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Review article

Improvement of yield and yield potential in soybean : An analysis and synthesis

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Abstract

Although an yield increase of about 80 to 100% can be potentially realised in soybean by fully adopting the available and recommended production technology, the increase in genetic yield potential is also imperatively needed as the yield gap cannot be fully bridged in a rainfed crop like soybean. Broadening the genetic base of cultivars, hauling in productivity genes and associated characters and crop raising with integrated nutrient management for efficient rubisco performance are the probable ways of breaking the yield barrier in case of Indian soybean. In conclusion, it may be summarised that as stated by Evans and Fischer (1999) greater yield potential remains a valid and by no means an exhausted goal for plant breeding programmes. Use of modern crop improvement techniques, as found appropriate and feasible, should be encouraged. Soybean is well poised to augment Indian economy but there is a need to consolidate the gains yet made and further take off to meet the national and global challenges of agriculture and to ensure household food and nutritional security.

Key words: Soybean, yield potential, genetic base broadening

Introduction

Soybean is the third largest oilseed crop of India. The crop is concentrated in the central Indian niche predominantly in Madhya Pradesh, Maharashtra and Rajasthan states around a latitude range of about 16° to 26° N and longitude range of about 73° to 84° E wherein Indore, the epicentre of soybean renaissance is situated at 22° 44' N and 75° 50' E. Some area is beyond this range also and it is feasible to grow soybean in most parts of the country. Soybean is generally grown as a rainy season crop under rainfed situation. The area predominantly has vertisols and associated soils. Soybean, particularly in its early years of spread, largely occupied the rainy season fallow land. This resulted in an enhancement in the cropping intensity and an increase in the unit area profitability from the land use. Soybean also replaced some less remunerative crops like *sorghum and minor millets. In western Madhya Pradesh,* Maharashtra and Karnataka, some area under cotton is also being replaced by soybean.

The estimates showed that the crop presently covered an area of about 6 million hectares with a production of about 6.8 million tonnes and a productivity of about 1.1 tonne(Table-1). However, the annual capacity of soybean solvent extraction plants is a staggering 16 million tonnes. Soybean cultivation has brought about socio-economic upliftment of farmers especially in the Malwa plateau of M.P. (Badal *et al.*, 2000). The success story of soybean has been told by Tiwari *et al.* (1999).

Table 1 ***Estimates for area, production and productivity of soybean in India***

Year	Area (m.ha)	Production (m.tonnes)	Productivity (kg/ha)
1997-98	5.99	6.46	1079
1998-99	6.49	7.14	1100
1999-2000	5.98	6.79	1135

The basics - defining yield potential

Yield has different meanings depending upon the use of the term. The 'yielding capacity' or 'yielding ability' have been quite frequently used in the 1960's. A clear cut distinction, however, is realised between 'potential yield' and 'realised yield' (Bingham, 1967) wherein 'potential yield' is obtained in farm cultivation but free from the hazards of lodging, fast, insect-pests and diseases whereas the 'realised yield' is a result of these and other stresses. The distinction at the genetic level is between the genes conferring resistance to the various stresses and the genes increasing yield potential, the 'productivity genes'. Yield potential is built up by progressive

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3.5 tonnes/ha is not so uncommon in individual farmer's fields in southern Maharashtra (Table-2), Malwa plateau and some areas of Rajasthan. In particular, certain areas like Kolahapur, Sangli and Aurangabad in Maharashtra state have exhibited very high yield of soybean. There is also a singular report of attaining even 6.5 tonnes/ha soybean yield as cited by Bhatnagar and Tiwari (1997).

Table 2 Districts with high soybean yields in India

District	Area ('000 ha)	Production ('000 t)	Productivity (kg/ha)
Kolhapur	63.6	151.81	2387
Sangli	56.7	127.97	2257
Aurangabad	3.33	5.71	1729
Maharashtra state	1163.6	1619.60	1392

The total yield gap is conceptually divided into two components i.e., Yield Gap I existing between experiment station and potential yields at the farm level, and Yield Gap II existing between potential and actual yield at the farm level. Gap I is conditioned by irreducible environmental factors, while Gap II deals with the biological and socio-economic constraints, the amelioration of which will lead to the realization of the production potential. It is my observation and belief, substantiated by other studies as well, that the Yield Gap II can never be fully bridged in a rainfed crop like soybean. Even in case of cereals under best production systems, it has been observed that annual improvement in national crop yield shows a decline and ceases once the crop reaches about 80% of the potential productivity established by the nation's very best producers (Cassman, 1999, PNAS, USA, 96: 5952-5959). Accordingly, the realisable soybean yield ceiling at the farm level under present situations in India can be estimated to be about 1.6 tonnes/ha on an average at national level.

An average yield level of slightly above two tonnes/ha is easily realised in countries like USA. Yield comparisons across latitudes need adjustment for duration. To offset the latitudinal differences and differences in crop duration or the length of the growing period, the reliable measure for comparison could be the productivity/day. The present national average productivity is about 11-12 kg/day as against about 15 to 20 kg/day in the leading countries. We have to target an average per day productivity of above 15 kg/day and desirably 20 kg/day as national average. If we adjust this average for crop duration of our country, it makes a target of about 1.6 to 1.8 tonnes/ha which should be achievable by all means. The Yield Gap-II has to be bridged to the extent possible by transfer of technology and by enabling farmers to have timely supply of inputs. Availability of quality seeds as the carrier of genetic potential is to be ensured at farm level.

The right approach, however, is to keep on raising the genetic potential for yield along with effective transfer of technology. The trend as observed over the last 12 years in FLDs, however, establishes almost stagnant yield under improved technology.

Theoretical maxima for yield

A linear model often provides the best fit when crop yield is regressed on production year. This, however, can not be the sole basis to project crop yield into the future. This is owing to the fact that a finite supply of solar energy can not be translated into an infinite supply of reduced carbon. There is a biological ceiling or maxima for yield. Thirty-five years ago, de Wit (1967), using some reasonable assumptions about photosynthetic efficiency and respiratory losses, deduced that the biological maximum for biomass yield was about 45 mg/ha (at 40° latitude). Assuming a 50% harvest index, the seed yield limit is inferred to be 22.5 mg /ha.

The agronomy and supply of inputs

Rainfed condition and inadequate water obviously limit absolute crop yield, but these also seem to be an obstacle in terms of the rate of yield improvement. The improvement is more in input-starved environments and the effect decreases as the input supply increases. Cassman (1999) noted that in many countries, annual improvement in national crop yield slowed and ceased once the crop reached 80% (or so) of the potential productivity established by the nation's best producers.

Soils of many soybean growing regions, particularly vertisols and associated soils of Madhya Pradesh (i) have a pH range of about 7.5 to 8.0, (ii) are deficient in phosphorus, (iii) are deficient in sulphur , and (iv) are rich in potassium. Recommended application of macro-nutrients for sole crop of soybean under Indian conditions is basal application of 20 kg N, 60 kg P_2O_5, 20 kg K_2O and 20 kg S/ha. The total nutrient uptake by soybean crop, yielding about 1.5 to 2 tonnes/ha, in the predominant soybean growing region of Malwa Plateau was reported to be around 90 kg N, 7 kg P_2O_5, 40 kg K_2O and 6 kg S which increased on application of fertilisers containing nitrogen and sulphur (Sharma and Gupta, 1992). Phosphorus and sulphur nutrition is of special significance in case of soybean. In addition, 10 tonnes/ha of farmyard manure is also recommended.

In soybean-safflower system on black clay soils, high yield and water use efficiency was found to be optimised through the use of N, P and S @ 40, 22 and 60 to 80 kg/ha in soybean crop and safflower was grown without further fertilizer application and on residual nutrients only (Sharma and Gupta, 1992).

In India, the yield stagnation in several crops is also attributable to poor nutrient management. The main limitations are deterioration of soil organic stock, low assembling of productivity genes as against simultaneous progress in assembling genes for quality and for resistance to insect-pests and diseases and environmental stresses.

Evans (1993) defined yield potential as the yield of a cultivar when grown in environments to which it is adapted; with nutrients and water non-limiting; and with insect-pests, diseases, weeds, lodging and other stresses effectively controlled. This definition has been accepted by others also (Evans and Fisher, 1999) who, however, suggested that 'potential yield' should be used for the maximum yield that could be obtained in a crop as determined by simulation models whereas 'yield potential' should be used mainly for majored comparison of cultivars. This also means that 'potential yield' should be used for comparison between different crops and different environment as well as for estimating plausible future limits to crop yields.

Soybean yield scenario in USA

Recently, Specht *et al.* (1999) have given a perspective of soybean yield potential. It is estimated that soybean yield in the USA have risen at the rate of 22.6 kg/hectare/year from 1924 to 1997, but in the last quarter century (1972-1997) have risen 40% faster, 31.4 kg/hectare/year. Published estimates of the annual gain in yield attributable to genetic improvement averaged about 15 kg/hectare/year prior to the 1980s, but is now averaging about 30 kg/hectare/year in both the public and proprietary sectors.

Soybean yield scenario in China

The average soybean yield in China was only 1.38 t/ha in 1995, while it was 2.30 in the US, 1.92 in Brazil and 2.23 t/ha in Argentina in the same year (Gai, 1999). The restricted growing season in multiple cropping might be a reason for the relatively low unit acreage yield, but the low fertility, cultivation conditions and low yield potential of genotypes could be other important reasons.

Depending upon region and growing conditions the yield goals in a farmers' contest in China were (i) 4.88 t/ha for single cropping in Northeast China, (ii) 4.5 t/ha for double cropping in Huang-Huai-Hai valley, and (iii) 3.75 t/ha for double or multiple cropping in southern China. The record yield reaped in the contest were 4.64 t/ha in Huang-Huai-Hai valley and 6.39 t/ha under irrigated conditions in northern Xinjiang Uygur Autonomous Region. This was against the average field yield of about 1.5 t/ha and high field production yield of about 3.75 t/ha (Gai, 1999).

The Indian soybean yield scenario

Priorities/thrust areas *vis-a-vis* constraints in soybean production: Several constraints to Indian soybean production and productivity namely, a relatively short stay of soybean as a crop, limited genetic diversity, narrow genetic base of Indian soybean varieties, short growing period available in Indian latitudes, stagnant genetic potential for yield, hindered agronomy/availability of inputs at farm level, rainfed nature of crop and water scarcity at critical stage(s) of plant growth, insect-pests and diseases, quality improvement problems, poor seed longevity and mechanical damage to soybean seed, inadequate mechanisation and partial adoption of technology by farmers have been identified (Bhatnagar and Tiwari, 1989; Tiwari, 2001a). The research priorities identified are as follows.

- Assessing system-efficiency and identifying appropriate systems for specific regions/situations
- Integrated nutrient management towards efficient Rubisco performance and increasing cropping system efficiency and global competitiveness
- Broadening of genetic base of Indian soybean varieties
- Hauling in productivity genes and associated characters through development of improved varieties
- Insulation against stresses and yield losses
- Development of early maturing varieties to suit specific conditions
- Augmenting food and feed uses of soybean
- Appropriate mechanisation including that for land treatment, post-harvest processing and value addition,
- Rural and farm credit support, and
- Related technical backstopping, transfer of technology and establishment of "soy-clinics".

Use of modern crop improvement and production techniques should be appropriately and feasibly encouraged. The aspects related to genetic improvement are discussed later in this paper.

Realised and realisable yield potential in India: In India, the exploitable yield potential of varieties is 3 to 3.5 tonnes/ha. It has been estimated that from the year 1969 to 1993, the annual genetic gain in seed yield of soybean varieties has been about 22 kg/ha (Karmakar and Bhatnagar, 1996). Earlier, the emphasis was on breeding varieties mainly with high yield and, to some extant, resistance to diseases but recently equal importance is being given to attributes namely resistance to insects, suitability for food uses, long juvenility and also resistance to rust.

It would be worthwhile to take a stock of the present realised and realisable average yield levels in India. The results from Front Line Demonstrations (FLDs) have shown that the nationwide average realised yield obtained by adopting improved technology is about 2 tonnes/ha as against about one tonne/ha obtained under farmers' practices. It is, however, to be noted that yield level of 2 to er use efficiency, mis-match between nutrient removal and their replenishment, imbalance in NPK ratio, regional disparity in fertiliser consumption and overall sustainability of the system (Singh and Biswas, 2000).

In oilseed crops, sulphur (S) availability is essential (Sexton *et al.*, 1997; Altaf Ahmad and Abdin, 2000; Altaf Ahmad *et al.* 2000). In soybean, a critical level of 1.7 mg available S/kg soil averaged across the root zone, or 34 kg/ha available S has been found to be essential below which specific leaf S declined in a corresponding manner. Rubisco (ribulose 1,5 biphosphate carboxylase/ oxygenase) content and photosynthesis were linearly related. In S-deficient plants, the decline in the ratio of Rubisco/soluble protein implies that other house keeping enzymes become more important than Rubisco for survival (Sexton *et al.*, 1997). Thus, S-application is needed so that a linear increase in yield may be obtained by enhanced nitrogen application.

The fields receiving regular dressings of organic manure may not require supplementation of micronutrients. Application of micro-nutrients *viz.*, zinc @ 2.5 to 5.0 kg/ha, boron @ 2.0 kg/ha, iron @ 4 to 5 kg/ha and molybdenum @ 0.5 to 1.0 kg/ha has been found to increase the soybean grain yield by 2-4 q/ha. Therefore, the balanced application/supplementation of phosphorus, sulphur and micro-nutrients is needed to improve the productivity of soybean under Indian conditions.

Long term experiment (1971-89) on soybean-wheat-corn fodder conducted at Jabalpur (Nambiar and Abrol, 1989) established that (i) the yields of soybean and wheat showed a steady increase provided the system received balanced nutrition, (ii) the average productivity which was 4.0 t/ha for wheat and 2.3 t/ha for soybean during 1971-89 rose to 5.8 and 2.7 t/ha, respectively during 1987-89 by application of recommended levels of NPK fertilizer (Sharma and Gupta, 1992). (iii) beneficial effects of continuous application of sulphur and coupling of farmyard manure were realised with passage of time. These application of recommended levels of fertilizer nutrients integrated with FYM @ 5-10 tonnes/ha/year or at least in alternate years were found to be cost effective and maintained the soil fertility as well.

Studies conducted at the NRCS, Indore on soybean-wheat crop sequence have shown enhanced yield on integrating organic sources *viz.*, FYM, poultry manure, cow-dung slurry and town-waste compost with inorganic sources. A consistent beneficial effect of organic sources by way of physical and microbiological enrichment of soil was also noted.

More studies are, however, warranted on combination of conservation tillage with fertilization, reducing the cost per unit produce, long term sustainability particularly for organic carbon in soil and identification of components in a system, which is desirable yet feasible, to enhance the remunerativeness and global competitiveness of Indian soybean-based cropping system(s). We have to essentially go for a system approach in which components of cropping system, preceding and succeeding soybean, are to be taken comprehensively for standardising not only the most productive but also sustainable systems. Early soybean varieties for maize soybean system in Himachal Pradesh and soybean safflower, soybean pigeonpea and soybean-maize system in Madhya Pradesh are some of the examples which have been found to be highly remunerative and also to have high water use efficiency (WUE) and other desirable attributes of sustainability. It should be remembered that when Green revolution was in offing, commensurate agronomic practices to realise the yield potential of Mexican wheats were given timely. This only exhorts us to emulate the experience and to bring about a much needed impact in realisable yield through agronomic maneuvours.

Insulation against stresses and yield losses

Soybean diseases such as rust, yellow mosaic, collar rot, *Rhizoctonia* aerial blight etc. are collectively causing significant yield losses in soybean. Of late, diseases like rust, *Rhizoctonia* solani rot and some other diseases have become more serious than before. Since last 3-4 years soybean crop is getting regularly damaged by soybean rust caused by the fungus *Phakopsora pachyrhizi*. Earlier the menace used to be confined to north eastern region. Recently, the rust has spread to several parts of Mahakoshal (Hoshangabad, Betul, Chhindwara etc.) and Malwa region of M.P. and also to Vidarbha region of Maharashtra. There is a need to breed resistant varieties for all or the three predominant rust isolates viz. India73 1, Taiwan 72 1 and Taiwan 80 2. Each of the soybean genotypes PI 200492, PI 230970 and PI 462312 (Ankur) had a major gene, i.e., `$Rpp_1$', `Rpp2' and `$Rpp_3$' respectively conferring specific resistance to each one soybean rust isolates. The line PI 459075 carries a single (the fourth) dominant gene i.e. `Rpp_4' for resistance to all the three rust isolates. These sources are, unfortunately, yet to be tapped in India. Rabi/summer crop of soybean should not be taken. Varieties like Ankur, JS 80 21, PK 1024, PK 1029 and Indira Soya 9 showing tolerance to the disease should be promoted.

Basic and strategic research on diseases, incorporation resistance and comprehensive management of diseases including use of bioagents are to be taken up as thrust. Yellow mosaic disease, earlier confined to northern India, is now occurring in the central India. Fortunately, sources of genic resistance are available in adapted genetic background.

Management of insect pests like girdle beetle is also to be taken up on priority. In the predominant soybean growing area in Central India, green semi looper (*Diachrysia orichalcea*), girdle beetle (*Obereopsis brevis*), stemfly (*Melanagromyza sojae*) and blue beetle (*Cneorane* sp.)

are the major insect pests. Some other pests like leaf miner (*Bilobata subsecivella*) in Marathwada region, Bihar hairy caterpillar (*Spilosoma obliqua*) in parts of northern plains and *Terai* region and a few others are also becoming serious. However, breeding for insect pests is yet to receive impetus it deserves.

In order to rationalize use of pesticides and promote alternate management practices, Integrated Pest Management (IPM) is now gaining desired impetus. Based on component wise recommendations, the GOI finalized an IPM package for soybean (TMOP, 1998). NRCS, Indore further undated and refined the package and recommended the IPM practices to be adopted by the farmers.

Losses due to pod-shattering and post-harvest handling are also to be minimised. Several shattering-resistant varieties are available.

Effect of global warming on soybean yield

Rising concentration of atmospheric CO_2 is estimated to have a positive effect on soybean yields (Waggoner, 1984; Allen *et al.*, 1987; Specht *et al.* 1999). This relentless rise in atmospheric CO_2 is currently estimated to be 1.5μL/L/yr. It is estimated that about 10 to 20% of US yield increase i.e. about 1.7 to 3.4 kg /ha/yr of the total increase of 17.3 kg/ha/year from 1963 to 1976 might be owing to a 60 μL/L (about 3.5 μL/ L/yr) increase in CO_2. It is implied that collateral improvement in the photosynthesis/transpiration ratio (i.e. water use efficiency) would certainly offset some of the negative effects of global warming particularly for a C_3 species like soybean that is often exposed to water stress. Farquhar stated that "doubling the CO_2 concentration is almost like doubling the rainfall'.

Genetic improvement of yield and yield potential

There is a need to enhance the genetic potential for yield in soybean. As stated earlier, this is different from and in addition to checking the yield erosion due to insect pests and diseases, shattering loss etc. This also differs from minimising the yield gap II through adoption of package of practices, input supply including seed etc., which is also important.

Gai (1999) has summarised the approaches for genetic improvement for soybean yield as - (i) assembling positive yield genes, (ii) to support yield genes with plant architecture genes as their genetic background, (iii) utilising hybrid vigour, and (iv) to ensure the yield potential realisation through genetic control of negative factors like biotic and abiotic stresses. Broadening the present narrow genetic base of the soybean cultivars, suitable improvisation of breeding methods, use of biotechnology and precision agriculture are important future media for yield enhancement and its realisation. Some of these are briefly discussed below:

Broadening the genetic base: Results of pedigree analysis and diversity analysis in soybean have indicated narrow genetic base of cultivated varieties. Studies in major soybean growing countries like USA (Delannay *et al.*, 1983; Manjarrez-Sandoval, *et al.*, 1997; Kisha *et al.*, 1998; Thompson and Nelson, 1998), Brazil (Hiromoto and Vello, 1986; Vello *et al.* 1988), India (Karmakar and Bhatnagar, 1996) and China (Gai, 1999) have indicated that up to now breeders have used only a small part of available genetic resources and the soybean varieties have a very narrow genetic base. Germplasm enhancement and pre-breeding is needed. There is a need to strengthen the activities in this aspect by resorting to crossing between unadapted genotypes (cultivated)/ alien species especially Glycine soja Siebet Zucc., and elite cultivars.

Strategies for broadening the genetic base of soybean in breeding and production in India have been suggested (Tiwari, 2001b). These comprise : (i) assessing the genetic base through pedigree and other analyses, (ii) directed introductions, (iii) consolidating the national germplasm collections, (iv) evaluation and establishment of a core collection of soybean genetic resources, (v) pre-breeding and germplasm enhancement using the cultigen as well as wild species, (vi) population improvement, (vii) enhancing genetic diversity at farm level by farmer participatory approaches, and (viii) facilitated access to soybean genetic resources for the users. Further enhancement of genetic resources, pre-breeding and ultimate widening of the genetic base of the cultivars at farm level will eventually lead to the realisation of high productivity.

Assembling the 'Productivity Genes': As stated earlier assembling yield genes is different from genetic protection against stresses. Quantitative trait loci for seed yield and closely related characters have been mapped in soybean (Mansur *et al.*, 1993, 1996; Maughan *et al.*, 1996; Mian *et al.*, 1996). These are either available or will become eventually available especially with the tools of marker-assisted selection.

Effect of associated characters: The yield potential can be enhanced by increasing the contribution of yield components *viz.* pods per plant and physiological characters like specific leaf weight, efficient and high nodulation, better translocation and partitioning etc. Most soybean varieties are highly sensitive to changes in latitude or planting date because of their responsiveness to variations in photoperiod. The short photoperiod of the tropics caused most soybean germplasm to flower and mature too rapidly for adequate growth and yield. The use of the long juvenility trait was the solution found by soybean breeders. This trait is being incorporated in the Indian soybean varieties by the NRCS scientists.

Substantial genetic gain in yield may be achieved if breeders are able to produce cultivars with faster growth rates and greater biomass at maturity. Genetic

...soybean yields has been found to be associate... assimilate supply during seed filling period [redacted] ...changes in harvest index. There appeared to ...little change in soybean harvest index (Frederick and Hesketh, 1994). Along with photosynthate supplied to sinks, changes in some other traits namely more pods, lodging resistance, greater N_2 fixation, greater stress tolerance and (Specht *et al.*, 1999) have also been, more or less, responsible for yield improvement. In India, screening for several of these characters has been undertaken and varieties such as 'Hardee' have been identified to possess desirable physiological and morpho-anatomical characters, for use as donors in breeding programmes (Bhatia *et al.*, 1996).

Some worrying trends indicated that improvement in yield through breeding of high yielding cultivars was associated with greater seed size and poorer seed quality and also less protein and more oil (Voldeng *et al.*, 1997).

Hybrid soybean: Soybean is a self-pollinated crop. Still, enhancing the yield and other characters through hybrid vigour appeared to be a realisable possibility in this crop. The earlier attempts of using genetic male sterility have recently been replaced by a better option of tapping cytoplasmic male sterility. The first report of cytoplasmic male sterility in soybean came through a USA patent taken by Davis (1985). He used 'Elf', 'Bedford' and 'Braxton' as parents to create a cytoplasmic-nuclear male-sterile line. Later, several sources of nuclear-cytoplasmic male sterile lines and their maintainers and restorers were reported in China by Sun *et al.* (1997) and Sun *et al.* (1999) such as 035x167, NJCMS1A and NJCMS1B, W931A and W931B, and FuCMS series. The former one was developed from an interspecific cross, and the latter three were developed from crosses between cultivated parents. In addition, a photoperiod-sensitive male sterile line was also reported to have potential for hybrid seed production. Vectors such as bees and thrips have also been tried for pollination by some researchers.

Identification of desirable cross combinations giving significantly higher seed yield combined with the use of male sterile lines and methods of producing large quantities of hybrid soybean seed have not yet reached the level of commercial acceptability.

Augmenting food and feed uses of soybean

Soybean has a long history of its use as a traditional source of food and feed in the Indian sub-continent especially in northern regions starting from the erstwhile North West Frontier Province to Kumaon to Nagaland as documented by Tiwari (2001). At present, soybean is being utilised as a cash crop through the import of DOC earning about Rs. 1500 crores annually. A negligible portion of soybean is utilised for food uses in the country. Oil, in fact, comes as a by product. Country loses a huge amount of protein owing to the export of soymeal. The recent trend of increased home-utilisation of soymeal to the tune of 1.0 million tonnes in India is highly encouraging (Jain, 1999). Recession in the global price of soymeal has also prompted several private agencies and solvent extraction plant owners to initiate diversified use of soymeal in the country itself. Still in near future the use of soybean as an animal feed will be much more than as human food.

There is a great need to introduce nullness for anti-nutritional factors viz. trypsin inhibitor and lipoxygenses. In India, the varieties developed with high protein and oil namely, 'Punjab 1' (41% protein) and 'NRC 7' (up to 22% oil) are available. Similarly varieties like 'Punjab 1', 'Hardee' and 'PK 472' have been found suitable for food uses and 'tofu'-making and the 'tofu', soy-paneer, prepared using these varieties has organoleptic acceptance in India (Bhatnagar and Tiwari, 1991).

As stated earlier, null-lines/varieties for anti-nutritional factors (ANF) are not yet available in India. However, screening for lipoxygenases and trypsin inhibitor content at the NRCS, Indore has helped in identifying varieties with relatively lower content of these ANFs. Varieties namely 'Hardee' and 'Punjab-1' were identified to possess low level of trypsin inhibitor activity (Kumar *et al.* 2001). 'Shilajeet' and 'KhSb2' were found to possess the lowest level of lipoxygenase-I and lipoxygenase-II + III (collectively) among the Indian varieties tested whereas among indigenous material, 'Punjab 1' and 'JS 2' were found to be low in lipoxygenases-I as well as lipoxygenase II+III (collectively) (Kumar *et al.* 2002). The varieties identified with low level of lipoxygenases can be exploited for food uses of soybean as the various soy-products prepared therefrom would be associated with low level of beany flavour/off-flavour. Recently a green soybean variety, 'Hara Soya (Himso 1563)', has been developed which is suitable for use as a vegetable at green pod stage.

The presently available and identified varieties with relatively low levels of ANFs may not be enough to meet the growing need of the industry. There is a need to further develop varieties suitable for food uses. This is being attended to at the NRCS (ICAR). Further efforts in breeding varieties for diversified uses and their qualitative evaluation are continuing with a renewed thrust. There is a need to introduce null-lines for ANFs and also lines with desirable food quality characters for use in Indian soybean improvement programme.

References

Allen, Jr., L.H., Boote, K.J., Jones, J.W., Jones, P.H., Valle, R.R., Acock, B., Rogers, H.H. and Dahlman, R.C. 1987. Response of vegetation to rising carbon dioxide: Photosynthesis, biomass, and seed yield of soybean. *Global Biogeochemical cycles*, **1**: 1-14.

Altaf Ahmad and Abdin, M.Z. 2000. *Photosynthesis and its* related physiological variables in the leaves of Brassica genotypes as influenced by sulphur fertilization. *Physiologia Plantarum*, **110**: 144-149.

Altaf Ahmad, Ishrat Khan, and Abdin, M.Z. 2000. Effect of sulfur fertilisation on oil accumulation, acetyl-CoA concentration, and acetyl-CoA carboxylase activity in the developing seeds of rapeseed (*Brassica campestris* L.). *Australian Journal of Agricultural Research*, **51**:1023-1029.

Badal, P.S., Praduman Kumar, Billore S.D., Sharma A.N. and Joshi, O.P. 2000. Socio-economic impact of soybean cultivation in Madhya Pradesh. Project Report of IARI and NRCS (ICAR). pp. 1-35.

Bhatia, V.S., Tiwari S. P. and Joshi, O. P. 1996. Interrelationship of leaf photosynthesis, specific leaf weight and leaf anatomical characters in soybean. Indian *Journal of Plant Physiology New Series*, **1** (1) : 6-9.

Bhatnagar, P.S. and Tiwari, S.P.1989. Yield gap and constraint analysis for harnessing productivity potential of soybean in India. *Proc. World Soybean Research Conference IV* (5-9 march, 1989). Buenos Aires, Argentina, Vol. II. pp. 811-819.

Bhatnagar, P. S. and Tiwari, S.P.1991. Genotypic differences for organoleptic acceptance of soyapaneer (tofu). *Biovigyanam*, **17**(2): 90-93.

Bhatnagar, P.S. and Tiwari, S.P. 1997. *Soybean* yield gap analysis in India. In *Proceedings of the World Soybean Research Conference V* (21-27 February, 1994) held at Chiang Mai, Thailand'. Kasetsart Univ. Press, Thailand. pp. 547-548.

Bingham, J. 1967. Breeding cereals for improved yielding capacity. *Annals of Applied Biology*, **59** : 312 - 315.

Cassman, K.G. 1999. Ecological intensification of cereal *production systems : yield potential*, soil quality and precision agriculture. *Proceedings of National Academy of Sciences*. **96** : 5952 - 5959.

Davis, W.H. 1985. Route to hybrid soybean production. *United States Patent*, 4,545,146.

Delannay X., Rodgers, D.M. and Palmer, R.G. 1983. Relative genetic contributions among ancestral lines to North American soybean cultivars. *Crop Science*, **23**: 944-949.

De Wit, C.T. 1967. *Photosynthesis : Its relationship to overpopulation*. In : A. San Pietro *et al.* (ed.) Harvesting the sun. Academic Press, New York. pp. 315-320.

Evans, L.T. 1993. *Crop evolution, adaptation and yield*, Cambridge University Press, Cambridge.

Evans, L.T. and Fischer, R.A. 1999. Yield potential : its definition and significance. *Crop Science*, pp.**39** (6) : 1544 - 1551.

Frederick, J.R. ***and*** **Hesketh, J.D.** ***1994.*** *Genetic improvement in soybean : Physiological attributes*. P. 237-286. In G.A. Slafer (ed.) *Genetic improvement of field crops*. Marcel Dekker, New York.

Gai, Junyi. 1999. *Strategies and approaches for future breeding* toward high yields in China. In *"Proceedings of the World Soybean Research Conference VI"*, held at Chicago, USA, August 4-7, 1999. Ed. H.E. Kauffman, The University of Illinois, USA. pp.126-130.

Hiromoto, D.M. and Vello, N.A.. 1986. [illegible] Brazilian soybean (*Glycine max* (L.) Me[illegible]vars. *Brazil Journal of Genetics*, **9**: 295-306.

Jain, Davish. 1999. Soya-industry scenario. SOPA Digest: Soybean Processors Association of India Publication, May, 1999 Issue. pp. 27-30.

Karmakar, P.G. and Bhatnagar, P.S. 1996. Genetic improvement of soybean varieties released in India from 1969 to 1993. *Euphytica*, **90**: 95-103.

Kisha T.J., Diers, B.W., Hoyt, J.M. and Sneller, C.H. 1998. Genetic diversity among soybean plant introductions and North American germplasm. *Crop Science*, **38** : 1669-1680.

Kumar, Vineet, Anita Rani and Tiwari S.P. 2001. Comparative activity of trypsin inhibitor among released soybean varieties/strains of India. *Ind J. Nutr. Dietet.* **38**: 437-440.

Kumar, Vineet, Patra, S., Anita Rani and Tiwari, S.P. 2002. Indian soybean varieties with low levels of lipoxygenase isozymes. *Journal of Food Science and Technology*, **39** (1): 75-76.

Manjarrez-Sandoval, **P.,** ***Carter, Jr.T.E.,*** **Webb D.M. and Burton, J.W. 1997.** RFLP genetic similarity and coefficient of parentage as genetic variance predictors for soybean yield. *Crop Science*, **30**: 1033-1040.

Mansur, L.M., Orf, J.H., Chase, K., Jarvik, T., Cregan, P.B. and Lark, K.G. 1996. Genetic mapping of agronomic traits using recombinant inbred lines of soybean. *Crop Science*, **36** : 1327 - 1336.

Mansur, L.M., K.G. Lark, Kross H. and Oliveira A. 1993. Interval mapping of quantitative trait loci for reproductive, morphological and seed traits of soybean (*Glycine max* L.). *Theoritical and Applied Genetics*, **86** : 907 - 913.

Maughan, P.J., Saghai Maroof, M.A. and. Buss, G.R. 1996. Molecular-marker analysis of seed weight : Genomic locations, gene action and evidence for orthologous evolution among three legume species, *Theoritical and Applied Genetics*, **93** : 574 - 579.

Mian, M.A.R., Bailey, M.A., Tamulonis, J.P., Shipe, E.R., Carter, Jr., T.E., Parrot, W.A., Ashley, D.A., Hussey, R.S. and Boerma, H.R. 1996a. Molecular markers associated with seed weight in two soybean populations. *Theoritical and Applied Genetics*, **93** : 1011 - 1016.

Nambiar, K.K.M. and Abrol, I.P.. 1989. Long term experiments in India-a review. *Fertilizer News*, **34**:11-20.

Sexton, P.J., Batchelor W.D. and Shibles, Richard. 1997. Sulfur availability, Rubisco Content, and Photosynthetic-Rate of Soybean. *Crop Science*, **37**:1801-1806.

Sharma, R.A. and Gupta, R.K. 1992. Response of rainfed soybean (Glycine max) - safflower (*Carthamus tinctorius*) sequence to nitrogen and sulphur fertilization in vertisols. *Indian Journal of Agricultural Sciences*, **62**: 529-534.

Singh, G.B. and Biswas P.P. 2000. Balanced and integrated nutrient management for sustainable crop production. *Fertiliser News*, **45**(5) : 55-60.

Col· ...J.E.,. **Hume D.J and Kumudini S. V. 1999.** Soybean eld potential - A genetic and physiological perspective. *rop Science*, **39** (6) : 1560 - 1570.

Sun, H., Linmei, Z. and Mei, H. 1997. Cytoplasmic-nuclear male sterile soybean line from interspecific crosses between *G. max* and *G. soja*. In *"Proc. World Soybean Research Conference V"*, Chiang Mai, Thailand (Feb. 21-27, 1994)". Kasetsart Univ. Press, Thailand. pp. 99-102.

Sun, H., Zhao, L.M., Li, J.P. and Wang, Q.A. 1999. The investigation of heterosis and pollen transfer in soybean. In *"Proceedings of the World Soybean Research Conference VI"*, held at Chicago, USA, August 4-7, 1999. Ed. H.E. Kauffman, The Univ. of Illinois, USA.pp. 489-490.

Thompson J.A., and Nelson, R.L. 1998. Utilisation of diverse germplasm for soybean yield improvement. *Crop Science*, **38**: 1362-1368.

Tiwari, S.P., Joshi, O.P. and Sharma, A.N. 1999. The advent and renaissance of soybean in India - A landmark in Indian agriculture. NRCS Publication, pp. 1-58.

Tiwari, S.P. 2001a. Introduction, diversity and enhancement of Soybean Genetic Resources in India - A status report. Consultancy Report for the IPGRI, Rome Italy. pp. 1-67.

Tiwari, S.P. 2001b. Shattering the production constraints in soybean-based cropping systems. *JNKVV Research Journal*, **35**(1&2): 1-7.

Vello, N.A., Hiromoto D.M. and Azevedo Filho A.J.B.V.1988. Coefficient of parentage and breeding of Brazilian soybean germplasm. *Brazil Journal of Genetics*, **11**: 679-697.

Voldeng, H.D., Cober E.R., Hume D.J., Gillard C. and Morrison, M.J. 1997. Fifty-eight years of genetic improvement of short-season soybean cultivars in Canada. *Crop Science*, **37**: 428-431.

Waggoner, P.E. 1984. Agriculture and carbon dioxide. *Am. Sci.* **72**:179-184.

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Review article

Stability analysis in niger : A Review

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Abstract

Niger is extensively grown as a rainfed crop in marginal and submarginal sloppy lands by tribal farmers. The fluctuating yields in different parts of India, require the development of stable genotype of niger across the environment. Niger varieties show a wide range of fluctuations in their performance. Some genotypes perform well over a wide range of environments while others require specific environmental conditions to express their full genetic potential. This paper critically reviews the existing information on stability and G x E interaction (linear and nonlinear) in niger crop, which can be helpful to the Breeder to make progress in niger improvement program for development of stable variety with high yield potential across the environments.

Key words: Stability, G x E, niger

Introduction

A successfully developed new cultivars should have sustained stable performance and broad adaptation over a wide range of environments, in addition to high yield potential. Evaluating performance stability and range of adaptation is becoming increasingly important for breeding programs. Many methods of analysis for stability have been proposed. The regression technique for examining the G x E interaction was first suggested by Yates and Cochran (1938). This technique was used and modified by Finlay and Wilkinson (1963) to analyze the adaptation of 277 barley cultivars grown at different environments. Later, Eberhart and Russel (1966) proposed the use of two stability statistics i.e., regression coefficient (bi) and deviation from regression (S^2_d) to estimate stability. They defined a stable cultivar as one having a regression coefficient of unity (bi = 1) and a minimum deviation from regression ($S^2_d = 0$). Genotypic stability analysis was proposed by Tai (1971), using a model that measures the linear response of a genotype to environmental effects (ai) and the deviation from linear response (λi). He defined a perfectly stable cultivar as one that has (ai, λI) = (-1, 1). A cultivar of average stability has (ai, hi) = (o, 1). Tai (1971) approach is similar to that of Eberhart and Russel (1966) in attempting to determine the linear response of a cultivar to the environmental effects. Tai's model differs in the estimation of statistics determining stability. Theoretically, it involves an extension of the conventional mathematical model for the analysis of variance, and it estimates the potential of a genotype to stabilize its performance over various environments. Plaisted and Peterson (1959)used analysis of variance to estimate the variance component of G x E interaction for individual genotype in one year. Wricke (1962) proposed to use to G x E interaction effects for each genotype as a stability measure ,which he termed as ecovalence (Wi). Shukla (1972) developed an unbiased estimate using stability variance of a genotype and a method to test significance of the stability variance for determining stability of a genotype. This method used a covariant to remove the linear effect from G x E interaction . The remainder of this interaction could be assigned to each cultivar and the significance of each component could be tested. The statistical formulae, application, and relationship of some of the methods described above were discussed by Lin *et al.* (1986) and by Becker and Leon (1988). Eberhurt and Russel (1966) method has been used extensively in crop breeding programmes, but those proposed by Tai (1971) and Shukla (1972) have seldom been used. Lin and Binns (1988) concluded that since stability and adaptability are important selection criteria in breeding programmes, additional research on stability is needed for a better estimate of crop performance and adaptability.

The adaptation of a crop, its ability to survive in a particular environment and to exploit its various productivity features, is under extremely complex genetic control (Hawtin *et al.*,1996) . A plant must be able to withstand extremes of temperature, moisture, photoperiods, light intensity, and a range of soil physical and chemical

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...itions. *It* must be capable of exploiting both its physical and biological environments, and be able to remain productive under biotic stresses. It must thrive in a diversity of locations and under conditions that may vary widely, gradually rapidly, throughout its life cycle.

The total edible oil consumption is projected to increase at 5.5 to 6.0%/annum, of which about 2% will be on account of rise in population and the rest due to increase in purchasing power. Thus, there is an urgent need to step up oilseed production on a sustainable basis to meet the needs of increasing population and expanding demands (Hegde, 1998). Therefore, significant improvement in crop productivity must be achieved by identifying suitable stable variety over locations and seasons for seed yield is today's demand. In view of this, the present paper deals with the current status of knowledge and future research needs to develop genotypes with desired responses at varying environmental conditions in niger.

Stability and G x E interaction in niger

In India, niger although a minor oilseed crop in the World and national economy of India, is of considerable importance for rainfed conditions on poor soils in marginal lands. India is the chief producer of niger in the world. The low yields of niger are due to poor seed setting resulting from protrandrous self incompatibility mechanism reinforced by vector pollination and inconsistency in performance of a genotype over locations and seasons. Thus, the goal of the niger breeder must be to develop superior varietal population, to obtain diverse types and churning of suitable recombinants for stable genotypes of niger over a wide range of environments, otherwise it will be a day dream. The presence/absence of linear/nonlinear G x E interaction as reported by different research workers is presented in Table-1.

Joshi and Patil (1982) studied four promising introductions of niger at three locations in Maharashtra State for seed yield. They observed significant G x E interaction for seed yield; however the nonlinear component of G x E interaction was larger in magnitude. The Digraj location was the favourable environment and Igatpuri location was the poorest environment. IGP-76 had highest seed yield, though its regression value was little more but its deviations were the least, indicating its adaptability to different environments and an ideal genotype in the present study. The performance of all introductions was very poor at Igatpuri.

Verulkar and Upadhyay (1989) evaluated nine varieties of niger for stability parameters with respect to seed yield and its components in nine environments, created by agronomic manipulations under rainfed condition. The creation of environments by manipulating sowing dates and fertilizer doses was effective in generating variability in environments as indicated by significant environments. There were significant differences among the regression values of nine genotypes as indicated by significant G x E sum of squares. This suggested that variations in the performance of varieties when grown over environment could be predicted. The linear component of G x E interaction was larger in magnitude than nonlinear component for all the traits. Mean square due to pooled deviation were also significant for all attributes, except 1000 seed weight. Thus, the performance of varieties with respect to 1000 seed weight was entirely predictable in nature; while that of other traits was not. CHH-1 was the only genotype found to be stable and desirable for seed yield/plant. This variety was found stable for plant height and 1000 seed weight also. However, Gaudaguda-1 and N-71 has yielded significantly higher than other cultivars but significant deviation from regression renders them unstable and hence undesirable. Variety ONS-4 with lowest yield was found to be the most unstable and undesirable for all the traits except 1000 seed weight.

Misra *et al.* (1991) studied eighteen improved niger varieties during rainy and winter season for two years. Average yield during rainy and winter season were 4.6 and 6.4 q/ha respectively. A yield reduction of 28% (1.8 q/ha) in rainy season was mainly due to rains during flowering period which prevented insect pollination. The varieties showed differential adaptation to different seasons. The varieties suitable for rainy season were: ONS-7, ONS-5, ONS-2, GA-10 and CHH-1 and winter season were: ONS-4, GA-1, ONS-2, ONS-8 and GA-5.

Upadhyay (1993) evaluated ten genotypes of niger over four years for stability parameters with respect to seed yield and six other yield components under rainfed conditions. Linear as well as nonlinear G x E interaction was observed; however, nonlinear portion was larger in magnitude for yield components and linear portion for seed yield. CHH-3 was found to be stable and desirable genotype for all traits studied under varied environmental conditions. Varieties like CHH-1, CHH-2 and Ootacmund with high seed yield were also stable for most of the characters including seed yield

Kumar *et al.* (1993 and 1994) studied 20 niger selections for their stability of yield and seven yield attributing traits over four different crop growing conditions. They observed presence of G x E interaction; however, linear portion of G x E was much larger in magnitude for all characters except days to 50% flowering and capitula/plant. They have identified few stable selections viz; Phule-1 and GA-10 for seed yield/plant. Similarly N-5 and ONS-8 for 1000 seed weight and NBC-2 and KEC-7 for oil content, Gaudaguda for days to maturity, over a wide range of environments. Therefore, they have suggested that such genotypes may be used in hybridization programme to converge stability characteristics of these genotypes for different yield contributing traits to the development of a stable variety/varieties in a wide range of environments.

Kumar *et al.* (1998) studied 20 niger genotypes under four micro-environments for yield/ plant, oil content, harvest index and five other yield components. They have compared the model of Eberhart and Russel (1966) and Perkins and Jinks (1968) and concluded that both the models were associated with each other, thus ranking pattern of genotypes for their stability in both the models were same. However, no genotype has shown average stability for all the traits. The genotypes Phule-1 and GA-10 were stable for yield/plant and NBC-2 and KEC-7 were stable for oil content.

Borole *et al.* (1998) evaluated eight genotypes of niger at seven locations in Maharashtra State for selection of stable variety of niger. They observed significant G x E interaction. On partitioning of it, the linear component was larger in magnitude for all traits studied; indicating prediction can be possible across the environments. The genotype IGP - 76 was found with average stability for yield and yield components.

Kumar *et al.* (1998a) studied 20 niger genotypes for stability, on the basis of 12 yield related traits obtained from trials conducted at Ranchi (Bihar) during *kharif* 1998 under four experiments (combination of late sown/ normal sown and fertilizer/ non-fertilized). G x E interactions were found to be significant for several characters. They have concluded that the cultivars Phule-1, Gaudaguda, GA-1, GA-10, N-5, NBC-2 and RCR-140 may be used in hybridization programme for development of stable varieties for range of environments.

Patil *et al.* (1999) studied adaptability analysis for seed yield and other seven yield components for 12 genotypes of niger over six environments. Significant differences were observed for genotypes and environments, suggesting presence of substantial genetic variability among genotypes and environments studied. G x E interaction was observed significant for all traits studied. However, the linear component has contributed major share. The genotypes *viz.*; IGP - 76 and IGPN - 9628 were found responsive and adaptable to all environments for all the traits; while, IGPN - 9610 was responsive and stable for seed yield (q/ha), days to flower, days to maturity and branches/ plant. The correlation among the stability parameters indicates that those are under the control of different gene or genes in combination in niger.

Hegde *et al.* (1999b) studied 13 genotypes of niger over seven locations in India for seed yield, days to flower, days to maturity, capsules/plant and branches/plant. They observed presence of G x E interaction; however, linear G x E interaction shares more than the nonlinear G x E interaction. for all the traits studied; suggesting possibility of predicting the performance of a genotype across the environment. The genotype *viz.*; JNS - 1, JNC - 3, GA - 10 and IGP - 76 were responsive and stable across the environments for all traits studied.

Hegde *et al.* (1999a) evaluated six niger composites along with three check varieties at seven locations *viz*: Semiliguda, Udaipur, Kanke, Jagadalpur, Igatpuri, Raichur and Chhindwara. They have reported presence of G x E interaction for all characters; however, linear component was larger in magnitude than the nonlinear G x E interaction for all characters, suggesting the variation in the performance of different composites can be predicted over environment. Environment + (G x E) interaction was also found significant for all traits. On examination of individual parameters of stability for different composites and varieties, it is concluded that the composite JNC - 11 and variety IGP-76 possess average stability for all characters, suggesting their suitability for inclusion in breeding programme for development of stable variety/composite. The correlation among stability parameters indicated that stability parameters are under the control of different gene or genes in combination.

Hegde *et al.* (1999) evaluated eight genotypes of niger over seven locations with respect to seed yield. Significant G x E interaction was observed. On partitioning linear component was higher than the nonlinear component. Accordingly, the genotypes *viz.* JNS-7, GA-10, BNS-9, SNS-8 and No.71 were observed to be well adapted over environments. Mean performance was positively and significantly associated with regression coefficient and coefficient of determination, indicating that the genotypes with high mean performance were in general, better responsive to favourable environment. A positive and significant correlation was also observed, indicating that the stability parameters were governed by independent genetic system in niger.

Patil *et al.* (1999) conducted adaptability analysis for seed yield and other seven-yield component for 12 genotypes of niger over six environments. Significant differences were observed for genotypes and environments, suggesting presence of substantial variability among the genotypes and environments studied. Genotypes x Environment interaction were observed for all characters studied. However the linear component has contributed major share. The genotypes *viz.*, IGP-76 and IGPN-9628 were found adaptive and responsive to all environments for all the traits, while IGPN-9610 was found responsive and stable for seed yield q/ha, days to flower, days to maturity and branches/plant. The correlation among parameters indicates that they appeared to be under the control of different gene or genes in combination in niger.

Goswami *et al.* (2000) studied the performance of eight strains of niger under All India Co-Ordinated Programme at six locations during *kharif* 1998 for four characters. The G x E linear was significant for grain yield (q/ha). Suggesting the differential responses under different locations. The strain JNC-11 was found highly stable for all characters studied.

Hegde *et al.* (2000) evaluated eight elite genotypes of niger over seven locations for seed yield and other three attributes. Significant mean sum of square due to genotypes, environments, G x E interaction were observed. Both the components of G x E interaction for the expression of these traits, however, linear component was larger in magnitude than the non-liner. BNS-9, SDN-8 and IGP-76 possessed average stability for all the traits studied. Thus, it was recommended that these genotypes may be utilized for hybridization programme in the niger improvement work. Significant and positive correlation between mean performance and regression coefficient, coefficient of determination was observed for all the traits, revealing that the genotypes with high mean performance for these traits were in general better responsive to the favourable environments. The stability parameters appeared to be governed by different gene or genes in combination in niger.

Patil and Purkar (2000) evaluated seven elite genotypes of niger along with three released varieties as check for stability parameters with respect to seed yield and oil content at five locations in Maharashtra state under rainfed condition. Significant differences for genotypes and environments were observed indicating presence of sufficient genetic variability among genotypes and environments studied. The G x E interaction was found significant On partitioning of it into linear and non-linear, both components were observed significant. However, linear component was larger in magnitude than the nonlinear component of G x E interaction, suggestion that prediction can be possible across the environment for seed yield and oil content. The genotypes IGPN-9628 and IGP-76 for oil content were found to be stable. The study of association among the stability parameters indicated that the stability parameters were found under the control of different gene or genes in combination.

Patil *et al.*(2000) evaluated eight genotypes of niger over seven locations in Maharashtra State for seed yield and five yield components. The variance due to genotypes, environments, G x E interactions, environment + (G x E) and environment linear were found significant. On partitioning of G x E interaction, both components were significant; however, linear component was larger in magnitude, indicating its significance in the inheritance of these traits. On perusal of individual parameter of stability, the genotype IGP - 76 was found most responsive and stable for all characters studied. The genotype Phule - 4 was found stable for seed yield and capitula/plant; whereas, UN - 4 have shown below average stability for 1000 seed weight and seeds/capitulum.

Patil (2001) studied ten genotypes of niger at five locations in the Maharashtra state during *kharif* 1997-98 under rainfed conditions. Genotype x Environment interaction was present for all the characters studied. On partitioning of it, linear and non-linear, both components were equally responsible. However, the linear component was larger in magnitude for all traits except days to flower. The genotypes IGP-76 for all traits and IGPN-9628 for all traits except days to maturity were found responsive and stable. The study on correlation among stability parameters suggested that the stability parameters appeared to be governed by different gene or genes in combination with niger.

Patil *et al.* (2002) studied adaptability analysis for seed yield and seven yield components for 12 genotypes of niger. Significant differences were observed for genotypes and environments, suggesting presence of substantial genetic variability among the genotypes and environments studied. G x E interaction was observed for all characters studied. However, the linear component has contributed major share. The genotypes *viz*; IGP - 76 and IGPN - 9628 were found responsive and stable for seed yield, days to flower, days to maturity and branches/plant. The correlation among the stability parameters indicated that they appeared to be under the control of different gene or genes in combination in niger.

Strategies to be followed to develop stable genotype

The breeding approach should be based on sporophytic self incompatibility system. The methodology to enhance inbreeding, should be standardized to develop S_1, S_2 lines as in maize. The best combiners based on combining ability studies can be selected and suitable mating system may be followed to develop synthetics and composites. The progress in these systematic studies depends on continuous hard work and the generation of quality data.

When fixable additive variance is more, the parents show a high GCA indicating the absence of inbreeding depression. However, in niger the heterozygosity is maintained by the presence of self incompatibility. Hence, the breeding programmes should based on the reproductive system. Secondly, the thrust should be given for oil quality and byproducts utilization since they are of having export value which will fetch more foreign exchange to the country and will help in boosting up the economy of the country.

The niger seed contains 40 to 43% oil with fatty acid composition of 75 to 80% linolic acid, 7 to 8% palmitic and stearic acid (Dagne and Jonsoon, 1997). Thus, it is very good and safe oil for human consumption as the oil containing high amount of linolic acid prevent cardiovascular disorders such as coronary heart disease, antherosclerosis and high blood pressure. There are reports also that niger oil is used for birth control and for treatment of syphilis (Belayneh, 1991). Such an important oilseed crop improvement must get momentum in the improvement work by utilizing the breeding techniques such as development of self compatible lines and inbreeds, synthetics, composites, component breeding approach and heterosis breeding approach as suggested by Trivedi *et al.*(1987) and their evaluation across the environments for consistency in the performance.

Table 1 Presence/absence and magnitude of G x E interaction in niger as reported by different workers

Reference	Year	Character	Linear	Nonlinear
Joshi and Patil	1982	Seed yield	* Low	** High
Verulkar and Upadhyay	1989	Days to flower	** High	** Low
		Days to maturity	** High	** Low
		Plant height	** High	**Low
		Branches/plant	** High	** Low
		Capsules/plant	** High	** Low
		1000 seed weight	NS Low	* High
		Seed yield/plant	** High	** Low
Upadhyay	1993	Days to flower	** Low	** High
		Days to maturity	** Low	** High
		Plant height	** High	** Low
		Branches/plant	** High	** Low
		Capsules/plant	** High	** Low
		1000 seed weight	** Low	** High
		Seed yield/plant	** High	** Low
		Oil content	** High	** High
Kumar et al.,	1993	Days to flower	* Low	** High
		Days to maturity	* High	* Low
		Plant height	** High	** Low
		Capsules/plant	NS Low	NS High
		Capsule diameter	* High	NS Low
		1000 seed weight	** High	** Low
		Seed yield/plant	NS High	NS Low
		Oil content	* High	** Low
Kumar et al.,	1994	Days to flower	* Low	** High
		Days to maturity	* High	* Low
		Plant height	** High	NS Low
		Capsules/plant	NS High	NS Low
		Capsule diameter	NS Low	* High
		1000 seed weight	** High	** Low
		Seed yield/plant	NS High	NS Low
		Oil content	** High	** High
Kumar et al.,	1998	Days to flower	* Low	* High
		Days to maturity	* High	* Low
		Plant height	** High	NS Low
		Capsule diameter	* High	NS Low
		1000 seed weight	* High	** Low
		Seed yield	NS High	NS Low
		Oil content	NS High	** Low
		Harvest index	NS High	NS Low
Kumar et al.,	1998a	---Original not seen---		
Hegde et al.,	1999	Days to maturity	** High	* Low
		Branches / plant	* High	* Low
		Capsules / plant	** High	** Low
		Seed yield q/ha.	** High	** Low
Hegde et al.,	1999	Days to maturity	** High	* Low
		Branches / plant	** High	** Low
		Capsules / plant	** High	** Low
		Seed yield q/ha.	** High	** Low

Contd....

Reference	Year	Character	Linear	Nonlinear
Hegde *et al.*,	1999	Seed yield q/ha.	** High	** Low
Patil *et al.*,	1999	Seed yield q/ha	** High	* Low
		1000 seed weight	** High	* Low
		Seeds / capitulum	** High	* Low
		Capitula / plant	* High	* Low
		Days to maturity	** High	* Low
		Plant height	* High	* Low
Hegde *et al.*,	2000	Days to maturity	* High	* Low
		Branches / plant	* High	* Low
		Capsules / plant	** High	** Low
		Seed yield q/ha.	** High	** Low
Patil *et al.*,	2000	Seed Yield (q/ha)	** High	* Low
		1000 seed weight	** High	* low
		Seeds/Capsule	** High	** low
		Capsules/plant	* High	* low
		Days to Maturity	** High	* low
		Plant height	* High	* low
Patil and Purkar	2000	Seed Yield (q/ha)	* High	* low
		Oil content per cent	** High	** low
Goswami *et al.*,	2000	Grain Yield q/ha	** High	-
		Days to Maturity	-	High
		Branches/plant	-	High
		Capsules/plant	-	High
Patil	**2001**	Seed Yield (q/ha)	* High	* Low
		Oil content (per cent)	NS High	NS low
		Seeds/capsule	** High	** low
		Capsules/plant	* High	* low
		Branches/plant	* High	* low
		Days to Maturity	* High	* low
		Days to flower	NS low	NS High
		Plant height	* High	* low
Patil *et al.*,	2002	Seed Yield (q/ha) and its components	* High	* low

References

Becker, H. C. and Leon, J. 1988. Stability analysis in plant breeding. *Plant Breeding*, **101**:1-23.

Belayneh, H. 1991. Oil crop germplasm: A vital resource for the plant breeders. In J. M. M. Eagles; J. G. Hawkers and M. Worede edited "*Genetic Resources of Ethiopia*", Cambridge. pp.344-354.

Dagne, K. and Jonsoon, A. 1997. Oil content and fatty acid composition of seeds of *Guizotia* Cass (Compositae). *Journal Science, Food and Agriculture*, **73**:274-278.

Eberhart, S. A. and Russel, W. 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 programmes. *Australian Journal of Agriculture Research*, **14**:742-754.

Goswami, U., Duhoon, S.S. and Singh, B. R. 2000. Stability performance of some yield attributes in niger (*G. abyssinica* Cass.). A paper presented in national seminar on "Oilseeds and Oils- Research and development needs in the Millennium, held at DOR, Hyderabad during 2-4 Feb, 2000. Extended summaries Abstract No. 69 p. 107.

Hawtin, G., Iwanga, M. and Hodgkin, T. 1996. Genetic resources in breeding for adaptation. *Euphytica*, **92**:255-266.

Hegde, D. M. 1998. Integrated nutrient management for production of Oilseeds: A Review. *Journal of Oilseeds Research*, **15**(1):1-17.

Hegde, D. M., Patil. H. S., Singh B. R. and Goswami, U.1999. Phenotypic stability for seed yield in niger. *Journal of Oilseeds Research*, 16(2):241-244.

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

Hegde, D. M., Patil ,H. S., Singh, B.R. and Goswami, U. 1999. Genotype x Environment interaction in niger composites. *Journal of Maharashtra Agricultural Universities*, **24**(3):246-248

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

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

Kumar, S., Mahto, J. and Prasad, K.D. 1998. Analysis of stability for yield and yield attributes in niger (*Guizotia abyssinica* Cass). *Journal of Oilseeds Research*, **15**(1):18-24.

Kumar, S., Mahto, J., Prasad, K.D. and Kumar, Amrendra. 1998a. Genotype x Environment interaction stability analysis in niger. *Journal of Research* (Birsa Agriculture University), **10**(1): 20-24.

Kumar, S., Singh, P. K. and Trivedi, H. B. P. 1993. Stability of yield and its components in niger (*Guizotia abyssinica* Cass) in different growing conditions. *Oil Crop Newsletter*, **10**:71-73.

Kumar, S., Singh, P. K. and Trivedi, H. B. P. 1994. Stability of yield and its components in niger (*Guizotia abyssinica* Cass). *Journal of Research* (Birsa Agricultural University), **6**(1):1-5.

Lin, C. S., Binns, M. R. and Lefkovitch, L. P. 1986. Stability analysis: Where do we Stand. *Crop Science*, **26**: 894-900.

Lin, C. S. and Binns, M. R. 1988. A method of analysing cultivar x location x year experiment: A new stability parameter. *Theorotical and Applied Genetics*, **76**:425-430.

Misra, R. C., Pradhan, K., Paikaray, R. K., Sahu, P. K. and Panda, B. S. 1991. Seasonal adaptability of niger varieties. *Oil Crop Newsletter*, **8**:26-27.

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

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

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

Patil, H. S. and Purkar, J. K.. 2000. Analysis of stability for seed yield oil content in niger. *Journal of Oilseed. Research*, **17**(1):43-46.

Patil, H. S., Purkar, J. K. and Duhoon, S. S. 1999. Adaptability analysis in niger. National Seminar on "Regulatory Measures and Crop Improvement-policy Implications". MPKV, Rahuri - 413 722 (M.S.), during 23 - 24 December 1999. Souvenir pp. 125-126.

Perkins, J. M. and Jinks, J. L. 1968. Environmental and genotype-environmental components of variability. III. Multiple lines and crosses. *Heredity*, **23**:339-356.

Plaisted, R. L. and Peterson, L. C. 1959. A technique for evaluating the ability of selections to yield consistently in different locations or seasons. *American Potato Journal*, **36**:381-385.

Shukla, G. K. 1972. Some statistical aspects of partitioning genotype-environment components of variability. *Heredity*, **29** : 237-245.

Tai, G. C. C. 1971. Genotypic stability analysis and its application to potato regional trials. *Crop Science*, **11**:184-190.

Trivedi, H. B. P., Haider, Z. A. and Sinha, P. K. 1987. Approaches for higher oil yield in niger (*Guizotia abyssinica* Cass). *Oil Crop Newsletter*, **4**:65-69.

Upadhyay, P. C. 1993. Stability analysis for seed yield and its components in niger under rainfed conditions. *Journal of Oilseeds Research*, **10**(2):206-210.

Verulkar, S. B. and Upadhyay, P. C. 1989. Phenotypic stability for yield and yield contributing characters of niger under rainfed conditions. *Journal of Oilseeds Research*, **6**(2):322-327.

Wricke, G. 1962. Uber eine methate zur erfassung der okologischen streubreite in Feldversuchen. *Z. Pflanzenzuchtg*, **47**:92-96.

Yates, F. and Cochran, W. G. 1938. The analysis of groups of experiments. *Journal of Agricultural Sciences*, **28**:556-580.

Variation in seed and pod characteristics in relation to cooking time among valencia groundnut, *Arachis hypogaea* L. germplasm

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Abstract

The freshly harvested in-shell groundnut (*Arachis hypogaea* L.) and groundnut seeds boiled in brine are consumed as snacks in many parts of the world. Groundnuts with 3-4 seeded pods, large-seeds, low cooking time (CT), low oil and high protein contents, and sweet taste are preferred for boiling uses. Thirty-three valencia germplasm lines were grown during the 1995 rainy and 1995/96 postrainy seasons at ICRISAT Center, Patancheru, India. Fresh- and cured-pods and seeds of each genotype were evaluated for physicochemical traits and CT. The CT of untreated (without pre-soaking) and pre-soaked (water or 1% brine) seeds and pods were compared. The pre-soaked treatments resulted in significant reduction in CT. The reduction in CT was greater in brine-soaked seeds and pods than that of in water-soaked seeds and pods. Growing season had significant influence on CT. For fresh-seed boiling, the produce of postrainy season and for cured-seed boiling, the produce of rainy season was preferable. There was no consistency in association of CT with seed traits. It changed with treatments of seeds. ICG# 326, 1307, 2148, and 6224 were the most preferred genotypes identified for boiling uses. These can be used in a breeding program to develop better boiling type groundnuts.

Key words: Peanut (*Arachis hypogaea*), cooking time, boiled groundnut, germplasm

Introduction

Groundnut (*Arachis hypogaea* L.) is the world's fifth most important source of edible oil and vegetable protein. It contain 44 to 56% oil and 22 to 30% protein on a dry seed basis and is a rich source of minerals (phosphorus, calcium, magnesium, and potassium) and vitamins (E, K, and B group) (Savage and Keenan, 1994). Oleic, linolic, and palmitic acids together account for over 80% of the total fat in groundnut oil (Dwivedi *et al.*, 1993). Sucrose accounts for 90% of the total carbohydrates among different botanical types in groundnut (Pattee *et al.*, 2000). About two thirds of the world groundnut production is crushed for high quality edible oil and the remainder is consumed as human food in various forms. Over the last three decades, there has been a gradual shift away from oil and meals into confectionery use, with major increase in Asia, Latin America, and the Caribbean countries than in Africa (Freeman *et al.*, 1999). The food uses of groundnut include (i) peanut butter, (ii) roasted shelled nuts, (iii) in-shell roasted nuts, (iv) in-shell boiled nuts, (v) confections and candies, and (vi) groundnut-based fortified foods.

The freshly harvested in-shell groundnut and groundnut seeds boiled in brine are consumed as snack in many parts of the world. Genotypes with a greater proportion of 4- and 3-seeded pods, large-seeds, low cooking time, low oil, high protein, and sweet taste are preferred for boiling. Groundnut genotypes belonging to the valencia group (subsp. *fastigiata* var. *fastigiata*) have higher proportion of 3- and 4-seeded pods, and seeds are sweater in taste than other botanical groups. Not much is known about seed and pod traits preferred in boiling use, their interaction with each other, and the genetic variation available for them.

Duration of cooking time affects the seed composition of groundnut. Long duration causes a reduction in soluble carbohydrates, soluble protein, and free amino acids, but total protein, insoluble carbohydrates, and oil remain unaffected. While the total seed protein content remains unaffected during boiling, the protein and polypeptide compositions are greatly altered (Murugesu and Basha, 1989). The duration of cooking and cooling time also affects the salt concentration of frozen boiled valencia groundnut (Ammerman *et al.*, 1971). Heating temperature has a highly significant effect on the flavor scores of peanut paste. Samples heated in water at higher temperatures had less of the flavor usually associated with raw, wet groundnuts and were not as 'harsh' or 'bitter' as those heated at lower temperatures (McWatters and Heaton, 1974). Seed weight and volume, swelling index, and hydration capacity were positively correlated with cooking time in chickpeas (Williams *et al.*, 1983). Cooking time was negatively correlated with soluble sugar and positively correlated with protein content of dry legumes (Akinyele *et al.*, 1986).

The present experiment was carried out to study variation in 33 valencia groundnut germplasm lines for seed and pod characteristics in relation to cooking time, and to identify genotypes with desirable traits for boiling uses.

Materials and methods

Thirty-three valencia germplasm lines including control cultivar Gangapuri were grown unreplicated under high input (4.2 kg P/ha as basal, 400 kg Gypsum/ha at peak flowering, irrigation, and protection against insect pests and foliar diseases) conditions during the 1995 rainy and 1995/96 postrainy seasons at ICRISAT Center, Patancheru, India. They were individually bulk harvested at maturity in each season and the bulk pod samples were brought to laboratory for cleaning and storage. The cleaned fresh- pods and-seeds, and cured-pods and-seeds (pods sun dried to seed moisture content of about 8%) bulks, each divided into nine samples, were stored in a cold room at 5° C. The nine samples, which served as experimental units corresponding to each pod/seed treatment, were randomly allocated to three soaking treatments, untreated (without effecting pre-soaking), pre-soaking (16 h) of pods and seeds in distilled water, and pre-soaking (16 h) of pods and seeds in brine (1% saline), each treatment receiving three samples. Observations on optimum cooking time of seeds and pods of each genotype under three soaking treatments, fresh- and cured-pod weight; seed weight, seed volume, and seed density of the cured-seed; and hydration and swelling capacity of the pre-soaked (in water and brine) fresh- and cured-pods and-seeds were recorded as follows.

Cooking time (CT): For determination of CT of seed, a block digestor (Model 20 DB, Tecator, Sweden) was used to maintain uniform and constant temperature. Twenty-five mature seeds of uniform size were placed in a 250 ml glass digestion tube containing 100 ml of boiling distilled water. For determining CT of pod, 10 mature pods of uniform size were placed in 100 ml boiling water in a 250 ml glass beaker covered with watch glass on a sand bath. Boiling in both cases continued until the desired softness of the seed, as determined by pressure of the fingers, was realized. The time taken (in min) to achieve the desired softness in the seed was recorded as the CT of the sample (seed or pod).

Pod weight (PW) and seed weight (SW): Randomly selected ten mature pods or 25 mature seeds were weighed (in g).

Hydration capacity (HC): Twenty-five seeds or ten pods were transferred to a 250 ml beaker containing 100 ml water or brine and left at room temperature for 16 h. The hydrated seeds or pods were taken out and the water on pods or seeds surface was removed by absorbent paper. These pods or seeds were reweighed to determine HC;

HC/seed = (Weight of sample after soaking – weight of sample before soaking)/ # seed

HC/pod = (Weight of sample after soaking – weight of sample before soaking)/ # pod

Seed volume (SV): Twenty-five mature seeds were placed in a 100 ml measuring jar containing 30 ml of water and the increase in volume was recorded as the volume of the seeds (in ml).

Seed density (SD): It was calculated as the ratio of seed weight to seed volume in g/ml.

Swelling capacity (SC): The soaked seeds obtained from HC observation were placed in a 100 ml measuring cylinder containing 40 ml distilled water and the increase in volume was determined to calculate SC;

SC/seed = (volume of the sample after soaking – volume of the sample before soaking)/ # seed

The observations on shelling and chemical characteristics of each genotype were recorded as follows.

Shelling characteristics: A random sample of 500 g mature cured pods of each genotype was taken to record pod and seed characteristics. For seeds per pod, the bulk pod sample was separated into 4-, 3-, 2- and 1-seeded pods. The proportion for each category of pods was determined and seeds per pod was expressed based on the descending order of their proportions of different number of seeds per pod for a given genotype. Later on, same pod sample was shelled to determine the shelling outturn. From the shelled seeds, 100-mature seeds were randomly selected and weighed for seed mass (in g).

Chemical characteristics: Bulk sample of untreated (without pre-soaking) sound mature cured-seeds of each genotype was analysed for oil and protein contents and fatty acid composition. Oil content was determined using Nuclear Magnetic Resonance Spectrometry (Jambunathan *et al.*, 1985). For estimating protein content, nitrogen content was determined by Technicon auto analyzer (Singh and Jambunathan, 1980) and a factor of 5.46 was used to convert nitrogen into crude protein content. Fatty acid methyl esters (FAME) of triglycerides were prepared (Hovis *et al.*, 1979) and analysed to estimate individual fatty acid contents (Dwivedi *et al.*, 1993). From the fatty acid estimates, the following seed quality characteristics were determined (Mozingo *et al.*, 1988) : (i) oleic (O)/linolenic (L) acid ratio = % oleic acid/% linolenic acid; (ii) polyunsaturated (P)/saturated (S) acid ratio = % linolenic acid/total saturated fat (TSF), where TSF = % palmitic acid + % stearic acid + % arachidic acid + % behenic acid + % lignoceric acid.

Statistical analysis for PW, SW, SV, SD, HC, and CT was carried out following a multi-factor completely randomized design analysis of variance. Simple correlations among these traits were determined. No statistical analysis was carried out for shelling and chemical characteristics as they were based on single determination.

Results and discussion

Variation in PW, HC, and CT of fresh- and cured-pod

Pod boiled in water without pre-soaking: The genotypic differences in PW and CT of the fresh-and cured-pod were significant (P<0.01). Their range and mean are presented in Table-1. The average fresh PW was significantly greater than cured PW because of higher moisture content in seed and shell in the former. No genotype recorded significantly greater fresh PW than control Gangapuri (49 g). However, ICGs 43, 288, 2738, 3195 and 6479 had significantly lower fresh PW (35-39 g) than Gangapuri. None of the genotypes showed significantly greater or lower cured PW than Gangapuri (31 g). This indicated that genotypes had varying moisture content in pod at the time of harvest. However, after curing the difference in moisture content disappeared and cured PW became similar. The average CT of cured-pods was 6 times more than that of fresh-pods (34 min). The CT of fresh-pod in all genotypes including Gangagpuri (34 min) did not differ significantly with each other. The differing moisture content of fresh-pod of genotypes did not have any influence on their CT. While ICGs 319, 355, and 1961 recorded significantly lower CT for the cured-pods (180-187 min), the remaining genotypes did not differ significantly from Gangapuri (205 min).

Pod pre-soaked prior to boiling: The differences for HC and CT between fresh- and cured-pods, and pre-soaking treatments (water and brine), and among genotypes were significant (P<0.05-0.01).

The range and mean for HC and CT of the pre-soaked fresh- and cured-pods of 33 genotypes are also presented in Table-1. The HC (g/seed) of cured-pods was more than 2.5 times greater than that of fresh-pods in both pre-soaking treatments, primarily because of the initial higher moisture content in the latter. The HC of fresh-pods was similar in both water and brine. The same was also true for cured-pods. The HC of water soaked-fresh pods of test genotypes was similar to that of Gangapuri; but for cured-pods, it was, in case of ICG 1384 (1.04 g/seed), ICG 6224 (0.74 g/ seed), and ICGs 1307 and 6479 (0.73 g/seed each), significantly greater than Gangapuri (0.62 g/ seed). The HC of brine soaked-cured-pods of ICGs 42, 288, 1611, and 30 was significantly lower (0.44-0.45 g/seed) and that of ICG 6224 (0.78 g/seed) significantly greater than that of Gangapuri (0.64 g/seed). The average CT of brine-soaked fresh- and cured-pods was significantly lower than that of the water-soaked fresh- and cured-pods. The average reduction in CT of brine-soaked pod was 3 min for fresh-pods and 7 min for cured-pods. Genotypic differences in CT of water- and brine-soaked fresh-pods were nonsignificant. The CT of water-soaked cured-pods of 29 genotypes (112-127 min) and of brine- soaked cured-pods of 9 genotypes (105-112 min) was significantly lower than Gangapuri (135 min for water-soaked and 120 min for brine-soaked cured-pods). ICGs 42, 319, 326, 355, 1384, 1830, 2148, and 3195 were common in both soaking treatments. ICGs 319 and 326 in water-soaked (111.7 min) and ICG 2148 in brine-soaked (105.0 min) treatments had the lowest CT. These three genotypes also had the lower CT than Gangapuri for cured-pods without pre-soaking treatment.

Table 1 Range and mean of 33 groundnut genotypes for pod weight (PW) and cooking time (CT) of fresh and cured pods boiled in water and for hydration capacity (HC) and CT those soaked for 16 h in water and brine prior to boiling, 1995 rainy season

Pod type		Fresh and cured pods boiled in water			
		PW (g)		CT (min)	
		Range	Mean	Range	Mean
Fresh-pod		35-55	46	32-38	34
Cured-pod		24-37	30	180-217	203
SEm±			0.5		1.1
Pre-soaking	Pod type	Fresh and cured pods soaked for 16 hr in water and brine prior to boiling			
		HC (g/pod)		CT (min)	
		Range	Mean	Range	Mean
Water	Fresh pod	0.16-0.34	0.25	26-32	29
	Cured pod	0.46-1.04	0.63	112-137	123
Brine	Fresh pod	0.14-0.31	0.22	23-29	26
	Cured pod	0.44-0.78	0.61	105-123	116
SEm±			0.009		0.6

Variation in SW, SV, SD, HC, SC, and CT of the fresh- and cured-seed

Seed boiled in water without pre-soaking: Differences between seasons (except for SD), and seed curing, and among genotypes were significant (P<0.05-0.01) for SW, SV, SD, and CT. Season x seed curing (except for SD), season x genotype, seed curing x genotype interactions were also significant (P<0.05-0.01) for these characteristics. Season x seed curing x genotype interaction effect was significant only for SV (P<0.05) and CT (P<0.01).

The post-rainy season produce recorded greater mean SW (fresh-seed 17.1 g in post-rainy and 12.2 g in rainy and cured-seed 10.4 g in post-rainy and 7.2±0.09 g in rainy seasons) and SV (fresh-seed 18.2 ml in post-rainy and 13.1 ml in rainy and cured-seed 10.6 ml in post-rainy and 7.4±0.10 ml in rainy seasons) than rainy season. Season had no effect on average SD of fresh- and cured-seeds. The average CT of post-rainy season cured-seeds was significantly greater (85 min) than that of the rainy season cured-seeds (62±0.26 min). The average CT of rainy season fresh-seeds, on the contrary, was significantly greater (22 min) than that of the post-rainy season fresh-seeds (17±0.26 min).

The range and mean of 33 genotypes for SW, SV, SD, and CT of the fresh- and cured-seeds are presented in Table-2. The average SW and SV of fresh seeds were significantly greater than those of the cured-seeds. The reverse was observed for SD and CT. The average CT of cured-seeds was 3.86 times greater than that of the fresh-seeds (19 min). ICG 6224, USA 857, and ICGs 3195 and 1929 for SW (15.7-18.1 g), ICGs 1693 and 6224 for SV (17.3-19.4 ml), and ICG 1929 for SD (0.99 g/ml) recorded significantly greater values than Gangapuri (SW 14.7 g, SV 15.9 ml, and SD 0.91 g/ml) for fresh-seeds. The CT differences of fresh-seeds of genotypes were nonsignificant. For cured-seeds, no genotype recorded significantly greater SW and SV than Ganagapuri (SW 9.3 g, and SV 9.9 ml). The SD of cured-seeds of ICGs 1307, 1672, and 1693 was significantly greater (1.03-1.08 g/ml) than Gangapuri (0.95 g/ml). Except for ICG 408, which had significantly lower CT and ICGs 58 and 1757 which had similar CT as that of Gangapuri (64 min), all other genotypes showed significantly greater CT (68-87 min) than the latter for cured-seeds. USA 857 took longest time to cook.

Seed pre-soaked prior to boiling: The differences between seed curing and pre-soaking treatments, and seasons, and among genotypes were significant (P<0.1) for HC, SC, and CT. Genotype x seed curing, genotype x season, and seed curing x season effects were also significant (P<0.05-0.01) for these traits. Several other interactions were also significant (P<0.01) for CT.

Effect of seasons was significant for seed HC, SC, and CT. The HC and SC of postrainy season pre-soaked fresh- and cured-seeds were significantly greater than those of the rainy season. The CT of rainy season pre-soaked fresh- and cured-seeds, on the contrary, was significantly greater than that of the postrainy season.

The average HC, SC, and CT were significantly reduced in brine soaked compared to water-soaked fresh- and cured-seeds (Table-3). The % reduction in HC and SC was greater in fresh- seeds than in cured-seeds. On the contrary, the % reduction in CT was greater in cured-seeds than in fresh-seeds.

Table 2 Range and mean of 33 groundnut genotypes for seed weight (SW), seed volume (SV), seed density (SD) and cooking time (CT) of fresh and cured seeds boiled in water, 1995 rainy and 1995/96 post-rainy season

Seed type	SW (g)		SV (ml)	
	Range	Mean	Range	Mean
Fresh seed	12.0 - 18.0	14.6	12.7 - 19.4	15.6
Cured seed	5.8 - 10.3	8.8	6.3 - 10.4	9.0
SEm ±		0.06		0.07

Seed type	SD (g/ml)		CT (min)	
	Range	Mean	Range	Mean
Fresh seed	0.90 - 0.99	0.94	17-21	19
Cured seed	0.92 - 1.08	0.97	61-87	74
SEm±		0.003		0.2

Table 3 Range and mean of 33 groundnut genotypes for hydration capacity (HC), selling capacity (SC) and cooking time (CT) of fresh and cured seeds soaked for 16 h in water and brine prior to boiling, 1995 rainy and 1995/96 post-rainy seasons

Pre-soaking	Seed type	HC (g/seed)		SC (ml/seed)		CT (min)	
		Range	Mean	Range	Mean	Range	Mean
Water	Fresh-seed	0.02-0.09	0.05	0.02-0.08	0.05	19-26	21.8
	Cured-seed	0.25-0.34	0.28	0.20-0.35	0.27	18-22	36.9
Brine	Fresh-seed	0.02-0.05	0.03	0.02-0.07	0.04	29-42	19.4
	Cured-seed	0.22-0.33	0.26	0.21-0.34	0.26	23-35	28.7
SEm±			0.003		0.002		0.13

The water-soaked fresh-seeds of ICG 30 and both, water- and brine-soaked cured-seeds, of ICG 6224 showed significantly greater HC (g/seed) than similarly pre-soaked seeds of Gangapuri (water soaked fresh-seed 0.042 g/seed, water soaked cured-seeds 0.284 g/seed, and brine soaked cured-seeds 0.265 g/seed). ICGs 2148, 3114, 3195, 6224, 6479, 1961, and 7223 in water soaked fresh-seeds, ICG 6224 in water soaked cured-seeds, ICG 2148 in brine soaked fresh-seeds, and ICGs 326, 1929, 3114, and 6224, and USA 857 in brine soaked cured-seeds showed significantly greater SC (ml/seed) than *Gangapuri (water soaked fresh-seeds 0.027ml/seed, water* soaked cured-seeds 0.287 ml/seed, brine soaked fresh-seeds 0.040 ml/seed, and brine soaked cured-seeds 0.243 ml/seed). ICGs 42 and 58 in water soaked fresh-seeds, ICG 1307 in water soaked cured-seeds, and ICGs 30, 43, 58, 288, 326, 1307, 1377, 1384, 1611, 1672, 1693, 1830, and 2148 in brine soaked fresh-seeds had significantly lower CT than Gangapuri (water soaked fresh-seeds 21.8 min, water soaked cured-seeds 32.7 min, brine soaked fresh-seeds 21.2min, and brine soaked cured-seeds 22.5 min). Several genotypes which had lower than or similar CT as Gangapuri, in both water and brine soaked seeds, had higher CT than Gangapuri on curing. ICGs 42, 1307, 1693 and 355 had lowest CT under different treatments.

Variation in shelling and chemical characteristics

The genotypes differed in seeds per pod, shelling outturn, 100-seed weight, and seed color. All the genotypes, except for ICGs 30, 42, 43, and 319, were grouped into either 4-3-2-1 or 3-4-2-1 seeded pods, a trait very much preferred for in-shell boiled groundnut uses. ICGs 30, 288, 335, 326, 409, 1611, 1693, 2148, 3114, 3195, 3217, 6224, and 7223, and USA 857 recorded 70-73% shelling outturn compared with 68% of Gangapuri. Of these, ICGs 30, 409, and 6224 had also higher 100-seed weight (50-55 g) than Gangapuri (42 g). Except for ICGs 319 and 1693 with tan color seeds, the other genotypes were red seeded. Both red and tan color seeded groundnuts are acceptable for edible purpose.

The untreated (without pre-soaking) fresh- and cured-seeds were boiled and eaten to determine their taste. Genotypes identified with sweet taste for both fresh- and cured-seeds were ICGs 30, 1377, 1830, 3117, 6479, and 7223.

ICGs 1377, 1612, and 1757 had relatively low oil (450-460 g/kg dry seeds) and high protein (290 g/kg dry seeds) contents. All the genotypes showed a lower O/L ratio (0.88-1.02) indicating their shorter shelf-life (Branch *et al.*, 1990; James and Young, 1983), but had better nutritional quality because of their higher P/S ratio (1.61-1.96) (Mozingo *et al.*, 1988).

Relationship of seed and pod characteristics with CT

Fresh PW (without pre-soaking) was not correlated with CT but cured PW (without pre-soaking) was correlated with CT ($r = 0.45^{**}$). While pre-soaked fresh PW was negatively correlated with CT ($r = -0.27^{**}$ for water- and -0.34^{**} for brine-soaked fresh-pods), no such relationship was observed in pre-soaked cured-pods.

