side and 180 cm across the plot on both sides 30 days after sowing, 1st application of NSKE @ 5% and 2nd application with dimethoate @ 0.05% on reaching ETL of 27 aphids/5 cm apical shoot length was done. In farmers' practices, where only recommended variety was used, sowing was late and no plant protection measures were undertaken, the mean aphid population was significantly higher (52.45 aphids/5 cm apical shoot length) (Table 2). The population of coccinellids (0.73/plant) and chrysopid (0.87/plant) was significantly higher in non-IPM (*i.e.* farmers' practices) as no plant protection measures were undertaken as compared to IPM module. The natural conservation and multiplication of the natural enemies were taken place in farmers' practices as no chemical pesticides were applied under this treatment. Parasitization of aphids by *E. aphidimyza* was also significantly higher (20.73%) in farmers' practices than module (4.99%) (Table 2). Incidence of *Helicoverpa* was very low in both the treatments (0.16 and 0.58 larvae/m row length in IPM module and farmers' practices respectively) which did not attain the ETL (2 larvae/m row length) throughout the season. Wilting was significantly reduced in IPM module (0.51%) as compared to farmers' practices (6%). The usefulness of seed treatment with carbendazim @ 2 g/kg seed has been clearly demonstrated in IPM module. Incidence of *Alternaria* leaf blight did not appear throughout the season in any of the plots.

The results revealed that significantly more plant height (Table 3) was observed in IPM module as compared to farmers' practices. Significantly higher number of capitula/plant (40), no. of grains/capitulum (41) and 1000 grain weight (68 g) were observed in IPM module than farmers' practices. The seed yield was significantly more in IPM module (1525 kg/ha) as compared to farmers' practices (810 kg/ha). It seems that the higher incidence of insect pests and diseases affected the plant health which resulted in lower plant height, grain weight and poor

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yield under non IPM treatment in comparison to IPM treatment. The economics of treatments revealed that highest returns could be obtained with IPM module, with cost benefit ratio of 1: 7.10 as compared to farmers' practice (1: 5.1). Parlekar (1997) had also reported that the effective control of safflower aphid and higher C:B ratio (1:13.32) have been obtained with dimethoate 0.03%. Application of NSKE @ 5% and dimethoate @ 0.05% 15 days there after has been found effective for the control of safflower aphid (Anonymous, 2000).

It can be concluded that the IPM package comprising timely sowing, seed treatment with carbendazim @ 2g/kg seed, border spraying against aphids, ETL based 1st application of NSKE @ 5% and 2nd with dimethoate @ 0.05%, installing bird perches and pheromone traps proved effective and remunerative as compared to the farmers' practices *i.e. non-IPM*.

Table 1 IPM module for safflower crop

Crop stage	Pest (Insect and disease)	Treatment details
Before sowing	Wilt	Select well drained soil, without history of wilt incidence.
	Aphid	Destruction of alternate hosts (*Euphorbia* sp., *Trichodesma indicum* and *Sonchus arvensis*) in and around the field.
At sowing	Aphid and wilt	Use Sharda (BSF 168-4) variety (moderately tolerant to aphid and wilt).
	Aphid and *Alternaria*	Sow the crop from mid September to 1st week of October.
	Fusarium wilt and other seedling diseases	Treat the seed with carbendazim 50 WP @ 2 g/kg seed.
At seedling/ vegetative stage	Weeds	One hoeing and one hand weeding.
	Aphid	Border spraying with dimethoate @ 0.05 % on four rows on each side and 18 cm across the plot on both sides 30 days after sowing to check the aphi population at the initial level of attack so that further spread can be avoidec If the pest incidence exceeds ETL (27 aphids/5 cm apical shoot or twig) apply NSKE @ 5 %. If the pest incidence again exceeds ETL spray the crop with dimethoate @ 0.05 %.
	Helicoverpa	Mechanical collection and destruction of larvae. Install bird perches @ 25/ha (artificial T- shaped bamboo sticks) for resting, watching and predating the insect stages. Install pheromone trap @ 5/ha for monitoring *Helicoverpa*.
	Wilt	Collection and destruction of wilt affected plants.
	Alternaria leaf blight	If disease incidence is noticed spray the crop with 0.2% mancozeb 75WP.
At flowering	Helicoverpa	If the pest incidence exceeds ETL (2 larvae/m row length) treat the crop with HaNPV @ 250 LE/ha or endosulfan @ 0.07 %.
	Alternaria leaf blight	If disease incidence is noticed spray the crop with 0.2% mancozeb 75WP.
At capsule formation/ maturity stage	*Helicoverpa*	If the pest incidence exceeds ETL (2 larvae/m row length) treat the crop with HaNPV @ 250 LE/ha or endosulfan @ 0.07% .