Correlations among SW, SV, SD, HC, SC, and CT of the untreated (without pre-soaking) and pre-soaked fresh- and cured-seeds are presented in Table-4. For both fresh- and cured-seeds without pre-soaking, SW, SV, SD, and CT (except for SV with CT for fresh-seed) were significantly positively correlated with each other. SW and SV were strongly correlated. In comparison with fresh-seeds, a stronger correlation was observed between SW and SD and SW and CT in cured-seeds. The reverse happened in the case of association between SV and SD and SV and CT. The positive relationship of CT with HC and SC in water-soaked fresh-seeds reversed to negative in brine-soaked fresh-seeds. HC and SC were positively correlated with each other both in water- and brine-soaked cured-seeds. The positive correlation of SC with CT in brine-soaked cured-seeds was not maintained in water-soaked cured-seeds.

Table 4 Correlation of seed weight (SW), seed volume (SV), seed density (SD), hydration capacity (HC), swelling capacity (SC) and cooking time (CT) of fresh and cured seeds of groundnut boiled in water and those soaked for 16 h in water and brine prior to boiling

Treatment	Character	SW	SV	SD	CT
Fresh and cured seeds# (without pre-soaking)	SW	-	0.97**	0.35**	0.13*
	SV	0.96**	-	0.11*	0.09
	CT	0.47**	0.50**	0.19**	-
		HC	*SC*	*CT*	
Pre-soaked fresh seed##	HC	-	0.19**	0.25**	
	SC	0.09	-	0.47**	
	CT	-0.11**	-0.21**	-	
Pre-soaked cured seed###	HC	-	0.84**	0.08	
	SC	0.85**	-	0.06	
	CT	0.08	0.40**	-	

above diagonal = fresh-seeds boiled in water and below diagonal = cured seeds boiled in water

Above diagonal = fresh seeds soaked for 16 h in water and below diagonal = fresh seeds soaked for 16 h in brine prior to boiling

Above diagonal = cured seeds soaked for 16 h in water and below diagonal = cured seeds soaked for 16 h in brine prior to boiling

*, ** $P<0.05$ and 0.01, respectively

Discussion

Very little information is available in literature on seed and pod traits preferred in boiling-type groundnuts. In addition to taste and flavor, CT is the most important consideration in selection of genotypes for boiling uses. Greater CT adds directly to the cost of processing. From the results obtained from this study, it is clear that cured-pods take much longer (6 times) than fresh-pods to cook. However, genotypic differences do occur in CT for cured-pods. Cured-pods of ICGs 319, 355, and 1961 took lesser CT than other genotypes included in the study. In case of fresh- pods, there was no difference in CT among genotypes.

In the case of pre-soaking, the treatment with brine is beneficial over water in lowering the CT for both fresh- and cured-pods. Similar results were obtained with black beans (*Phaseolus vulgaris*) when presoaked in Na salt solutions prior to cooking due to bean softening. The bean softening was caused by replacement of ions which stabilize the structure of the intercellular cement by Na ions through ion exchange or their removal by chelatin (Varriano-Marston and Omana, 1979) Genotypic differences for fresh-pod CT, under both water and brine pre-soaking treatments, were nonsignificant. But for cured-pods, ICGs 319 and 326 under water and ICG 2148 under brine pre-soaking treatment, had the lowest CT. As expected, the HC of cured- pods was greater than fresh-pods under both pre-soaking treatments because of the higher initial moisture content in the latter. The pre-soaking treatments did not have significant influence on HC of fresh- and cured-pods. Genotypic differences in HC of water-soaked fresh-pods were nonsignificant. But ICGs 1384, 6224, 1307, and 6479 had significantly greater HC than Gangapuri for water soaked cured-pods. ICG 6224 also had significantly greater HC than Gangapuri for brine soaked cured-pods.

Like cured-pods, cured-seeds also took longer time (3.9 times) than fresh-seeds to cook. Genotypic differences in CT for fresh-seeds were non-significant. But for cured-seeds, ICG 408 had CT lower than and ICGs 58 and 1757 similar to that of Gangapuri. All other genotypes had significantly greater cured-seed CT than Gangapuri. The average SW and SV were greater in fresh-seeds than in cured-seeds mainly due to higher initial moisture content in the former. The reverse was true for SD. ICG 6224 had SW and SV, ICG 1929 SW and SD, USA 857 and ICG 3195 SW, and ICG 1693 SV for fresh-seeds greater than Gangapuri. For cured-seeds, no genotype was superior to Gangapuri for SW and SV. ICGs 1307, 1672, and 1693 had greater cured-seeds SD than that of Gangapuri.

Like pods, soaking of fresh- and cured-seeds in brine reduced CT over soaking in water. ICGs 42, 1307, 1693, and 355 had the lowest CT under different treatments.

Several other genotypes, which had CT lower than or similar to as Gangapuri in the fresh-seeds under both water and brine soakings, had higher CT than the latter on curing. Although soaking in brine reduced CT, it also reduced HC and SC for both fresh- and cured-seeds. Dry beans, soaked in salt solution, absorbed less water than when soaked in water (Del Valle *et al.*, 1992) probably because of the decrease of osmotic pressure gradient across membranes of cotyledon cell (Woodstock, 1988). The HC was greater than Gangapuri in ICG 30 water soaked-fresh seeds and in ICG 6224 both water- and brine-soaked cured-seeds. ICG 6224 also had higher SC than Gangapuri for cured water and brine soaked seeds and fresh brine soaked seeds. Many other genotypes had greater SC than Gangapuri under different treatments.

Growing season had a profound effect on most of the seed characteristics. The produce of postrainy season had higher SW, SV, HC, and SC both for fresh- and cured-seeds and lower CT for fresh-seeds than rainy season. However, CT for cured-seeds of the former was higher than the latter. For fresh-seed boiling, the produce of postrainy and for cured-seed boiling the produce of rainy season should be preferred due to differences in their CTs. All valencia genotypes have 3- or 4-seeded pods among others. But their proportion in total pod composition may vary among genotypes. In the present set of genotypes, ICGs 58, 288, 326, 335, 408, 409, 1307, 1377, 1830, 1961, 3114, 3117, 3195, 3217, 6224, 6479, 7223, 10462, and 10900 had higher proportion of 4- and 3-seeded pods than other genotypes. But only ICGs 409 and 6224 scored over Gangapuri for shelling outturn, which determines edible yield, and 100- seed weight. For sweetness, ICGs 1377, 1830, 3117, 6479, and 7223 scored over others. ICG 1377 also had low oil content.

Many genotypes (ICGs 30, 326, 1307, 1377, 1693, 2148, 3114, 3195, 6224, 6479, and 7223) had 3 or more desirable characteristics associated with boiling use. ICG 6224 had ten desirable traits (greater HC for water soaked-cured pods, brine soaked cured-pods, water soaked cured-seeds, and brine soaked cured-seeds, greater SC for water soaked fresh-seeds and brine soaked cured-seeds, greater SW and SV for fresh seeds, higher proportion of 4-3 seeded pods with high shelling outturn, and greater 100-seed weight) followed by ICG 1307 which had four (greater HC for water soaked cured-pods, greater SD of cured-seeds and lesser CT of water soaked cured-seeds and brine soaked fresh-seeds). The rest had only 3 desirable traits. ICGs 319, 326, 2148, and 1307 had lesser CT than Gangapuri for pod and/or seed in at least two treatments.

The association between PW and CT was not clear. The lack of association between fresh PW and CT became a negative association on pre-soaking. On the contrary, the positive association between cured PW and CT disappeared on pre-soaking. In the case of cure-seeds, CT was positively associated with SW, SV, and SD. But in

...ase of fresh-seeds only SW and SD were positively ...sociated and the magnitude of association was smaller than that of cured-seeds. There was reversal of association between CT and HC and SC on pre-soaking of fresh-seeds. In the case of water soaking, the association was positive but it became negative and smaller when seeds were soaked in brine. Only SC was positively associated with CT in case of brine soaked cured-seeds. HC and SC were not correlated with CT in water soaked cured-seeds.

Except for the preliminary knowledge of traits preferred by consumers in boiling type groundnuts, not much is known about their association with each other and with cooking time. Further, how these traits affect cooking time is also not well understood. More studies are required to address these issues.

References

Akinyele, I.O., Onigbinde, A.O., Hussain, M.A., and Omololu, A. 1986. Physiochemical characteristics of 18 cultivars of Nigerian cowpeas (V. unguiculata) and their cooking properties. *Journal of Food Science*, **51**:1483.

Ammerman, G.R., Glenn, R.C., and Owens, C.R. 1971. Evaluation of frozen boiled peanuts as affected by cook time, cool time, and salt concentrations. *Journal of Food Science*, **36**:948-950.

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

Del Valle, J., Stanely, D., and Bourne, M. 1992. Water absorption and swelling in dry bean seeds. *Journal of Food Preservation*, **16**:75-98.

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

Freeman, H.A., Nigam, S.N., Kelly, T.G., Ntare, B.R., Subrahmanyam, P., and Boughton, D. 1999. The world groundnut economy: Facts, trends, and outlook. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics. pp52.

Hovis, A.R., Young, C.T., and Kuhn, C.W. 1979. Effect of two strains of peanut mottle virus on fatty acids, amino acids, and protein of six peanut lines. *Peanut Science*, **6**:88-92.

Jambunathan, R., Raju, S.M., and Barde, P.S. 1985. Analysis of oil contents of groundnuts by Nuclear Magnetic Resonance Spectrometry. *Journal of the Science of Food and Agriculture*, **36**:162-166.

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

McWatters, K.H. and Heaton, E.K. 1974. Influence of moist-heat treatments of peanuts on peanut paste characteristics. *Journal of the Science of Food and Agriculture*, **39**: 494-497.

Mozingo, R.W., Coffelt, T.A., and Wynne, J.C. 1988. In quality evaluations of virginia type peanut varieties released from 1944-1985. *Southern Crop Series Bulletin*, **335**:1-28.

Murugesu, V. and Basha, S.M. 1989. Effect of salt concentration and duration of boiling on peanut seed composition. *Journal of Agricultural and Food Chemistry*, **37**:756-760.

Pattee, H.E., Isleib, T.G., Giesbrecht, F.G., and McFeeters, R.F. 2000. Investigations into genotypic variation of peanut carbohydrates. *Journal of Agricultural and Food Chemistry*, **48**:750-756.

Savage, G.P. and Keenan, J.I. 1994. The composition and nutritive value of groundnut kernels. *in The Groundnut Crop: A Scientific Basis of Crop Improvement*, Ed by J Smart, Chapman and Hall, London, pp, 173-213.

Singh, U. and Jambunathan, R. 1980. Evaluation of rapid methods for the estimation of protein in chickpea (*Cicer arietinum* L.). *Journal of the Science of Food and Agriculture*, **31**:247-254.

Varriano-Marston, E. and Omana, E.D. 1979. Effect of sodium salt solutions on the chemical composition and morphology of black beans (*Phaseolus vulgaris*). *Journal of Food Science*, **44**:531-536.

Williams, P.C., Hanni, N., and Singh, K.B. 1983. Relationship between cooking time and some physical characteristics in chickpea (*Cicer arietinum* L.). *Journal of the Science of Food and Agriculture*, **34**:492-496.

Woodstock, L. 1988. Seed inhibition: a critical period for successful germination. *Journal of Seed Science and Technology*, **12**:1-15.

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Combining ability and heterosis for flowering pattern and reproductive efficiency in groundnut

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Abstract

With the objective of studying combining ability and heterosis for flowering pattern and reproductive efficiency (conversion of flowers into pegs, pods and kernels), four Virginia runner (VR) cultivars were crossed as lines with three testers comprising of two Spanish bunch (SB) and one Virginia bunch (VB) following Line x Tester mating design. The genotypes Girnar 1 (among three testers) and ICGV 86325 (among four lines) were good general combiners for most of the reproductive efficiency parameters. Besides, Girnar 1 was a good general combiner for pod yield. Two lines, GAUG 10 and B 95 were good combiners for total number of flowers and days to 25% flowering (an index for early maturity). Among the crosses involving VR and SB genotypes, B 95 x Girnar 1 recorded high positive *sca* effects for most of the reproductive characters, days to 50% flowering and pod yield. Similarly, among VR x VB crosses, CSMG 84-1 x R 33-1 recorded positive *sca* effects for total flowers and ratio of mature pods/total flowers. Positive *sca* effects were observed for pod yield and ratio of mature pods/total flowers (ICGV 86325 x Chico), days to 75% flowering (ICGV 86325 x R 33-1), ratio of total pods/total pegs (CSMG 84-1 x Chico), days to 50% flowering (GAUG 10 x Chico) and ratio of mature pods/total pods (GAUG 10 x Girnar 1). This indicated that significant *sca* effects were prominent for most of the characters in VR x SB crosses. Both additive and non additive genetic variances were important for RE 1, RE 3, RE 4 and RE 5. Non additive genetic variance was more important for pod yield and RE 6. All the crosses gave significant positive heterosis for total numbers of flowers. For days to 25% flowering three crosses gave significant positive heterosis. Crosses CSMG 84-1 x Ch[illegible] and B 95 x Girnar 1 having significant positive *sca* effects for pod yield also gave significant positive heterosis. In general, heterosis and *sca* effects were associated for days to 50% flowering, ratio of total pods/total flowers, mature pods/total flowers and pod yield. Based on *gca* and *sca* effects and heterosis, it may be concluded that VR x SB crosses, B 95 x Girnar 1 and CSMG 84-1 x Chico are potential cross combinations for the improvement of reproductive efficiency in groundnut.

Key words: *Arachis*, reproductive efficiency, combining ability, flowering pattern

Introduction

The groundnut (*Arachis hypogaea* L.) plant has indeterminate growth habit. Flowering pattern and quantum of flowers at a given time is very important as it determines to a great extent the yielding potential of a genotype. Number of flowers, pegs, pods (mature and immature) and kernels (sound and immature) are the important parameters which determine the reproductive efficiency (RE) of the groundnut plants. However, a groundnut genotype with high RE may not necessarily be a high yielder of pods or kernels. The information on conversion of flowers into pegs, pods and kernels (RE) is important to develop/ select high yielding genotypes (Coffelt *et al.*, 1989). Percentage of flowers resulted in mature pods have been used as measures of RE in groundnut (Coffelt *et al.*, 1989; Chuni Lal *et al.*, 1998).

In autogamous crops like groundnut, recombination breeding has extensively been used to develop the variability reservoir for exploitation in breeding programmes. In a systematic breeding programme, it is essential to identify the elite parents for hybridization, and superior crosses to expand the variability reservoir for selection of superior genotypes. The information on combining ability and heterosis on flowering pattern and reproductive efficiency parameters in groundnut is almost lacking. Keeping this in view, the present investigation was undertaken using well adapted and widely grown cultivars of groundnut crossed in line x tester design.

Materials and methods

Seven groundnut genotypes (Chico, Girnar 1, Robut 33-1, ICGV 86325, CSMG 84-1, GAUG 10 and B 95) were selected based on their geographical adaptation, growth habit and morphological diversity. Chico, Girnar 1 and Robut 33-1 were used as testers, and each was crossed with ICGV 86325, CSMG 84-1, GAUG 10, and B 95 used as lines. The crosses were made in line X tester design during *kharif*, 1996. Twelve F_1's along with seven parents were planted in randomized complete block design with three replications at the Experimental Farm of National Research Centre for groundnut, Junagadh (20.21° N, 80.55°E, 178 m amsl) during *Kharif*, 1997. Each treatment in a replication had single row of 3 m length at 45 x 10 cm spacing. The observations were recorded on five random plants on pod yield per plant (g) and five flowering characters namely, days to 25% flowering (days taken to produce 25% of total flowers), days to 50% flowering (days taken to produce 50% of total flowers), days to 75% flowering (days taken to produce 75% of total flowers), total number of flowers produced, and number of flowers produced after 65 days after sowing (an index related with high number of mature pods), number of mature pods/ plant, number of immature pods/ plant, number of non-pod bearing pegs/plant and total biomass yield above ground level. The following six reproductive efficiency indices were computed (Shibuya, 1935, Ghosh *et al.*, 1997; Samdur *et al.*, 2000).

The analysis of variance was done (Cochran and Cox, 1950). The combining ability analysis was done following Kempthorne (1957). The total variance among F_1 hybrids was further partitioned into variance due to lines, testers and interaction components, which was used to estimate the additive and non-additive component of variance.

Results and discussion

The analysis of variance for combining ability revealed that mean square due to lines for total number of flowers and days to 25% flowering; testers for days to 25% flowering and RE 2, and due to line x tester interaction for RE 6 and pod yield were significant, indicating the importance of both additive and non additive gene effects (Table-1).

The high ratio (>1) of *gca* : *sca* variances were recorded for number of flowers at 65 days after sowing, indicating that this character was governed predominantly by additive component of heritable variance. The *gca* : *sca* ratios were less than unity for total number of flowers, days to 25% flowering, days to 50% flowering, days to 75% flowering, RE 1, RE 2, RE 3, RE 4, RE 5 and RE 6, suggesting that these characters were governed predominantly by non additive component. The component of variance attributable to sca was more than six times for pod yield and three times for RE 6 than for gca in magnitude, indicating that non genetic variance was more important for these two traits. Both additive and non additive genetic variances were important for RE 1, RE 3, RE 4 and RE 5 as indicated by less degree of dominance for these characters (Table-1).

The estimates of *gca* effects (Table-2) recorded the genotypes Girnar 1 and ICGV 86325 were good general combiners for most of the reproductive efficiency related characters. Besides, Girnar 1 was also a good general combiner for pod yield/ plant. Among the four lines GAUG 10 and B 95 were good general combiners for total flowers. Two lines, ICGV 86325 and GAUG 10 and one tester, Chico, were good general combiners for early completion of 25% flowering (an indicator of early flowering/ maturity and could be used as an index for selection of drought tolerant genotypes for mid/ end-of-season drought conditions) while CSMG 84-1 and B 95 (both lines) were good combiners for lateness. Hence, ICGV 86325, GAUG 10 and Chico could be utilized in breeding programmes aimed at developing early maturing groundnut cultivars whereas CSMG 84-1 and B 95 could be included in breeding programmes for medium/ long duration types. Sufficient heterosis for total flowers produced was available, the need to select recombinant(s) having more early period flowering and high reproductive efficiency would help the breeder in tagging high yielding recombinants in future segregating generations.

Table 1 Analysis of variance (mean squares) for combining ability and estimates of genetic components for pod yield and reproductive efficiency indices in groundnut

Source	d.f.	Total flowers	Days to 25% flowering	Days to 50% flowering	Days to 75% flowering	Flowers after 65 DAS	RE 1	RE2	RE3	RE 4	RE 5	RE6	Pod Yield
Replication	2	0.028	3.028	1564.528	56.250	5.250	81.211	34.569	6.224	127.316	112.493	0.348	42.038
Lines	3	2.694*	192.694*	4778.231	18.890	6.768	466.021	7.017	1.263	425.939	534.968	2.112	96.664
Testers	2	0.028	61.028*	5692.708	15.25	12.333	180.16	109.32*	47.53*	546.673	384.099	5.302	134.564
Lines x testers	6	0.028	10.028	7951.912	72.36	4.407	131.360	18.421	7.615	140.028	215.724	2.674*	149.18*
Error	22	0.028	10.028	4802.891	63.55	6.856	91.390	21.89	4.807	62.247	176.400	0.825	26.220
gca variance	$\sigma^2 g$	0.126	11.12	258.70	-5.26	0.489	18.259	3.78	1.59	32.97	23.22	0.098	-3.196
sca variance	$\sigma^2 s$	0.253	22.25	532.25	-7.59	0.163	49.84	6.41	4.13	91.88	59.54	0.81	34.59
gca : *sca* variances	$\sigma^2 g/\sigma^2 s$	0.50	0.50	0.49	0.69	3.0	0.37	0.59	0.38	0.36	0.38	0.12	-0.812
Additive genetic variance	$\sigma^2 A$	0.25	22.25	-517.92	-10.53	0.98	36.52	7.57	3.20	65.96	46.44	0.20	6.39
Dominance genetic variance	$\sigma^2 D$	-	-	1049.67	2.94	-0.82	13.32	-1.16	0.94	25.93	13.11	0.62	40.99
Degree of dominance	$\sigma^2 D/^2 A$	-	-	-2.03	-0.28	-0.83	0.36	-0.15	0.29	0.39	0.28	3.10	6.41

Significant at 5% level

Table 2 General combining ability (*gca*) effects of lines testers for pod and reproductive efficiency indices in groundnut

Parents	Total flowers	Days to 25% flowering	Days to 50% flowering	Days to 75% flowering	Flowers after 65 DAS	RE 1	RE 2	RE 3	RE 4	RE 5	RE 6	Pod Yield
ICGV 86325	-0.53**	-3.47**	-17.00	-2.11	-0.69	9.76**	-1.12	0.53	8.95**	7.30*	0.59**	-2.34
CSMG 84-1	-0.42**	3.42**	14.56	0.89	0.75	0.05	-0.01	-0.29	0.36	-10.87**	-0.58*	4.78**
GAUG 10	*0.47***	*-4.47***	*-22.11*	*0.22*	*-0.81*	-2.47	*0.09*	*-0.23*	-1.61	2.30	*0.10*	-1.90
B 95	0.47**	4.53**	24.56	1.00	0.75	-7.34*	1.04	0.00	-7.70**	1.27	-0.10	-0.55
SEm.±	0.04	0.73	15.90	1.83	0.60	2.19	1.07	0.50	1.81	3.05	0.21	1.17
Chico	-0.03	-2.47**	-16.36	0.08	0.50	2.34	-2.16	-0.79	0.29	6.34*	0.06	1.49
Girnar 1	–0.03	0.53	24.72	-1.17	-1.17*	2.13	3.45	2.26**	6.60**	-1.80	0.63**	2.34*
R 33-1	0.06*	1.94**	-8.36	1.08	0.67	-4.47*	-1.29	-1.48**	-6.89**	-4.54	-0.69**	-3.84**
SEm ±	0.03	0.59	12.98	1.49	0.49	1.79	0.88	0.41	1.48	2.49	0.17	0.96

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

Among the crosses involving VR and SB genotypes, B 95 x *Girnar 1 gave high positive sca effects for most of the* reproductive characters and pod yield (Table-3). Similarly, among VR x VB crosses, CSMG 84-1 x R 33-1 gave positive *sca* effects for total flowers and ratio of mature pods/total flowers. Positive *sca* effects were observed for pod yield and ratio of mature pods/total flowers (ICGV 86325 x Chico), days to 75% flowering (ICGV 86325 x R 33-1), ratio of total pods/total pegs (CSMG 84-1 x Chico), days to 50% flowering (GAUG 10 x Chico) and ratio of mature pods/total pods (GAUG 10 x Girnar 1). The results indicated that *sca* effects were significant for most of the characters in VR x SB crosses. The estimates of variance (*gca* and *sca*) components indicated that additive components were predominant for most of the characters, though appreciable non-additive effects were noted for ratio of mature pods to total flowers. All the crosses gave significant positive heterosis for total flowers (Table 4). For *days to 25% flowering three crosses gave significant* positive heterosis. Crosses CSMG 84-1 x Chico and B 95 x Girnar 1 having significant positive *sca* effects for pod yield and most reproductive efficiency indices, also had significant positive heterosis. In general, heterosis and *sca* effects were closely associated for days to 50% and 100% *flowering, ratio of total pods/total flowers, mature* pods/total flowers and pod yield. Based on *gca* and *sca* effects and heterosis, it may be concluded that VR x SB crosses (B 95 x Girnar 1 and CSMG 84-1 x Chico) are the potential cross combinations which may yield trangressive segregants for higher yield coupled with earliness and high reproductive efficiency.

These observations suggest that in groundnut breeding, the methodology that can exploit both additive as well as non-additive effects would be of immense value. Diallel selective mating design (Jensen, *1970)*, which provides better opportunity for recombination, accumulation of desirable genes and selection would help in concentrating most of such genes in a pure line. A judicious integration of the classical approaches (pedigree and bulk) with diallel selective mating may be of great help in achieving the quantum jump in groundnut improvement.

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Table 3 Specific combining ability (*sca*) effects of crossed for pod yield and reproductive efficiency indices in groundnut

Crosses	Total flowers	Days to 25% flowering	Days to 50% flowering	Days to 75% flowering	Flowers after 65 DAS	RE 1	RE 2	RE 3	RE 4	RE 5	RE 6	Pod yield
ICGV 86325 x Chico	0.03	-0.53	-45.75	-4.97	0.94	5.30	1.80	1.05	3.66	6.12	1.02**	2.92
ICGV 86325 x Girnar 1	0.03	-0.53	21.83	-1.72	-1.39	-5.63	-0.95	-0.93	-4.52	-8.07	-0.89**	-4.29*
ICGV 86325 x R 33-1	-0.06	1.06	23.92	*6.69**	*0.44*	0.33	-0.85	-0.12	0.85	1.94	-0.13	1.37
CSMG 84-1 x Chico	-0.08	1.58	40.03	2.69	-0.50	4.48	-1.26	0.17	5.56*	1.25	0.08	8.35**
CSMG 84-1 x Girnar 1	-0.08	1.58	-19.06	-0.72	1.17	-4.82	-1.27	-0.96	-5.08	-7.97	-0.71*	-3.23
CSMG 84-1 x R 33-1	0.17**	-3.17**	-20.97	-1.97	-0.67	0.34	2.52	0.79	-0.48	6.92	0.64*	-5.12**
GAUG 10 x Chico	0.03	0.53	52.03*	-2.64	0.06	-3.03	1.78	0.69	0.23	-6.19	-0.19	-3.69*
GAUG 10 x Girnar 1	0.03	-0.53	-53.72*	3.61	-0.94	0.89	-1.12	-0.68	-0.35	10.09*	0.40	-0.86
GAUG 10 x R 33-1	-0.06	1.06	1.69	-0.97	0.89	2.15	-0.66	-0.01	0.11	-3.90	-0.20	4.55*
B 95 x Chico	0.03	-0.53	-46.31	4.92	-0.50	-6.75*	-2.33	-1.91*	-9.45**	-1.18	-0.90**	-7.58**
B 95 x Girnar 1	0.03	-0.53	50.94*	-1.17	1.17	9.56**	3.33*	2.58**	9.94**	5.94	1.20**	8.37**
B 95 x R 33-1	-0.06	1.06	-4.64	-3.75	-0.67	-2.81	-1.00	-0.66	-0.48	-4.77	-0.30	-0.80
SEm±	0.05	1.03	22.48	2.59	0.85	3.10	1.52	0.71	2.56	4.31	0.29	1.66

*,** significant at F% and 1% levels respectively.

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Non-random outcrossing in groundnut, *Arachis hypogaea* L.

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Abstract

Nearly 38,000 individual plants of Spanish groundnut varieties were scored for selfing versus outcrossing in various populations. Normal cultivar TAG 24 was used to determine the male gametes which had effected fertilization in the homozygous recessive females (golden yellow and puckered leaf). More than 40,000 and 50,000 fertilizations in Valencia and Virginia groundnuts, respectively, were studied using a dominant marker "krinkle leaf". The estimates of outcrossing, a, were found to differ with years, botanical groups and for the markers used in the estimation. Highest outcrossing was observed in Valencia followed by Virginia and Spanish groundnuts. The nature of outcrossing, in general, was non-random in all the botanical groups. Selfing predominated in all the botanical groups of groundnut.

Key words: Groundnut, outcrossing, golden yellow leaf, puckered leaf, krinkle leaf

Introduction

Mating systems are important factors contributing to the nature and magnitude of genetic variability in populations. Many plant species have mating systems which allow *partial intermating in addition to self fertilization.* Knowledge of amount and nature of outcrossing in a plant species is of paramount importance for its genetic amelioration. Procedures have been given for estimation of outcrossing which assume no selection and population equilibria for gene frequencies (Fyfe and Bailey, 1951; Nei and Syaktdo, 1958). The methods for estimating outcrossing when selection is present and/or equilibrium can not be assumed were developed later on (Allard and Workman, 1963; Harding and Tucker, 1964). These methods are based on estimates of gene frequency in the population and estimates of the frequency of dominant individuals appearing in progeny of recessive individuals taken at random from the population.

Indian cultivated groundnut has three distinct botanical groups. These groups are Spanish (*A. hypogaea* sub-species *fastigiata* var. *vulgaris*), Virginia (*A. hypogaea* sub-species *hypogaea* var. *hypogaea*) and Valencia (*A. hypogaea* sub-species *fastigiata* var. *fastigiata*). Natural out crossing in all the botanical groups of groundnut is insect dependent. In literature no report of cross pollination due to air-born pollens is available. Among the insects, thrips are claimed to be the dominant insect vectors causing natural hybridization in groundnut (Kushman and Beattie, 1946). Evidences are also available (Hammons, 1963; Hammons *et al.*, 1963; Leuck and Hammons, 1965a; Leuck and Hammons, 1965b; Hammons and Leuck, 1966) which indicated that bees are the principal pollen vectors of natural cross pollination in groundnut. The extent of natural hybridization in groundnut is variable and may play greater role than commonly believed. There is no information whether the cross pollination is random or non-random, and also whether its pattern varies with botanical groups of this crop. Natural hybridization was reported by Kushman and Beattie (1946) after finding 17 natural crosses in test plots at the Tidewater Research Station, Holland, Va. Average natural crossing frequencies of approximately 2% were reported in Java (Bolhuis, 1951) and in India (Srinivasalu and Chandrasekaran, 1958). Natural crossing ranging from 0.73 to 2.56% in nine varieties at Tifton, Ga., was reported by Hammons (1964a). Most studies of outcrossing in groundnut have reported a rate of 2% or less (Hammons, 1964b; Hammons and Leuck, 1966; Culp *et al.*, 1968; Gibbons and Tattersfield, 1969; Stone *et al.*, 1973; Coffelt, 1989; Nigam *et al.*, 1990). In one study (Dutta *et. al.*, 1987), examined induced mutations as a method for enhancing cross- pollination in groundnut, and identified a line with 20.8% outcrossing. Thus natural crossing in groundnut is sufficient to account for frequent "off type" plants in otherwise homozygous lines, making it difficult to maintain varietal purity. The purpose of the present investigation was to find out whether the natural outcrossing in groundnut is random or not and to find out whether its extent is same or different in different botanical groups.

Materials and methods

True breeding "golden yellow leaf" and "puckered leaf" mutants (Spanish bunch botanical group) were planted with TAG 24 (a Spanish bunch variety with homozygous dominant leaf i.e., with normal leaf with respect to golden yellow/puckered leaf) in alternate rows in separate plots.

Table 4 Heterosis over mid parent in crosses for pod yield and reproductive efficiency indices in groundnut

Crosses	Total flowers	Days to 25% flowering	Days to 50% flowering	Days to 75% flowering	Flowers after 65 DAS	RE 1	RE 2	RE 3	RE 4	RE 5	RE 6	Pod yield
ICGV 86325 x Chico	100**	-50.00	-41.81	-10.12	0.00	29.60	-6.62	-13.66	-13.75	11.38	8.19	127.03*
ICGV 86325 x Girnar 1	100**	26.32	3.35	-5.71	-4.21*	-17.68	-40.79*	-33.16	-2.91	-11.53	-46.38*	-17.62
ICGV 86325 x R 33-1	50**	114.29*	-1.79	7.08	-0.35	-27.68	-29.77	-42.29	-17.09	6.21	-41.26	-17.26
CSMG 84-1 x Chico	100**	36.84	26.16	15.09	1.97	-12.88	-7.73	-26.24	-19.65	-32.11	-53.08	183.17**
CSMG 84-1 x Girnar 1	100**	45.45	13.91	7.30	1.97	-47.64*	-30.64	-32.74	-14.46	-55.27*	-69.06*	28.93
CSMG 84-1 x R 33-1	75**	105.41*	6.87	2.69	1.97	-56.17**	32.56	-21.48	-32.28	-26.60	-45.86	-35.87
GAUG 10 x Chico	200**	-72.73**	-5.06	-9.84	-1.05	-27.60	21.94	-14.00	-33.36*	-25.38	-37.76	43.45
GAUG 10 x Girnar 1	200**	-52*	-33.84	-0.83	-3.86	-25.09	-31.17	-28.70	-7.75	11.45	-12.48	42.17
GAUG 10 x R 33-1	125**	17.39	-18.12	-9.66	0.00	-49.29*	-5.23	-40.21	-35.22*	-25.64	-55.83	44.90
B 95 x Chico	200**	-4	-32.34	2.15	0.00	-55.11	-4.73	-64.22	-63.00**	-9.98	-68.58	-23.22
B 95 x Girnar 1	200**	7.14	19.01	-8.94	0.00	-3.31	0.01	22.22	4.13	12.93	22.01	145.95**
B 95 x R 33-1	125**	96.36**	-8.03	-14.14	0.00	-75.70**	9.72	-45.64	-49.88*	-20.71	-64.55	-23.90
SEm±	0.13	2.48	47.61	5.07	1.83	6.71	4.17	1.55	6.94	8.69	0.80	3.12

*,** significant at 5% and 1% levels respectively.

References

Chuni Lal, Basu, M. S. and Rathnakumar, A. L. 1998. Reproductive efficiency and genetic variability in Spanish bunch peanut (*Arachis hypogaea* L.). *Green Journal*, **1**(1): 43-48.

Cochran, W. G. and Cox, G.M. 1950. *Experimental Designs*. John Wiley & Sons, Inc., New York. pp. 107-108

Coffelt, T. A., Seaton, M. L. and Vanscoyoc, S. W. 1989. Reproductive efficiency of 14 Virginia-type Peanut Cultivars. *Crop Science*, **29**: 1217-1220.

Ghosh, P.K., Mathur, R. K., Bandyopadhyay, A., Manivel, P., Gor, H. K. and Chikani, B. M. 1997. Flowering pattern and reproductive efficiency of different habit groups of groundnut. *In Plant Physiology for sustainable agriculture* (eds. G.C. Srivastava, Karan Singh and Madan Pal). Pointer Publishers, Jaipur-302 003, India.

Jensen, N. F. 1970. A diallel selective mating system for cereal breeding. *Crop Science*, **10**: 629-635.

Kempthorne, O. 1957. *An introduction to Genetical Statistics* John Wiley and Sons, New York. pp. 545.

Samdur, M.Y., Mathur, R. K., Manivel, P., Gor, H. K. and Chikani, B. M. 2000. Screening groundnut genotypes for drought tolerance- a novel approach. *In National Seminar on Plant Physiology at interface of Agri-Horticulture and Industry*, Rajasthan College of Agriculture, Udaipur from December 30, 1999 – January 1, 2000. pp-C13-66.

Shibuya, T. 1935. Morphological and physiological studies on fractification on peanuts (*Arachis hypogaea* L.). pp.1-20. *In Memoirs of the Faculty of Science and Agriculture*, Taihoko Imperial, University of Formosa, Japan (Phytotechny, No.2).

for Valencia and 0.0551 for Virginia group. It is evident in Table-1 that estimates for α in Valencia cultivar F 623 varied from 0.0638 in the year 1988 to 0.1250 in 1990. However, these were similar in case of cultivar V 803 in all the three years. Similarly, in Virginia group, estimates of ? varied from 0.0226 to 0.063 in variety F 636 and from 0.0198 to 0.0672 in V 655.

A set of two genotypes each in Valencia and Virginia were the same over years, the pooled estimates of out-crossing in each botanical groups were compared. These were found to be heterogeneous both in Valencia (χ^2_{1df} = 18.862; $p < 0.001$) and Virginia (χ^2_{1df} = 558.840; $p < 0.001$). The lack of homogeneity, however, does not explain whether the differences in the estimates of out-crossing were due to variation in years only. Since the populations varied genetically, the entire variation can not be attributed to environment alone. Binomial index χ^2's for the test of heterogeneity of the estimates of outcrossing (α) revealed that genotypes with in Valencia (χ^2_{1df} = 633.736; $p < 0.001$) and Virginia (χ^2_{1df} = 13.604; $p < 0.001$) were heterogeneous.

All the observations over years for each varietal groups were pooled and a composite estimate was made, giving α = 0.1236 for Valencia and 0.0326 for Virginia groundnut. The observed fluctuation (s_α) of these composite estimates were above 58 and 48 times more than the expected ones in Valencia and Virginia respectively (s_α/σ_α = 58.12 in Valencia and 48.97 in Virginia). This indicates that cross pollination in general is non-random in both the Valencia and Virginia groups.

Table 1 Estimates of outcrossing for different botanical groups in different years using different markers

Habit group	Marker	Year	Variety	a$	N+	q	α	σ_α
Spanish	Golden Yellow leaf	*Kharif*, 1997	GAG 24	8	1147	0.5	0.0140	0.0049
		Summer, 1997	TAG 24	9	5822	0.5	0.0031	0.0010
		Kharif, 1998	TAG 24	239	25928	0.5	0.0184	0.0012
			Total	256	32897	0.5	0.0156	0.0010
	Puckered leaf	Summer, 1997	GAG 24	12	619	0.5	0.0388	0.0111
		Kharif, 1998	TAG 24	93	5297	0.5	0.0351	0.0036
			Total	105	5916	0.5	0.0355	0.0034
			G.Total	361	38813		0.0186	0.0010
Valencia*	Krinkle leaf	1998	F 623	303	9506	0.5	0.0638	0.0036
			V 803	964	11868	0.5	0.1624	0.0050
			Total	1267	21374	0.5	0.1186	0.0032
		1989	F 623	195	5260	0.5	0.0742	0.0052
			V 803	615	7824	0.5	0.1572	0.0061
			Total	810	13084	0.5	0.1238	0.0042
		1990	F 623	149	2383	0.5	0.1250	0.0099
			V 803	288	3832	0.5	0.1504	0.0085
			Total	437	6215	0.5	0.1406	0.0065
			G. Total	2514	40673	0.5	0.1236	0.0024
Virginia*	Krinkle leaf	1998	F 636	263	23200	0.5	0.0226	0.0014
			V 655	142	14393	0.5	0.0198	0.0017
			Total	405	37593	0.5	0.0216	0.0011
		1990	F 636	309	9798	0.5	0.0630	0.0035
			V 655	111	3306	0.5	0.0672	0.0063
			Total	420	13104	0.5	0.0642	0.0031
			G. Total	825	50697	0.5	0.0326	0.0011

* *Knauft et al.* (1992); # Heterozygotes; + Total individuals

..e spacing in all the plots were 30cm between rows and 10 cm between plants. The experiment was conducted at National Research Centre for Groundnut, Junagadh (20.21° N, 80.55° E, 178 m amsl), Gujarat during summer 1997 and *kharif* 1998. In addition, experiment involving golden yellow leaf mutant was conducted during *kharif* 1997 also (Table-1). The recommended agronomic practices, except the application of insecticides, were followed to raise the crop. Since, mutants and the normal (TAG 24) were equally frequent in both the artificially constructed populations, the gene frequency 'q' in both the cases was assumed to be 0.5.

The estimation procedures developed by Harding and Tucker (1964) were followed. If a random sample of recessives is selected from a population, then heterozygotes (a) and recessive homozygotes (b) will be observed in their offspring. The observed proportion of outcross, T, and its variance are:

$$T = \frac{a}{a+b} \quad \text{and} \quad \text{Var } T = \frac{ab}{(a+b)^3}$$

which are the maximum likelihood estimators. However, not all crosses will be observed because homogenous mating result in homozygotes. The maximum likelihood estimate of total outcrossing, α, is

$$\alpha = \frac{T}{(1-q)}$$

where q is the gene frequency associated with the homozygote selected. If 'q' is known, then using maximum likelihood method

$$\text{Var } \alpha = \frac{\alpha(1-\alpha p)}{Np} \quad \text{Where } p + q = 1 \text{ and } N = a + b$$

The expected standard deviation (σ_α) and the observed standard deviation (s_α) of α were computed using appropriate procedures (Harding and Tucker, 1964).

The same method of estimation of α was applied for the earlier published data (Knauft *et al.*,1992). These authors studied cross-pollination in Valencia and Virginia populations where homozygous dominant (krinkle leaf) and homozygous recessive (normal leaf) plants were equally frequent in the experimental population; hence 'q' was taken to be 0.5 when estimating α from these data.

Results and discussion

Table-1 presents frequencies of heterozygotes (a), total populations (N), estimates of outcrossing (α) and their standard deviations (σ_α) for different years, seasons and genotypes of different botanical groups of groundnut using dominant marker krinkle leaf for Valencia and Virginia and two recessive markers golden yellow leaf and puckered leaf for Spanish bunch groundnut.

Golden yellow leaf: Golden yellow leaf was used as a recessive marker to investigate outcrossing in Spanish groundnut. The estimates of outcrossing parameter, α varied from 0.0031 to 0.0184 over seasons/years. The binomial index chi-square test revealed that outcrossing was heterogeneous (χ^2_{2df} = 72.939; $p < 0.001$) in different seasons/years. As the parents were common during all the seasons/years, differences observed for outcrossing may be attributed to the non-genetic factors alone. All the observations for this marker were pooled and a composite estimate was made giving α = 0.0156. The observed standard deviation (s_α = 0.0152) among seasons/ years for this marker was much larger than the expected one (σ_α = 0.0010). Thus observed fluctuations in outcrossing was approximately 15 times more than the fluctuation expected on the basis of random chance alone (s_α/σ_α = 15.69), indicating non-randomness of outcrossing.

Puckered leaf: Puckered leaf, a recessive marker, used to study outcrossing in Spanish groundnut, indicated that estimates of outcrossing (α) were similar during summer 1997 and *kharif* 1998. It was further supported by the test of binomial chi-square which revealed that outcrossing was homogeneous (χ^2_{1df} = 0.22; $p > 0.05$) in different seasons/years. All the observations for this marker were pooled and a composite estimate was made, giving α = 0.0355. The ratio between the observed fluctuation and fluctuation based on random chance alone as measured by s_α and σ_α respectively was 13 times more than unity (s_α/σ_α = 13.37) and thus indicating non-random nature of outcrossing when puckered leaf was used as marker for estimations.

As the pollen source used for detection of outcrossing for both golden yellow leaf and puckered leaf was common (TAG 24), all the estimates across these markers were pooled to make a composite estimate, giving α = 0.0186. The observed fluctuation of this composite estimate was approximately 29 times higher than the fluctuations on the basis of chance alone (s_α/σ_α = 29.04) indicating non-random nature of outcrossing in general when both the markers were considered together. Pooled estimates of outcrossing were found to be heterogeneous (χ^2_{1df} = 73.161; $p < 0.001$) among puckered and golden yellow leaf. However, recessive parents in this comparison were genetically different, hence, at least a part of the observed heterogeneity could be ascribable to the built in genetic differences in outcrossing in these two recessive markers.

Krinkle leaf: The mean estimate of outcrossing (α) using krinkle leaf as marker was 0.1236 in Valencia varieties, and it was only 0.0326 in case of Virginia group. This difference would seems to be significant in view of their expected standard deviations of 0.0024 and 0.0011, respectively. However, the observed standard deviations between genotypes for the same marker (krinkle) are much larger than their expected values, *viz.*, s_α = 0.1388

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Exploitation of heterosis breeding in Indian mustard, *Brassica juncea* (L.) Czern & Coss

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Abstract

Diverse lines of Indian mustard [*Brassica juncea* (L.) Czern & Coss] were crossed to assess heterosis for yield and its components and oil content through *gca* and *sca* ability of parents and crosses. Thirty F_1 crosses obtained by crossing three testers and ten lines in a line x tester fashion along with their parents were used in the experiment. Heterosis was expressed for only six characters studied. The estimate of predictability ratio indicated the importance of *gca* effect for judging the performance of progenies. The *gca* and *sca* effect showed wide variation in the level of significance for different characters. The parent PCR-7, Varuna and RAURD-9505 were identified as a good general combiner for yield and yield contributing characters. Besides this ACN-9 was identified as a good general combiner for earliness and dwarfness. The cross Varuna x TM-17 was the best F_1 which can be forwarded to next generation with an aim to get useful transgrates in succeeding generation.

Key words: Heterosis, mustard, *gca, sca*

Introduction

Genetic architecture of the parents and their crosses necessitate the assessment of the parents in hybrid combination through systematic genetic studies of the parents for general and specific combining ability effects. Hence, the present investigation was undertaken to determine the heterosis and combining ability with ten lines with three testers with broad genetic base for various economic traits of Indian mustard.

Materials and methods

The experimental material comprising ten lines of diverse origin and three testers *viz.*,Varuna, PCR-7and ACN-9 were crossed in Line x Tester design. The 30 F_1 and their parents were grown in Randomized Complete Block Design with three replication during *rabi*, 2000 at Botany Section Farm, College Of Agriculture, Nagpur, with a spacing of 45x15 cm. The observations were recorded on five randomly selected plants per line for various yield parameters. Heterosis and standard heterosis were calculated over mid parent and check variety Varuna, respectively, following the standard procedure. The data were also subjected to combining ability analysis as per Kempthrone (1957) and Eisenhart(1947).The importance of *gca* versus *sca* were calculated for fixed effect model as suggested by Baker(1978).

Results and discussion

The parents exhibited significant amount of genetic variation for days to flowering, days to maturity, plan height, number of primary branches, silquae /plant, seeds/silquae, seeds yield/plant, 1000 seed weight and harvest index except for oil content. However, parent vs crosses exhibited significant difference for days to maturity, plant height, number of siliquae/plant, seed yield/plant, 1000 seed weight and harvest index. While non-significant variation was recorded for days to 50 % flowering, number of primary branches, number of seeds/siliqua and oil content and hence heterosis and standard heterosis were not calculated for these characters.

Heterosis: The phenomenon of heterosis was observed for six characters. The magnitude of heterosis and standard heterosis varied substantially from cross to cross and from character to character. This indicated the existance of potential heterosis in Indian mustard. The crosses showing maximum heterosis for all six characters studied were sorted and listed out in Table-1.The level of heterosis observed in these crosses justified the development of commercial hybrids in Indian mustard. The lack of restorer has hampered the exploitation of CMS system for producing commercial hybrids in Indian mustard (Amandeep and Banga, 1996; Singn and Verma,1997).The major difficulty in finding restorer in natural accession is the multilocus control of incompatibility between mitochondrial and nuclear genome (Anand *et al.*,1985; Downy and Chopra,1996). Therefore it would be worth enough to find out whether superior crosses showing high heterosis were also throwing out superior segregates. This would enable the breeder to concentrate on a few promising crosses rather than handling many in later generations of selection.

[illegible]teresting to note that in Spanish groundnut nature of outcrossing varied in genotypes used for estimation. It might be possible that some genetic mechanisms do exist which control the nature and extent of outcrossing in groundnut. As evident from the heterogeneity of estimates of outcrossing over years in most of the cases, this genetic mechanism is considerably influenced by the non-genetic factors. Present data confirm earlier reports (Bolhuis, 1951; Hammons, 1964a) that natural crossing may vary with seasons and cultivars. The range of variation in the estimates of outcrossing was between 0.0198 and 0.1624 in Virginia and Valencia groups (Knauft *et. al.*, 1992). It was between 0.0031 and 0.0388 in the presently studied Spanish group. Highest outcrossing was observed in Valencia group followed by Virginia and Spanish groundnuts.

The mating system is commonly considered to be one of the main factors determining the genetic structure and evolutionary potential in a population. The observed variability in the mating system of groundnut under the influence of genetic and non-genetic factors may well contribute to a complex population structure. The present evidence does not suggest that groundnut populations follow models of complete random mating or complete inbreeding, rather that the mating system of the present populations is partial inbreeding.

References

Allard, R.W. and Workman, P.L. 1963. Population studies in predominantly self-pollinated species. IV. Seasonal fluctuations in estimated values of genetic parameters in lima bean populations. *Evolution*, **18**:470-480.

Bolhuis, G. G. 1951. Natuurlijke Bastaardering bij de Aardnoot, (*Arachis hypogaea*) Landbouk. *Tijdschr*, **63**:447-455.

Coffelt, T. A. 1989. Natural crossing of peanut in Virginia. *Peanut Science*, **16**:46-48.

Culp, T. W., Bailey, W. K. and Hammons, R. O. 1968. Natural hybridization of peanuts, *Arachis hypogaea* L., in Virginia. *Crop Science*, **8**: 109-111.

Dutta, M., Arunachalam, V. and Bandyopadhyay, A. 1987. Enhanced cross pollination to widen the scope of breeding in groundnut (*Arachis hypogaea* L.). *Theoretical and Applied Genetics*, **74**: 466-470.

Fyfe, J.L. and Bailey, N.T.J. 1951. Plant breeding studies in leguminous forage crop. I. Natural crossing in winter beans. *Journal of Agricultural Sciences*, **41**:371-378.

Gibbons, R. W. and Tattersfield, J. R. 1969. Out-crossing trials with groundnuts (*Arachis hypogaea* L.). Rhodesian. *Journal of Agricultural Research*, **7**(1):71-85.

Hammons, R. O. 1963. Artificial cross-pollination of the peanut with bee-collected pollen. *Crop Science*, **3**:562-563.

Hammons, R. O. 1964a. Krinkle, a dominant leaf marker in the peanut, *Arachis hypogaea* L. *Crop Science*, **4**: 22-24

Hammons, R. O. 1964b. Pedigreed natural crossing - a new genetic technique. *Proceedings of Third National Peanut Research Conference*, pp. 49-53.

Hammons, R. O., Krombein, K. V. and Leuck, D. B. 1963. Some bees (*A. poidea*) associated with peanut flowering. *Journal of Economic Entomology*, **56**: 905.

Hammons, R. O. and Leuck, D. B. 1966. Natural Cross-pollination of the peanut, *Arachis hypogaea* L., in the presence of the bees and thrips. *Agronomy Journal*, **58**: 396.

Harding, J. and Tucker, C.L. 1964. Quantitative studies on mating systems. I. Evidence for non-randomness of out crossing in Phaseolus lunatus. *Heredity*, **19**:369-381.

Knauft, D.A., Chiyembekeza, A.J. and Gorbet, D.W. 1992. Possible reproductive factors contributing to outcrossing in peanut (*Arachis hypogaea* L.). *Peanut Science*, **19**: 29-31.

Kushman L. J. and Beattie, J. H. 1946. Natural hybridization in peanuts. *Journal of American Society of Agronomy*, **38**:755-756.

Leuck. D. B. and Ray Hammons, R.O. 1965a. Further evaluation of the role of bees in natural cross-pollination of the peanut. *Arachis hypogaea* L. *Agronomy Journal*, **57**:94.

Leuck. D. B. and Ray Hammons, R.O. 1965b. Pollen-collection activities of bees among peanut flowers. *Journal of Economic Entomology*, **58**:1028-1030.

Nei, M. and Syaktdo, K. 1958. The estimation of outcrossing in natural population. *Japanese Journal of Genetics*, **33**: 46-51.

Nigam, S. N., Vasudeva Rao, M. J. and Gibbons, R. W. 1990. Artificial hybridization in groundnut. *ICRISAT Information Bulletin No. 29.* ICRISAT, Andhra Pradesh, India.

Srinivasalu, N. and Chandrasekaran, N. R. 1958. A note on natural crossing in groundnut, *Arachis hypogaea*, Linn. *Science and Culture*, **23**: 650

Stone, E. G., Bailey, W. K. and Bear, J. E. 1973. Natural outcrossing of peanuts, *Arachis hypogaea* L., in Puerto Rico. *Proceedings of Journal of American Peanut Research Education Association., Inc.* **5**: 134-140.

Table 2 General combining ability effect of parents in Indian mustard

Genotype	Days to 5% flowering	Days to maturity	Plant height (cm)	No. of primary branches	No. of siliquae/ plant	No. of seeds/ siliquae	Seed yield/plant (g)	1000 seed weight (g)	Harvest index (%)
TESTERS									
ACN-9	-0.52*	-1.76**	-11.64**	N.S	-2.00	-0.26	-1.03**	-0.26**	0.14**
PCR-7	0.88**	1.88**	7.21**	N.S.	-16.25**	-0.22	1.17**	0.59**	0.58**
Varuna	-0.36	-0.12	4.43**	N.S.	18.25**	0.48**	-0.13	-0.33**	-0.72**
SE(gi)	0.21	0.17	1.19	N.S.	1.99	0.13	0.36	0.03	0.032
LINES									
ACN-12	-0.06	-0.34	N.S.	-0.10	-35.08**	N.S.	N.S.	0.09	0.85**
ACN-13	-0.28	-0.90*	N.S.	0.14	8.66*	N.S.	N.S.	-0.17**	-0.61**
ACN-14	-1.28**	0.99**	N.S.	-0.12	-42.34**	N.S.	N.S.	0.08	-0.16**
ACN-15	-0.50	-1.23**	N.S.	-0.66**	-7.65*	N.S.	N.S.	0.17**	-0.48**
TM-1	-1.06*	-0.68	N.S.	-0.12	13.37**	N.S.	N.S.	-0.10*	0.47**
TM-17	-0.61	-0.46	N.S.	-0.19	41.05**	N.S.	N.S.	-0.04	0.44**
TN-18	0.17	-0.90**	N.S.	-0.26	-5.03	N.S.	N.S.	-0.40**	-1.01**
RAURD-9505	0.72	0.10	N.S.	0.59**	4.70	N.S.	N.S.	0.34**	0.86**
HUM-9601	0.61	0.77**	N.S.	0.05	-0.39	N.S.	N.S.	0.16**	-0.27**
LOCAL	2.28**	2.66**	N.S.	0.68**	22.26**	N.S.	N.S.	-0.13*	-0.09
SE (gj)	0.45	0.35	N.S.	0.17	3.64	N.S.	N.S.	0.05	0.059

*P > 0.05 ** P > 0.01

Among the crosses studied for *sca* effect (Table-3) significant positive *sca* effe Among ct was observed in five crosses for days to 50 % flowering, eight for days to maturity, *eleven for number of siliquae/plant, four for 1000* seed weight, and thirteen for harvest index. In contrast significant negative *sca* effect was observed in five crosses for days to 50 % flowering, eight for days to maturity, two for plant height, twelve for number of siliquae/plant, four for 1000 seed weight and eleven for harvest index. It is important to note here that among crosses showing significant *sca* in desirable direction in respect of all the traits either involved or did not involve one or both parents as the good general combiner of the concerned traits. *Sca* effects generally do not contribute a lot in the improvement of self pollinated crops except where commercial exploitation of heterosis is feasible.

In autogamous crop like mustard a study of segregating generation for *sca* effect would be important, as superiority of cross *per se* might not indicate their ability to produce transgressive segregates due to non fixable effects. In predominantly self pollinated crops like mustard the breeder is restricted to produce true breeding varieties only, as non additive portion of phenotypic variation is not fixable in later generations. Therefore the potentiality of a variety as a parent may be judged by comparing it's performance , the F_1 value and combining ability (Singh *et al.*,1985).

. . . Crosses showing maximum heterosis (%) for different characters in Indian mustard

Characters	Heterosis	Heterobeltiosis	Useful heterosis
Days to maturity	-8.0** (ACN-9 x RAURD 9505)	-8.56** (ACN-9 x RAURD 95-5	-7.99** (ACN-9 x RAURD 9505)
	-5.92** (ACN-9 x ACN-12)	-7.64** (ACN-9 x ACN-12)	-7.07** (ACN-9 x ACN-12)
	-5.44** (Varuna x ACN-13)	-7.04** (ACN-9 x TM-18)	-6.46** (ACN-9 x TM-18)
Plant height	-8.68 (ACN-9 x ACN-13)	-10.79 (PCR-7 x TM-18)	-0.42 (ACN-9 x ACN-12)
	-4.15 (PCR-7 x HUM 9601)	-9.69 (ACN-9 x Local)	-0.16 (ACN-9 x TM-1)
	-3.97 (ACN-9 x ACN-12)	-7.69 (ACN-9 x ACN-12)	
No. of siliquae/plant	98.79** (Varuna x TM-18)	58.31** (ACN-9 x TM-17)	92.73** (ACN-9 x TM-17)
	59.47** (ACN-9 x TM-17)	55.30** (Varuna x TM-18)	65.19** (ACN-9 x HUM 9601)
	43.38** (ACN-9 x TM-18)	31.19** (Varuna x RAURD 9505)	55.30** (Varuna x TM-18)
Seed yield/plant	76.70 (Varuna x TM-18)	48.79 (ACN-9 x TM-17)	104.30** (PCR-7 x RAURD 9505)
	62.51** (ACN-9 x TM-17)	47.27 (Varuna x ACN-15)	98.11** (PCR-7 x Local)
	59.35 (ACN-9 x TM-18)	41.64 (Varuna x TM-17)	90.21** (PCR-7 x TM-17)
1000 seed weight	*19.19** (ACN-9 x TM-1)*	5.18 (ACN-9 x ACN-12)	*51.72** (PCR-7 x RAURD 9505)*
	13.60* (ACN-9 x TM-17)	5.18 (ACN-9 x TM-1)	48.28** (PCR-7 x ACN-14)
	12.19* (PCR-7 x TM-17)	3.19 (ACN-9 x TM-17)	44.44** (PCR-7 x ACN-15)
Harvest index	10.07** (PCR-7 x TM-18)	6.67** (ACN-9 x TM-17)	8.84** (ACN-9 x TM-17)
	9.86* (ACN-9 x TM-18)	6.21** (ACN-9 x Local)	8.38** (ACN-9 x Local)
	8.57* (ACN-9 x TM-17)	3.16** (ACN-9 x TM-1)	8.38** (PCR-7 x ACN-12)
			8.23** (PCR-7 x RAURD 9505)

*P > 0.05; ** P > 0.01

Combining Ability: The mean squares due to testers were greater in magnitude than those due to lines indicating large diversity among the testers than among the lines for number of primary branches per plant and oil content. The estimates of mean squares due to Line x Testers were also significant for five characters viz. days to 50% flowering, days to maturity, number of siliquae/ plant, 1000 seed weight and harvest index. The lower magnitude of variance in Line x Tester interactions suggested greater uniformity among the crosses than among the parents. Earlier Chaudhary *et al.*,1997 also reported the same observation. Fixed effect model adopted in the present investigation does not provide the estimates of variance components and thus it was not possible to know precisely the relative importance of additive and dominance components in the control of different characters. However, in this model an idea about relative importance of *gca* and *sca* in determining progeny performance can be obtained by calculating the general predictability ration on the basis of *gca* and *sca* mean squares (Baker,1978). The estimates of this ratio in the present study indicated that for almost all characters the predictability ratio was almost closer to unity. Under such situations the performance of progeny can be judged on the basis of *gca* of this trait. The estimates of *gca* and *sca* effects among the parents and crosses showed wide variation in the level of significance for different characters. The comparison of *gca* effect with the *per se* performance of parents revealed that the ranking of parents on the basis of *per se* mean values was nearly same as that on the basis of *gca* effect for most of the characters (Table-2 and 3). This revealed the potentiality of a variety as a parent may be judged by comparing it's *per se* performance, the F_1 value and combining ability effects (Singh *et al.*, 1985).The estimates of *gca* effects (Table-2) showed that the parent PCR 7 was observed to be the best general combiner as it recorded highest *gca* effect for seed yield/plant,1000 seed weight and harvest index, followed by Varuna for number of siliquae/plant and number of seeds/siliqua. Also the parent RAURD-9505 was noticed to be the best general combiner for number of primary branches, harvest index and 1000 seed weight, however parent ACN-9 was found to the best general combiner for earliness and dwarfness.

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Combining ability and heterosis in Indian mustard

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Abstract

Combining ability and heterosis were studied in 7 x 7 diallel set of Indian mustard, *Brassica juncea* (L.) Czern & Coss. Analysis of variance for combining ability revealed the presence of genetic variability due to *gca* among the parents and due to *sca* among the crosses for all the traits, studied except days to maturity for *gca*. Low estimates of predictability ratio in correspondence with low estimates of narrow sense heritability indicated predominance of non-additive gene effects for seed yield, biological yield, harvest index, seeds/siliqua, primary branches, est weight, days to flower, days to maturity and plant height. On the contrary high estimates of predictability ratio for oil content and protein content showed predominance of additive gene effects. CS-52 and RLM-514 were identified as good general combiner for seed yield. The magnitude of heterosis was highest for biological yield followed by seed yield. Significant heterosis over standard variety was observed for biological yield (61.4 %), seed yield (56.0 %) and seeds/siliqua (17.8 %) while, over better parent for biological yield (76.3 %), seed yield (50.0 %), primary branches and seeds/siliqua. No cross could out yield the standard variety for primary branches, test weight, harvest index, oil content and protein content. Heterosis over better parent was also not recorded for harvest index, oil content and protein content.

Key words: Heterosis, combining ability, diallel, *gca effect*, Indian mustard

Introduction

With the availability of perfect restoration for *moricandia* CMS (Prakash *et al.*, 1998), heterosis breeding is being looked as a promising tool to overcome the yield barriers in Indian mustard (Pandey *et al.*, 1999), which is a predominant oilseed crop of Indian subcontinent. A successful heterosis breeding programme is mainly determined by the extent of heterosis and identification of good combiners for yield and its contributing traits. The present investigation was undertaken to estimate the level of heterosis and for identification of good combiners from high yielding varieties of Indian mustard..

Materials and methods

A set of 7 x 7 diallel crosses of mustard excluding reciprocals were evaluated along with their parents (VLS-5, CS-52, Varuna, PCR-7, Rohini, RLM-514 and RH-781) in a randomized block design with three replications at National Research Centre on Rapeseed-Mustard, Bharatpur during *rabi*, 1999-2000. Each genotype consisted of one row plot of 1 m length in a replication. Row to row and plant-to-plant spacing was kept 30 cm and 10 cm, respectively. Observations were recorded on five randomly selected plants from each plot pertaining to yield and its components (Table-1). Combining ability analysis were made following method 2 model I of Griffing (1956). The F_1 hybrid performance was computed as the estimates of heterosis over better parent and standard check (CS-52) and their significance was examined with 't' test. The general predictability ratio was computed as suggested by Baker, 1978.

Results and discussion

Analysis of variance for combining ability revealed the variance due to *gca* and due to *sca* were significant for all the traits except for days to maturity for which variance due to *gca* was non-significant (Table-1). This indicated existence of genetic variability among parents included in the parent study and role of both additive and non-additive gene effects in the inheritance of these traits. The relative importance of additive and non-additive gene effects in determining the progeny performance is better judged by predictability ratio as per Baker (1978). High estimates of predictability ratio for oil and protein content indicated predominance of additive gene effects in the inheritance of these traits, while, for the remaining traits non-additive gene effects played major role (Table-1). These findings are in conformity with reports from Thakur and Bhateria (1993), Kumar *et al.* (1997) and Sheikh and Singh (1998). Estimates of narrow-sense heritability were in correspondence to the predictability ratio being high for oil and protein content and low for other remaining characters. The predominance of additive gene effects for oil and protein content as reflected by high estimates of

Table 3 Specific combining ability effects of crosses

Crosses	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of siliquae/ plant	1000 seed weight (g)	Harvest index (%)
ACN-9 X ACN-12	0.19	-2.69**	-2.74	-27.51**	-0.10	-1.01**
ACN-9 X ACN-13	2.08**	3.20**	2.73	-13.98**	-0.14	-0.29**
ACN-9 X ACN-14	-0.92	2.31**	-3.87	-4.24	-0.37**	0.17*
ACN-9 X ACN-15	-1.03	1.87**	-0.81	22.93**	0.03	-0.88**
ACN-9 X TM-1	0.19	-0.36	-1.30	-25.89**	0.08	0.10
ACN-9 X TM-17	-0.26	0.09	-0.30	79.11**	-0.02	1.13**
ACN-9 X TM-18	0.30	-1.47**	4.08	-6.96	0.21*	0.21**
ACN-9 X RAURD 9505	-2.26**	-4.13**	-0.32	-22.16**	0.09	-1.09**
ACN-9 X HUM 9601	-0.14	-1.47**	5.68	64.93**	0.09	0.11
ACN-9 C LOCAL	1.86**	2.64**	-3.16	-66.24**	0.14	1.53**
PCR-7 X ACN-12	1.12	0.68	2.48	1.21	0.16*	0.16*
PCR-7 X ACN-13	-1.32*	-0.10	0.61	27.74**	-0.15	0.25**
PCR-7 X ACN-14	0.34	-2.99**	2.55	-5.72	0.29**	-0.07
PCR-7 X ACN-15	1.57*	-0.10	4.88	3.45	0.09	-0.98**
PCR-7 X TM-1	-0.88	1.01*	4.12	33.50**	-0.07	-0.83**
PCR-7 X TM-17	0.68	-0.88	-2.88	-38.70**	0.13	-0.90**
PCR-7 X TM-18	-1.77**	-0.10	-8.16**	-22.24**	-0.35**	0.88**
PCR-7 X RAURD 9505	2.68**	3.57**	0.70	20.83**	0.12	0.11
PCR-7 X HUM 9601	-0.88	0.57*	-9.10*	-47.41**	0.00	0.65**
PCR 7 X LOCAL	-1.54*	-1.66**	4.79	27.34**	-0.22**	0.73**
VARUNA X ACN-12	-1.31*	2.01**	0.26	26.30**	-0.05	0.85**
VARUNA X ACN-13	-0.76	-3.10**	-3.34	-13.76**	0.29**	0.04
VARUNA X ACN-14	0.58	0.68	1.33	9.97*	0.09	-0.10
VARUNA X ACN-15	-0.53	-1.77*	-4.07	-26.39**	-0.12	1.85**
VARUAN X TM-1	0.69	-0.66	-2.83	-7.61	-0.01	0.73**
VARUNA X TM-17	-0.42	0.79	3.17	-40.41**	-0.11	-0.24**
VARUNA X TM-18	1.47*	1.57**	4.08	29.19**	0.14	-1.09**
VARUNA X RAURD 9505	-0.42	0.57	-0.38	1.32	-0.21*	0.98**
VARUNA X HUM 9601	1.02	0.90	3.42	-17.52**	-0.09	-0.76**
VARUNA X LOCAL	-0.31	-0.99	-1.63	38.90**	0.08	-2.27**
SE (Sij) ±	0.63	0.50	3.57	4.14	0.08	0.067

* P > 0.05 ** P > 0.01

References

Amandeep and Banga, S.K. 1996. Identification and characterization of fertility restoring genotypes for Shifolia CMS in *Brassica juncea*. *Crop Improvement*, **22**(2): 164-166.

Anand, I.J., Mishra, P.K. and Rawat, D.S. 1985. Mechanism of male sterility in *Brassica juncea* L. Manifestation of sterility and fertility restoration. *Cruciferae News letter*, **10**: 44-46.

Baker, R.J. 1978. Issues in diallel analysis. *Crop Science*, **18**(4): 533-536

Chaudhary, S.P.S., Sharma, S.N. and Singh, A.K. 1997 Line x tester analysis in Indian mustard. *Indian Journal of Plant Breeding and Genetics*, **51**(2): 168-173.

Downey, R.K. and Chopra, V.L. 1996. Emerging trends in oleiferous *Brassica* In: *Second international crop science congress*. New Delhi, India, pp.167-173

Eisenhart, C., 1947. The assumptions underlying the analysis of variance. *Biometrics*, **3**: 1-27.

Kempthrone, O. 1957. *An introduction to genetic statistics.* John Wiley and Sons. Inc. New York, Chapman and Hall Ltd., London, pp., 468-470.

Singh, D.N. and Verma, D.K. 1997. Scope of heterosis breeding in rapeseed mustard. *Journal of Oilseed Research*, **14**(2): 157-164.

Singh, R.S., Singh, O.N. and Choudhary, R.K. 1985. Combining ability for yield in Indian mustard. *Indian Journal of Agricultural Sciences*, **55**(4): 240-242.

In general, the range for most of the traits was wider in hybrids than their parents (Table-3) and range for heterosis was higher for better parent heterosis than for the standard heterosis. Six crosses showed significant positive heterobeltiosis and four crosses showed significant positive standard heterosis for seed yield. Highest extent of standard heterosis (61.4 %) and heterobeltiosis (76.3 %) was observed for biological yield. Seed yield also exhibited high extent of both standard (56.0 %) and better parent (58.8 %) heterosis. Among the remaining characters seeds/siliqua, primary branches and plant height also showed good amount of heterosis. Days to flower, days to maturity and seed weight exhibited poor heterosis. Significant heterosis for seed yield in Indian mustard has earlier been reported (Banga and Labana, 1984; Pradhan *et al.*, 1993). None of the crosses exhibited heterosis for harvest index, oil content and protein content. It is expected for oil and protein content as the both traits are being governed predominantly by additive gene action. Absence of heterosis for harvest index may be due to balancing the positive and negative genes. Though, no standard heterosis was observed for primary branches and test weight, but three crosses exhibited significant positive heterobeltiosis for primary branches and four crosses exhibited significant positive heterobeltiosis for test weight.

Top ranking cross combination for different traits have been listed in Table-4 along with *per se* performance, *sca* effects and *gca* status of parents. *Sca* effects and *per se* performance were not always in consistency. Top ranking crosses involved high, medium and low combiners as parents. Kumar *et al.* (1997) also reported the involvement of high, medium and low combiners in superior crosses for seed yield and its components in Indian mustard. CS-52 x Rohini was the highest yielding cross combination on the basis of both per se performance and standard heterosis. This cross also had highest significant positive heterosis for biological yield but non-significant heterosis for primary branches and seeds/siliqua. Another cross between PCR-7 and RLM-514 exhibited highest better parent heterosis for seed yield though it was second on the basis of *per se* performance and standard heterosis. This cross also showed highest standard heterosis for seeds/siliqua along with significant positive standard heterosis for biological yield. The heterosis for yield appeared as a manifestation of heterosis for biological yield as depicted by high heterosis for both seed yield and biological yield by the same crosses. High extent of heterosis coupled with high *sca* effects for seed yield presented bright prospect for developing commercial hybrid in Indian mustard.

Table 3 Range, heterosis and number of crosses showing significant heterosis in desirable direction for yield and yield contributing traits in Indian mustard

Character	Range				No. of crosses showing heterobeltiosis	No. of crosses showing standard heterosis
	Parents	Hybrids	Heterobeltiosis	Standard heterosis		
Days to flower	64.7-72.7	67.3-77.7	-6.8-17.9	-9.0-4.9	2	6
Days to maturity	137.7-140	136.3-145.3	-2.6-5.3	-2.6-4.3	1	1
Plant height	162.2-205.8	176.7-222.9	-10.7-29.6	-14.2-8.3	2	5
Primary branches	3.1-6.3	3.9-7.1	-38.2-40.4	-38.2-12.6	3	Nil
Seeds/siliqua	10.5-14.1	11.3-16.7	-20.1-22.3	-20.1-17.8	3	1
Test weight	4.0-6.2	4.7-6.4	-16.9-17.6	-23.4-4.2	4	Nil
Yield/plant	8.3-16.9	7.3-28.2	-55.6-58.8	-61.5-56.0	6	4
Biological yield	37.1-71.6	27.8-121.1	-39.8-76.3	-58.5-61.4	10	8
Harvest index	20.4-27.4	12.3-26.0	-52.2-15.7	-55.2-1.8	Nil	Nil
Oil content	38.4-43.4	38.8-43.6	-5.7-1.9	-10.6-0.6	Nil	Nil
Protein content	19.3-21.3	19.2-20.7	-7.0-0.4	-9.6-0.7	Nil	Nil

predictability ratio, *pedigree selection for these traits* is suggested. The predominance of non-additive gene action for seed yield and its components could be exploited through heterosis breeding (Patel *et al.*, 1993) or through population improvement by intermating the improved genotypes in successive generations (Jensen, 1970). The estimates of *gca* effects for all the eleven characters are presented in Table-2. Good general combiners were CS-52 for seed yield, primary branches and protein content, RLM 514 for seed yield, seeds/siliqua, biological yield and protein content, Varuna and PCR-7 for test weight, VSL-5 for harvest index and days to flower and Rohini for oil content. CS-52 and RLM-514 are the parents which could be selected to produce desirable segregants for yield and its contributing traits. Rohini and RH-781 may be crossed to produce transgressive segregants for oil content.

Table 1 Analysis of variance (MSS) for combining ability of 11 characters in Indian mustard

Character	GCA Mg	SCA Ms	Error Me	h^2n	Predictability ratio
Days to flower	15.6**	13.5**	1.9	0.18	0.2
Days to maturity	2.6	6.6**	1.3	0.04	0.05
Plant height	234.2**	256.2**	36.6	0.15	0.17
Primary branches	0.8**	0.9**	0.2	0.12	0.13
Seeds/siliqua	1.9**	1.7**	0.3	0.18	0.03
Test weight	0.5**	0.2**	0.03	0.3	0.33
Yield/plant	32.0**	24.0**	1.4	0.22	0.23
Biological yield	329.5**	463.5**	5.6	0.13	0.13
Harvest index	8.5**	11.1**	1.6	0.12	0.14
Oil content	6.8**	0.6**	0.1	0.7	0.74
Protein content	0.9**	0.09**	0.02	0.67	0.74

** Significant at 1% level

Table 2 GCA effects for yield and its contributing traits in mustard

Character	Parents						
	VSL-5	CS-52	Varuna	PCR-7	Rohini	RLM-514	RH-781
Days to flower	-2.0**	-0.6	0.3	1.6**	-0.2	1.6**	-0.7
Days to maturity	-0.7	0.1	0.3	1.0**	-0.1	-0.5	-0.1
Plant height	-3.1	0.9	-4.6*	1.4	-2.0	10.4**	-3.0
Primary branches	-0.02	0.5**	-0.3*	-0.1	-0.4**	0.1	0.1
Seeds/siliqua	-0.8**	0.1	0.1	-0.1	-0.1	0.8**	-0.2
Test weight	-0.03	-0.1	0.4**	0.3**	-0.1	-0.3**	-0.04
Yield/plant	-0.04	2.6**	-3.6**	-0.5	0.2	1.3**	-0.05
Biological yield	-2.7**	9.9**	-10.4**	0.9	1.2	1.5*	-0.4
Harvest index	1.01**	0.4	-1.5**	-0.8*	-0.2	1.3**	-0.2
Oil content	-0.9**	-0.1	-0.4**	-0.7**	1.6**	0.2	0.4**
Protein content	0.4**	0.1*	-0.1*	-0.2**	-0.5**	0.4**	-0.2**

*, ** = significant at 5% and 1% level, respectively

References

Baker, R.J. 1978. Issues in diallel analysis. *Cross Science*, **18** : 533-536.

Banga, S.S. and Labana, K.S. 1984. Heterosis in Indian mustard (*Brassica juncea* L. Czern & Coss). *Z. Pflanzenzuchtg*, **92** : 61-70.

Griffing, B. 1956. Concepts of general and specific combining ability in relation to diallel crossing system. *Australian Journal of Biological Sciences*, **9** : 463-493.

Jensen, N.F. 1970. A diallel selective mating system for cereal breeding. *Crop Science*, **10** : 629-635.

Kumar, R., Sinhamahapatra, S.P. and Subrata Maity. 1997. Genotype x Environment interaction in relation to combining ability in Indian mustard. *Indian Journal of Genetics and Plant Breeding*, **57** : 274-279.

Pandey, I.D., Singh, Basudeo and Sachan, J.N. 1999. Brassica hybrid research in India : Status and prospects. Abstract *New Horizons for an old crop. 10th International Rapeseed Congress* 26-29 Sept. 1999, Australia, p.91.

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

Pradhan, A.K., Sodhi, Y.S., Mukhopadhyay, A. and Pental, D. 1993. Heterosis breeding in Indian mustard. Analysis of component characters contributing to heterosis for yield. *Euphytica*, **69** : 219-229.

Prakash, S., Kirti, P.B., Bhatt, S.R., Gaikwad, K., Kumar, V.D. and Chopra, V.L. 1998. A *moricandia arvensis* based cytoplasmic male sterility and fertility restoration system in *B. juncea*. *Theoretical and Applied Genetics*, **97** : 488-492.

Sheikh, I.A. and Singh, J.N. 1998. Combining ability analysis of seed yield and oil content in *Brassica juncea* (L.) Czern & Coss. *Indian Journal of Genetics and Plant Breeding*, **58** : 507-5121.

Thakur, H.L. and Bhateria, S. 1993. Heterosis and inbreeding depression in Indian mustard. *Indian Journal of Genetics and Plant Breeding*, **53** : 60-65.

Table 4 Top ranking cross combinations selected on the basis of *per se* performance along with respective *sca* effect and *gca* status

Cross	*Per se* performance	*sca* effects	*gca* status of parents	Heterosis over better parents	Heterosis over standard check
Days to flower					
VSL-5 x CS-52	67.3	-1.03	H x M	-2.42	-9.01**
VSL- 5 x Rohini	67.3	-1.40	H x M	-2.42	-9.01**
VSL-5 x RH-781	68	-0.21	H x M	-1.45	-8.00**
Days to maturity					
VSL-5 x Rohini	136.3	-4.03	M x M	-2.62*	-2.62*
RLM-514 x RH-781	138.3	-2.25	M x M	-1.19	-1.19
VSL-5 x RLM-514	139.7	-0.36	M x M	-0.24	-0.24
Plant height					
VSL-5 x CS-52	176.7	-17.33	M x L	-10.65*	-14.17**
Varuna x PCR-7	182.3	-10.67	H x L	-1.67	-11.43**
VSL-5 x RH-781	183.7	-6.37	M x M	-7.10	-10.75*
Primary branches					
CS-52 x PCR-7	7.1	1.57	H x M	26.97*	12.57
Varuna x RLM-514	6.6	1.64	L x M	40.4**	3.7
CS-52 x Rohini	6.5	1.20	H x L	15.3	2.6
Seeds/siliqua					
PCR-7 x RLM-514	16.7	2.35	L x H	22.26**	17.84**
VSL-5 x RLM-514	15.5	1.83	L x H	13.74*	9.63
CS-52 x Rohini	15.4	1.50	M x L	11.30*	9.28
Test weight					
VSL-5 x Varuna	6.4	0.81	M x H	4.20	4.20
CS-52 x PCR-7	6.3	0.83	M x H	9.60*	1.99
PCR-7 x RH-781	6.1	0.56	H x M	6.13	-1.24
Yield/plant					
CS-52 x Rohini	28.2	9.38	H x M	56.00**	56.00**
PCR-7 x RLM-514	24.4	7.59	L x H	58.83**	34.76**
CS-52 x PCR-7	22.8	4.73	H x M	26.93**	26.93**
CS-52 x RLM-514	22.2	2.36	H x H	22.91*	22.91*
PCR-7 x RH-781	20.4	4.93	M x M	45.00**	12.79
Biological yield					
CS-52 x Rohini	121.1	40.77	H x M	61.4**	61.97**
CS-52 x PCR-7	110.9	30.88	H x M	47.87**	47.87**
PCR-7 x RLM-514	100.4	28.89	M x H	67.48**	33.87**

H, L, M indicate high, low and medium combiners, respectively
*, ** = significant at 5% and 1% levels, respectively

better parent (578%) and standard check (193%) for seed yield. This hybrid also displayed significant positive heterosis over standard check (164%) for harvest index (Table-2). The hybrid 7-1-A x 98-2-3 exhibited maximum heterosis for oil content over better parent (50%) and standard check (20%). These results in general are in agreement with those of earlier workers in other crosses studies by them (Chidambaram and Sundaram, 1990; Giriraj and Virupakshappa, 1992; Dedio, 1993).

Table 1 Heterosis for different characters of sunflower pooled over two environments

Character	Range of heterosis in percentage		No. of hybrids superior on the basis	
	BP	SC (MSFH-8)	BP	SC (MSFH-8)
Days to flowering	-12.83 to -0.44	-22.66 to -4.49	34	75
Plant height	-9.91 to 124.15	-33.87 to 13.62	2	16
Number of leaves	1.09 to 42.52	0.13 to 18.17	36	16
Days to maturity	-11.18 to -0.95	-14.73 to -2.19	14	35
Head diameter	14.62 to 113.53	0.14 to 8.77	72	0
Autogamy	2.95 to 272.55	1.35 to 32.25	52	2
100 seed weight	29.38 to 54.75	18.78 to 47.46	44	44
Seed yield	147.00 to 688.31	0.07 to 193.44	75	43
Harvest index	4.40 to 257.52	0.53 to 164.43	60	36
Oil content	6.22 to 49.86	0.75 to 20.01	64	28

The best crosses involving 234A female performed better for number of leaves, days to maturity, a 100 seed weight and harvest index. For short days to flowering, dwarf plant height and early maturity, the crosses involving male 261-2 gave good performance. Among the top yielding hybrids (Table-2) the hybrid 234A x 187-333 showed highest heterosis over the check. This hybrid was better than the check for days to early flowering, early maturity, short plant height, 100 seed weight, harvest index and oil content also. The hybrids like 86A$_3$ x 68-3 and 7-1-A x 187-333 were also better hybrids than check for these traits. However, all the best five crosses on the basis of seed yield showed negative heterosis for autogamy. These promising hybrids can be further exploited for hybrid breeding and these above two lines 234A and 261-2 may be further used for heterosis breeding.

References

Chidambaram, S. and Sundram, N. 1990. Heterosis in varietal crosses of sunflower. *Madras Agricultural Journal*, 77: 517-519.

Dedio, W. 1993. Heterosis and prediction of achene oil content in sunflower hybrids from parental lines. *Canadian Journal of Plant Science*, **73**: 737-742.

Gangappa, E., Channa Krishnaiah, K.M., Ramesh, S. and Harini, M.S. 1997. Exploitation of heterosis in sunflower (*Helianthus annuus* L.). *Crop Research*, **13**(2): 339-348.

Giriraj, K. and Virupakshappa, K. 1992. Heterotic effect for seed yield and component characters on sunflower over seasons. *Proceedings of 13th International sunflower Conference*, Vol.2., Pisa, Italy, Sept., 7-11.

Kempthorne, O. 1957. *An introduction to genetic statistics.* New York : John Wiley and Sons. Inc., pp.88-96.

Madrap, I.A. and Maken, V.G. 1993. Heterosis in relation to combining ability effect and phenotypic stability in sunflower (*Helianthus annuus* L.). *Indian Journal of Agricultural Sciences*, **63** : 484-488.

Robinson, R.G. 1980. Artifact Autogamy in sunflower. *Crop Science*, **20** : 814-815.

Sugoor, R.K., Giriraj, K., Salimath, P.M. and Hanamaraitti, N.G. 1996. Genetic potential of induced mutant restorer lines for producing high yielding early maturing sunflower hybrids. *Indian Journal of Genetics*, **56(1)** : 16-20.

Table 2 Heterosis (%) over standard check (MSFH-8) of best five crosses selected for seed yield along with their *per se* performance (parenthesis)

	Seed yield	Days to flowering	Plant height	Number of leaves	Days to maturity	Head diameter	Autogamy	100 seed weight	Harvest index	Oil content
234A x 187-333	193.44** (74)	-16.49** (70)	-10.91* (130)	4.33 (31)	-7.99** (8)	-13.66 (12)	-40.65** (46)	41.62** (6)	164.43** (65)	12.98** (42)
234A x 143-1	103.54** (51)	-16.88** (70)	9.15 (159)	12.59** (33)	-5.16** (100)	-9.18 (13)	-40.56** (46)	18.53** (5)	55.36** (38)	5.51** (39)
234A x 68-3	71.72** (43)	-22.66** (65)	-15.97 (122)	-3.89 (28)	-7.52 (98)	-13.44 (12)	-29.82** (54)	38.32** (5)	105.24** (50)	0.75 (38)
86A$_3$ x 68-3	62.10** (40)	-19.67** (67)	-10.62* (130)	-9.27 (27)	-4.54** (102)	-10.48 (12)	-17.81** (63)	26.14** (5)	9.06 (27)	9.12** (41)
7-1-A x 187-333	38.90** (35)	-14.88 (71)	-12.82** (127)	2.20 (30)	-3.90 (102)	-6.36 (13)	-43.03** (44)	12.18 (4)	30.45 (32)	4.15** (41)
MSFH-8	(25)	(64)	(146)	(30)	(106)	(14)	(77)	(4)	(25)	(38)

*, ** indicated the significance at 5% and 1% levels, respectively.

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Heterosis for seed yield and its components in sunflower, *Helianthus annuus* L.

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Abstract

Heterosis for seed yield and its components was studied in a set of line x tester crosses of five CMS lines and 15 testers, over better parent and standard check (MSFH-8). For seed yield maximum heterosis of 688% and 193% was observed over better parent and standard check, respectively. All the 75 hybrids showed significant positive heterosis over better parent, while 43 hybrids exceeded the standard check for seed yield. The hybrid 234A x 187-333 displayed maximum heterosis for seed yield and harvest index over the better parent as well as standard check. This cross was better than standard check for early flowering, early maturity, short plant height, 100-seed weight and oil content. For oil content, the hybrid 7-1-A x 98-2-3 exhibited maximum heterosis over the better parent (50%) and standard check (20%). Large number of crosses showed significant amount of heterosis for different characters which can be further exploited in sunflower breeding.

Key words: Sunflower, heterosis, hybrids

Introduction

Sunflower (*Helianthus annuus* L.) has now become the oilseed crop of major economic importance world wide. Due to its cross pollinated nature, it offers considerable scope for commercial exploitation of heterosis utilizing cyto-restorer system (Madrap and Makne, 1993; Sugoor *et al.*, 1996; Gangappa *et al.*, 1997). The present attempt has been taken to study heterosis for seed yield, oil content and the yield components.

Materials and methods

Five cytoplasmic genetic male sterile (cms) lines *viz.*, 300A x 234A, 7-1-A, 207A and 86A_3 were crossed with 15 males, *viz.*, 68-3, 187-333, 113-3, 108-3, 261-2, 38-2, 98-2-3, 74-2, 143-1, 195-2, 255-1, 293-1, 349-1, 272-1 and 18-1-2. Crosses were made in a line x tester fashion (Kempthorne, 1957) to synthesize 75 F_2 hybrids. The parents and hybrids along with standard check (MSFH-8) were grown in a randomized block design with three replications in two environments. The environments were created by applying nitrogen 60 kg/ha and 90 kg/ha in first and second environment, respectively. The experiment was conducted at Punjab Agricultural University, Ludhiana. Crossing was carried out during *kharif*, 1995 and the evaluation of the crosses and their parents was done during spring, 1996. Each entry was grown in a single row of 3 m length with a spacing of 60 cm row to rows and 30 cm plant to plant. Recommended agronomic practices were followed to raise the crop. Data for morphological characters was recorded on five randomly selected competitive plants. Autogamy was calculated by following the method of Robinson (1980). Oil content was estimated by wide line NMR (Newport analyzer MK 111A). Heterosis was calculated over two environments as the percentage of F_1 performance in the favourable direction of its, better parent (BP) and standard check (MSFH-8) for seed yield, yield components and oil content.

Results and discussion

The pooled analysis of variance over two environments revealed large variability and indicated highly significant variance of parents as well as hybrids for all the traits. The contrast between the parents and hybrids showed the presence of dominance for all the traits except for days to maturity.

The experimental results of the parent study indicated the presence of significant amount of heterosis for the traits under consideration. For seed yield/plant, all the hybrids showed highly significant positive heterosis varying from 147 to 688% over better parents. The 43 hybrids showed superiority over the standard check. For seed yield, all the 75 hybrids under study exhibited significant positive heterosis over the better parents, thereby expressing over dominance for this character. The extent of heterosis over, better parent and standard check for oil content was varying from 6 to 50% and 1 to 20%, respectively (Table-1). Large number of crosses showed significant amount of heterosis for other characters also (Table-1), which can be further exploited in sunflower breeding. The hybrid 234A x 187-333 gave maximum heterosis over seed yield (11.40 %) in positive direction, maintaining at par performance with check for head diameter, number of seeds/plant, 100 seed weight and harvest index. However, this hybrid was found significantly superior over its better parents for all the characters except days to maturity and oil content.

In view of the overall performance with regard to heterosis response, the two hybrids *viz.*, CMSH 6A x RHA 272 and CMS 290A x HRHA 5 were found superior for oil content and seed yield. However, the hybrid CMS 290 x HRHA 5 recorded higher seed yield over Jwalamukhi. High heterotic response for seed yield, oil content and 100 seed weight were earlier reported by Rajugounda *et al.* (1992), Kandhola *et al.* (1995), Chidambaram *et al.* (1996) and Gangappa *et al.* (1997). Further, there was a close agreement between *per se* performance and magnitude of heterotic response displayed by hybrids over Jwalamukhi for oil content and seed yield (Table-2). It is interesting to note that both the hybrids CMSH 6A x RHA 272 and CMS 290A x HRHA 5 involved high x low gca status of female and male parents for oil content and seed yield, respectively indicating additive and non-additive gene effects and their interactions in the expression of these traits. On the basis of *per se* performance, the hybrids CMSH 6A x RHA 272 and CMS 290A x HRHA 5 were also identified promising over Jwalamukhi (Table-2). The identified promising hybrids need to be further tested extensively in different agro-climatic zones for their superiority and stability for seed yield and oil content before their recommendation for commercial cultivation.

Table 1 Heterotic values of best selected hybrids over BP and SC for oil content, seed yield and other component traits in sunflower

Hybrid	Days to maturity		Head diameter (cm)		No. of seeds/plant		100 seed weight (g)		Seed yield/plant (g)		Harvest index (%)		Oil content (%)	
	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC	BP	SC
CMSH 6A x RHA 265	6.42**	5.00**	35.14**	-1.54	35.93**	-7.76	20.15**	-2.14	95.45**	-7.46	66.77**	0.26	7.53*	2.50
CMSH 6A x RHA 272	-6.69**	-2.33	41.91**	-3.40	57.69**	7.01	18.90**	-3.17	112.09**	0.42	67.75**	0.85	27.10**	2.95**
CMS 290A x RHA 296	1.65	2.33	79.10**	-0.70	156.79**	-1.57	50.04**	3.92	276.98**	-0.95	35.37**	13.69	11.95**	-0.43
CMS 290A x HRHA 5	3.97*	4.67**	90.71**	5.72	188.50**	10.65	38.81**	4.15	324.01**	11.40*	28.09**	7.58	-0.78	-10.46**

*, ** Significant at P=0.05 and 0.01 respectively BP = Better Parent; SC = Standard Check

Table 2 *Per se* performance of selected parental lines and their hybrids for oil content, seed yield and other component traits in sunflower

Parent/Hybrid	Days to maturity	Head diameter (cm)	No. of seeds/ plant	100 seed weight (g)	Seed yield/ plant (g)	Harvest index (%)	Oil content (%)
CMSH 6A	110	18	790	4.7	25.9	7.5	33
CMSH 290A	101	14	447	2.8	14.4	10.4	35
RHA 265	99	16	773	3.4	24.9	7.2	37
RHA 272	105	14	508	3.2	15.7	6.1	33
RHA 296	101	10	331	4.0	12.7	6.9	34
HRHA 5	101	13	245	4.3	9.5	4.9	35
CMSH 6A x RHA 265	105	25	1074	5.7	50.5	12.5	40
CMSH 6A x RHA 272	98	26	1246	5.6	54.9	12.5	42
CMS 290A x RHA 296	102	25	1147	6.0	54.1	14.1	39
CMS 290A x HRHA 5	105	26	1289	6.1	60.9	13.4	34
Jwalamukhi (check)	100	25	1165	5.8	54.6	12.4	39
Range	96-110	10-26	143-1289	2.8-6.7	1.8-60.9	4.8-22.5	28-42
CD (P=0.05)	3.53	1.76	96.39	0.51	5.17	1.79	2.76

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Evaluation of certain hybrids for oil content, seed yield and other component traits in sunflower

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Abstract

The magnitude of heterosis for oil content, seed yield and other component traits was worked out in 56 single cross hybrids produced, crossing 7 CMS lines with 8 fertility restorers through Line x Tester mating design in sunflower (*Helianthus annuus* L.). There was a close agreement between *per se* performance and magnitude of heterotic resonse displayed by hybrids over Jwalamukhi for oil content, seed yield and contributing traits. The identified hybrid CMSH 6A x RHA 272 involved high x low *gca* status of female and male parents for oil content and CMS 290A x HRHA 5 for seed yield, indicating additive and non-additive gene effects and their interactions in the inheritance of these traits.

Key words: Hybrid vigour, Heterosis, Line x tester, seed yield, oil content

Introduction

The establishment of CGMS system in sunflower two decades back (Leclercq, 1969; Kinman, 1970) has opened the new vistas for commercial exploitation of heterosis in the development of hybrids. However, USA, Bangalore has made a dent by developing India's first sunflower hybrid BSH-1 through CGMS system (Seetharam, 1980). The superiority of hybrids over open pollinated cultivars for productivity, yield stability, oil content, autogamy, homogeneity, uniformity and tolerance to disease and pest has experimentally been well established. Thus, in recent past, the breeding emphasis has shifted from population breeding to heterosis breeding in a bid to meet the challenges and tremendous demand of sunflower oil in the market owing to anticholesterol properties in its oil. The present investigation was undertaken to develop and identify new hybrids with high magnitude of heterosis for oil content, seed yield and other important attributes.

Materials and methods

The experimental material comprised of seven CMS lines *viz.*, CMSH 6A, CMSH 4A, CMS 290A, CMS 300A, CMSH-8A, CMS 10A and CMS 336A (E) and eight fertility restorer lines, *viz.*, RHA 265, RHA 272, RHA 273, RHA 856, RHA 347, RHA 296, HRHA 5 and HRHA 8. Each seed parent was individually crossed with each pollen parent in line x tester mating design (Kempthorne, 1957) to produce 56 single cross hybrids. Thus, 15 parental lines, 56 single cross hybrids along with a check Jwalamukhi were evaluated in a randomised block design, replicated thrice for oil content, seed yield and other important traits at the research farm of Seed Technology Centre, CCS Haryana Agricultural University, Hisar. In lieu of CMS lines, their corresponding isogenic maintainer lines were assessed. Recommended package of practices were adopted to raise the healthy crop. The observations were tapped on 72 entries including Jwalamukhi for days to maturity, head diameter (cm), number of seeds/plant, 100 seed weight (g), *seed yield/plant (g), harvest index (%) and oil content* (%). The analysis was carried out as per Kempthorne (1957) and the heterosis over better parents and Jwalamukhi was calculated as per Falconer and Mackey (1996).

Results and discussion

The significant magnitude of heterosis was displayed by four crosses out of 56 either over their respective better parent or check hybrid Jwalamukhi (Table-1). The rest of the hybrids manifested significantly negative heterosis over Jwalamukhi for almost all the traits studied (Kumar, 1998). The hybrids CMS 290A x RHA 296 and CMSH 6Ax RHA 265 exhibited significant superiority over their better parent for all the characters barring days to maturity. These hybrids did not perform better against Jwalamukhi even for a single trait. The hybrid CMSH 6A x RHA 272 showed intrinsic superiority (9.95 % heterosis) against Jwalamukhi for oil content, but it was observed at par in seed yield. This hybrid also registered highly significant heterosis over its better parent for all the traits *viz.*, days to maturity (earliness), head diameter, number of seeds/plant, 100 seed weight, seed yield/plant, harvest index and oil content. The other hybrid CMS 290 A x HRHA 5 registered significant heterosis over check for

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Phenotypic stability of hybrids and parents for seed yield and its components in castor, *Ricinus communis* L.

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Abstract

The phenotypic stability of castor (28 hybrids and 8 parents), grown in six environments over two seasons, was studied for seed yield and other traits. Both linear and non-linear components of G x E interaction were found important for stability of seed yield and its components. Pistillate line, MCP 2 for seed yield and capsules/spike, the male parent, RG184 for capsules on primary raceme, RG299 for spikes/ plant, and RG125 for 100 seed weight were found to be stable. The hybrids MCP2 x RG184 and VP1x RG125 were identified as stable for seed yield and some component traits.

Key words: Castor, G x E interaction, stability, linear and non-linear components

Introduction

Castor is an important industrial oilseed crop in India. Country earns valuable foreign exchange by the export of oil and seeds of castor. Stability of production is essential for crops having export potential. In general, genotype interacts with the environments, hence studies helps in the identification of genotype suitable for wider adaptation\ specific environments. Significant genotype x environment interaction in castor has been reported (Gopani *et al.*, 1972; Laureti, 1995). The genotype x environment interactions could mitigate the progress of selection and cause hindrance in identification of stable cultivars. A number of statistical and biometrical techniques have been developed, among these stability model developed by Eberhart and Russell (1966) is being commonly used. The information available on stability analysis is meagre in castor. Hence, under the present study, diverse material was used to study the stability parameters for seed yield and its component traits in castor.

Materials and methods

Eight parents consisting of four each pistillate lines and male parents and their 28 crosses were used as experimental materials. Parents were crossed in diallel mating design (excluding reciprocals). In all, 36 genotypes were grown in six environments. The environments were created by three dates of sowing i.e., 15 July, 30 July and 15 August, over two seasons. The experiments were grown in a randomised block design with three replications. Each genotype consisting of two rows were spaced planted and seeding rate was one seed/60 cm in rows spaced at 90 cm apart. Recommended package of practices were adopted to raise the crop under irrigated condition. Observations on seed yield i.e., at 120 days after sowing (DAS), 240 DAS and other component traits *viz.*, effective and total length of primary raceme, capsules on primary raceme, effective length of S_1T_1 raceme (tertiary one on secondary one), nodes upto primary raceme, spikes/plant, capsules/spike and 100 seed weight were recorded on ten randomly selected competitive plants. The mean values were subjected to statistical analysis. The stability analysis was done as per Eberhart and Russell (1966).

Results and discussion

The analysis of variance revealed significant differences among genotypes for all the traits (Table-1), it indicated the presence of sufficient variability in the materials. Highly significant mean squares due to environments indicated variation in different environments used. The combined environment and genotype x environment interaction was also significant for seed yield and other traits. Partitioning of genotype x environment interaction into linear and non-linear components revealed the significance of both the components. Higher magnitude of linear component for all the traits, suggested that G x E interaction for these attributes was predictable. The present findings were in agreement with those obtained by Hirachand *et al.*, (1982) and Henary and Dauley (1985) for seed yield; and Patel (1994) for effective length of primary raceme. However, Patel *et al.*, (1984), Mandal and Dana (1994) and Patel (1994 a & b) reported higher magnitude of non-linear component for seed yield in castor.

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References

Chidambaram, S., Shankarapondian, R. and Pallikonda, R.K. 1996 A note on heterosis in self-fertile lines of sunflower. *Annals of Agricultural Research*, **17** : 171-173.

Falconer, D.S. and Mackey, T.F.C. 1996. *Introduction to Quantitative Genetics*. (4th Ed.), Longman, England.

***Gangappa, E., Chennakrishnaiah, K.M., Ramesh, S. and* Harini, M. 1997.** Exploitation of heterosis in sunflower (*H. annuus* L.). *Crop Res.* **13** : 339-348.

Kandhola, S.S., Behl, R.K. and Punia, M.S. 1995. Heterosis and combining ability in sunflower. *Annals of Bilology* (India). **11** : 96-106.

Kempthorne, O. 1957. *An introduction to genetical statistics.* John Willey, Sons Inc., New York.

Kinman, M.L. 1970. New developments in the USDA and state experimental station sunflower breeding programme. *Proc. 4th Int. Sunflower Conf.*, Memphis, Too Woomba, Australia, pp.181-182.

Kumar, D. 1996. *Studies on heterosis, combining ability and* seed quality characters in some hybrids of sunflower (*Helianthus annuus* L.). *Ph.D. Dissertation*, CCS HAU, Hisar.

Leclercq, P. 1969. Line sterility cytoplasmique chezk tournesol. *Annuls Amel. Planta*, **12** : 99-106.

Rajugovinda, T.A., Sindagi, S.S., Virupakshappa, K. and Ranganatha, A.R.G. 1992. Heterosis for achene yield and its components in sunflower. *Mysore Journal of Agricultural Sciences*, **26** : 236-238.

Seetharam, A. 1980. Hybrid sunflower for higher yield. *Seeds and Farms*, **6** : 27-29.

References

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

Gopani, D.D., Joshi, S.N. and Kabaria, M. M. 1972. Expression of hybrid vigour in castor under different agro climatic conditions of Gujarat. *Indian Journal of Agricultural Sciences*, **42** (10): 946 - 949.

Henary, A. and Dauley, H S. 1985. Genotype x environment interactions for seed yield in castor bean. *Madras Agricultural Journal*, **64** (8): 537 -541.

Hirachand, Joshi, H. C., Dholaria, S.J. and Patel, P. K.1982. Stability parameters for hybrid castor. *Indian Journal of Agricultural Sciences*, **52** (4): 222 - 224.

Laureti, D. 1995. Genotype and genotype x environment interaction effects on yield and yield components in castor (*Ricinus communis* L.). *Journal of Genetics and Breeding*, **49**: 27 - 30.

Mandal, H. and Dana, I. 1994. Phenotypic stability in castor (*Ricinus communis* L.). *Annals of Agricultural Research*, **15** (4): 504 -505.

Patel, B. N. 1994a. Line x tester analysis over environments in castor (*Ricinus communis* L.). Ph.D. Thesis. Gujarat Agricultural University, S. K.Nagar.

Patel, I. D., Dangaria, C. J., Dholaria, S. J. and Patel, V. J. 1984. Phenotypic stability of seed yield in eight hybrids of castor. *Indian Journal of Agricultural Sciences*, **54** (8): 629- 632.

Patel, R.G. 1994b. Heterosis, combining ability and stability parameters in castor (*Ricinus communis* L.). Ph.D. Thesis, Gujarat Agricultural University, S K Nagar.

Stability parameters for pistillate lines revealed that MCP 2 was prominent stable pistillate parent for seed yield (240 DAS) and capsules per spikes. Pistillate line, MCP2 was suitable for favourable growing situations. Commercially exploited pistillate line VP 1 and another newly developed pistillate line, MCP1 were poor in *per se* performance for seed yield, however, these pistillate lines are useful in heterosis breeding. On the other hand NES type pistillate line 240 was unstable for seed yield, capsules on primary raceme, effective length of S_1T_1 raceme and capsules per spike. Evidently, it showed higher sensitivity to change in environments.

Amongst male parents, RG 184 for capsules on primary raceme, RG 299 for spikes/plant and RG 125 for 100 seed weight were found stable.

As regards the stability parameters for hybrids, critical examination of deviation mean square for crosses revealed that high magnitude of pooled deviations for yield and most of the other traits were largely due to few crosses involving unstable parents. For example, the crosses involving pistillate line, 240 and mostly male parent, 846 contributed maximum share of 29.8 and 23.7% in total deviation from regression for seed yield at 240 DAS, respectively. Similarly, for seed yield at 120 DAS, mostly male parent, 846 and crosses involving this parent contributed 42.3% in total non-linear component. Similar trend was also observed for the other traits.

The stability parameters for seed yield and other component traits indicated that hybrids identified as stable for seed yield were also stable for at least two or more component traits. The crosses VP1 x RG184 and MCP2 x RG299 showed stability for the maximum number of component traits. Nodes up to primary raceme (earliness in emergence of primary raceme) was the most stable character amongst the hybrids. Based on present study it could be concluded that involving stable parents in breeding programme would have better chances of developing stable hybrids.

The stability parameters for seed yield at early picking (120 DAS) indicated that crosses, MCP2 x RG184, 240 x RG184, MCP2 x RG125 and VP1 x RG299 recorded higher mean performance, average response to the changing environments and non-significant deviation from regression. Thus, these crosses were considered as well buffered and adapted to all the environments At final picking i.e., 240 DAS, considering all the three parameters of stability, crosses found stable in average response group were MCP2 x RG184, MCP1 x RG125, MCP1 x RG184, MCP2 x RG299, 240 x RG184, and MCP2 x RG125. In second group exhibiting 'b' values less than unity, only five crosses satisfied all the parameters of stability. Among these, prominent crosses were VP1 x RG125, VP1 x RG299 and VP1 x RG184. These crosses were found suitable for unfavourable growing condition. *The cross, 240 x RG125 was highly responsive* to favourable growing conditions.

Based on stability parameters for seed yield at early (120 DAS) and final picking (240 DAS), crosses i.e., MCP2 x RG184 and VP1 x RG125 were identified as the best crosses. The best cross MCP2 x RG184 exhibiting high mean performance and average response for seed yield was also found stable for important yield contributing traits i.e., capsules on primary raceme, and spikes/plant. Another superior cross, VP1 x RG125 recorded high *per se* predominance and below average response for seed yield which was also found stable for other attributes *viz.*, 100 seed weight, nodes up to primary raceme, and spikes/plant. The hybrid, VP 1 x RG 125 was found suitable for unfavourable growing situations. These superior crosses could be exploited directly as F_1 hybrids or could be used in breeding programme.

Table 1 Storability analysis for seed yield and its component traits in castor

Source	DF	Mean sum of squares									
		Effective length of primary raceme	Total length of primary raceme	Capsules on primary raceme	Effective length of S_1T_1 raceme	Nodes upto primary raceme	Spikes/ plant	Capsules/ spike	100 seed weight	Seed yield at 120 DAS	Seed yield at 240 DAS
Genotypes	35	1024.28**	393.16**	14132.41**	315.54**	17.37**	21.38**	170.57**	172.29**	2079.36**	13198.94**
Env. + (Gen x Env)	1805	23.00**	23.38**	116.06**	18.71**	0.66**	1.28**	1.36**	1.39**	63.98**	612.62**
Environments	175	228.65**	285.70**	826.02**	332.90**	6.42**	35.33**	21.71**	11.37**	1908.82**	17254.17**
Genotypes x Env.	1	17.12**	16.35**	95.78**	9.73**	0.49**	0.31**	0.78**	1.11**	11.27**	137.15**
Environments (Lin.)	35	1143.00**	1428.49**	4130.00**	1664.48**	32.12**	176.56**	108.57**	56.87**	9544.09**	86270.85**
Gen. x Env. (Lin.)	144	19.86**	19.57**	149.16**++	14.07**+	0.68**+	0.47**+	1.29**+	1.49**+	20.52**++	264.34**++
Pooled deviation	420	15.98**	15.11**	80.15**	8.41**	0.43**	0.26**	0.63**	0.96**	8.71**	102.43**
Pooled error		4.42	5.09	27.22	2.98	0.28	0.08	0.15	0.53	2.96	34.99

** Significant at P=0.01 and tested against pooled error; +, ++ Significant at P=0.05, P=0.01 and tested against pooled deviation disease while, M-541 and M-574 exhibited <10% incidence of wilt (Anonymous, 1994). High degree of wilt resistance in M-619 followed by M-571, M-574, M-584 and M-568 was confirmed by artificial screening employing root dip inoculation technique (Table-1) (Raoof and Nageshwar Rao, 1996).

Evaluation of five pistillate lines *viz.*, M-619, M-574, M-584, M-571 and M-568 (20 plants each) in *Rabi* 1999-2000 and 2000-2001 indicated M-619 (with green stem, triple bloom and dwarf plant type) to be the most stable pistillate line with 90% of the plants as pistillate in the entire spike orders (Table-1). Mutant M-571 recorded 100 % pistillate plants with interspersed staminate flowers (ISFs) irrespective of the season and needs for intensive selection for stable pistillate plants with environment sensitive ISF production. Other pistillate lines M-574, M-584 and M-619 expressed interspersed staminate flower character in the early spike orders and later reverted to monoecious condition. Similar results were obtained (Rudraradhya and Habib, 1986) when M_1 plants of CV RC 7 treated with 10 Kr gamma radiation produced 100% pistillate spikes and 40% of the population reverted to normal monoecious nature while 60% continued as pistillate lines in the M_2 generation.

Table 1 Breeding behaviour of mutant VP-1 pistillate lines*

Mutant pistillate line	Morphological characters	No. of nodes to primary	Effective spikes/plant	Wilt incidence (%)+	Number of plants showing (%)			
					Pistillate	Pistillate with ISF	Pistillate to ISF or ISF to pistillate	Monoecious
M-571	R_3SpD	12.9	6.1	26.7	0	100	0	0
M-574	G_2SpD	13.1	6.6	29.6	0	29	57	14
M-584	G_3SpD	12.0	7.9	33.3	0	66	0	34
M-619	G_3SpD	14.8	6.2	12.5	90	0	10	0
M-568	G_2SpD	15.0	5.8	20.0	75	15	0	10
VP-1	G_3SpD	18.0	6.6	55.6	25	75	0	0

* G - Green; R - Red stem; 2- Double; 3- Triple bloom; Sp - Spiny capsule; D - Dwarf stem condensed nodes; + Under artificial screening technique

Reversion to monoecious condition indicated the operation of S type of sex expression. S type of sex expression in castor is characterized by dominant and epistatic effects of the pistillate gene with environmentally sensitive modifying genes for the production of ISF character (Classen and Hoffman, 1950; Zimmerman and Parkey, 1954; Shifriss, 1960). Hybrid seed production using S type pistillate line was taken up during the cool season of August to February because of 100% pistillate expression under low temperatures by the pistillate line. The maintenance of pistillate line in summer season was based on the presence of environmentally sensitive genes for ISFs (Ramachandram and Ranga Rao, 1989).

These stable and wilt resistant mutants were used to reconstitute GCH 4 hybrids using 48-1 as male parent. Among them DCH 158, DCH 168 and DCH 173 hybrids were free from wilt even in wilt sick plot (Anonymous, 1994). Five hybrids *viz.*, DCH 149, DCH 158, DCH 161, DCH 171 and DCH 519 recorded <20% wilt incidence in wilt sick plot during *kharif*, 1998-99 (Table-2). These hybrids provide the scope for breaking the genetic vulnerability of castor hybrids to fusarium wilt.

Table 2 Wilt incidence in hybrids

Hybrid	Pedigree	Wilt incidence (%)
DCH 149	M-571 x DCS 9	9.5
DCH 158	M-568 x 48-1	10.0
DCH 161	M-584 x DCS 9	8.7
DCH 171	M-619 x DCS 9	8.3
DCH 519	M-574 x DCS 78	16.7

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Development of wilt resistant pistillate lines in castor, *Ricinus communis* L. through mutation breeding

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Abstract

A mutation breeding programme was initiated in 1988 to incorporate wilt resistance in a susceptible pistillate line VP-1 of castor. The seeds of VP-1 were subjected to 45, 55 and 65 Kr gamma rays at BARC Mumbai and selections were made for stable pistillate behavior and wilt resistance in wilt sick plot. Among the several VP-1 mutants selected, M-568, M-571, M-574, M-591 and M-619 were found to be stable for pistillate behavior and resistant to wilt.

Key words: Castor, VP-1, mutation, *Fusarium* wilt

Introduction

The development of an indigenous pistillate line Vijapur -1 (VP-1) from Texas stable pistillate line 10 R (TSP 10 R) resulted in the development of three castor hybrids *viz.*, GAUCH 1, GCH 2 and GCH 3. These hybrids with >25 % yield advantage over prevailing varieties were however, susceptible to *fusarium* wilt. Intensive cultivation of these hybrids with improper crop rotation led to high incidence of wilt in castor growing areas. VP-1 with its unique morphological characteristics (green stem, triple bloom, dwarf stature, condensed internodes, cup shaped leaves, long compact spike and spiny capsules) and high *gca* was a superior female line except for its susceptibility to wilt. Hence, a mutation breeding programme was initiated in 1988 with the sole objective of incorporating wilt resistance in VP-1.

Materials and methods

A preliminary study of VP-1 was made by treating the seeds with 0,15, 30, 45, 55 and 65 Kr gamma rays at BARC, Mumbai to determine optimum dose (Shivraj and Ramana Rao, 1963; Ankineedu and Kulkarni, 1965; Sindagi and Ansari, 1969). Observations were recorded on seedling height up to tip of cotyledonary leaf 16 days after sowing and intensity of necrotic spotting based on visual scoring.

Based on the pilot trial, 45 Kr, 55 Kr and 65 Kr doses of gamma rays were selected. About 600 selfed seeds were irradiated for each dose in April 1988. M_1 generation was raised in summer 1988 and continued through *kharif*. Wilt incidence was recorded both at early and later stages of the crop. Mitotic and meiotic abnormalities, varied seedling emergence, survival, growth, chimeras and pollen sterility were observed in M_1 generation. These mutant generations were evaluated under natural field conditions with high wilt inoculum load. The surviving plants were selfed and advanced to next generation. In M_2 population 250 plants each were observed for seedling markers in normal field and for wilt disease in sick plot. Morphological deviants like chlorophyll mutants on seedling emergence, sex expression, reversion and all deviations in the proportion of male, female and bisexual flowers, number of nodes to primary spike or early flowering were observed. Progeny wise selections were selfed and advanced to M_{12} generation in addition to selection for resistant or tolerant plants in disease sick plots.

Results and discussion

The progenies of 55 Kr and 65 Kr radiation exhibited marked variation for plant type, node number, spike characters. In both treated and untreated progenies all the plants were pistillate but produced interspersed staminate flowers with high temperature after March, 1990. All the progenies were uniformly female and no markers associated with female and monoecious character could be detected. The progenies also expressed marked difference for their reaction to wilt and considerable shift for low node number on the main stem (11 to 12 as against 15 in control). Wilt resistance was also associated with certain alterations in the plant morphology like internodal length, solid stem, thin rachis (floral axis). All the stable mutant VP-1 selections were dwarf, with condensed nodes, cup shaped leaves, spiny capsules, and either with double or triple bloom. In the M_{13} generation, five pistillate lines *viz.*, M-619, M-574, M-584, M-571 and M-568 were identified as stable pistillate lines with long compact spikes.

Four mutant VP-1 pistillate lines *viz.*, M-568, M-591, M-601 and M-619, screened in a sick field were free from

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Genetic architecture of some quality traits in castor, *Ricinus communis* L. under different environments*

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Abstract

Nine genotypes of castor with a range of genetic variability in morphological and biometrical attributes were crossed in a diallel fashion excluding reciprocal. Thirty six F_1s and their F_2s along with nine parents were evaluated under two environments *viz.*, irrigated and rainfed during *kharif*, 1995-96 at Gujarat Agricultural University, Sardar Krushinagar. Significant differences were observed among genotypes, F_1s, F_2s and parents Vs. F_2s (except oil content) for three quality traits *viz.*, oil content, oil density and iodine value under both the environments. The mean squares due to parents Vs F_1s were significant for oil content under irrigated condition and for density of oil under rainfed condition. The mean squares due to both *gca* and *sca* were significant for all three quality traits indicating the involvement of both additive and non-additive gene actions for the genetic control of these traits. The proportion of components of genetic variances, however, suggested the preponderance of non-additive gene action. The genotypes *viz.*, 2-73-11 for oil content and 48-1 for oil density appeared to be best general combiners under both the environments and both the generations. Both in F_1 and F_2 generations, 2-73-11 and VI-9 were good general combiners for iodine value.

Key words: *Gca*, *Sca*, quality traits, castor

Introduction

Castor (*Ricinus communis* L.), a mono specific crop plays an important role in the economy of the country. India is the major castor producing country wherein, Gujarat ranks first in area (3.5 lakh ha), production (6.2 lakh mt) and productivity (1994 kg/ha) (Anonymous, 2000). Commercial cultivation of hybrids in large scale boosted the yield level from 470 kg/ha (1967-68) to 1994 kg/ha (1999-2000) in Gujarat. Still there is a scope to increase the productivity along with quality traits of castor oil through genetic improvement and development of superior lines/hybrids.

Castor oil is one of the most important industrial raw material used in the manufacturing of large number of industrial products. Hence, improvement of oil content is one of the most important breeding objective. Castor oil is mainly used for lubricant because of its property to remain liquid at very low temperature (-32°C). It possesses high density at higher temperature and high viscosity which is (18 times more than other oils). No systematic efforts have been made to know the nature and magnitude of genetic components involved in the inheritance of quality traits in castor. The present study was therefore attempted to have the information on the genetic architecture for oil content, density of oil and iodine value of castor oil.

Materials and methods

On the basis of wide morphological variability for certain economic qualitative traits, nine genotypes of castor *viz.*, VI-9, 48-1, SKI 22, TMV-5, SKI 107, SPS-43-3, SKI 119, 116-1 and 2-73-11 were selected from the germplasm pool available at GAU, S.K. Nagar were crossed in all possible combinations (excluding reciprocals) in 1993-94 and advanced to F_2 in 1994-95. Thirty six F_1s and their six F_2s along with nine parents were grown in a randomized block design with three replications under rainfed and irrigated conditions during *kharif*, 1995-96 at Main Castor-Mustard Research Station, Gujarat Agricultural University, Sardar Krushinagar. Each progeny was represented by a single row of parents and F_1s and three rows of F_2s having 9 m length with inter and intra-row spacing of 90 cm and 60 cm, respectively having 15 plants/row. The composite seed samples from different treatments for each replication from both environments were analyzed for oil content, density and iodine value as per Sadasivam and Manickam (1996). The analysis of combining ability variances and effects was done as per Griffing (1956) method-2, model-1 whereas, genetic components along with different ratios were estimated as per Hayman (1954).

Results and discussion

Analysis of variance over two environments showed that mean sum of squares due to genotypes was significant for

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References

Ankineedu, G. and Kulkarni, L.G. 1965. Studies in the exploitation of hybrid vigour with monoecious lines in castor. *Indian Oilseeds Journal*, **9**(3) : 206-208.

Anonymous, 1994. Annual castor research workers group *meeting*, held at Directorate of Oilseeds Research, Hyderabad-500 030, AP May 25-27th, 1995. *Annual Progress Report, Castor*, p.145.

Classen, C.E. and Hoffman, A. 1950. The inheritance of the *pistillate character in castor and its possible* utilization in the production of commercial hybrid seed. *Agronomy Journal*, **42** : 79-82.

Ramachandram, M. and Ranga Rao, V. 1989. *In Seed production in castor. Technology bulletin*. Directorate of Oilseeds Research, Rajendranagar, Hyderabad - 500 030. pp., 42.

Raoof, M.A. and Nageshwara Rao, T.G. 1996. A simple screening technique for early detection of resistance to castor wilt. *Indian Phytopathology*, **49** (4): 389-392.

Rudraradhya, M. and Habib, A.F. 1986. Isolation of 100% pistillate spikes by recourse to gamma irradiation in castor. *Current Research*, **14** (4/6) :29-30.

Shifriss, O. 1960. Conventional and unconventional systems controlling sex variations in *Ricinus communis* L.. *Journal of Genetics*, **57**: 361-388.

Shivraj, A. and Ramana Rao, B.V. 1963. Comparative effects of fast neutrons and gamma rays on dry seeds of castor. *Madras Agricultural Journal*, **50** (7) : 274-278.

Sindagi, S.S. and Ansari, Z. A. 1969. A dwarf mutant in castor (*Ricinus communis* L.). *Mysore Journal of Agricultural Science*, **40**(3) : 231-232.

Zimmerman, L.H. and Parkey, W. 1954. Pistillate F_1 castor beans : their possible significance in producing commercial hybrid seed. *Agronomy Journal*, **46**(6) : 287.

environments. The symmetrical distribution of positive and negative alleles in parents was observed to be deviating from the theoretical value under both the generations as well as environments. The ratio measuring the proportion of dominant and recessive genes in parents under both the conditions indicated that for each one recessive gene there were two dominant genes involved for the inheritance of oil content, oil density and iodine value. The ratio h^2/H_2 which measures the number of alleles or allele groups exhibiting dominance was observed to be very low under both the conditions for these characters. This might have been under estimated because of the presence of complementary interaction (Mather and Jinks, 1971) or due to asymmetrical distribution of positive and negative alleles in parents. The lower value recorded for the ratio indicated that no valid interpretation about gene groups exhibiting dominance could be made. The heritability values for these traits were medium to high under both the environments.

The combining ability and genetic component analysis have sown the preponderance of non-additive genetic variance (non-fixable) towards the inheritance of oil content, density and iodine value in castor. However, the importance of additive (fixable) genetic variance can not be ruled out. Therefore, a breeding methodology using both the fixable and non-fixable components of genetic variances would be the most desirable for further exploitation of genetic material under study. It seems that selection in early segregating generations for high yield with high oil content, oil density and low iodine value of oil followed by *inter-se* crossing could be the most appropriate for the simultaneous exploitation of additive and non-additive genetic components.

References

Anonymous. 2000. *Margdarsika*, Directorate of Agriculture, Gujarat State, Gandhinagar.

Dobaria, K.L., Patel, I.D., Patel, P.S. and Patel, V.J. 1989. Combining ability and genetic architecture of oil content in castor. *Journal of Oilseeds Research*, **6**:92-96.

Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel crossing system. *Australian Journal of Biological Sciences*, **9** : 463-493.

Hayman, B.I. 1954. The theory and analysis of diallel cross. 11, *Genetics*, **43**:63-85.

Mather, K. and Jinks, J.I. 1971. *Biometrical genetics*. 2nd Edition Chapman and Hall Ltd., London.

Patel, A.A. 1996. Genetic analysis in castor. M.Sc. Thesis submitted to Gujarat Agricultural University, Sardar *Krushinagar-385 506*.

Sadasivam, S. and Manickam, A. 1996. *Biochemical methods*. 2nd Edition Pub., New Agricultural Enterprises (P) Ltd., publishers and TNAU, Coimbatore.

Table 4 Three best crosses (F_1s), range of mean value and *sca* effects for various characters under different environments (F_1 generation)

S.No.	Oil content				Density of oil				Iodine value				Oil yield/plant			
	I		R		I		R		I		R		I		R	
	Mean value	*sca* effects	Mean value	*sca* effects	Mean value	*sca* effects	Mean value	*sca* effects	Mean value	*sca* effects	Mean value	*sca* effects	Mean value	*sca* effects	Mean value	*sca* effects
1.	50.46	SKI-119 x 2-73-11 (1.87**)	50.02	SKI-107 x 2-73-11 (2.86**)	0.924	SKI-107 x SKI-119 (20.66**)	0.966	48-1 x TMV-5 (17.58**)	94.49	TMV-5 x SKI-119 (8.47**)	92.22	TMV-5 x 116-1 (8.51**)	97.50	SKI-22 x TMV-5 (36.58**)	54.61	SKI-22 x SKI-119 (6.76**)
2.	50.20	48-1 x TMV-5 (1.74**)	48.18	SKI-22 x SKI-119 (2.21**)	0.964	VI-9 x SKI-107 (20.30**)	0.965	SKI-22 x TMV-5 (15.48**)	91.57	SKI-107 x 2-73-11 (6.41**)	92.61	48-1 x SKI-119 (6.88**)	134.86	48-1 x SKI-119 (28.32**)	52.19	SKI-107 x SKI-119 (5.37**)
3.	49.21	SKI-107 x SPS-43-3 (1.62*)	50.23	TMV-5 x 2-73-11 (2.14**)	0.964	48-1 x TMV-5 (17.75**)	0.961	VI-9 x SKI-107 (12.45**)	91.59	SKI-107 x 116-1 (4.48**)	90.58	VI-9 x TMV-5 (6.51**)	82.53	VI-9 x 2-73-11 (19.43**)	51.63	SKI-22 x TMV-5 (5.08**)
Range	44.54 to 51.14	-1.52 to 2.57	44.07 to 50.40	-2.07 to 2.86	0.921 to 0.964	-22.88 to 20.66	0.925 to 0.966	-17.42 to 17.58	78.25 to 94.49	-6.89 to 8.47	78.47 to 92.22	-7.74 to 8.51	79.42 to 143.38	-17.07 to 36.58	30.70 to 54.61	-4.81 to 6.76

I = Irrigated; R = Rainfed; * = Significant at 0.05; ** = Significant at 0.01 Figures in parenthesis are *sca* effect of concerned cross all the traits (Table-1). Variances due to parents, F_1s and F_2s for all the traits were also highly significant indicating considerable amount of variability. The test for homogenity of arrays and regression coefficient for Wr Vr against unity indicated non-significant values for both these tests which suggested that further analysis can be carried out.

The mean sum of squares due to both *gca* and *sca* were significant for the characters under study. The magnitude of σ^2s was higher than the corresponding σ^2g indicating the preponderance of non-additive gene action for the genetic control of these quality traits (Table-2).

Table 1 ANOVA showing mean squares for different characters of castor studied under irrigated (I) and rainfed (R) conditions

Character	Environments	Replications 2*	Genotypes 80*	Parents 8*	F_1s 35*	F_2s 35*	Parents Vs. F_1s 1*	Parents Vs. F_2s 1*	Error 160*
Oil content	I	8.683**	4.989**	6.759**	3.427**	5.804**	10.019**	0.189	1.235
	R	4.722**	7.004**	6.872**	9.028**	5.400**	0.306	0.661	0.346
Density of oil	I	0.0013**	0.0004**	0.00029**	0.0004**	0.0004**	0.00004	0.0007**	0.00002
	R	0.0011**	0.0003**	0.0005**	0.0003**	0.0003**	0.0002**	0.0003**	0.00002
Iodine value of oil	I	6.080	67.711**	61.127**	52.644**	49.441**	10.125	602.793**	10.399
	R	3.065	62.097**	58.789**	73.875**	51.630**	7.286	65.340**	2.890

* = Degree of freedom for respective source

Table 2 Analysis of variance of combining ability for different characters over two environments

Effects	Generation	d.f.	Oil content		Density of oil		Iodine value of oil	
			I	R	I	R	I	R
GCA	F_1	8	2.9129**	6.4004**	59.0455**	109.6416**	24.5731**	12.4762**
	F_2	8	2.9489**	2.7497**	247.591**	44.6924**	29.4243**	7.7627**
SCA	F_1	36	1.0566*	2.0158**	152.9169**	125.6259**	16.2211**	25.5906**
	F_2	36	1.7279*	1.6531*	115.567**	111.963**	19.5933**	19.9656**
Error	F_1	88	0.5065	0.0941	5.6140	6.4715	0.3604	0.2449
	F_2	88	0.3429	0.1291	10.1493	8.2911	5.9258	1.6589
σ^2g	F_1	-	0.111	0.399	-8.534	-1.4532	0.759	-1.192
	F_2	-	-0.399	0.099	12.002	-6.1155	-0.894	-1.109
σ^2s	F_1	-	0.550	1.922	147.303	119.155	15.861	25.346
	F_2	-	1.35	1.524	105.418	103.672	13.667	18.307
$\frac{2\sigma^2g}{2\sigma^2g + \sigma^2s}$	F_1	-	0.288	0.293	0.104	0.024	0.08	0.104

* = Significant at -0.05; ** = Significant at -0.01 I = Irrigated condition; R = Rainfed condition

The excess amount of iodine value in castor oil reduces its keeping quality, therefore genetic material having negative *gca* and *sca* effects were desirable, whereas for oil content and density of oil those with positive effects were superior. In general, the experiments result revealed that the significant negative effect for iodine value and highly significant positive effects for oil content under rainfed condition and highly significant positive effect for oil density under irrigated condition were recorded. Two parents, 2-73-11 and VI-9 showed significant negative *gca* effects for iodine value, whereas, 2-73-11 and 48-1 for oil content and 48-1 and 2.59 and VI-9 for density of oil showed significant positive *gca* effects (Table-3).

Out of 36 F_1s and 36 F_2s under irrigated and rainfed conditions, three best crosses for each trait showing significant desirable *sca* effects are given in Table-4. It was observed that ranking of cross combinations on the basis of *per se* performance and *sca* effects were not the same (Table-5). This may be due to the fact that *per se* performance is a realized value whereas *sca* effects is an estimate, measured as the deviation of F_1 over parental performance. Selection of a particular cross combination on the basis of *per se* performance was more reliable than on *sca* effects (Dobaria *et al.*, 1989; Patel, 1996).

The estimates of genetic components with respect to oil content, iodine value and density of oil have been presented in Table-6. The additive component (D) and dominance component (H_1) were significant for these characters in both F_1 and F_2 generations under both the environments. However, the magnitude of H_1 was much higher than the corresponding D component indicating the preponderance of non-additive genetic component for the inheritance of oil content, iodine value and density of castor oil under irrigated and rainfed conditions. The ratio $(H_1/D)^{1/2}$, which measures the degree of dominance, also showed the presence of over dominance under both the

Table 6 Estimates of genetic components and their ratios for various traits under two environments

Components	Characters	Oil content		Density of oil		Iodine value of oil	
		I	R	I	R	I	R
D	F_1	1.75**	2.20	93.64	161.97**	20.02**	19.35
	F_2	1.91	2.16**	89.10*	160.15**	14.45	17.94*
H_1	F_1	3.46**	9.29**	719.79**	593.24**	80.16**	118.20**
	F_2	27.85*	29.66**	1995.05**	2112.16**	257.17*	360.20**
H_2	F_1	2.58**	7.00**	529.98**	422.93**	54.59**	92.24**
	F_2	22.57**	22.69**	1546.02**	1466.81**	198.26*	265.59**
h_2	F_1	1.27*	0.01	2.43	25.19	1.35	0.97
	F_2	-0.10	0.04	98.15	35.04	85.85**	8.90
F	F_1	1.71	1.73	245.92	290.72*	34.57*	76.42
	F_2	4.41	5.77	187.23	622.26*	37.86	76.85*
E	F_1	0.51**	0.09	5.61	6.47	0.36	0.24
	F_2	0.34	0.13	10.15	8.29	5.93	1.66
$(H_1/D)^{1/2}$	F_1	1.41	2.06	2.77	1.91	2.00	2.47
	F_2	3.82	3.70	4.73	3.63	4.22	4.43
$(H_2/4H_1)$	F_1	0.19	0.19	0.18	0.18	0.17	0.20
	F_2	0.20	0.19	0.19	0.17	0.19	0.18
KD/KR	F_1	2.06	1.47	2.80	2.766	2.52	2.40
	F_2	1.87	2.13	1.57	3.30	1.87	2.82
$K(F)=h_2/H_2$	F_1	0.10	0.01	0.00	0.059	0.02	0.01
	F_2	0.01	0.01	0.06	0.024	0.43	0.03
Heritability	F_1	31.62	21.67	15.87	33.03	29.85	19.52
	F_2	23.77	29.97	16.66	39.04	17.20	23.51

I = Irrigated; R = Rainfed * = Significant at 0.05; ** = Significant at 0.01

Table 3 Estimates of *gca* effects and mean values of parents under different environments

Parent	Gen.	Oil content				Density of oil				Iodine value of oil				Oil yield/plant		Mean values	
		gca effects		Mean values		*gca* effects		Mean values		*gca* effects		Mean values		*gca* effects			
		I	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R
VI-9	F_1	0.27	-0.30**	46.75	45.65	3.20**	2.28**	0.944	0.952	1.14**	0.46**	81.25	83.87	1.73	1.70*	93.43	45.68
	F_2	0.00	0.33**	-	-	-4.06**	-01.68*	-	-	-3.19**	-1.75**	-	-	-	-	-	-
48-1	F_1	0.19	1.07**	47.46	47.75	3.60**	1.76*	0.950	0.958	0.57**	-0.40**	91.20	91.33	4.39**	2.07**	96.83	48.08
	F_2	0.30	0.99**	-	-	7.52**	2.59**	-	-	-2.03**	0.51	-	-	-	-	-	-
SKI-22	F_1	0.35	-0.20	49.63	45.94	-1.40*	2.52**	0.939	0.953	-1.47**	1.46**	88.21	90.83	6.85**	-0.05	115.80	32.92
	F_2	0.30	-0.04	-	-	-3.64**	-0.01	-	-	0.44	-0.49	-	-	-	-	-	-
TMV-5	F_1	0.30	0.31**	48.10-	47.40	1.14	1.03	0.929	0.932	0.90**	-2.31**	88.19	82.10	-2.67*	-0.04	88.13	36.34
	F_2	0.51**	0.09	-	-	0.67	-2.26**	-	-	-0.16	0.06	-	-	-	-	-	-
SKI-107	F_1	0.16	0.63**	48.45	45.67	-0.68	0.64	0.933	0.943	2.34**	0.25	89.54	83.64	-1.94	-1.08	80.73	36.52
	F_2	-0.12	0.55**	-	-	-6.15**	-0.98	-	-	-0.73	0.52	-	-	-	-	-	-
SPS-43-3	F_1	-0.54**	0.21**	44.54	48.58	-0.89	-1.09	0.946	0.940	0.34*	0.85**	91.56	91.65	5.46**	1.20	93.54	40.76
	F_2	-0.72**	-0.08	-	-	4.85**	0.29	-	-	2.10**	0.50	-	-	-	-	-	-
SKI-119	F_1	-0.24	-0.68**	47.15	45.37	-1.16	-7.72**	0.928	0.928	-0.40*	0.21	80.86	81.25	-0.49	1.25	84.76	40.80
	F_2	-0.83**	-0.53**	-	-	-4.42**	1.92*	-	-	0.55	0.05	-	-	-	-	-	-
116-1	F_1	-0.82**	-1.08**	46.19	46.06	-3.56**	-0.78	0.958	0.967	-0.72**	0.10	82.30	82.76	-12.24**	-4.83**	81.51	30.70
	F_2	-0.31	-0.49**	-	-	3.12**	0.56	-	-	-1.16	-0.53	-	-	-	-	-	-
2-73-11	F_1	0.89**	1.12**	48.56	46.38	-0.25	1.37	0.951	0.959	-2.67**	-0.64**	81.25	90.00	-1.08	-0.23	82.53	42.44
	F_2	0.63**	0.27**	-	-	2.42**	3.41**	-	-	0.05	1.13**	-	-	-	-	-	-
SE(g)±	F_1	0.20*	0.09	-	-	0.67	0.72	-	-	0.17	0.14	-	-	0.112	0.457	-	-
	F_2	0.17	0.10	-	-	0.91	0.89	-	-	0.69	0.37	-	-	-	-	-	-
CD (P=0.05)	F_1	0.40	0.17	-	-	1.32	1.42	-	-	0.34	0.28	-	-	38.818	15.835	-	-
	F_2	0.33	0.20	-	-	1.78	1.60	-	-	1.34	0.72	-	-	-	-	-	-
SE(gi-gl)±	F_1	0.30	0.13	-	-	1.02	1.09	-	-	0.26	0.21	-	-	2.521	1.025	-	-
	F_2	0.25	0.15	-	-	1.39	1.23	-	-	1.04	0.55	-	-	-	-	-	-

** = Significant at 0.05; ** = Significant at 0.01; I = Irrigated; R = Rainfed*

Table 5 Generationwise three best crosses, *sca* effect and *per se* performance for various characters under different environments

Character	*sca* effects				*per se* performance			
	I		R		I		R	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
Oil content	SKI 119 x 273-11 (1.87)**	SPS-43-3 x 2.73-11 (3.12)**	SKI-107 x 2.73-11 (2.86)**	SKI-22 x SKI-119 (2.65)**	VI-9 x 2-73-11 (51.14)	SPS-43-3 x 2-73-11 (50.33)	TMV-5 x 2.73-11 (50.23)	48-1 x TMV-5 (49.35)
Oil content	48-1 x TMV-5 (1.74)**	48-1 x 2-72-11 (1.96)**	SKI-22 x SKI-119 (2.21)**	VI-9 x TMV-5 (2.19)**	SKI-119 x 2-73-11 (50.46)	48-1 x 2-73-11 (50.00)	SKI-107 x 2.73-11 (50.02)	VI-9 x TMV-5 (49.24)
Oil content	SKI-107 x SPS-43-3 (1.62)*	VI-9 x 116.1 (1.88)**	TMV-5 x 2-73-11 (2.14)**	VI-9 x SKI-107 (2.10)**	48-1 x TMV-5 (50.20)	VI-9 x 116-1 (49.09)	48-1 x SPS-43-3 (49.46)	SKI-22 x SKI-119 (48.70)
Density of oil	SKI-107 x SKI-119 (20.66)**	TMV-5 x SPS-43-3 (17.52)**	48-1 x TMV-5 (17.58)**	SKI-107 x SKI-119 (15.02)**	VI-9 x SKI-107 (0.964)	48-1 x 2-73-11 (0.964)	48-1 x TMV-5 (0.966)	48-1 x TMV-5 (0.958)
Density of oil	VI-9 x SKI-107 (20.30)**	48-1 x 2-73-11 (15.79)**	SKI-22 x TMV-5 (15.48)**	SKI-22 x SKI-107 (13.45)**	48-1 x TMV-5 (0.964)	48-1 x TMV-5 (0.958)	SKI-22 x TMV-5 (0.965)	SKI-22 x SKI-107 (0.956)
Density of oil	48-1 x TMV (17.75)**	SKI-107 x SKI-119 (12.31)**	VI-9 x SPS-43-3 (12.45)**	TMV-5 x 116-1 (12.15)**	SKI-107 x SKI-119 (0.960)	TMV-5 x SPS-43-3 (0.961)	VI-9 x SKI-107 (0.961)	SKI-22 x SPS-43-3 (0.967)
Iodine value	SKI-107 x SKI-119 (-4.95)**	VI-9 x SKI-107 (-13.17)**	48-1 x SPS-43-3 (-7.74)**	48-1 x SPS-43-3 (-6.69)	SPS-43-3 x 273-11 (80.50)	VI-9 x 116-1 (72.77)	TMV-5 x 2-73-11 (78.47)	VI-9 x 2-73-11 (79.14)
Iodine value	SPS-43-3 x 116.1 (-6.89)	48-1 x 2-73-11 (-4.61)**	48-1 x SKI-22 (-6.27)**	48-1 x SKI-22 (-5.50)**	TMV-5 x 2.73-11 (80.58)	VI-9 x SKI-107 (64.75)	48-1 x SPS-43-3 (78.62)	48-1 x SPS-43-3 (79.31)
Iodine value	SKI-22 x SKI-107 (-4.11)**	SPS-43-3 x SKI-119 (-4.82)*	VI-9 x 116.1 (-7.37)**	SKI-22 x SPS-43-4 (-6.19)**	SKI-22 x 2-73-11 (80.55)	SKI-22 x TMV-5 (78.04)	VI-9 x 116-1 (79.11)	TMV-5 x 116-1 (79.44)

I = Irrigated; R = Rainfed; * = significant at 0.05; ** = significant at 0.01

Figures in parenthesis are sca effect and per se performance of concerned cross

F_3 and BIP progenies in all the three crosses. Further, the estimates obtained in F_3 were compared with that in BIPs to assess the impact on biparental mating in F_2 through these estimates.

Results and discussion

A perusal of the data clearly indicated the shift in the mean values in respect of number of branches/plant, number of capsules/plant, capsule width, dry capsule weight, oil content and seed yield/plant, in a positive direction from F_2-F_3-BIP generations in all the three crosses (Table-1). Earlier Joshi (1979), Yunus and Paroda (1983) and Gurudev Singh *et al.* (1986) in wheat, Srivastava and Sharma (1987) in opium poppy, Srivastava *et al.* (1989) in wheat, Bajaj *et al.* (1990) in barley, Nematullah and Jha (1993) in wheat, Sethi *et al.* (1995) in durum wheat, Kaushik *et al.* (1996) in wheat, Alarmelu *et al.* (1998) in sesame, Parameswari and Muralidharan (1999) in sesame, Ahmed and Mehra (2000) in cotton and Parameswari *et al.* (2000) in sesame have also reported shifts in the mean values due to intermating in F_2 generation. The higher mean values of the BIP generation could be because of the advantage of increased heterozygosity at many loci for the characters compared to the corresponding F_2 and F_3 generations. On the contrary, there was a reduction in the mean values with respect to days to 50% flowering and days to maturity in all the three crosses. Nevertheless, from the breeder's point of view, such a result is encouraging since most of the times he is interested in developing short duration cultivars to fit into different cropping patterns. Thus, the shift of mean values in the negative direction is a welcome change in this context. The superior performance of BIPs could also be attributed to the possible accumulation of favourable genes of low frequency, thus making possible the convergence of those segregants, which could have been rarely obtained in F_2 and F_3 populations (Gurudev Singh *et al.*, 1986). From the theoretical genetical principles, the means of F_2 and BIP should be same in the absence of linkage (Mather and Jinks, 1982). The fact that, there was a considerable shift in the mean values from F_2-F_3-BIP in the positive direction indicated the presence of linkage amongst the characters. Thus, BIP progenies are significantly superior to F_2 in the desirable direction for all the characters, in all the generations as for as mean values are concerned, due to the constellation of favourable genes as a result of intermating, thus proving the efficiency of biparental mating over standard selfing series.

Higher estimates of PCV and GCV in BIPs was noticed for number of branches/plant, number of capsules/plant and capsule width in all the three crosses. However, higher PCV and GCV estimates were also noticed for plant height, capsule weight and test weight in C-I, test weight and oil content in C-II and capsule length, dry capsule weight, days to 50% flowering and days to maturity in C-III. This could be attributed to uncovering of the hidden genetic variability in F_2 generation, by way of breaking linkages especially, in repulsion phase. Further, the biparental mating in F_2 generation offered great opportunity for forced recombinations thus generating higher variability. Similar reports were reported by Yunus and Paroda, 1982; Alarmelu *et al.*, 1998; Parameswari and Muralidharan, 1999; Ahmed and Mehra, 2000 and Parameswari *et al.*, 2000. On the other hand, a lower estimate of GCV and PCV was observed for number of seeds/capsule and seed yield in all the crosses, plant height, capsule length, dry capsule weight, days to 50% flowering and days to maturity in C-I; plant height, capsule length, dry capsule weight, days to 50% flowering and maturity in C-II and plant height, test weight and oil content in C-III. This could be attributed to (a) genetic drift, (b) coupling phase of linkage and (c) sampling size.

Heritability estimates were higher for all the characters coupled with genetic advance as per cent of mean. This suggested that, selection would be effective in improving all the traits. The findings of Meredith and Bridge (1971), Yunus and Paroda, (1983); Nanda *et al.* (1990); Sethi *et al.* (1995); Kaushik *et al.* (1996) and Parameswari and Muralidharan, (1999) lend sufficient support to the present investigation.

It was quite interesting to note here that, heritability estimates in F_2 was slightly higher than in F_2 for most of the traits. This is most surprising as biparental matings would tend to increase additive variability by converting repulsion phase of linkage into coupling phase (Singh and Murthy, 1973; Sharma, 1994). The obvious corollary of this result is an increase in the expected genetic advance. Therefore, genetic gain would be higher in BIPs compared to that in F_3 as a result of increase in additive genetic variability coupled with expected genetic advance.

From this study, it could be concluded that, BIP progenies are significantly superior to F_3 in the desirable direction for all the characters, in all the crosses with respect to the mean values due to the constellation of favourable genes as a result of intermating, thus providing the efficiency of biparental mating over standard selfing series. With regard to other genetic parameters, BIPs are superior for only some of the traits studied.

References

Ahmed, M.A. and Mehra, R.B. 2000. Impact of mating systems on genetic variability in a cross of *Gossypium barbadense*. *Indian Journal of Genetics and Plant Breeding*, 60(3) : 359-371.

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

J. Oilseeds Res., **20**(1): 56-60 (2003)

Extent of genetic variability created through biparental mating in sesame, *Sesamum indicum* L.

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Abstract

An investigation was undertaken to determine the nature and magnitude of genetic variability created through biparental mating in F_2 generation of sesame. Out of three crosses *viz.*, C-I (E-8 x Co-1), C-II (E-8 x Rajeshwari) and C-III (TC-25 x Co-1), 50 pairs of plants were selected at random to effect biparental mating (BIP). The results indicated a shift in the mean values in respect of number of branches/plant, number of capsules/plant, capsule width, dry capsule weight, oil content and seed yield/plant in a positive direction from F_2-F_3-BIP generations in all the crosses. On the contrary, there was a reduction in the mean values with respect to days to 50% flowering and maturity in all the three crosses. Higher estimates of PCV and GCV in BIPs were noticed for number of branches/plant, number of capsules/plant and capsule width in all the three crosses. Heritability estimates were higher for all the characters coupled with genetic advance as per cent of mean.

Key words: Sesame, biparental mating, variability

Introduction

In autogamous crops like sesame, conventional procedures have been effective in breeding improved cultivars. However, these procedures have been inadequate to exploit the full genetic variability for the characters like yield due to restriction on genetic recombination as a consequence of selfing, which in turn leads to (a) rapid fixation of linked genes, (b) precludes free exchange of favourable genes, and (c) greatly prevents the emergence of desirable gene constellation, thereby limiting genetic variability (Bajaj *et al.*, 1990; Parameswari *et al.*, 2000). Further, the genes controlling different traits are generally dispersed in different genotypes having linkages with desirable as well as undesirable attributes also (Parameswari and Muralidharan, 1999). There have been many reports on the utility of biparental mating as a powerful tool for crop improvement (Redden and Jensen, 1974; Jensen, 1979). It is well known that the magnitude of genetic variability alone can not be the best criterion for selection, as the effectiveness of selection depends on the heritability of the character under investigation. Hence, the magnitude of genetic variability in terms of GCV, PCV coupled with heritability should be estimated in both BIPs and F_3 generations to explore the impact of biparental mating in F_2 generation. Hence, an investigation was undertaken to determine the nature and magnitude of genetic variability created through biparental mating in F_2 generation of sesame.

Materials and methods

The study was conducted using three sesame crosses *viz.*, C-I (E-8 x Co-1), C-II (E-8 x Rajeshwari) and C-III (TC-25 x Co-1). From each of the three crosses, a large F_2 population was raised and 50 pairs of plants were selected at random to effect biparental matings. The seeds from each of the BIP crosses were harvested separately and a *sample of bulked seed was used to raise the next* generation. Simultaneously, selfed seeds (F_3) from each of the plants involved in the development of BIPs were also harvested separately and a sample from each of the plants was used to raise the next generation. These generations were grown during *kharif*, 2000 following randomized block design with two replications at the Main Research Station, Hebbal, University of Agricultural Sciences, Bangalore. Each replication consisted 10 rows each of 3 m length of BIPs and F_2 generations in all the three crosses; 15 rows of 3 m length each for F_2 following a spacing of 30 cm between the rows and 10 cm between the plants within a row. A total of 200 plants were chosen randomly from F_2 and 100 plants each from F_3 and BIP generations for recording observations. Observations were recorded on plant height, number of branches/plant, number of capsules/plant, number of seeds/capsule, capsule length, capsule width, dry capsule weight, test weight, days to 50% flowering, days to maturity, oil content and seed yield/plant. The genetic parameters such as genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h^2) and genetic advance as per cent of mean (GA) were estimated in F_2,

Cross	Generation	7. Dry capsule weight (g)					8. Test weight				
		Mean	PCV	GCV	Heritability	GA (% of mean)	Mean	PCV	GCV	Heritability	GA (% of mean)
	F_2	0.087	28.8	25.5	78.0	459.8	2.5	31.5	30.9	96.3	62.5
	F_3	0.091	19.6	15.7	64.2	219.8	2.4	24.1	23.8	97.1	48.1
C-I	BIP	0.106	23.6	21.1	80.1	386.8	2.7	36.5	36.2	98.4	73.7
	F_2	0.098	23.5	18.9	64.4	306.1	2.5	31.8	31.4	97.6	64.0
	F_3	0.100	22.6	21.6	91.8	420.0	2.6	32.1	31.9	99.1	65.5
C-II	BIP	0.109	22.4	19.4	74.6	339.4	2.8	32.0	32.0	99.6	65.6
	F_2	0.092	24.1	20.7	73.3	358.7	2.4	28.1	27.7	97.4	56.6
	F_3	0.102	20.2	18.5	84.1	352.9	2.9	25.1	25.0	99.2	51.2
C-III	BIP	0.113	21.7	18.9	76.2	345.1	2.7	24.8	24.4	96.8	49.4

Cross	Generation	9. Days to 50% flowering					10. Days to maturity				
		Mean	PCV	GCV	Heritability	GA (% of mean)	Mean	PCV	GCV	Heritability	GA (% of mean)
	F_2	39.6	5.3	4.7	77.3	8.4	113.7	5.6	5.5	96.4	11.2
	F_3	39.5	5.6	5.3	88.4	10.3	108.5	3.8	3.7	93.2	7.3
C-I	BIP	38.9	4.0	3.6	80.8	6.6	105.7	3.1	2.8	82.3	5.2
	F_2	40.6	4.6	3.8	69.5	6.5	113.7	6.0	5.9	97.1	11.9
	F_3	40.6	4.9	4.5	84.7	8.5	111.8	3.1	3.0	92.8	6.0
C-II	BIP	39.3	5.5	5.1	88.0	9.9	105.1	2.8	2.6	84.0	4.9
	F_2	40.4	5.1	4.4	73.5	7.7	110.6	5.7	5.5	95.4	11.2
	F_3	38.8	4.3	3.9	82.0	7.2	107.2	2.2	1.8	68.0	3.0
C-III	BIP	39.4	4.6	4.2	83.9	7.9	105.9	2.6	2.1	62.7	3.4

Cross	Generation	11. Oil content (%)					12. Seed yield/plant (g)				
		Mean	PCV	GCV	Heritability	GA (% of mean)	Mean	PCV	GCV	Heritability	GA (% of mean)
	F_2	41.1	16.5	15.3	86.0	29.2	4.1	101.1	101.0	99.9	107.6
	F_3	41.9	14.1	13.5	91.9	26.7	3.7	92.9	92.9	99.8	191.3
C-I	BIP	45.4	13.8	12.2	77.9	22.1	6.1	79.5	79.5	99.8	163.5
	F_2	42.6	11.3	10.2	82.6	19.1	4.3	103.2	103.2	99.9	212.2
	F_3	43.8	11.7	11.4	94.8	22.8	4.3	70.9	70.8	99.7	145.5
C-II	BIP	43.7	12.4	12.1	95.0	24.3	5.7	67.0	67.0	99.8	137.7
	F_2	40.7	15.6	15.0	92.5	29.7	3.6	94.3	94.6	99.8	194.7
	F_3	40.8	14.3	14.0	94.7	27.9	3.5	64.4	64.3	99.6	132.2
C-III	BIP	43.8	11.3	11.0	94.9	22.2	6.6	55.2	55.2	99.8	113.9

Table 1 Mean performance of F_2, F_3 and BIP generations in C-I, C-II and C-III

Cross	Generation	1. Plant height (cm)					2. Number of branches/plant				
		Mean	PCV	GCV	Heritability	GA (% of mean)	Mean	PCV	GCV	Heritability	GA (% of mean)
	F_2	96.9	22.6	22.4	98.2	44.2	4.0	38.1	34.3	81.3	63.8
	F_3	105.7	20.1	19.9	97.9	42.8	4.2	27.8	23.8	72.9	41.8
C-I	BIP	99.6	24.1	23.90	98.4	48.6	5.0	5.0	5.0	5.0	67.1
	F_2	99.7	24.9	24.7	98.2	50.2	4.0	37.1	32.1	74.8	57.2
	F_3	104.2	18.9	18.7	97.5	39.6	4.2	28.5	25.7	81.0	47.6
C-II	BIP	95.7	17.3	17.1	97.9	33.3	4.7	33.2	30.0	81.6	55.6
	F_2	93.9	21.8	21.6	98.0	41.3	3.9	39.0	34.0	76.3	61.3
	F_3	95.1	20.0	19.8	98.5	38.5	3.7	24.1	21.2	76.9	38.1
C-III	BIP	106.8	16.5	16.3	97.9	35.4	4.8	25.7	21.0	66.5	35.2

Contd...

Cross	Generation	3. Number of capsules/plant					4. Number of seeds/capsule				
		Mean	PCV	GCV	Heritability	GA (% of mean)	Mean	PCV	GCV	Heritability	GA (% of mean)
	F_2	41.2	60.6	58.7	94.0	117.3	39.9	34.6	31.8	84.4	60.1
	F_3	45.0	48.7	45.9	89.0	89.2	37.8	35.9	32.3	80.9	59.8
C-I	BIP	58.8	63.2	61.5	94.7	123.3	46.5	32.3	26.8	68.0	45.3
	F_2	42.4	51.2	47.6	86.2	91.0	41.0	43.5	38.8	79.7	71.4
	F_3	45.2	38.2	35.6	87.0	68.5	39.8	38.3	35.9	88.0	69.4
C-II	BIP	50.8	63.8	32.8	96.0	127.3	44.3	30.4	27.4	81.1	50.8
	F_2	40.9	77.1	34.3	92.9	147.5	38.9	38.1	31.6	68.7	53.9
	F_3	35.5	28.4	27.0	90.4	52.9	35.7	33.2	32.0	92.7	63.4
C-III	BIP	55.8	39.6	37.0	87.2	71.2	45.6	29.9	27.3	83.6	51.4

Cross	Generation	5. Capsule length (cm)					6. Capsule width (cm)				
		Mean	PCV	GCV	Heritability	GA (% of mean)	Mean	PCV	GCV	Heritability	GA (% of mean)
	F_2	2.2	16.0	14.5	82.9	26.9	0.7	13.6	10.9	64.2	17.6
	F_3	2.3	13.5	12.7	88.4	24.5	0.8	10.2	8.8	73.8	15.2
C-I	BIP	2.6	14.7	13.5	84.2	25.5	0.8	13.2	11.05	70.5	19.0
	F_2	2.3	14.0	12.6	80.4	23.5	0.8	12.6	10.0	63.7	15.8
	F_3	2.3	12.9	12.1	88.9	23.9	0.8	8.0	6.8	73.1	24.7
C-II	BIP	2.7	12.5	11.9	90.3	23.1	0.9	12.0	10.7	79.4	20.2
	F_2	2.4	12.9	11.2	75.1	20.3	0.8	12.0	9.1	56.6	14.3
	F_3	2.2	11.4	9.7	72.8	17.0	0.8	9.2	7.8	73.0	12.8
C-III	BIP	2.8	12.9	11.9	86.0	22.8	0.9	13.2	11.2	72.3	20.0

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Stability of hybrids and their parents in sesame, *Sesamum indicum* L.

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Abstract

Phenotypic stability for seed yield and related traits of 79 genotypes (60 hybrids and their 19 parents) of *Sesamum indicum* L. grown on three different dates indicated that unpredictable component constituted more to the G x E component. Correlations between bi and mean ($\bar{x}$) values for different characters indicated that better genotypes are suited more to better environment. The correlations also revealed that capsules/plant to be the most important yield component. About 40% of the high yielding stable hybrids had RT-54 as one of the parent. Among parents RT-103 and Uma are the other parents which are stable whereas RT-54 was more responsive under optimum sowing time.

Key words: Sesame, stability

Introduction

Rajasthan is the largest sesame growing state in India (4.5 to 6 lakh ha). However, its average productivity (195 kg/ha from 1991 to 1997) has been low and fluctuating over the years. Low yield potential and inconsistent yield performance of the sesame genotypes under varied environmental conditions due to high genotype-environment interaction are the major factors of low productivity. Hence, the identification of phenotypically stable genotypes is very important for breeding as well as for cultivation purposes. In the present investigation an attempt has been made to identify genotypes with good seed yield and adaptability and phenotypic stability.

Materials and methods

Fifteen diverse varieties/ advance lines of sesame *viz.*, RT-46, RT-103, RT-106, RT-125, RT-127, RT-238, RT-282, TC-25, HT-1, IS-231, TKG-21, Pb. Til Nol, Uma, TNAU-65, and CST-783 used as females were crossed with four male parents, *viz.*, RT-54, IS-208, RT-49, and BS-6-1 to develop 60 F_1s using line x tester mating design during kharif 1997. The resultant F_1s along with their parents were evaluated in randomized block design with three replications at three dates of sowing representing three environments, 20th June, 5th July and 20th July at ARS, Mandore, Jodhpur. Individual plots consisted of two rows of 2 m length following a geometry of 30 x 15 cm. Data were recorded on ten randomly selected competitive plants for seed yield/plant, capsule bearing length, capsules/plant, capsule length, and 1000-seed weight. Days to flowering were recorded on plot basis. The stability analysis was done as per method suggested by Eberhart and Russell (1966). During the crop growth period, the recommended package of practices were followed for raising a normal crop.

Results and discussion

Pooled analysis of variance showed that the differences due to genotype (G), environment (E) and the interaction were highly significant for all the characters (Table-1). Significant G x E interactions indicated differential response of genotypes to changing environments. The linear component of environment accounted more than the G x E (linear)component. Pooled deviations were significant for all the characters, indicating the greater role of unpredictable components in the G x E interaction. Such results are commonly reported in sesame (Kumar, 1988; Madhey and Bakhiet, 1988; Verma and Mahto, 1994).

According to Eberhart and Russell (1966) a stable genotype is one that shows high mean yield, regression coefficient (*bi*) around unity and pooled deviation from regression (S^2_d) near zero. However Jatsara and Paroda (1980) emphasized the use of deviation from regression alone as a measure of stability, whereas linear regression could be treated as varietal response. Accordingly, in the present study the mean ($\bar{x}$) and deviations from regression (S^2_{di}) of each genotype were considered for stability and linear regression was used for testing the varietal response.

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Bajaj, R.K., Bains, K.S., Chahal, G.S. and Khera, A.S. 1990. Effect of intermating and selection in Barley. *Crop Improvement*, **17**(1) : 54-58.

Gurudev Singh., Bhullar, G.S. and Gill, K.S., 1986. Comparison of variability generated following biparental mating and selfing in wheat. *Crop Improvement*, **13**(1) : 24-28.

Jensen, N.F. 1979. A diallel selective mating system for cereal breeding. *Crop Science*, **10** : 629-635.

Joshi, A.B. 1979. Breeding methodology for autogamous crops. *Indian Journal of Genetics and Plant Breeding*, **39** : 567-578.

Kaushik, S.K., Sharma, S.C., Pawar, I.S. and Sharma, G.R. 1996. Effectiveness of sib mating in wheat breeding. *Indian Journal of Genetics and Plant Breeding*, **56**(2): 202-206.

Mather, K. and Jinks, J.L. 1982. *Biometrical Genetics : The theory of continuous variation*. 3rd Ed. Chapman and Hall, London.

Meredith, M.R, Jr., and Bridge, R.R. 1971. Breakup of linkage blocks in cotton (*Gossypium hirsutum* L.). *Crop Science*, **2** : 695-698.

Nanda, G.S., Gurudev Singh and Gill, K.S. 1990. Efficiency of intermating in F_2 generation of an intervarietal cross in bread wheat. *Indian Journal of Genetics and Plant Breeding*, **50**(4) : 364-368.

Nematullah and Jha, P.B. 1993. Effect of biparental mating in wheat. *Crop Improvement*, **20**(2) : 173-178.

Parameswari, C. and Muralidharan, V. 1999. Estimates of genetic variability in intermated progenies of sesame. *Journal of Oilseeds Research*, **16**(2) : 320-322.

Parameswari, C., Muralidharan, V. and Subbalakshmi, B. 2000. Effect of intermating on the association pattern of quantitative traits in sesame. *Journal of Oilseeds Research*, **17**(1) : 47-50.

Redden, R.J. and Jensen, N.F. 1974. Mass selection and mating systems in cereals. *Crop Science*, **14** : 345-350.

Sethi, S.K., Srivastava, R.B., Yunus, M. and Yadav, B. 1995. Relative efficiency of different methods of generating variability in *Triticum durum*. *Indian Journal of Genetics and Plant Breeding*, **55**(3) : 273-278.

Sharma, J.R. 1994. *Principles and practices of plant breeding.* Tata Mc Grow Hill Publication, New Delhi.

Singh, B.B. and Murthy, B.R. 1973. A comparative analysis of biparental mating and selfing in pearl millet (*Pennisetum typhoides* S & H). *Theoretical and Applied Genetics*, **43** : 18-22.

Srivastava, R.B., Paroda, R.S., Sharma, S.C. and Yunus, M. 1989. Impact of different mating approaches in generating variability in wheat (*Triticum aestivum* L. EM Thell.). *Indian Journal of Genetics and Plant Breeding*, **49**(3) : 331-336.

Srivastava, R.K. and Sharma, J.R. 1987. Changes in character association following biparental mating in a population of opium poppy. *Crop Improvement*, **14** : 84-86.

Yunus, M. and Paroda, R.S. 1983. Extent of genetic variability created through biparental mating in wheat. *Indian Journal of Genetics and Plant Breeding*, **43** : 76-81.

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Inheritance of yield and yield components in safflower, *Carthamus tinctorius* L.

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Abstract

In the absence of exploitable cytoplasmic genetic male sterility system in safflower, genetic male sterility system is important from the point of view of developing potential hybrids for cultivation. Therefore, an experiment was undertaken to study inheritance of yield and yield contributing characters involving genetic male sterile lines. The studies revealed that most of the characters studied had the influence of both additive (d) and dominance (h) genetic effects in their inheritance, however, the dominance component was quite predominant. Epistatic interactions were also found to be controlling most of the characters, except in GMS-104 x GMU-1553 for diameter of capitulum. Seed weight and yield/plant were predominantly under the control of dominance (p) and additive x additive (i) gene effects. Duplicate epistatis was observed for the characters studies however, complementary epistatis was important for diameter of capitulum and yield/plant in majority of the crosses.

Key words: Inheritance, safflower, epistatis

Introduction

Method of hybridization and selection procedure is dependent on type of gene actions operating for yield and yield contributing characters in field crops. Information on the inheritance of various genetic components is a prerequisite in the development of safflower hybrids and also for selecting crosses and desirable recombinants for yield and yield contributing characters showing further exploitable gene effects. In order to generate more precise information on gene actions and gene interactions, the present investigation was carried out on a set of six generations of eight crosses of safflower, involving genetic male sterile line as one of the parents. This study was planned keeping in view the importance of genetic male sterile lines in developing hybrids in the absence of usable cytoplasmic genetic male sterility in safflower.

Materials and methods

The genetic male sterile lines of safflower *viz.*, GMS-104 and GMS-105 were crossed with four diverse genotypes GMU-178, GMU-1553, GMU-1825 and VI-92-2-4 for yield and yield contributing characters to produce eight hybrids. Their subsequent six generations *viz.*, P_1, P_2, F_1, F_2, B_1 and B_2 of each crosses were obtained for all the crosses and studied during *rabi*, 1999-2000 in completely randomised block design with three replications. The data on 10 random plants/replication (parents and F_1s), 20 plants/replication (B_1s and B_2s) and 80 plants/replication (F_2s) were recorded for yield and yield contributing characters. The data were analysed to study presence or absence of epistatis (Mather, 1949), the gene actions and gene interactions were obtained by following six parameter model (Hayman, 1958).

Results and discussion

Significant estimates of at least one of the three Mather's scaling tests for the characters studied indicated presence of epistatis for all the characters in all the crosses, except for diameter of capitulum in the cross GMS-104 x GMU-1553 where A, B and C scaling tests had non-significant estimates (Table-1).

In majority of the crosses estimates of additive (d) and dominance (h) effects were significant for all the characters *viz.*, seeds/capitulum, diameter of capitulum, seed weight, yield/plant, days to 50% flowering, maturity, plant height and primary branches/plant, however, the magnitude of dominance (h) component was higher in most of the crosses, which indicated that these characters were under the control of both gene effects with predominance of dominance effect.

Days to 50% flowering and maturity were found to be under the control of additive x additive (i) type of gene

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Table 1 Pooled analysis of variance for seed yield per plant and its components over three environments in sesame

Source	D.f.	Mean squares: Seed yield/ plant	Capsule bearing length	Capsules/ plant	Capsule length	1000-seed weight	Days to flowering
Genotype (G)	78	4.084	206.099**	194.569**	0.035**	0.067**	9.241**
Environment (E)	2	67.158**	5021.225**	5815.326**	0.653**	3.302**	1734.796**
E + (G x E)	156	0.757**	45.764**	49.383**	0.009**	0.022**	1.307
E (linear)	1	134.316++	10042.387++	11630.634++	1.306++	6.065++	3449.412++
G x E (linear)	78	0.998++	50.726	43.719	0.01++	0.023	1.3012
Pooled deviations	79	0.510**	40.287**	54.350**	0.007**	0.020**	1.287**
Pooled error	468	0.063	13.829	6.529	0.003	0.005	1.140

* Significant at P = 0.05 and ** significant at P=0.01; ++ Significant at P=0.01 against pooled deviations

The stability parameters of the parents and hybrids were estimated for the seed yield and other characters of the 79 (parents + hybrids), 35 genotypes showed stability for seed yield as indicated by their non-significant (S^2_{di}) values. Among these stable genotypes, the stability parameters for the top high yielding 15 genotypes (parents and hybrids) are presented in Table-2. Top yielding genotypes included parents as well as hybrids. Among the hybrids, crosses involving RT-54 were highest in proportion (41.67%), showing that RT-54 is a desirable parent and may be considered for inclusion in hybridization programmes for higher seed yield. Improvement of seed yield on its own is not a profitable proposition, as seed yield being complex trait is amenable to environmental influences. Hence it would be ideal to concentrate equally on such traits which show meaningful correlation with seed yield. Estimation of correlations in the present investigation indicated that capsules/plant had highest positive association (r=0.8021) with seed yield. However, the days to flowering had negative association (r=-0.5511). Estimation of correlations among different characters for *bi* values indicated that correlations between seed yield and capsules/plant (r=0.7828), capsules/plant with capsule length were highest, while *correlation between seed yield and days to flowering was* negative. Thus it can be said that selection for higher and stable seed yield is possible using capsules/plant and capsule length. The other general observation is that later flowering is detrimental to higher seed yield (data not presented).