Table 2 **Incidence of pests, their natural enemies and wilt disease under different treatments**

Treatment	Pests		Natural enemies			Wilt incidence (%)
	No. of aphids/ 5 cm apical shoot	No. of *Helicoverpa* larvae/m row	Coccinellids/ plant	Chrysopids/ plant	% parasitism by *E. aphidimyza*	
IPM Module-I	10.12 (3.23)*	0.16 (0.81)	0.26 (0.86)	0.32 (0.90)	4.99 (12.75)**	0.51 (3.89)**
Farmers' practice	52.45 (7.28)	0.58 (1.03)	0.73 (1.10)	0.87 (1.16)	20.73 (26.98)	6.00 (14.07)
Probability values	3.9682E-20	1.88309E-13	2.39201E-16	1.5137E-18	3.12858E-18	7.32215E-20
't' test	S***	S	S	S	S	S

* Figures in parenthesis are √x+0.5 values; ** Figures in parenthesis are angular transformed values; *** Significant

Table 3 Effect of different treatments on the plant biometric parameters, crop yield and cost benefit ratio

Treatments	Biometric parameters					C : B ratio
	Plant height (cm)	No. of capitula/plant	No. of seeds/capitulum	1000 seeds weight (g)	Yield (kg/ha)	
IPM Module-I	99	40	41	68	1525	1:7.1
Farmers' practice	76	17	22	54	810	1:5.1
Probability values	5.75E-20	2.34638E-14	1.41331E-16	5.06734E-15	1.57664E-18	
't' test	S	S	S	S	S	

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References

Anonymous. 2000. Recommendation on plant protection. *Joint AGRESCO Report of Maharashtra Agricultural Universities*, 2000. pp:2.

Parlekar, G.Y. 1997. Screening for aphid (*Uroleucon compositae* Theobald) resistance in safflower (Carthamus tinctorius L.) and management of pest. *Ph.D. thesis*, Mahatma Phule Agricultural University, Rahuri, Maharashtra.

Rai, B.K. 1976. *Pests of Oilseed Crops in India and their Control.* I.C.A.R. publication, New Delhi. p.89.

Sastry, R. Kalpana., Ramachandram, M. and Prasad, M.V.R. 1993. Current status of wilt disease of safflower in India. In : Third International Safflower Conference, June 9-13, 1993, (eds. Li Dajue and Han Yuanzhou) *Beijing, China, pp. 635 (Abstr.).*

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Short communication

Growth rate and income stability of soybean, *Glycine max* (L.) Murrell. in different agro climatic zones of Madhya Pradesh

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Soybean, *Glycine max* (L.) Murrell crop occupies important role in achieving self-sufficiency in edible oil requirement in India. It occupies third place in contribution to national pool of edible oil. Madhya Pradesh produces 70% of total production of soybean in the country. The area under this crop for the country is 6 m. ha with productivity of 1080 kg/ha. Where as world average is 2140 kg/ha. This crop is generally grown under rainfed system. It is concentrated in central India predominantly in M.P., Maharashtra and Rajasthan states. This crop brought immense socio-economic upliftment of farmers especially in M.P. for the last three decades. Athavale (2000) concluded in his study that decline in yield and reduction in price are the main causes for low production in two agro climatic zones of M.P. Gupta and Athavale (1993) concluded that area was the dominant factor for increase in the production of soybean in all the major soybean producing states in the country. The objective of this study is to know the present status of the crops in all the zones of Madhya Pradesh by comparing the growth rates of different districts of soybean producing Agro Climatic zones and between zones.

To find the compound growth rate of the crop for district wise and zone wise, exponential curve $Y = ab^x$ has been employed. It has been estimated as linear equation after taking the log for both sides. The data used for the period is 1990-91 to 1999-2000 i.e. ten years.

log y = log a + x (log b)

Growth rate (%) = [Antilog (log b)-1] x 100

Series of indices of gross income using price discounted to risk has been created to know the stability of returns from this crop.

Index = CV of gross income x (Price of current year/Price of base year)*100

Support Price has been discounted for risk.

There was highly significant increase in area and production of the crop for Narmada Valley zone (Table 1 and Fig. 1). For Satpura zone only area for Betul district showed non-significant positive growth rate. In Vindhya zone all the districts showed highly significant growth rates for area and significant growth rates for production. The growth rates for yield were either non-significant or negative. The growth rates of area and production for Malwa zone were highly significant in most of the districts despite of slow growth of productivity. In this zone, the productivity growth was highly significant for Mandsaur district only. For the Kymore plateau also positive growth rates can be observed for area and production where as growth rates for yield are either non-significant or negative. In aggregate for the MP state both area and productions were highly significant where as yield growth rate was very small and non-significant.

Income indices for Soybean in the state as a whole showed 63.1 % when adjusted for variation due to price and productivity. The maximum indices were noted for Malwa plateau (79.02%) followed by Narmada Valley (69.29%). Lower indices for Satpura plateau was mainly due to rain fed nature of agriculture in the zone.

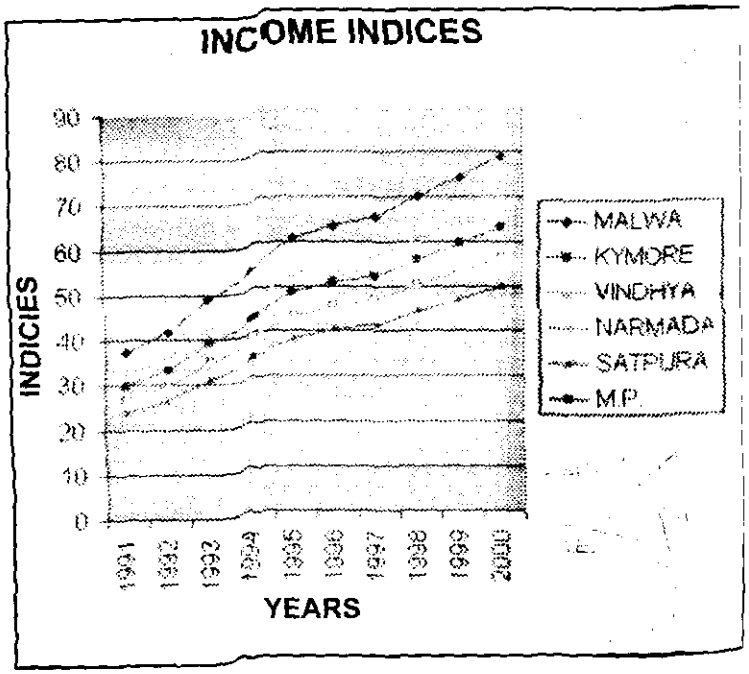

Fig. 1 Zone-wise indices of income of soybean

Table 1 **Compound growth rate of soybean**

Zone	Narsinghpur			Hoshangabad															Zone		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Narmada Valley	10.14**	7.88*	1.85	3.32	4.10	0.09													5.37	6.66	0.94

Zone	Betul			Chindwara															Zone		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Satpura	2.56	-2.55	-4.43	-0.11	-0.79	-2.67													1.50	-2.63	-3.4

Zone	Sagar			Damoh			Bhopal			Sehore			Raisen			Vidisha			Zone		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Vindhya	8.83**	8.59	-2.19	23.21**	22.84**	0.52	6.33**	5.[illegible]	-0.03	4.61**	6.27**	1.75	4.01	7.24*	3.10	8.91*	10.10*	1.08	6.91**	7.81*	0.84

Zone	Ujjain			Mandsour			Ratlam			Sajapur			Indore			Raigharh			Zone		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Malwa	4.91**	7.58**	2.20	12.28*	22.48**	7.72**	7.60**	15.11**	6.77*	5.78**	9.07	3.71*	3.19**	4.06*	0.87	5.45**	16.77**	10.72**	6.11**	9.85*	4.15*

	Dewas			Dhar		
	A	P	Y	A	P	Y
	7.12**	10.04**	2.99	5.94**	6.05*	-0.05

Zone	Jabalpur			Satna			Panna			Seoni			Rewa			Sidhi			Zone		
	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y	A	P	Y
Kymore	10.48*	12.22	1.59	22.74**	19.94*	-0.23	10.36	16.39**	-0.42	0.70	0.71	0.01	25.01**	23.2**	-1.33	39.57**	37.39**	0.63	7.44*	6.88	-0.96
M.P.	10.02**	12.29**	0.94																		

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

Situation for soybean cultivation is alarming in Satpura region, as almost all the growth rates were showing negative trend except area for Betul district. The soybean cultivation may be discouraged in this zone. Some remedial measures were needed for Vindhya and Malwa zones since growth rates for yield in all the districts were non- significant but positive in majority of the districts. For Kymore plateau the yield growth rates were in negative direction for some districts and positive and non-significant for others and for the entire zone also it was negative. For the MP State the aggregate growth rate for yield was just positive and non-significant.