In crop improvement programmes aimed at for rainfed conditions, specific breeding has a great importance. A high yielding stable genotype for wide range of sowing times has a great practical utility to minimize the risk due to uncertainty at onset of monsoon and erratic rainfall specially in western Rajasthan. On the basis of the above results, the parental varieties, RT-103 and Uma were found most stable for seed yield/plant and could be successfully planted from 20th June to 20th July, whereas, RT-54 was more responsive under optimum sowing time. Amongst the hybrids, TNAU-65 x RT-54, HT-1 x RT- 49 and HT-1 x RT-54 were most stable for seed yield/plant and more responsive under optimum sowing time. It is expected that from stable hybrids true breeding lines in advanced generation of selfing may be obtained, as the direct exploitation of hybrids in sesame is still a far cry.

Table 2 Stability parameters of best 15 genotypes for seed yield

Genotype (parent/hybrid)	Mean seed yield/plant (g) ($\bar{x}$)	Regression coefficient (bi)	Deviation from regression (S^2_{di})
RT-103	2.31	0.89	-0.02
Uma	2.30	1.69	0.15
RT-54	4.15	3.03**	0.04
HT-1 x RT-54	4.42	2.29**	0.20
IS-231 x RT-54	2.10	1.01	-0.02
Uma x RT-54	2.27	1.34	0.01
TNAU-65 x RT-54	5.44	2.45**	0.08
CSI-783 x IS-208	2.24	0.95	0.04
RT-106 x RT-49	2.28	1.08	0.03
HT-1 x RT-49	4.44	2.19*	0.11
TKG-21 x RT-49	3.01	1.66	0.00
TNAU-65 x RT-49	2.38	0.74	-0.01
HT-1 x BS-6-1	3.45	1.71	0.06
TNAU-65 x BS-6-1	2.53	1.48	0.21
CST-783 x RT-54	5.68	3.09**	0.22

*, ** = significant at 0.05 and 0.1

References

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

Jatsara, D.S. and Paroda, R.S. 1980. Phenotypic adaptability of characters related to productivity in wheat cultivars. *Indian Journal of Genetics and Plant Breeding*, **40**: 132-139

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 effects on genetic components of some morphological traits in sesame. *Assuit Journal of Agricultural Sciences*, **19** (2): 72-88.

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.

interaction for most of the crosses studied, confirming the results of Manjre (1993), while, Narkhede *et al.* (1992) observed additive x additive (i) and additive x dominance (j) gene interaction for days to 50% flowering and days to maturity, respectively. Plant height was under the control of all the three type of gene interactions, Manjre (1993) also recognised the major involvement of dominance x dominance (1) type of interaction in the control of plant height. In majority of the crosses additive x additive (i) gene interaction had major role in the control of primary and secondary branches/plant. Manjre (1993) also reported similar results while Narkhede *et al.* (1992) observed duplicate type of epistatis for primary and secondary branches. In the inheritance of seeds/capitulum on primary branch, additive x additive (i) gene interaction played important role, while dominance x dominance (l) gene interaction had major role in the inheritance of seeds/capitulum on secondary branch. Manjre (1993) also reported additive x additive (i) and dominance x dominance (l) gene interactions for seeds/capitulum on primary and secondary branch. In case of diameter/capitulum, dominance x dominance (l) interactions were important, however, in the cross GMS-104 x GMU-1553 epistatic interactions were absent. Manjre (1993) reported additive x additive (*i*) type of gene interaction for diameter of capitulum in safflower.

In majority of the crosses, 100 seed weight and yield/plant, all non-allelic interactions were involved, however, the predominance of additive x additive (i) interaction was observed for both the characters, as their estimates were in positive direction. Prasad *et al.* (1993) also reported additive x additive (i) interactions to be important for yield/plant, however, Channeshappa (1984) observed importance of additive x additive (d) and dominance x dominance (l) interactions in the control of seed yield/plant.

Duplicate type of epistatis was important for most of the characters under consideration, however, diameter of capitulum and yield/plant exhibited predominance of complementary epistatis.

The importance of gene effects and interactions observed in the present study suggested the possibility of improvement of safflower through combined expression of gene effects and interactions for yield and yield contributing characters. The available varieties possessed the genetic potential to yield 10-20 q/ha, under optimal conditions of input and management. Further, these varieties suffered from low seed yield and oil content. The varietal improvement in safflower has serious limitations to achieve an appropriate combination of seed yield and oil content due to negative association between these two economically important attributes. However, it is possible to combine these two characters in appropriate combination in hybrid background. The recessive and dominant male sterility systems have offered promise in practical safflower breeding as, both types are not accompanied by female sterility and apparently normal plants. The literature (Anjani, 1996) suggested the existence of significant heterosis of 270% for seed yield and 50-80% for oil/unit area. Therefore, safflower offers considerable scope for exploitation of dominance variation through production of hybrids on commercial scale. In the absence of usable cytoplasmic genic male sterility and availability of genetic male sterile lines, the hybrid development programme on the results of the present study may prove fruitful.

References

Anjani, K. 1996. Utilisation of genetic male sterility in safflower hybrid. Proc. Group Meeting on "*Heterosis Breeding in Safflower*". Eds. D.M. Hegde, C.V. Raghavaiah and D. Pati, pp.63-69.

Channeshappa, M.G. 1984. Genetics of seed yield, oil content and other quantitative characters in safflower (*Carthamus tinctorius* L.). *Journal of Mysore Agricultural Sciences*, 14(3) : 463.

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

Manjre, M.R. 1993. Heterosis, combining ability and gene effect studies in safflower. Ph.D. Thesis submitted to Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra.

Mather, K. 1949. *Biometrical genetics*. Dover Publication Inc., New York, pp.883.

Narkhede, B.N., Patil, A.M. and Deokar, A.B. 1992. Gene action of some quantitative characters in safflower. *Journal of Maharashtra Agricultural Universities*, **17** : 4-6.

Prasad, S., Agrawal, R.K. and Chaudhary, B.R. 1993. Inheritance of yield and yield components in safflower (*Carthamus tinctorius* L.). *Sesamum and Safflower Newsletter*, **8**:82-88.

Table 1 Scaling tests for 10 quantitative characters in eight crosses of safflower

	GMS 104 x GMU 1553	GMS 105 x GMU 1553	GMS 104 x GMU 1825	GMS 105 x GMU 1825	GMS 104 x GMU 178	GMS 105 x GMU 178	GMS 104 x VI 92-2-4	GMS 105 x VI 92-2-4
				Days to 50% flowering				
A	6.67*	1.33	3.67	3.00	-2.00*	8.67*	6.67*	5.67*
B	-0.67	2.66*	2.33	1.33	1.67	1.33	1.33	2.00
C	9.33*	16.67*	13.33*	31.67*	8.33*	17.33*	16.00*	20.33*
				Days to maturity				
A	7.000*	-1.330	-7.33*	0.67	8.00	1.33	7.67*	7.33*
B	-2.30*	-3.33*	3.67*	5.00*	-0.47	5.67*	1.33	1.00
C	9.00*	22.33*	23.00*	25.67*	32.33*	41.00*	18.33*	21.67*
				Plant height (cm)				
A	-0.03	-24.87*	1.60	-12.23*	7.20*	8.53*	7.80*	-1.03
B	6.60*	9.17*	3.97*	-1.40	16.40*	28.53*	1.93	-6.37*
C	-0.03	26.50*	-10.30	-19.90*	39.07*	39.533*	39.47*	17.80*
				Number of primary branches/plant				
A	2.23*	0.20	-7.50*	-4.47*	-1.13*	-0.47	1.40*	2.30*
B	5.03*	1.20*	-8.33*	-2.80*	0.70	-0.30	-0.90	0.13
C	-10.40*	-4.53*	-16.37*	-12.87*	1.30	-0.77*	-18.43*	-2.17*
				Number of secondary branches/plant				
A	-4.60*	-1.40	-16.93*	-7.03*	0.07	-0.57	-1.47*	3.00*
B	3.37*	-3.50*	-6.07*	-8.63*	0.50	2.20*	-1.37*	2.80*
C	-5.97*	-7.30*	-16.67*	-23.47*	-3.90*	-2.03*	-6.83*	-3.27*
				Number of seeds/capitulum on primary branch				
A	-19.33*	-2.50*	-13.23*	-16.97*	-1.87	-2.50*	1.67	7.97*
B	-20.53*	-2.20*	-7.87*	-27.97*	14.37*	-1.43*	5.33*	2.43
C	-19.67*	-13.97*	-34.77*	-61.27*	12.03*	5.07*	-46.97*	-5.87*
				Number of seeds/capitulum on secondary branch				
A	-15.23*	-6.80*	0.70	-4.10*	0.97	-0.63*	-3.67*	-0.27
B	-7.97*	-7.63*	10.57*	-13.17*	-4.50*	-2.63*	-3.23*	-1.17*
C	-3.73	-39.23*	-10.67*	-16.00*	10.53*	1.93*	-11.23*	-2.97*
				Diameter of capitulum				
A	0.17	-1.20*	-1.33*	-1.73*	0.03*	-0.03	-0.47*	-1.00*
B	0.17	-0.23*	-0.30*	-0.23*	0.40*	-0.80*	-0.57*	-0.67*
C	0.27	-2.50*	-1.40*	-2.43*	-0.30	0.37	-1.23*	-2.60*
				100 seed weight				
A	-35.03*	-0.97*	2.63*	-1.33*	-0.17*	-0.40*	0.63*	-0.37*
B	14.73*	-0.23*	-0.43*	-0.73*	0.87*	-0.80*	-1.00*	-0.90*
C	-157.37*	-1.47*	-3.40*	-4.27*	-0.63*	-2.00	-0.03	-1.60*
				Yield/plant				
A	-6.93*	5.33*	-29.40*	-9.33*	-0.57	-1.67*	-5.50*	-5.66*
B	-0.00*	-3.17*	-25.93*	-14.63*	1.83	-2.73*	-8.17*	-5.60*
C	-19.20*	-8.63*	-64.47*	-42.43*	-8.20*	-13.07*	-19.60*	-16.40*

*, ** significant at 5% and 1% respectively.

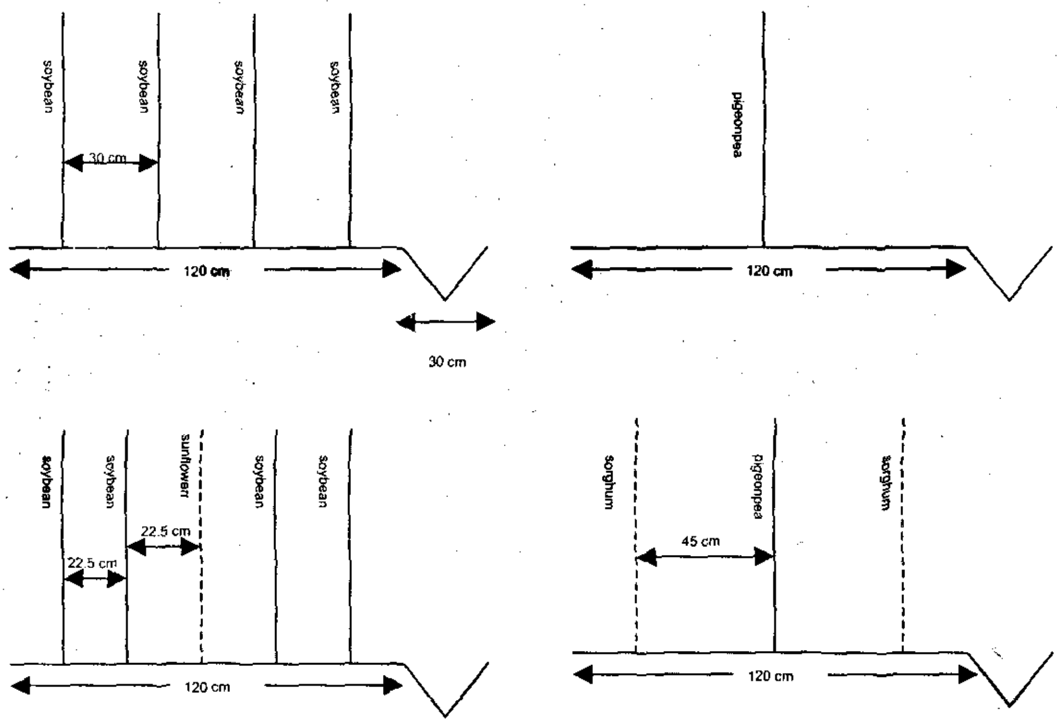

Fig-1 Arrangement of crops in different systems

the frame. Sensor was attached to a readout integrator. Data on PAR transmission to the soil surface on any given day under any given canopy represented the average of 18 readings i.e., from the six nitrogen treatments each replicated three times. Quantum sensor was placed above the crop canopy to record the PAR incident on the canopy (io) and interception of PAR was calculated using the io and PAR transmission values.

Interception of PAR taken during the growing season was plotted and interception per day was calculated. Solar radiation on each day at ICRISAT was used to calculate PAR values for each day from the relation between solar radiation and local PAR. PAR intercepted each day and cumulative intercepted PAR for the growing season for each canopy was calculated from daily PAR and data for canopy interception.

The extinction coefficient was determined using the relationship ln i_z/i_o= -KL Where: l_n is natural log, i_z is light below a given LAI, i_o is incoming light above the canopy, K is extinction coefficient, L is LAI.

The relation between cumulative intercepted PAR and dry matter for different crops was estimated using regression equations and the line fitted between cumulative intercepted PAR (X) and drymatter (Y) was forced through origin. The slope of the regression line (regression coefficient b,g/MJ) implies that drymatter production (g)/ MJ of PAR intercepted.

Results and discussion

Meteorological data for the growing seasons show that July, August and September were characterized as high rainfall months, August being very wet with low average daily solar radiation. The amount of rainfall received during crop season was 1016 mm in 1996; 604 mm in 1997. Soil water balance of a typical vertisol watershed was estimated using Ritchie's model. During 1996, 38% of rainfall was lost as run off and deep drainage, and 49% was used as evapotranspiration. In 1996, soil moisture was maintained at 200 mm level, whereas in 1997, during the entire season the soil moisture could not reach a level of 150 mm. Hence there was no run off and deep drainage in 1997. Pooled analysis was done for seed yields and this showed that all the crops except soybean, differed significantly between the years. Therefore the data was presented and discussed yearwise separately.

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Productivity of soybean and pigeonpea based intercropping systems in relation to radiation interception

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Abstract

Growth and interception of photosynthetically active radiation (PAR) in sole soybean, sole pigeonpea, soybean/sunflower and sorghum/pigeonpea systems grown in vertisol watershed were compared at ICRISAT Patancheru center, Andhra Pradesh. Efficiency of conversion, calculated from the relations between dry matter production and cumulative intercepted PAR, was the highest in intercropping systems, followed by sole pigeonpea and sole soybean. This shows the utility of such intercrops in making better use of resources in the semiarid tropics (SAT). Extinction coefficient, an indicator of PAR distribution within the canopy, was high in sorghum/pigeonpea and sole soybean compared to other systems.

Key words: Intercropping, PAR, radiation use efficiency, extinction coefficient

Introduction

Yield advantages or disadvantages in intercropping systems measured through traditional methods give little information about which environmental resource is limiting and how competition is affected by different crops and their planting pattern. Understanding how light utilization is affected by crop canopies helps in identification of systems with more efficient resource use (Anders *et al.*,1996). Dry matter production was linearly related to intercepted radiation (Biscoe and Gallagher, 1977). Information on photosynthetically active radiation (PAR) use efficiency has been used in crop modelling (Huda, 1987). Since information on comparing the different systems specific to radiation use is meager, a study was taken up to evaluate the attenuation of radiation in different crop canopies, to relate the light interception to canopy leaf area index (LAI) by using Beer's law and to determine the efficiency of conversion of intercepted light into dry matter in the crop canopies. The crop canopies considered here were sole soybean, soybean/sunflower, sole pigeonpea and sorghum/pigeonpea.

Materials and methods

The experiment was conducted during rainy seasons of 1996-97, 1997-98 on a deep vertisol watershed. The broad bed (120 cm) and furrow (30 cm) were tilled with a multipurpose tool bar immediately after harvesting the previous crop. Seed bed preparation was completed during the dry season, well ahead of planting time, with minimal tillage and soil compaction. N treatments included combinations of three levels from two sources (FYM and fertilizer) and were imposed as main plot treatments (not discussed in this paper). Cropping systems (sole soybean; soybean/sunflower 4:1; sole pigeonpea; sorghum/ pigeon pea 2:1) were assigned to subplots. The treatments were allocated in split plot design with three replications. All the crops were sown in last week of June in 1996 and in the first week of July in 1997. Soybean (Var. PK 472), sunflower (Var. Morden), sorghum (hy. CSH 5) and pigeonpea (Var. ICPL 87) were planted on broad bed (Fig-1) with an intra row spacing of 10, 20, 7.5 and 25 cm respectively. The plot size was 72 m^2. To permit greater light interception by intercrops soybean and pigeonpea, sunflower and sorghum were harvested just above ground level after physiological maturity.

Whole plants (excluding roots) were sampled in three replications in an area of 1 m^2 of each crop. The leaf area of each plant was determined with LICOR leaf area meter and plant samples were then dried to constant weight at 65° C in hot air oven.

Canopy interception of Photosynthetically Active Radiation (PAR) in all the crops was measured using line quantum sensor (LICOR model no. LQA 1322). The frame was placed horizontally at the soil surface in each canopy so that the crop rows in a 150 cm wide bed were centered in

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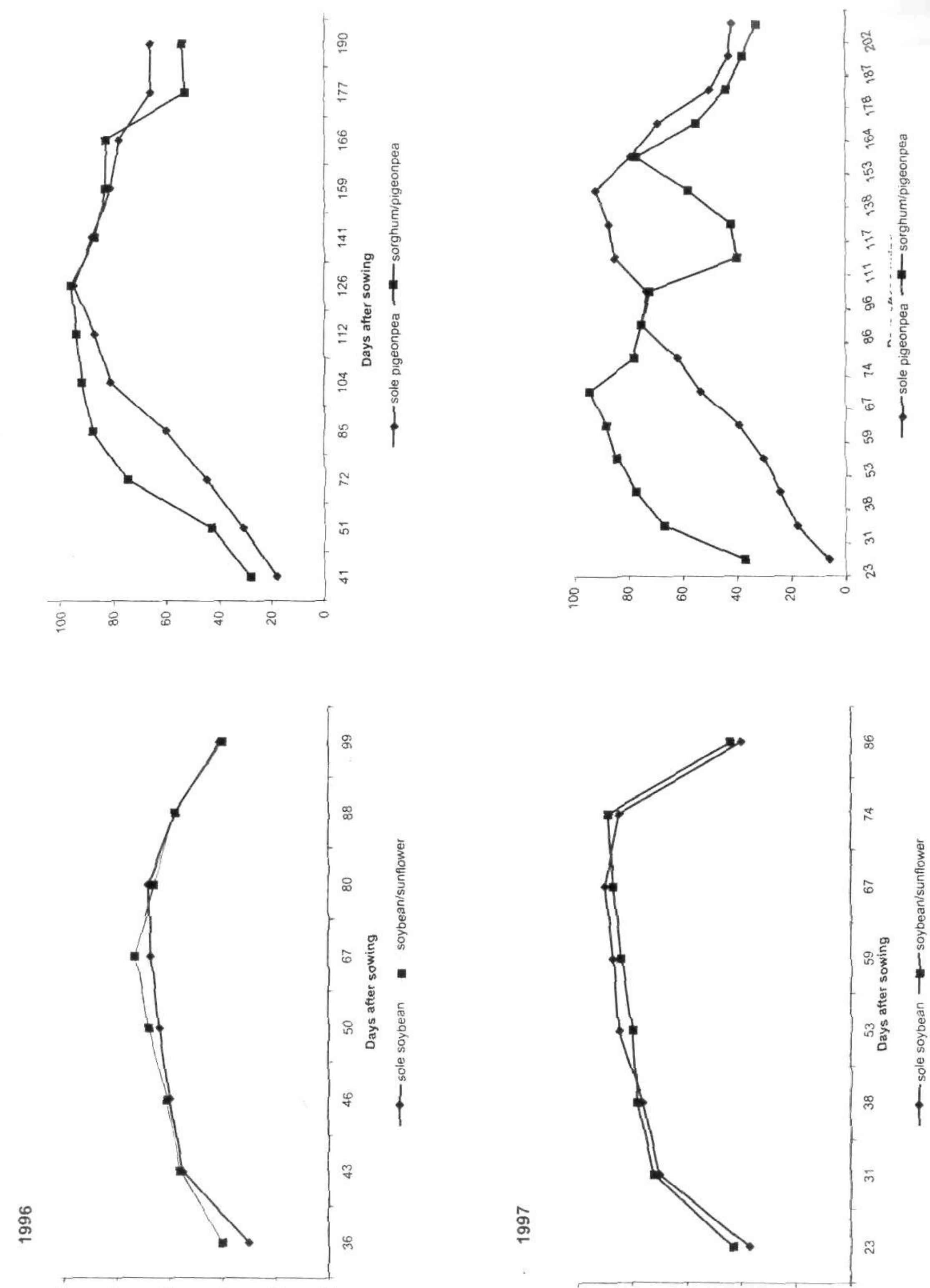
Figure 2. Interception of light by different crop canopies



1996 (wet year)

Soybean: Sole soybean and soybean/sunflower attained its maximum LI and LAI at flowering. Soybean and sunflower grew fast, as reflected by the changes in LAI and LI and drymatter (Figs 2, 3 & 4). Till 40 days, the difference in drymatter production between sole soybean (246 kg/ha) and intercropped soybean (223 kg/ha) was negligible. As the growth of sunflower crop was affected due to heavy rain at the time of flowering during August (451 mm), there was not much competition from sunflower to soybean. This could be the reason for less reduction (16%) in dry matter production of intercrop soybean compared to sole soybean. The yield of sole soybean and intercropped soybean was 900 kg/ha and 700 kg/ha respectively. Seed yield of sunflower was only 188 kg/ha as the crop was badly affected by heavy rain at the time of flowering.

Changes in the interception of PAR for the sole soybean and soybean/sunflower showed that similar values were observed from 40 days after sowing until harvest of crops (Fig-2). During the initial stages of crop growth (upto 40 days after sowing) sole soybean intercepted 10% less PAR than soybean/sunflower system when LAI was only about 0.47 and 0.65 respectively.

The relation between total drymatter produced and cumulative intercepted PAR for both the canopies is shown in Fig-5. For the soybean /sunflower intercrop, the total drymatter of both crops up to sunflower harvest, after which the total drymatter of sunflower produced at harvest, was added to the drymatter of soybean taken at each subsequent sampling date. Production efficiency was 0.54 in soybean/sunflower system, but it was 0.37 in sole soybean (Table-1). The overall production efficiency of interception by the intercropping systems is more than that of sole cropping (Sivakumar and Virmani, 1980).

Table 1 Conversion efficiency of light into drymatter (g/MJ)

System	1996	R^2	1997	R^2
Soybean	Y=0.37x	0.99	Y=0.45x	0.99
Soybean/Sunflower	Y=0.54x	0.92	Y=0.53x	0.97
Pigeonpea	Y=0.55x	0.99	Y=0.60x	0.88
Sorghum/Pigeonpea	Y=0.85x	0.97	Y=0.97x	0.90

Extinction coefficient (Table-2) for soybean/sunflower (0.66) was lower than that of sole soybean. It indicates that LAI to intercept the same amount of PAR was greater in soybean/sunflower system than that of sole soybean (0.89). The difference in interception of PAR by crop canopies of sole soybean and soybean/sunflower was not much during the entire crop growth period, but significant difference in LAI was observed (soybean/sunflower 1.22 to1.72; sole soybean 0.70 to 1.02). It indicated that though more LAI was seen under intercropping, but it resulted in shading to soybean by the companion crop of sunflower.

Pigeonpea: Changes in LI, LAI and drymatter production for the sole and intercrops present a comparative evaluation of the efficiency of different systems (Figs 2, 3 and 4). Sole and Intercropped pigeonpea grew slowly, as reflected by the slow changes in total drymatter. Because of the absence of competition from the companion crop, pigeonpea in pure stands showed better canopy growth. Sole pigeonpea attained maximum LAI of about 3.4 around 120 DAS, whereas in sorghum/pigeonpea, it attained maximum LAI (3.6) at 96 days after sowing.

As the growth of sorghum was affected due to continuous wet weather during August (13.3 MJ/m/d radiation; 451 mm rainfall) which also caused grain mould, there was not much competition from sorghum to pigeonpea. This could be the reason for less reduction (19% at the time of sorghum harvest) in dry matter production of intercropped pigeonpea compared to sole pigeonpea. The sorghum crop produced 7950 kg/ha of drymatter at the time of harvest and yielded 630 kg/ha of grain. Data on drymatter accumulation in the sorghum/pigeonpea system showed the contribution of sorghum was only 50% to total drymatter. After sorghum harvest, pigeonpea showed appreciable accumulation of drymatter (4000 to 8100 kg/ha). The total drymatter production of intercropped pigeonpea was 89% of that of sole pigeonpea.

In sole pigeonpea, PAR interception was low with a slow increase in LAI upto 60 DAS (38%) and it was maintained at a fairly high rate for the next 80 days (38 to 92%) after which it declined due to leaf senescence (Fig-2). Changes in the interception of PAR in the sorghum/pigeonpea canopy showed that the system maintained higher levels of interception upto the time of sorghum harvest because of its higher LAI values. PAR interception declined after sorghum harvest. The yield of sole pigeonpea and intercropped pigeonpea was 1500 and 1300 kg/ha respectively.

The relation between total drymatter produced and the cumulative intercepted PAR for the two canopies is shown in Fig-5. For the sorghum/pigeonpea intercrop, the total drymatter is for both crops upto sorghum harvest, after which the total drymatter of sorghum produced at harvest was added to the dry weight of pigeonpea taken at each subsequent sampling date. Production efficiency (g/MJ) was lower for the sole pigeonpea (0.55) than sorghum/ pigeonpea (0.85). Similar observation was also reported by Sivakumar and Virmani (1980) in maize/pigeonpea intercropping system.

Figure 4. Drymatter Production of different crops

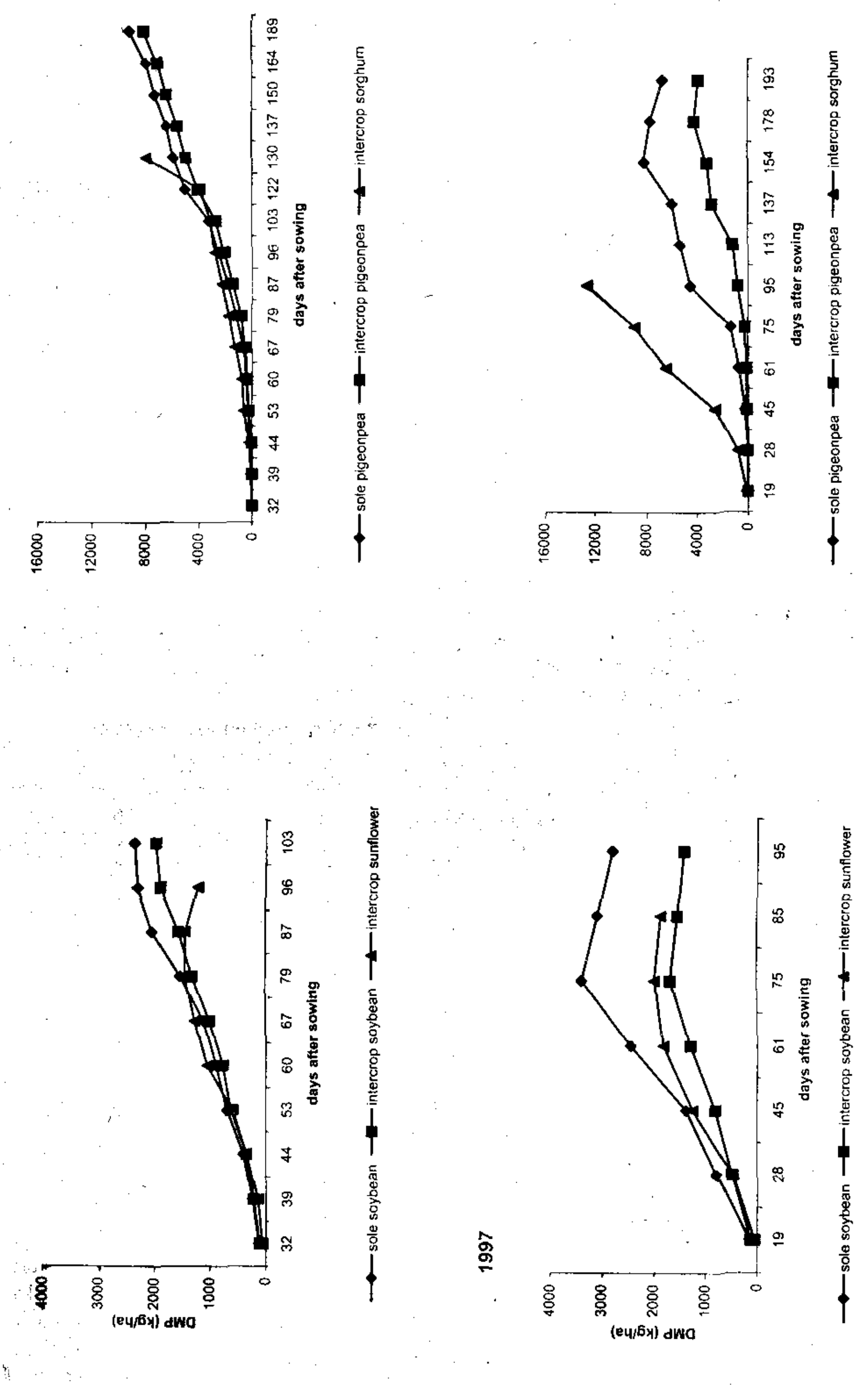


Figure 3. Leaf Area Index of different crops/ systems

1996

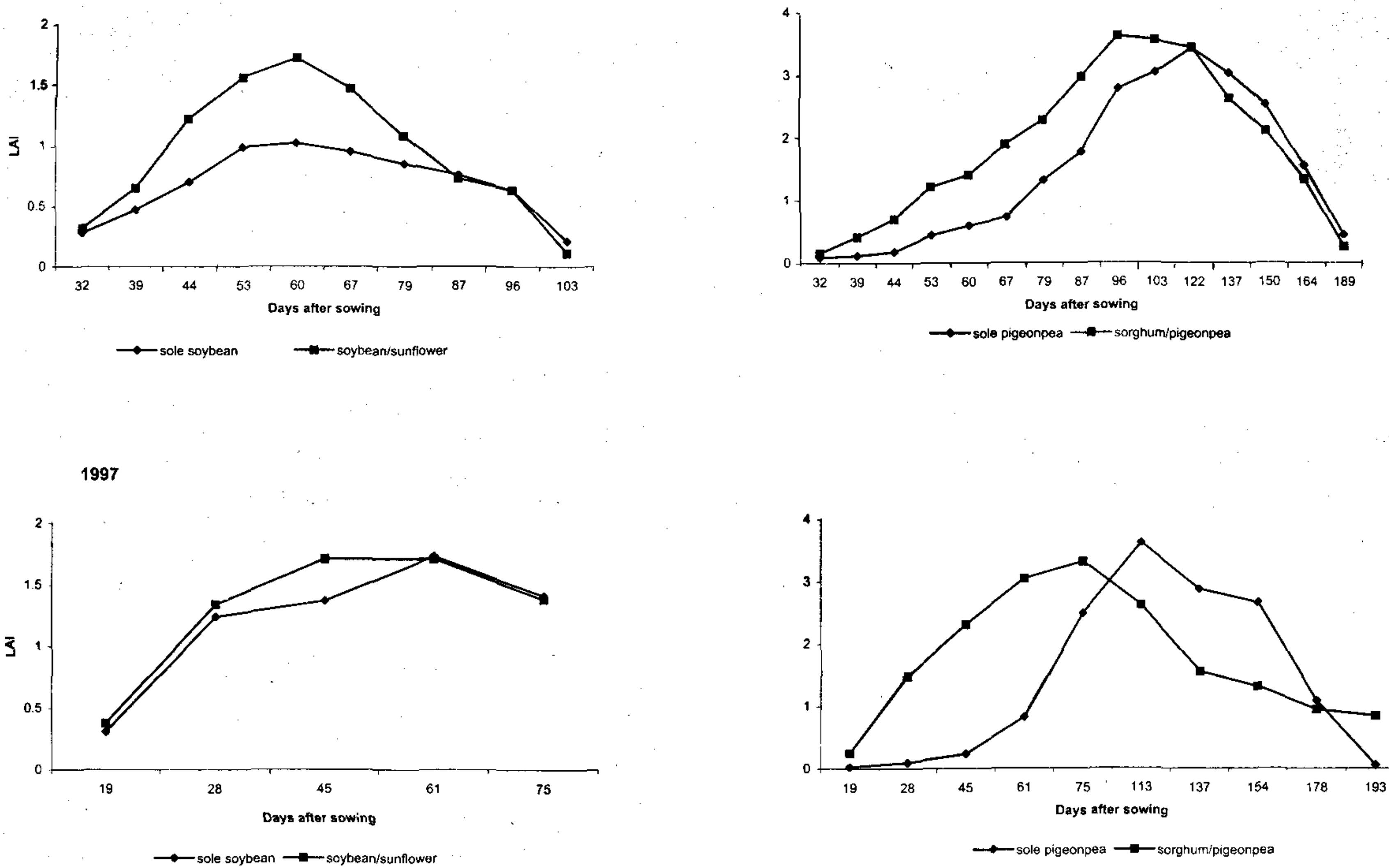
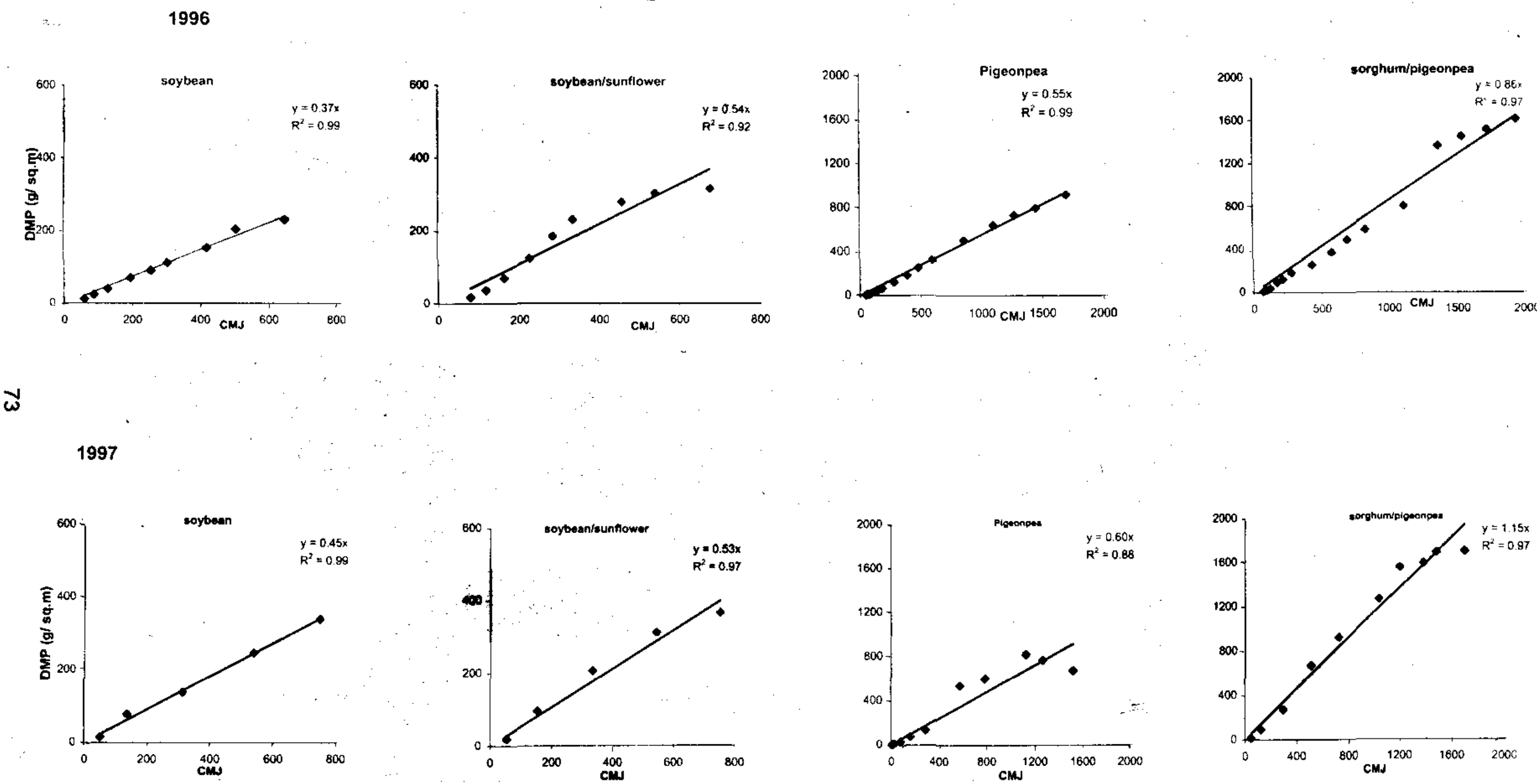


Figure 5. Radiation Use Efficiency (g /MJ) in different crops/systems



Extinction coefficient was 0.70 in sole pigeonpea and 0.76 in sorghum/pigeonpea (Table-2). This relationship further suggested that the LAI required to intercept the same amount of PAR was greater in sole pigeonpea than in sorghum/pigeonpea. Low values of k for sole pigeonpea suggested greater PAR transmission to the lower layers in the canopy and also to the ground resulting in low PAR interception.

1997 (dry year)

Soybean: Sole soybean (1.73) and soybean/sunflower (1.71) attained maximum LAI at 60 and 45 DAS respectively (Fig-3). Both the systems intercepted the light similarly throughout crop growth period eventhough LAI is greater in soybean/sunflower system (Fig-2). Sole soybean produced 40% by 45 DAS and 73% by 60 DAS compared with 24 and 38% respectively by the intercropped soybean, to that of maximum dry matter production of sole soybean. The total dry matter production of intercropped soybean was 50% of that of sole soybean (Fig-4). It indicated that there was competition for resources between sunflower and soybean due to similar growth pattern. The yield of sole soybean and intercropped soybean was 989 and 672 kg/ha respectively. The seed yield of sunflower was 397 kg/ha.

Production efficiency was (g/MJ) was 0.45 in sole soybean and 0.53 in soybean/sunflower system. It indicates that soybean/sunflower system was more efficient in conversion of interception of PAR into dry matter than sole soybean (Fig-5).

Extinction coefficient for soybean/sunflower (0.96) was lower than that of sole soybean (1.04). It indicates that sole soybean and soybean/sunflower intercepted PAR similarly but LAI was more in soybean/sunflower than sole soybean (Table-2).

Pigeonpea: Growth pattern of sole and intercrop pigeonpea was similar to that of pigeonpea in 1996, but only the magnitude differed. Sole pigeonpea showed better canopy growth than of intercropped pigeonpea. It recorded maximum LAI of 3.6 around 110 DAS while sorghum/pigeonpea recorded maximum LAI of 3.3 at 75 DAS (Fig-2). The maximum dry matter production of intercrop pigeonpea was 3900 kg/ha and that of sorghum was 12676 kg/ha. Sole pigeonpea produced 65% of its maximum dry matter by 110 DAS and 100% by 155 DAS, compared to 15 and 40% respectively for intercropped pigeonpea to that of sole pigeonpea (Fig-4). It indicated that sorghum crop competed with pigeonpea for moisture as the soil moisture did not reach a level of 150 mm during crop growth period. The yield of sole pigeonpea was 1363 kg/ha and that of intercropped pigeonpea was 620 kg/ha. The sorghum crop growth was good during this season and recorded 3560 kg/ha of grain yield, which was six times higher than that in the earlier year. At the time of sorghum harvest, intercrop pigeonpea's total dry matter was around 1/5th of that of sole pigeonpea.

Interceptions of PAR by sole pigeonpea was low, with a slow increase in LAI upto 60DAS (40%) and it was maintained at a fairly high level for the next 90 DAS (40 to 90%) after which increasing leaf senescence decreased PAR interception (Fig-2). Sorghum/pigeonpea maintained higher levels of interception (30 to 89%) upto the time of sorghum harvest because of its higher LAI values. After sorghum harvest, interception dropped to about 40% and then increased to 68% as the leaf senescence started and the interception has gone down to 49%.

Production efficiency (g/MJ) of sorghum/pigeonpea (1.15) was 92% higher compared to the sole pigeonpea (0.60) (Fig-5). Though intercrop pigeonpea was affected due to the competition from the companion crop of sorghum, the dry matter produced per unit of MJ was comparatively higher than that of sole pigeonpea crop. The reasons could be that contribution from sorghum was high as the crop grew very well and utilized the resources efficiently.

Extinction coefficient as a function of foliage architecture was determined for pigeonpea and sorghum/pigeonpea (Table-2). Low value for sole pigeonpea suggested greater transmission to the lower layers in the canopy and to the ground resulting in low PAR interception. This relationship also suggested that the LAI required to intercept the same amount of PAR was greater in sole pigeonpea than sorghum/pigeonpea.

Table 2 Extinction coefficients calculated using the relationship ln (I_z/I_0) = - KL

System	1996	R^2	1997	R^2
Soybean	0.89	0.86	1.04	0.93
Soybean/Sunflower	0.66	0.84	0.96	0.68
Pigeonpea	0.70	0.85	0.76	0.72
Sorghum/Pigeonpea	0.76	0.89	0.82	0.75

Considering the performance in both the years, drymatter production was linearly related to intercepted radiation in all the systems/crops. Similar observation was also found in pearlmillet (Jarwal *et al.*, 1990). Efficiency of conversion of intercepted light into drymatter was superior in intercropping systems *viz*, soybean/sunflower and sorghum/pigeonpea compared to their respective legume sole crops. Sivakumar and Virmani (1980) also found that maize/pigeonpea intercropping system was more efficient than sole crops in converting PAR into drymatter. Interception of light by crop canopy has not differed much between sole soybean and soybean/sunflower systems, even though leaf area index was greater in intercropping system. Because of similar duration of component crops,

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Studies on the growth, N uptake, seed yield and quality of *Brassica* genotypes as affected by fertility levels under rainfed conditions

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Abstract

A field experiment was conducted to study the effect of different fertility levels on growth, N uptake, seed and oil yield of *Brassica carinata* (genotype PBC-9221 and DLSC-1) and *Brassica juncea* (genotypes PR-8988, BIO-772 and Kranti) under rainfed conditions during 1996-97 and 1997-98. *B. carinata* genotype PBC-9221 had significantly higher LAI at 60 and 90 DAS but the mustard genotype PR 8988 had significantly more value at 30 DAS. Crop growth rate and relative growth rate were higher in mustard in early stage but at later two stages Ethiopian mustard had higher value. Between 90 DAS - harvest stage CGR and RGR values were maximum in PBC 9221 but CGR remained at par with DLSC-1 and PR 8988. Oil content of Kranti was higher, whereas, oil yield was more in PBC-9221 due to higher seed yield. N uptake and protein content in seeds was higher in PBC-9221 and increase in fertility levels also enhanced these parameters. Seed yield was higher in variety PBC-9221. The leaf area index, drymatter accumulation, CGR, RGR and NAR increased at higher fertility levels. With the application of fertilizer, oil content decreased, whereas oil yield increased due to more seed yield. Application of 125% of the recommended fertility levels produced significantly higher seed yield irrespective of genotypes.

Key words: Growth analysis, yield, N uptake, *Brassica* genotypes, Fertility levels

Introduction

Fertilizer application, particularly nitrogen in right amount enhanced the yield of rapeseed and mustard remarkably as these crops are exhaustive in nature and require more energy for growth and development of plants. Researches done in the country have indicated that fertilizer requirement differed with the fertility status of soils. With the improvement of new genotypes particularly *Brassica carinata*, it has become imperative to study their growth behaviour and yield potential under varying levels of fertility and to find out the optimum rate for increasing the productivity. The performance of a genotype depends largely on the development of morphological characters for contributing towards growth and yield of the crop and the economic yields are the result of leaf area production and drymatter accumulation pattern in the plant types. Therefore, the present investigation was conducted to study the growth, yield and quality of promising genotypes of mustard (*Brassica juncea*) and Ethiopian mustard (*Brassica carinata*) at different fertility levels under rainfed conditions.

Materials and methods

The present investigation was carried out on a silty clay loam soil at the Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantnagar, during *rabi* seasons of 1996-97 and 1997-98 under rainfed conditions. The experiment was laid out in a Randomized Block Design with three replications. The experimental field was rich in organic matter (1.21%) and potassium (265.0 kg/ha), medium in phosphorus content (73.61 kg/ha) and neutral in reaction (pH 7.0). The fertilizer dose was 60 kg N, 40 kg P_2O_5 and 20 kg K_2O/ha. An uniform basal application of whole amount of phosphorus in the form of single super phosphate and potassium in the form of muriate of potash along with 3/4 quantity of nitrogen through urea was applied as per the treatment. Remaining quantity of nitrogen was top dressed after one month. Five plants were tagged from each pot randomly and their seeds were analyzed for oil content, oil yield and protein content. The oil determination was done using NMR technique. Estimation of protein content in seeds was made by determining nitrogen content using Micro-Kjeldahl's method and multiplying by a constant factor of 6.25. The leaf area index and drymatter were recorded at an interval of 30 days from five randomly selected plants in marked rows. The computation of various growth parameters was done as per Radford (1967).

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there was *overlapping of growth periods* which resulted in competition for light in the intercropping system. Leaf area index and interception of light by crop canopy was superior in *sorghum/pigeonpea than in sole pigeonpea.* It is because of spatial and temporal complementarities of the system as sorghum grand growth *period was completed* well before pigeonpea started its grand growth period, thereby avoiding competition for light and other resources (*Natarajan and* Willey, 1980). Considering advantages and disadvantages of intercropping systems studied, it can be concluded that sorghum/pigeonpea system is more efficient in resource *(light) utilization* compared to soybean/sunflower.

References

Anders, M. M, Potdar, M.V and Francis, C. A. 1996. Significance of intercropping in cropping systems. In *Dynamics of Roots and Nitrogen in cropping systems of the Semi Arid Tropics* (Eds. O. Ito, C. Johansen, J.J. Adu-Gyamfi, K. Katayama, J.V.D.K. Kumar Rao and T. J. Rego). Japan International Research Center for Agricultural Sciences,1-2, Ohwashi, Tsukuba, Ibraki 305, Japan.

Biscoe, P.V and Gallagher, J.N. 1977. Weather, drymatter production and yield. In. *Environmental effects on crop physiology*, (Eds. J.J.Landsberg & C.V. Cutting) Academic Press, London, pp., 75-100.

Huda, A. K.S. 1987. Simulating yields of sorghum and pearlmillet in the semi arid tropics. *Field crops Research.* **15**: 309-325.

Jarwal, S. D., Phool Singh and Virmani, S.M. 1990. Influence of planting geometry on photosynthetically active radiation interception and drymatter production relationships in pearlmillet. *Biomass*, **21**:273-284.

Natarajan, M and Willey, R.W. 1980. Sorghum-Pigeonpea intercropping and the effects of plant population density. 2. Resource use. *Journal of Agriculture*, Cambridge, **95**: 59-65.

Sivakumar, M V K and Virmani, S.M. 1980. Growth and resource use of maize and maize/pigeonpea intercrop in an operational research watershed. *Experimental Agriculture*, **16**: 377-386.

Table 1 Effect of different *Brassica* genotypes and fertility levels on leaf area index, total drymatter production, N uptake, seed yield, oil and protein content (Pooled over two years)

Treatment	Leaf area index			Total drymatter (g/plant)				Nitrogen uptake (kg/ha)	Yield (kg/ha)		Oil content (%)	Protein content (%)
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	Harvest		Seed	Oil		
Genotypes												
PBC-9221	0.3	1.0	1.1	1.0	2.5	6.5	29.2	22.8	1180	470	39.9	15.2
DLSC-1	0.3	1.1	1.1	1.1	2.4	8.1	26.2	20.6	1070	420	39.1	13.7
PR-8988	0.4	1.1	0.5	1.3	5.9	9.0	17.0	13.6	850	350	40.9	9.1
BIO-772	0.4	0.8	0.2	1.1	6.2	8.3	9.5	17.1	730	300	40.8	11.5
Kranti	0.3	1.5	0.4	1.3	5.9	8.3	16.9	13.6	780	320	41.6	9.1
CD (P=0.05)	0.03	0.1	0.1	0.2	0.3	0.6	0.6	0.7	76	31	0.4	0.5
Fertility levels												
50% of RDF	0.2	0.8	0.4	0.9	4.0	7.0	16.7	11.6	660	270	41.4	7.8
75% of RDF	0.3	1.2	0.5	1.1	4.4	7.5	19.7	15.3	890	360	40.5	10.0
RDF	0.4	1.5	0.7	1.3	4.7	8.2	19.5	18.9	1020	410	40.2	12.6
125% of RDF	0.5	1.7	1.0	1.5	5.2	9.3	23.4	24.4	1120	440	39.9	16.4
CD (P=0.05)	0.03	0.1	0.1	0.2	0.3	0.6	0.5	0.6	68	28	0.3	0.4

DAS = Days after sowing; RDF = Recommended dose of fertilizer

Table 2 Effect of genotypes and fertility levels on the crop growth rate, relative growth rate and net assimilation rate at different growth stages (Pooled over two years)

Treatment	CGR x 10 (g/day)			RGR x 10 (g/day)			NAR (g/m^2/day)	
	30 x 60 DAS	60 x 90 DAS	90 harvest	30-60 DAS	60-90 DAS	90 harvest	30-60 DAS	60-90 DAS
Genotypes								
PBC-9221	0.36	1.34	2.56	0.10	0.13	0.07	7.08	2.4
DLSC-1	0.42	1.88	2.13	0.10	0.18	0.05	6.41	2.1
PR-8988	1.53	1.15	1.98	0.22	0.08	0.04	8.03	1.8
BIO-772	1.67	0.70	0.57	0.24	0.04	0.02	8.03	2.0
Kranti	1.59	0.77	1.35	0.21	0.05	0.05	8.08	1.6
CD (P=0.05)	0.11	0.24	0.85	0.04	0.03	0.10	0.20	0.1
Fertility levels								
50% of RDF	1.04	0.12	0.18	0.16	0.09	0.04	7.18	1.8
75% of RDF	1.12	1.00	1.58	0.17	0.10	0.05	7.51	2.0
RDF	1.15	1.12	1.59	0.18	0.10	0.05	7.55	2.0
125% of RDF	1.25	1.38	1.89	0.20	0.10	0.05	7.86	2.1
CD (P=0.05)	0.10	0.22	NS	NS	NS	NS	0.18	0.1

References

Arthamwar, D.N., Shukla, D. and Ekshinge. 1995. Pattern of leaf and drymatter production in mustard genotypes under nitrogen and phosphorus levels. *Journal of Maharashtra Agriculture Universities*, 20(30) : 379-382.

Kumar, D. and Malik, R.S. 1983. Salt tolerance of six Indian mustard cultivars. *Indian Journal of Agronomy*, **28**(4):225-231.

Radford, P.J. 1967. Growth analysis formulae, their use and disuse. *Crop Science*, **7**:171-175.

Shukla, A. and Kumar, A. 1992. Studies on seed yield, contribution of different branches and oil development pattern of Indian mustard genotypes at varying rates of nitrogen fertilization. *Journal of Oilseeds Research*, **9**(1):136-143.

Shukla, A. and Kumar, A. 1993. Physiological analysis of growth, development and yield of Indian mustard in relation with nitrogen fertilization. *Bhartiya Krishi Anusandhan Patrika*, **8**(3-4):131-136.

Tomar, T.S., Singh, S. Kumar, S. and tomar, S. 1997. Response of Indian mustard (*Brassica juncea*) to nitrogen, phosphorus and sulphur fertilization. *Indian Journal of Agronomy*, **42**(1):148-151.

Results and discussion

Performance of genotypes: The growth analysis indicated significant varietal differences with respect to leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR) and net assimilation rate (NAR). Significantly higher LAI at 30, 60 and 90 days stages was recorded in PR-8988, Kranti and DLSC-1, respectively, except at 90 days stage where DLSC-1 was at par with PBC-9221. PR-8988 had also significantly higher value of total drymatter at 30 and 90 days stages but at 30 days stage, it was at par with Kranti. At 60 days stage, BIO-772 and at harvest PBC-9221 had significantly higher value over other genotypes (Table-1). The LAI, CGR and NAR values were higher in Ethiopian mustard compared to mustard at later stages. The leaf area has been reported to be the main factor in biomass production (Arthamwar *et al.*, 1995). The NAR value at 60-90 days stage was significantly more in PBC-9221 (Ethiopian mustard) but at earlier stage mustard genotypes had more NAR value. The CGR and RGR between 30-60 days stage was higher in mustard but at later stage, Ethiopian mustard had higher value and PBC-9221 recorded maximum value between 90 days to harvest stage. The higher CGR in PBC-9221 during later phase was because of higher drymatter production in different plant parts, at a comparatively higher pace for longer duration than other genotypes. The duration of PBC-9221 was 27 days higher than mustard in better reproductive growth in Ethiopian mustard. Similar findings indicating the varietal differences for various yield attributes have also been reported by Kumar and Malik (1983). Genotypes also influenced the nitrogen uptake significantly. PBC-9221 had significantly higher nitrogen uptake followed by DLSC-1 and PR-8988.

The vigorous reproductive growth phase in genotype PBC-9221 recorded significantly higher seed yield over the other genotypes followed by DLSC-1. Both the genotypes of Ethiopian mustard had significantly more seed yield than mustard. Amongst mustard genotypes, PR-8988 recorded higher seed yield but was at par with Kranti.

Genotypes also differed significantly in oil content and oil yield. Oil content in Kranti was highest followed by PR-8988 and lowest was in DLSC-1. This may be due to their genetic make up. However, genotype PBC-9221 produced significantly more oil yield in comparison with other genotypes. Genotypes BIO-772 had significantly lower oil yield than other genotypes but was at par with Kranti.

Protein content in seeds was also significantly higher in PBC-9221 than all other genotypes. This was primarily due to the fact that genotype PBC-9221 had higher nitrogen uptake by seeds. Thus, an adequate supply of nitrogen not only stimulated photosynthesis but also amino acids and protein synthesis.

Effect of fertility levels: The leaf area index increased with increasing fertility level at all the growth stages of crop. Drymatter accumulation in plant increased with increase in fertility level upto 125% of the recommended levels at all the stages. The beneficial effect of fertilizer on leaf area index and drymatter production were also reported by Shukla and Kumar (1993). The highest CGR was recorded at 125% of the recommended level at all the stages but was at par with the recommended fertility level during earlier stage. The CGR at last stage and RGR value at all the stages did not differ significantly at various fertility levels. Net assimilation rate increased upto 125% of the recommended fertility level between 30-60 days stage but during 60-90 days stage, recommended and 125% of recommended level were at par. Enhanced CGR and RGR contributed towards the stronger reproductive phase which resulted in higher seed yield under higher fertility levels. Further, increased NAR at 125% of recommended fertility level added positively towards the seed yield. It was because of higher percentage increase in crop growth rate and more production of functioning leaves even at later stage of crop growth under higher levels of fertility.

With successive increase in fertility levels, the seed yield increased and significantly higher seed yield was recorded at 125% of the recommended fertility level under rainfed situation. The increase in seed yield with the application of 75% recommended and 125% of recommended level over 50% of recommended level of fertilizers amounted to 25.8, 35.2 and 41.0% respectively.

Higher oil content in seeds was recorded at lower fertility levels and vice versa at higher fertility levels. Contrary to oil content, oil yield increased significantly upto 125% of the recommended fertility level. This may be due to the fact that increasing availability of nitrogen increased the proportion of protenous substances in the seeds. Although, higher rate of fertilizer application resulted in reduced oil per cent in seeds but it increased the oil yield/hectare, significantly. Since, oil yield/hectare was the resultant of seed yield and oil per cent and oil/hectare also increased due to fertilizer application upto 125% of the recommended level because of increased seed yield. These findings are also supported by Tomar *et al.* (1997). With every successive increase in fertility level upto 125% of the recommended level, there was significant increase in protein content in seeds. Nitrogen is a basic constituent of protein and with the increase in rate of nitrogen application, the nitrogen availability increased which resulted in increased protein content in seeds. The positive correlation between protein content and fertilizer rates was also reported by Shukla and Kumar (1992).

It can be inferred from the above results that Ethiopian mustard variety PBC-9221 had more leaf area index, CGR, RGR, NAR, drymatter production and seed yield over PR-8988, BIO-772, Kranti genotypes of mustard. Application of 125% of the recommended fertility level produced significantly higher amount of drymatter and seed yield.

Table 1 Effect of zinc, growth hormone and biofertilizer on growth characters, yield attributes, yield and economics of sesame

Treatment	Plant height (cm)		No. of branches/plant		Drymatter production (kg/ha)		Number of capsules/plant		No. of seeds/ capsule		Seed yield (kg/ha)		Return/rupee invested	
	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II	Crop I	Crop II
T_1 : Control	63	63	8	10	1850	2176	33	39	35	36	402	464.8	1.4	1.6
T_2 : Soil application of $ZnSO_4$ @ 5 kg/ha	69	72	10	13	2114	2453	41	46	37	38	482	560	1.6	1.8
T_3 : Foliar application of $ZnSO_4$ @ 0.5% at 40 and 55 DAS	76	80	12	15	2341	2715	48	54	39	40	552	642	1.8	2.0
T_4 : Foliar application of planofix @ 30 ppm at 40 and 55 DAS	82	88	13	17	2599	3043	55	61	41	43	624	733	2.0	2.2
T_5 : Seed inoculation with *Azospirillum*	69	72	10	13	2097	2430	41	46	37	38	476	552	1.6	1.8
T_6 : $ZnSO_4$ @ 5 kg/ha (soil) + $ZnSO_4$ @ 0.5% (foliar)	96	105	18	24	3111	3649	69	77	45	47	774	910	2.4	2.7
T_7 : $ZnSO_4$ @ 5 kg/ha (soil) + planofix @ 30 ppm (foliar)	89	96	16	22	2846	3368	63	70	43	45	702	827	2.4	2.5
T_8 : $ZnSO_4$ @ 5 kg/ha (soil) + *Azospirillum* (seed)	89	96	15	20	2820	3316	61	69	43	45	694	819	2.3	2.5
T_9 : $ZnSO_4$ @ 0.5% (foliar) + planofix @ 30 ppm (foliar)	96	106	18	24	3115	3656	70	77	45	47	777	914	2.4	2.8
T_{10} : $ZnSO_4$ @ 0.5% (foliar) + *Azospirillum* (seed)	89	96	15	21	2839	3333	62	69	43	45	700	823	2.3	2.5
T_{11} : $ZnSO_4$ @ 5 kg/ha (soil) + $ZnSO_4$ @ 0.5% (foliar) + planofix @ 30 ppm (foliar)	109	122	22	29	3619	4243	84	92	48	51	916	1077	2.7	3.0
T_{12} : $ZnSO_4$ @ 0.5% (foliar) + planofix @ 30 ppm (foliar) + *Azospirillum* (seed)	103	114	20	26	3369	3957	76	85	47	49	846	997	2.6	2.9
T_{13} : $ZnSO_4$ @ 5 kg/ha (soil) + $ZnSO_4$ @ 0.5% (foliar) + planofix @ 30 ppm (foliar) + *Azospirillum* (seed)	116	130	24	31	3863	4513	91	100	50	54	985	1163	2.9	3.3
CD (P=0.05)	6.5	7.5	1.8	2.1	221.2	252.9	6.73	7.2	1.8	1.9	68.4	78.9	-	-

Effect of zinc, growth hormone and biofertilizer on the growth and yield of sesame, *Sesamum indicum* L.

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Abstract

Field experiments were conducted to study the effect of zinc, growth hormone and biofertilizer on the growth and yield of sesame (*Sesamum indicum* L.) cv. TMV-3 during March to June of 1999 and 2000, at Annamalai University experimental farm, Annamalai Nagar, Tamil Nadu. There were altogether thirteen treatments comprising of individual and combined use of soil application of $ZnSO_4$ @ 5 kg/ha, seed inoculation with *Azospirillum* foliar application of $ZnSO_4$ @ 0.5% and planofix @ 30 ppm twice at 40 and 55 DAS. It was observed that combined use of soil application of $ZnSO_4$ @ 5 kg/ha, seed inoculation with *Azospirillum* and foliar application of $ZnSO_4$ @ 0.5% and planofix @ 30 ppm twice at 40 and 55 DAS exhibited a pronounced effect on the growth characters *viz.*, plant height, number of branches/plant and drymatter production in both seasons. The yield attributes *viz.*, number of capsules/plant, number of seeds/capsule and seed yield were significantly influenced by the same treatment.

Key words: Sesame, zinc, Azospirillum

Introduction

Sesame (*Sesamum indicum* L.) is an important oilseed crop but has low yield potential. It is gaining considerable importance on account of its high economic value as edible oil. Mean seed yield of this crop in India is very low (180 kg/ha) as compared to Venezuela (1960 kg/ha) (Shanker *et al.*, 1999). Poor soil fertility especially of micronutrient, hormonal imbalance, etc., are limiting the growth and yield of sesame in India. Among the micronutrients, zinc has been found to increase the yield considerably (Prakash, 1998). *Azospirillum*, an important biofertilizer component presently supplemental source of nitrogen, fixes abundant quantity of nitrogen in soil (Rao, 1981). Hence, an attempt was made to find out the effect of zinc, growth hormone and biofertilizer on the growth and yield of sesame.

Materials and methods

Field experiment was conducted during March to June of 1999 and 2000 at Annamalai University experimental farm, Annamalai Nagar, Tamil Nadu. The soil of the experimental field was low in available nitrogen (206.5; 237.2) medium in phosphorus (18.7; 19.4) and high in potassium (353.2; 342.5 kg/ha). There were thirteen treatments comprising of individual and combined application of *Azospirillum* seed inoculation, soil and foliar application of $ZnSO_4$ and planofix twice at 40 and 55 DAS (Table-1). For seed treatment, *Azospirillum* inoculant was mixed well with rice gruel and a slurry was prepared in a plastic container and the seeds were mixed with slurry to have uniform coating of *Azospirillum*. The experiment was laid out in randomized block design with three replications. Sesame variety TMV 3 was sown adopting a seed rate of 5 kg/ha and a spacing of 30 x 30 cm. A fertilizer dose of 35:23:23 N, P_2O_5 and K_2O kg/ha, respectively was applied to all plots. Half the dose of N was applied as basal and the remaining half at 30 DAS. Need based crop protection measures were taken.

Results and discussion

Growth characters: Soil application of zinc sulphate @ 5 kg/ha, seed inoculation with *Azospirillum* and foliar application of zinc sulphate @ 0.5% planofix @ 30 ppm twice at 40 and 55 DAS (T_2) had significant influence on growth characters at harvest stage in sesame (Table-1). Same treatments recorded the highest plant height *viz.*, 116 and 130 cm, number of branches/plant *viz.*, 24 and 31 and drymatter production *viz.*, 3863 and 4513 kg/ha in the first and second crop, respectively. The lowest growth characters were observed in control plots. This may be due to synergistic and cumulative effect of zinc, growth hormone and biofertilizer. Planofix (NAA), being a stable synthetic auxin that complements the naturally occurring IAA might have increased the activity of meristemic tip, auxiliary buds, resulting in higher plant height, number of branches and number of leaves and ultimately caused greater photosynthetic efficiency might have aided in higher crop drymatter. The results of the present

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Effect of tillage and irrigation regimes on seedling emergence, growth and yield performance of post-rainy season sunflower under rice fallows-I

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Abstract

Field experiments were conducted during post-rainy season of 1997-98 and 1998-99 on sandy clay loam soil after rainy (*kharif*) season puddled rice at University Research Farm, Rajendranagar, Hyderabad. Five tillage practices constituting deep and shallow primary tillage in combination with rotavator or cultivator as secondary tillage treatments besides zero tillage treatment and four soil water regimes constituting of scheduling irrigations at IW/CPE = 0.6, 0.8, 1.0 and 1.2 were evaluated. Significantly higher seedling emergence was observed when secondary tillage was carried out with rotavator either tractor drawn (75%) or power tiller operated (73%). Higher sunflower growth and seed yield of 1531 kg/ha was realized when tillage was done with tractor drawn disc plough + rotavator twice coupled with scheduling irrigations at IW/CPE=1.2. Deep tillage with tractor drawn disc plough + rotavator in combination with soil water regime of IW/CPE=1.0 or 1.2 resulted in significantly higher seed yield compared to other combinations. Highest net returns of Rs. 8565/ha was obtained in deep-fine tillage (tractor drawn disc plough followed by rotavator) at IW/CPE=1.0.

Key words: Tillage, soil moisture regime, sunflower, rice fallow

Introduction

Sunflower has emerged as potential oilseed crop in rice fallow situation of command areas of Sreeramsagar and Nagarjunasagar (Andhra Pradesh), Tungabhadra (Karnataka) and Bhavanisagar (Tamil Nadu) irrigation projects, where farmers are cultivating sunflower profitably compared to traditionally grown rice. Soil conditions after puddled rice pose limitations for growing upland crops and thus the yield levels of crops following rice are generally low as compared to normal yields (Reddy and Reddy, 1979). Loosening puddled soil may require special tillage. Large tractors with attachements that pulverise hard soil are becoming available, but they are too expensive for small farmers. Inexpensive, effective tillage practices to eliminate drudgery and ensure proper seedbed preparation are badly needed (Prihar *et al.*, 1985). Keeping the above in view field experiments were conducted for two years to study the effect of tillage and soil water regimes on productivity of post-rainy season sunflower in rice-sunflower sequence.

Materials and methods

The experimental site was located at the Research Farm of ANGRAU, Rajendranagar, Hyderabad (17°19' E, 78°28' N, 535 m above mean sea level, annual rainfall of 760 mm). The soil was sandy clay loam, composition of the topsoil (0-15 cm) was sand 66.00 %, silt, 12.33 %; clay 21.67 %. The depth of the soil was medium (50-60 cm). The pH and EC (dS/ m) of the soil were 7.54 and 0.19, respectively in 1:2 soil-water ratio. The available water capacity of the soil profile of 45 cm depth was 7.25 cm.

The experiment was laid out in strip plot design (five main tillage treatments and four soil moisture regime), replicated thrice. Sunflower variety `Morden' was the test crop. The seed rate, fertilizer dose, plant protection measures, harvesting and threshing of crop were similar for all treatments. The crop was raised with the recommended package of practices for the region.

The mean weekly pan evaporation ranged from 4.2 to 8.6 mm/ day (average 6.32) and 4.5 to 9.1 mm/ day (average 6.72) during crop growth period of 1997-98 and 1998-99, respectively. However, there was no precipitation during the crop growing seasons. The mean weekly maximum and minimum temperatures during the crop period ranged from 38.1°C to 31.9°C and 22.0°C to 16.9°C and 41.3°C to 31.7°C and 27.0°C to 14.6°C during 1997-98 and 1998-99,

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investigation are in confirmity with the findings of Tiwari *et al.* (1995); Saxena and Chandel (1997) and Prakash *et al.* (1999). Likewise, this treatments also excelled all the other treatments and recorded the highest number of capsules/plant *viz.*, 91 and 100 number of seeds/capsule *viz.*, 50 and 54, seed yield of 985 and 1163 kg/ha in the first and second crops, respectively. The lowest yield attributes and yield were under the control treatment. This might be due to increased plant height, LAI, DMP, number of capsules/plant and number of seeds/capsule. Similar findings were also documented by Murthy *et al.* (1999) and Prakash *et al.* (1999).

The same treatment registered the highest return/rupee invested of Rs. 2.9 and 3.3 in the first and second crop, respectively. The control treatment recorded the least return/rupee invested of 1.4 and 1.6 in both the crops.

Based on the above results, it can be concluded that seed inoculation with *Azospirillum*, soil and foliar application of $ZnSO_4$ and foliar application of planofix was beneficial in increasing growth characters, yield attributes and seed yield in sesame.

References

Murthy, I.Y.L.N., Virupakshappa, K. and Mev Singh. 1999. Micronutrient studies in sunflower and sesame. *Fertilizer News*, **44**(10) : 45-51.

Prakash, M. 1998. Studies on physiological aspects to improve yield in sesame (*Sesamum indicum* L.). Ph.D., Thesis, Annamalai University, Annamalai Nagar.

Prakash, M., Tholkappian, P., Sundaram, M.D. and Ganesan, J. 1999. Effect of plant growth regulators and *Azospirillum brasilense* on growth and yield of sesame. *Sesame and Safflower Newsletter*, **14**:43-45.

Rao, S.M.S. 1981. Contribution of biofertilizer in supplementing nitrogen requirements. *Indian Farming*, **31**(7):13-16.

Saxena, S.C. and Chandel, A.S. 1997. Effect of micronutrients on yield, nitrogen fixation by soybean (*Glycine max*) and organic carbon balance in soil. *Indian Journal of Agronomy*, **42**(2) : 329-332.

Shanker, H., Bhushan Chandra and Lallu. 1999. Effect of levels of zinc on growth, drymatter and yield of sesame varieties. *Journal of Oilseeds Research*, **16**(1) : 74-77.

Tiwari, K.P., Namdeo, K.N., Tomar, R.K.S. and Raghu, J.S. 1995. Effect of macro and micronutrients in combination with organic manures on the production of sesame (*Sesamum indicum* L.). *Indian Journal of Agronomy*, **40**(1) : 134-136.

The combination of deep-fine tillage (T_5) coupled with irrigations scheduled at IW/CPE = 1.0 was found best to achieve higher yields of sunflower grown after puddled transplanted *kharif* rice.

Economics

In general tillage practices shown their superiority over zero tillage under rice fallows in benefit cost ratio (Table-4). Scheduling irrigations at IW/CPE of 1.2 (M4) resulted in highest B: C ratio of 2.35 in the first year and 2.18 in the second year. Critical examination of B: C ratio revealed that, under deep tillage (T_5 and T_4) conditions the response to irrigation was up to IW/CPE =1.0, however, the crop responded up to IW/ CPE = 1.2 under shallow and zero tillage conditions. Deep and fine tillage (T_5) resulted in highest B: C ratio. At IW/CPE = 1.0 and 1.2, T_4 and T_3 tillages did not differ much in B: C ratio, however, the difference due to these tillage practices (T_4 and T_3) was wide under limited moisture supply (IW/ CPE = 0.6 and 0.8). It confirmed the overall superiority of deep tillage treatments under limited water supply as stated by Vittal *et al.* (1983).

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Table 1 Effect of tillage treatments on clod size distribution and mean mass diameter (MMD) and depth of ploughing

Tillage treatment	Clod size (mm. Diameter) per cent							Mean mass diameter (mm)	Mean depth of tillage (cm)	Seedling emergence (%)
	>100	50-100	20-50	10-20	5-10	2-5	<2			
					1997-98					
T_1	-	-	-	-	-	-	-	-	-	52
T_2	11.3	20.9	22.2	14.3	10.5	9.2	11.6	38.3	11.1	61
T_3	3.4	13.0	16.4	19.6	16.7	14.1	16.9	23.8	11.0	72
T_4	12.2	18.1	21.4	16.5	8.5	11.9	11.4	37.0	21.2	62
T_5	Nil	12.5	17.4	19.7	15.2	17.4	17.8	20.5	21.6	74
CD (P=0.05)	-	-	-	-	-	-	-	-	-	5.0
					1998-99					
T_1	-	-	-	-	-	-	-	-	-	53
T_2	13.34	16.1	18.8	14.3	10.7	13.2	13.6	35.7	10.9	59
T_3	Nil	13.0	18.4	21.2	16.6	14.6	16.2	21.4	11.4	73
T_4	12.9	14.9	17.7	16.6	12.0	12.6	13.4	34.3	20.7	62
T_5	Nil	12.2	16.4	22.3	14.2	16.4	18.5	20.4	21.4	77
CD (P=0.05)	-	-	-	-	-	-	-	-	-	4.5

T_1 - zero tillage
T_2 - ploughing twice with bullock drawn wooden plough followed by twice with bullock drawn cultivator
T_3 - ploughing twice with bullock drawn wooden plough followed by twice with power tiller drawn rotavator
T_4 - ploughing once with tractor drawn mould board plough followed by twice with tractor drawn cultivator
T_5 - ploughing once with tractor drawn disc plough followed by twice with tractor drawn rotavator

espectively. The mean relative humidity ranged from 89 to 63 and 85 to 52% during crop growth periods of first and second years, respectively. The mean weekly bright sunshine hours varied from 10.9 to 9.0 during 1997-98 and 10.7 to 7.7 during 1998-99, respectively.

The IW/CPE of 0.6, 0.8, 1.0 and 1.2 received 4, 6, 8 and 9 irrigations during 1997-98 with total amount of irrigation water of 240, 360, 480 and 540 mm respectively during 1998-99 the same treatments were provided 5, 7, 9 and 11 irrigations with total quantity of 300, 420, 540 and 600 mm irrigation water, respectively. To minimize the interference of water from one treatment to another a 50 cm wide drain and successive 50 cm levee were constructed in between different plots. Irrigation water was applied according to the treatments and was measured by V- notch weirs

The clod size distribution was determined and expressed in terms of mean mass diameter (MMD) calculated in accordance with the procedure explained in the Test Code and Procedure for Rotary Tillers – part-2 (RNAM, 1983).

Seedling emergence was determined by counting number of seed hills emerged from each test plot. Growth was expressed in terms of LAI and dry matter (above ground parts) at harvest. The heads in each net plot were harvested and threshed separately (this was carried out manually). Clean seed yield at 10% moisture was recorded for each test plot. The experimental data were subjected to Fisher's method of 'Analysis of Variance' (ANOVA) as per Panse and Sukathme (1978).

Results and discussion

Quality of seedbed

Tillage with high drought machinery like tractor (T_4 and T_5) tilled the soil to deeper soil depth of 22 cm, while tillage with bullock drawn wooden plough tilled to 11 cm soil depth (Table-1). Ploughing once with disc plough followed by twice with rotavator, both tractor drawn (T_5) contained higher percentage of smaller clods and lower percentage of larger ones. It also revealed that different tillage treatments especially secondary tillage implements could induce considerable differences in clod MMD (Mean mass diameter). The MMD of clods was higher in case of secondary tillage with cultivator (either bullock drawn or tractor drawn) and lower under rotovator either power tiller drawn or tractor drawn irrespective of primary tillage. High speed tynes in rotavator break large size clods to small clods could be the reason for low clod mean mass diameter under rototiller treatments. Bhushan and Ghildyal (1971) reported larger clods under mould board plough due to the increase in radius of curvature of the mould board plough.

Seedling emergence

Seedling emergence percentage was significantly higher in plots tilled with rotavator either tractor drawn or power tiller drawn as secondary tillage, which was significantly higher than cultivator tilled treatments (Table-1). Lowest seedling emergence (54.8%) was observed in zero tillage plots. Soil water regimes had no effect on seedling emergence. The highest percent seedling emergence with rotavator (as secondary tillage) compared to cultivator and zero tillage was attributed to improved seed- soil- water contact and favorable soil physical conditions for germination and emergence.

Growth parameters

Leaf area index (LAI): Tillage, soil moisture regimes and their interaction affected the leaf area index of sunflower (Fig.1). At 60 DAS, higher LAI was recorded when the soil was tilled to deeper depths and made to fine tilth (T_5) as compared to other treatments. Finer tilth coupled with deep ploughing (T_5) resulted in higher plant population (Table-1) and higher plant growth producing high LAI. Similar results were reported in case of mungbean (IRRI, 1984) and groundnut (Khan, 1984). Irrigation given at shorter intervals by adopting relatively higher soil moisture regimes (IW/CPE= 1.0 and 1.2) resulted in higher LAI compared to those scheduled at longer intervals (IW/CPE= 0.6 and 0.8).

Drymatter accumulation: Favorable soil conditions created with tractor drawn disc plough once + rotavator twice (T_5) supported the crop with higher relative leaf water content and leaf water potential, thus resulting in higher dry matter accumulation (Table-2). Increase in soil moisture regime significantly increased the dry matter accumulation at harvest. This could be attributed to lower soil moisture stress prevailing before next irrigation in the plots irrigated with IW/CPE ratio of 1.0 and 1.2. On the other hand in IW/CPE = 0.8 and 0.6 moisture regimes, plants experienced relatively higher soil water stress thereby low dry matter accumulation. The interaction effects of tillage and soil moisture regime significantly affected the dry matter production, which appeared due to high seedling emergence and relatively better growth in the initial stage of crop.

Seed yield: Significantly higher seed yield (Table-3) were registered with tractor drawn disc plough once followed by rotavator twice (T_5) compared to other tillage treatments due to congenial physical edaphic conditions. Providing 60 mm of irrigation water at IW/CPE ratio of 1.2 (M_4) registered highest seed yield which was on par with IW/CPE = 1.0 (M_3) and both were significantly superior to M_1 and M_2.

Table 2 Effect of tillage treatments and soil moisture regimes on drymatter accumulation at harvest

Treatment	Shoot drymatter (kg/ha)									
	1997-98					1998-99				
	Soil moisture regime					Soil moisture regime				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
Tillage (T)										
T_1	1626	1952	2131	2178	1973	1536	1746	2040	2168	1872
T_2	1847	2280	2576	2664	2342	1802	2195	2490	2639	2281
T_3	2087	2580	2857	2952	2619	1993	2527	2862	3036	2604
T_4	2210	2706	3065	3154	2745	2253	2767	3052	3101	2793
T_5	2490	3079	3465	3545	3145	2493	2990	3287	3407	3044
Mean	2052	2522	2810	2899		2015	2445	2743	2870	

	1997-98	**1998-99**
Tillage (T)		
CD (P=0.05)	169	111
Soil moisture regime (M)		
CD (P=0.05)	132	97.9
Interaction (T at M)		
CD (P=0.05)	272	171
Interaction (M at T)		
CD (P=0.05)	312	232

M_1 - IW/CPE ratio of 0.6; M_2 - IW/CPE ratio of 0.8; M_3 - IW/CPE ratio of 1.0; M_4 - IW/CPE ratio of 1.2

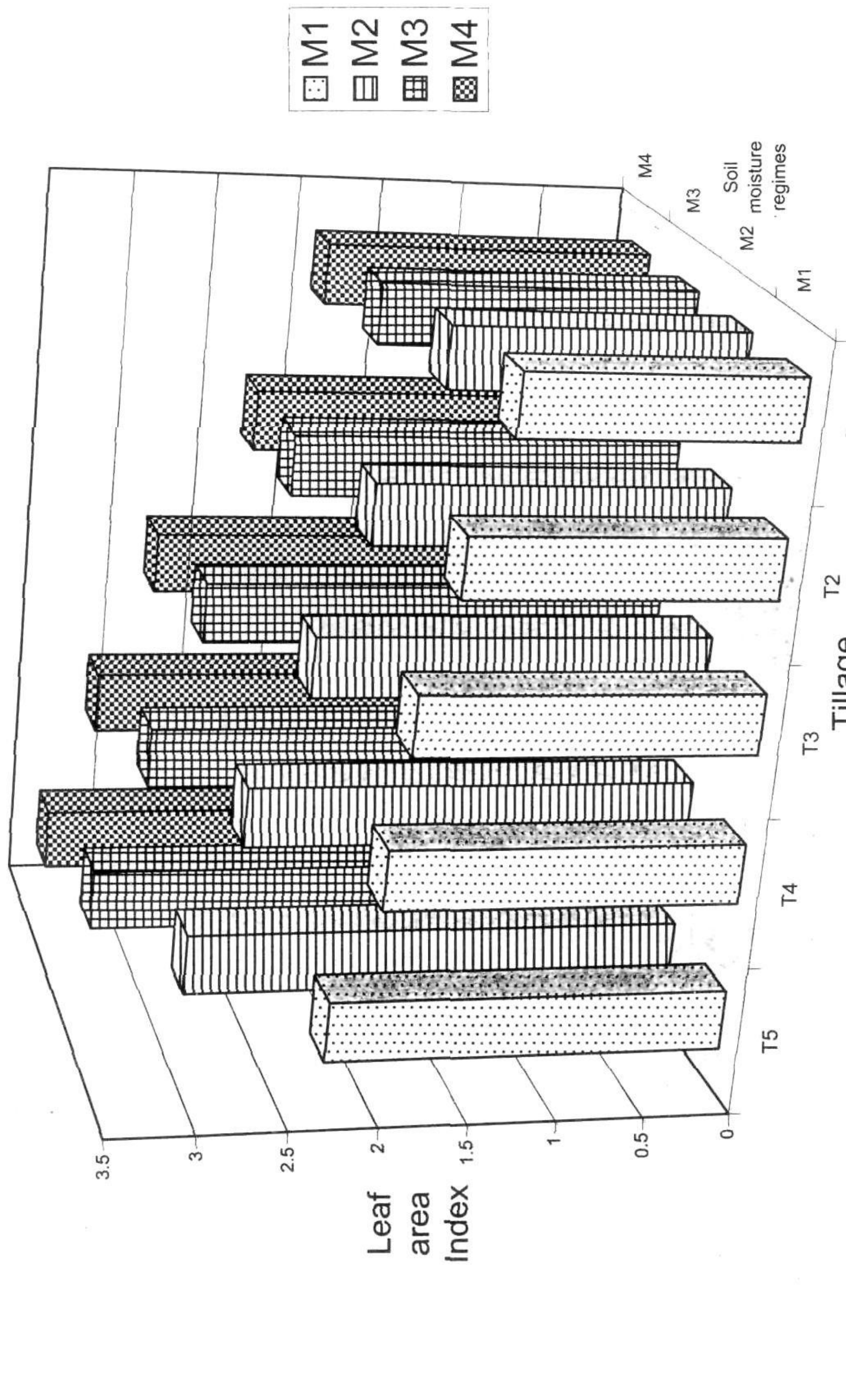
Table 3 Effect of tillage treatments and soil moisture regimes on seed yield of sunflower

Treatment	Seed yield (kg/ha)									
	1997-98					1998-99				
	Soil moisture regime					Soil moisture regime				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
Tillage (T)										
T_1	557	742	838	876	753	580	633	767	834	686
T_2	693	924	1097	1156	967	651	838	1004	1085	894
T_3	774	1036	1228	1305	1086	718	975	1158	1256	1022
T_4	881	1176	1315	1398	1192	851	1131	1285	1341	1152
T_5	996	1321	1528	1584	1357	944	1248	1392	1478	1265
Mean	780	1040	1201	1264		735	965	1121	1199	

	1997-98	**1998-99**
Tillage (T)		
CD (P=0.05)	62.6	73.3
Soil moisture regime (M)		
CD (P=0.05)	75.4	84.4
Interaction (T at M)		
CD (P=0.05)	161	127
Interaction (M at T)		
CD (P=0.05)	190	121

M_1 - IW/CPE ratio of 0.6; M_2 - IW/CPE ratio of 0.8; M_3 - IW/CPE ratio of 1.0; M_4 - IW/CPE ratio of 1.2

Fig-1 Effect of tilage and Soil moisture regimes on leaf area index, means of 1997-98 & 1998-99



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Effect of tillage and soil moisture regimes on water stress indices and seed yield of post-rainy season sunflower under rice fallows-II

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Abstract

Field experiments were conducted at the University College Farm during 1997-98 and 1998-99 in order to study the effect of tillage and soil moisture regimes on water stress indices, viz., relative leaf water content (RLWC), leaf (xylem) water potential (LWP), leaf diffusion resistance (LDR), leaf temperature (LT), dry matter and seed yield of post rainy season sunflower (*Helianthus annuus* L.) grown in rice fallow Alfisols. Higher moisture content, RLWC and LWP at different growth stages were observed in deep tillage plots worked either with tractor drawn disc plough or tractor drawn mould board plough and with irrigation regimes of IW/CPE of 1.2 and 1.0, but the reverse trend was observed for LDR and LT. Dry matter accumulation was associated with deep-fine tillage (disc plough once followed by rotovator twice), IW/CPE of 1.2 moisture regime individually and in combination. Higher mean sunflower seed yield of 1531 and 1460 kg/ha were obtained with disc plough once followed by rotovator (deep fine tillage) in combination with irrigations scheduled at IW/CPE =1.2 and 1.0, respectively.

Key words: Tillage, soil moisture regime, water stress indices, sunflower

Introduction

Plant water status controls the physiological processes and conditions, which determine the quantity and quality of its growth (Kramer, 1969). Morphological, physiological and biochemical modifications caused by water stress in the plant may substantially reduce crop yield (Hasiao, 1973). Different indices have been used to evaluate the plant water status, these are affected by various factors *viz.*, soil and water management practices, plant and atmosphere parameters. Certain stages of plant growth are comparatively more sensitive than others to moisture stress. Tillage practices on corn (Reicosky *et al.*, 1976) and water management practices in sunflower (Singh *et al.*, 1995) have been reported on the effect of moisture stress. But the combined effect of tillage and moisture has not been reported hitherto. The present study was therefore undertaken to study the individual and interaction effects of tillage and soil moisture regimes on water stress indices and yield of sunflower under rice fallows.

Materials and methods

A field experiment was conducted on sunflower (*Helianthus annuus* L.) in rice fallows at Research Farm, ANGRAU, Hyderabad during post rainy seasons of 1997-98 and 1998-99 (other details are in *J. Oilseed Res.*, 20(1) : 81-86).

Soil moisture content from 0- 45 cm soil depth for each 15 cm soil layer was determined at regular intervals of crop growth by following gravimetric method. Relative leaf water content (RLWC) was measured as per Turner(1981), leaf water potential (LWP) as per Scholander *et al.* (1965), leaf diffusion resistance (LDR) and leaf temperature (LT) were measured using Steady State Porometer (Model, LT-1600), before giving scheduled irrigation at regular intervals of 30, 45 and 60 DAS coinciding vegetative, flowering and grain filling stages, respectively during crop growth period for both the years of study. The above parameters were measured before irrigation schedule around stipulated time.

The experimental data collected on various moisture stress indices, growth and seed yield of sunflower were subjected to statistical analysis (Panse and Kukhatme, 1978). Correlations were worked out for seed yield with water stress parameters.

Results and discussion

Soil moisture content: Higher soil moisture content was observed in deep ploughing treatments (T_5 and T_4),

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Table 4 Effect of tillage treatments and soil moisture regimes on benefit cost ratio of post-rainy season sunflower under rice fallows

Treatment	Benefit : cost ratio									
	1997-98					1998-99				
	Soil moisture regime					Soil moisture regime				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
Tillage (T)										
T_1	1.19	1.17	1.18	1.69	1.31	1.06	1.27	1.48	1.56	1.34
T_2	1.48	1.90	2.16	2.23	1.94	1.36	1.68	1.94	2.02	1.75
T_3	1.59	2.04	2.33	2.43	2.10	1.44	1.88	2.15	2.25	1.93
T_4	1.67	2.15	2.32	2.42	2.14	1.58	2.03	2.23	2.25	2.02
T_5	1.82	2.33	2.60	2.65	2.35	1.86	2.13	2.33	2.39	2.18
Mean	1.55	1.92	2.12	2.28		1.46	1.80	2.03	2.10	

References

Bhushan, L.S., and Gildhayal, B.P., 1971. Influence of shape of implements on soil structure. *Indian Journal of Agricultural Sciences*, **41**: 744-751.

IRRI, 1984. International Rice Research Institute, Los Banos, Phillippines, Annual Report, pp.315-324.

Khan, A.R. 1984. Studies on tillage induced physical edaphic properties in relation to peanut crop. *Soil and Tillage Research*, **4** : 225-236.

Panse, V.G. and Sukhatme, BP.V. 1978. *Statistical Methods for Agricultural Workers*. Indian Council of Agricultural Research, New Delhi.

Prihar, S.S., Ghildyal, B.P., Painuli, D.K. and Sur, H.S. 1985. Physical properties of mineral soils affecting rice-based cropping systems. pp 57 –70 In: *Soil Physics and Rice*. International Rice Research Institute, Los Banos, Phillippines.

Reddy, G.H.S. and Reddy, A.A. 1979. Causes of low yields of groundnut in six districts of Andhra Pradesh. Survey Report, Acharya N.G. Ranga Agricultural University, Hyderabad, India.

RNAM part-2 1983. Test code procedure for rotary tillers. Regional Network for Agricultural Machinery, ESCAP, UNDP, Phillippines.

Vittal, K.P.R., Vijayalakshmi, K. and Rao, U.M.B. 1983. Effect of deep tillage on dryland crop production in red soils of India. *Soil Tillage and Research*, **3** : 377-384.

Table 2 Effect of tillage and soil water regimes on plant water stress indices of post-rainy season in sunflower

Treatment	RLWC (%)						XWP (bars)					
	1997-98			1998-99			1997-98			1998-99		
	45 DAS	60 DAS	75 DAS	45 DAS	60 DAS	75 DAS	45 DAS	60 DAS	75 DAS	45 DAS	60 DAS	75 DAS
Tillage (T)												
T_1	81.6	78.3	70.2	80.3	75.5	71.0	-15.0	-16.6	-19.7	-15.6	-16.7	-20.1
T_2	82.6	79.6	71.0	81.7	76.4	72.1	-14.4	-16.0	-18.9	-14.5	-16.4	-19.0
T_3	82.6	79.6	70.8	82.0	76.7	72.2	-14.4	-16.0	-18.6	-14.5	-16.0	-18.9
T_4	84.9	81.7	73.1	84.4	78.9	74.2	-13.3	-15.0	-17.9	-13.6	-15.7	-18.5
T_5	84.9	81.7	72.9	84.8	78.7	74.8	-13.2	-14.7	-17.8	-13.6	-15.4	-18.2
CD (P=0.05)	1.49	1.92	1.53	1.26	1.00	1.38	1.47	1.27	1.58	1.18	0.99	1.14
Soil moisture regime (M)												
M_1	77.4	76.8	68.6	76.9	71.4	69.5	-15.5	-17.3	-20.1	-16.2	-17.9	-20.6
M_2	81.5	78.2	70.0	81.3	76.9	71.2	-14.4	-15.8	-20.2	-15.0	-16.2	-19.3
M_3	86.8	82.5	73.9	85.5	80.1	75.0	-13.7	-15.2	-18.2	-14.0	-15.3	-18.4
M_4	87.5	83.7	74.1	86.7	80.8	76.0	-12.7	-14.2	-16.7	-12.1	-14.3	-17.5
CD (P=0.05)	*0.97*	*1.42*	*0.98*	*0.80*	*0.83*	*1.22*	*0.87*	*0.85*	*1.00*	*0.79*	*1.14*	*0.78*
	Leaf diffusion resistance (S/m)						**Leaf temperature (°C)**					
Tillage (T)												
T_1	63.3	67.7	74.2	61.9	70.5	77.9	27.2	28.2	28.6	28.4	28.8	29.3
T_2	60.2	65.8	74.3	59.8	68.6	76.7	26.2	27.7	28.3	27.0	28.1	28.7
T_3	59.7	64.9	73.3	60.2	68.3	75.8	26.2	27.5	27.7	26.9	28.3	28.4
T_4	56.4	62.1	70.0	56.2	65.2	72.5	25.9	26.8	27.1	26.2	27.5	27.7
T_5	56.0	61.9	69.5	56.3	65.0	72.0	25.1	26.4	26.9	26.3	27.3	27.6
CD (P=0.05)	2.25	1.90	1.60	1.48	2.96	2.53	1.49	1.35	1.10	1.67	0.96	1.36
Soil moisture regime (M)												
M_1	70.2	73.8	83.0	70.5	78.2	83.7	28.3	29.6	30.0	29.8	30.2	30.6
M_2	63.6	68.0	75.0	62.2	69.9	78.9	26.6	28.1	28.4	26.7	28.5	29.3
M_3	53.0	60.3	67.1	55.2	62.8	69.8	25.4	26.3	27.5	26.0	27.4	27.4
M_4	49.7	55.9	64.3	47.5	59.1	67.5	23.4	24.4	25.0	24.5	25.9	25.6
CD (P=0.05)	1.16	1.21	1.17	1.73	1.55	1.68	0.74	0.77	0.95	0.53	0.87	1.07

RLWC : Relative leaf water context; XWP : Xylem water potential
LDR : Leaf diffusion resistance; LT : Leaf temperature

... irrigating soil moisture regimes (IW/CPE of 1.2 ...) individually and in combination (Table-1). Vittal ... reported higher soil moisture content with deep tillage under rainfed conditions owing to higher water storage capacity of soil profile.

Table 1 **Effect of tillage treatments and soil moisture regimes on soil moisture content (%) at different sunflower growth stages**

Treatment	Soil moisture content (%) on dry weight basis									
	1997-98					1998-99				
	10 DAS	30 DAS	45 DAS	60 DAS	75 DAS	10 DAS	30 DAS	45 DAS	60 DAS	75 DAS
Tillage (T)*										
T_1	8.90	6.97	6.63	6.34	7.11	8.91	6.33	6.10	5.91	6.23
T_2	10.28	7.47	7.12	6.54	7.57	9.97	6.64	6.32	6.16	6.47
T_3	11.55	8.08	7.40	6.72	7.70	11.41	7.16	6.75	6.63	6.88
T_4	11.11	8.60	8.22	7.39	8.22	10.94	7.95	7.44	7.29	7.54
T_5	12.36	8.89	8.58	7.88	8.49	12.08	8.31	7.81	7.57	7.86
Soil moisture regime (M)**										
M_1	10.84	6.92	6.48	6.00	6.73	10.66	6.45	5.98	5.80	6.11
M_2	10.84	7.83	7.39	6.65	7.45	10.66	6.88	6.52	6.32	6.63
M_3	10.84	8.25	7.98	7.28	8.27	10.66	7.50	7.16	7.02	7.26
M_4	10.84	9.00	8.50	7.96	8.82	10.66	8.27	7.89	7.71	7.98

* (T_1 to T_5, details under seed yield)
** (60 mm irrigation at IW/CPE ratio of 0.6 (M_1), 0.8 (M_2), 1.0 (M_3) and 1.2 (M_4)

Water stress indices: Tillage and soil moisture regimes significantly influenced the plant water stress parameters during both the years of study (Table-2). The plots received deep tillage (T_5 and T_4) and frequently scheduled irrigation (IW/CPE= 1.20), individually and in combination of both, maintained higher soil moisture (Table-1), RLWC and XWP and lower LDR and LT (Table-2) at flowering (45 DAS), seed filling (65 DAS) and maturity stages (75 DAS). Lowest plant water status was observed in zero tillage (T_1) at all growth stages. This may be due to favourable integrated effect of soil physical environment and higher moisture availability in deep tillage treatment which enhanced root growth for greater uptake of water and nutrients and thereby maintained higher plant water status. Deep ploughing has favourable effect on the modification of soil physical properties (Allamaras *et al.*, 1977).

Irrigation at IW/CPE ratio of 1.2 recorded significantly higher plant water status (high RLWC and XWP) and low LDR and LT compared to 1.0, 0.8 and 0.6. This is because of the crop receiving irrigation at relatively shorter intervals maintained higher soil moisture facilitating the crop to draw required amount of moisture.

In general, plant water status i.e., XWP and RLWC decreased, but LDR and LT increased with age of the crop. This was due to high evaporative demand at flowering than at preceding stage. Leaf water potential was highly influenced by evaporative conditions due to change in relative humidity and net radiation as long as soil water is unlimited. Soil moisture content had significantly and positively correlated with LWP (r= 0.911) and RLWC (r= 0.945) and negatively correlated with LDR (r= -0.885) and LT (r= -0.869) (Table-4).

Total dry matter accumulation: Tractor drawn disc plough once + rotovator twice (T_5) supported the crop with higher relative leaf water content and leaf water potential, resulting in higher dry matter accumulation (Fig-1). Increase in soil moisture regime from IW/CPE 0.6 to 1.2 significantly increased the dry matter accumulation at 60 DAS and at harvest. This could be attributed to lower soil moisture stress in the plots irrigated with IW/CPE ratio of 1.0 and 1.2 having higher relative leaf water content and leaf water potential and lower leaf diffusion resistance and leaf temperature. On the other hand in IW/CPE=0.8 and IW/CPE=0.6 moisture regimes, growing plants experienced relatively higher soil water stress and lower leaf water potential, hence lower dry matter accumulation.

Table 3 Effect of tillage treatments and soil moisture regimes on seed yield of sunflower

Treatment	Seed yield (kg/ha)*				
	Soil moisture regime				
	M_1	M_2	M_3	M_4	Mean
Tillage (T)					
T_1	534	688	803	855	720
T_2	672	881	1051	1121	931
T_3	746	1006	1193	1281	1057
T_4	866	1154	1300	1370	1173
T_5	970	1285	1460	1531	1312
Mean	758	1003	1161	1231	
			CD (P=0.05)		
Tillage (T)			62.6		
Moisture regime (M)			75.4		
Interaction T at same M			161		
M at same T			190		

* mean of two years, 1997-98 and 1998-99

Seed yield: The tillage treatment, tractor drawn disc plough once + rotovator twice (T_5) produced 80, 40, 25 and 14% higher seed yield over zero tillage (T_1), bullock drawn wooden plough twice + cultivator twice (T_2), bullock drawn wooden plough twice + power tiller drawn rotovator twice (T_3) and tractor drawn mould plough once + cultivator twice (T_4), respectively in 1997-98 and the corresponding percentages in 1998- 99 were 84, 45, 24 and 10 (Table-3). These changes were attributed to changes in amount and distribution of water in the profile and to change in plant rooting patterns. Irrigation at IW/CPE ratio of 1.2 resulted in 5.2, 21.5 and 62% higher yield over IW/CPE of 1.0, 0.8 and 0.6 respectively in 1997-98 and the corresponding percentages for 1998-99 were7.0, 24.2 and 63.1. Talati and Mehta (1963) reported that grain yield of pearl millet in sandy loam soils was more than double in deep tillage over shallow tillage. Scheduling 6 cm irrigation at IW/CPE=1.0 also recorded significantly highest yield compared to 0.6 and 0.8, and is at par with IW/CPE=1.2. Interaction effects of tillage and soil moisture regimes showed that there was a saving of 180 (1997-98) to 240 mm (1998-99) irrigation water by providing deep tillage (21 cm) either with disc plough or with mould board plough compared to shallow tillage (11 cm) maintaining yield at optimum levels. Deep fine tillage and frequently irrigated soil moisture regime combination resulted in significantly higher seed of 1531 kg/ha (Table-3). This could be ascribed to higher plant water status resulting in higher net photosynthetic activity (Upreti and Sirohi, 1985). Although both the deep tillage treatments maintained high RLWC and XWP and shown similar individual plant growth and seed yield, because of significantly higher plant stand under tractor drawn disc plough + rotovator (T_5) compared to tractor drawn mould board plough + cultivator (T_4). This difference in plant stand was the result of finer tilth achieved with secondary tillage with rotovator. Sunflower seed yields were significantly correlated positively (Table-4) with RLWC (r= 0.850**), XWP (r= 0.892**) and negatively significant with LDR (r= -0.836**) and LT (r= -0.901**). The results indicate that the combination of providing irrigation at IW/CPE of 1.0 (M_4) and deep fine tillage (T_5) maintained higher plant water status at all phenotypic phases, resulted higher plant growth and thus gave higher crop yields of post rainy season sunflower under rice fallows.

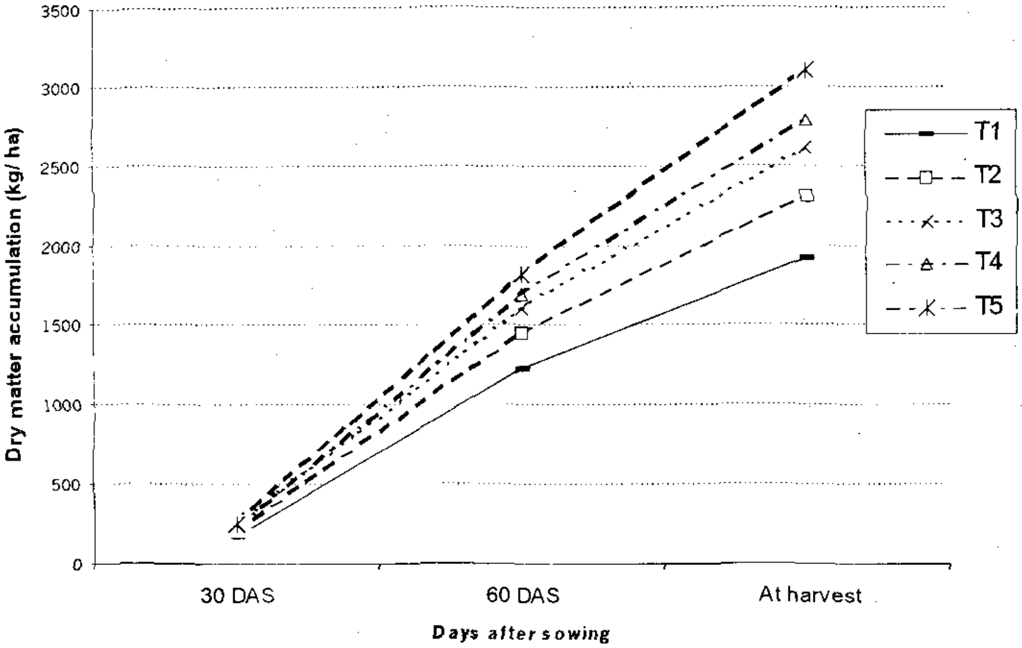
Table 4 Correlation matrix for yield and plant water stress parameters at 45 DAS of sunflower

	X_1	X_2	X_3	X_4	X_5	Y
X_1	1.000	0.904	-0.931	-0.945	0.911	0.892
X_2		1.000	-0.970	-0.950	0.945	0.850
X_3			1.000	0.953	-0.885	-0.850
X_4				1.000	-0.869	-0.901
X_5					1.000	0.816
Y						1.000

R (P=0.05) = 0.444
R (P=0.01) = 0.561

X_1 : Leaf water potential (bars)
X_2 : Relative leaf water content (per cent)
X_3 : Leaf diffusion resistance (S m^{-1})
X_4 : Leaf temperature (°C)
X_5 : Soil moisture content (per cent) on dry weight basis
Y : Seed yield (kg/ha)

Conclusion: Improved plant water status through improved soil and water management practices can result in efficient crop production. The effect of tillage and soil moisture regimes on of post rainy season Sunflower (*Helianthus annuus* L.) had measurable effect on relative leaf water content (RLWC), leaf (Xylem) water potential (LWP), leaf diffusion resistance (LDR) and leaf temperature (LT). Tillage particularly deep tillage facilitated crop roots to grow deep and can explore moisture and nutrients from larger soil volume and thus resulted in higher plant water content. Providing irrigation of 60 mm water at IW/CPE ratio=1.0 under deep tillage and 1.2 under shallow tillage conditions for post rainy season sunflower crop was found ideal in maintaining optimum plant water indices besides higher seed yields.



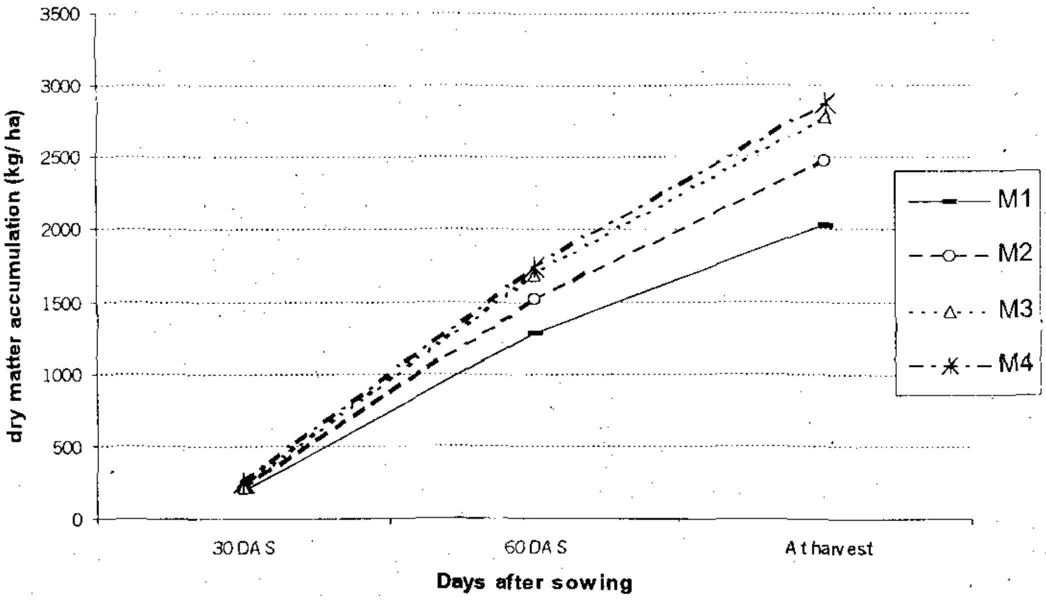


Fig-1 Effect of tillage and soil water regimes on total drymatter accumulation of **post-rainy season** *sunflower* ***(means of 1997-98 and 1998-99)***

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Effect of different levels of nitrogen and phosphorus on growth and yield of summer castor after *kharif* rice

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Abstract

Field experiments on summer castor after *kharif* rice were carried out during 1996-97 and 1997-98 at College Farm, College of Agriculture, ANGRAU, Rajendranagar, Hyderabad, AP on sandy clay loam soil with four levels of nitrogen (0, 40, 80 and 120 kg/ha) in combination with three levels of phosphorus (0, 40 and 80 kg/ha). Application of 80 kg each of N and P/ha recorded significantly higher growth, yield components and seed yield than all other levels of N and P and additional returns of Rs. 2091/- and Rs. 1352/- were obtained with application of 80 kg N/ha and 80 kg P_2O_5/ha respectively as compared to control (no N and no P).

Key words: Castor, Nitrogen and Phosphorus

Introduction

In Southern Telangana zone of Andhra Pradesh under situations of limited water availability for second rice crop, instead of growing rice with limited water or keeping the land fallow, castor can be grown successfully after *kharif* rice because of its low water requirement (Rao, 1983; Pratibha *et al.*, 1994). The productivity of castor following *kharif* rice in general is very much lower and however, can be enhanced through suitable agronomic practices. Among the various factors influencing the production of castor, application of N and P plays an important role in improving the yield levels of the crop grown after *kharif* rice. Further, the nutrient requirements of castor in soils that follow flooded rice are entirely different from that grown after an upland crop and the information available on this aspect is scanty for castor following *kharif* rice. Hence, in the present study an attempt has been made to assess the effect of different levels of N and P on growth and yield of summer castor following *kharif* rice.

Materials and methods

Field experiments were conducted during early summer seasons of 1996-97 and 1997-98 at College Farm, College of Agriculture, ANGRAU, Rajendranagar, Hyderabad (17° 19' N and 78 ° 28' E and 542.6 m above MSL) on a sandy clay loam soil. The experimental soil had N, P and K of 150.1, 22.8 and 200 kg/ha, respectively with pH 8.0. There were twelve treatment combinations comprising of four levels of N and three levels of P tested in a randomized block design with factorial concept with three replications. GCH-4 hybrid of castor was sown with a spacing of 60 cm x 45 cm on 5th January, 1996 and 10th January, 1997 with gross plot size of 5.4 m x 3.6 m and net plot size of 4.8 m x 3.2 m. The land was prepared by tractor drawn cultivator twice followed by rotovating with power tiller twice. N and P were applied in each plot as per the treatments. Full dose of P_2O_5 and 30 kg K_2O/ha and half the level of N were applied as basal uniformly to all the plots. The remaining half N was top dressed twice at 30-35 DAS and 70-75 DAS in two equal splits. Six irrigations were given based on evaporative demand. The pooled data of biometric observations were analysed as per Steel and Torie (1980).

Results and discussion

Growth: Application of 80 and 120 kg N/ha resulted in significantly higher dry matter production (DMP) and leaf area index (LAI) over 40 kg N/ha and control at different stages of crop growth and DMP at former levels were almost same. The DMP was significantly lower than that at all other levels at all stages of crop growth when N was not applied. The LAI was significantly lower in control at harvest but was almost similar with 40 kg N/ha at 90 and 120 DAS (Table-1). Higher DMP and LAI at higher levels of N might be due to significantly higher photosynthetic activity of the plants at higher N levels (Devi, 1989).

Among different levels of P applied, 80 kg P_2O_5/ha resulted in significantly higher DMP over 40 kg P_2O_5/ha which inturn recorded significantly higher DMP over control at all the stages of crop growth. The LAI recorded with 80 and 40 kg P_2O_5/ha was almost similar and significantly superior to control except at 90 DAS where application of 80 kg P_2O_5/ha recorded significantly higher LAI over 40 kg P_2O_5/ha application and control (Table-1). The differences in DMP due to application of P at higher doses might have

References

Allamaras, P.R., Richman, R.W., Ekin, I.G. and Kemball, B.A, 1977. Chiseling influences on soil Hydraulic properties. *Proceedings of Soil Science Society of America*, 41, 796

Hasiao, T.C. 1973. Plant responses to Stress. *Annual Review of Plant Physiology*, 24, 519

Kramer, P.J. 1969. *Plant and Water Relationships*. A Modern Synthesis, Mc Graw Hill, New York, pp.183.

Panse, V. G, and Sukhatme, P. V. 1978. *Statistical methods for agricultural workers*. Indian Council of Agricultural Research, New Delhi. pp. 186

Reicosky, D.C., Campbell, R.B. and Doty, C.W. 1976. Corn plant water stress as influenced by Chiseling, irrigation and Water table depth. *Agronomy Journal*, 68 : 499

Scholandar, P.F., Hamnael, H.T., Badstreet and Hemmingsen, E.A., 1965. Sap pressure in vascular plants. *Science*, 148: 339-346.

Singh, V, Sharma, S.K, Verma, B.L, and Singh, B. 1995. Response of rainy season sunflower (*Helianthus annuus* L.) to irrigation and nitrogen under North Western Rajasthan. *Indian Journal of Agronomy*, **40**(2): 239-242.

Talati, N. R. and Mehta, B. V. 1963. Effect of deep and shallow tillage on nutrient release, moisture conservation and yield of pearl millet in Goradu soils of Anand. *Journal of the Indian Society of Soil Science*, **11**(1): 9-16.

Turner, N. C. 1981. Techniques and experimental approaches for the measurement of plant water stress. *Plant and Soil*, **58**: 339-366.

Upreti, D.C. and Sirohi, G.S. 1985. Effect of water stress on photosynthesis and water relations of wheat varieties. *Indian Journal of Plant Physiology*, **28** : 107- 114

Vittal, K. P. R., Vijayalakshmi, K. and Rao, U. M. B. 1983. Effect of deep tillage on dryland crop production in red soils of India. *Soils and Tillage Research*, **3**(4): 377-384.

The interaction effect of N and P levels was significant in case of seed yield only. Application of 80 kg each of N and P_2O_5/ha resulted in mean castor yield similar to that observed with application of 120 kg N with 80 kg P_2O_5/ha. Thus, as a consequence of increase in level of N and P application from 0 to 80 kg/ha, growth, yield attributes and seed yield increased significantly (Ganga Saran and Gajendra Giri, 1987; DOR, 1990; 1991; Mathukia and Modhwadia, 1993). Increase in seed yield was associated with the increment in growth parameters and yield attributing characters which was evident from the significant positive correlation between yield and growth parameters and yield and yield attributing characters (Table-3). Response of summer castor to N was quadratic ($y = 1782.1 + 0.0014\ x - 0.000196\ x^2$). The optimum economic dose was worked out to be 80 kg N/ha. On the other hand, linear response of seed yield of summer castor after *kharif* rice was recorded upto 80 kg P_2O_5/ha with the response equation as $y = 2.9375\ x + 1821.5$.

Table 3 **Correlation and regression values between seed yield Vs. yield attributes, growth parameters and oil yield of summer castor under different levels of nitrogen and phosphorus after *kharif* rice (pooled mean over two years)**

Character	Correlation values (r)	Regression equation
Seed yield Vs. Yield attributes		
Number of effective spikes/plant	0.935**	Y = 1935.1 - 0.002 X
Number of capsules/plant	0.630*	Y = 7.7 + 0.045 X
Length of primary spike	0.690*	Y = -9.4 + 0.017 X
100 seed weight	0.846**	Y = 19.07 + 0.06 X
Growth parameters		
Drymatter production at 90 DAS	0.868**	Y = 4 + 0.08 X
Drymatter production at 120 DAS	0.947**	Y = 68 + 0.201 X
Drymatter production at harvest	0.954**	Y = 84.6 + 0.212 X
Leaf area index at 90 DAS	0.962**	Y = -0.11 + 0.0004 X
Leaf area index at 120 DAS	0.764**	Y = 0.25 + 0.0003 X
Leaf area index at harvest	0.638*	Y = 0.23 + 0.003 X
Oil yield	0.960**	Y = -30.1 + 0.523 X

Economics: Economics of N fertilization indicated significant gains upto application of 80 kg N/ha. Application of 80 kg N/ha increased net returns by Rs. 2091/- over control and recorded highest B:C ratio of 2.49 compared to 2.36 in control (Table-2). Increasing rate of P application upto 80 kg P_2O_5/ha increased the net returns and B:C ratio. On mean basis, P application from 0 to 40 and 40 to 80 kg P_2O_5/ha increased net returns by 272 and 1080 Rs/ha, respectively.

References

Devi, M.U. 1989. Effect of different tillage practices and nitrogen levels in castor. M.Sc. (Ag.) Thesis submitted to Andhra Pradesh Agricultural University.

DOR 1990. Annual Progress Report on Castor. Directorate of Oilseeds Research, Hyderabad-500 030, AP., pp.74-90.

DOR 1991. Annual Progress Report on Groundnut, Sesame, Niger, Sunflower and Castor. Directorate of Oilseeds Research, Hyderabad-500 030, AP., pp.468.

Ganga Saran and Gajendra Giri. 1987. Effect of seeding time and nitrogen on summer castor. *Indian Journal of* Agronomy, **32**(2) : 155-157.

Kumar, C.V., Rama Rao, S., Singa Rao, M. and Prabhu Prasadini, P. 1999. Effect of tillage and phosphorus fertilization on growth and yield of groundnut grown after puddled rice. *Journal of Oilseeds Research*, **16** (2) : 362-366.

Mathukia, R.K. and Modhwadia, M.M. 1993. Response of castor (*Ricinus communis* L.) to nitrogen and phosphorus. *Indian Journal of Agronomy*, **38** (1) : 152-153.

Pratibha, G., Pillai, K.G., Satyanarayana, V. and Mir Mustaffa Hussain. 1994. Productivity of certain oilseed crops as influenced by different tillage systems in rice based cropping systems. *In* Prasad M.V.R. *et al.*, (ed) *Sustainability in Oilseeds*, Indian Society of Oilseeds Research, Hyderabad-500 030, AP, pp.297-301.

Rao, K.S. 1983. Water management in light irrigated crops after *kharif* paddy in light soils. Ph.D., Thesis submitted to Andhra Pradesh Agricultural University.

Steel, G.D.R. and Torie, H.J. 1980. *Principles and procedures of statistics*. Mc Grew and Hill Company, Inc., New York.

Willet, J.R. 1979. The effect of flooding for rice culture on soil chemical properties and subsequent maize growth. *Plant and Soil*, **52** : 373-383.

encouraged the root growth which inturn might have increased the uptake of nutrients and water from greater volumes of soil (Willet, 1978; Kumar et *al*., 1999) resulting in higher growth in terms of DMP and LAI. The interaction between N and P levels had no significant effect on growth parameters.

Table 1 Effect of different levels of nitrogen and phosphorus on drymatter production (g/m²) and leaf area index of summer castor after *kharif* rice (pooled mean over two years)

Treatment	Days after sowing					
	Dry matter production (g/m²)			Leaf area index		
	90	120	At harvest	90	120	At harvest
N (kg/ha)						
0	146	418	452	0.5	0.7	0.7
40	155	455	483	0.6	0.7	0.7
80	167	478	521	0.6	0.8	0.8
120	171	483	5.3	0.6	0.8	0.8
SEm±	2.6	6.0	15.5	0.01	0.02	0.01
CD (P=0.05)	7.6	17.6		0.03	0.05	0.04
P_2O_5 (kg/ha)						
0	149	427	468	0.6	0.7	0.7
40	159	461	491	0.6	0.7	0.7
80	171	488	525	0.6	0.8	0.8
SEm±	2.2	5.2	4.6	0.01	0.01	0.01
Cd (P=0.05)	6.6	15.2	13.4	0.03	0.03	0.03

Yield attributes: Yield components *viz*., number of effective spikes/plant, number of capsules/plant and length of primary spike were significantly superior with application of 80 and 120 kg N/ha over 40 kg N/ha and control and were on par with each other. On the other hand, application of 40 kg N/ha and control were comparable with each other in number of effective spikes and capsules/plant. However, significantly shorter primary spikes were recorded in control as compared to all other levels of N application. Application of 40, 80 and 120 kg N/ha recorded similar 100 seed weight, which was significantly lower in control as compared to N application.

Number of effective spikes/plant, number of capsules/plant, length of primary spike and 100 seed weight were significantly superior when the crop was applied with 80 kg P_2O_5/ha as compared to 40 kg P_2O_5/ha and control. On the other hand, number of effective spikes and capsules/plant were on par with each other in the latter two treatments.

The interaction between N and P levels was significant only in case of number of spikes/plant (Table-2). Application of 80 kg each of N and P_2O_5/ha recorded significantly higher number of effective spikes/plant over all other N and P combinations except with application of 120 kg N/ha + 80 kg P_2O_5/ha where it was on par in number of effective spikes/plant.

Yield: Application of 80 or 120 kg N/ha did not show any significant variation either in seed or oil yields. Application of 80 or 120 kg N/ha recorded significantly higher seed and oil yields over that of 40 kg N/ha and control. Further, significantly lower seed and oil yields were recorded in control as compared to 40 kg N/ha (Table-2). Significantly higher yields were recorded with application of 80 kg P_2O_5/ha over that of 40 kg P_2O_5/ha and control while the latter two treatments were comparable regarding seed yield.

Table 2 Effect of different levels of nitrogen and phosphorus on yield components of summer castor after *kharif* rice (pooled mean over two years)

Treatments	Spikes/ plant	Capsules/ plant	Primary spike length (cm)	100 seed weight (g)	Seed yield (kg/ha)	Oil yield (kg/ha)	Net returns (Rs/ha)	B:C ratio
N (kg/ha)								
0	2.3	82	20	29.1	1760	869	4656	2.36
40	2.5	88	23	30.7	1889	959	5523	2.41
80	2.9	104	28	31.4	2051	1061	6742	2.49
120	3.0	107	27	31.5	2056	1032	6374	2.45
SEm±	0.08	2.3	0.8	0.3	29	23	-	-
CD (P=0.05)	*0.24*	*6.8*	2.2	0.8	86	69	-	-
P_2O_5 (kg/ha)								
0	2.5	89	22	29.9	1815	928	5578	2.42
40	2.6	94	24	30.6	1912	970	5850	2.45
80	2.9	105	28	31.6	2070	1043	6930	2.51
SEm±	0.07	2.0	0.6	0.2	25	20	-	-
CD (P-0.05)	0.21	5.9	1.9	0.6	74	59	-	-

par but at 30kg S/ha, the differences in seed and oil yield with different sulphur sources were significant (Table-1). The differences in seed and oil yield among sulphur levels were not significant with ammonium sulphate, elemental sulphur and gypsum. Application of 30 kg S/ha through single super phosphate resulted in the highest seed yield (2065 kg/ha) and oil yield (566 kg/ha). Hegde and Koli (1997) reported the significant increase in seed yield up to 45kg S/ha through single super phosphate.

Economics: Gross returns followed the similar trend as that of seed yield with sulphur levels, sources and their interaction (Table-2). The net returns significantly increased from Rs. 9493/ha in control to Rs. 14,806/ha in 30kg S/ha and there was no further significant increase with 45kg S/ha (Table-2). Among the sulphur sources, application of single super phosphate recorded significantly highest net returns of Rs. 15,527/ha. ı ne ratio followed the similar trend. There was significant interaction between levels and sources of sulphur on net returns. The results indicated that at 15 kg S/ha, all the sources were at par but at 30 and 45 kg S/ha, the differences were significant. There was no significant difference in net returns among sulphur levels with ammonium sulphate, elemental sulphur and gypsum. Application of 30 kg S/ha through single super phosphate resulted in the maximum net returns (Rs. 17,507/ha) and B:C ratio (3.58).

So, the application of 30 kg S/ha in the form of single super phosphate along with recommended dose of N, P and K was found to be more remunerative and productive in safflower.

Table 1 Safflower yield, oil content and oil yield as influenced by levels and sources of sulphur (Pooled data of two years)

Sources of sulphur	Seed yield (kg/ha)					Oil content (%)					Oil yield (kg/ha)				
	Sulphur levels (kg/ha)														
	0	15	30	45	Mean	0	15	30	45	Mean	0	15	30	45	Mean
Ammonium sulphate	-	1609	1829	1724	1720	-	27.6	27.6	27.3	27.5	-	445	506	479	477
Single super phosphate	-	1649	2065	1975	1896	-	27.2	27.2	27.2	27.2	-	447	566	543	519
Elemental sulphur	-	1694	1764	1921	1793	-	27.1	27.1	27.3	27.2	-	463	483	530	492
Gypsum	-	1752	1689	1788	1742	-	27.3	27.3	26.5	27.1	-	483	462	478	474
Mean	1373	1676	1837	1852	-	27.58	27.3	27.3	27.1	-	379	460	504	507	-
	C.D. (P=0.05)					C.D. (P=0.05)					C.D. (P=0.05)				
Levels (L)	126					NS					35				
Sources (S)	146					NS					40				
L x S	253					NS					69				
Control vs. Treat	323					NS					88				

Effect of sulphur nutrition on productivity of safflower

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Abstract

The experiment was conducted during *rabi* seasons of 1996-97 and 1998-99 to study the effect of levels and sources of sulphur on the productivity of safflower in vertisols under rainfed conditions. The results showed that safflower responded significantly upto 30 kg S/ha. Among the sulphur sources, single super phosphate was found superior to ammonium sulphate and gypsum but comparable to elemental sulphur. The interaction effect indicated the highest yield of safflower (2065 kg/ha) at 30 kg S/ha applied through single super phosphate. The net returns (Rs.17,507/ha) and B:C ratio (3.58) followed the similar trend.

Key words: Safflower, sulphur sources, yield

Introduction

Adoption of suitable fertilizer management practices including use of recommended dose of fertilizer, identification of correct source of fertilizer etc., helped in increasing the crop productivity and improving the crop quality. Productivity of oilseed crops can be increased by application of sulphur (Tandon, 1984). Response of safflower to sulphur application in India was reported by Abbas *et al.* (1995). Though sulphur is known to augment the oil content and seed yield of safflower, the farmers are not using sulphur and sulphur bearing fertilizers. Imbalanced nutrition is one of the reasons for low yields of safflower. The present investigation, was, therefore undertaken to find out the optimum dose and suitable source of sulphur for increasing the safflower productivity.

Materials and methods

The experiment was conducted at Agricultural Research Station, Annigeri (Karnataka) during *rabi* seasons of 1996-97 and 1998-99 under rainfed conditions. The soil was Vertisol with available sulphur status of 4.3 ppm, medium in available N (255 kg/ha), low in available P_2O_5 (9.4 kg/ha) and high in K_2O (770 kg/ha) with pH of 8.1. The treatments comprised of three levels (15, 35, and 45 kg/ha) and four sources (ammonium sulphate, single super phosphate, elemental sulphur and gypsum) of sulphur along with a control (no sulphur). These treatments were tested in factorial randomized block design with three replications. The safflower cv. A-1 was sown on 11[th] Oct. 1996 and 24[th] Oct. 1998 at 45 x 20 cm spacing. All the sulphur containing fertilizers along with recommended dose of fertilizer [40-40-20 kg NPK/ha] were applied as per the treatments at sowing. The total rainfall of 1190 mm during 1996 and 649 mm during 1998 was received. The yield data were presented after pooling as similar trend was noticed during both years. Economics of sulphur fertilization was worked out based on prevailing market prices.

Results and discussion

Seed and oil yield: The pooled data indicated that there was significant effect of both levels and sources of sulphur. The safflower yield increased significantly from 1373 kg/ha without sulphur application to 1837 kg/ha with 30 kg S/ha (Table-1). However, there was no further significant increase in yield beyond 30 kg S/ha although an increasing trend was noticed up to 45 kg S/ha. Different sources of sulphur had significant effects on seed yield of safflower. Application of sulphur in the form of single super phosphate resulted in highest yield of safflower (1896 kg/ha) which was at par with elemental sulphur (1793 kg/ha) but significantly higher than yields with ammonium sulphate (1720 kg/ha) and gypsum (1742 kg/ha). Significant response to sulphur in safflower was reported by Abbas *et al.* (1995) and Hegde and Koli ([1997). Improvement in plant growth could partly be attributed to the beneficial effects of sulphur fertilization as nutrient (Tandon, 1989). Similar results were reported by Rathore and Manohar (1989) in mustard.

The oil content was not significantly influenced by sulphur levels, sources and their interaction. Nevertheless, the oil yield was significantly influenced by both levels and sources of sulphur and followed the similar trend as that of seed yield (Table-1). The interaction effects were significant with seed and oil yield only. It was observed that at 15 and 45kg S/ha, all the sulphur sources were at

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Optimization of safflower production under resource constraints

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Abstract

A field experiment was conducted during 1996-97 to 1998-99 at Regional Research Station, Arnej, Gujarat to assess the contribution of production factors on seed yield of safflower. The results indicated that adoption of complete package of practices (fertilizer + thinning + plant protection + weeding) resulted in significantly higher seed yield (1776 kg/ha), net returns (Rs. 14297/ha) and benefit-cost ratio (3.73). Among the various production constraints, plant protection was found to be most crucial followed by fertilizer. Thinning and weeding are of minor importance in Bhal region of Gujarat State in terms of their contribution to yield of rainfed safflower.

Key words: Safflower, production constraints

Introduction

Different factors (fertilizer + thinning + plant protection + weeding) contribute towards the establishment of the crop stand, growth of plant and ultimately the final yield of safflower. But, relative contribution of these factors have not been quantified in safflower under Bhal and coastal agro-climatic zone of Gujarat. Hence, the experiment was conducted to study the influence of different input factors alone or in combination on productivity of rainfed safflower.

Materials and methods

The field trial was conducted during the winter season of 1996-97 to 1998-99 at Regional Research Station, Gujarat Agricultural University, Arnej. The soil of the experimental plot was medium black with pH 8.4. It contained 214 kg/ha available N, 17 kg/ha available P_2O_5 and 715 kg/ha available K_2O. The experiment was laid out in randomized block design with eight treatments replicated three times on safflower cv. Bhima. The treatments consisted of full package and deletion one or more of inputs like fertilizer, plant protection, thinning and weeding (Table-1). Rainfall received during 1996, 1997 and 1998 amounted to 568, 1042 and 678 mm, respectively.

Results and discussion

Seed yield: Adoption of full package of practices realized the maximum seed yield during all the three years of experimentation as well as in pooled results (Table-1). Studies conducted at Tandur, Indore and Annigeri on optimization of safflower production under resource constraints also indicated the need for adoption of full package of practices to obtain the highest yield of safflower (Anonymous, 1997). The whole package oriented demonstrations conducted in different states during 1995-96 have also conclusively proved the superiority of the improved technology over the prevailing farmers' practices (Reddy *et al.*, 1997). During the first year, yield of safflower was reduced significantly in absence of plant protection whereas other production constraints like thinning, weed control and fertilizer application reduced yield of safflower but did not cross the level of significance. In subsequent years, all the production constraints resulted in significant yield reduction. The effect of production constraints on crop yield was found in the order of plant protection > thinning > weeding > fertilizer application during 1996-97. However, in subsequent years and in pooled results it was in the order of plant protection > fertilizer application > thinning > weeding.

On an average, full package of practices resulted in achieving highest yield of 1776 kg/ha which was reduced to 1374, 1451, 1141 and 1516 kg/ha without fertilizer, thinning, plant protection and weeding, respectively. The combinations of different resource constraints further reduced the yield of safflower.

Economics: Economics of various treatments worked out on the basis of pooled results (Table-1) indicated that, among the various treatments, full package rendered the highest net return of Rs. 14297/ha with the highest value of B:C ratio (3.73). It was followed by full package without weed control and thinning. The treatment without fertilizer, plant protection, thinning and weeding recorded the lowest net returns (Rs. 5813/ha) and B:C ratio (2.99).

Table 2 **Economics of safflower as influenced by levels and sources of sulphur (Pooled data of two years)**

Sources of sulphur	Gross returns (Rs/ha)					Net returns (Rs/ha)					B:C ratio				
	Sulphur levels (kg/ha)														
	0	15	30	45	Mean	0	15	30	45	Mean	0	15	30	45	Mean
Ammonium sulphate	-	18717	21637	20198	20184	-	12240	15000	13361	13534	-	2.89	3.26	2.95	3.03
Single super phosphate	-	19207	24295	23382	22295	-	12833	17507	16243	15527	-	3.01	3.58	3.28	3.29
Elemental sulphur	-	19779	20867	22584	21077	-	12932	13494	14688	13705	-	2.89	2.83	2.86	2.86
Gypsum	-	20379	19665	20892	20312	-	14092	13223	13908	13741	-	3.24	2.95	2.99	3.06
Mean	15838	19520	21616	21764	-	9493	13024	14806	14550	-	2.50	3.00	3.17	3.02	-
			C.D. (P=0.05)					C.D. (P=0.05)							
Levels (L)			1421					1411							
Sources (S)			1641					1629							
L x S			2043					2822							
Control vs. Treat			3621					3594							

References

Abbas, M., Tomar, S.S. and Nigam, K.B. 1995. Effect of phosphorus and sulphur fertilization in safflower (*Carthamus tinctorius*). *Indian Journal of Agronomy*, 40(2) : 243-248.

Hegde, D.M. and Koli, B.D. 1997. Response of levels and sources of sulphur on the productivity of safflower. *IVth International Safflower Conference*, Bari (Italy), 2-7 June, pp.60-61.

Rathore, P.S. and Manohar, S.S. 1989. Response of mustard to nitrogen and sulphur. I. Effect of N and S on growth and chlorophyll content of mustard. *Indian Journal of Agronomy*, 34(3) : 328-332.

Tandon, H.L.S. 1984. *Sulphur Research and Agricultural Production in India.* Fertilizer Development and Consultation organization, New Delhi.

Tandon, H.L.S. 1989. *Sulphur fertilizer for Indian Agriculture.* A guide book. Fertilizer Development and Consultation Organization, New Delhi.

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nterception of bacterial wilt, *Burkholderia solanacearum* in groundnut jermplasm imported from Australia

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\bstract

3acterial wilt caused by *Burkholderia solanacearum* [= *Pseudomonas solanacearum*] was intercepted in six)ut of 93 groundnut accessions received from Australia during post entry quarantine inspections at nternational Crops Research Institute for Semi Arid Tropics (ICRISAT). The infection varied from 10 to 33.3%. Physiological and biochemical tests revealed that the bacterium was *B. solanacearum* biovar '3', pathogenicity of which was proven on groundnut and tomato. Bacterial wilt appeared after five weeks of planting when the harvested seeds of infected accessions were sown in glass house, thus proving the seed transmission. The differences observed among accessions were highly significant with a probability value of <0.001. Further, the presence of the bacterium was noticed both in the cotyledonary portion as well as in the seed coat, but the differences observed in infection percentage were statistically non-significant. When the original imported seed of infected accessions was tested after a period of one year, all seeds showed the presence of same bacterium indicating its survival in the seed for more than one year.

Key words: Bacterial wilt, *Burkholderia solanacearum*, Groundnut, Australia

Introduction

Bacterial wilt [*Burkholderia solanacearum* (Yabuuchi *et al.*, 1992) =*Pseudomonas solanacearum* Smith] of groundnut (*Arachis hypogaea* L.) is an important disease reported to be a serious problem in several Asian countries (Mehan *et al.*, 1994). Despite its sporadic occurrence in Nagaland (Baleshwar Singh and Hussain, 1991) and Orissa (Dhal *et al.*, 1993), bacterial wilt of groundnut is still of quarantine significance to India because of existence of strains and biovars. Seed transmission of this bacterium in groundnut plays a significant role in the international exchange of groundnut germplasm. Recent detection of bacterial wilt in groundnut germplasm imported from Brazil, where its occurrence was not reported earlier, indicated that the pathogen is latent at the prevailing temperate conditions (Prasada Rao *et al.*, 2000).

Six of 93 accessions of groundnut imported from Australia showed symptoms of bacterial wilt in the Post Entry Quarantine Isolation field. The objective of the present study was to identify the pathogen and its biovar, to determine the infection percentage and location of bacterium in different parts of seed (cotyledonary tissue adjoining embryo, cotyledonary tissue away from embryo, seed coat adjoining embryo and seed coat away from embryo) and its significance in seed transmission.

Materials and methods

Isolation of the pathogen: The Tetrazolium Chloride Agar (TZCA) method described by Mehan (1995) was adopted for isolation of bacterium from wilted plants. Two stems were taken from each infected plant and were cut into 4cm long pieces. Each piece was given a vertical cut with sterile knife upto bottom and was transferred into a 10 *ml* sterile water blank and kept for 15min for bacterial oozing. Pieces from healthy plants were used as control. The same procedure was repeated thrice for confirmation. A loopful of bacterial suspension was streaked onto TZCA medium and the plates were incubated at 30°C for 72 hours.

On noticing bacterial wilt symptoms in the Post Entry Quarantine Isolation field, part of original seed sample of infected accessions was tested for the presence of bacterium by plating different portions of surface sterilized seed on Nutrient Agar plates.

Identification of the bacterium: Several biochemical tests were carried out with the help of *Neferm-* test kit for the identification of the bacterium. To determine the biovar, sorbitol test was adopted by using the modified medium (Hayward, 1995). Before inoculation, pH of the medium was adjusted to 7.0-7.1 (Olivaceous green colour)

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From the above results it is concluded that adoption of full package of practices gave the highest seed yield and proved more remunerative in terms of net return and benefit cost ratio. Among the various production constraints, plant protection was found most crucial followed by fertilizer. Thinning and weeding did not contribute more on yield of rainfed safflower in Bhal region of Gujarat.

Table 1 Effects of different treatments on seed yield (kg/ha) and economics of safflower

Treatments	Seed yield (kg/ha)				Gross income (Rs/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)	B:C ratio
	1996-97	1997-98	1998-99	Pooled				
T_1 : Full package	2167	1611	1550	1776	19536	5239	14297	3.73
T_2 : T_1-Fertilizer	1829	1160	1134	1374	15114	5030	10084	3.00
T_3 : T_1-Thinning	1702	1300	1253	1451	15961	4759	11202	3.35
T_4 : T_1-Plant protection	1524	822	1079	1141	12551	3999	8552	3.14
T_5 : T_1-Weeding	1725	1410	1413	1516	16676	4839	11837	3.45
T_6 : T_1-(Fertilizer + Plant protection)	1692	593	880	1055	11605	3790	7815	3.06
T_7 : T_1-(Weeding + Thinning)	1881	1248	1296	1475	16225	4359	11866	3.72
T_8 : Control (without fertilizer, plant protection, weeding, thinning	1238	378	763	793	8723	2910	5813	2.99
SEm±	137.7	52.5	32.6	81.3	-	-	-	-
CD (P=0.05)	417.6	159.4	98.8	246.7	-	-	-	-
CV (%)	13.9	8.5	4.8	11.4	-	-	-	-

	SEm±	CD (P=0.05)
Y x T	87.3	249.0

Price of safflower seed : Rs. 11/kg

Cost of inputs/operations (Rs/ha)

Fertilizer	:	209
Thinning	:	480
Plant protection	:	1240
Weed control	:	400

References

Anonymous. 1997. Executive summary, Annual Progress Report, Safflower, 1996-97. Directorate of Oilseeds Research, Rajendranagar, Hyderabad-500 030, AP, pp.3.

Reddy, P.S., Kiresur, V., Ramana Rao, S.V. and Ramanjaneyulu, G.V. 1997. Potentials of improve technologies in oilseeds (A feedback from frontline demonstrations, 1995-96), Directorate of Oilseeds Research, Hyderabad-500 030, AP., pp.57-63.

prevent further spread of this pathogen in the area, all affected entries were detained and incinerated.

Even after one year, when the original seed samples of infected accessions kept in cold storage (18±2°C) were plated on NA, all seeds tested expressed the presence of bacterial colonies in at least two portions of each seed. These colonies were once again isolated and identified as *B. solanacearum* based on the results of biochemical tests. This showed that the bacterium could survive in seed even after storing for more than one year. However, Zeng *et al.*(1994) could not prove the survival of *B. solanacearum* in groundnut seeds which were stored for one year.

It may be concluded that the geographical transportation of infected groundnut seeds may facilitate the transmission of bacterial wilt. He (1990) expressed that groundnut seeds and pods are suspected to be a potential source of inoculum and suggested that integrated management of this disease should include restriction of seed movement to avoid any possibility of spread of inoculum. There were several areas in the world, where the disease was recorded in the past but due to sparse information available now, the present status is not known. Hence, there is a need to test groundnut seed samples thoroughly for such diseases, especially when imported from reported areas before releasing to the indentors.

Table 1 Particulars of botanical wilt infection in different groundnut accessions grown in PEQIA of ICRISAT and infection of bacterial wilt at different locations

Accession No.	No. of plants	No. of plants with wilt symptoms	Infection (%)	No. of seeds tested for bacterial location (*in vitro*)	Bacterial growth +ve	Infection (%)	Cotyledonary tissue adjacent to embryo	Seed coat adjacent to embryo	Cotyledonary tissue away from embryo	Seed coat away from embryo
EC-452061	7	1	14.3	12	7	58.3	-0.088***	-0.789^NS^	-0.195**	-0.920^NS^
EC-452055	8	1	12.5	14	13	92.9	-0.158**	3.461**	-0.109***	6.13**
EC-452011	9	3	33.3	10	10	100.0	1.333^NS^	6.999**	2.448^NS^	8.54**
EC-452014	10	2	20.0	16	15	93.8	-0.429^NS^	5.727**	-0.351^NS^	11.76***
EC-452062	10	1	10.0	18	15	83.3	1.167^NS^	12.43***	1.130^NS^	23.00***
EC-452074	10	1	10.0	18	18	100.0	11.67**	5.307**	0.955^NS^	11.96***
Constant							3.0	0.3	3.7	0.2

** Significant; *** Highly significant; NS : Non-significant

Parameters for factors are differences compared with reference level ICGVSM-93535

References

Baleshwar Singh and Hussain, S. M. 1991. Bacterial wilt of groundnut- a new record for India. *Indian Phytopathology*, **44**: 369-370.

Dhal, N. K., Biswal, G. and Narain, A. 1993. Occurrence of bacterial wilt of groundnut in Orissa. *Indian Journal of Mycology and Plant Pathology*, **23**: 322.

Hayward, A. C. 1964. Characteristics of *Pseudomonas solanacearum*. *Journal of Applied Bacteriology*, **27**: 265-277.

Hayward, A. C. 1995. Phenotypic methods for differentiation of *Pseudomonas solanacearum*: Biovars and supplementary observations. In The Technical Manual NO. 1, Techniques for diagnosis of Pseudomonas solanacearum and for resistance screening against groundnut bacterial wilt", Ed. by Mehan V.K.and McDonald, D. ICRISAT. pp.27-33.

Hayward, A. C., El-Nashaar, H. M., Nydegger, U. and De Lindo, L. 1990. Variation in nitrate metabolism in biovars of *Pseudomonas solanacearum*. *Journal of Applied Bacteriology*, **69**: 269-280.

by dropwise addition of 40% Sodium hydroxide (NaOH) solution.

Hypersensitivity and pathogenicity tests: Hypersensitivity test was carried out with two-day old pure bacterial culture on 21-day old tobacco seedlings by injection-infiltration method. Plants injected with sterile water served as control.

Twenty five healthy seeds of TMV-2 groundnut cultivar, after pin-pricking the seed surface, were soaked in bacterial suspension ($1x10^9$ cells/ml) for 30 min and then sown in pots containing sterile soil for proving pathogenicity. Observations were recorded at weekly intervals for bacterial wilt symptoms. Pathogenicity test was also conducted on a local variety of tomato, a solanaceous host of the bacterium.

Location of wilt pathogen in different parts of the seed: To locate the bacterium in different parts of the seed, two seeds from each plant and all plants (5-9) in each accession based on the availability of seed were tested. The accession, ICGVSM 93535 was used as a constant (Susceptible check). Seeds were surface sterilized and each seed was cut into four pieces (Cotyledonary tissue adjoining embryo, Cotyledonary tissue away from embryo, Seed coat adjoining embryo and Seed coat away from embryo) with a sterilized blade. The pieces were plated on Nutrient Agar plates and incubated at 28-30°C. Seeds harvested from healthy accessions served as control. Observations on bacterial growth from cut ends of the seed were taken after 72 hours of incubation. Presence and absence of the bacterium were scored as one and zero, respectively. The data thus obtained were statistically analyzed by generalized linear regression analysis (Mc Cullagh and Nelder, 1989).

Results and discussion

Six groundnut accessions of 93 imported from Australia grown in the Post Entry Quarantine Isolation Area of International Crops Research Institute for Semi Arid Tropics (ICRISAT), expressed bacterial wilt symptoms. The first suspected wilt symptoms were observed during the flowering stage of crop when temperature was over 28°C. The symptoms included drooping or curling of terminal leaves in some or all branches followed by slight bending of the tip, drying, complete wilting and death of plants. When the stems from infected plants were tested for bacterial oozing, they showed positive results (milky appearance of water in test tubes). There was no change in test tubes with stem from healthy plants. Bacterial growth was seen when the suspension from positive reaction was streaked on TZCA plates. Colonies with pink centres and white borders on TZCA medium indicated the presence of *B. solanacearum*.

The bacterium from the infected plants, upon isolation and purification was found to be aerobic, rod-shaped and gram-negative. Based on the physiological and biochemical characteristics of the isolated bacterium, the identity was confirmed as *B. solanacearum*. The specific test conducted for oxidation of sorbitol (hexose alcohol) resulted in positive reaction. The pH of medium changed to 5.0 after 3rd day of inoculation, which was indicated by the colour change in medium from olivaceous green to yellow, indicating that this bacterium belongs to biovar '3'. The isolates of biovar '3' are more virulent to groundnut than the isolates of other biovars (Mehan *et al.*, 1994). Hayward *et al.*(1990) also reported that there were three biovars *viz.*, 1, 3 and 4 of race 1 that attack groundnut. These characteristics were similar to those listed by Hayward (1964) and He *et al.* (1983). The disease was previously reported on groundnut from Queensland in Australia (Mehan *et al.*, 1986), but information is sparse and the present status of this disease in Australia is not known. This is the first report on the interception of *B. solanacearum* from groundnut seed imported from Australia.

Hypersensitivity test resulted in positive reaction with brown necrotic patches within 24 hours and no such change was noticed in control plants. Pathogenicity of the bacterium was proven on tomato and groundnut when the seed treatment with the same bacterium resulted in wilting of tomato and groundnut.

Apparently, the infection varied from 10 to 33.3% among infected accessions as two out of six exhibited a minimum of 10% while a maximum of 33.3% was recorded in one accession, i.e., EC-452011. When seeds harvested from all plants of each infected accession (irrespective of presence / absence of symptoms) were tested on TZCA medium, the infection varied from 58.3%-100% (Table-1). When the presence of bacterium on different parts and accessions was compared against susceptible check (ICGVSM-93535), significant differences among accessions were observed. The cotyledonary portion of two accessions (EC-452061 and EC-452055) contained significantly less bacterium than the check in the cotyledonary portion while the seed coat of all accessions except EC-452061 carried more bacterium in relation to susceptible check. Machmud and Middleton (1991) also isolated *Pseudomonas solanacearum* from many parts of the pod, *viz.*, pod shell, seed coat and embryo.

To prove the seed transmitted nature of bacterium, the seeds harvested from infected accessions were sown in green house under sterile conditions. The seedlings exhibited bacterial wilt symptoms when they were of five week old and the infection varied from 20-60%. Machmud and Middleton (1991) provided further evidence of seed transmission of *Pseudomonas solanacearum* wherein the groundnut seedlings grown from seed obtained from infected plants in sterile soil wilted in 2-4 week at rates of 5-8%. Thus, this disease is of quarantine significance as the infected seed is likely to provide a primary source of inoculum in disease free areas (Mehan *et al.*, 1994). To

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Evaluation of groundnut cultivars for plant water status and productivity during rainy season Alfisol condition

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Abstract

Ten cultivars of groundnut, *Arachis hypogaea* (L.) were evaluated on Alfisols under rainfed situation and assessed for plant water content in terms of relative water content (RWC) and leaf water potential, dry matter production in relation to pod yields. During dry spell, local check TPT 1 consistently over years recorded high relative water content and high water potential values. Two other cultivars tested namely, K 134 and JL 24 produced maximum dry matter. Ancillary characters like, sound mature kernel % (SMK) showed positive significant correlation with yield.

Key words: Groundnut, RWC, water potential

Introduction

Groundnut (*Arachis hypogaea* L.) is cultivated over 2.35 m ha with a productivity of 2.55 m t in Andhra Pradesh. Five districts namely, Mahaboobnagar, Nalgonda, Ranga Reddy, parts of Warangal and Medak comprising the Southern Telangana zone, accounts for 11 % of groundnut area of the state. In this zone, groundnut is cultivated on Alfisols as rainfed crop, which suffers from mid and end of season drought. Instability in yields by abiotic stresses are common under tropical and subtropical areas (Talwar *et al.*, 2002). For improvement of yield under drought, study of plant characters that confer tolerance to moisture stress and identification of variability in physiological traits is critical (Reddy *et al.*, 2000). Leaf water potentials had shown a decrease under water stress in dry lands (Subramanian *et al.*, 1993). Changes in plant water status caused, yield differences among genotypes (Annerose, 1988). Drought tolerance efficiency was worked out in terms of physiological parameters by imposition of stress (Dhopte *et al.*, 1991) and under natural conditions (Chavan *et al.*, 1992). However, such studies on groundnut are meager. Therefore, the present study was conducted to find the changes in plant water content and dry matter production of groundnut cultivars with improved yields under rainfed situations.

Materials and methods

Ten cultivars of groundnut including six pre-released entries namely, TCGS No's 26, 29, 30, 37, 88, 91 along with four local checks TPT 1 and TMV 2 (recommended for rainfed situation), K 134 and JL 24 (recommended for irrigated situation) were selected from Tirupati and Kadiri Agricultural Research Stations. These cultivars were grown in a randomized block design with three replications on Alfisols in first week of June, 1994; 1995 and last week of May, 1996 *Kharif* under rainfed situation at Regional Agricultural Research Station, Palem, Mahaboobnagar. The soil type was silty clay loam with 27 % field capacity and 14 -16 % wilting point values. Net plot consisting of five rows each 4.8 m long were spaced 30 cm apart with 10 cm plant to plant distance. Fertilizer was applied at 30, 40 and 50 kg/ha N, P, K respectively. Gypsum at 500 kg / ha was incorporated into soil at 30 DAS. Adequate plant stands free from weeds and pests were maintained.

The crop experienced 27 day long dry spell from beginning of pod initiation to full seed development (65-92 DAS) in 1994, 16 days dry spell from beginning of peg initiation to beginning of pod development (34-50 DAS) in 1995 and 15 days long dry spell from full pod development to full seed development (70-85 DAS) in 1996. The crop growth stages experiencing drought were identified following Shantha Kumari *et al.* (1988). Total rainfall of 524 (40 rainy days), 712 (47 rainy days) and 785 mm (46 rainy days) was received during June to November for the three years of studies. For measuring water stress, soil samples were collected from 0-15 cm depth and soil moisture content was assessed gravimetrically. At weekly intervals the *effect of drought on crop growth was quantified by* measuring relative water content as per Barrs and Weatherley, (1962) and leaf water potential using PMS pressure chamber following Scholander *et al.* (1965). Five plants from each treatment at the time of harvest were sampled and oven dried at 80 °C till constant weight was achieved for estimation of total dry matter produced / plant. Yield and yield components namely SMK, hundred kernel weight and shelling percent were recorded and analyzed statistically.

He, L. Y. 1990. Control of bacterial wilt of groundnut in China with emphasis on cultural and biological methods. *ACIAR Proceedings series*, **31**: 22-25.

He, L. Y., Sequeira, L., and Kelman, A. 1983. Characteristics of strains of *Pseudomonas solanacearum* from China. *Plant Disease*, **67**: 1357-1361.

Machmud, M. and Middleton, K. J. 1991. Transmission of *Pseudomonas solanacearum* through groundnut seeds. *Bacterial Wilt Newsletter*, **7**: 4 –5.

Mc Cullagh,P. and Nelder, J.A. 1989. *Generalised Linear Models*, Second Edition, London, Chapman & Hall.pp.254.

Mehan, V. K. 1995. Isolation and identification of *Pseudomonas solanacearum*. In: The Technical Manual No: 1, *Techniques for diagnosis of Pseudomonas solanacearum and for resistance screening against groundnut bacterial wilt*. Published by ICRISAT, Patancheru, Andhra Pradesh, India. pp. 23-34.

Mehan, V. K., Liao, B. S., Tan, Y. J., Robinson-Smith, A., Mc Donald, D. and Hayward, A. C. 1994. Bacterial wilt of groundnut. In: Information Bulletin No: 35. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, A. P. 502 324, India, p.28.

Mehan, V. K., Mc Donald, D. and Subramanyam, P. 1986. Bacterial wilt of groundnut: Control with emphasis on host plant resistance. In: *Bacterial wilt disease in Asia and the South Pacific* (Ed. Persley, G.J.). ACIAR Proceedings No: 13. Canberra, Australia: Australian Centre for International Agricultural Research, pp.112-119.

Prasada Rao, R. D. V. J., Chakrabarty, S. K., Girish, A. G., Varaprasad, K. S. and Singh, S. D. 2000. Interception of bacterial wilt (*Pseudomonas solanacearum*) in groundnut imported from Brazil. *Indian Journal of Plant Protection*, **28**: 51-56.

Yabuuchi, E., Kosako, Y., Oyaizu, H., Yano, I., Hotta, H., Hashimoto, Y., Ezaki, T. and Arakawa, M. 1992. Proposal of *Burkholderia* gen. nov. and transfer of seven species of the genus *Pseudomonas* homology group II to the new genus, with the type species *Burkholderia cepacia* (Palleroni & Holmes, 1981) combnov. *Microbiology and Immunology*, **36:** 1251-1275.

Zeng, D. F., Tan, Y. J. and Xu, Z. Y. 1994. Survival of *Pseudomonas solanacearum* in peanut seeds. *Bacterial Wilt Newsletter*, **10**: 8-9.

Dry matter produced / plant in different genotypes showed significant variation over years (Table-2). K 134 and JL 24 produced maximum dry matter, being on par with TCGS 37 and TPT 1. Genotype x years interaction showed that K 134 and JL 24 to be superior. Dry matter production was found to have positive direct effect on pod yield (Arjunan *et al.*, 1992; 1999; Nautiyal *et al.*, 2002). However, stress resulted in a decrease in dry matter production by 61.8 % (Dhopte *et al.*, 1991) and pod yield (Ravindra *et al.*, 1990).

Pod yields recorded irrespective of the genotypes were on par during 1994 and 1995. However cultivars K 134 and TPT 1 were found the high yielders followed by TCGS 37. These results were in conformity with the previous findings of Ramesh and Prasad, (1996). Genotype x years interaction also revealed that K 134 followed by TPT 1, TCGS 37 and TCGS 91 were high yielding ones. Some of these high yielders also recorded superior ancillary characters (Table-2). Significant correlation (r=.785) existed between SMK with pod yield irrespective of genotypes.

It is concluded that, RWC and water potential can be used to identify drought tolerant cultivars, though, the water status values are subjected to sampling problems in lab situations (Kramer, 1983). The two cultivars namely K 134, which recorded maximum dry matter along with high yield, and TPT 1 the second top yielder which showed high RWC and high water potential values under stress are recommended for cultivation in rainfed areas.

Table 2 Drymatter production, yield and yield components of groundnut cultivars grown in rainfed Alfisols condition

Cultivar	Drymatter production (g/ha)				Sound mature kernel (%)	Test weight (g)	Shelling (%)	Pod yield (kg/ha)			
	1994	1995	1996	Mean				1994	1995	1996	Average
TCGS 26	6.7	6.5	5.1	6.1	83	29	54	1370	1594	1143	1369
TCGS 29	6.4	6.1	5.5	6.0	82	31	69	1552	1343	1065	1320
TCGS 30	7.3	5.8	5.5	6.2	66	35	71	886	1590	1002	1159
TCGS 37	8.5	7.4	7.6	7.8	77	36	65	1653	1606	925	1394
TCGS 88	7.1	6.8	6.2	6.6	76	30	60	1581	1317	938	1278
TCGS 91	7.8	7.6	7.1	7.5	76	27	65	1176	1658	1224	1352
TPT 1 (C)	9.1	8.8	8.4	8.8	89	24	65	1905	1655	1029	1529
JL 24 (C)	9.9	9.2	9.2	9.4	72	35	72	1643	1123	929	1231
K 134 (C)	10.2	9.8	9.8	9.9	83	35	70	2232	1539	1173	1648
TMV 2 (C)	8.5	7.2	8.1	7.9	77	24	67	1224	1465	1075	1254
Grand mean	8.1	7.5	7.2	7.6	78	31	66	1526	1486	1056	1356
SEm±	0.66	0.74	0.70		3.4	2.6	3.1	131	143	141	
CD (P=0.05)	1.38	1.55	1.42		7.4	5.6	6.5	283	236	232	

	SEm±	CD (P=-0.05)		SEm±	CD (P=0.05)
Cultivars	0.78	1.56	Cultivars	1.24	248
Years	0.48	0.97	Years	68	136
Cultivars x Years	1.53	3.96	Cultivars x Years	119	238

Results and discussion

The soil moisture content values during dry spell ranged from 6.5 to 14.7 % (Table-1). During *kharif* 1994, at the beginning of dry spell (at 70 DAS), RWC values ranged from 56 to 84 %. Local checks, namely, TPT 1, JL 24, K 134 and TMV 2 have recorded low RWC values (56-70%) as compared to other cultivars. During the dry spell, RWC of all cultivars declined (43-66% at 77 DAS and 38-59% at 84 DAS). Amongst the cultivars, TPT 1 recorded maximum RWC of 66 and 59 %, which was on par with TCGS 37 at 77 DAS and TCGS 91 at 84 DAS, respectively. Bennet *et al.* (1984), stated that, genotypes that maintain high plant water status during low soil moisture stress and ability to maintain developmental plasticity were partially responsible for drought tolerance. JL 24, maintained the minimum RWC (43 % at 77 DAS and 38 % at 84 DAS) during dry spell, which indicated its sensitive nature to drought. Joshi *et al.* (1998) also reported the drought sensitiveness of JL 24. The ability of groundnut genotypes to recover rapidly indicated their plasticity in adjusting to fluctuations to soil moisture status and the accompanying soil temperatures (Ravindra *et al.* 1990). On relief of water stress, in the present study, the groundnut cultivars recovered and recorded increased RWC values (60-76 % at 91 DAS and 70 to 85 % at 98 DAS). Four local checks excepting TPT 1 at 98 DAS recorded low RWC values as compared to TCGS entries.

During dry spell of *kharif* 1995, leaf water potential of various cultivars varied between -8 and -19 bars (Table-1). Four entries TPT 1, JL 24, TCGS 30 and TCGS 37 maintained high water potentials (- 8 to – 12 bars). During 1996 dry spell also, TCGS 37, TPT 1 along with TCGS 91 and TMV 2 have maintained high water potentials (-13 to -14 bars). The high water status of the cultivars during the dry spell indicated their ability to tolerate drought. The studies were in concurrence with Gautreau (1977) and Chavan *et al.* (1992).

Table 1 Soil moisture content in different plots from 15-30 cm depth, relative water content and leaf water potential values of groundnut cultivars in field condition

Cultivars	Soil moisture content (%) at the end of stress			Years							
				1994					1995	1996
				Relative water content (%)					Water potential (bars)	Water potential (bars)
				Before dry spell	During dry spell		After dry spell		During dry spell	During dry spell
	1994	1995	1996	70 DAS	77 DAS	84 DAS	91 DAS	98 DAS	45 DAS	85 DAS
TCGS 26	10.3	12.6	12.1	80	55	46	73	74	-19	-22
TCGS 29	10.9	11.1	9.3	75	45	47	71	76	-13	-23
TCGS 30	12.6	11.6	9.5	76	47	52	77	81	-12	-20
TCGS 37	11.6	11.7	9.4	74	60	51	76	77	-12	-14
TCGS 88	8.5	9.3	9.6	75	45	51	60	85	-16	-19
TCGS 91	9.6	9.5	9.4	84	54	56	72	81	-16	-13
TPT 1 (C)	10.7	12.4	10.7	70	66	59	74	70	-8	-13
JL 24 (C)	11.4	10.7	11.3	56	43	38	76	70	-12	-19
K 134 (C)	8.4	10.3	9.7	70	48	50	75	73	-13	-16
TMV 2 (C)	8.6	8.7	9.6	65	48	46	76	70	-13	-13
SEm±	1.99	2.24	1.79	3.1	3.4	3.7	3.7	3.4	2.6	2.3
CD (P=0.05)	4.18	4.71	3.78	6.6	7.2	7.3	7.4	7.2	5.4	4.8

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Genetic differentiation of growth parameters in *Brassica* species

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Abstract

Fourteen collections from the *Brassica* species, *B. juncea, B. napus, B. carinata* and *B. campestris* showed substantial variability for growth parameters including vegetative (VPD) and reproductive phase (RPD) duration. In general, seed yield in all maturity groups was associated with growth parameters, particularly, VPD, RPD and flowering phase duration. For example, high yielders in the early maturity group had 60-75 days of VPD and 38-40 days of RPD. In contrast, those in the late maturity group had more than 100 days of VPD and relatively short, but varying RPD of 25-50 days. In the medium maturity group, high yields were often found to be associated with relatively long RPD. The yields of *B. napus* and *B. carinata* could be improved by shortening total crop duration and increasing RPD. Selection for optimal vegetative phase durations in the progeny of inter-specific hybrids could further improve the yields in *Brassica*.

Key words: Vegetative and reproductive phase duration, *Brassica*

Introduction

Developing pure lines from interspecific crosses is gaining importance in breeding for improved yields in *Brassica*. The species that are in common use are *B. juncea, B. napus, B. carinata* and *B. campestris*. While *B. napus* and *B. carinata* are relatively new, the other two species have long been cultivated in India. The amphidiploid *B. juncea*, ranks over the diploid, *B. campestris* in yield (Rai, 1989). Therefore, most of the *B. campestris* tract is now grown to *B. juncea*.

Inter-specific hybridization is a common breeding technique to improve yields and based mostly on phenotypic divergence between parents. Concerted efforts are needed to understand major physiological differences between species *vi-a-vis* their realized yields in India. Such studies would identify novel criteria of selection of desired intra and interspecific variability. Potential biological efficiency (Tollenaar, 1983) is reportedly associated with increased absorption of incidental radiation and consequent increase in photosynthate availability (Crosbie, 1982). Further, optimal partitioning of photo-assimilates has been a known requisite behind improved yields in crops. In a way, it is reflected in various traits in the vegetative and reproductive stages of plant growth.

Unlike cereals, *Brassica* plants, despite being morphologically determinate, lack a distinct demarcation of vegetative and reproductive phases making it difficult to evaluate their role in yield differences between and within species. We attempted therefore a study of those growth phases in various species of *Brassica* in relation to their *yield variation*.

Materials and methods

Fourteen high yielding collections *viz*., TN 3, YN 3, RNBL-68 and Jap-nig of *B. juncea* (jn); ISN 706, BO 54, G 1286 and G 1237 of *B. napus* (np);p BCR 171 and *Carinata* 4B of *B. carinata* (cr) and Pusa Kalyani, KN 792, EC 223406 and EC 223048 of *B. campestris* (cm) were chosen for the study.

The others were collected from various sources and selected for phenotypic uniformity. The experiment was laid in a randomized block design with three replications at the Indian Agricultural Research Institute, New Delhi. Seeds were sown in plots of two rows of 5 m length with a spacing of 45 cm between rows and 15 cm between plants after thinning. Five plants were labelled at the seedling stage to record data. Days to first flowering (DFF), days to green pod stage (GPS, the stage when the pods became dark green and started constricting showing developing seeds inside) to be denoted as vegetative phase duration (VPD), days to last flowering (DLF) and days to maturity (DM) reckoned from the date of sowing and recorded for each labelled plant. The labeled plants were harvested and seed yield (SY)/plant (g) was recorded. The growth parameters, reproductive phase duration (RPD) = [DM-GPS] and flowering phase duration (FPD) = [DLF-DFF], were computed. The following method was employed to rank the performance of collections/species based on the

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References

Annerose, D. J. 1988. Physiological criteria for improving groundnut adaptation to drought. *Oleagineux,* **43** : 2117-222.

Arjunan, A., Manoharan, V. and Senthil, N. 1999. Path analysis of characters contributing to drought resistance in groundnut. *Madras Agricultural Journal,* **86** : 36-39.

Arjunan, A., Manoharan, V. and Thangavelu, S. 1992. Field screening for drought resistance in groundnut. *International Arachis News Letter,* **12** : 11-12.

Barrs, H. D. and Weatherley, P. E. 1962. A re-examination of the relative turgidity technique for estimation of water deficit in leaves. *Australian Journal of Biological Science,* **15** : 413-428.

Bennet, J. M., Boote, K. J. and Hammond, L. C. 1984. Relationship among water potential components, relative water content and stomatal resistance of field grown peanut leaves. *Peanut Science,* **11** : 31-35.

Chavan, A. A., Dhoble, M.V. and Khating, E. A. 1992. Effect of natural water stress on different genotypes of groundnut (*Arachis hypogaea*) in dryland. *Indian Journal of Agricultural Sciences,* **62** (6) : 376-381.

Dhopte, A. M., Ramteke, S. D. and Thote, S. G. 1991. Water use and drought tolerance efficiency of peanut genotypes in relation to canopy growth under field conditions. *Annals of Plant Physiology,* **5** (2) : 202-212.

Gautreau, J. 1977. Levels of intervariety leaf potentials and adaptation of the groundnut to drought in Senegal. *Oleagineux,* **32** : 323-332.

Joshi, Y. C., Nautiyal, P. C., Ravindra, V. and Snehi Dwivedi, R. 1988. Water relations in two cultivars of groundnut (*Arachis hypogaea* L.) under soil water deficit. *Tropical Agriculture,* **65** (2) : 182-184.

Kramer, P. J. 1983. *Water relations of plants.* Academic Press Inc, London , pp. 342-389.