There was an increasing trend in income indices for Soybean crop revealing that over the years even after higher fluctuation in yield and prices of Soybean, the income from this crop increases over the time.

References

Athavale, M. C. 2000. Factor responsible for declining status of soybean in two Agro Climatic Zones of Madhya Pradesh. *Agricultural Situation in India*, **54** (5): 257-260

Gupta, S. K., Athavale, M. C. 1993. Dynamics of soybean and sunflower in India: A state wise analysis. *Indian Journal of Agricultural Economics*, **XLVIII** (3): 423-424

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Short communication

Effect of seed size on growth characteristics and pod yield in groundnut, *Arachis hypogaea* L.

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Seed size is one of the characters that improved significantly during domestication of many crop species. It is not only an important primary component of grain yield but also valuable seed parameter of seedling establishment and crop growth. For the last four to five decades the concept of seed size was studied on physiological parameters and yield for several crops including groundnut and results are controversial in most of the characters studied. A positive relationship was reported between seed sizes of planted seed and seed yield in groundnut (Varman *et al.*, 1992; Borate *et al*, 1993), and in soybean (Saka *et al.*, 1996). However, perusal of the data in oilseed crops indicated that bold seeds did not have any significant influence on yield in soybean (Singh *et al.*, 1972) and in groundnut (Sahoo *et al.*, 1988). Majority of the farmers invariably use their own seeds but ungraded seed. Hence, the present investigation was undertaken in order to determine the effect of seed size on growth characteristics and pod yield in two prominent groundnut cultivars.

A field experiment was conducted during *rabi*, 2002 at wetland farm of S.V. Agricultural College, Tirupathi, A.P on sandy clay loams with two cultivars (JL-24 and TPT-4) and five seed sizes (Bold, medium, small, shrivelled and ungraded seed). The experiment was laid out following factorial randomized block design with three replications. The seed material harvested from the *kharif* crop was obtained from Regional Agricultural Research Station, Tirupathi. The bulk seeds of the two cultivars were graded into five different sizes manually and by its 100 seed mass. The 100 seed mass was 54.8 g in JL-24 and 46.5 g in TPT-4 of bold seed, 41.6 g in JL-24 and 38.03 g in TPT-4of medium seed, 29.5 g in JL-24 and 28.7 g in TPT-4of small seed, 22.05 g in JL-24 and 21.25 g in TPT-4 of shriveled seed and 34.2 g in JL-24 and 33.15 g in TPT-4 of ungraded seed. The crop was sown in an individual plot size of 5.0 m x 2.1 m with a spacing of 30 cm x 10 cm. Recommended doses of fertilizers, 20 kg N, 40 kg P_2O_5 and 50 kg K_2O/ha were applied at the time of sowing. At flowering, 10 kg N/ha and 500 kg gypsum/ha were applied at 5 cm depth by drawing separate lines besides seed rows. The data on leaf area and dry matter was obtained from five randomly selected plants in each treatment and data on yield and yield components were recorded from pods obtained from a square meter of each treatment. The basic data on leaf area and dry matter were used to calculate the growth characteristics as described by Watson and Radford (1967). Seed mass was calculated by taking the weight of 100 seeds obtained from a square meter in each treatment.

Significant differences were observed in crop growth rate and leaf area index among seed sizes, between cultivars and interaction between cultivars and seed sizes (Table 1). Plants from bold seed recorded significantly higher CGR and LAI followed by medium sized seed. This could be ascribed partly to large food reserves present in bold seed and partly attributed to the smaller embryonic activation and enhanced growth rate (Ponnuswamy and Rama Krishnan, 1985 and Khare *et al.*, 1996). Similar results were reported by Chitti Babu (1992) in groundnut. Among the cultivars, JL-24recorded significantly higher CGR and LAI values than TPT-4.