Nautiyal, P. C, Ravindra, V. and Joshi, Y. C. 2002. Dry matter partitioning and water use efficiency under water deficit during various growth stages in groundnut. *Indian Journal of Plant Physiology,* **7** (2) (N. S.) : 135-139.

Ramesh Thatikunta and Durga Prasad, M. M. K. 1996. Identifying groundnut genotypes for the Southern Telangana zone in India. *International Arachis News Letter,* **16** : 19-20.

Ravindra, V., Nautiyal, P. C. and Joshi, Y. C. 1990. Physiological analysis of drought resistance and yield in groundnut (*Arachis hypogaea* L.). *Tropical Agriculture,* **67** (2) : 290-296.

Reddy, P.V., Asa Latha and Babitha, M. 2000. Relationship of mineral ash and chlorophyll content with transpiration efficiency in groundnut under different moisture regimes. *Indian Journal of Plant Physiology,* **5** (1) : 59-63.

Scholander, P. F., Hammel, H. T., Bradstreet, E. D. and Hemmingsem, E. A. 1965. Sap pressure in vascular plants. *Science,* **148** : 339-349.

Shantha Kumari, S. T., Gopal Singh, B. and Rao, L. M. 1988. Analysis of growth stages in groundnut genotypes (*Arachis hypogaea* L.). *Journal of Oilseeds Research,* **5** : 62-71.

Subramanian, B.V., Jayaramreddy, G. and Maheshwari, M. 1993. Photosynthesis and plant water status of irrigated and dryland cultivars of groundnut. *Indian Journal of Plant Physiology,* **36** (4) : 236-238.

Talwar, H. S., Chandra Sekhar, A. and Nageswara Rao, R. C. 2002. Genotypic variability in membrane thermostability in groundnut. *Indian Journal of Plant Physiology,* **7** (2) (New Series) : 97-102.

Table 1 Mean, range and CV growth parameters and yield in species of *Brassica*

Species		VPD	FPD	RPD	SY
B. juncea	Mean	86.8	57.5	57.3	26.4
	Range	75.7-96.0	41.0-73.0	51.7-60.3	16.6-30.9
	Coefficient variation	13.3	25.6	17.8	27.3
B. napus	Mean	110.3	49.9	46.7	20.5
	Range	108.7-110.0	46.7-54.7	43.3-50.3	13.8-26.7
	Coefficient variation	4.8	12.9	11.7	32.1
B. carinata	Mean	116.7	42.2	50.3	31.4
	Range	111.3-122.0	25.3-49.0	39.0-64.3	18.4-44.3
	Coefficient variation	7.1	23.4	28.9	47.6
B. campestris	Mean	75.0	50.7	62.7	16.8
	Range	63.0-92.0	38.7-57.0	52.7-72.0	9.1-35.4
	Coefficient variation	21.4	21.0	17.5	70.4

Table 2 Estimates of genetic variance for three growth parameters and yield in species of *Brassica*

Species	VPD	FPD	RPD	SY
B. juncea	200.3	541.1	100.8	130.2
B. napus	@	10.6	13.0	131.5
B. carinata	30.4	57.3	296.8	330.9
B. campestris	599.5	174.9	161.6	461.9

@ Negative estimate

Table 3 Mean values of three growth parameters and yield in 14 *Brassica* collections classified in three maturity groups

Collection	Species	DM	VPD	FPD	RPD	SY
Short duration (<135 days)						
KN 792	cm	124.7	63.0a	61.7ab	50.7a	9.1a
EC 223406	cm	135.0	63.0a	72.0b	38.7a	12.6a
YN 3	jn	128.0	75.7a	52.3a	41.0a	16.6
Mean		129.2	67.2	62.0	43.5	12.8
Medium duration (136-155 days)						
Pusa Kalyani	cm	144.7	92.0a	52.7ab	57.0a	10.1a
EC 223048	cm	146.3	82.0a	64.3ab	55.7a	35.4cd
TN 3	jn	147.7	96.0a	51.7a	52.3a	27.1c
RNBL 68N	jn	150.0	85.0a	65.0b	73.0ab	30.8c
Jap-nig	jn	151.0	90.7a	60.3ab	63.7a	30.9c
BO 54	np	154.0	108.7ab	44.0a	54.7a	26.7c
Car 4B	cr	150.3	111.3b	39.0a	49.0a	18.4b
Mean		149.1	95.1	53.8	57.9	25.6
Long duration (>155 days)						
ISN 706	np	159.0	110.0a	49.0a	46.7b	15.5a
G 1286	np	157.3	114.0a	43.3a	46.7b	13.8a
G 1237	np	159.0	108.7a	50.3a	51.7b	25.9b
BCR 171	cr	186.3	122.0a	64.3b	25.3a	44.3c
Mean		164.4	113.7	51.7	42.6	24.9
CD (P=0.05)			14.96	14.26	17.44	6.99

cm: *B. campestris*; jn = *B. juncea*; np = *B. napus*; cr = *B. carinata*
within columns, means followed by the same letter are not significantly different; DM = Days to maturity

four traits, VPD, FPD, RPD and SY. The six possible mean differences between the four species were first tested by a t-test. Taking the desired direction of a trait also into account, a significant difference in the desired direction was given a score +1, and in the undesired direction a score -1 and non-significant differences a score zero. An aggregate score is the total of the scores received by the possible comparisons of each species with the rest. The aggregate scores were arranged in descending order to provide a final ranking of the species/collections.

Results and discussion

There were distinct maturity differences between *B. juncea* and *B. campestris* on the one hand (140-145 days) and *B. napus* and *B. carinata* on the other (160-170 days) (Table-1). On the contrary, the mean reproductive phase spanned about 60 days (40-43 % of the total maturity) in the former compared to about 50 days (30-32 % of the total maturity) in the latter. But, this distinct difference was masked in seed yield. The results were, however, supported by the relatively shorter vegetative phase in jn and cm compared to np and cr. Associated differences in flowering phase were not distinct.

The variation between and within species for growth parameters and seed yield was significant. Such significant variation was observed in all the species except *B. napus* (which had significant variation for seed yield only). However, the variation within *B. carinata* based on only two collections, must be considered with caution. Genetic variances for growth parameters and seed yield were the lowest in *B. napus* (Table-2), moderate in *B. juncea* and *B. carinata* and highest in *B. campestris*. Low variance for vegetative phase duration was found accompanied by high variance for reproductive phase duration and vice-versa (Table-3). Taking into account the estimates of error variances, it would seem that heritability for the growth parameters, VPD, FPD and RPD was, in general, much lower in *B. napus* and *B. carinata* than in *B. juncea* and *B. campestris*.

The substantial intra-specific variability for the three parameters and SY (Table-3) made it possible to rank the collections in each species on a joint evaluation across them. RNBL 68, of 'jn', BO 54 of 'np', both *Carinata* 4B and BCR 171 of 'cr and EC 223406 of 'cm were ranked at the top. Likewise *B. carinata, B. campestris, B. juncea* and *B. napus* were ranked in that order (Table-4, details not shown), while the affinity of the cultivated species (in India) 'cm' and 'jn' was upheld, 'cr' appeared to have highest breeding potential than 'np' for the growth parameters. The collections were classified into short, medium and long maturity groups based on observed maturity of varieties in *Brassica* growing tracts in India. While, *B. campestris* and *B. juncea* collections were assigned into early or medium maturity groups, *B. carinata* and *B. napus* (except one collection in each) were classified in long duration groups (Table-3). Though, generalization on the basis of few collections tested is risky, it would appear that cultivated species in India have undergone intense selection for early maturity. Though, clear-cut differences were not visible in seed yield of the three maturity groups, high yield ranges appeared more frequently in medium than in other maturity groups. The highest yield of 44.3 g/plant of *B. carinata*, collection BCR 171 was found in long maturity group and the lowest of 9.1 g/plant of *B. campestris*, collection KN 792 in short maturity group.

In general, high yielders like YN 3 and EC 223406 in the short duration group were about 60-75 days of VPD and 38-40 days of RPD. Those in the medium duration group had 80-90 days of RPD and those in late maturity group had more than 100 days of VPD with relatively short and widely varying RPD (25-50 days).

In C_3 and C_4 crops, distinguishing features like rate of photosynthesis, rate and duration of grain development would suggest intra-specific and inter-specific differences for growth parameters such as those studied here. Differences in rate of drymatter accumulation were earlier reported in *Brassica* species. For instance, 85% of the total drymatter was accumulated after anthesis in *B. campestris* compared to 50% of *B. napus* (Thurling, 1974a). Thus, defining VPD and RPD in *Brassica* and discovering their relationships with seed yield in various species is a gainful exercise. Though, VPD and FPD overlap, it was found feasible to define a green pod stage and RPD. It was further observed that longer RPD was an advantage in realizing high yields in medium duration *B. campestris* and *B. juncea* (Table-4). In Indian conditions, *B. carinata* and *B. napus* are late maturing and their relatively high yields resulted from long VPD and short RPD. Such results were also reported in West Australian conditions (Thurling, 1974b; Thurling and Das, 1979).

The following results of this study are novel for breeding improved productivity: (a) four species of *Brassica* had fairly distinct differences in VPD, FPD and RPD; (b) at least, in medium duration collections, high yields were associated with relatively long RPD; (c) high yields in species like *B. carinata* and *B. napus*, yet to be cultivated in large scale in India, were still characterized by long VPD. Since genetic variation for VPD, RPD and FPD was substantial in those species (Table-2), it should theoretically be possible to improve yields of these species keeping total duration unchanged but by increasing RPD at the cost of VPD. One must be cautious about the threshold for VPD, reduction below which could affect LAI, LAD and photosynthesis; (d) in the context of increasing *Brassica* area grown to *B. napus* and *B. carinata*, the results of this study are gainful pointers to study yield increases as a function of VPD, FPD and RPD and employ strategies like direct selection or recombination breeding; (e) even in the sample of collections of four species studies here, substantial variability was observed.

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Manipulation of sex expression in castor, *Ricinus communis* L. by chemical treatments

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Abstract

Manipulation of sex expression by chemical means will be of great importance in parental line maintenance and also in quality hybrid seed production in castor. Keeping in view, four chemicals *viz.*, Gibberellic acid (GA_3), Silver Nitrate (Ag No_3), Urea and Ethrel were sprayed at 25 and 57 days after sowing on three pistillate lines of castor *viz.*, VP-1, DPC 9 and LRES-17. The total number of pistillate whorls upto tertiary spike order increased significantly with the application of GA_3 at 25 ppm and Ethrel at 200 ppm when compared to control. Further, total number of interspersed staminate flower (ISF) upto tertiary spike order were significantly increased with the application of GA_3 upto 100 ppm and $AgNO_3$ upto 100 ppm and urea 2% when compared to the control whereas, Ethrel sprayed at 200 ppm gave maximum number of pistillate whorls, while, $AgNO_3$ at 50 ppm gave maximum number of ISF when sprayed twice at 25 and 57 days after sowing which are the optimum doses towards production of pistillate flowers and ISF, respectively in castor.

Key words: Sex expression, GA_3, $AgNO_3$, Urea, Ethrel, pistillate whorls, ISF, castor

Introduction

Castor (*Ricinus communis* L.) is grown under varied climatic conditions including tropical, sub-tropical and temperate. India is one of the principal producer of castor by growing on an area of about 0.71 m.ha with a production of 0.85 MT. Andhra Pradesh is also one of the important producer of castor by cultivating on an area of 0.39 m.ha with a production of 0.13 MT (Damodaram and Hegde, 2002). The seed yield in castor is directly/indirectly influenced by several characters, of which sex expression i.e., male and female flowers in a spike is very much important.

Castor (*Ricinus communis* L.) pistillate lines are generally sown during summer to induce environmentally sensitive, temperature dependent (>32°C) interspersed staminate flower (ISF) character for their multiplication and maintenance through modified method of pistillate line multiplication (Ramachandram and Ranga Rao, 1988) while the hybrid seed production is taken up in winter at cooler temperatures. As the pistillate character in castor is polygenically controlled, highly unstable, depending on input management levels, time of planting, nutrition, age of the plant and other environmental factors, it can be reverted to monoecism at any stage during sequential development of racemes. Until now, the pistillate lines in castor are being maintained either by conventional method in which 20-25% monoecious plants are retained in the field in order to supply adequate pollen or by renovated method in which environmentally sensitive ISF are utilized in order to supply pollen to affect pollination. Even though, renovated method results in higher genetic purity, lesser cost of production when compared to conventional method, it has certain drawbacks namely excessive dependence on environmentally sensitive ISF, problems associated with desiccating winds which are restricting the usage of this system as a method of maintenance of pistillate lines during summer. In order to overcome the drawbacks of both the methods, the well directed manipulation of sex expression i.e., induction of ISF during maintenance of pistillate lines and supression of male flowers while taking up hybrid seed production will help enormously the maintenance of pistillate lines and hybrid seed production irrespective of season.

As per the available literature, it is known that plant growth regulators can alter sex expression in cucurbits (Yang *et al.*, 1985) and castor (Shifriss, 1961). Earlier studies suggest that an endogenous auxin-gibberellin balances/ determines the sex expression. Modification of the balance in favour of auxin is associated with femaleness (Galun, 1959), conversely, an increase in gibberellins is associated with maleness (Contliffe and Robinson, 1971).

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Table 4 Test of differences in mean values of three growth parameters and yield among four species of *Brassica*

Comparison	VPD	FPD	RPD	SY
jn-np	-23.5*	6.5	10.7*	5.9*
jn-cr	-29.8*	20.3*	5.7	-5.0*
jn-cm	11.8*	7.0	-5.3	9.6*
np-cr	-6.3	13.8	-5.0	-10.9*
np-cm	35.3*	0.4	-16.0*	3.7
cr-cm	41.7*	-13.4*	-11.0*	14.6*

* Significant at P=0.05

References

Crosbie, T.M. 1982. Changes in physiological traits associated with long-term breeding efforts to improve grain yield of maize. In: H.D. Loden and D. Vilkinson (eds.) *Proc. 37th Annu. Corn and Sorghum International Research Conference*, Chicago. IL. 5-9 Dec. American Seed Trade Association, Washington D.C., pp.206-223.

Rai, B. 1989. Brassicas. In: V.L. Chopra (ed.). *Plant Breeding - Theory and Practice.* Oxford and IBH Publishing Company Pvt. Limited, pp.159-170.

Thurling, N. 1974a. Morpho-physiological determinants of yield in rapeseed (*Brassica campestris* and *Brassica napus*). I. Growth and morphological characters. *Australian Journal of Agricultural Research*, **25** : 697-710.

Thurling, N. 1974b. Morpho-physiological determinants of yield in rapeseed (*Brassica campestris* and *Brassica napus*). II. Yield components. *Australian Journal of Agricultural Research*, **25** : 711-721.

Thurling, N. and Vijendra Das, L.D. 1979. Genetics control of the pre-anthesis development of spring rape (*Brassica napus* L.). I. Diallel analysis of variation in the field. *Australian Journal of Agricultural Research*, **30** : 251-259.

Tollenaar, M. 1983. Potential vegetative productivity in Canola. *Canadian Journal of Plant Science*, **63** : 1-10.

Table 3 Mean values for number of ISF in different order spikes of VP-1, DPC 9 and LRES-17 in different order spikes under different chemical treatments

Chemical treatment	Primary				Secondary				Tertiary			
	VP-1	*DPC-9*	*LRES-17*	*Mean*	*VP-1*	*DPC-9*	*LRES-17*	*Mean*	*VP-1*	*DPC-9*	*LRES-17*	*Mean*
GA_3 25ppm	10.0	10.3	9.0	**9.8**	31.0	36.0	32.7	**33.2**	74.0	63.3	46.0	**61.1**
GA_3 50ppm	8.7	5.0	3.0	**5.6**	118.3	106.0	97.7	**107.3**	46.0	37.0	25.0	**36.0**
GA_3 100ppm	23.5	20.8	18.9	**21.4**	60.7	51.0	41.7	**51.1**	15.0	11.0	7.7	**11.2**
GA_3 200ppm	0.0	0.0	0.0	**0.0**	6.0	3.0	2.0	**3.7**	2.0	1.0	0.0	**1.0**
$AgNo_3$ 25 ppm	0.0	0.0	0.0	**0.0**	12.0	9.0	6.0	**9.0**	60.0	54.3	38.0	**50.8**
$AgNo_3$ 50 ppm	60.3	58.3	50.0	**56.2**	150.0	140.3	123.7	**138.0**	90.0	87.7	61.0	**79.6**
$AgNo_3$ 100 ppm	10.0	6.7	5.0	**7.2**	19.0	15.7	12.0	**15.6**	68.3	59.3	36.3	**54.7**
$AgNo_3$ 200 ppm	0.0	0.0	0.0	**0.0**	8.0	5.3	3.3	**5.6**	2.0	1.0	0.0	**1.0**
Urea 1%	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**	8.0	5.0	3.1	**5.4**
Urea 2%	2.0	0.3	0.0	**0.8**	4.0	1.0	0.0	**1.7**	32.0	24.0	19.0	**25.0**
Urea 3%	1.0	0.0	0.0	**0.3**	2.0	0.3	0.0	**0.8**	9.7	8.0	6.0	**7.9**
Ethrel 100ppm	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**
Ethrel 200ppm	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**
Ethrel 300ppm	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**
Control	8.0	6.0	5.0	**6.3**	5.5	4.7	4.0	**4.7**	6.0	3.5	0.0	**3.2**
Mean	**8.2**	**7.2**	**6.1**	**7.2**	**27.8**	**24.8**	**21.5**	**24.7**	**27.5**	**23.7**	**16.1**	**22.5**
CD (P=0.05)												
Genotypes (F_1)				0.32				0.38				0.43
Treatments (F_2)				0.71				0.87				0.96
Interaction ($F_1 \times F_2$)				1.23				1.50				1.66

It can be concluded from the results that spraying of Ethrel upto 300 ppm will help to suppress male flowers (ISF) and inducing of female flowers production during hybrid seed production programmes, whereas, application of GA_3 and Ag No_3 upto 100 ppm, urea at 2% after 25 and 57 days after sowing can be utilized to induce ISF production to take up maintenance of pistillate parents without much environmental influence. Therefore the present study has come out with some valuable solutions of practical significance especially in the maintenance of pistillate lines and in hybrid seed production of castor where there is no stable system of hybrid seed production because of its high dependence on environmental conditions.

References

Contliffe, D. J. and Robinson, R. W. 1971. Response of cucumber to soil application of (2-chloroethyl) phosphonic acid. *Horticultural Science*, **6** : 336-337.

Damodaram, T. and Hegde, D. M. 2002. Oilseeds *Situation - A statistical compendium.* Directorate of Oilseeds Research (ICAR), Hyderabad, AP.

Galun, E. 1959. Effects of gibberellic acid and naphthaleneacetic acid on sex expression and some morphological characters in the cucumber plant. *Phyton*, 13 : 1-8.

Kumar, R., Dandin, S. B. and Ravindra, S. 1985. Modification of *sex expression* in mulberry (*Morus alba* L.) by silver nitrate. *Indian Journal of Experimental Biology*, **23**(5) : 288-289.

Lakshmamma, P., Lakshmi Prayaga and Lavanya, C. 2002. Physiological manipulation of sex expression in a pistillate line of castor. *Journal of Oilseeds Research*, **19**(1) : 104-106.

Ramachandram, M. and Ranga Rao, V. 1988. Maintenance and multiplication of *varieties and parental lines. (In) Seed production in castor*, Directorate of Oilseeds Research, Hyderabad, pp.39-45.

Ramesh, T., Reddy, D. V. V., Venkat Reddy, T. and Durga Prasad, M. M. K. 2001. Effect of Ethrel *on sex* expression and yield of castor (*Ricinus communis* L.). *Journal of Oilseeds Research*, **17**(2) : 279-281.

Shifriss, O. 1961. Gibberellin *as sex regulator* in *Ricinus communis*. *Science*, **133**:2061-2062.

Yang, Q., Ren, L. and Du, G. 1985. Effects of ethiphon, GA_3 and nutrient elements on expression of Chinese chestnut. *Scientia Horticulturae*, **26**(3) : 209-215.

Hence, an experiment was conducted to study the influence of exogenous application of chemicals *viz.*, GA_3, $AgNO_3$, Urea and Ethrel on sex expression in VP-1, DPC-9 and LRES-17 pistillate lines of castor during *kharif*, 2001.

Materials and methods

An experiment was conducted with three pistillate lines of castor *viz.*, VP-1, DPC-9 and LRES-17 obtained from Directorate of Oilseeds Research, Rajendranagar, Hyderabad at College Farm, College of Agriculture, Rajendranagar, Hyderabad. The material was sown during August, 2001 in RBD replicated thrice. The chemicals were sprayed on one row plots having 10 plants at a spacing of 90 x 60 cm. The following chemicals/ growth regulators were sprayed at 25 and 57 DAS (Table-1).

Table 1 Details of various chemicals and their concentrations

Chemical	Concentration
GA_3	25, 50, 100 and 200 ppm
$AgNO_3$	25, 50, 100 and 200 ppm
Urea	1%, 2% and 3%
Ethrel	100, 200 and 300 ppm

(Time of spray : 25 and 57 DAS)

Results and discussion

Total number of pistillate whorls were maximum with the application of GA_3 at 25 ppm and Ethrel at 200 ppm when compared to control (Table-2). The genotype, VP-1 recorded maximum average number of pistillate whorls in different order spikes over all the chemicals tested whereas the minimum was recorded by LRES-17 showing the significant genotypic differences in sex expression. Also the variation was at different spike orders. Primary spike recorded highest number of pistillate whorls compared to other order spikes irrespective of the genotypes. It is evident from the results that GA_3 and Ethrel are effective substances for increasing female tendency in the castor bean. These results are in consonance with the earlier findings of Shifriss (1961) and Ramesh *et al.* (2001).

The environmentally sensitive, interspersed staminate flower play a key role in the maintenance of pistillate lines. However, their expression during hybrid seed production, in the pistillate parents will result in more selfed plants resulting in failure of certified seed lots. Hence, the manipulation of the ISF through chemicals will be of great importance in order to maintain the quality of seed lots. The present experimental results showed that the application of Ag No_3 at 50 ppm recorded highest number of interspersed staminate flowers followed by GA_3 at 50 ppm (Table-3). At the same time, Ethrel suppressed the expression of ISF. Among the genotypes studied, VP-1 recorded maximum ISF followed by DPC-9 in all the treatments while the lowest was recorded in LRES 17. Also it was observed that secondary order spikes recorded maximum number of ISF irrespective of the genotype in all the treatments. From these results, it is evident that GA_3 and $AgNO_3$ both at 50 ppm and urea at 2% are potential chemicals when sprayed at 25 and 57 DAS in inducing ISF production in castor for effective maintenance of the pistillate lines. Similar response was noted by Kumar *et al.* (1985); Ramesh *et al.*, (2001) and Lakshmamma *et al.*, (2002).

Table 2 Mean values for number of pistillate whorls in different order spikes of VP-1, DPC 9 and LRES-17 under different chemical treatments

Treatment	Primary spike				Secondary spike				Tertiary spike			
	VP1	DPC 9	LRES-17	Mean	VP1	DPC 9	LRES-17	Mean	VP1	DPC 9	LRES-17	Mean
GA_3 25ppm	35.4	30.5	27.4	**31.1**	30.7	26.0	22.7	**26.5**	21.5	16.3	19.8	**19.2**
GA_3 50ppm	27.0	28.4	25.4	**26.9**	25.7	25.7	21.6	**24.3**	18.0	11.7	15.0	**14.9**
GA_3 100ppm	25.6	32.5	24.6	**27.6**	22.5	26.6	20.6	**23.3**	18.6	12.0	14.1	**14.9**
GA_3 200ppm	24.4	31.4	22.5	**26.1**	21.4	27.7	18.6	**22.6**	18.7	13.0	15.1	**15.6**
AgNo_3 25 ppm	26.6	27.2	23.2	**25.7**	22.0	22.0	20.8	**21.6**	18.0	12.0	15.0	**15.0**
AgNo_3 50 ppm	19.6	24.2	21.3	**21.7**	24.2	24.0	16.5	**21.6**	20.5	14.4	18.3	**17.7**
AgNo_3 100 ppm	26.4	22.6	21.4	**23.5**	21.7	21.4	18.8	**20.6**	19.2	16.0	16.5	**17.2**
AgNo_3 200 ppm	21.5	28.7	19.2	**23.1**	22.7	26.7	16.5	**21.9**	18.7	13.2	14.3	**15.4**
Urea 1%	21.0	25.4	16.2	**20.9**	25.4	19.3	11.4	**18.7**	22.8	18.2	13.0	**18.0**
Urea 2%	22.8	26.5	19.2	**22.8**	18.6	24.3	16.4	**19.8**	18.1	13.7	15.7	**15.8**
Urea 3%	15.8	22.5	12.5	**16.9**	22.5	21.5	9.8	**17.9**	18.8	15.5	8.7	**14.3**
Ethrel 100ppm	32.6	24.5	24.8	**27.3**	28.7	22.0	24.3	**25.0**	20.1	14.7	17.1	**17.2**
Ethrel 200ppm	36.5	30.2	29.7	**32.1**	30.9	27.7	26.7	**28.4**	21.7	16.0	18.1	**18.6**
Ethrel 300ppm	32.5	25.5	26.8	**28.3**	28.3	19.5	22.3	**23.4**	19.5	14.4	15.6	**16.5**
Control	30.0	22.5	22.5	**25.0**	27.0	19.1	20.0	**22.0**	19.6	14.0	16.1	**16.5**
Mean	**26.5**	**26.8**	**22.5**	**25.3**	**24.8**	**23.6**	**19.1**	**22.5**	**19.6**	**14.3**	**15.5**	**16.5**
CD (P=0.05)												
Genotypes (F_1)				0.43				0.38				0.38
Treatments (F_2)				0.96				0.86				0.85
Interaction (F_1 x F_2)				1.67				1.50				1.48

tolerant lines may not be used directly as variety, but may be used as parent in future breeding programmes.

In the present study the SB x SB crosses were found more heterotic for early flowering and pod weight/plant than VB x SB crosses. Such crosses may yield good recombinants, if the additive x additive type of epistasis is the main component of the heterosis. GG 2 x NRCG 2746 is having second higher negative heterosis for days to flowering and at the same time having heterosis for pod number and pod mass/plant. Hence this cross is expected to produce maximum range of segregants for days to flowering, pod number and pod mass in segregating generations upon which breeders can profitably make selection for early maturing and pod yielding segregants. The cross PBS 197 x NRCG 7453 is likely to produce desirable variation in days to flowering in segregating generations. Heterosis for pods/plant and pod mass/plant of this cross is significant and quit high (45.3% heterosis and 36.5 % heterobeltiosis). Hence, predicting selection in segregants of this cross is likely to end up with high yield and early maturing in Virginia types.

Table 1 Heterosis (in percentage) over better parent (H_1) and mid parent (H_2) for different traits in groundnut

Crosses	Days to first flower		Plant height		No. of nodes on main stem		Primary branches/plant		No. of pods/plant		Pod mass/plant	
	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2	H_1	H_2
INTRA-SPECIFIC CROSSES												
SPANISH x SPANISH												
GG 2 x ICG 4074	-8.3*	-17.0*	9.4	-4.1	-30.0*	-19.8*	0.0	2.0	8.0	15.9*	28.2*	29.3*
GG 2 x NRCG 2746	-8.3*	-13.7*	-0.5	-9.6*	-3.4	1.8	-21.9*	-10.7*	-14.5*	30.0*	21.2*	95.0*
Girnar 1 x NRCG 2746	7.4*	1.8	32.4*	17.2*	39.4*	51.0*	13.6	22.0*	-51.0*	-27.5*	-30.4*	-2.0
Girnar 1 x ICGS 11	0.0	-3.9*	-4.8	-12.4*	-41.2*	-26.7*	-17.3*	-10.4*	-19.1*	-19.1*	-12.8*	-8.2
Girnar 1 x GG 2	0.0	-8.3*	23.3*	15.6*	-20.6*	0.3	6.5	8.9*	-1.2	8.8	7.9	27.3*
PBS 8 x NRCG 7453	0.0	-3.9*	14.6	11.7*	42.2*	54.3*	2.4	4.9	4.3	12.3	43.0*	50.2*
JL 24 x ICG 4833	3.9	1.9	27.2*	14.0*	26.3*	29.7*	18.2	15.6*	71.4*	68.4*	17.4*	45.1*
VIRGINA x SPANISH												
GG 20 x Chico	21.7*	7.7*	49.1*	4.3	23.5*	38.5*	-6.3	21.6*	-30.6*	-5.7	-54.3*	-14.8
M 13 x Chico	17.4*	8.0*	98.7*	33.6*	70.0*	96.2*	0.0	28.2*	40.0*	48.9*	48.8*	79.1*
Somnath x Chico	8.7*	4.2*	86.4*	7.9	31.0*	59.4*	5.9	16.1*	3.7	16.7*	13.6*	56.6*
HNG(HPS)2 x PI 337409	3.7	-1.8	52.7*	36.1*	33.3*	37.9*	1.9	10.4*	2.2	27.0*	-34.3*	0.5
ICGV 89235 x PI 337409	7.7*	3.7*	28.4*	25.8*	42.9*	51.5*	12.5*	17.4*	-15.4*	0.0	-59.0*	-53.8*
Kadiri 3 x NCAc 17090	0.0	-3.6*	24.6*	20.8*	44.7*	48.7*	2.2	2.2	11.4	59.2*	8.0	55.5*
Kadiri 3 x PBS 105	24.0*	8.8*	*21.7*	1.2	2.1	19.5*	0.0	11.1*	0.0	24.6*	12.2*	34.9*
ICGV 88473 x J 11	8.0*	5.9*	2.0	-13.3*	-9.9	-1.2	15.2*	23.3*	2.4	34.4*	-33.3*	-13.6
PBS 197 x NRCG 7453	-3.7	-7.1*	62.3*	32.5*	38.5*	69.4*	0.0	9.1*	25.3*	36.5*	20.0*	45.3*
INTER-SPECIFIC CROSSES												
GG 2 x *A. monticola*	-4.2	-9.8*	-18.6*	-49.6*	-40.3*	-26.8*	-43.9*	-35.1*	-2.6	51.0*	-35.9*	4.11
JL 24 x *A. monticola*	0.0	-1.9	21.9*	-26.7*	-41.5*	-21.1*	-34.9*	-23.2*	-41.4*	-2.9	-62.0*	-29.1*

* Significant at 0.05%

References

Arunachalam, V. 1977. Heterosis for characters governed by two genes. *Journal of Genetics*, 63: 15-24.

Arunachalam, V., Bandyopadhyay, A., Nigam, S.N., and Gibbons, R.W. 1982. Heterotic potential of single crosses in groundnut (*Arachis hypogaea* L.). *Oleagineux*, **37**: 415-420.

Arunachalam, V., Bandyopadhyay, A., Nigam, S.N., and Gibbons, R.W. 1984. Heterosis in relation to genetic divergence and specific combining ability in groundnut (*Arachis hypogaea* L.). *Euphytica*, **33**: 33-39.

Durga Prasad, M.M.K., Arunachalam, V. and Bandyopadhyay, A. 1985. Diversity pattern elucidating choice of parents for hybridization in varieties of groundnut (*Arachis hypogaea* L.). *Tropical Agriculture*, **62**: 237-242.

Joshi, Y.C., Nautiyal, P.C. and Ravindra, V. 1996. Screening for cold tolerance and osmoconditioning to enhance germination of groundnut in sub-optimal temperatures. *Tropical Science*, **36:** 224-228.

Krapovickas, A. and Gregory, W.C. 1994. Taxonomia del genero Arachis (Leguminosae). *Bonplandia*, 8:1-18.

Reddy, P.S. 1988. Genetics, breeding and varieties *In: Groundnut* (Ed. P.S. Reddy). Indian Council of Agricultural Research, New Delhi. pp. 200-317.

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Short communication

Heterotic potential of crosses in groundnut, *Arachis hypogaea* L.

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Exploitation of hybrid vigour in crop plants for quantum jump in yield and other quantitative characters is one of the approaches in crop improvement to cope up with the ever increasing demand for food grains and oil production. The approach is of direct interest for developing hybrids in cross-pollinated crops. There is no practical means of utilizing this heterosis, at present in groundnut because of difficulty in obtaining true F_1 hybrid seeds. However, this heterosis can be used to assess the worthiness of cross combinations for obtaining superior recombinants in later segregating generations if additive x additive epistasis is involved (Araunachalam *et al.*, 1982). Taxonomically the cultivated groundnut may be divided in to two sub species with few varietal groups (Krapovickas and Gregory, 1994)

Arachis hypogaea

subsp. *hypogaea* var. *hypogaea* (Virginia) and var. *hirsuta* (Virginia)

subsp. *fastigiata* var. *fastigiata* (Valencia) var. *vulgaris* (Spanish)

var. *peruviana*

var. *aequatoriana*

The Virginia types are generally late maturing than the Spanish types but are more productive than the later (Reddy, 1988). Hence development of early maturing high yielding varieties would be suitable for fit in different cropping systems and avoid losses by sprouting of seeds when caught in the end season rains due to lack of fresh seed dormancy in *rabi*/summer groundnut. The present study reports the results of 18 crosses in their F_1 generation for six quantitative traits.

Eighteen crosses including 16 intra- and two inter-specific crosses were effected at National Research Centre for Groundnut, Junagadh. The parents and crosses were evaluated in *kharif*, 96 in a randomized complete block design replicated thrice. Each entry consisted of three rows of 3 m length maintaining inter- and intra- row spacing at 60 cm and 10 cm, respectively. Observations were recorded on various traits on five competitive random plants (Table-1). Average heterosis was worked out as the percent deviation of the cross from its mid-parental value (average heterosis) and from the better parent (Heterobeltiosis).

The degree of heterosis varied from cross to cross for all the characters studied. Three characters *viz.*, number of nodes, number of pods and pod mass/plant had high degree of heterosis (Table-1). The range of heterosis was from -17.0 to 8.8% for days to first flower and from -53.8 to 95.5% for pod mass/plant. The Spanish bunch (SB) x Spanish bunch (SB) crosses were more heterotic for early flowering and pod mass/plant. For pod mass/plant, five crosses out of seven in the SB x SB group and five out of nine in the Virginia bunch (VB) x SB group were heterotic. VB x SB crosses showed high degree of heterosis for number of pods, number of branches, number of nodes, and plant height. In the crosses where Girnar1 was used as a female parent, both positive and negative heterosis were observed. This could be due to the divergence for different traits and the presence of interaction effects (Arunachalam *et al.*, 1984).

To incorporate earliness in Virginia the Spanish bunch gene system could be introgressed into the Virginia system. On this line, PBS 197 x NRCG 7453 had significantly higher heterosis for pod number, pod weight and days to first flower. Hence, selection in the segregating generations of this cross is likely to end up with obtaining superior Virginia recombinants for yield and early flowering if the nature of gene action is additive and additive x additive interactions are involved.

The crosses GG 2 x NRCG 2746, JL 24 x ICG 4833, PBS 8 x NRCG 7453 were highly heterotic for early flowering and pod yield. Hence these crosses may yield better trangressive segregants in later generations, if their heterosis was the result of additive x additive epistasis (Arunachalam, 1977; Durga Prasad *et al.*,1985). VB x VB crosses were more heterobeltiotic than SB x SB crosses for late flowering, plant height and number of primary branches.

The use of *A. monticola* in crossing programme may not be helpful for obtaining yield promising recombinants (as the heterosis for this character is negative), but other desirable characters like cold tolerance (Joshi *et al.*, 1996) could be transferred to cultivated forms as an intermediate step to breed high yielding cold tolerant varieties. In this line GG 2 x *A. monticola* may yield early flowering and high pod bearing characters of GG 2 with cold tolerance character of *A. monticola*. It is likely that so developed cold

Table 1 Mean, range and coefficient of variation (CV) for different characters in 3 F_2 populations

Character	Parameter								
	Cross-I			Cross-II			Cross-III		
	Mean	Range	CV	Mean	Range	CV	Mean	Range	CV
Main shoot length (cm)	43.8	14.3-66.0	45.2	49.3	26.0-90.0	29.7	47.8	22.0-88.0	25.5
Siliquae on main shoot	33.7	12.0-48.0	58.3	32.2	16.0-53.0	24.5	34.6	13.0-60.0	23.7
Siliqua length (cm)	4.4	3.0-6.0	13.1	4.0	2.9-5.0	13.0	4.1	3.2-5.3	10.8
Seeds/siliqua	11.5	2.7-17.3	91.5	12.6	5.0-16.2	65.0	13.2	9.0-18.3	12.3
200-seed weight (g)	0.6	0.3-0.9	19.7	0.7	0.3-1.0	19.8	0.8	0.4-1.1	19.4
Yield/plant (g)	5.1	1.4-14.1	63.1	3.8	1.4-14.1	78.0	6.0	1.8-30.9	79.3

Table 2 Correlation coefficient between different characters in F_2 generation of Indian mustard

Character	Cross	Main shoot length	Siliquae on main shoot	Siliqua length	Seeds/ siliqua	Seed weight
Siliquae on main shoot	I	0.63**				
	II	0.73**				
	III	0.74**				
Siliqua length	I	0.29**	0.16*			
	II	0.52**	0.28**			
	III	0.22**	0.06			
Seeds/siliqua	I	0.22**	0.17*	0.47**		
	II	0.00	-0.03*	0.27**		
	III	0.22*	0.23*	0.01		
Seed weight	I	0.15*	0.02	0.14*	0.04	
	II	0.17*	0.10	0.19*	0.02	
	III	0.15	0.11	0.29**	-0.13	
Yield/plant	I	0.48**	0.47**	0.30**	0.19**	0.32**
	II	0.52**	0.52**	0.41**	0.31**	0.38**
	III	0.46**	0.44**	0.12	0.43**	0.22*

References

Dubey, O.P. and Khan, R.A. 1996. Correlation between growth, quality characters and seed yield of mustard. *Journal of Oilseeds Research*, **13** : 235-238.

Singh, H.G. and Chauhan, Y.S. 1984. Factors-limiting rapeseed-mustard population in north-eastern part of India. In : Jaiswal, P.L. and Gupta, R.S. (Ed) *Research and Development Strategies for Oilseed Production in India*, pp.17-84, ICAR, New Delhi.

Sneep, J. 1976. Selection for yield in early generation of self-fertilizing crops. *Euphytica*, **26** : 27-30.

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Short communication

Variability and character association in segregating generation of mustard

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Rapeseed-mustard occupies second position after groundnut in the production of oilseeds in India. Mustard [*Brassica juncea* (L) Czern & Coss] is the major crop of this group. Though substantial increase in the production of mustard has been achieved after the inception of Technology Mission on Oilseeds and Pulses (TMOP), however, the crop suffers from low productivity due to narrow genetic base. F_2 generation provides an active breeding material for selection of desirable plants. Sneep (1976) has advocated the selection from F_2 generation itself because erosion of the variability occurs in the subsequent generations as a result of selfing. The present investigation was undertaken to estimate the extent of variability in F_2 generation for yield and its contributing traits and to estimate the inter-relationship between the different characters.

F_2 population of three crosses *viz.*, QM 14 x Bio 902 (population 1), PBCM 11565 x Varuna (population 2) and NRC 3 x Pusa bold (population 3) were raised in three adjoining plots keeping 30 cm row to row and 10 cm plant to plant spacings in the year 1997-98 at NRCRM, Bharatpur. All the recommended agronomic practices of irrigated ecology were followed to raise the crop. At the time of maturity, individual plants were harvested to record the observations and only competitive plants from each F_2 population were selected for recording the observations to minimize the environmental effects on yield parameters (Table-1). Observations were recorded on 214 plants from F_2 population of QM 14 x Bio 902, 140 plants from PBCM-11565 x Varuna and 96 plants from NRC 3 x Pusa bold. Data on individual plants were subjected for statistical analysis to estimate the variability and character association in each F_2 population.

Among all the characters studied, high variability was recorded for yield/plant irrespective of the crosses and among the crosses, maximum variability for yield/plant was reflected in the F_2 of cross NRC 3 x Pusa bold (Table-1). Variability for seed weight was almost equal in all the three crosses. Lowest variability was recorded for siliqua length in all three F_2 populations. However, variation for seeds/siliqua which is often considered as proportionate to siliqua length, was high and varied in each cross, being highest in the population QM 14 x Bio 902 and lowest in NRC 3 x Pusa bold. It suggests that during the selection emphasis should be given to seeds/siliqua instead of length. Singh and Chauhan (1984) have also advocated seeds/siliqua as the key character for higher seed yield. Variability for the remaining characters i.e., for main shoot length and siliquae on main shoot was though adequate, it varied from cross to cross. Among the crosses, QM 14 x Bio 902 exhibited maximum variability for most of the characters.

Yield/plant had positive and significant correlation with all the characters studied, in all three F_2 populations except with siliqua length in population NRC 3 x Pusa bold (Table-2). These findings have conformity with the previous findings of Dubey and Khan (1996). In this population correlation between siliqua length and seeds/siliqua was also non-significant. It means that long siliqua is not necessarily an indication of more seeds/siliqua; therefore, selection should be based on seeds/siliqua for high yield. Main shoot length had positive and significant correlation with all the characters in all three populations except with seeds/siliqua in PBCM 11565 x Varuna and with seed weight in NRC 3 x Pusa bold. Correlation of siliqua on main shoot and other characters varied between population to population. It showed positive and significant association with siliqua length and seeds/siliqua in QM 14 x Bio 902 with siliqua length in PBCM 11565 x Varuna and with seeds/siliqua in NRC 3 x Pusa bold. Positive and significant correlation between siliquae on main shoot and seeds/siliqua in two population made it possible to select the genotypes having more siliqua with more seeds/siliqua. Seed weight had positive and significant correlation with siliqua length in all three F_2 populations but correlations between seed weight and seeds/siliqua were non-significant. It revealed that a genotype having more siliquae on main-shoot with more number of seeds/siliqua with bold seeds, is a rare combination. On the other hand, long siliqua bears the bold seeds, therefore, selection on the basis of long siliqua with more seeds/siliqua should be emphasized for selecting high yielding genotypes in F_2 generation. Since, the variability for seeds/siliqua was highest in population QM 14 x Bio 902, such genotypes may be selected from this population.

Table 1 General and specific combining ability effects for seed quality characters of sunflower

Parent & Crosse	Unaged seeds						Aged seeds				
	100-seed weight (g)	Germination (%)	Root length (cm)	Shoot length (cm)	Drymatter (mg)	Vigour index	Germination (%)	Root length (cm)	Shoot length (cm)	Drymatter (mg)	Vigour index
CMS 7-1A	-0.25	0.49	-0.17	-0.79**	-0.11**	-31.76	2.72**	0.19**	-1.11**	-0.28	-4.68
CMS 86A	-0.56	-16.50**	-1.20**	-1.40**	-3.50**	-914.73**	-9.19**	-2.33**	-2.29**	-3.20**	-613.74**
CMS 234A	-0.68**	11.09**	-0.61**	-0.71**	-0.68*	298.11**	0.04	-0.80**	0.54**	-2.93**	-103.37**
CMS 290A	1.50**	4.91**	1.93**	2.90**	5.29**	648.39**	7.03**	2.94**	3.94**	6.42**	721.79**
6D-1	-0.20**	-1.79**	0.24	-0.13	0.27	-36.95	-0.26	0.59*	0.33	-0.21	67.82*
RHA 83-R6	-0.57**	-4.14**	-0.45	-0.24	-3.01**	-239.39**	-5.55**	-0.32	-0.78**	-2.01**	-294.87**
RHA 265	-0.40**	-1.73*	0.23	-0.51	-0.27	-130.45	-1.28*	-0.59*	0.62*	0.20	-35.68
RHA 271	0.63**	2.35**	0.48	0.70**	3.28**	163.73**	3.67**	0.73**	-0.02	1.43**	254.69**
RHA 272	-0.04	-1.95**	0.21	-0.70**	1.31**	-91.45**	-1.09*	-1.85**	-1.70**	-0.73	-263.37**
RHA 274	0.11*	2.39**	-0.09	0.25	0.04	101.55*	4.44**	1.34**	0.59*	1.45**	264.69**
RHA 859	0.08	1.98**	-0.66*	-0.29	-0.77	20.98	1.10*	-0.75**	-0.17	-0.10	-33.62
RHA 3376	0.38**	2.89**	0.03	0.92**	-0.85	211.98**	-1.04*	0.85**	1.13**	-0.02	40.32
7-1A x 6D-1	-0.97**	-0.78	-1.19*	-0.28	-4.47**	-160.73	-2.59*	-1.77**	-1.65**	-3.28**	-323.51**
71-A x R 83-R6	0.26**	-1.33	1.27*	1.65**	-2.34**	190.95*	0.95	1.37*	-1.06*	-1.92*	71.93
7-1A x R 265	0.57**	-9.83**	-1.43**	1.55**	5.88**	-395.98**	-5.20**	0.06	-0.18	-0.08	-215.26**
7-1A x R 271	0.30**	4.63**	0.50	-2.45**	7.19**	37.33	2.78**	-0.61	-1.10*	4.92**	-97.63
7-1A x R 272	0.45**	6.00**	2.16**	2.01**	-4.08**	594.26**	0.77	1.58**	3.34**	-0.64	344.43**
7-1A x R 274	-0.98**	1.81	-3.16**	-2.21**	-1.77*	-380.23**	1.34	-2.69**	0.62	0.40	-62.18
7-1A x R 859	0.32**	-1.94	2.10**	-0.12	1.14	90.83	2.42*	1.95**	0.26	-0.60	258.93**
7-1A x R 3376	0.05	1.44	-0.25	-0.14	-1.56	23.58	-0.48	0.10	-0.23	1.21	23.24
86A x 6D-1	-0.44**	1.14	-1.46**	-1.60**	-0.78	184.51*	-5.79**	-2.34**	0.32	-0.74	-340.19**
86A x R 83-R6	-0.10	-0.10	-0.63	-0.71	3.58**	-103.33	2.35	-1.13*	-0.77	3.80**	33.49
86A x R 265	0.05	4.89**	3.27**	0.90	0.06	515.45**	-1.06	0.59	-1.30**	1.48	-109.44
86A x R 271	-0.16	-12.23**	-2.23**	-0.22	-3.76**	-748.70**	-13.96**	-2.07**	-2.62**	-3.65**	-729.82**
86A x R272	0.08	-8.21**	-0.75	-3.76**	3.36**	-655.01**	1.95	-0.37	-1.82**	2.87**	-10.76
86A x R274	0.37**	2.41	1.29**	2.73**	-1.03	395.23**	3.91*	0.54	0.96	-1.13	170.93**
86A x R859	0.15	8.34**	-0.71	1.66**	-1.16	465.80**	7.39**	3.18**	3.45**	-0.94	611.24**
86A x R 3376	0.05	3.76**	1.19*	1.00	-0.26	315.05**	5.21**	1.60**	1.79**	-1.68*	374.55**
234A x 6D-1	0.70**	3.15**	2.03**	2.46**	4.70**	517.39**	8.27**	3.14**	2.80**	4.76**	709.68**
234A x R83-R6	0.21*	4.44**	-1.35**	0.14	-2.25*	68.83	-0.97	-0.82	0.91	-0.70	-29.38
234A x R 265	-0.18	1.03	-2.00**	-2.37**	-3.54**	-331.61**	0.09	-1.23*	-0.22	-0.82	-116.32
234A x R271	-0.21*	0.52	0.77	1.50**	0.93	240.45**	5.49**	0.94	1.06*	-0.52	251.05**
234A x R272	-0.35**	3.42*	0.20	1.32*	1.44	227.14**	-2.71**	-0.66	0.25	-1.64*	-125.88**
234A x R274	-0.25**	-2.75	1.20*	-0.79	4.02**	-61.36	-2.67**	1.79**	-0.64	1.55	-26.94
234A x R859	-0.63**	-3.65**	-1.18*	-2.73**	-2.93**	-519.80**	-5.91**	-3.76**	-4.26**	-0.36	-643.63**
234A x R3376	0.21*	-6.16**	0.32	0.45	-0.52	-141.05	-1.59	0.61	0.11	-2.28**	-18.57
290A x 6D-1	0.71**	-3.52*	0.62	-0.59	0.55	-172.14*	0.11	0.97	-1.46**	-0.74	-45.98
290A x R83-R6	-0.38**	-3.01*	0.71	-1.08*	1.01	-156.45	-2.33**	0.59	0.92	-1.18	-76.04
290A x R265	-0.44**	3.91**	0.16	-0.08	-2.40	212.11*	6.17**	0.57	1.70**	-0.58	441.02**
290A x R271	0.07	7.07**	0.96	1.17	-2.50	470.92**	5.68**	1.74**	2.66**	-0.74	576.40**
290A x R272	-0.17	-1.20	-1.64**	0.43	-0.72	-166.39**	-0.01	-0.55	-1.77**	-0.59	-207.79**
290A x R274	0.35**	-1.47	0.66	0.27	-1.22	46.36	-2.57*	0.35	-0.94	-0.82	-81.85
290A x R859	0.16	-2.74	-0.21	1.18*	2.95**	-36.83	-3.91*	-1.36*	0.54	1.90*	-226.54**
290A x R3376	-0.31**	0.97	-1.26*	-1.30*	2.34**	-197.57*	-3.14**	-2.31**	-1.66*	2.75**	-379.23**
SE (gi) lines	0.04	0.49	0.18	0.19	0.30	28.67	0.35	0.19	0.17	0.29	22.31
SE (gj) testers	0.05	0.70	0.26	0.26	0.43	40.54	0.50	0.27	0.24	0.40	31.55
SE (Sij) hybrids	0.10	1.40	0.52	0.53	0.86	81.09	1.00	0.55	0.49	0.81	63.10

References

Abdul-Baki, A.A. and Anderson, J.D. 1973. Vigour determination in soybean seed by multiple criteria. *Crop Science*, **13** : 630-633.

Arunachalam, V. 1974. The fallacy behind the use of modified line x tester design. *Indian Journal of Genetics*, **34** : 280-287.

Delouche, J.C. and Baskin, C.C. 1973. Accelerated ageing techniques for predicting the relative storability of seed lots. *Seed Science and Technology*, **1** : 427-452.

Giriraj, K., Sivaraju, N., Shantha, R.H. and Prasad, T.G. 1987. Bioproductivity and its relationship to yield attributes and seed yield in inbreds, hybrids and populations of sunflower. *Journal of Oilseeds Research*, **4** : 35-40.

Kempthorne, O. 1957. In: *An Introduction to Genetic Statistics.* John Wiley & Sons, Inc., New York, USA, pp.458-471.

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Short communication

General and specific combining ability for seed quality traits in sunflower

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Identification of superior parental lines and their hybrid combinations for enhanced economic value shall pave the way for exploration of commercial oil yield on per hectare basis. Therefore, the present endeavour on combining ability analysis in sunflower was carried out.

Material consisted of four cytoplasmic genic male sterile lines (CMS 7-1A, CMS 86A, CMS 234A and CMS 290A) as lines and eight fertility restoring genetic accessions of sunflower inbreds (6D-1, RHA 83-R6, RHA 265, RHA 271, RHA 272, RHA 274, RHA 859 and RHA 3376) as testers. The parents were crossed in 32 possible combinations at Tamil Nadu Agricultural University, Coimbatore and the seeds harvested from the parents and their hybrid combinations were evaluated at Seed Technological Laboratory. The unaged seeds and accelerated aged seeds were evaluated for different seed quality parameters to assess the seed vigour and viability potential of parents and hybrids (Delouche and Baskin, 1973). Uniform seeds of test material were subjected for accelerated ageing in an ageing chamber maintained at 40±1°C and 98±2% RH for six days. The germination test was conducted as per the set procedures of international seed testing rules using between paper (BP) method. The roller paper towels with seeds were placed at slanting position in a cabinet seed germinator at 25±1°C with 95±1% RH. The germination count was taken after seven days. The data on root length and shoot length was recorded for ten seedlings/test material, which were air dried and then oven dried at 80±1°C for 24 hours to assess the dry weight. Seedling vigour index was computed as per Abdul-Baki and Anderson (1973). The combination ability analysis was carried out by the line x tester method as per Kempthorne (1957) and Arunachalam (1974).

The analysis of variance for lines, testers and lines x testers was highly significant for all the characters revealing the wide variability existing among the genotypes for seed quality traits. The general combining ability estimates revealed that among lines, CMS 290A had positive and significant *gca* effects for all the seed quality parameters of both unaged and aged seeds (Table-1). It also showed the highest positive and significant *gca* values for all the vigour and viability characters excepting germination of unaged seeds. These observations indicated that CMS 290A carried large number of favourable genes for seed vigour and viability potential. Line CMS 234A showed positive and significant *gca* effects for germination and vigour index of unaged seeds indicating its capability to combine for initial seed vigour. Tester RHA 271 proved as better general combiner for initial germination and vigour of seeds but not for viability potential. Whereas, RHA 274 performed well as a good general combiner for germination, vigour and viability potential. Among the parents, CMS 290A, CMS 234A, RHA 274 and RHA 271 were considered to be the preferable general combiners for seed quality traits.

The cross CMS 234A x 6D-1 was the best combiner among others for seed viability potential by recording the highest *sca* values for germination and vigour index of aged seeds. The hybrids 234A x 6D-1, 86A x RHA 859, 290A x RHA 271, 290AxRHA 265 and 86A x RHA 3376 combined all four characters with positive and significant *sca* effects. Excepting the germination of unaged seeds with positive and non-significant *sca* effects, CMS 86A x RHA 274 and CMS 234A x RHA 271 showed significantly positive *sca* values for remaining three important seed quality traits. Similarly, the cross CMS 7-1A x RHA 272 had significantly positive *sca* effects for three important seed quality traits while for germination of aged seeds it possessed positive and non-significant effect. Giriraj *et al.* (1987) were of the opinion that in majority of crosses high *sca* effect was due to low x low or low x high combining parents.

It is inferred that CMS 290A, CMS 234A, RHA 274 and RHA 271 as preferable general combiners for seed quality traits. The hybrid CMS 234A x 6D-1 had positive and significant *sca* effects for most of the seed quality traits, indicating its wide capability in combining vigour and viability characters of seeds. The crosses CMS 86AxRHA 859, CMS 290AxRHA 271, CMS 290AxRHA 265, CMS 86AxRHA 3376, CMS 7-1AxRHA 272, CMS 86AxRHA 274 and CMS 234AxRHA 271 appeared to be the better hybrid combinations for seed quality based on their positive *sca* effects for seed vigour and viability parameters.

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The two genotypes differed in the per cent rooting cultures. Maximum rooting of 17 and 20 % was recorded in Kranti and GCH-4 respectively on MS+NAA 0.5 mg/l by 21 DAI increase or decrease in the NAA concentration to 0.1 or 1.0 mg/l or even change in PGR to BA decreased the per cent of rooting cultures.

Table 1 Response of shoot tips of castor cv. Kranti and GCH-4 at 28 DAI on MS+BA/NAA+BA medium

PGR mg/l	Average number of shoots/shoot tip		Medium
	Kranti	GCH-4	
BA 0	1.0	1.0	1.0
BA 2.0	4.7	3.2	4.0
BA 3.0	4.7	3.5	4.1
BA 4.0	5.5	4.2	4.9
BA 5.0	5.7	4.0	4.9
BA 6.0	3.2	3.7	3.5
NAA 0.01+BA 5.0	5.0	3.5	4.3
NAA 0.1+BA 5.0	5.2	4.0	4.6
NAA 1.0 + BA 5.0	5.7	3.5	4.6
NAA 10.0 + BA 5.0	2.7	2.7	2.7
Mean	4.4	3.7	

The protocol for *in vitro* multiple shoot proliferation from shoot tips and rooting has thus been standardized in two castor genotypes. Kranthi produced a maximum of 5.7 axillary shoots by 28 DAI on MS+NAA 1.0 mg/l+BA 5.0 mg/l or on MS+BA 5.0 mg/l. GCH-4 initiated a maximum of 4.2 shoots on MS+BA 4.0 mg/l. Shoots initiated roots in 17 and 20% cultures upon transfer to MS+NAA 0.5 mg/l in Kranthi and GCH-4 respectively.

References

Berrios, E.F., Gentzbittel, L., Sericys, H., Alibert, G. and Saraffi, A. 1999. Influence of genotype and gelling agents on *in vitro* regeneration by organogenesis in sunflower. *Plant Cell Tissue and Organ Culture*, 59 : 65-69.

Damodaram, T. and Hegde, D.M. 2002. *Oilseed situation. A statistical compendium*, Directorate of Oilseeds Research, pp.210-229.

Mollina, S.M. and Schobert, C. 1995. Micropropagation of *Ricinus communis*. *Journal of Plant Physiology*, **147** : 270-272.

Murashige, T. and Skoog, F. 1962. A revised medium for rapid growth and bioassay with tobacco tissue culture. *Physiologia Plantarum*, **15** : 473-492.

Panse, V.G. and Sukhatme, P.V. 1975. *Statistical Methods for Agricultural Workers*, ICAR, New Delhi.

Sujatha, M. and Reddy, T.P. 1998. Differential cytokinin effects on simulation of *in vitro* shoot proliferation and merestematic explants of castor. *Plant Cell Reports*, **17** : 561-566.

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Short communication

Multiple shoot induction from shoot tip explants of castor, *Ricinus communis* L.*

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India ranks first in the world castor production with 8.5 lakh t from 7.1 lakh ha and with an average yield of 1197 kg/ha. Andhra Pradesh is a major castor producing state with a production of 1.3 lakh t having a low productivity of 333 kg/ha (Damodaram and Hegde, 2002). Towards yield improvement by genetic upgradation of this crop, gene transfer and biotechnological innovation appeared to be a solution (Sujatha and Reddy, 1998). As a first step for genetic manipulation, establishing a suitable protocol for plantlet regeneration of castor is essential. Multiple shoot but regeneration in castor has been reported previously by using apical buds (Mollina and Schobert, 1995) and in cv. Aruna, VP-1 and RC-8 using shoot tips (Sujatha and Reddy, 1998). Castor cv. Kranti and hybrid GCH-4 which are now popular in Andhra Pradesh state have not been tested for *in vitro* shoot regeneration. Hence, the objective of the study was first to develop a protocol for multiple shoot proliferation from the two genotypes Kranti and GCH-4.

Seeds of two castor genotypes Kranti and GCH-4 were washed under running tap water, surface sterilized with 0.1% $HgCl_2$ for ten minutes and rinsed with sterile distilled water before use. The seed were sown in plastic pots containing quartz sand. Shoot tips measuring 2.5 to 3.5 mm long, were excised from ten day old germinated seedlings using scalpel and surface sterilized with 0.01% $HgCl_2$ for ten min, washed with sterile water and then transferred to culture tubes and placed such that the cut end of the explants was in contact with the medium. Murashige and Skoog's (MS) medium (1962), supplemented with (BA 2-6 mg/l) alone or in combination with NAA (1-10 mg/l) was used for multiplication of shoot tips. The pH of the medium was adjusted to 5.8 prior to autoclaving at 121°C for 20 min. Twenty ml of medium was poured into each culture tube and maintained at 26±2°C under continuous light. Shoots elongated in the culture tubes and measuring around 1.5 cm were cut and transferred to MS+NAA or BA 0.1-1.0 mg/l for rooting. Four replicates containing 10 tubes with one explant in each culture tube were utilized for collecting data. Shoot tip cultures were visually scored for colour (light green, green, greenish brown) and size (small, medium and large). Data on callus characteristics (colour and nature) and number of shoots produced/shoot tip at 28 DAI were analysed using two-factor completely randomized block design following Panse and Sukhatme (1975).

The shoot tip explants appeared green coloured and attained large size by 28 DAI in the two genotypes tested *viz.*, Kranti and GCH-4. The explants of both the genotypes initiated callus from the basal ends two weeks after inoculation. The callus was initially light green to light yellow and compact. At 28 DAI, the callus was large sized, greenish brown in Kranti and light brown to brownish yellow in GCH-4.

Number of shoots initiated varied with respect to genotype and PGRs used (Table-1). The shoot tip explants of Kranti produced a mean number of 4.4 axillary shoots as compared to 3.7 shoots in GCH-4. Such differential response between genotypes was also observed in sunflower crop, wherein C-108 and C-96 produced 27 and 2 shoots on MS+BA 2.0 mg/l respectively (Berrios *et al.*, 1999). The PGRs incorporated into the medium in turn influenced the genotypic response (Table-1). By 28 DAI, on MS+NAA 1.0 mg/l+BA 5.0 mg/l and on MS+BA 5.0 mg/l Kranti initiated a mean maximum of 5.7 shoots as compared to 3.5 and 4.0 shoots respectively in GCH-4. Also, on MS+BA 4.0 mg/l a mean maximum of 5.5 shoots were produced by Kranti but only 4.2 in case of GCH-4. Mollina and Schobert (1995) reported that, combination of NAA+BA was more effective in inducing multiple shoot buds in castor, Sujatha and Reddy (1998) however, suggested that exogenous supply of auxin was not required as the shoot tip explants themselves are the sites of auxin synthesis. These findings in castor indicate that the effect of both PGR and genotype are important in determining the shoot bud induction.

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Competition from the component crops significantly reduced the matured groundnut pods/plant compared to sole groundnut in both the seasons. Differences in mature groundnut pods/plant due to cropping systems were marginal. However, reduction in pod number/plant was higher when groundnut was intercropped with pigeonpea. This was due to the fact that the component crops of sunflower and mustard were harvested earlier than the groundnut compared to harvest of both pigeonpea and groundnut at a time.

Ill filled pods (pods)/plant and hundred kernel weight did not vary significantly due to cropping systems. Pod yield of sole groundnut was significantly higher compared with its combination with other component crops. There were marginal differences in pod yield of groundnut due to cropping systems. Competition from component crops of sunflower, mustard and pigeonpea decreased the pod yield of groundnut compared with sole groundnut crop due to the adverse effect on growth and yield attributes. Haulm yield of groundnut also followed a similar trend.

Evaluation of cropping systems for their yield advantage indicated superiority of groundnut with mustard and sunflower (Table-1). The total productivity in terms of groundnut pod equivalent recorded in groundnut + mustard (3092 kg/ha) was on par with groundnut + sunflower (3187 kg/ha) and both were significantly higher than sole groundnut and groundnut + pigeonpea intercropping. The increase in pod equivalents in groundnut + mustard is attributable to better yield obtained from groundnut and higher prices of mustard which compensated the reduction in yield of intercropped groundnut. Thus, from the present studies it is evident that shorter duration component crops like mustard and sunflower contributed to higher yield advantage than component crop (pigeonpea) of similar duration with groundnut.

Table 1 Plant height, leaf area, drymatter production and yield of groundnut as affected by irrigation levels and cropping systems

Treatment	Plant height at 90 DAS (cm)		Leaf area/plant at 90 DAS (cm)		Drymatter production/ plant at harvest (g)		Mature pods/ plant		Ill filled pods/plant		100 kernel weight (g)		Pod yield (kg/ha)		Haulm yield (kg/ha)		Pod equivalent yield (kg/ha)	
	1991-92	1992-92	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93
Irrigation regime (IW/CPE ratio)																		
0.8	22	23	1117	1182	17	19	11	12	3	4	39	43	1779	1957	3293	3651	1985	2254
1.0	23	25	1251	1389	19	21	13	14	2	3	44	45	2315	2560	3878	4298	2373	2645
1.2	23	25	1269	1425	20	21	13	15	2	3	44	45	2439	2635	4065	4407	2303	2578
SEm±	0.3	0.4	17	22	0.5	0.7	0.1	0.1	0.1	0.1	0.3	0.4	61	70	86	103	54	34
CD (P=0.05)	0.9	1.3	58.4	74.6	1.8	2.3	0.5	0.4	0.3	0.3	1.2	1.3	211	242	296	355	187	199
Intercropping systems (C)																		
C_1-Sole Groundnut	35	26	1310	1403	21	22	17	18	3	4	44	45	2459	2646	4317	4791	2459	2646
C_2-Groundnut+Sunflower	22	24	1175	1299	19	20	12	13	2	3	42	44	2189	2382	3670	4047	2946	3237
C_3-Groundnut+Mustard	22	24	1159	1284	19	20	11	12	2	3	42	44	2140	2360	3584	3923	3013	3360
C_4-Groundnut+Pigeonpea	22	24	1205	1343	17	19	10	11	2	3	41	44	1922	2148	3409	3714	2349	2693
SEm±	0.4	0.4	18	22.7	0.6	0.7	0.4	0.3	0.1	0.1	0.7	0.6	80	89	108	125	90	96
CD (P=0.05)	1.4	1.3	52.3	65.8	1.9	2.1	1.3	0.9	0.3	0.4	NS	NS	231	258	313	364	255	273

References

De Rajat and Singh, S.P. 1981. Management practices for intercropping systems. Proceedings of International Workshop on Intercropping, ICRISAT, Hyderabad, January 10-13, 1979, 17-21.

Lakshmi, M.B. 1990. Studies on irrigation and phosphorus management in groundnut-maize cropping sequence. Ph.D., Thesis, Acharya N.G. Ranga Agricultural University, Hyderabad.

Ramesh, C. 1983. Water stress imposed growth and yield dynamics of groundnut (*Arachis hypogaea* L.). M.Sc. (Ag.) Thesis, Acharya N.G. Ranga Agricultural University, Hyderabad.

Reddy, P.R.R. 1991. Response of groundnut to water stress deficits at different growth stages. M.Sc. (Ag.) Thesis, Acharya N.G. Ranga Agricultural University, Hyderabad.

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Short communication

Effect of irrigation regimes on growth and yield of intercropped groundnut

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The practice of mixed or intercropping of two or more crops is an insurance against total crop failure under aberrant weather conditions and judicious use of inputs (De and Singh, 1981). However, the studies on intercropping at different levels of inputs particularly with regard to irrigation are very few and such work assumes importance in the context of present day awareness of better use of limited water. Groundnut being the important crop of Andhra Pradesh during *rabi* season, the present investigation was undertaken to ascertain the feasibility of intercropping groundnut with mustard, sunflower and pigeonpea under varying irrigation levels.

A field experiment was conducted during the *rabi* season of 1991-92 and 1992-93 at Agricultural College Farm, Hyderabad in split-plot design with three irrigation levels (IW/CPE ratios of 0.8, 1.0 and 1.2) as main plots and four cropping systems (C_1-Sole groundnut; C_2-groundnut + sunflower; C_3-groundnut + mustard and C_4-groundnut + pigeonpea) as sub plots replicated four times. The soil was sandy loam having pH 7.5, EC 0.28/dSm and organic carbon 0.44% with 215, 20.75 and 305.10 kg/ha of available N, P_2O_5 and K_2O respectively. Field capacity values in 0-20, 20-40 and 40-60 cm soil layers were 19.09, 16.85 and 15.40% while the respective permanent wilting point values were 7.92, 7.26 and 6.05%.

Groundnut cv., ICGS-11, while that of sunflower, mustard and pigeonpea was APSH-11, B-85 (Seetha) and MRG-66, respectively were tried. The component crops in intercropping systems were sown at 50% of sole crop population in 3:1 row arrangement. The recommended dose of fertilizers for groundnut was applied to sole groundnut and groundnut based intercropping system treatment (20-40-40 kg NPK/ha). Half of recommended fertilizer dose of component crop was placed by the side of rows of component crop included in intercropping system in the form of urea, single super phosphate and muriate of potash. For comparison of different intercropping systems with sole (base) crop, the yields of component crops were converted into pod equivalent of base crop to get the total productivity. The formula is as follows:

$$\text{Groundnut pod equivalent (kg/ha)} = \frac{\text{Seed yield of component crop (kg/ha)} \times \text{Price (Rs/ha)}}{\text{Groundnut price (Rs/ha)}}$$

Plant height and leaf area at 90 DAS was significant more due to 1.0 IW/CPE ratio compared with lower ratio of 0.8. However, the difference due to 1.0 and 1.2 ratios was not significant for both these characters (Table-1). Highest drymatter production at harvest also followed similar trend of plant height and leaf area at 90 DAS. Improvement in these growth attributes can be attributed to optimum soil moisture for crop growth at 1.0 and 1.2 ratio. Relatively lower soil moisture retentive capacity could not maintain optimum available soil moisture for crop growth at 0.8 ratio (Ramesh, 1983). The superiority of irrigation schedules at higher IW/CPE ratios was observed in number of pods/plant and hundred kernel weight compared with lower ratio of 0.8. Inadequate available soil moisture resulted in shorter plants and lower leaf area at 90 DAS leading to decreased pod number/plant and hundred kernel weight.

Highest pod and haulm yield and pod equivalent was with irrigation schedules of 1.0 and 1.2 IW/CPE ratios, both of which were on par and significantly superior to 0.8 ratio (Table-1). Improvement in growth and yield attributes with higher ratios contributed for higher pod and haulm yields (Lakshmi, 1990; Reddy, 1991). The increase in pod equivalent yield due to 1.0 and 1.2 IW/CPE ratios over 0.8 IW/CPE ratio was to the tune of 388 and 318 kg/ha during 1991-92 and 391 and 324 kg/ha during 1992-93 respectively.

Groundnut plant height at 90 DAS was significantly more compared with other cropping systems except in 1992-93 where it was on par with groundnut + pigeonpea system (Table-1). Sunflower and mustard as intercrops in groundnut reduced the leaf area of groundnut due to the competitive effect of the two oilseed crops. Drymatter production also followed the similar trend as that of leaf area except groundnut with sunflower during second year.

The experimental soil was sandy clay loam in texture (Typic Ustifluvent), medium in available N (282 Kg/ha), available P_2O_5 (22 Kg/ha) and available K_2O (258 Kg/ha). The nitrogen content in plant samples was determined by microkjeldahl method (A.O.A.C., 1970). Phosphorus and potassium content in plant samples were determined by adopting the procedures as described by Jackson (1973). The sulphur content in plant samples was determined by turbidimetric method (Vogel, 1978). The cationic micronutrients viz., Zn, Fe, Cu and Mn in plant samples were determined by using Atomic Absorption Spectrophotometer (Vogel, 1978).

The total dry matter production continuously increased as the crop advanced in its phenology i.e., 30, 60, 90 DAS and at harvest (Table-1). All the treatments significantly increased the drymatter production over control but the highest dry matter production was noticed when recommended dose of N, P and K fertilizers was applied. This may be due to the immediate availability of adequate amounts of N, P, K and S required for crop growth. These results are fairly well comparable with those of Chandrasekhar Reddy and Krishna Moorthy (1984).

All the treatments significantly increased the filled pods/plant over control (Table-1). The highest number of filled pods/plant was recorded in recommended dose of NPK fertilizers followed by incorporation of Pongamia cake @ 700 Kg/ha. These findings are in agreement with the findings of Mallikharjuna Chetty (1995) who reported that the favourable effect of the fertilizers on yield attributes of groundnut.

Further, recommended dose of NPK fertilizers and various organic manures significantly increased 100 pod weight and pod yield over control (Table-1). The increase in 100 pod weight and pod yield might be due to the positive effect of recommended dose of NPK fertilizers on yield attributes like pod weight and test weight. The 100 pod weight largely contributed for increase in pod yield due to fertilizer application which may be attributed to enhanced synthesis of carbohydrates and proteins (Sagare et al., 1992).

Application of recommended dose of NPK fertilizers and various organic manures significantly increased the uptake of N, P, K and S by haulms and pods at harvest over control (Table-2). However, application of recommended dose of N.P.K fertilizers resulted in significantly the highest uptake of N, P, K and S followed by the application of neem cake @ 700 Kg/ ha. The increase in nutrient uptake might be due to adequate supply of nitrogen, phosphorus and potassium through mineral fertilizers (Chandrasekhar Reddy and Krishna Moorthy (1984). Application of recommended dose of NPK fertilizers and various organic manures significantly increased the concentration and uptake of Fe, Zn, Cu and Mn by haulms and pods at harvest over control (Table-2). The highest uptake of these micronutrients occurred in plots receiving recommended dose of NPK fertilizers. These findings are similar to the findings of Swarup (1983).

Table 2 **Effect of recommended dose of NPK fertilizers and various organic manures on uptake of major and micronutrients by groundnut haulms and pods at harvest**

Treatment	N uptake (kg/ha)		P uptake (kg/ha)		K uptake (kg/ha)		S uptake (kg/ha)		Zn uptake (g/ha)		Cu uptake (g/ha)		Fe uptake (g/ha)		Mn uptake (g/ha)	
	Haulms	Pods	Haulms	Pods	Haulms	Pods	Haulms	Pods	Haulms	Pods	Haulms	Pods	Haulms	Pods	Haulms	Pods
T_1 : Control	32.7	67.7	2.9	5.2	12.8	11.1	7.2	6.8	35.4	28.6	13.9	12.2	510	418	127	109
T_2 : Recommended dose of NPK fertilizers	71.6	146.4	5.4	11.4	24.2	27.5	11.8	15.3	57.6	62.4	26.2	31.8	809	829	225	245
T_3 : FYM @ 8 t/ha	52.7	102.7	3.7	9.0	14.7	18.2	9.6	11.8	45.2	45.3	21.8	22.6	649	719	202	220
T_4 : Green leaf (Glyricidia) @ 16 t/ha	45.1	96.7	3.6	9.3	11.7	17.7	8.6	12.4	38.5	40.0	15.5	21.0	598	724	168	222
T_5 : Poultry manure @ 8 t/ha	41.8	111.1	4.0	6.9	13.5	19.6	9.1	9.7	40.6	44.3	17.8	22.0	611	551	170	161
T_6 : Neem cake @ 700 kg/ha	61.3	133.7	5.1	8.8	18.9	25.5	11.3	11.7	48.8	55.7	21.8	28.0	727	638	195	181
T_7 : Bio-agrorich compost @ 6 t/ha	45.9	106.9	3.9	8.9	13.9	18.8	9.7	11.5	46.9	48.7	18.0	22.5	620	688	181	225
T_8 : Pongamia cake @ 700 kg/ha	57.6	129.9	4.6	7.9	16.9	23.6	10.1	11.9	53.5	55.5	23.4	27.4	706	608	190	189
T_9 : Pressmud @ 4 t/ha	45.3	113.5	3.8	6.3	15.5	19.3	10.0	8.9	46.8	48.7	18.3	21.4	651	510	176	155
T_{10} : Vermicompost @ 4 t/ha	49.4	110.4	4.2	7.6	15.8	18.9	10.4	9.8	47.6	48.2	20.8	24.2	715	613	187	174
SEm±	1.5	0.4	0.2	0.5	0.6	0.3	0.2	0.3	1.1	0.7	0.4	0.4	16.3	7.2	7.1	3.6
CD (P=0.05)	4.5	1.2	0.6	1.5	1.8	0.9	0.6	0.9	3.3	2.1	1.2	1.2	48.9	21.6	21.3	21.8

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Short communication

Effect of inorganic fertilizers and organic manures on growth, yield and uptake of nutrients by groundnut, Arachis hypogaea

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Groundnut (*Arachis hypogaea* L) occupies first place among oilseed crops grown in the country with an area of 8.3 m.ha and contributes 7.1 million tonnes to the oilseed basket. Groundnut crop continues to be an unpredictable legume, showing inconsistency in pod and oil yields. Due to hike in prices of chemical fertilizers and cost of cultivation due to labour and other inputs, there is a tendency towards organic farming by using FYM, composts and other available oil cakes which possibly maintain the sustainability of crop yields and soil fertility. Further, groundnut yields are low in *rabi* season, which may be due to unbalanced fertilization (Chandrasekhar Reddy and Riazuddin Ahmed, 1999). Keeping in view, the importance of groundnut crop, which is predominantly grown in *rabi* season in Chittoor district, AP, where chemical fertilizers are used in combination with available organic manures, the present experiment was planned and executed.

A field experiment was conducted during *rabi* 1997-98 in the wet land farm of S.V. Agricultural College, Tirupati in a Randomized Block Design with 10 treatments and three replications. The test crop was groundnut (var. K-134). Earlier to the present investigation, the crops raised were greengram, crop museum and sunhemp followed by paddy during *kharif* 96, *rabi* 96 and *kharif* 97 respectively. All the organic manures were applied to individual plots as per treatments before sowing (Table-1). The seeds were sown on 7-1-1998 in plots of 5.4 x 4.5 m with a spacing of 22.5 x 10 cm at optimum moisture level to ensure good emergence and finally harvested on 25-2-98. All the recommended dose of NPK fertilizers were applied to the plots basally just before sowing through urea, single super phosphate and muriate of potash respectively.

Table 1 Effect of recommended dose of NPK fertilizers and various organic manures on the drymatter production at harvest and yield and yield attributes in groundnut

Treatment	Drymatter production at harvest (kg/ha)	No. of pods/plant		100 pod weight (g)	Pod yield (kg/ha)
		Filled	Unfilled		
T_1 : Control	36.3	12	4	74.6	1543
T_2 : Recommended dose of NPK fertilizers	56.8	21	1	96.4	2826
T_3 : FYM @ 8 t/ha	50.1	17	2	82.5	2201
T_4 : Green leaf (Glyricidia) @ 16 t/ha	47.6	16	2	83.9	2119
T_5 : Poultry manure @ 8 t/ha	42.3	18	2	78.7	2311
T_6 : Neem cake @ 700 kg/ha	49.3	18	1	87.7	2702
T_7 : Bio-agrorich compost @ 6 t/ha	50.1	17	2	83.1	2331
T_8 : Pongamia cake @ 700 kg/ha	49.3	19	1	87.4	2578
T_9 : Pressmud @ 4 t/ha	43.9	18	2	85.6	2406
T_{10} : Vermicompost @ 4 t/ha	48.2	18	1	88.7	2462
SEm±	0.5	0.2	0.1	0.7	26
CD (P=0.05)	1.6	0.7	0.5	2.2	77

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Short communication

Composted poultry waste and fertilizer levels : effect on yield and nutrient uptake of sunflower, *Helianthus annuus* L. and residual NPK status

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Sunflower is a physiologically efficient soil nutrient exhaustive crop. Its productivity can be sustained through integrated use of organic manures and chemical fertilizers. Poultry waste availability in the country is increasing due to the fast growth rate (5-20% per annum) of poultry industry in the recent years. Direct use of the poultry excreta is not recommended as it contains higher uric acid, which is phytotoxic. Hence, the present study on composting of poultry waste with crop residues and its effect on sunflower production was conducted at GKVK farm of the University of Agricultural Sciences, Bangalore.

Poultry waste (excreta and litter) was composted with crop residues (*ragi* husk, maize residue) by mixing with 0.25:1 (P_1), 0.50:1 (P_2), 0.75:1 (P_3) and 1:1 (P_4) proportions separately under Vat method for three months. The N, P_2O_5 and K_2O contents (%) of the compost were 2.80, 1.78 and 1.57 for P_1; 3.09, 3.59 and 1.76 for P_2; 3.36, 4.83 and 2.06 for P_3 and 3.50, 4.94 and 2.10 for P_4, respectively. A field experiment was conducted in red sandy clay loams (*Kandic Paleustalfs*) which are slightly acidic (pH 6.0), low in available N (186.10 kg/ha), medium in available P (38.30 kg P_2O_5/ha) and K (208.5 kg K_2O/ha). Four compost (P_1, P_2, P_3 and P_4) at 3 t/ha each and four fertilizer levels (F_1, F_2, F_3 and F_4 at 0, 50, 75 and 100% recommended N, P_2O_5 and K_2O of 60, 75 and 60 kg/ha) in 4 x 4 factorial treatments were tested adopting randomised complete block design. KBSH-1 sunflower cultivar was sown on 1st August, 1999. The crop was harvested during 1st week of November, 1999. The seed and biomass yield, oil content of the seed were recorded at 45 days after sowing (DAS) and at harvest and soil NPK status after harvest was assessed adopting standard procedures (Piper, 1966). The effect of compost and fertilizer applications were significant while interaction effects did not differ significantly (Table-1).

Application of composted poultry waste P_4 and P_3 produced significantly higher seed yield. This may be attributed to increase in biomass yield and its partitioning into seed as a consequence of better growth. In the present study, the recommended NPK use produced higher seed yield, which confirmed the adequacy of recommended NPK for higher seed yield. The oil content of seed increased with increased fertility levels from F_1 to F_4. However, there was marginal increase with the composts from P_1 to P_4.

NPK uptake by the crop at harvest followed the order N>K>P (93.45, 85.18, 13.73 kg/ha respectively). The trend remained same at 45 DAS (24.22, 20.83 and 3.86 kg/ha respectively). Twenty five % of the total NPK requirement was absorbed on 45th day. Among composts P_4 recorded higher NPK uptake both at 45 DAS and at harvest. Recommended NPK use recorded higher NPK uptake both at 45 DAS and at harvest. The findings are in line with those of Bahl *et al.* (1997).

The residual NPK of the soil was higher with P_4 compost. Use of recommended fertilizer also improved residual NPK status. However, perusal of residual with initial NPK status indicated greater depletion of N and K (5.3 and 11.9%) from initial status. NPK depletion was greater under F_2. Crop supplied with recommended NPK absorbed more NPK as a consequence, biomass yield was more and there was lower decline in the N and K status in soil over the respective initial status, but soil available P was maintained above initial P status.

References

Bahl, G.S., Pasricha, N.S. and Ahuja, K.L. 1977. Effect of fertilizer nitrogen and phosphorus on the growth yield, nutrient uptake and oil quality of sunflower. *Journal of Indian Society of Soil Sciences*, **45**(2) : 292-296.

Piper, C.S. 1966. *Soil and plant analysis.* Hans Publishers, Bombay, p.368.

It is concluded that the recommended dose of NPK fertilizers and various organic manures significantly increased the dry matter production, pod yield of groundnut and uptake of macro and micronutrients over control. However, application of recommended dose of NPK fertilizers (40kg, N, 50 kg. P_2O_5 and 50 kg K_2O/ha) was found to be superior to all other organic manures in increasing dry matter production, pod yield and uptake of nutrients by haulms and pods at harvest. Though the recommended dose of NPK fertilizers significantly increased the dry matter production, yield and uptake of nutrients, it is better to go for a judicious combination of organic and inorganic fertilizers for sustaining yields and soil fertility.