Significant differences were observed in relative growth rate, leaf area ratio and specific leaf area among seed sizes, between cultivars and interaction between cultivars and seed sizes were found to be nonsignificant (Table 1 &2). Higher RGR, LAR and SLA were observed in bold seed followed by medium size while lower values was observed in shrivelled seed. This might be due to large food reserves present in bold seed and high seedling vigor and persistence of seedling vigor during entire crop growth period. Similar results were reported by Chitti Babu (1992) in groundnut. Among the cultivars, JL-24 recorded higher RGR, LAR and SLA compared to TPT-4.

Analysis of the data indicated that significant differences were observed in flower to peg ratio and peg to pod ratio between cultivars and seed sizes (Table 2). The flower to peg ratio and peg to pod ratio were significantly higher in plants from bold seed (43 and 41%) followed by medium sized seed (40.0 and 38.5 %), where as shrivelled seed recorded lower value (29.5 and 27.0 %). This might be due to the influence of seed size over some of the growth parameters recorded had concomitant effect on reproductive efficiency. Similar results were reported by Chitti Babu (1992) in groundnut.

There was significant differences observed in number of pods per plant and 100 seed mass between cultivars and among seed sizes (Table 3). The number of pods per plant and 100 seed mass were significantly higher in plants from bold seed (15.10 and 39.6 g) followed by medium sized seed (12.90 and 35.7g). The lowest number of pods per plant and 100 seed mass were recorded in plants from shrivelled seed (6.9 and 27.1). This might be due to the fact that plants from smaller seed were not able to supply the required metabolites for better pod development. The higher photosynthetic efficiency coupled with higher translocation efficiency might have resulted in proper filling of pods in plants from bold seed (Chitti Babu, 1992). Similar results were reported by Trinadhamurthy (1974) in groundnut. Among the cultivars, JL-24 recorded higher pods per plant and 100 seed mass (11.3 and 34.6g) compared to TPT-4 (10.5 and 31.2 g).

Table 1 Effect of seed size on growth characters in groundnut cultivars

Seed size	Crop growth rate ($g/m^2/d$) (70-80 DAS)			Relative growth rate (g/g/d)(70-80 DAS)			Leaf area index (80 DAS)		
	JL-24	TPT-4	Mean	JL-24	TPT-4	Mean	JL-24	TPT-4	Mean
Bold	32.3	31.3	31.8	0.05	0.05	0.05	3.59	3.33	3.46
Medium	29.5	29.5	29.5	0.05	0.05	0.05	3.38	3.07	3.23
Small	23.7	23.3	23.5	0.04	0.05	0.04	2.84	2.46	2.65
Shrivelled	11.7	10.6	11.1	0.04	0.05	0.04	1.86	1.70	1.78
Ungraded	27.5	24.0	25.7	0.05	0.04	0.04	3.27	3.03	3.15
Mean	24.9	23.7	-	0.04	0.05	-	2.99	2.72	-
	V	**S**	**V x S**	**V**	**S**	**V x S**	**V**	**S**	**V x S**
SEm±	0.14	0.23	0.01	0.0002	0.0003	0.0005	0.006	0.009	0.012
CD (P=0.05)	0.42	0.68	0.03	NS	0.0009	NS	0.017	0.026	0.037

Table 2 Effect of seed size on growth characters in groundnut cultivars

Seed size	Leaf area ratio (cm2/g) (80 DAS)			Specific leaf area (cm2/g) (80 DAS)			Flower to peg ratio			Peg to pod ratio		
	JL-24	TPT-4	Mean	JL-24	TPT-4	Mean	JL-24	TPT-4	Mean	JL-24	TPT-4	Mean
Bold	84.6	80.5	82.6	320.1	310.7	315.4	44.0	42.0	43.0	42.0	40.0	41.0
Medium	84.3	74.3	79.3	303.8	297.1	300.4	40.0	40.0	40.0	38.0	39.0	38.5
Small	84.2	69.5	76.9	289.5	275.9	282.7	34.0	33.0	33.5	33.0	31.0	32.0
Shrivelled	70.2	65.0	67.6	253.4	251.2	252.3	30.0	29.0	29.5	29.0	25.0	27.0
Ungraded	86.9	72.5	79.7	293.9	285.7	289.7	38.0	37.0	37.5	35.0	35.0	35.0
Mean	82.0	72.4	-	292.1	284.1	-	37.2	36.2	-	35.4	34.0	-
	V	**S**	**V x S**	**V**	**S**	**V x S**				**V**	**S**	**V x S**
SEm±	1.05	1.66	2.35	0.40	0.64	0.90	0.03	0.06	0.85	0.04	0.06	0.09
CD (P=0.05)	3.16	5.02	7.08	1.19	1.88	2.70	NS	0.18	NS	0.128	0.20	NS