References

A.O.A.C., 1970. *Official and tentative methods of Analysis.* Association of Official Analytical Chemists, 12th edition, Washington D.C.

Chandrasekhar Reddy, K. and Krishna Moorthy, P. 1984. Uptake of nutrients, oil content and yield of groundnut as influenced by P, K, Ca, Mg and S application. *Andhra Agricultural Journal,* **40**:464-468.

Chandrasekhar Reddy, K. and Riazuddin Ahmed. 1999. Soil test based fertilizer recommendations for groundnut grown in rice fallows (Inceptisols) of Jagitial in Andhra Pradesh. *Journal of Oilseeds Research,* **16** (2): 257-262.

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

Mallikharjuna Chetty, K. 1995. The effect of applied phosphorus, calcium and sulphur on nutrient composition, uptake, quantity and yield of irrigated groundnut in red sandy clay loams. M.Sc. (Ag.) thesis submitted to Acharya N.G. Ranga Agricultural University, Hyderabad.

Sagare, B.N., Gute, Y.S., Deshmukh, B.A. and Deshmukh, A.B. 1992. Biological yield and uptake of nutrients by peanut as influenced by enriched FYM products. *Journal of Maharashtra Agricultural Universities,* **17**:100-102.

Swarup, A .1983. Effect of micronutrients and FYM on yield and micronutrient content in rice. *Journal of International Rice Research Newsletter,* **8**:22.

Vogel, A.I. 1978. *A textbook of quantitative inorganic analysis.* Richard clay, The chances press limited, Britain.

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Short communication

Yield, quality and economics of sunflower as influenced by nitrogen and sulphur nutrition

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In recent years, sunflower gained importance due to its wider adaptability, short duration, allows it to be fitted into various cropping systems. It is known for its excellent oil quality, as it contains high degree of poly unsaturated fatty acids. Despite the impressive strides in acreage and production over the last two decades, the productivity of sunflower remained far low (936 kg/ha). Inadequate and imbalanced nutrition is one of the prime reasons attributed to low productivity. The nitrogen requirement of sunflower is quite high (Singh *et al.*, 1987; Kumar *et al.*, 1991). Among secondary nutrients, sulphur is considered an important nutrient for oilseeds. Response to applied sulphur was reported by Sreemannarayana and Sreenivasa Raju (1994). Thus, emphasizing their importance the present study was taken up to study the response of crop to combined levels of nitrogen and sulphur fertilization.

The field experiment was conducted during *rabi*, 2000 at Sri Venkateswara Agricultural College, Tirupati, AP. The soil was sandy loam with 7.27 pH, low in organic carbon (0.26%), available N (172.0 kg/ha) and available S (7.0 ppm), medium in available P_2O_5 (30.1 kg/ha) and available K_2O (168 kg/ha). The treatments comprised of combinations of 3 levels of nitrogen i.e., 60, 80 and 100 kg/ha with 5 levels of sulphur i.e., 0, 10, 20, 30 and 40 kg/ha along with one control i.e., no N, S (N_0S_0) were tested in a randomized block design with three replications with a net plot size of 3.6 x 3.6 m. The sunflower hybrid MSFH-17 was sown on January 3, 2000 with 45 x 30 cm spacing. Nitrogen was applied in two splits (half at sowing and half at 30 DAS) through urea. Sulphur was applied through gypsum one week before sowing. A basal dose of 60 kg P_2O_5/ha was applied for all the treatments at the time of sowing. Potash was not applied. Crop was irrigated at weekly intervals of about 10 irrigations were given.

Effect of nitrogen and sulphur on yield: Nitrogen and sulphur application significantly increased the seed and stalk yield of sunflower. The highest seed yield of 2252 kg/ha was obtained with application of 100 kg nitrogen with 40 kg sulphur/ha which was comparable with 100 kg nitrogen with 30 kg sulphur/ha (2220 kg/ha) and 100 kg nitrogen with 20 kg sulphur/ha (2159 kg/ha) and these three were significantly superior to rest of the treatments (Table-1). Similar results were reported by Legha and Gajendra Giri (1999; Ajai Singh *et al.*, 2000). Application of 60, 80 and 100 kg/ha with out sulphur ($N_{60}S_0$, $N_{80}S_0$ and $N_{100}S_0$) has resulted in 64.4, 112.7 and 167.0% higher seed yield respectively over control (N_0S_0). As nitrogen is a major constituent of chlorophyll and protein synthesis and its availability through fertilizer application might have contributed towards increased protein synthesis and also due to combined effect of head diameter, filled seeds and test weight (Table-1). Application of sulphur @ 20, 30 and 40 kg/ha along with 100 kg N/ha i.e., $N_{100}S_{20}$, $N_{100}S_{30}$ and $N_{100}S_{40}$ has resulted in 20.5, 21.9 and 23.6% higher seed yield over 100 kg N alone ($N_{100}S_0$). Similar results were reported by Dubey *et al.* (1993); Krishnamurthy and Mathan, (1996). This is due to increased utilization of carbohydrates for synthesis of protein and favourable effect of sulphur on drymatter production. Higher harvest index at higher levels of nitrogen and sulphur is due to increased availability of photosynthates and physiological capacity to translocate them to the organ of economic value.

Effect of nitrogen and sulphur on oil content: Oil content reduced slightly with increase in the nitrogen level above 80 kg/ha, while sulphur application had a favourable effect. Reduction in oil content at higher levels of nitrogen might be due to degradation of carbohydrates in Tricarboxylic acid (TCA) cycle to Acetyl CoA. By reductive ammoniation and transamination process more amino acids are formed rather than fatty acids. The highest level of sulphur 40 kg/ha along with 80 kg N/ha produced significantly higher oil content (Table-1) over lower levels of sulphur (S_{20}, S_{10}) but was on par with 30 kg/ha. This might be attributed to favourable nutritional environment created for production of metabolite and involvement of sulphur in biosynthesis of oil. The results of present investigation confirm the findings of Kameswara Rao and Gangasaran (1991) and Legha and Gagendra Giri (1999).

Economics: the highest net returns were obtained with 100 kg nitrogen with 40 kg sulphur which was however, on

Table 1 Seed and biomass yield, oil content, nutrient uptake by sunflower and residual nutrient status as influenced by composts and fertilizer levels

Treatment	Seed yield (kg/ha)	Biomass yield (kg/ha)	Oil content (%)	Nitrogen (N) uptake (kg/ha)		Phosphorus (P) uptake (kg/ha)		Potassium (K) uptake (kg/ha)		Residual N, P_2O_5 and K_2O (kg/ha)		
				45 DAS	At harvest	45 DAS	At harvest	45 DAS	At harvest	N	P_2O_5	K_2O
Composts												
P_1	1027	2508	41.7	21.0	88.6	3.3	12.6	19.1	79.9	149	30	170
P_2	1072	2609	42.1	22.9	90.9	3.8	13.6	20.3	83.4	159	31	174
P_3	1115	2698	42.3	25.2	94.7	4.1	14.0	21.2	86.4	163	33	183
P_4	1155	2820	42.5	27.8	99.6	4.3	14.7	22.8	90.9	164	37	184
CD (P=0.05)	85.5	207	NS	3.0	7.9	0.5	1.5	2.4	6.8	6.4	3.9	NS
Fertilizer levels (% RDF)												
0	644	1661	40.96	15.8	59.6	2.6	8.8	13.8	55.1	144	26	171
50	981	2381	41.51	21.7	83.8	3.5	12.7	18.8	76.5	152	30	175
75	1283	3089	42.78	27.6	107.8	4.3	15.4	23.7	97.4	164	34	179
100	1462	3503	43.45	31.8	122.4	5.1	17.8	27.0	111.7	176	40	184
CD (P=0.05)	85.5	207.0	1.46	3.0	7.9	0.5	1.5	2.4	6.8	6.4	3.9	NS
Mean	1092	2658	42.2	24.2	93.5	3.9	13.7	20.8	85.2	159	33	178

P_1, P_2, P_3 and P_4 are the composted poultry waste and crop residues in 0.25:1, 0.50:1, 0.75:1 and 1:1 proportion respectively.
RDF - Recommended fertilizer dose (60:75:60 kg N, P_2O_5 and K_2O/ha, respectively)
DAS - Days After Sowing

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Short communication

Performance of sunflower, *Helianthus annuus* L. under varying irrigation and fertility levels

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Sunflower (*Helianthus annuus* L.) is an important oilseed crop in Satpura plateau zone of Madhya Pradesh. It is gaining more popularity as winter season crop particularly under irrigated ecosystem when traditional wheat crop suffers in late sowing. High yielding varieties show varying degree of yield potential under different levels of agro-inputs *viz.*, irrigation and fertilizer application depending on the soil type and weather conditions (Narwal and Malik, 1985). The present investigation has been under taken to generate the information regarding relative seed yield of sunflower varieties under different irrigation regimes and fertility levels.

A field experiment was conducted on sunflower in medium back soil at Zonal Agricultural Research Station, Chhindwara, MP. The soil was neutral in reaction (pH 7.2) having low available N (383 kg/ha), P_2O_5 (14.2 kg/ha) and high available K_2O (575 kg/ha). Twelve treatments were oriented in 3 irrigation regimes *viz.*, irrigation at 0.4, 0.6 and 0.8 IW/CPE in main plot and the combination of two fertility levels (60 kg N, 30 kg P_2O_5 : 30 kg K_2O/ha and 90 kg N : 45 kg P_2O_5 : 45 kg K_2O/ha), with two cultivars (variety: Morden and hybrid: MSFH-8) were sown in sub-plots. The experiment was laid out in split plot design with three replications. Sowing was done on November 15th and November 25th in the first and second year by using 10 kg seed/ha in row spacing of 50 cm apart and plant spacing of 20 cm was maintained in all plots by thinning extra plants. Half dose of the total N along with full P_2O_5 and K_2O was given as basal dose uniformly. Remaining N was top dressed on next day after first irrigation. Except an uniform irrigation of 75 mm applied to ensure the proper germination, all other irrigations were given as per treatments. The irrigation water of 50 mm was applied to the crop as per schedule by measuring the water with the help of 90° V'notch of 75 mm size. Morden was harvested on March 14th and 7th, while hybrid MSFH-8 was harvested after a fortnight of variety Morden in both the consecutive years.

Performance of hybrid, MSFH-8 was significantly superior to popular cultivar, Morden in both years (Table-1). Fifteen days more maturity period over the variety Morden, yield of hybrid MSFH-8 was 47% higher. The seed yield of MSFH-8 over Morden, at all irrigation regimes was markedly higher with successive increase in the frequency of irrigation as 0.4, 0.6 and 0.8 IW/CPE ratio (Table-2).

Table 1 Effect of irrigation and fertility levels on seed yield (kg/ha), consumptive use and water use efficiency in sunflower genotypes

IW/CPE ratio	Seed yield (kg/ha) (MSFH-8 and Morden)			Consumptive use of water (mm/ha)		WUE (yield kg/mm water)	
	1st year	2nd year	Mean	1st year	2nd year	1st year	2nd year
0.4	1246	1324	1285	247	266	5.04	4.97
0.6	1718	1706	1712	322	316	5.33	5.39
0.8	1892	1980	1936	372	366	5.08	5.40
SEm±	41	46	-	-	-	-	-
CD (P=0.05)	160	183	-	-	-	-	-
N:P:K (kg/ha)	1st year	2nd year	Mean	1st year	2nd year	1st year	2nd year
60:30:30	1472	1534	1503	313	316	4.70	4.85
90:45:45	1765	1805	1785	313	316	5.63	5.71
SEm±	18	28	-	-	-	-	-
CD (P=0.05)	54	97	-	-	-	-	-
Cultivars	1st year	2nd year	Mean	1st year	2nd year	1st year	2nd year
Morden (variety)	1144	1526	1335	272	291	4.20	5.24
MSFH-8 (Hybrid)	2092	1814	1953	355	341	5.90	5.32
SEm±	15	28	-	-	-	-	-
CD (P-0.05)	54	97	-	-	-	-	-

par with 100 kg nitrogen with 30 kg sulphur and 100 kg nitrogen with 20 kg sulphur indicating that application of sulphur beyond 20 kg/ha was not economical.

Table 1 Seed yield, stalk yield, harvest index (%) and benefit cost ratio of sunflower as influenced by nitrogen and sulphur nutrition

Treatment	Seed yield (kg/ha)	Stalk yield (kg/ha)	Harvest index (%)	B:C ratio
N_0S_0	681	1208	36.0	0.80
$N_{60}S_0$	1120	1740	39.2	1.13
$N_{60}S_{10}$	1170	1792	39.6	1.17
$N_{60}S_{20}$	1218	1840	39.9	1.21
$N_{60}S_{30}$	1470	2083	41.4	1.45
$N_{60}S_{40}$	1520	2130	41.6	1.49
$N_{80}S_0$	1449	2061	41.3	1.43
$N_{80}S_{10}$	1495	2105	41.5	1.47
$N_{80}S_{20}$	1550	2160	41.8	1.51
$N_{80}S_{30}$	1845	2431	43.2	1.79
$N_{80}S_{40}$	1900	2470	43.5	1.84
$N_{100}S_0$	1821	2402	43.1	1.77
$N_{100}S_{10}$	1870	2448	43.4	1.81
$N_{100}S_{20}$	2159	2712	44.8	2.10
$N_{100}S_{30}$	2220	2733	44.8	2.12
$N_{100}S_{40}$	2252	2750	45.0	2.13
SEm±	54.9	70.0	0.41	-
CD (P=0.05)	158	202	1.20	-

References

Ajai Singh, Singh, S.P., Katiyar, R.S. and Singh, P.P. 2000 Response of nitrogen and sulphur on economic yield of sunflower (*Helianthus annuus* L.) under sodic soil condition. *Indian Journal of Agricultural Sciences*, **70** (8) : 536-537.

Dubey, O.P., Sahu, T.R., Garg, D.C. and Khan, R.A. 1993. Response of mustard to sulphur and nitrogen under irrigated vertisol conditions of sulphur and nitrogen on ancillary character, yield and quality. *Journal of Oilseeds Research*, **10** : 11-15.

Kameswara Rao, S.V.C. and Gangasaran. 1991. Response of sunflower cultivars to planting density and nutrient application. *Indian Journal of Agronomy*, **36** (1) : 95-98.

Krishnamurthy, V.V. and Mathan, K.K. 1996. Influence of sulphur and magnesium on growth and yield of sunflower (*Helianthus annuus* L.). *Indian Journal of Agronomy*, **41** : 627-629.

Kumar, S., Dixit, R.S. and Tripathi, H.P. 1991. Effect of nitrogen uptake and oil content of sunflower (*Helianthus annuus* L.) under different moisture regimes. *Indian Journal of Agricultural Sciences*, **61**(1) : 766-768.

Legha, P.K. and Gajendra Giri. 1999. Influence of nitrogen and sulphur on growth, yield and oil content of sunflower (*Helianthus annuus* L.) grown in spring season. *Indian Journal of Agronomy*, **44** (2) : 408-412.

Singh, S.P., Singh, O.P. and Singh, V. 1987. Studies on the growth and yield of sunflower varieties in relation to nitrogen rates. *Journal of Oilseeds Research*, **4** (2) : 169-174.

Sreemannarayana, B. and Sreenivasa Raju, A. 1994. Influence of native and applied sulphur on yield and S uptake by sunflower at different stages of growth. *Journal of the Indian Society of Soil Sciences*, **42** : 80-84.

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Short communication

Effect of nitrogen levels on performance and seed quality of female parent, CMS 234A and its maintainer, CMS 234B of sunflower

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Sunflower is an important oilseed crop of the world. In India it occupies an area of 13.35 lakh ha with a production of 7.33 lakh tonnes. The development and research of first ever sunflower hybrid BSH-1 in the country gave a fillip to hybrid sunflower cultivation. Currently sunflower hybrids account for more than 80% of area under cultivation. With the increase in the area under the crop, the demand for quality seed increasing.

The two hybrids *viz.*, BSH-1 and KBSH-1 have revolutionised sunflower cultivation in the country. These hybrids have a common female/seed parent CMS-234A. The acreage under BSH-1 and KBSH-1 directly depends on the quality of CMS-234A. The present study was made to assess the effect of nitrogen nutrition on performance, yield and quality of the female parent, CMS-234A and its maintainer line CMS-234B.

A factorial experiment was laid out in randomized complete block design with four replications during the rainy season of 1997 at Main Research Station, University of Agricultural Sciences, Dharwad. The sunflower crop was sown in plots measuring 6.6 x 3.3 m using the seeds of CMS 234A and 234B from the selfed progenies selected in the crop raised during 1996 post-rainy season. CMS 234A and 234B were the main factors under three levels of nitrogen i.e., 30, 60 and 90 kg/ha as second factor. The initial soil fertility of the soil was: total N (0.05%), available P_2O_5 (40.0 kg/ha), available K_2O (252 kg/ha) with a pH of 7.5. The entire P_2O_5 at 90 kg/ha and K_2O at 60 kg/ha and 50 % of the N were applied as basal and the remaining 50 % N was top dressed at 25 days after sowing.

All the plants in 234A were hand pollinated daily with the pollen from 234B of the same treatment during the entire flowering period. Number of days for ray floret opening, days to 50% flowering and head diameter (cm) were recorded. The crop was harvested at physiological maturity stage and seeds were separated by gentle beating of the heads with a stick. After thorough sun drying the seeds were cleaned and weighed. Percentage of filled seeds/head was worked out by taking the number of filled seeds/head to that of total number of seeds. The weight of 1000 seeds selected at random from each net plot yield was recorded. Percentage oil content was determined by Nuclear Magnetic Resonance Spectrometer (NMR). Standard germination test was conducted using seeds that were stored for 45 days after harvest (ISTA, 1996). Vigour index was computed adopting the formula suggested by Abdul Baki and Anderson (1973). The experimental data were statistically analysed as per Cochran and Cox (1965).

Higher level of nitrogen significantly influenced the days required for ray floret opening and 50% flowering (Table-1). This is attributable to the effect of N in facilitating vegetative growth and delaying flowering as also sunflower being a nitro-negative crop. Mary Kamal *et al.* (1997) also reported the delay in flowering due to higher nitrogen doses. Application of nitrogen at 90 kg/ha resulted in larger heads (12.7cm) that might be due to better vegetative growth of the plant ultimately resulting in better source and translocation to the developing heads. Nagavani *et al.* (1997) also recorded increase in head diameter with 100 kg N/ha. However, nitrogen application has not influenced the seed filling percentage which is in agreement with the findings of Ujjinaiah *et al.* (1995). The highest seed yield of 1460 kg/ha was obtained with 90 kg N/ha which may be due to an increase in head size and number of filled seeds.

There was decrease in oil content with increased levels of nitrogen (Table-2). This may be due to the very fact that as the nitrogen supply increases, protein formation also increases at the cost of the formation of oil. Seeds that were produced with 90 kg N/ha had highest germination and vigour that may be due to the bold seeds and reduced oil content favouring early emergence due to less time and energy needed for conversion of lipids to glucose for initiation of germination. Mary Kamal *et al.* (1997) also reported higher germination and vigour due to higher nitrogen levels.

Among the genotypes sterile lines had larger heads and produced higher yield that could be attributed to their bold size.

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MSFH-8 being a long duration hybrid, needed more water than variety, Morden. Increased water use efficiency (WUE) with MSFH-8 attributed to higher seed yield under each increasing frequency of irrigation. Similar trend were observed by Narwal and Malik (1985) in sunflower cultivars.

MSFH-8 and Morden under higher level of fertilizers (90 kg N, 45 kg P_2O_5 and 45 kg K_2O/ha) had significantly higher seed yield than at lower level (60 kg N, 30 kg P_2O_5 and 30 kg K_2O/ha) under varying irrigation schedules in both years (Table-1 and Table-3). Results are in agreement with the findings of Singh *et al.* (1987); Kumar *et al.* (1991) and Bindra and Kharwara (1992) which reported higher seed yield in higher fertility levels. Increasing the growth period which resulted in improvement of growth and yield parameter and consequently the yield.

Table 2 Effect of irrigation schedules and genotypes on mean seed yield (kg/ha) of sunflower (mean of two years)

Cultivar	IW/CPE ratio		
	0.4	0.6	0.8
Morden (Variety)	999	1419	1587
MSFH-8 (Hybrid)	1570	2004	2285
SEm±	61	-	-
CD (P=0.05)	176	-	-

For germination, requirement of irrigation was uniform, however, but for the crop growth period, 2, 3, 4 irrigations for Morden and 2, 4, 5 for MSFH-8 under 0.4, 0.6 and 0.8 IW/CPE ratio respectively in both years were required. The CUW and WUE had correspondingly higher value with every increase in the irrigation schedules. Increase in frequencies of irrigation based on IW/CPE as 0.4, 0.6 and 0.8 exhibited corresponding significant gain in seed yield. All though consumptive use of water increased with successive increase in the frequency of irrigation, the corresponding increase in WUE attributed higher seed yields. These findings were in agreement with findings of Vivek and Chakar (1992).

Table 3 Effect of irrigation schedules and fertility levels on mean seed yield (kg/ha) of sunflower (mean of two years)

Fertility level (N, P_2O_5 and K_2O kg/ha)	IW/CPE ratio		
	0.4	0.6	0.8
60 : 30 : 30	1205	1569	1736
90 : 45 : 45	1364	1854	2137
SEm±	52	-	-
CD (P=0.05)	163	-	-

References

Bindra, A. and Kharwara, P.C. 1992. Response of spring sunflower (*Helianthus annuus* L.) to nitrogen application and spacing. *Indian Journal of Agronomy*, 37(2) : 283-284.

Kumar, S., Dixit, R.S. and Tripathi, H.P. 1991. Effect of nitrogen and nutrients uptake and oil content of sunflower (*Helianthus annuus* L.) under different moisture regimes. *Journal of Agricultural Sciences*, **61**(10) : 766-768.

Narwal, S.S. and Malik, D.S. 1985. Response of sunflower cultivars to plant density and nitrogen. *Journal of Agricultural Sciences*, **55** (1) : 95-97.

Singh, S.P., Singh, O.P. and Singh, V. 1987. Studies on the growth and yield of sunflower varieties in relation to nitrogen rates. *Journal of Oilseeds Research*, **4**(2) : 169-174.

Vivek, K. and Chakar, I.S. 1992. Effect of nitrogen and irrigation on growth and yield of sunflower (*Helianthus annuus* L.) under mid hills conditions of Himachal Pradesh. *Indian Journal of Agronomy*, **37** (3) : 500-502.

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Short communication

Influence of seeding time on oil content and oil yield in castor cultivars during *rabi* season

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India is the global leader in the production and trade of castor bean occupying 6.89 lakh ha. area, 8.41 lakh tonnes production with a productivity of 1220 kg/ha (CMIE, 2000). Crop growth and the resultant yield is a product of interaction between genetic makeup of the cultivar and the external environment, which in turn vary in nature. Agronomy plays a critical role not only in enhancing the yield and returns but also in improving the quality output. The information on the contribution of production factors of castor cultivars for post monsoon period in Andhra Pradesh, (especially under irrigated conditions) is insufficient. Therefore it is inadequate to launch production programmes on commercial scale to increase castor productivity. This prompted the present study to standardize agronomic practices for post monsoon period under irrigated conditions in Southern Telangana zone of Andhra Pradesh.

A field study was conducted at Farm, College of Agriculture, Rajendranagar, Hyderabad during *rabi* 2000 under irrigated conditions. The treatments comprising four dates of sowing and four cultivars were laid out in a factorial randomized block design with three replications (Table 1). The field was characterized by low, medium and high in available nitrogen (192.40 kg/ha), phosphorus (28.7 kg/ha) and potassium (302 kg/ha) respectively with pH of 7.9. Seed rate of 5 kg/ha with a spacing of 90 cm x 60 cm was adopted and recommended dose of N : P_2O_5: K_2O, 40: 40: 20 kg/ha was applied. Six irrigations were given during crop growth period in addition to the winter rainfall of 137.3 mm. Need based plant protection measures were adopted. Yield, yield attributes, oil content and oil yield were determined by following standard procedures.

The yield attributing characters of the castor were highly influenced both by sowing dates and cultivars. Among the sowing dates 1st September sowing recorded significantly higher number of spikes/plant and capsules/spike over remaining dates of sowing. As far cultivars concerned, hybrids recorded significantly more number of spikes/plant compared to varieties, giving an edge to GCH-4 though it was on par with DCH-177. But the difference in number/ capsules/spike in GCH-4 reached to a peak level significantly surpassing the values recorded by remaining genotypes. Surprisingly the values recorded by remaining genotypes corroborating with the findings of Hegde *et al.*, (2000).

In oilseeds, the synthesis of oil in the seed is a function of genetic makeup of a cultivar and is not much altered by environmental conditions. In the present study, dates of sowing have not exerted significant influence on oil content. The oil content of castor ranged between 48.7% and 49.4%. Though 1st September sown crop had less oil content in seeds, but it recorded higher oil yield of 862 kg/ha due to its higher bean yield compared to remaining dates of sowing. Significant improvement in number of spikes/plant and capsules/spike of September sowing have contributed for higher bean yield. As the bean yield distinctly reduced with every successive delay in sowing date beyond 1st September there was a concomitant decline in oil yield, although there was marginal increase in oil content. However, sowing dates and cultivars could not elicit any significant interaction, as for the above parameters under study.

Hybrid DCH-177 recorded significantly more oil content than GCH-4 and DCS-9 but on par with PCS-4. Though GCH-4 recorded significantly less oil content compared to DCH-177 its oil yield was highest (931 kg/ha). The increase in oil yield of GCH-4 over DCS-9, PCS-4 and DCH-177 was 37, 29 and 6% respectively. The increase in oil yield of GCH-4 was a direct out come due to significantly more bean yield. Increased number of spikes/plant especially number of capsules/spike contributed for enhanced bean yield of GCH-4 that reflected in final oil yield. These results are in agreement with Sudha Rani (2001).

Therefore, it can be concluded that September first week is the ideal for *rabi* castor for reaping more bean and oil yield. Hybrid like GCH-4 can be selected under similar agroecological conditions.

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Table 1 Effect of nitrogen levels (N) on yield and seed quality of CMS-234A and B lines of sunflower

Genotype (G)	Days to ray floret opening Nitrogen levels (kg/ha)				Days to 50% flowering Nitrogen levels (kg/ha)				Head diameter (cm) Nitrogen levels (kg/ha)				Seed filling (%) Nitrogen levels (kg/ha)				Seed yield (kg/ha) Nitrogen levels (kg/ha)			
	30	60	90	Mean	30	60	90	Mean	30	60	90	Mean	30	60	90	Mean	30	60	90	Mean
CMS-234A	50	51	56	52	54	56	60	57	11.8	13.0	13.6	12.8	84.08	86.02	85.60	85.23	940	1469	1833	1414
CMS-234B	51	53	58	54	54	56	61	57	10.5	10.7	11.9	11.0	94.67	91.30	93.11	93.03	736	884	1087	903
Mean	50	52	57	53	54	56	61	57	11.2	11.9	12.7	11.9	89.37	88.66	89.36	89.13	838	1177	1460	1158
For comparing	G	N	G x N		G	N	G x N		G	N	G x N		G	N	G x N		G	N	G x N	
SEm±	0.2	0.2	0.3		0.1	0.2	0.2		0.04	0.05	0.07		0.52	0.64	0.91		10.01	12.26	17.34	
CD (P=0.05)	0.6	0.7	NS		0.4	0.5	NS		0.12	0.14	0.20		1.58	NS	2.73		30.16	36.94	52.24	

Table 2 Effect of nitrogen levels (N) on seed quality parameters of CMS-234A and B lines of sunflower

Genotype (G)	Oil content (%) Nitrogen levels (kg/ha)				Test weight (g) Nitrogen levels (kg/ha)				Seed germination Nitrogen levels (kg/ha)				Vigour index (VI) Nitrogen levels (kg/ha)			
	30	60	90	Mean	30	60	90	Mean	30	60	90	Mean	30	60	90	Mean
CMS-234A	39.9	39.4	38.4	39.2	40.3	49.3	51.5	47.0	62.73 (79.00)	66.63 (84.25)	71.85 (90.25)	67.08 (84.50)	2031	2216	2404	2217
CMS-234B	38.8	38.3	38.0	38.4	37.5	41.5	45.3	41.3	62.23 (78.25)	68.05 (86.00)	71.80 (90.25)	67.36 (84.83)	1919	2197	2396	2171
Mean	39.3	38.8	38.2	38.8	38.9	45.3	48.4	44.2	62.48 (78.63)	67.34 (85.13)	71.83 (90.25)	67.21 (84.67)	1975	2207	2400	2194
For comparing	G	N	G x N		G	N	G x N		G	N	G x N		G	N	G x N	
SEm±	0.05	0.06	0.09		0.04	0.05	0.07		0.25	0.31	0.43		10.60	12.99	18.36	
CD (P=0.05)	0.15	0.19	0.26		0.12	0.15	0.21		NS	0.87	NS		31.9	39.1	55.3	

Figures in the parenthesis indicate original percentages
NS = Non-significant

References

Abdul Baki, A.A. and Anderson, J.D. 1973. Vigour determination in soybean seed by multiple criteria. *Crop Science*, **13** : 630-637.

Cochran, W.G. and Cox, G.M. 1965. *Experimental Designs*. Asia Publishing House, Bombay 2nd Ed pp.293-304.

ISTA. 1996. International rules for seed testing. *Seed Science Technology*, **24** (Suppl.) : 335-337.

Mary Kamal, P., Lawrence, M. and Shaik Mohammad. 1997. Influence of sowing method of parental lines and nitrogen rates on synchronisation of flowering, yield and seed quality of sunflower hybrid, APSH-11. *Journal of Oilseeds Research*, **14**(1) : 102-106.

Nagavani, A.V., Ramachandra Reddy, P., Soundararajan, M.S. and Anjaneyulu, A. 1997. Growth and yield of sunflower as influenced by irrigation and nitrogen management. *Journal of Oilseeds Research*, **14**(2) : 315-317.

Ujjinaiah, U.S., Thimmegowda, S., Sridhara, S. and Prasad, T.G. 1995. Effect of moisture, plant population and fertilizer regimes on yield of sunflower. *Helia*, **18**(22) : 77-82.

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Short communication

Performance of castor under different tillage systems in rice fallow situations in coastal Orissa

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In India, castor (*Ricinus communis* L.), an important crop is grown in an area of 10.77 lakh hectares and with a production and productivity of 8.67 lakh tonnes and 805 kg/ha respectively (DOR, 2000-2001). There is a possibility of increasing the area under this crop by growing it in rice (*Oryza sativa* L.) fallows (upland) which remain uncropped during *rabi* in Orissa state. This area is around 0.85 million hectares and offers good potential for raising castor crop after rice harvest. This may result in augmenting the production of castor, a potential foreign exchange earner for the country. Identification of a suitable castor variety/hybrid and proper establishment of crop stand through appropriate tillage is considered vital. Practically no work has been done on this aspect. Hence, the present study has been carried out to obtain information.

Preliminary field experiments were carried out in winter 1996-97 and 1997-98 at the Central Rice Research Institute, Cuttack, Orissa to identify a suitable variety/hybrid of castor and tillage practice for achieving desired level of yield in upland rice fallow situations. The soil was alluvial and sandy loam in texture (sand 60.82%, silt 24.08% and clay 15.0%) with a pH 6.28, cation exchange capacity 13.68 meq/100 g soil, organic carbon 0.573%, total N 0.074%, available P 13.5 kg/ha and available K 78 kg/ha. During *kharif* (June to September) a general crop of upland rice (cv. Annada) of short duration (100 days) was grown under direct-seeded system. After the harvest of rice, castor was sown under different tillage practices (as detailed in Table-1). The crop was sown on 8th October during the two years of studies. A spacing of 60 cm x 30 cm was adopted. A fertilizer level of 60 kg N and 30 kg each of P_2O_5 and K_2O/ha was given as basal application. During the first year, in treatment T_1, two irrigations, one each at 30 and 50 days after sowing were given. During the subsequent year only one irrigation at 50 days after sowing was given. The rainfall received during the crop growth period was 59.1 mm during the first year and 163.5 mm during the second year. All the recommended agronomic practices were followed for raising the crop. The data on seed yield, spikes/plant (mean of 5 plants) and 100-seed weight were recorded.

Crop performance as influenced by tillage practices

Among the tillage practices, the best performance in terms of seed yield was recorded by the treatment T_1 (conventional tillage + supplemental irrigation) during both the years. This treatment was significantly superior to other treatments. Next best was the treatment T_2 (conventional tillage without irrigation) (Table-1). The conventional tillage helped to loosen and pulverise the soil which helped in better stand establishment, root penetration and development, provided better aeration and consequently better growth of the plants possibly due to higher nutrient uptake. This favourable environment helped in improving the number of spike/plant and test weight. Providing supplementary irrigation to the crop under conventional tillage system (T_1) was beneficial in further boosting the mean yield to an extent of 21.3% over that without irrigation i.e., residual moisture and with winter rains. However, the findings suggested that castor crop can produce reasonably good yields even on residual moisture/with winter rains in rice fallow situations. It can thus be inferred that yields can be further boosted by providing supplementary irrigation (possibly through water harvesting) if available will be of some benefit. Improvement in the yield of castor by irrigation to an extent of 20% was reported by Rao and Venkateswarlu (1988) regarding the other tillage systems, it is observed that minimum tillage (tillage in the rows only without disturbing the interspaces) proved better than zero tillage. But both these tillage systems were inferior to conventional tillage. It was observed that the crop under these treatments (zero and minimum tillage systems) was stunted in growth with leaf yellowing. The low yields recorded in these treatments were due to less number of spikes/plant and test weight as compared to conventional tillage treatments. This was probably due to the fact that the restriction of root growth resulting in lower uptake of uptake of nutrients and lower fertilizer use efficiency.

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Table 1 Yield attributes, yield, oil content and oil yield of castor cultivars as influenced by sowing dates

Treatment	Number of Spikes/plant	Number of Capsules/primary spike	Bean yield (kg/ha)	Oil content %	Oil Yield (kg/ha)
Sowing dates					
1st September	9	67	1751	48.8	862
15st September	8	63	1691	49.3	832
1st October	7	59	1625	49.1	799
15st October	7	56	1539	49.5	757
SEm ±	0.2	0.8	27	0.3	13
CD (P=0.05)	0.6	2.3	78	NS	37
Cultivars					
DCS-9 (Jyoti)	6	57	1397	48.5	678
PCS-4 (*Kranti*)	7	60	1458	49.2	717
GCH-4	9	71	1903	48.9	931
DCH-177	9	66	1751	50.1	877
SEm ±	0.2	0.8	27	0.3	13
CD (P=0.05)	0.6	2.3	78	0.9	37
Sowing date x Cultivar					
SEm ±	0.4	1.6	54	0.67	26
CD (P=0.05)	NS	NS	NS	NS	NS
CV(%)	7.4	3.3	9	1.6	5.6

References

CMIE. 2000. Centre for Monitoring Indian Economy. Agriculture Economic Intelligence Service. November, 2000:180-183.

Hegde, D.M., Reddy, B.N., Raghavaiah, C.V., Sudhakara Babu, S.N. and Padmavathi, P. 2000. Low cost production technology of castor. Directorate of Oilseeds Research, Hyderabad 500 030, AP.

Sudha Rani. 2001. Crop growth and development of castor cultivars under optimal and sub-optimal water and nitrogen conditions in Telangana Region. Ph.D. Thesis submitted to Acharya N.G. Ranga Agricultural University, Hyderabad-500 030, AP.

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Short communication

Response of sunflower (*Helianthus annuus* L.) to application of organic manures and chemical fertilizers and their effect on soil properties

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One of the greater concerns of modern agriculture is the sustainability to produce higher yields from a single crop and higher total annual yields under intensive cropping system. The present conditions of reduced availability, rising prices and higher energy costs of non-renewable (fertilizers) sources of nutrients restrict the farmers from reaping full benefits of modern technology. Besides, continuous use of high analysis fertilizers has imposed additional problem of soil fertility such as acidity, alkalinity, soil and ground water pollution. Therefore, in order to maintain the soil health which is a prerequisite for sustaining productivity, the simplest and easiest way is by proper blending of chemical fertilizers with organic manures, which not only supplies the plant nutrients but also improves the soil physico-chemical properties.

A field experiment was conducted on a sandy clay loam soil during *rabi* 1995-96 at the College Farm, College of Agriculture, ANGRAU, Rajendranagar, Hyderabad. The soil was slightly alkaline in reaction (pH 8.0), low in available N (210 kg/ha), medium in P (42 kg/ha) and K (292 kg/ha).

The experiment was laid out in a randomized block design with 12 treatments, each replicated thrice (Table-1). The crop received an uniform dose of 60 kg/ha P_2O_5 and 40 kg/ha K_2O as basal through Single Super Phosphate and Sulphate of Potash respectively and nitrogen @ 6 kg/ha was applied through urea. Organic manures were applied 10 days before sowing.

The dry matter production increased with crop growth in all the treatments (Table-1) with maximum dry matter production being recorded at harvest, and increase in dry matter production from 55 days after sowing (DAS) to harvest was more when compared to increase in dry matter production from 30 DAS to 55 DAS in all the treatments. Treatment T_{11}, which received 1 t/ha poultry manure (PM) plus 75% of recommended dose of nitrogen (RDN) recorded significantly highest dry matter production which was on par with T_7, which received 3 t/ha PM. The combined application of organics and inorganic N fertilizer resulted in increase in dry matter production significantly at all stages of crop growth. The phosphorus and potassium in manure might have helped to maintain a higher level of available nutrients in the soil for a longer period than the fertilizers alone which led to an increased drymatter production by the crop. The results are in conformity with the results of Agasimani and Hosmani (1989); Balasubramanian and Palaniappan (1994) and Madhavi *et al.* (1995).

Application of manures alone and in combination with inorganic nitrogen increased the nutrient content of the crop at all the stages of the crop growth (Table-1). Increasing manure dose resulted in increase in the available nutrients content. Among the treatments, T_{11} recorded significantly the highest nutrient contents which were on par with T_7. The results are also in conformity with the studies of Naik and Ballal (1968) and Yadav *et al.* (1989). At higher levels of poultry manure i.e., 3 t/ha increase was not significant. The increase in nutrient contents due to the addition of organic manures may be attributed to the greater availability of nutrients to the plants in their presence due to solubilising effect on fixed forms of nutrients in soil.

The nutrient uptake was more due to manure application (Table-2). The increasing trend of nutrient uptake upto harvest was a consequence of progressive increase in the corresponding dry matter production. The uptake of nutrients was found to be higher in case of combined application than organic manures application alone (except in the treatment T_7 which received 3 t/ha of PM). The poultry manure might have prevented precipitation and fixation of nutrients and keep them in soluble form and this resulted in higher uptake of nutrients by the crop at all the stages of growth. Treatment T_{11}, which received poultry manure at 1 t/ha along with 75% of recommended dose of nitrogen (RDN) recorded significantly highest uptake rates of all the nutrients being at par with T_7, which received 3 t/ha of PM. The results of the present study are in conformity with the findings of Sagare *et al.*, 1992.

After harvest of the crop, the soils were analysed for both chemical and physical properties. The treatment (T_7), which received 3 t/ha PM, equivalent to 120 kg N/ha recorded higher values of available N, P and K and it was

Table 1 Effect of tillage treatments and genotypes on the performance of castor grown in rice fallow situations under uplands (pooled mean data of two years)

Treatment	Plant height (cm)	Number of spikelets/ plant	Seed yield (kg/ha)	Test weight (g)
Tillage practices				
T_1	120	4	1022	27.0
T_2	104	3	834	26.9
T_3	87	1	368	26.5
T_4	73	1	307	26.4
CD (P=0.05)	9.5	0.3	68	0.4
Genotypes				
V_1	95	2	594	27.6
V_2	97	2	671	25.9
CD (P=0.05)	NS	NS	34	0.3

T_1 : Conventional tillage-sowing castor irrigated (once or twice); T_2 : Conventional tillage and sowing castor-unirrigated; T_3 : Minimum tillage-making furrows and sowing castor seed-unirrigated; T_4 : Zero tillage-dibble seeding of castor in the interspaces between the harvested stubbles-unirrigated;
V_1 : DCS 9 (variety); V_2 : DCH 30 (hybrid)

Between the two genotypes, the hybrid DCH-30 produced significantly higher seed yield than that of the variety DCS-9. The increase in yield recorded in the hybrid DCH-30 over DCS-9 was worked out to be 14.4%. Such superior performance of castor hybrids over varieties was earlier reported by Fatteh *et al.* (1988). Similarly, Sudhakara Babu *et al.* (1994-95) reported better performance of DCS-9 and DCH-30 under late sown conditions.

The results of this study gave an indication that castor crop can produce a reasonably good yield when grown in rice fallow situations with conventional tillage system on residual moisture and the yield can be further improved by providing supplemental irrigation.

References

DOR. 2001-2002. Executive Summary. Annual Progress Report, 2001-2002, Castor. Directorate of Oilseeds Research, Hyderabad-500 030.

Fatteh, U.G., Patel, A. and Patel, P.S. 1988. Hybrids revolutionize castor production in Gujarat. *Indian Farming*, **38** (1) : 25-36.

Rao, C.M. and Venkateswarlu, M.S. 1988. Effect of irrigation, nitrogen and plant density on yield attributes and yield of castor varieties. *Journal of Research APAU*, **16 (1)** : 37-39.

Sudhakara Babu, S.N., Raghavaiah, C.V. and Muralidharudu, Y. 1994-95. Evaluation of promising prerelease genotypes of castor for agronomic management. *Annual Report, 1994-95*. Directorate of Oilseeds Research, Hyderabad-500 030.

Table 2 Effect of combined application of organic manures and inorganic nitrogen on uptake of nutrients (kg/ha) by sunflower at different stages of crop growth

Treatment	Nutrient content (%)											
	Nitrogen				Phosphorus				Potassium			
	30 DAS	55 DAS	Stalk	Seed	30 DAS	55 DAS	Stalk	Seed	30 DAS	55 DAS	Stalk	Seed
T_1	3.0	17.7	7.5	14.9	0.3	7.9	2.4	3.0	2.3	21.1	18.4	5.57
T_2	3.9	19.2	10.0	22.4	0.4	8.9	3.4	4.9	2.8	22.3	22.3	8.36
T_3	4.3	21.2	10.5	23.3	0.5	9.8	3.7	5.2	3.1	24.3	22.9	8.68
T_4	4.7	23.2	10.9	24.5	0.6	10.8	3.8	5.5	3.4	26.6	23.5	9.04
T_5	4.6	23.7	10.8	24.8	0.6	11.2	4.0	5.6	3.5	27.3	23.7	9.14
T_6	6.3	30.7	14.6	30.6	0.9	14.8	5.6	7.4	4.7	34.4	30.7	11.25
T_7	6.8	31.5	15.2	31.4	1.0	15.3	6.0	7.6	5.1	35.5	31.6	11.59
T_8	5.8	27.3	13.9	28.1	0.8	12.9	5.1	6.4	4.2	30.6	28.9	10.12
T_9	6.0	28.9	14.3	29.2	0.9	13.9	5.3	6.8	4.4	32.5	29.5	10.55
T_{10}	5.6	26.7	13.2	27.1	0.8	12.6	4.8	6.1	4.1	30.1	27.7	9.70
T_{11}	6.8	31.5	15.1	31.4	1.0	15.4	6.0	7.6	5.1	35.5	31.4	11.58
T_{12}	6.3	30.3	14.4	30.0	0.9	14.6	5.5	7.1	4.6	34.4	31.2	10.91
SEm±	0.2	0.3	0.2	0.3	0.0	0.2	0.1	0.1	0.2	0.6	0.4	0.1
CD (P=0.05)	0.3	0.7	0.4	0.7	0.1	0.5	0.3	0.2	0.3	1.2	0.8	0.3

T_1 : Control (No manure/fertilizers); T_2 : FYM 5 t/ha; T_3 : FYM 7.5 t/ha; T_4 : FYM 10 t/ha; T_5 : Poultry manure 1 t/ha
T_6 : Poultry manure 2 t/ha; T_7 : Poultry manure 3 t/ha; T_8 : Recommended dose of N T_9 : FYM 5 t/ha+75% RDN; T_{10}: FYM 5 t/ha+50% RDN
T_{11}: PM 1 t/ha+75% RDN and T_{12} : PM 1 t/ha+50% RDN

Table 1 Effect of combined application of organic manures and inorganic nitrogen on drymatter production (kg/ha) and nutrient content (%) of sunflower at different stages of crop growth

Treatment	Drymatter production (kg/ha)			Nutrient content (%)											
				Nitrogen				Phosphorus				Potassium			
	30 DAS	55 DAS	Harvest	30 DAS	55 DAS	Stalk	Seed	30 DAS	55 DAS	Stalk	Seed	30 DAS	55 DAS	Stalk	Seed
T_1	105.2	878.5	2174.2	2.9	2.0	0.9	2.5	0.3	0.9	0.3	0.5	2.2	2.4	2.2	0.9
T_2	124.5	904.5	2736.5	3.1	2.1	1.0	2.6	0.3	1.0	0.3	0.6	2.3	2.5	2.3	1.0
T_3	141.6	981.5	2798.0	3.1	2.2	1.0	2.6	0.4	1.0	0.4	0.6	2.3	2.5	2.3	1.0
T_4	147.4	1060.8	2871.4	3.2	2.2	1.1	2.7	0.4	1.0	0.4	0.6	2.3	2.5	2.3	1.0
T_5	145.6	1077.8	2899.6	3.2	2.2	1.0	2.7	0.4	1.0	0.4	0.6	2.3	2.5	2.3	1.0
T_6	189.6	1323.4	3563.1	3.3	2.3	1.1	2.8	0.4	1.1	0.4	0.7	2.5	2.6	2.4	1.1
T_7	204.6	1351.1	3633.0	3.3	2.3	1.1	2.8	0.5	1.1	0.4	0.7	2.5	2.6	2.4	1.0
T_8	177.8	1197.2	3207.7	3.3	2.3	1.1	2.8	0.5	1.1	0.4	0.6	2.4	2.6	2.3	1.1
T_9	181.5	1261.5	3311.2	3.3	2.3	1.1	2.8	0.5	1.1	0.4	0.7	2.4	2.6	2.3	1.0
T_{10}	170.9	1180.5	3194.1	3.3	2.3	1.1	2.8	0.4	1.1	0.4	0.6	2.4	2.6	2.3	1.0
T_{11}	203.3	1350.4	3631.6	3.3	2.3	1.1	2.8	0.5	1.1	0.5	0.7	2.5	2.6	2.4	1.0
T_{12}	189.9	1371.1	3465.6	3.3	2.3	1.1	2.8	0.5	1.1	0.4	0.7	2.4	2.6	2.4	1.1
SEm±	6.4	8.8	32.8	0.01	0.08	0.01	0.01	0.02	0.03	0.01	0.01	0.01	0.01	0.01	0.01
CD (P=0.05)	13.3	18.3	68.0	0.03	0.17	0.02	0.02	0.04	0.07	0.03	0.03	0.03	0.02	0.02	0.02

T_1 : Control (No manure/fertilizers); T_2 : FYM 5 t/ha; T_3 : FYM 7.5 t/ha; T_4 : FYM 10 t/ha; T_5 : Poultry manure 1 t/ha
T_6 : Poultry manure 2 t/ha; T_7 : Poultry manure 3 t/ha; T_8 : Recommended dose of N T_9 : FYM 5 t/ha+75% RDN; T_{10}: FYM 5 t/ha+50% RDN
T_{11}: *PM 1 t/ha+75% RDN and* T_{12} : *PM 1 t/ha+50% RDN*

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ıort communication

ıcreasing efficacy of phosphatic fertilizers through bi-inoculation of *ıradyrhizobium* and phosphate solubilizing bacteria in rainfed soybean, *ɜlycine max*

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Being a legume, soybean not only maintains the N status of the soil but also utilizes more P and K from the applied sources (Nimji and Seth, 1988; Dubey and Shrivastava, 1991). Phosphorus is also involved in several energy transformation and biochemical reactions. Thus, soil inoculation with phosphate solubilizers in the rhizosphere of the crop soils may benefit the plant by increasing the P availability from native fixed or added P from insoluble sources like rock phosphate and utilization efficacy of water soluble P fertilizers like super phosphate (Gaur, 1987). Therefore, it was considered appropriate to study the effect of phosphate solubilizing bacteria '*Pseudomonas striata*' as bi-inoculant with *Bradyrhizobium japonicum* alone as well as with P fertilizers in rainfed soybean on vertisols and its residual effect on some soil properties of Vindhyan plateau of Madhya Pradesh.

The field experiment was conducted during *kharif* 1995 and 1996 on vertisols. The soil was clayey having sand 28.2%, silt 30.7% and clay 41.1% and 41.1 me/100 g of soil cation exchange capacity, with pH (8.1), electrical conductivity (0.48 dS/m), available N (213.7 kg/ha), P (5.7 kg/ha) and K (373.2 kg/ha). The experiment was laid out in randomized block design with three replications. The ten treatments involving combination of *Bradyrhizobium japonicum* (Local Isolate-Sehore-1), *Pseudomonas striata*, (IARI, New Delhi), superphosphate and rock phosphate were tested. Inoculation with *B. japonicum* was common for all the treatments. Basal dose of 20 kg N/ha as urea and 16.8 kg K/ha as muriate of potash and P fertilizers were applied at sowing. Soybean cv. JS 75-46 was grown in 4.0 m x 2.7 m plots at 40 cm row spacing.

Total N and P contents in drymatter and seed were analysed (Tandon, 1993). Whereas, symbiotic efficiency ratio was determined at 60 days after sowing (Simhadri, 1975). Soil efficiency and nutrient requirement for N and P was computed as per Das *et al.* (1995).

Growth parameters: Plant height, branches and leaves/plant significantly increased with all the treatments compared to control except rock phosphate (T_6 and T_8) which was at par with control (Table-1). The difference among super phosphate (T_2 and T_4) and rock phosphate (T_6 and T_8) were found to be significant, but, become at par when applied with bi-inoculants. Present results are in confirmation with those of Nimji and Seth (1988).

Yield attributes: Number of pods/plant significantly increased only with treatment T_4, T_5, T_6 and T_9 compared to control, whereas pod weight, number of seed and seed weight/plant increased in all the treatments over control.

Symbiotic efficiency: The symbiotic efficiency ratio of the N fixation at 60 days after sowing improved by the P application coupled with P bio-inoculant.

Seed and biomass yield: Seed yield significantly increased with different levels and sources of P or with bi-inoculation of *B. japonicum* and *P. striata* (Table-2), except in case of rock-phosphate alone (T_6 and T_8).

Drymatter accumulated at harvest enhanced in all the treatments over control. While, shedded residues showed differential response, which, was maximum under T_3 and showed a further increase with the use of co-inoculants alone as well as with P fertilizers than the single inoculation probably due to availability of more P to the plants. These findings are in agreement with the findings of Raut and Kohire (1991).

Total N and P uptake: Total N and P uptake significantly increased in all the treatments except with T_6 which was at par with control and further enhanced with bioinoculation than in the control.

Soil efficiency: Soil efficiency (SE) for N and P of the different treatments showed that P-solubilizing bacteria alone or with P fertilizers was the factor which reduced the SE value for P but increases for N but SE for N and P showed less requirement for N and high for P by the soybean for obtaining good yields.

on par with treatment T_{11}, where PM at 1 t/ha plus 75% of RDN, equivalent to 85 kg N/ha was applied (Table-3). The increased availability of these nutrients in the soil is probably due to the mineralization of nutrients from the manure and reduction in fixation of nutrients by organic matter. Similar results on increase in available nutrient content in the soil due to the application of manures and their combination with inorganic nitrogen were also reported by Kanwar and Prihar (1962) and Sharma and Singh (1991).

Table 3 Physical and chemical properties of the soil after harvest of the sunflower crop

Treatment / Description		OC (%)	BD (g/cc)	Available nutrient content (kg/ha)		
				N	P_2O_5	K_2O
T_1	Control	0.53	1.54	195	39.0	270
T_2	FYM 5 t/ha	0.56	1.53	213	41.8	298
T_3	FYM 7.5 t/ha	0.56	1.52	215	42.2	304
T_4	FYM 10 t/ha	0.57	1.51	218	42.8	312
T_5	Poultry manure 1 t/ha	0.54	1.54	220	43.1	313
T_6	Poultry manure 2 t/ha	0.55	1.54	226	44.2	325
T_7	Poultry manure 3 t/ha	0.55	1.54	238	48.0	339
T_8	RDN*	0.54	1.54	224	43.0	324
T_9	FYM 5 t/ha + 75% RDN	0.56	1.53	232	44.4	329
T_{10}	FYM 5 t/ha + 50% RDN	0.56	1.53	225	43.5	325
T_{11}	PM 1t/ha + 75% RDN	0.54	1.54	241	49.3	343
T_{12}	PM 1 t/ha + 50% RDN	0.54	1.54	234	48.2	338
	Initial	0.54	1.54	210	42.0	292

* RDN = Recommended dose of nitrogen

References

Agasimani, C. A. and Hosmani, M. M. 1989. Response of groundnut crop to FYM, N and P in rice fallows in coastal sandy soils. *Journal of Oilseeds Research*, **6** (2) : 360-363.

Balasubramanian, P. and Palaniappan, S. P. 1994. Effect of combined application of bacterial inoculation along with farm yard manure on irrigated groundnut (*Arachis hypogaea* L.). *Indian Journal of Agronomy*, **39** (1) : 131-133.

Kanwar, J. S. and Prihar, S. S. 1962. Effect of continuous application of manures and fertilizers on some physical properties of Punjab soils. *Journal of the Indian Society of Soil Science*, **10** : 243-247.

Madhavi, B. L., Suryanarayan Reddy, M. and Chandrasekhar Rao, P. 1995. Integrated nutrient management using poultry manure and fertilizers for maize. *The Journal of Research APAU*, **23** (3&4) : 1-4.

Naik, B. N. and Ballal, D. K. 1968. Effect of the association of organic matter with nitrogenous fertilizer on availability and uptake of plant nutrients and the growth of plant. *Journal of the Indian Society of Soil Science*, **16** : 155-160.

Sagare, B. N., Guhe, Y. S., Deshmukh, B. A. and Desmukh, A. B. 1992. Biological yield and uptake of nutrient by peanut as influenced by enriched FYM product. *Journal of Maharashtra Agricultural Universities*, **17** (1) : 100-102.

Sharma, U. C. and Singh, K. 1991. Integrated management of phosphate and farmyard manure in potato-radish cropping sequence on an acidic soil. *Journal of the Indian Society of Soil Science*, **39** (2) : 468-471.

Yadav, K., Jha, K. K., Prasad, C. R. and Sinha, M. K. 1989. Kinetics of carbon mineralization from poultry manure and sewage sludge in two soils at field capacity and submergence moisture. *Journal of the Indian Society of Soil Science*, **37** (2) : 240-243.

Nutrient requirements: Nutrient requirement for N and P was maximum under superphosphate @ 26.4 kg/ha P + bi-inoculation but was close to same dose of rock-phosphate applied with bioinoculation and minimum under control.

Residual fertility status: The reduction in pH had positive relationship with the amount of P solubilized by phosphate solubilizing bacteria which indicated the production of organic acids which is considered to be sole mechanism responsible for the solubilization of insoluble and soluble phosphate. The performance of PSM might have affected if the pH of the nutrient medium is altered. The pH of the rhizosphere is also the controlling factor for availability of P and other essential nutrients and also activity of soil microorganisms. Electrical conductivity of the soil remained unaffected due to various treatments.

It is evident that both phosphate application and co-inoculation of *B. japonicum* and *P. striata* increased the status of available N (242 to 261 kg/ha) (Table-3). This enrichment was due to addition of organic matter through shedded residues, root and nodules in soil and increase in symbiotic and non-symbiotic N_2 fixation. The trend of available P also showed a significant increase (3.3 to 6.4 kg/ha in various treatments) than control but it was lower than the initial status (5.7 kg/ha). The status of available K also showed similar trends, which increased under treatment T_2, T_3, T_4 and T_5 than control but it was lower than initial K. This reduction in K was probably due to high K demand by soybean crop for vegetative growth and seed formation. It seems that plants have removed some native soil K as well due to premising effect of fertilization causing depletion in K from soil (Dubey and Srivastava, 1991). Above information indicated that there is a need to relook on K recommendation for soybean specially in vertisols.

Table 3 Initial and post-harvest status of soil as influenced by various treatments in soybean

Treatment	pH	EC (1:2) (dS/m)	Available nutrients (kg/ha)		
			N	P	K
Initial status post-harvest	8.1	0.48	213	5.7	373
T_0	8.0	0.41	242	3.3	270
T_1	7.6	0.39	248	4.6	276
T_2	7.9	0.42	247	4.5	266
T_3	7.7	0.42	252	5.8	293
T_4	7.9	0.40	260	5.4	294
T_5	7.7	0.40	267	7.3	268
T_6	8.0	0.41	246	4.0	259
T_7	7.6	0.41	260	5.0	279
T_8	8.1	0.41	251	4.1	276
T_9	7.6	0.41	261	6.4	287
CD (P=0.05)	0.17	NS	7.37	0.54	NS

It is observed that availability of P to soybean can be enhanced by mobilization of natural P or through added P fertilizers and to facilitate establishment of higher population of efficient inoculum of *B. japonicum* and P solubilizing bacteria *P. striata* when applied simultaneously through seed treatment. Resource poor farmers can save 13.2 kg P/ha applied as super phosphate by dual inoculation to harvest respectable yield levels. The

Table 1 Effect of *Pseudomonas striata* and *Bradyrhizobium japonicum* as co-inoculant on growth, yield, yield attributes and symbiotic efficiency of rainfed soybean (Mean of 2 years)

Treatment	Plant height (cm)	Branches/ plant	Leaves/ plant	Pods/ plant	Pod weight/ plant (g)	Seeds/ plant	Seed weight/ plant (g)	Seed index (g)	Symbiotic efficiency ratio (60 days)
T_0	43	2	7	26	9	42	7	12	-
T_1	46	3	8	28	11	52	9	13	1.09
T_2	47	3	10	28	11	55	9	13	1.09
T_3	48	3	10	29	12	56	10	13	1.12
T_4	47	3	11	30	14	62	11	13	1.17
T_5	50	3	12	34	15	66	13	14	1.29
T_6	43	3	8	27	10	48	8	13	1.02
T_7	48	3	9	28	12	55	10	13	1.08
T_8	45	3	8	27	10	50	8	13	1.04
T_9	49	3	10	32	15	63	12	14	1.18
CD (P=0.05)	2.05	0.61	1.20	2.63	0.61	3.48	0.60	0.61	-

T_0 - *Bradyrhizobium* inoculated control No P + No *Pseudomonas striata*)
T_1 - Bi-inoculation with *Pseudomonas striata*
T_2 - Superphosphate @ 13.2 kg P/ha
T_3 - Superphosphate @ 13.2 kg P/ha + *Pseudomonas striata*
T_4 - Superphosphate @ 26.4 kg P/ha
T_5 - Superphosphate @ 26.4 kg P/ha + *Pseudomonas striata*
T_6 - Rock phosphate @ 13.2 kg P/ha
T_7 - Rock phosphate @ 13.2 kg P/ha + *Pseudomonas striata*
T_8 - Rock phosphate @ 26.4 kg P/ha
T_9 - Rock phosphate @ 26.4 kg P/ha + *Pseudomonas striata*

Table 2 Seed and drymatter yields, shedded residues, total uptake, soil efficiency, nutrient requirement of soybean as influenced by bi-inoculation of *Bradyrhizobium japonicum* and *P. seudomonas striata* (Mean of 2 years)

Treatment	Seed yield (kg/ha)	Drymatter yield (straw+pod husk (Kg/ha)	Shedded residues at harvest (t/ha)	Total uptake (kg/ha)		Soil efficiency (%)		Nutrient requirement (kg/q)	
				N	P	N	P	N	P
T_0	1560	2090	0.53	117.3	8.3	48.5	251.5	7.52	0.53
T_1	1660	2700	0.50	138.9	10.5	56.1	228.3	8.36	0.63
T_2	1690	2740	0.56	143.6	10.8	58.1	240.0	8.47	0.64
T_3	1790	3180	0.57	160.5	12.4	63.7	213.8	8.95	0.69
T_4	1870	3020	0.57	163.9	13.0	63.0	240.7	8.77	0.69
T_5	1930	3490	0.60	186.6	14.6	70.0	200.0	9.66	0.75
T_6	1600	2460	0.53	125.0	9.1	50.8	227.5	7.79	0.57
T_7	1880	2840	0.57	147.4	11.2	56.7	224.0	7.84	0.59
T_8	1630	2510	0.54	133.3	9.5	53.1	231.7	8.20	0.58
T_9	1880	3120	0.58	172.3	13.4	65.9	209.4	9.16	0.71
CD (P=0.05)	63	28	0.018	7.36	0.51	-	-	-	-

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Short communication

Effect of crop geometry, phosphorus levels and phosphate solubilizing bacteria on growth, yield and oil content of sunflower, *Helianthus annuus*

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Sunflower is an important oilseed crop grown after rice harvest in eastern part of Chhattisgarh. Being a new introduction in rice based cropping system it required development of a suitable agro-technique for realising the higher yield. Suitable crop geometry and phosphorus application besides other agronomic practices are of paramount importance as it has higher phosphorus requirement. Application of phosphorus and phosphate solubilizing bacteria (PSB) has been reported promising in increasing the yield of sunflower (Jones and Sreenivasa, 1993; Mishra *et al.*, 1994). The information on these aspects for eastern part of Chhattisgarh is lacking. Therefore, the present investigation was undertaken to find out optimum crop geometry and phosphorus nutrition with or without PSB for sunflower.

A field experiment on sunflower was conducted during the winter season of 1999-2000 at Regional Agricultural Research Station, IGAU, Raigarh after harvesting of medium duration rice grown under puddle condition. The treatment consisted were three crop geometries (40x30 cm, 50x20 and 60x20 cm) as main plot and three levels of phosphorus (40, 60 and 80 kg P_2O_5/ha) with and without phosphate solubilizing bacteria (5 kg/ha) as sub plot. The experiment was laid out in split plot design with three replications. The soil was clay loam in texture having 85 cm soil depth, slightly acidic in reaction (pH 6.2) low in available nitrogen (210 kg/ha) and phosphorus (11.2 kg/ha) and medium in available potassium (375 kg/ha). Phosphorus as per treatment along with 60 kg N and 40 kg K_2O/ha were applied through single super phosphate, urea and muriate of potash, respectively. Nitrogen was applied in two equal splits as basal and 30 days after sowing at button initiation stage. The sunflower hybrid KBSH 1 was sown on December 20, 1999 and harvested on March 27, 2000. The seeds were dibbled and the field was irrigated after sowing. After 30 days of sowing one inter-cultivation and weeding was performed before the application of nitrogen at button initiation stage. All other recommended agronomical practices were followed to raise the crop. The data on growth and yield attributes obtained from ten randomly selected plants and yield obtained from net plot were subjected to statistical analysis. Five irrigations were given to the crop at different stages i.e. just after sowing, 30 days after sowing, flowering, grain filling and dough stage. A total of 43.6 mm rainfall was received during the crop period. Oil content was analysed using Soxhlet apparatus.

The results revealed that crop geometry of 60x20 cm recorded significantly higher values of growth, yield attributes, seed yield and oil yield as compared to crop geometry of 40x30 cm. However, it was at par with crop geometry of 50x20 cm in respect of plant height, head diameter, seed weight/head and 1000 seed weight (Table-1). The crop geometry of 40x30 cm significantly reduced the head diameter, 1000 seed weight, seed weight/head and seed yield. Higher number of filled seeds/head, grain weight/head and 1000 seed weight were mainly responsible for higher yield at crop geometry of 60x20 cm. Besides, these factors the crop geometry of 60x20 cm provided more light interception and there by higher photosynthesis. The results are in conformity with the findings of Ujjinaiah et *al.* (1994). Oil content in seed was not influenced significantly with different crop geometry. Similar results were also reported by Rao and Saran (1991).

Phosphorus application significantly increased the plant height, filled seeds/head, 1000 seed weight, seed weight/head and seed yield, whereas head diameter remained unaffected due to different phosphorus levels. (Table-1). Significantly higher plant height, filled seeds/head, 1000 seed weight, seed yield (1311 kg/ha) and oil yield (540 kg/ha) were recorded with the application of 80 kg P_2O_5/ha over 60 and 40 kg P_2O_5/ha. However, it was found at par with 60 kg P_2O_5/ha in respect of seed weight/head. Plant height and 1000 seed weight were found similar with the application of 40 and 60 kg P_2O_5/ha. Application of 80 kg P_2O_5/ha increased the seed yield by 6.2 % and 13.0 % as compared to 60 and 40 kg P_2O_5/ha, respectively. In P deficient soils application of phosphorus increased the concentration of P ions in soil solution

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application of super phosphate @ 26.4 kg P/ha with co-inoculants was found to be more beneficial than applied without inoculants. Rock phosphate applied either 13.2 to 26.4 kg P/ha with co-inoculation was at par with the same dose applied by super phosphate alone. These results suggested that 40-45% P/ha could be saved with the use of 13.2 kg P/ha as SSP and co-inoculation with *B. japonicum* and P solubilizing bacteria to seed.

References

Das, S.K., Sharma, K.L., Saharan, Neelam and Srinivas, K. 1995. *Soil fertility management* and fertilizer use (in) *Sustainable Development of Dryland Agriculture in India*, Eds. Singh, R.P., Scientific Publishers, 54, New Pali Road, P.O. Box 91, Jodhpur, pp.15-44.

Dubey, S.K. and Srivastava, S.K. 1991. Response of *Bradyrhizobium japonicum* inoculation on soybean (*Glycine max.*) and its residual effect as succeeding wheat (*Triticum aestivum*) crop. *Indian Journal of Agricultural Sciences*, **61**(10) : 769-71.

Gaur, A.C. 1987. *Organic manures and bio-fertilizers*. Division of Microbiology, Indian Agricultural Research Institute, New Delhi, pp.46-65.

Nimji, P.M. and Seth, J. 1988. Effect of phosphorus and farm yard manure on nutrient uptake by soybean. *Indian Journal of Agronomy*, **33**(2) : 139-142.

Raut, R.S. and Kohire, O.D. 1991. Phosphorus response in chickpea (*Cicer arietinum*) with *Rhizobium* inoculation. *Legume Research*, **14**(2) : 78-82.

Simhadri, P. 1975. Relationship between the physiological properties of different strains of *Rhizobium* sp., and their performance on pigeonpea. M.Sc. (Ag.) Thesis submitted to G.B. Pant University of Agriculture and Technology, Pantnagar, p.142.

Tandon, H.L. 1993. *Methods of analysis of soils, plants, waters and fertilizers*. Fertilizer Development and Consultation Organization, 204-204A, Bhanot corner, 1-2 Pamposh enclave, New Delhi, pp.13-15, 54-58.

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Short communication

Relative efficiency of herbicides for weed control in sunflower

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Weeds pose serious problem in the cultivation of sunflower. If unchecked, weeds can reduce the crop yield to a greater extent. Wet soil conditions due to incessant rains do not permit mechanical weeding to create weed free condition. Hence use of herbicides has become necessary to reduce weed menace during the early stages of sunflower crop. An investigation was, therefore, conducted to study the efficacy of herbicides in sunflower.

An experiment was conducted on Vertisols at MRS, UAS, Dharwad, during *kharif* 1998 in a randomized block design with three replications. Sunflower variety KBSH-1 was sown on June 23rd and recommended package was followed to raise the crop. The herbicides were sprayed on the same day of sowing using herbicide solution @ 750 l/ha with the help of a low volume sprayer. Weed dry weight/metre^2 was recorded at harvest, yield and yield attributing characters were also recorded.

The weed flora in the experimental plot consisted of monocot weeds like *Cyperus rotundus, Cyanodon dactylon, Digitaria* sp, *Echinochloa crus-galli*, and *Setaria* spp. and dicotyledonous like *Acalypha indica, Abutilon indicum, Commelina benghalensis, Convolvulus arvensis, Euphorbia hrita* and *Phyllanthus nirui.*

The results indicated that weed-free check recorded significantly higher yield (1220 kg/ha) and was on par with pre-emergent application of alachlor @ 2.0 kg a.i./ha (1180 kg/ha) (Table-1). The higher yields in these treatments could be related to their favourable effects on yield components like head diameter, 1000-seed weight and filled seeds/head, which in turn could be attributed to effective weed control. Alachlor recorded the highest weed control efficiency (72.7 %) and the lowest weed dry weight, since it was able to control the weeds effectively by inhibiting weed seed germination, early seedling growth and root growth. (Mehrotra *et al.*, 1984; Suresh and Venkat Reddy, 1994). Other herbicides were comparable in weed control and were next in the order.

Table1 Effect of herbicides on weed control in sunflower

Treatment	Dose (kg/ha)	Weed drymatter at 30 DAS (g/m^2)	Weed control efficiency at harvest (%)	Plant height at harvest (cm)	Yield parameters			Yield (kg/ha)	Reduction over weed free check (%)
					Head diameter (cm)	Filled seeds/head	1000 seed weight (g)		
Imazethapyr+ pendimethalin* (pre- emergent)	2	1.17 (0.90)	54.5	146	13	617	28.0	960	21.3
Imazaquin + pendimethalin** pre-emergent)	2	1.13 (0.70)	64.6	47	2	54	27.0	230	81.2
Acetachlor (pre-emergent)	2	1.15 (0.85)	57.1	154	13	760	30.0	850	30.3
Alachlor (pre-emergent)	2	0.95 (0.45)	72.1	172	14	987	33.4	1180	3.3
Trifluralin (Pre-plant)	2	1.11 (0.73)	63.1	167	14	691	29.0	910	25.4
Weed free check	--	0.70 (0.00)	100.0	168	15	900	36.5	1220	-
Unweeded control	--	1.98	-	164	9	492	29.0	620	48.8
SEm±		0.04	1.87	3	0.4	23	1.1	70	
CD (P=0.05)		0.12	5.47	10	1.2	71	3.5	210	

Note- figures in the parenthesis are transformed values, DAS- days after sowing * Pursuit plus ** Squdron (Trade names)

However, pre-emergent application of Imazaquin+ pendimethlin @ 2 kg/ha had complete killing effect on crops and the resown seeds had very poorly (head diameter-2 cm, 1000-seed weight-27g and number of filled seeds/head 54.0) resulting in lower yield (230 kg/ha). Still it recorded 64.6% weed control efficiency and 1.13 g/m of weed dry matter.

It is concluded that presently recommended practice of alachlor @ 2 kg/ha is superior to other herbicides. Of the two mixed herbicides Imazaquin + pendimethlin is toxic to sunflower at the rates studied.

References

Mehrotra, U. N., Tewari, R. N. and Kumar, A. 1984. Weed control in sunflower through herbicides. *Indian Journal of Agricultural Research*, **18** : 30-34.

Suresh, G. and Venkat Reddy, N. 1994. Weed management studies in *kharif* sunflower. *Journal of Oilseeds Research*, **11**(2) : 297-299.

resulted in to enhanced vigorous root growth and over all development of plants which, ultimately resulted in increased yield attributes and yield. The increased yield attributes and yield of sunflower in the present investigation corroborated with Mishra *et al.* (1994), Chandrashekara and Patil (1997) and Agrawal *et al.* (2000). Oil content in seed increased gradually with increasing level of phosphorus and the highest was recorded with the application of 80 kg P_2O_5/ha. Jones and Sreenivasa (1993) and Mishra *et al.* (1994) also reported increased oil content in seeds of sunflower with the application of phosphorus. Inoculation with phosphate solubilizing bacteria significantly increased the 1000 seed weight, seed yield, oil content in seed and oil yield as compared to uninoculated condition. Jones and Sreenivasa (1993) have reported increase in seed yield and oil content in seed of sunflower due to inoculation with phosphate solubilizing bacteria. However, head diameters, filled seeds/head and seed weight/head were remained unaffected. Interaction effects were not significant.

Table 1 Growth, yield and its attributes in sunflower as influenced by crop geometry, phosphorus levels and phosphate solubilizing bacteria

Treatment	Plant height at maturity (cm)	Head diameter (cm)	Filled seeds/ head	Seed weight/head (g)	1000 seed weight (g)	Seed yield (kg/ha)	Oil content (%)	Oil yield (kg/ha)
Crop geometry								
40 x 30 cm	86	10	537	24	46	1082	39.9	452
50 x 20 cm	98	11	550	27	48	1252	40.0	501
60 x 20 cm	107	11	590	28	49	1371	40.2	551
SEm±	2.9	0.1	8.4	0.5	0.5	27.7	0.5	13.7
CD (P=0.05)	11.5	0.6	33	2.1	1.8	109	NS	54
P_2O_5 (kg/ha)								
40	92	11	547	25	48	1160	38.8	450
60	96	11	559	26	48	1235	40.1	495
80	103	11	572	27	49	1311	41.2	540
SEm±	1.6	0.3	3.8	0.3	0.2	22.8	0.2	8.9
CD (P=0.05)	4.6	NS	11	0.9	0.7	66	0.8	26
Phosphate Solubilizing bacteria								
Uninoculated	96	11	559	26	47	1212	39.8	482
Inoculated (5 kg/ha)	99	11	560	26	49	1259	40.4	509
SEm±	1.3	0.3	3.1	0.2	0.3	13.5	0.1	7.3
CD (P=0.05)	NS	NS	NS	NS	1.0	39	0.4	21
CV (%)	7.0	10.1	2.9	5.4	2.2	7.8	3.0	7.6

References

Agrawal, M. M., Verma, Bhagat Singh and Kumar, Chunchun. 2000. Effect of phosphorus and sulphur on yield, N, P and S content and uptake by sunflower (*Helianthus annuus*). *Indian Journal of Agronomy*, **45**(1) : 184-187.

Chandrashekara, C. P. and Patil, V. C. 1997. Influence of VAM inoculation and phosphorus on dry matter production and seed yield of two sunflower (*Helianthus annuus* L.) genotypes. *Journal of Oilseeds Research*, **14**(2) : 210-215.

Jones, Nirmalnath P. and Sreenivasa, M. N. 1993. Response of sunflower to the inoculation of VA mycorrhiza and/or phosphate solubilizing bacteria in black clayey soil. *Journal of Oilseeds Research*, **10**(1): 86-92.

Mishra, A., Das. P., and Paikaray, R. K. 1994. Performance of sunflower in relation to nitrogen and phosphorus in acid soils of Orissa. *Journal of Oilseeds Research*, **11**(2): 288-290.

Rao, Kameswara S. V. C. and Saran, Ganga. 1991. Response of sunflower cultivars to planting density and nutrient application. *Indian Journal of Agronomy*, **36**(1): 95-98.

Ujjinaiah, U. S. Rajashekara, B. G. and Seenappa, K. 1994. Spacing and nitrogen requirement of sunflower hybrids. *Journal of Oilseeds Research*, **11**(1): 20-23.

It was observed that plant height, primary spike length and seed yield/plant varied significantly for Zn levels. Differential response to zinc levels was observed in castor genotypes. Significant response to zinc application by GCH-4 was reported (DOR 2000-2001). Interaction effects were found to be significant for seed yield/plant. Seed yield of castor genotypes was influenced significantly by increasing levels of zinc. Higher seed yield/plant was observed in GCH-4, DCH-32 and Kranti when zinc at 5 kg/ha was applied and at 10 kg Zn/ha it was found redundant whereas 48-1 recorded a slightly higher seed yield at 10 kg Zn/ha. DCH-32 seed yield was significantly highest at 5 kg Zn/ha application.

From the above studies, it may be inferred that in red soils (Alfisol) having low zinc status castor hybrid GCH-4 was found superior and zinc at 5 kg/ha was found to be optimum dose.

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References

DOR 2000-2001. Annual Progress Report, Castor, 2000-2001. Directorate of Oilseeds Research, Rajendranagar, Hyderabad - 500 030, AP., pp.167.

Gomez, K. and Gomez. A. 1984. *Statistical Procedures for Agricultural Research*. 2nd Ed. John Willey & Sons, New York. pp. 680.

Naik, K.G.A., Manure, G.R. and Badiger, M.K. 1993. Yield of castor by fertilizing with phosphorus, sulphur and boron. *Journal of the Indian Society of Soil Science*, **41** (4): 686-688.

Tandon, H.L.S. (Ed.) 1995. *Micronutrient Research and Agricultural Production*. Fertilizer Development and Consultation Organisation, New Delhi, India. pp. 614+ix.

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Short communication

Evaluation of castor genotypes under low zinc Alfisols

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Castor (*Ricinus communis* L.) is an important rainfed oilseed crop in the Telangana region of Andhra Pradesh characterized by low soil fertility especially low organic carbon, low P and Zn status and thus productivity of castor is lowest in the country. Castor is grown in different soil types in India, which are in general found to be deficient in zinc. Soils having DTPA extractable Zn below 0.6 mg/kg, in general were considered as zinc deficient (Tandon, 1995). Castor is classified as one of the very sensitive crop to zinc deficiency in soil. Few researchers (Naik *et. al.*, 1993; DOR, 2000-2001) have reported response to micronutrients application in castor. Several newer genotypes of castor are available for cultivation being recommended for wide range of agro climatic conditions. These genotypes have varying growth habits and also respond differently to management practices. An attempt was made to evaluate few promising castor varieties/hybrids to determine the response and optimum dosage of zinc in low Zn red soils (Alfisols).

A pot culture experiment was conducted at the Directorate of Oilseeds Research, Rajendranagar, Hyderabad during *kharif*, 1999. The physico-chemical properties of the soil were pH (1:2) 6.7, E.C. (1:2) 0.3 dS/m, Organic carbon 0.4%, available N, P and K 129.3, 5.8 and 336.0 kg/ha respectively. DTPA extractable zinc was 0.46 mg/kg. In each polythene lined earthen pot five kg of zinc deficient red soil was filled. Recommended dose of NPK (40:30:0) and Zn @ 0, 5 and 10 kg/ha was applied in a completely randomized design with three replications. Two castor plants per pot were maintained by following all the recommended cultural practices until primaries harvest. Growth parameters and seed yield were recorded and analyzed statistically (Gomez and Gomez, 1984).

Castor hybrids/varieties showed significant variation in their growth characteristics (Table-1). Castor hybrids, GCH-4 and DCH-32 were found relatively superior. Among the varieties, 48-1 recorded higher plant height, spike length and number of capsules/spike. The seed yield/plant was higher with hybrids and GCH-4 recorded highest seed yield, which was significantly higher over varieties (Table-1).

Table 1 Growth parameters of castor hybrids/varieties at different Zn levels

	Plant height (cm)	Primary spike length (cm)	No. of nodes upto primary	No. of capsules/plant	Seed yield (g/plant)
Genotypes					
DCH-32	54	13	12	7	4.9
GCH-4	54	13	13	10	5.4
Kranti	57	9	12	7	4.0
48-1	58	16	14	11	3.4
SEm±	2.9	0.7	0.5	0.9	0.4
CD (P=0.05)	NS	2.0	1.5	1.5	1.1
Zn levels (kg/ha)					
0	51	12	12	8	3.3
5	61	14	13	10	5.3
10	56	13	13	9	4.6
SEm±	2.5	0.6	0.4	0.8	0.3
CD (P=0.05)	7.3	1.7	NS	NS	0.9
Interaction (Genotype x Zn level)					
SEm±	4.9	1.2	0.9	1.6	0.6
CD (P=0.05)	NS	NS	NS	NS	1.8

Table 1 Effect of weed management on oil content and yield, protein content and yield, sinigrin content and iodine value of Brassica species

Treatment	Oil content		Oil yield (kg/ha)		Protein content (%)		Protein yield (kg/ha)		Sinigrin (%)		Iodine value (No.)		Seed yield (kg/ha)	
	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1996-96	1996-97	1995-96	1996-97
Brassica species														
Brassica juncea cv. RH-30	40.0	41.2	532	703	17.1	16.9	229	290	2.0	2.1	106.0	107.9	1339	1712
Brassica juncea cv. Laxmi	39.9	40.4	532	627	16.7	16.6	224	259	2.0	2.0	105.1	107.1	1343	1556
Brassica carinata cv. HC-2	37.0	37.0	435	477	17.4	17.2	207	222	2.7	2.7	111.9	112.1	1191	1293
SEm±	0.6	0.6	7	11	0.2	0.1	4	5	0.1	0.1	0.4	0.6	12	30
CD(P=0.05)	2.2	2.2	27	45	0.6	0.5	15	18	0.3	0.3	1.8	2.3	47	120
Weed management levels														
Isoproturon @ 0.5 kg a.i/ha-1 (PE)	39.9	40.5	345	479	16.8	16.2	148	190	2.2	2.2	107.0	110.3	884	1175
Pendimethalin @ 1.0 kg a.i./ha (Pre)	38.5	39.0	577	655	17.0	16.8	252	280	2.2	2.2	107.1	108.1	1495	1672
Trifluralin @ 1.0 kg a.i./ha-1 (PPI)	39.6	39.9	499	594	17.2	17.1	215	252	2.2	2.3	108.0	109.3	1257	1482
One manual weeding at 25 DAS	38.9	39.3	552	613	17.0	16.9	238	260	2.2	2.2	107.5	109.0	1415	1553
Two manual weedings at 25 & 45 DAS	38.1	39.0	607	702	17.5	17.4	276	309	2.2	2.3	108.4	110.4	1593	1792
Weed Free	37.7	38.8	642	759	17.7	17.8	298	343	2.3	2.3	109.0	111.3	1705	1945
Weedy check	40.1	40.3	276	416	16.4	16.3	113	166	2.1	2.2	106.7	107.0	687	1024
SEm±	0.9	1.0	20	25	0.3	0.4	11	13	0.02	0.03	0.7	0.8	30	35
CD (P=0.05)	NS	NS	57	71	0.9	1.1	31	36	0.1	0.1	2.0	2.2	87	100

The weed management treatments had significant effect on sinigrin content and iodine value. The weed free and two manual weedings resulted into higher sinigrin and iodine value during both the years. The increase in sinigrin may be due to higher content and uptake of sulphur by crop under these treatments. The increase in glucosides e.g. sinigrin of *Brassica* species with increase in sulphur application have been reported by earlier workers Singh and Singh (1978). The increase in iodine value might be due to the increase in protein content. Since there existed a positive correlation between protein content and iodine value as reported by Thakral *et al.* (1996) and Sharma *et al.* (1997).

References

A.O.A.C. 1980. *Association of Official Methods of Analysis.* 13th Edition (Association of Official Chemists : Washington, D.C.).

Khan, G.M. and Agarwal, S.K. 1985. Effect of moisture stress, sowing methods and nitrogen levels on the quality and oil yield of mustard. *Haryana Agricultural University Journal of Research*, 15 (1) : 82-86.

Pandey, C.S. and Kumar, A. 1984. Efficacy of different weed control measures in Indian mustard (*Brassica juncea* L.) planted at different dates. *Indian Journal of Weed Science*, 16 (4) : 273-275.

Saran, G. and Giri, G. 1987. Influence of dates of sowing on *Brassica* species under semi-arid rainfed conditions of north-west India. *Journal of Agricultural Sciences, Cambridge*, 108 : 561-566.

Sharma, S.K.; Ram Mohan, D.S. and Gupta, S.K. 1997. Effect of crop geometry and nitrogen on quality and oil yield of *Brassica* species. *Indian Journal of Agronomy*, 42 (3) : 498-501.

Singh, M. and Singh, N. 1978. Effect of sulphur on the quality of *raya (Brassica juncea Coss). Journal of Indian Society of Soil Science*, 26 (2) : 203-207.

Thakral, S.K.; Singh, B.P.; Faroda, A.S. and Gupta, S.K. 1996. Effect of irrigation and fertility levels on the oil yield and quality of *Brassica species. Annals of Agricultural Research*, 17 (4) : 416-418.

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Short communication

Effect of weed management on the oil yield and quality of *Brassica* species

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The study was conducted during 1995 and 1996 to determine effect of weed management in *Brassica* species at CCS Haryana Agricultural University, Hisar. Three *Brassica* species in main plots and seven weed management treatments in sub plots were compared on sandy loam soil in a split plot design, with three replications. The *Brassica juncea* cultivars recorded higher oil content, oil yield and protein yield, whereas, higher sinigrin content and iodine value in oil were recorded in *Brassica carinata*. The weed management treatments did not show significant effect on oil content in *Brassicas* but recorded significantly higher oil yield, protein content, protein yield, sinigrin content and iodine value over weedy check.

There has been a significant improvement in the performance of India's vegetable oil sector in the last one decade. But demand of edible oil is ever increasing with the increasing population and improvement in living standard of the people. To bridge the gap of short supply, now choice has widened to non-traditional *Brassica* species too, having comparatively large production potential over traditional. These are relatively slow growing during the early vegetative phase. Weeds take a heavy toll of rapeseed-mustard production and maximum competition of weeds is recorded in the initial stage of crop growth. Keeping the above in view, suitable weed management in *Brassica* species and their effect on quality aspects were assessed.

A field experiment was conducted during *rabi* season in 1995-96 and 1996-97 at CCS Haryana Agricultural University, Hisar on a sandy loam soil (pH-7.8) and organic carbon content 0.2%. The experiment was laid out in a split plot design with three replications. The main plot treatments were comprised of three *Brassica* species and sub-plot treatments were comprised of seven weed management levels (Details in Table 1). The seed was sown with *pora* in rows 30 cm apart on 24[th] November in 1995 and on 14[th] November in 1996. The herbicides were sprayed using knapsack sprayer with 700 l/ha of water. Recommended doses of fertilizer nutrients (80 kg N and 30 kg P_2P_5/ha) were applied to the crop. Half of the nitrogen and whole of phosphatic fertilizer was added at sowing and remaining half of the dose of nitrogen was applied at first irrigation. Oil content in seed was determined by using a non-destructive, quick pulsed Nuclear Magnetic Resonance (NMR) technique and the sinigrin content of oil and iodine value were estimated by AOAC (1980) method.

Effect of *Brassica*

Brassica species differed significantly with each other in respect of oil content, oil yield, protein content and protein yield (Table 1). *Brassica juncea* cultivars registered higher oil content, oil yield, and protein yield as compared to *B. carinata* whereas protein content was higher in *B. carinata* during both the crop seasons. Saran and Giri (1987) also reported higher oil content in *B. juncea* as compared to *B. carinata*. The higher protein in *B. juncea* may be attributed to higher grain yield. The significantly high sinigrin content and iodine value in oil recorded in *B. carinata* as compared to *B. juncea*. These results are in close conformity with the findings of Thakral *et al.* (1996).

Effect of weed management

The weed management treatments did not show significant effect on oil content in *Brassicas* but significantly higher yield, protein content and protein yield were recorded in weed management treatments over weedy check in both the years. Pandey and Kumar (1984) also reported non-significant effect of weed control methods on oil content in mustard. The higher oil yield under weed management treatments was due to the increase in seed yield. The increase in protein content under weed management treatments was probably due to better control of weeds under these treatments which reduced the crop-weed competition for nutrients in general and nitrogen in particular. High N content and uptake observed under these treatments resulted in more protein synthesis. The higher protein content with increasing fertility has been reported by Khan and Agarwal (1985).

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Table 1 Effect of different weed control treatments on weed growth, yield attributes and yield of groundnut

Treatment	No. of weeds/m²	Weed dry weight (g/m²)	Weed control efficiency (%)	Plant population at harvest/m²	No. of pods/ plant	100 seed weight (g)	Pod yield (kg/ha)	Per cent increase in yield over control	Weed index (%)
Fluchoralin 1.0 kg a.i/ha+HW 35 DAS	35	60.6	67.3	29	22	32.6	2583	87	8.5
Pendimethalin 1.0 kg a.i/ha + HW 35 DAS	31	48.6	73.8	30	22	33.1	2610	89	7.6
Butachor 1.0 kg a.i/ha + HW 35 DAS	60	81.0	56.3	30	20	33.8	2412	75	14.6
Oxyfluorfen 0.15 kg a.i/ha + HW 35 DAS	26	39.1	78.9	30	24	32.6	2615	90	7.5
Oxyfluarfen 0.20 kg a.i/ha + HW 35 DAS	22	43.7	76.4	29	22	33.9	2593	88	8.2
Oxyfluorfen 0.25 kg a.i/ha + HW 35 DAS	29	34.5	81.4	29	20	33.9	2500	81	11.5
Weed free	60	12.9	93.0	30	23	34.7	2824	105	-
Weedy check (control)	176	185.4	-	29	14	32.7	1378	-	51.2
SEm±	-	7.0	-	2.6	1.4	1.1	91	-	-
CD (P=0.05)	-	21.2	-	7.9	4.2	NS	276	-	-
CV (%)	-	19.2	-	15.3	11.5	5.7	6.5	-	-

DAS - Days after sowing; HW = Hand Weeding

lower weed control efficiency of butachlor and splash injury to the germinating crop with higher concentration of oxyfluorfen as earlier reported by Patel *et al.* (1997a) and Patel *et al.* (1997b). Maximum percent of yield increase (105%) over control was recorded in weed free treatment, whereas weed index value which showed overall percentage reduction in yield was more (51.2 %) in weedy check compared to weed free.

From the above findings it was concluded that pre-emergence application of oxyfluorfen @ 0.15 kg a.i./ha followed by one hand weeding at 35 days after sowing can be safely advocated for effective control of annual weeds in *rabi*-summer groundnut.

References

Gnanamurthy, P.N. and Balasubramaniyan, P.1998. Weed management practices and their influence on weed growth and yield of groundnut (*Arachis hypogaea* L.). *Indian Journal of Agronomy*, **43**(1): 122-125.

Guggari, A.K., Manjappa, K., Desai, B.K. and Chandranath, H.T. 1995. Integrated weed management in groundnut. *Journal of Oilseeds Research*, **12**(1): 65-68.

Kondap, S.M., Rani, Usha., Reddy, B.B., Swamy, K.R., Rao, A.R. and Reddy, Venkateswara. 1989. Effectiveness of herbicides and cultural methods for the control of weeds in Spanish and Virginia habit group of groundnut (*Arachis hypograea* L.). *Journal of Oilseeds Research*, **6**(1): 128-132.

Murthy, B.G., Agasimani, C.A. and Prathibha, N.C. 1994. Influence of herbicides on yield, quality and economics in rainfed groundnut. *Journal of Oilseeds Research*, **11**(2) : 285-287.

Patel, S. R., Lal, N. and Thakur, D.S. 1997a. Weed control efficiency of different herbicides in rainfed groundnut (*Arachis hypogaea* L.). *Indian Journal of Agricultural Sciences*, **67**(9): 399-401.

Patel, S.R., Agrawal, S.K. and Chandrakar, P.K. 1997b. Weed management studies in *rabi*-summer groundnut (*Arachis hypogaea* L.) grown after rice. *Journal of Oilseeds Research*, **14**(1): 55-58.

Somani, L.L. 1992. *Dictionary of weed science.* Agrotech Publishing Academy, Udaipur. p., 175.

Sumathi, V., Chandrika, V., Muneendra Babu, A. and Nagavani, A.V. 2000. Integrated weed management in rainfed groundnut (*Arachis hypogaea*). *Indian Journal of Agronomy*, **45**(4) : 765-770.

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Short communication

Integrated weed management in *rabi*-summer groundnut, *Arachis hypogaea* L. under rice based cropping system*

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Groundnut is an important oilseed crop grown after rice in eastern part of Chhattisgarh. Among different agronomic practices, weed menace is one of the serious bottlenecks for increasing the yield. The first 4-5 weeks of crop- weed competition in *rabi*-summer groundnut is critical due to the initial slow growth habit of the crop and low temperature during the month of January. Uncontrolled weed growth reduced groundnut yield upto 76% (Gnanamurthy and Balasubramaniyan, 1998). Chemical weed control was found to be the best alternative to manual weeding in the initial stage of growth. Fluchloralin and pendimethalin have been widely recommended for the control of weeds in groundnut (Kondap *et al.*,1989; Patel *et al.*, 1997b). However, pre-emergence application of herbicides may allow the emergence of weeds after sometime. Therefore, the present study was undertaken to find out the effective integrated weed control method in *rabi*-summer groundnut.

A field experiment was conducted during the *rabi*-summer season of 2000 at Regional Agricultural Research Station, IGAU, Raigarh. The eight weed control treatments *viz*; fluchloralin, pendimethalin and butachlor each @ 1.0 kg a.i./ha and oxyfluorfen @ 0.15, 0.20 and 0.25 kg a.i./ha along with a weed-free control and a weedy control were tested in a randomised block design with three replications. The soil of the experimental field was clay loam in texture with pH 7.2 having 280, 15 and 360 kg/ha available N, P_2O_5 and K_2O respectively. Groundnut cv. ICGS 11 was sown at 30 x 10 cm spacing on January 20, 2000 using 120 kg seed/ha in a plot size of 5 x 4 m. The crop was fertilized with 30 kg N, 60 kg P_2O_5 and 30 kg K_2O/ha. Seeds were treated with *Bradichizobium japonicum* culture @ 5 g/kg seed and Bavistin @ 2 g/kg seed before sowing. Fluchloralin @ 1.0 kg a.i./ha was applied before sowing and incorporated in the soil, other herbicides were used as pre-emergence after 48 hours of sowing as the crop was irrigated just after sowing. Hand weeding and inter-culture was done in all weed control treatments at 35 days after sowing except weedy check. Seven irrigations were given to the crop, apart from this a total of 43.6 mm rainfall was received during the 2nd and 3rd week of February 2000. Yield attributes were recorded from ten randomly selected plants and yield was recorded net plot wise. Weeds within the two quadrates of 0.25 m^2 were removed and counted at 30 days after sowing and dried in hot air oven at 60°C. Weed control efficiency and weed index values were calculated as per Somani (1992).

The predominant weed species observed in the experimental field were *Echinochloa colonum* (L.) Link, *Echinochloa crusgalli* (L.) Beauv., *Melilotus alba* L., *Chenopodium album* (L.), *Solanum nigrum* (L.), *Cynodon dactylon* (L.) Pers. and *Cyperus rotundus* (L.). A marked reduction in weed population was observed due to herbicide application as compared to weedy check. Among the different herbicides oxyfluorfen showed lowest weed population and their dry weight, lower concentration of oxyfluorfen was found as effective as the higher concentration in terms of controlling the population and dry weight of weeds. Lowest weed dry weight was recorded with weed free treatment. Maximum weed control efficiency was noticed in weed free treatment followed by oxyfluorfen and pendimethalin as compared to butachlor. Higher weed control efficiency of pendimethalin than butachlor was also reported by Guggari *et al.* (1995). Similar number of pods/plant was recorded with the application of herbicides coupled with one hand weeding and inter-culture at 35 days after sowing but were found significantly superior over weedy check. However, shelling percentage and 100 seed weight were comparable in all the treatments including control. Sumathi *et al.* (2000) obtained higher number of pods/plant with herbicide application followed by hand weeding compared to no weeding.

Highest pod yield (2824 kg/ha) was obtained with weed free treatment. Though it was at par with pre-emergence application of oxyfluorfen @ 0.15 and 0.20 kg a.i./ha, pendimethalin @ 1.0 kg a.i./ha, and pre-sowing incorporation of fluchloralin @ 1.0 kg a.i./ha followed by one hand weeding and inter-culture at 35 day after sowing. This is in conformity with the findings of Murthy *et al.* (1994). Comparatively lower pod yield was obtained with the application of butachlor @ 1.0 kg a.i./ha and oxyfluorfen @ 0.25 kg a.i./ha. This may be due to the on congenial temperatures. However external mycelial growth and sporulation on the cadavers are both temperature and humidity dependent. Good mycelial growth and sporulation occurred at humidity 65% or above. However at 27.5 and 30 °C with humidity less than 60%, mostly mycelial growth with limited or no sporulation was observed (Fig-1). Thus, humidity above 60% was critical for sporulation and proved essential for establishment of *N. rileyi*. These requirements have implication for initiation and development of field epizootics of *N. rileyi*.

A late epizootic of *N. rileyi* was recorded during the rainy season of 1996 at DOR research farm at Narkhoda. Maximum temperature and minimum RH (mean of four standard weeks, 33 - 36) during the epizootic were 28.9 ± 0.47°C and 78 ± 1.14% respectively. Infection in *S. litura* larvae was higher in close canopy groundnut crop (50.9%) when compared to the open canopy crops castor (35.1%) and sunflower (27.1%). Although the prevailing temperature was higher than optimum, all the cadavers observed were with full sporulation as the prevailing humidity was high. It is thus inferred that higher humidity is more crucial for field establishment of *N. rileyi*.

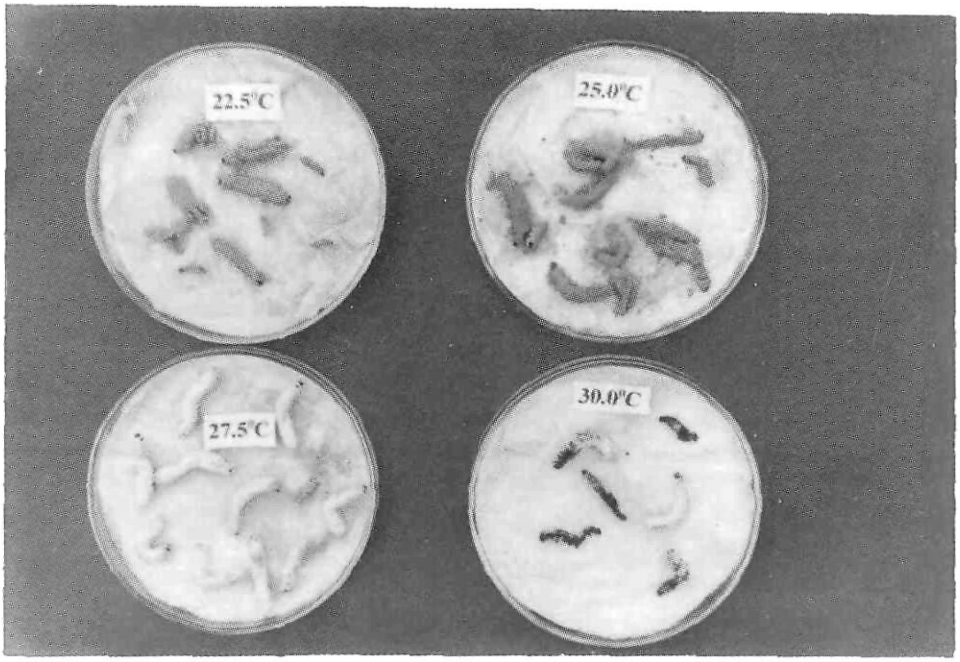

Fig.1 Complete sporulation on mycosed larvae at 22.5 and 25°C (RH 79 and 65% respectively); few larvae sporulated at 27.5°C (RH 59%); varied symptoms on cadavers at 30°C (RH 49%) *viz*., mummification followed by mycelial growth, partly mummified with mycelial growth and partly darkened (mixed infection due to fungus and bacteria) and darkening with putrefication (bacterial infection)

Table 1 Effect of temperature and relative humidity of *N. rileyi* efficacy against *S. litura*

Treatment	RH (%)	Per cent cumulative mortality of *S. litura* due to mycosis at indicated days after spraying			
		6	7	8	9
22.5°C	79	66.7 (54.8)#	91.7 (76.4)	100.0 (90.0)	100.0 (90.0)
25.0°C	65	70.1 (56.9)	100.0 (90.0)	100.0 (90.0)	100.0 (90.0)
27.5°C	59	38.1 (38.2)	75.9 (64.0)	85.4 (71.8)	88.4 (72.0)
30.0°C	49	0	18.1 (25.2)	49.0 (44.4)	59.8 (50.7)
32.5°C	43	0	0	0	0
SEm±		0.8	3.8	3.3	3.2
CD (P=0.05)		3.6	17.9	15.9	15.1
CV (%)		5.59	12.8	12.6	11.7

Values in parentheses are angular transformed

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Short communication

Influence of different temperatures on the efficacy of *Nomuraea rileyi* (F.) *Samson against Spodoptera litura* (Fabricius)

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Fungal pathogens are known to cause epizootics under congenial conditions of humidity and temperature. In India, natural occurrence of *Nomuraea rileyi* (F.) Samson was recorded on *Spodoptera exigua* (Phadke *et al.*, 1978), *Helicoverpa armigera* (Gopalakrishnan and Narayanan, 1989) and *Junonia orithyia* (Rajak *et al.*,1991). *N. rileyi* is a key natural mortality factor of *S. litura* (Fab.) populations in coastal Andhra Pradesh, India on groundnut and cotton (Sridhar and Devaprasad, 1996). *N. rileyi* epizootics have been recorded even in the semi-arid tropics (Hyderabad region, Andhra Pradesh) during the rainy season of 1995 and 1996 (Vimala Devi *et al.*, 1996), and in the post-rainy season in 1998 (Karimnagar district, Andhra Pradesh) (Vimala Devi and Prasad, 1998). Optimum temperature for growth and sporulation of *N. rileyi* was 25°C with severe restriction of growth at 30°C (Ignoffo *et al.*, 1976). Susceptibility of *H. zea* larvae increased with temperature except in instars I and II (Mohammed *et al.*, 1977). Effective utilization of a fungal pathogen in the field requires a knowledge of the critical temperature and humidity requirements by the fungi. This paper presents results of a study carried out with *N. rileyi* against *S. litura* at different temperatures and humidity levels in order to identify the critical temperature and humidity requirements contributing to the establishment of the fungus and to correlate them with the field conditions.

Bioassay with a local isolate of *N. rileyi* (first isolated from *S. litura*) was conducted at the effective dose of 2×10^8 conidia/ml (Vimala Devi, 1994) in a temperature gradient chamber (Nippon, Japan) simultaneously at five different constant temperatures (22.5, 25.0, 27.5, 30.0 and 32.5°C). Prevailing humidity in each of the five chambers was recorded with a hygrometer but was not controlled. *N. rileyi* spore suspension prepared in 0.02% Tween-80 solution was sprayed on to castor leaves with their stalks dipped in water. Fifteen 3rd instar larvae of *S. litura* were released onto the sprayed leaves (when still wet) kept in a glass jar. Three such replicates were maintained for each treatment. Fresh untreated leaves were fed daily two days after exposure. Controls were maintained by releasing larvae on leaves sprayed with 0.02% Tween-80 solution. Observations of larval mortality, mycelial growth and sporulation on cadavers were recorded daily. Data was subjected to ANOVA. Observations of infected and live larvae were recorded during an epizootic at the DOR research farm. Per cent infection was worked out from the total larvae sampled in different cropping systems.

Initial mortality due to mycosis at six days and the cumulative mortality at eight days after exposure was high (P=0.01) at 22.5 and 25°C. Complete sporulation was observed on all the cadavers due to the constant high humidity (79 and 65% respectively). At 27.5°C, the fungus caused low initial mortality at six days (38.13%) but resulted in significant cumulative mortality by nine days (88.44%) after exposure. Good mycelial growth was observed on all the cadavers but sporulation was only partial due to the low humidity (59%). At 30°C, a delay in the initial larval mortality was observed with a cumulative mortality of 59.84% by 9th day after exposure. The dead larvae exhibited varied symptoms *viz.*, mummification followed by mycelial growth, partly mummified with mycelial growth and partly darkened (mixed infection due to fungus and bacteria) and darkening with putrefication (bacterial infection). During the process of fungal infection, invasion of the haemocoel involves injury to the cuticle by the germ tube of the germinating conidia throwing open areas for bacterial entry. Weakening of the defences may predispose the host to bacterial infection (Bucher, 1981). Thus the congenial temperature along with the low humidity could have supported the considerable amount of bacterial infection observed. This bacterial infection could therefore be a secondary effect of fungal infection. At 32.5°C, there was no death due to fungus indicating that the temperature and humidity (43%) were unfavourable for initiation and development of fungal infection. Consequently there was no scope for secondary bacterial infection (Table-1).

Infectivity of *N. rileyi* to *S. litura* occurred at temperatures ranging from 22.5 to 30°C. Infectivity decreased with increasing temperatures above 25°C. The infection process beginning with the germination of conidia on insect cuticle, penetration and development inside the host leading to mummification might or perhaps mostly depend

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Short communication

Influence of sulphur application on the incidence of the mustard aphid, *Lipaphis erysimi* (Kalt.) and *Myzus persicae* (Sulzer)

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Insect pests are one of the major limiting factors influencing mustard yields. About three dozen insect pests have been found infesting rapeseed-mustard crops in India (Rai, 1976). On the basis of economic importance, the mustard aphid, *Lipaphis erysimi* (Kalt.) is considered the key pest. Increasing the level of nitrogen increased the aphid infestation (Upadhyay, 1996), however, an application of 60 kg N + 40 Kg P_2O_5 and 40 kg K_2O/ha has been found suitable, both in terms of pest tolerance and mustard yield (Binay *Kumar et al.*, 1998). However, application of potash had no significant effect on the incidence of mustard aphids (Saha and Kanchan, 1999). Information on the effect of sulphur on the key pests of mustard is very meagre. Hence, the present study was undertaken to study the influence of sulphur application on the incidence of aphids in mustard.

The study on the influence of sulphur application on the incidence of aphids was laid out in randomized block design with four replications. Mustard cv. Varuna was sown as per recommended agronomic practices with the spacing of 30 x 10 cm between rows and plants, respectively. Five different doses of elemental sulphur i.e., 0, 20, 40, 60 and 80 kg/ ha, were given at sowing. Five plants/plot were randomly selected, tagged and the incidence of the aphids i.e., *L. erysimi* and *M. persicae* was recorded at weekly intervals commencing from 30 days after sowing of the crop until a week before harvest. Total aphids counted on five plants were converted on per plant basis. Extent of parasitism of aphids was also counted per treatment 15 days prior to maturity. Sulphur in mustard was estimated and expressed in per cent on per plant basis. For estimating the sulphur content, mustard leaves from randomly selected plants from each plot were plucked at 30, 60 and 90 days after sowing. The sampling dates were 15^{th} December, 15^{th} January and 15^{th} February for 1999-2000 and 2000-2001, respectively. The sulphur content in dried and powdered mustard leaves was determined by the barium chloride gelatin reagent, as per turbidimetric method given by Tabatabai and Bremner (1970).

During 1999-2000, the seasonal incidence of aphids ranged from 157 to 238 and it ranged from 25 to 81/plant during 2000-2001 (Table-1). The aphids reached a peak of 532 and 170/plant in the third week of January during 1999-2000 and 2000-2001, respectively. The population of aphid parasitoids in the different sulphur treatments increased along with the aphid populations and the parasitization percentage was almost steady. The parasitoids recorded were identified as *Diaretus rapae* M'. Intosh (Hymenoptera: Aphidiidae) and *Aphidius* spp. (Hymenoptera: Braconidae).

The different levels of sulphur (0 to 80 kg/ha) applied at the time of sowing did not have any significant effect on the population of aphids infesting the crop during both seasons. During 1999-2000, the maximum aphid population (238 aphids/plant) was observed on plants that received no sulphur (0 level) and the minimum (157 aphids/plant) on plants that received 80 kg/ha. During 2000-2001, the maximum aphid population (81 aphids/plant) was observed on plants that were given 80 kg/ha of sulphur and the minimum (24 aphids/plant) on the plants that received 40 kg/ha, but there was no significant difference. The linear relationship between aphid population and sulphur content in leaves was negative though non-significant. Sulphur content in mustard leaves also did not have any significant difference among the different sulphur levels. However, sulphur application indicated a significant difference in the grain yield. The highest yield was recorded when sulphur was applied @ 60 kg/ha and minimum yield when no sulphur was applied during both the seasons (Table-1). Earlier reports indicate that application of 40 kg N/ha together with 80 kg P_2O_5 and 40 kg K_2O/ha resulted in considerable reduction in aphid infestation and a significant increase in yield (Singh *et al.*, 1995). Potassium applied @ 80 kg/ha reduced the infestation of aphids without use of insecticides (Singh *et al.*, 1997).

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References

Bucher, G.E. 1981. Identification of bacteria found in insects. In *"Microbial control of Pests and Plant diseases 1970-1980"* (H.D. Burges, Ed.), pp. 7-34, Academic Press, New York.

Gopalakrishnan, C. and Narayanan, K. 1989. Epizootiology of *Nomuraea rileyi* (Farlow) Samson in field populations of *Helicoverpa* (= *Heliothis*) *armigera* (Hubner) in relation to three host plants. *Journal of Biological Control*, **3**: 50-52.

Ignoffo, C.M., Garcia, C. and Hostetter, D.L. 1976. Effects of temperature on growth and sporulation of the entomopathogenic fungus *Nomuraea rileyi*. *Environmental Entomology*, **5**: 935-936.

Mohammed, A.K.A., Sikorowski, P. and Bell, J.V. 1977. Susceptibility of *Heliothis zea* larvae to *Nomuraea rileyi* at various temperatures. *Journal of Invertebrate Pathology*, 30: 414-417.

Phadke, C.H., Rao V.G. and Pawar, S.K. 1978. Natural outbreak of the muscardine fungus *Nomuraea rileyi* (Farlow) Samson on leaf eating caterpillar, *Spodoptera exigua* HB. in Maharashtra. *Current Science*, **47**: 476.

Rajak, R.C., Sandhu, S.S., Mukherjee, S., Khare, S. and Gupta, A. 1991. Natural outbreak of *Nomuraea rileyi* (Farlow) Samson on *Junonia orithyia* (Nymphalidae: Lepidoptera). *Journal of Biological Control*, **5**,123-124.

Sridhar, V. and Devaprasad, V. 1996. Life table studies on natural populations of *Spodoptera litura* in on groundnut, *Arachis hypogaea*. *Annals of Plant Protection Sciences*, **4**: 142-147.

Vimala Devi, P.S.1994. Conidia production of the entomopathogenic fungus *Nomuraea rileyi* and its evaluation for the control of *Spodoptera litura* (Fab) on *Ricinus communis*. *Journal of Invertebrate Pathology*, **63**: 145-150.

Vimala Devi, P.S., and Prasad, Y.G. 1998. Fungus to control bollworm in cotton. *The Hindu*, 14th May, 1998

Vimala Devi, P.S., Prasad, Y.G., Rajeswari, B. and Vijay Bhaskar. L. 1996. Epizootic of the entomo-fungal pathogen, *Nomuraea rileyi*, on lepidopterous pests of oilseeds. *Journal of Oilseeds Research* **13**: 144-148.

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Short communication

Influence of time of sowing on bud fly, *Dasyneura lini* Barnes infestation in linseed

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Linseed (*Linum usitatissimum* Linn.) is one of the important nonedible *rabi* oilseed crops and a major source of industrial oil in India. Asynchrony between acreage and productivity is due to many factors, of which insect pests are one of them. The most obnoxious insect pest is the linseed bud fly, *D. lini* Barnes. Under favourable conditions it caused severe losses to the extent of 88% floral bud damage. Complete crop failure was also recorded under pest endemic areas (Malik and Singh, 2000).

Linseed crop is cultivated by resource poor, marginal and sub-marginal farmers, thus application of costly pesticides is not within their reach. Time of sowing is one of the major component of integrated management of bud fly in linseed. Keeping this in view, the present studies were therefore, conducted to determine the most suitable date of sowing, which will not only reduce the bud damage due to bud fly also help to increase linseed yield.

Linseed variety Neelam was sown on seven different dates *viz.*, 30th September (D_1), 15th October (D_2), 30th October (D_3), 15th November (D_4), 30th November (D_5), 15th December (D_6) and 30th December (D_7) at JNKVV Farm, Jabalpur (MP) as per recommended agronomic practices. Weekly observations were recorded on bud infestation due to bud fly by randomly picking 20 buds/10 plant from the first appearance of pest till the crop maturity under all the above dates of sowing.

Studies revealed that the most suitable date of sowing was 15th October, *which had significantly lowest bud infestation* by bud fly as compared to other dates of sowing (Fig-1). Similar findings of least bud damage in October sown linseed crop have been reported (Mathur *et al.*, 1984; Malik and Singh 2000). Since, bud fly is a regular and specific insect pest of linseed, therefore clear cut impact of abiotic factors on bud fly infestation could not be ascertained. However, average temperature of 19-28° C coupled with 62-78% RH and rainfall (3-85 mm) proved conducive for its faster development in the 4th to 8th standard weeks.

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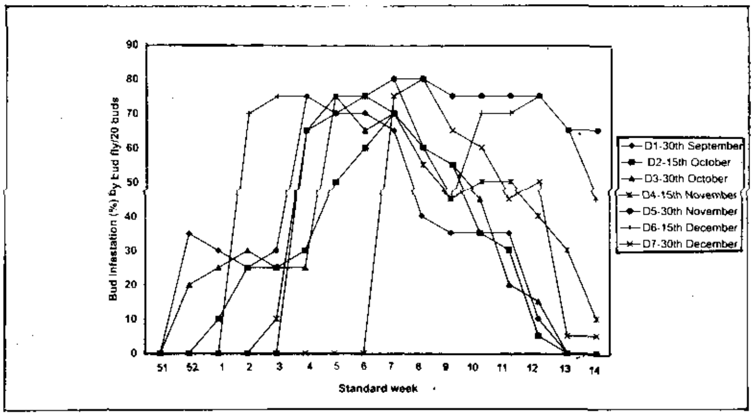

Fig-1 Bud infestation due to bud fly (*Dasyneura lini*) in linseed variety-Neelam as influenced by date of sowings

References

Malik, Y.P. and Singh Harvir. 2000. Insect pests of linseed. In: *Applied Entomology Vol.2. Insect pests of pulses and oilseeds and their management.* (Ed) Anand Kumar and Jagadiswari Rao, pp.214-222.

Mathur, Y.P., Singh, B., Anjor, R. and Srivastava, J.P. 1984. Effect of dates of sowing on the incidence of *Dasyneura lini* Barnes (Diptera : Cicidomyidae) and yield of linseed. *Journal of Oilseeds Research*, **1** (1) : 77-79.

Table 1 Effect of sulphur treatment on the aphids incidence and seed yield of mustard

Sulphur (kg/ha)	Aphids/10 cm top twig/plant		Sulphur content (%) (Plant basis)		Yield (kg)/plot (10 m^2)	
	1999-2000	2000-2001	1999-2000	2000-2001	1999-2000	2000-2001
0	238 (28 to 44)	41 (31-45)	0.61	0.42	0.19^{a}	0.70^{a}
20	178 (31 to 45)	49 (32 to 44)	1.02	0.64	0.21^{a}	1.21^{b}
40	214 (31 to 45)	25 (32 to 44)	0.52	0.47	0.53^{b}	1.58^{bc}
60	222 (30 to 44)	76 (32 to 44)	0.91	0.55	0.66^{b}	1.94^{c}
80	157 (31 to 44)	81 (34 to 44)	0.91	0.38	0.59^{b}	1.58^{bc}
SEm±					0.08	0.15
CD (P=0.05)					0.24	0.46

References

Binay Kumar, Avinash Kumar, Ali, M. S. and Prasad, J. 1998. Effect of different levels of nitrogen on the incidence of mustard aphid, *Lipaphis erysimi* (Kalt.). *Shashpa*, **5**(1): 111-112.

Rai, B. K. 1976. *Pests of Oilseed Crops in India and their Control*, ICAR Publication, New Delhi.

Saha, C. S. and Kanchan B. 1999. Effect of dates of sowing and potash levels on incidence of mustard aphid *Lipaphis erysimi* (Kalt.). *Environment Ecology*, **17**(1): 211-215.

Singh, N. N., Singh, K., Rai, P. C. and Abhijit Sen 1997. Effect of potassium in combinations with insecticides against mustard aphid. *Indian Journal of Entomology*, **59**(3): 253-256.

Singh, R. P., Yazdani, S. S., Verma, G. D. and Singh, V. N. 1995. Effect of different levels of nitrogen, phosphorus and potash on aphid infestation and yield of mustard. *Indian Journal of Entomology*, **57**(1): 18-21.

Tabatabai, M. A. and Bremner, J. M. 1970. A simple turbidimetric method of determining total sulphur in plant materials. *Agronomy Journal*, **62**: 805-806.

Upadhyay, S. 1996. Influence of sowing dates and fertiliser levels on the incidence of aphid (*Lipaphis erysimi* Kalt.) on Indian mustard. *Indian Journal of Entomology*, **57**(3): 294-297.

Table-2 Per cent loss in yield and test weight due to Alternaria blight in different genotypes of linseed

Genotype	*1000-seed weight (g)*			Yield (kg/ha)		
	Protected	Unprotected	% loss	Protected	Unprotected	% loss
Neelam	8.0	7.2	10.0	1191	808	32.1
Garima	7.1	6.7	5.6	1281	1048	18.2
Chambal	6.9	6.2	10.9	1051	674	35.8
Sweta	6.6	6.2	6.1	1110	888	20.1
NDL-8806	6.8	6.2	8.8	958	692	27.8
NDL-8808	7.2	6.8	5.6	1078	875	18.9

Significant higher yield was recorded in Garima followed by Neelam and Sweta while maximum test weight was recorded in Neelam followed by NDL 8808 and Garima (Table-2) under protected condition. Highest loss in yield and 1000-seed weight was recorded in Chambal followed by Neelam, NDL 8806, Sweta, NDL 8808 and Garima. The extent of loss in yield of different genotypes varied from 18.2 to 35.8%. Loss in yield, concurrent with the present findings, in general from 28 to 60% depending upon the severity of the disease has been reported by Chauhan and Srivastava (1975). Eighty per cent yield loss was estimated in susceptible line RLC 28 at Faizabad (Anonymous, 1995).

Kaushik *et al.* (1984) reported 19.30 to 38.80% extent of losses due to Alternaria blight in mustard cultivars. Kolte (1982) also observed 17 to 60% loss due to Alternaria blight in different crops species. Variation in yield loss of different genotypes due to Alternaria blight is in agreement with these findings. Kadian (1982) reported 25% yield loss in Alternaria blight infected rapeseed and mustard crops under humidity and low temperature condition. Fifteen to 25% reduction in yield in case of radish due to Alternaria blight has also been reported by Suhag *et al.* (1983).

References

Anonymous, 1995. Annual Progress Report on Linseed. Directorate of Oilseed Research, Rajendranagar, Hyderabad-500 030 pp.132-134.

Chauhan, L.S. and Srivastava, K.N. 1975. Estimation of loss of yield caused by blight disease of linseed. *Indian Journal of Farm Science*, **31** : 107-109.

Conn, K.L., Tewari, J.P. and Awasthi, R.P. 1990. A disease assessment Key for Alternaria black spot in rapeseed and mustard. *Canadian Plant Disease Survey*, **70** : 19-22.

Dey, P.K. 1933. An Alternaria blight of the linseed plant. *Indian Journal of Agricultural Sciences*, **3** : 881-896.

Kadian, A.K. 1982. Studies on Alternaria blight of Raya (*Brassica juncea* (L.) Czern & Coss.). M. Sc. (Ag.) Thesis, Haryana Agriculture University, Hisar.

Kaushik, C.D., Saharan, G.S. and Kaushik, J.C. 1984. Magnitude of losses in yield and management of Alternaria blight in rapeseed mustard. *Indian Phytopathology*, **37** : 388 (Abstract).

Kolte, S.J. 1982. Diseases of rai and toria. *Indian Farming*, **32** : 91-93.

Suhag, L.S., Singh, R. and Malik, Y.S. 1983. Assessment of losses caused by Alternaria alternata on radish seed crop and its control by chemicals. Indian *Phytopathology*, **36** : 758-760.

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Short communication

Assessment of yield losses due to Alternaria blight of linseed

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Alternaria blight of linseed (*Linum usitatissimum* L.) caused by *Alternaria lini* Dey, first reported from India in 1933 (Dey, 1933), though previously designated as a minor disease, has now become a major problem in different parts of the country, specially in eastern parts of Uttar Pradesh. Since the disease attacks both the assimilative and reproductive, parts of the plant, therefore resulting in higher yield losses. Thus, the present communication deals with the assessment of yield losses due to Alternaria blight of linseed in different genotypes.

The experiment was conducted in *rabi* season during 1995-96 and 1996-97 at the farm of N.D. University of Agriculture & Technology, Narendra Nagar (Kumarganj, Faizabad U.P.) under split plot design in three replications by using six genotypes, namely, Neelam, Garima, Sweta, Chambal, NDL 8806 and NDL 8808. The plot size was 3x2 m and all the recommended practices were followed to have a good crop. Half of the seed of each genotypes was treated with Thiram @ 2.5 g/kg seed separately before sowing. The seeds were sown in third week of October during the testing years. The treated seeds were sown only in protected plots. In unprotected plots untreated seeds of each genotypes were sown. The required amount of spray fungicide (Indofil M-45, 0.25%) was dissolved in a small amount of water and then the volume was made up to the desired level and sprayed in protected plots using high volume Knap-Sack sprayer of 10 litre capacity. Three sprays of fungicide were given in the protected plots starting from the first appearance of the disease and subsequently at 15 days interval. The unprotected plots were sprayed with water only. The disease severity on leaves of protected and unprotected plots was recorded after 10 days of last spray by using 0-5 scale as suggested by Conn *et al.* (1990) and disease intensity (%) was calculated. Bud damage was also recorded separately in each test genotype. Seed yield/plot and 1000-seed weight were also recorded. The data of both the years were pooled and presented in Table-1 and 2.

Significantly higher disease severity on leaves and bud damage (%) were recorded in Chambal followed by Neelam and lowest in Sweta. Severity of the disease on leaves and buds was significantly higher under unprotected conditions irrespective of genotypes. Highest disease control on leaves was observed with genotypes Garima followed by Sweta and Neelam while highest bud protection was observed with genotype Sweta followed by NDL 8806 and Garima. Lowest disease control on leaves was associated with genotype NDL 8806 and bud protection with genotype Neelam (Table-1).

Table-1 Disease severity on leaves and pods under protected and unprotected conditions in different genotypes of linseed

Genotype	Disease severity					
	On leaves (PDI)			On pods (% bud damage)		
	Protected	Unprotected	% disease control	Protected	Unprotected	% bud protected
Neelam	35.1	50.1	30.0	21.4	37.7	43.2
Garima	30.1	47.0	35.9	15.1	29.4	48.6
Chambal	39.6	54.9	27.9	23.0	41.8	45.0
Sweta	28.1	43.3	35.1	11.7	27.1	56.8
NDL-8806	35.4	48.8	27.5	17.5	34.2	48.8
NDL-8808	31.5	44.8	29.7	15.4	29.4	47.6

Table 1 Effect of PEG induced water stress on seedling vigour index, proline and nitrate reductase activity of castor genotypes

Genotype	Seedling vigour index					Proline (μg/g fresh weight)					NRA ($mgNO_2$/g fresh weight/hr)				
	PEG (Bars)					PEG (Bars)					PEG (Bars)				
	0	-3	-6	-9	Mean	0	-3	-6	-9	Mean	0	-3	-6	-9	Mean
GCH 4	*16.0*	*14.8*	*11.0*	*2.0*	*11.0*	*243.8*	*583.7*	*961.6*	*1041.7*	*707.7*	*11.75*	*5.78*	*3.66*	*2.99*	*6.05*
DCH 177	13.9	12.9	8.5	2.0	9.3	293.5	503.5	519.2	534.6	462.7	5.87	2.13	1.75	0.87	2.66
DCH 32	12.2	10.2	6.0	1.6	7.4	153.4	241.3	400.0	00.0	198.1	4.17	1.68	1.59	0.00	1.86
PCH 8	11.0	9.7	4.9	0.0	6.4	116.4	139.4	209.6	00.0	116.4	1.95	1.86	1.00	0.00	1.20
Bhagya	15.5	14.3	10.0	2.4	10.5	259.2	494.4	562.1	646.6	490.6	6.84	6.06	2.16	1.95	4.25
Aruna	13.3	11.0	7.1	1.6	8.3	222.2	352.1	736.2	991.7	575.6	11.75	1.32	1.02	0.94	3.76
Jyoti	11.6	9.9	5.5	0.9	7.0	179.5	181.6	209.2	00.0	142.6	0.89	0.72	0.59	0.00	0.55
Kranti	12.6	11.0	3.7	0.0	6.8	113.5	138.2	150.3	00.0	105.8	1.84	1.52	0.93	0.00	1.07
Mean	13.3	11.7	7.1	1.3		200.3	329.3	468.5	401.8		5.63	2.63	1.59	0.84	

	SEm±	CD (P=0.05)	SEm±	CD (P=0.05)
Genotypes	1.51	4.53	0.09	0.29
Treatments	1.06	3.20	0.07	0.21
G x T interaction	3.02	9.06	0.19	0.58

Damodaram, T. and Hegde, D.M. 1999. *Castor.* pp 134-145. (In) *Oilseed situation. A Statistical Compendium.* Directorate of Oilseeds Research, Rajendranagar, Hyderabad.

Gaecia, A. L., Galinda, L. and Soldatini, G. F. 1992. Biochemical effects of water and salt stress induced by sodium chloride and polyethylene glycol in sunflower seedlings. *Agricultura Mediterranea*, 122 : 322-327.

Jayaraj, T. and Karivartha Raju, T. V. 1992. Influence of harvesting stage on seed vigour in groundnut cultivars. *Seed Research*, 20 : 41-43.

Klepper, L., Flesher, D. and Hageman, R. H. 1971. Generation of reduced nicotinamide adenine dinucleotide for nitrate reduction in young leaves. *Plant Physiology*, 48 : 580-590.

Koti, R. V., Chetti, M. B., Manjunath and Ameragowda, A. 1982. Effect of water stress at different growth stages on biophysical characters and yield in groundnut (*Arachis hypogea* L.) genotypes. *Karnataka Journal of Agricultural Sciences*, 7 : 158-162.

Singh, K. P. and Singh, K. 1983. Water uptake and germination of wheat seeds under different extent water potentials in osmoticum solutions. *Seed Research*, 11 : 13-19.

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Short communication

Screening of castor, *Ricinus communis* L. genotypes for drylands using PEG induced stress*

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Castor (*Ricinus communis* L.) is an important non-edible oilseed crop. In Andhra Pradesh the crop is cultivated over an area of 1.71 lakh ha primarily on dry lands, where moisture is a limiting factor for maintenance of adequate crop stand, crop growth and full expression of its genetic potential. Thus the yield of the crop hovers around a low of 275 kg/ha as compared to all India average of 1048 kg/ha (Damodaram and Hegde, 1999). In dryland situations germination and early seedling growth determine crop stands and seed yields. Amino acids like proline bring about osmotic adjustment and nitrate reductase that reduces nitrate nitrogen assumes importance. To suit such dry situations there is a need to identify genotypes that perform well. The present study was therefore undertaken to screen genotypes on the basis of morphological and biochemical parameters and identify genotypes that would tolerate water stress.

Eight castor genotypes were selected for the study (Table-1). To study the seedling growth, germinated castor seeds were transferred on to the filter paper boats placed in sterile test tubes containing different concentrations of PEG solutions. Seedlings grown for 15 days were utilized for computing seedling vigour index (SVI) as per Jayaraj and Karivartha Raju (1992). Form the leaf tissues of 15 day old seedlings proline and nitrate reductase activity (NRA) were estimated as per Klepper *et al.* (1971) and Bates *et al.* (1973). Data from eight castor genotypes x four PEG concentrations were analyzed in mixed factorial experiment laid out in CRD.

Seedling vigour index (SVI) decreased under PEG induced stress from 11.7 to 1.3 as compared to 13.3 in control (Table 1). GCH 4 and Bhagya were on par (14.8 - 14.3SVI) at - 3 bars stress as was observed in mean SVI values. Differences among genotypes were evident at increased PEG stress. GCH 4 recorded significantly superior SVI (11.0) followed by Bhagya (10.0) and DCH 177 (8.5) at - 6 bars. Seedling growth was not promoted at - 9 bars stress. Singh and Singh (1983) reported a similar decline in SVI due to fall in mobilization of reserve carbohydrates and fats to seedlings thus preventing their growth under water stress.

Proline content increased from 329.3 to 468.5 μg/g fresh weight with increase in PEG stress from -3 to -6 bars as compared to 200.3 μg/g fresh weight in control. Genotypes showed variation in proline content in response to PEG induced stress (Table 1). PEG x Genotype interaction showed GCH 4 recorded high proline (961.6 μg/g) and maintained superiority at -6 bars. Such proline accumulation conferred the adaptive mechanism to water stress, acted as nitrogen storage compound and helped in tolerating stress either by rehydration of protoplasm or by providing energy for recovery of plants. Tolerance to water stress with increased proline content was also observed in groundnut (Koti *et al.*,1982) and sunflower (Garcia *et al.*, 1992).

Nitrate reductase activity (NRA) decreased in response to water stress. At -3, -6, and -9 bars stress 2.63, 1.59 and 0.84 mg NO_2/g fresh weight/hr respectively were recorded. Genotypes under study differed in their response to water stress (Table 1). Bhagya (6.06) followed by GCH 4(5.78) and DCH 177 (2.13) were superior at -3 bars. GCH 4 proved superior to Bhagya at -6 bars (3.66; 2.16) and at -9 bars (2.99, 1.95). The decrease in NRA under water stress was also reported in groundnut Koti *et al.*, 1982 and sunflower (Gaercia *et al.*, 1992).

The present study revealed that at -6 bars PEG induced stress cv. GCH 4 was superior to the castor genotypes in respect of SVI, proline content and NRA. The screening technique could be used for identifying better genotypes that would suit drylands.

References

Bates, L.S., Waldren, R. P. and Teare, L.D. 1973. Rapid determination of free proline for water stress studies. *Plant and Soil*, 57 : 167-176.

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Table 1 Fatty acid composition of six sunflower genotypes during rainy and summer seasons (in %)

Genotype	Palmitic (16:0)		Stearic (18:0)		Oleic (18:1)		Linoleic (18:2)	
	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer
MSFH-17	4.8	7.2	3.5	3.6	48.2	52.1	42.2	37.0
PAC 36	5.2	5.5	1.5	2.5	45.4	49.4	46.6	42.5
KBSH-1	4.4	5.9	3.5	3.0	56.3	46.0	35.8	45.1
DSH-1	4.3	5.3	3.2	4.6	62.6	56.3	29.7	33.8
DSF-15A	1.7	3.7	2.1	2.9	82.4	81.5	11.2	11.6
RHA-857	6.2	6.6	2.8	3.0	45.1	39.7	45.9	50.8
Mean	4.4	5.7	2.8	3.3	56.7	54.2	35.2	36.8
SEm±	0.75	0.51	039	0.33	7.02	5.78	6.57	5.42

References

Canvin, D.T., 1965. The effect of temperature on the oil content and fatty acid composition of the oils from several oil seed crops. *Canadian Journal of Botany*, 43: 63-69.

Fernandez-Martinez, J., Jimenez, A., Dominguez, J., Garces, R. and Mancha, M. 1989. Genetic analysis of high oleic acid content in cultivated sunflower. *Euphytica*, **41**: 39-51.

Fernandez-Martinez, J., Munoz, J. and Gomez-Aman, J. 1993. Performance of near-isogenic high and low oleic acid hybrids of sunflower. *Crop Science*, **33**: 1158-1163

Giriraj, K. 2001. Sunflower. In *Breeding Field Crops Ed.* V.L. Chopra, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi pp. 433-469.

Kinman, M.L. and Earle, FL.R., 1964. Agronomic performance and chemical composition of the seed of sunflower hybrids and introduced varieties. *Crop Science*, **4** : 417-420.

Lakshminarayana, M.R., Giriraj, K., Ramanathan, K.V. and Khetrapal, C.L. 1984. Oil build up and quality in developing sunflower seeds. *La Rivista Italiana Delle Sostanze Grasse*, **61**: 487-490.

Miller, J.F., Zimmerman, D.C. and Vick, B.A. 1987. Genetic control of high oleic acid content in sunflower oil. *Crop Science*, **27**: 923-926.

Paquot, C. 1988. *Standard methods for analysis of the oils, fats and derivatives.* Pergman Press, Oxford, pp. 100-109.

Rather, A.G., Sandha, G.S., Shafiq, Wani, A., and Sheikh, F.A. 1988. Correlation and Path analysis in Sunflower (*Helianthus annuus* L.). *Journal of Oilseeds Research*, **15**: 67-70.

Soldatov, K.I. 1976. Chemical mutagenesis in sunflower breeding. In Proceedings of 7th International Sunflower Conference, Krasnador, USSR. pp. 352-357.

Urie, L. 1985. Inheritance of high oleic acid in sunflower. *Crop Science*, 25: 986-989.

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Short communication

A high oleic acid sunflower genotype

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Cultivated sunflower seed oil contains approximately 10% saturated, mostly palmitic and stearic and 90% unsaturated, mostly oleic and linoleic fatty acids. Soldatov (1976) derived a mutant with high oleic acid from VNIMK 8931 following chemical mutagenesis (0.5% diethyl sulfate). Soon after, emphasis was laid in sunflower breeding for the development of cultivars with high oleic acid. The present communication reports relative fatty acid composition in six sunflower genotypes over two environments.

Four hybrid cultivars, *viz.;* MSFH-17, PAC-36, KBSH-1, DSH-1 and two inbreds *viz;* DFS-15A and RHA-857 were *chosen for the study. DSF-15A, the seed parent of DSH-1* was developed by repeated back crossing NDOL-2 inbred *with CMS-852, a petiolaris based cytoplasmic male sterile* line. RHA-857 is the pollen parent of DSH-1 hybrid. All the six genotypes were planted in rainy (July-sown) and summer (January-sown) seasons of 1999-2000 under uniform fertility conditions with a spacing of 60 x 30 cm. Each genotype was grown in 3 rows of 5 m length. Five random plants in each row and in each genotype were harvested after maturity and bulked. The oil from the bulked seeds was extracted with petroleum ether (40-60°C) which was transesterifried with 2 N methonolic KOH (Paquot, 1988). The fatty acid methyl esters were separated *using GLC on a column of DEGS at 190°C (FID* and injector temperatures were 230°C). Nitrogen at a flow rate of 40ml/min was used as a carrier gas. Identification of individual fatty acids was based on RT values of standard and test fatty acids.

Palmitic acid level in the genotypes was high in summer over corresponding rainy season (Table-1). Similarly, except KBSH-1, the genotypes recorded slightly higher content of stearic acid in summer than in rainy season. The palmitic and stearic acids were low for high oleic acid containing DSF-15A inbred. Miller *et al.* (1987) have also obtained similar results. Varying magnitude of oleic and linoleic acids within a genotype was apparent in both the *environments. Influence of environment on fatty acid* accumulation was well documented. During seed development, high temperatures favoured accumulation of oleic acid (Kinman and Earie, 1964; Canvin, 1965). In the present also, except RHA-857, the other genotypes recorded higher level of oleic acid and reduced linoleic acid in summer season. Inverse relationship between oleic and linoleic acid content confirmed the earlier reports of Kinman and Earie (1964); Canvin (1965); Lakshminarayana *et al.* (1984) and Rather *et al.* (1988). Amongst six genotypes chosen for the study, DSF-15A *recorded substantially high oleic acid (81.5 to 82.4%) and* it was stable across environments. Genetic control of oleic acid in sunflower has been well established (Urie, 1985; Miller *et al.*, 1987; Fernandez-Martinez *et al.*, 1989). These studies have indicated involvement of one or more major dominant OL genes and also modifier genes in the inheritance of this character. High oleic acid in DSF-15A is supposedly due to the accumulation of OL alleles of NDOL-2 (donor parent) in the back cross programme. The oleic acid content in DSH-1 hybrid which involved DSF-15A as one of the parents in hybrid synthesis also differed *substantially from the other commercially cultivated hybrid* cultivars. It recorded increase of oleic acid content of 19.93% over other three hybrids across two environments.

High oleic hybrid is reported to have positive association with seed yield, harvest index and earliness but negative influence on self-compatibility and seed germination (Fernandez-Martinez *et al.*, 1993). These parameters have not been measured in the present investigation. Therefore, studies have to be conducted to assess relevance of these traits to our agro-ecological situations (Giriraj, 2001).

Development of a high oleic acid inbred (DSF-15A) is the first effort in India and it serves as a source material for initiating studies on the inheritance of oleic acid.

Thanks are due Dr. J.F. Miller, North Dakota State University, Fargo, USA, for the supply of seeds of NDOL sunflower population.

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salinity levels in leaf, seed and siliqua wall of *B. juncea*. It also seems that proline is accumulated under stress conditions, perhaps as a last resort to survive and to avoid osmotic death.

Seed yield was positively and significantly correlated with seedling vigour and K : Na ratio in normal environment (Table-2). Seed yield also exhibited positive though non-significant correlation with relative water content, chlorophyll in both the environments, seedling vigour, K : Na ratio and proline in saline environment. Further, the traits was observed to have negative but non-significant association with protein and proline in control condition. Seedling vigour was positively and significantly associated with relative water content, chlorophyll and protein in stress environment. All the character possessed non-significant association.

Table 1 Effect of salinity on potassium, sodium, potassium : sodium, relative water content, chlorophyll, protein and proline content at flower initiation stage in Ethiopian mustard

Genotype/ Crops	Potassium (%)			Sodium (%)			Potassium/Sodium ratio			Relative water content (%)		
	Normal	Saline (125 meq/l)	Percent reduction	Normal	Saline (125 meq/l)	Percent reduction	Normal	Saline (125 meq/l)	Percent reduction	Normal	Saline (125 meq/l)	Percent reduction
BC 2	1.17	1.16	-0.01	0.33	0.68	106.06	3.55	3.52	-0.01	73.75	78.77	6.80
HC 7	1.21	1.19	-1.65	0.42	0.89	111.90	2.95	1.34	-54.57	70.65	78.75	11.46
C6YS7B	1.20	1.13	-5.83	0.36	0.96	166.67	3.33	1.17	-64.86	72.61	75.22	4.00
CAR 5	1.48	1.18	-20.27	0.46	1.26	173.91	3.22	0.94	-70.80	75.99	77.75	2.31
BC2 x HC 7	1.26	1.20	-4.76	0.34	1.23	282.35	3.70	0.92	-75.14	73.76	79.27	7.47
BC 2 x CAR 5	1.46	1.00	-31.30	0.47	0.80	77.78	3.22	1.25	-61.18	76.01	80.05	5.31
C6YS7B x CAR 5	1.08	1.04	-3.70	0.28	0.80	185.77	3.86	1.20	-66.32	78.46	80.90	3.11

Table 1 (Contd...)

Genotype	Chlorophyll (μg/g, f.w.)			Protein (μg/g, f.w.)			Proline (μg/g, f.w.)		
	Normal	Saline (125 meq/l)	Percent reduction	Normal	Saline (125 meq/l)	Percent reduction	Normal	Saline (125 meq/l)	Percent reduction
BC 2	1362.34	1734.78	30.79	33.96	42.14	24.09	539.96	1382.19	155.98
HC 7	1510.53	1876.21	24.21	44.48	59.01	32.67	451.12	1314.12	191.30
C6YS7B	1418.50	1695.19	19.51	31.28	35.29	12.82	348.43	650.72	86.75
CAR 5	1025.05	1419.86	38.52	32.41	39.64	22.31	385.35	696.86	80.83
BC2 x HC 7	1760.14	2039.60	15.88	42.14	51.24	21.59	456.89	1218.06	166.70
BC 2 x CAR 5	1655.86	2153.10	30.03	44.14	55.52	25.78	431.13	1011.83	134.69
C6YS7B x CAR 5	1271.61	1696.25	33.39	37.94	44.72	17.87	363.06	799.54	120.22

Saline = 125 meq/l which was equivalent to EC of 10 dS/m

Table 2 Simple correlations between physico-chemical parameters, seedling vigour and seed yield in Ethiopian mustard under normal and saline environments

Character	Seedling vigour		Relative water content		K/Na ratio		Chlorophyll		Protein		Proline	
	Normal	Saline	Normal	Saline	Normal	Saline	Normal	Saline	Normal	Saline	Normal	Saline
Seed yield	0.782*	0.454	0.370	0.270	0.913*	0.742	0.206	0.459	-0.078	0.138	-0.264	0.751
Seedling vigour			0.603	0.850*	0.747	-0.030	0.314	0.784*	0.404	0.832*	-0.285	0.632
Relative water content					0.574	0.071	-0.348	0.415	0.128	0.596	-0.588	0.378
K/Na ratio							0.016	-0.077	-0.182	-0.166	-0.307	0.557
Chlorophyll									0.726	0.746	0.310	0.516
Protein											0.457	0.618

* Significant at P=0.05

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Short communication

Studies on some physiological parameters in relation to salt tolerance in Ethiopian mustard

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Ethiopian mustard (*Brassica carinata* A. Braun) an exotic species in India which performed better than other species of *Brassica* under various stresses like late sowing, rainfed and saline conditions (Malik, 1990). However, the information on genetic studies of physiological parameters of salt tolerance in it under saline conditions is very meager. Therefore, the present studies were undertaken to establish some parameters related to salt tolerance in Ethiopian mustard under normal and saline conditions.

The experiment was conducted in earthen pots (30 cm diameter) internally lined with sealed polythene bags having five kg sand. The pots were saturated to field capacity with water or 125 meq/l chloride dominating salt solution (prepared by addition of NaCl, $CaCl_2$, $MgCl_2$ and $MgSO_4$ using Na : Ca : Mg in the ratio of 4 : 1 : 3 and Cl : SO_4 ans 7 : 3 on meq basis).

The plants of identified tolerant cultivars (BC 2 and HC 7) and susceptible (C6YS7B and CAR 5) cultivars of *B. carinata* and their crosses *viz*., tolerant x tolerant (BC 2 x HC 7), tolerant x susceptible (BC 2 x CAR 5) and susceptible x susceptible (C6YS7B x CAR 5) were raised to maturity (Thakral, 1993). Plant samples for various physiological parameters were collected at flower initiation stage and analysed for potassium and sodium (Flame photometrically), chlorophyll (Arnon, 1956), proteins (Lowry *et al.*, 1951), free proline (Bates *et al.*, 1973) and relative water content by using the following formula:

$$\text{Relative water content} = \frac{\text{Fresh weight - dry weight}}{\text{Saturated weight - dry weight}} \times 100$$

Salinity in general reduced potassium content in parents as well as in hybrids but maximum reduction was observed in hybrids BC2 x CAR 5 (31.30 %) followed by the parent CAR 5 (20.27 %) (Table-1). Contrary to potassium, the sodium content increased remarkably from 77.78 % (tolerant x susceptible lines i.e., BC2 x CAR 5) to 282 % (tolerant x tolerant lines i.e., BC 2 x HC 7). In saline medium, sodium level was higher in susceptible genotypes compared to the tolerant genotypes. Subsequent to decrease in K^+ and increase in Na^+, the K : Na ratio declined in the salinity medium. K : Na ratio was again lower in susceptible group of genotypes compared to tolerant genotypes. The observation became possible because of altered ion accumulation by tolerant genotypes, where the uptake of Na^+ to some extent is restricted by partial avoidance of Na^+ in the saline environment. The capacity to maintain high level of K^+ in the presence of high level of Na^+ is strongly correlated in salt tolerance both in halophytes and glycohytes (Rains and Epstein, 1967).

The expression of relative water content (RWC) was better in saline over non-saline environment for all the parents and hybrids. Among the parents, the highest and lowest RWC was exhibited by CAR 5 (75.99 %) and HC 7 (70.65 %), respectively in normal and BC 2 (78.77 %) and C6YS7B (75.22 %) in saline environment. The increase in RWC under salinity was possibly because of the low salinity level whereas reduction in RWC has been recorded in salt treated plants (Prisco and O'Leary, 1976) which may be due to high salinity level or the nature of solute involved in osmotic adjustment.

The chlorophyll, protein and proline content in salinity level increased in parents as well as in hybrids. The increase of chlorophyll content to salinity at the flower initiation stage at which the leaves were collected for this estimation for all these entries, despite the presence of high concentration of Na^+ and Cl^- in the leaf tissues must have been associated with the prevention of excessive ion accumulation in cytoplasm and chloroplast. Similar results were also obtained by Cho Jin Wong and Kim Choongsoo (1998) in barley.

In increase in protein which is contradictory to the earlier reports may again be due to low salinity levels or the nature of salt used. The stimulatory effect of NaCl salinity on nitrate reductase activity was common observations (Sankhla and Huber, 1975). So, the results obtained suggested that possibly low salinity level has stimulated the NR activity and resulted in enhanced protein synthesis. The crosses BC2 x CAR 5 and C6YS7B x CAR 5 exhibited potential for exploitation as they had over dominance for this trait under both the environments.

The present results of proline content are in corroboration with that reported by Parti *et al.* (2000). They found increase in proline content consistently with increase in

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Short communication

Trends in growth of mustard production in Rajasthan

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India witnessed a yellow revolution through a phenomenal growth in oilseed production after Technology Mission on Oilseeds in 1986. Rapeseed-mustard is one of the most important crops spearheading the yellow revolution. Rapeseed-mustard production and productivity increased from 2.68 mt and 650 kg/ha in 1985-86 to 6.12 mt and 968 kg/ha in 1999-2000. Rajasthan is the principal mustard growing state contributing about 45% of the area (2.99 mha) and 43% of the production (2.48 mt) of the production in India during 1998-99 (Damodaram and Hegde, 1999). The state also witnessed a very spectacular growth in production of rapeseed-mustard during pre - and technology mission period. The Mission brought out a significant growth of rapeseed-mustard in Rajasthan by increasing production and area by 3.7 and 3.1 times, respectively. The present investigation is aimed at examining the trend/pattern of growth in area and yield and their contribution in increasing the production of mustard in different regions of Rajasthan before and after the implementation of the Technology mission on Oilseeds.

Rajasthan comprises of six administrative regions namely, Jaipur, Bharatpur, Ganganagar, Jodhpur, Kota and Udaipur (including Bhilwara). The variability in area, production and yield of these regions were estimated by coefficient of variation. To study the growth, compound growth rate (CGR) of area, production and yield of different regions were calculated for different periods using least squares technique of fitting the exponential function $y= ab^t$ in the log linear form. i.e, log y= log a + t log b (Kathuria and Rao, 1983; Verma, 1984); where t is the time variable, y is the variable for which growth rate is to be calculated: $\text{Log } b = [\Sigma t.\log y-\{(\Sigma t).(\Sigma \log y / N)\}]/[\Sigma t^2 - \{(\Sigma t)^2/N\}]$, CGR (%) = (b-1)x 100.

The contribution of area, yield and their interaction in increasing total production of different regions was computed as per (Kumar and Singh, 1990).

$P_0 = A_0 Y_0$ = Production in base year, $P_t = A_t Y_t$ = Production in t year

Where A_0 and Y_0 and A_t and Y_t are area & yield in base and t year, respectively.

Further $A_t = A_0 + \Delta A$; $Y_t = Y_0 + \Delta Y$, $P_t = P_0 + \Delta P$

$P_t = A_t . Y_t = (A_0 + \Delta A).(Y_0 + \Delta Y)$

$\Delta P = P_t - P_0 = (A_0 + \Delta A).(Y_0 + \Delta Y) - A_0 Y_0 = A_0.\Delta Y + Y_0.\Delta A + \Delta Y.\Delta A$

Where $A_0.\Delta Y$ =Yield effect, $Y_0.\Delta A$ = Area effect, $\Delta Y.\Delta A$ = Interaction of yield and area.

The fluctuations in area, production and yield of mustard were low as years progressed (Table-1). The coefficient of variation in all the six regions and state was much lower after the TMOP then before. The coefficient of variation for production in the state as a whole, decreased with progressing period exception was period 1986-91, during which the state experienced a good jump in production. The compound growth rate (CGR) of area, production and yield before and after TMOP period was in general, positive for different regions and state, however, the rate was higher during pre TMOP period. The CGR of area and production was the highest for Kota in both pre TMOP and TMOP periods, followed by Udaipur, Jaipur, Jodhpur and Ganganagar/Bharatpur during pre TMOP and Jaipur, Jodhpur, Udaipur, Ganganagar and Bharatpur during TMOP period. The yield growth was the highest for Bharatpur during pre TMOP, however, the same was the highest for Jaipur region during TMOP.

During TMOP period (1986-87 to 1999-2000), contribution of yield to total production was more pronounced than pre TMOP period for all the regions. From the period 1971-72 to 1985-86, Ganganagar, Jodhpur, Kota and Udaipur the production increase was more due to increase in area than yield (Table-2). On contrast, during TMOP period, increase in the production was more contributed by increased yield.

It can be concluded that area and production of mustard showed more variation as compared to yield, however, these three parameters were more stable during TMOP. The compound growth of area, production and yield for all the regions were generally lower during TMOP than before. The first quinquennium after mission was important for area and production growth. The contribution of yield increase was in general, higher than area towards increase in production in most cases, which became more prominent during the oilseed mission period.

A differential response of salinity level (125 meq/l) on different physiological parameters of salt tolerance was observed in four genotypes of Ethiopian mustard i.e., BC 2, HC 7 (tolerant to salinity), C6YS7B and CAR 5 (susceptible to salinity) and their crosses *viz.*, BC2 x HC 7, BC 2 x CAR and C6YS7B x CAR 5. Salt tolerant genotypes had sodium at low level and potassium at high level there by tolerant genotypes had wider K : Na ratio. Relative water content, chlorophyll content, protein content and proline content increased by salinity at flower initiation stage in parents and crosses. The parents BC 2 and HC 7 (*Brassica carinata*) had higher content of free proline as compared to their susceptible counterparts.

References

Arnon, D.J. 1956. Chlorophyll absorption spectrum and quantitative determination. *Biochemistry and Biophysics Acta*, 20 : 449-461.

Bates, L.S., Waldren, R.P. and Teare, T.D. 1973. Rapid determination of free proline for water stress studies. *Plant and Soil*, **39**: 205-208.

Cho Jin Woong and Kim Choongsoo. 1998. Effect of NaCl concentration on photosynthesis and mineral content of barley seedlings under solution culture. *Korean Journal of Crop Science*, **43** (3) : 152-156.

Lowry, O.H., Resebrought, N.J., Farr, A.L. and Randall, R.L. 1951. Protein measurement with Folin-Phenol reagent. *Journal of Biological Chemistry*, **193** : 265-275.

Malik, R.S. 1990. Prospects for *Brassica carinata* as an oilseed crop in India. *Experimental Agriculture*, **26** : 125-129.

Parti, R.S., Gupta, S.K. and Chhabra, M.L. 2000. Effect of salinity on chlorophyll and free proline of mustard (*Brassica juncea* L.). *Cruciferae Newsletter*, **22** : 31-32.

Prisco, J.T. and O'Leary, J.W. 1976. Osmotic and 'Toxic' effects of salinity on germination of *Phaseolus vulgaris* L. seeds. *Turrialba*, **20** : 177-184.

Rains, D.W. and Epstein, E. 1967. Preferential absorption of potassium by leaf tissue of mangrove (*Avicennia marina*) : an aspect of halophytic competence in coping with salt. *Australian Journal of Biological Science*, **20** : 847-857.

Sankhla, N. and Huber, W. 1975. Effect of salt and abscissic acid on *in vivo* activity of nitrate reductase in seedlings of *Phaseolus acontifolius*. *Zeistschriftfur Pflanznphysiology*, **76** : 467-470.

Thakral, N.K. 1993. Genetic studies on the morpho-physiology factors for tolerance to salinity in Indian and Ethiopian mustard. Ph.D. Thesis submitted to CCS Haryana Agricultural University, Hisar, India.

Table-2 Contd..

Region		1971-72 to 75-76	76-77 to 80-81	81-82 to 85-86	86-87 to 90-91	91-92 to 95-96	96-97 to 99-00	71-72 to 85-86	86-87 to 99-00
Kota	Area effect	-1.2	1.3	30.5	10.6	67.6	34.7	17.4	17.0
		(-121.7)	(63.1)	(95.2)	(5.3)	(74.7)	(577.7)	(44.5)	(3.7)
	Yield effect	0.8	0.3	0.3	154.0	18.9	-26.8	2.7	316.4
		(76.2)	(14.7)	(1.0)	(76.4)	(20.8)	(446.4)	(6.9)	(69.4)
	Interaction effect	-0.5	0.4	1.2	37.0	4.2	-1.9	18.9	122.6
		(-54.6)	(22.0)	(3.8)	(18.4)	(4.6)	(-31.3)	(48.6)	(26.9)
Udaipur	Area effect	1.2	1.8	7.0	83.1	-44.3	17.6	6.2	-2.2
		(55.6)	(59.9)	(112.5)	(91.8)	(-110.5)	(92.3)	(45.3)	(-3.5)
	Yield effect	0.2	0.2	-0.4	1.0	8.0	-30.9	0.4	77.3
		(9.0)	(8.0)	(-6.6)	(1.1)	(20.0)	(-162.0)	(2.6)	(124.6)
	Interaction effect	0.8	1.0	-0.4	6.4	-3.8	-5.8	7.1	13.1
		(35.4)	(32.1)	(-5.9)	(7.1)	(-9.6)	(-30.4)	(52.1)	(-21.1)
State	Area effect	-49.0	58.0	110.5	992.7	445.2	-238.8	136.2	116.0
		(-887.3)	(39.5)	(81.5)	(97.9)	(175.2)	(-109.9)	(28.9)	(6.6)
	Yield effect	82.5	57.0	20.2	8.4	-157.8	23.5	159.2	1387.3
		(1494.6)	(38.8)	(14.9)	(0.8)	(-62.1)	(10.8)	(33.7)	(79.3)
	Interaction effect	-28.0	33.0	4.9	12.7	-33.2	-2.2	176.6	245.5
		(-507.3)	(22.4)	(3.6)	(1.3)	(-13.1)	(-1.0)	(37.4)	(14.0)

Note: Figures in parenthesis indicate the corresponding percentages

References

Damodaram, T. and Hegde, D.M. 1999. Oilseeds situation: *A statistical compendium.* Directorate of oilseeds Research, Hyderabad.

Kathuria, O.P. and Rao, D.V.S. 1983. Growth rate of some important oilseed crops in India. *Agricultural Situation in India*, **36** : 275-282.

Kumar, P.R. and Singh, N.P. 1990. Growth analysis of rapeseed-mustard. *Agricultural Situation in India*, **45** (2):915.

Verma, K.K. 1984. Agricultural Growth of major edible oilseeds crop in India. *Agricultural Situation in India*, **37** : 277-282.

Trends in growth of mustard production in Rajasthan

Table 1 **Coefficient of variation (CV) and compound growth rate (CGR) of area, production and productivity of rapeseed-mustard in Rajasthan**

Region		1971-72 to 1975-76		1976-77 to 1980-81		1981-82 to 1985-86		1986-87 to 1990-91		1991-92 to 1995-96		1996-97 to 1999-2000		1971-72 to 1985-86		1986-87 to 1999-2000	
		CV (%)	C G R	CV (%)	C G R	CV (%)	C G R	CV (%)	C G R	CV (%)	C G R	CV (%)	C G R	CV (%)	C G R	CV (%)	C G R
Jaipur	A	47.7	-16.6	46.3	13.5	21.9	12.5	46.3	13.5	17.2	10.9	15.3	-10.5	86.5	12.9	37.2	11.5
	P	60.3	-7.2	61.2	13.0	28.1	8.7	44.8	35.0	14.5	4.6	16.1	-2.2	105.7	19.4	31.7	14.1
	Y	42.4	11.1	41.9	2.5	19.0	-3.3	9.6	4.2	18.7	-5.7	22.0	9.2	37.9	5.9	14.6	2.3
Bharatpur	A	26.2	-13.7	28.9	-6.3	29.1	18.0	22.7	15.4	5.6	-1.0	10.4	-5.6	46.2	3.5	18.6	3.4
	P	52.9	2.3	51.4	9.1	37.4	18.5	26.8	19.0	6.6	1.8	23.4	0.9	81.0	12.2	17.6	2.9
	Y	52.7	18.6	42.9	16.5	12.5	0.4	9.9	3.1	6.5	2.8	22.2	6.9	42.9	8.4	12.0	-0.5
Ganganagar	A	19.4	-2.4	31.7	8.3	38.4	28.0	27.6	18.0	16.4	4.4	9.4	-0.3	57.1	9.6	24.1	7.4
	P	22.1	-10.3	27.3	9.1	36.6	27.5	27.6	14.8	32.5	10.7	5.9	-4.2	63.5	11.2	27.4	8.2
	Y	20.2	-8.2	5.2	0.8	5.1	-0.4	9.6	-2.7	18.1	6.1	9.8	-3.9	13.2	1.4	13.0	0.7
Jodhpur	A	48.0	35.8	36.6	26.4	32.4	-15.0	43.4	30.8	21.1	10.8	19.8	-8.6	59.3	12.6	39.1	10.7
	P	42.9	24.6	42.3	35.3	26.0	-13.2	37.9	29.0	27.8	3.1	11.1	-4.8	64.2	14.1	36.6	11.8
	Y	25.1	-8.3	22.4	6.0	9.3	2.2	12.5	-1.3	30.9	-7.0	8.3	4.2	21.2	1.3	17.4	1.0
Kota	A	47.5	-15.3	59.3	38.0	82.8	62.4	52.1	38.8	8.6	4.1	6.5	0.9	162.8	25.0	29.7	14.5
	P	63.5	-5.2	50.0	39.0	87.3	63.5	63.4	37.7	16.2	5.7	21.0	2.3	181.4	33.3	28.6	16.0
	Y	28.6	7.9	19.2	5.4	5.9	1.8	20.1	-0.8	11.0	1.5	19.3	1.4	27.3	5.2	14.2	1.4
Udaipur	A	71.3	65.1	95.4	71.9	38.6	13.1	68.1	63.3	29.1	-12.7	10.9	5.8	110.1	26.6	30.4	9.9
	P	61.4	32.5	99.8	112.3	39.0	11.4	70.6	69.9	29.5	-13.0	15.5	-3.7	123.9	29.8	36.7	8.2
	Y	38.3	8.2	23.9	7.6	7.9	-0.1	11.2	4.1	9.1	-0.3	22.6	-8.9	28.9	4.9	17.7	-1.5
State	A	20.3	-4.5	16.7	9.1	23.5	10.6	32.6	23.8	8.8	4.1	9.0	-4.7	51.4	8.2	26.2	8.1
	P	38.6	2.6	32.2	18.6	29.0	12.8	33.3	24.4	15.0	3.8	10.6	-1.7	75.2	13.8	24.1	8.4
	Y	37.9	7.3	23.4	8.5	5.8	1.9	6.2	0.5	10.4	-0.9	14.6	3.2	28.8	5.1	9.2	0.3

A-Area, P-Production, Y- Yield

Table 2 **Contribution of area, productivity and their interaction to change the production of rapeseed-mustard in different regions of Rajasthan**

Region		1971-72 to 75-76	76-77 to 80-81	81-82 to 85-86	86-87 to 90-91	91-92 to 95-96	96-97 to 99-00	71-72 to 85-86	86-87 to 99-00
Jaipur	Area effect	-5.7	4.0	17.9	93.3	165.6	-96.5	11.9	38.9
		(-142.6)	(50.0)	(255.0)	(72.0)	(429.0)	(-193.0)	(25.9)	(13.4)
	Yield effect	6.0	1.7	-7.9	11.9	-81.3	62.0	13.7	135.4
		(149.1)	(21.5)	(-112.5)	(9.2)	(-210.6)	(124.0)	(29.8)	(46.7)
	Interaction effect	-4.3	2.3	-3.0	24.3	-45.9	-15.5	20.4	115.6
		(-106.5)	(28.5)	(-42.9)	(18.8)	(-118.8)	(-31.0)	(44.3)	(39.9)
Bharatpur	Area effect	-29.3	5.0	117.5	277.7	-4.1	-100.1	15.8	43.4
		(-571.7)	(8.6)	(139.8)	(76.7)	(-14.0)	(-152.9)	(7.8)	(11.2)
	Yield effect	75.6	48.8	-20.0	43.4	32.9	40.0	145.6	300.8
		(1474.3)	(82.7)	(-23.8)	(12.0)	(113.3)	(61.1)	(71.4)	(77.4)
	Interaction effect	-41.2	5.2	-13.5	41.1	0.2	-5.4	42.7	44.5
		(-802.5)	(8.9)	(-16.1)	(11.4)	(0.7)	(-8.2)	(20.9)	(11.5)
Ganganagar	Area effect	-11.0	27.5	92.3	123.9	36.4	10.9	113.0	-0.9
		(-63.2)	(105.7)	(99.2)	(171.1)	(28.7)	(23.6)	(101.8)	(-0.4)
	Yield effect	-8.6	-0.8	0.3	-29.4	79.5	-55.8	-0.6	226.5
		(-49.7)	(-3.0)	(0.3)	(-40.6)	(62.6)	(-120.7)	(-0.6)	(100.9)
	Interaction effect	2.2	-0.7	0.5	-22.2	11.1	-1.4	-1.7	-1.3
		(12.9)	(-2.9)	(0.5)	(-30.6)	(8.7)	(-3.0)	(-1.6)	(-0.6)
Jodhpur	Area effect	30.2	20.6	-98.0	197.1	339.6	-82.3	49.8	28.0
		(152.1)	(45.0)	(-115.3)	(124.8)	(3948.6)	(-187.8)	(84.4)	(8.6)
	Yield effect	-3.6	12.6	34.2	-12.7	-212.1	46.6	2.3	230.5
		(-17.9)	(27.5)	(40.2)	(-8.0)	(-2466.4)	(106.3)	(3.8)	(70.5)
	Interaction effect	-6.8	12.4	-21.0	-26.4	-136.1	-8.2	7.0	68.3
		(-34.2)	(27.1)	(-24.6)	(-16.7)	(-1582.2)	(-18.8)	(11.8)	(20.9)

Book Review

"Oilseeds and Oils : Research and Development Needs". Mangala Rai, Harvir Singh and D.M. Hegde, Editors. Published by the Indian Society of Oilseeds Research, Rajendranagar, Hyderabad-500 030, India. 2002. Pages 490+vii.

India is one of the largest vegetable oilseeds producing countries in the world. Advances in oilseeds research continue to be made at a strikingly rapid rate. The adoption of new technologies and an understanding of the research and development needs have resulted in an increased production and productivity of oilseeds during last two decades. The book - **"Oilseeds and Oils : Research and Development Needs"** is very timely publication, in view of the progress made and the challenges we are facing. It is an outcome of National Seminar on "Oilseeds and Oils : Research and Development Needs in the Millennium" held from February, 2 -4, 2000; and is edited by three eminent scientists with very rich and long experience in oilseed crops research.

The book has 41 chapters in different theme areas, namely biodiversity conservation; hybrid breeding; biotechnology; quality improvement; apomixis; management of biotic and abiotic stresses; diversification of production systems; processing, product development and value addition; transfer of technology and policy interventions.

The information given in each chapter is exhaustive, up-to-date and meticulously compiled. Chapters on biodiversity conservation also include information on holdings of genetic diversity of oilseed crops at various centres in different countries. The information on appropriate production technology for oilseed cultivation in traditional and non-traditional areas are well covered in three chapters under diversification of production systems. The role of biotechnology, heterosis and apomixis in improvement of oilseed crops have been dealt in view of current research and development needs for productivity enhancement. Three chapters under input use efficiency provide information on judicious use of fertilizers, pesticides and weedicides to increase productivity; and these contain vital information to reduce cost of cultivation at the farmers levels. The chapters on biotic and abiotic stress management include useful information on biological control of diseases and insect-pests as well as the management of salinity and drought problems through eco-friendly approaches. The chapters on quality improvement, processing and value-added product development carry information of critical importance and relevance in the diversification of oilseed crops. The needs for technology transfer and priorities in oilseed research so as to increase production and competitive ability, along with policy support, for oilseed sector have been well documented with the overall objective to improve the socio-economic status of the farmers and progress of the nation. The authors and editors have very successfully endeavoured to give readers a comprehensive and lucid scenario of research and development including the needs.

The book will be a valuable source of information and ready reference for all research scientists, managers, administrators, policy makers, engaged in research and development of oilseed crops particularly in India. To enhance the utility of the book further, a subject index would have been useful. There are a few typographical mistakes.

On the whole, the book is 'all in one' for an oilseed worker for which the authors and the editors deserve all praise and complements.

(B.S. DHILLON)
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