Table 3 Effect of seed size on yield and yield components in groundnut cultivars

Seed size	No. of pods/plant			100-seed mass (g)			Pod yield (kg/ha)			Harvest index (%)		
	JL-24	TPT-4	Mean	JL-24	TPT-4	Mean	JL-24	TPT-4	Mean	JL-24	TPT-4	Mean
Bold	15.5	14.7	15.1	40.2	38.9	39.6	2425	1953	2189	58.2	60.8	59.5
Medium	13.3	12.5	12.9	36.8	34.5	35.7	2001	1563	1782	59.3	58.9	59.1
Small	9.7	8.9	9.3	32.4	27.7	30.1	1527	1155	1341	51.4	51.7	51.6
Shrivelled	7.3	6.5	6.9	28.4	25.8	27.1	903	895	899	40.4	39.9	40.2
Ungraded	10.5	10.0	10.3	35.1	28.9	32.0	1501	1349	1425	52.3	55.8	54.4
Mean	11.3	10.5	-	34.6	31.2	-	1671	1383	-	54.1	54.6	
	V	**S**	**V x S**	**V**	**S**	**V x S**				**V**	**S**	**V x S**
SEm±	0.06	0.10	0.15	0.28	0.45	0.64	76	12	169	0.37	0.59	0.84
CD (P=0.05)	0.19	0.31	NS	0.85	1.35	1.91	226	357	NS	NS	1.77	NS

The pod yield and harvest index were more in the plants from bold seed followed by medium sized seed while plants from shrivelled seed recorded less pod yield (Table 3). Among the cultivars, JL-24 recorded higher pod yield and harvest index (1671 kg/ha and 59.5%) compared to TPT-4 (1383 kg/ha and 59.1%). This might be due to higher number of pods/plant and 100 seed mass. Dharmalingam and Ramakrishnan (1981) observed increased yield in plants from bold seed because of persistency of seedling vigor during the entire crop growth, high vegetative growth and high peg to pod ratio in peanut. The results obtained in present study have indicated that plants from bold seed produced higher growth characteristics and pod yield in groundnut.

References

Borate, D.N., Dumbre, A.D. and Bhingarde, M.T. 1993. Effect of seed size on growth, yield and seed quality of groundnut under summer conditions. *Seed Research*, **21**: 107-109.

Chitti Babu, G. 1992. Performance of groundnut under different levels of pod grading, plant population and seed invigorations M.Sc. (Ag.) Thesis submitted to ANGRAU, Hyderabad.

Dharmalingam, C. and Ramakrishnan, V. 1981. Studies on the relative performance of sized seed in peanut Cv. Pol. 2. *Seed Research*, **9**: 57-66.

Khare, D., Rout, N.D. Rao, S. and Lakshmi, J.P. 1996. Effect of seed size on growth and field emergence in soybean. *Seed Research* , **23**: 75-79.

Ponnuswamy, A.S. and Ramakrishnan, V. 1985. Seed size in relation to imbibition, emergence and speed of emergence in peanut. *Madras Agricultural Journal*, **72**: 53-56.

Sahoo, A.K., Kulkarni and Vyakaranahal, B.S. 1988. Effect of seed size on yield and quality in bunch groundnut. *Seed Research*, **16**: 136-142.

Saka, K., Shipe, E.R. and Wallace, S.U. 1996. Relationships among plant characters in soybean with different seed size. *Soybean-Genetics News Letter*, **23**: 225-229.

Singh, J.N., Tripathi, S.K. and Megi, P.S. 1972. Not on the effect of seed size an germination, growth and yield of soybean. *Indian Journal Agricultural Sciences*, **42**: 83-86.

Trinadhamurthy, B. 1974. Effect of seed size on plant stand, growth and yield of groundnut. M.Sc (Ag.) Thesis submitted to Acharya N.G. Ranga Agricultural University, Hyderabad.

Varman, P.V., Arjunan, A, Manoharn, V., Ramalingam, R. S. and Sivaram, M.R. 1992. Effect of seed size on dry matter, production and pod yield in groundnut. *Madras Agricultural Journal*, **77**:5-6.

Watson, D. J. and Radford. 1967. The physiological basis of variation in yield. *Advances in Agronomy*, **4**: 101-145.

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