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Contents

Research Papers

Official publication of
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***J. Oilseeds Res.*, 19(2) : 157-270 (December, 2002)**

Short communications

J. Oilseeds Res., **19**(2): 157-170 (2002)

Review article

Genetic resources and intellectual property rights in agricultural perspective*

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I. Prelude

1. Improved plant varieties may be considered as the backbone of technology being extensively used for attaining and sustaining gains in agricultural productivity and production, in terms of both quantity and quality, to meet the needs of ever-increasing human population. In classical breeding, such improvement has been brought about by using 'selection-crossing-segregation-selection' cycle. The input essentially comprised two categories of components – the tangible genetic resources required for, and intangible or tangible intellectual property involved in the manipulations leading to the development of improved variety.

2. With the advent of genetic engineering, the breeding approach has been modified to an 'insertion-selection' cycle. The insertion of genetic material or gene insertion herein is not a natural process and this has to be artificially done. A gene 'gun', a bacterial 'truck' or a chemical or electrical treatment is used to insert the genetic material into the host plant cell. Further, with the help of genetic elements in the construct, this genetic material inserts itself into the chromosomes of the host plant. Also a 'promoter' gene is inserted from a virus, to make the inserted gene express itself. This process, involving a gene gun or a comparable technique, and a promoter, is basically different from conventional breeding, even if the primary goal is only to insert genetic material from the same species (Hansen, 2000). The input, in this case essentially comprises the tangible genetic resource required for insertion of gene, technology, which may or may not be protected by law, and the intellectual property involved in other manipulations leading to the development of improved variety and associated marketing of the product thereof. The intellectual property related to genetic engineering is clearly dependent on costlier, technical and technological components, which is now the added cause of more economic and proprietary concerns on the part of the innovator.

3. Trademarks, among the other forms of protection, can be effectively applied to agriculture, for example, to market seeds, sprayers or agro-chemicals. The essential purpose of the trademark is providing exclusivity to the protected goods or services from other similar products or services available in the market, thereby maintaining the goodwill of the right holder, and also to lawfully prevent misuse of commercial marks (Rai and Kochhar, 2001). The Geographical Indications are marks associated with goods originating from a country, region or locality where the quality, reputation or its other characteristics are essentially attributable to the geographical origin. Plant varieties developed with traditional knowledge and associated with a particular region can also be protected as geographical indications. Trade secrets can be used to withhold certain vital information related to generation/production of technology to ensure lasting commercial gains, such as the parental lines of hybrids. These can be protected against third party misappropriation through legislations relating to unfair competition, restrictive trade practices or contract law. There is no obligation to disclose the inventive or creative ideas/steps under trade secrets while recognising the increased role of IPR in the agricultural R&D.

4. As a consequence, the concern for intellectual property protection for plant varieties has intensified more recently mainly with a view to recover the high costs of R&D besides profiteering by excluding others for certain period to use the protected technology for commercial purposes. At the same time, concern for equitable sharing of benefits with the farming communities, being the providers of basic genetic resources, has equally grown in recent

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years. Treatment of the subject in the subsequent paras is, therefore, made with a view to essentially construct and dispense with the two imminent facets of intellectual property – the perpetually fostered genetic resources, and the finished products being the new plant varieties or other agricultural commodities which can be protected by law.

II. The glorious and triumphant agricultural R&D

5. Agricultural research institutions, particularly in developing economies until recently had been keenly engaged in developing public good in the past. The key role that the public plant breeders played was to mainly generate new variants for improvement through selection and adaptation. International centres amply facilitated such public sector plant breeding for majority of food crops in the developing countries through pre-breeding and coordinating international nurseries and trials. Hands-on practical training to scientists and technicians of various institutions for selection in the segregating generations was quite common at different advance centres of crop breeding at the national and international levels. These trainees, in turn, also carried with them, as token, the promising local materials for free exchange with these centres. There was hardly any concern or resistance for the free flow/exchange of germplasm of crops.

6. Eventually, the results achieved through research and technology development were adequately translated into higher national production of food and other agricultural commodities. Scientists, along with policy makers, political leaders and farmers, emerged as leaders of Green Revolution. This glorious phase of development through agricultural research definitely yet involuntarily reflected high social values and tradition. The strength that lied in iceberg of 'give and take' helped new generations to emerge out of food self-insufficiency despite their burgeoning size over that of their ancestral populations.

7. Growth in technology-led production of foodgrain and other agricultural commodities has continued substantially during the past four decades. Such technology mainly emerged from public sector R&D. At the turn of the millennium, a record production of 209 million tonnes of foodgrain was recorded in India as against the estimated demand of 197 mt, thereby indicating a marginal surplus. This apparent surplus may, however, be attributed to less economic and ecological access to foodgrains. Production of oilseeds increased to 25 mt, milk 75 mt, fish 5.5 mt, eggs 31 bn in number, fruits 43 mt and vegetables 86 mt, which together amounted to a higher availability of food and nutrition. A Green Revolution with over 2,600 high-yielding varieties/hybrids of field crops and nearly 500 those of horticultural crops; a yellow revolution with significant breakthrough in yields of rapeseed and mustard, successful introduction and promotion of soybean and sunflower as oilseeds, and first in the world hybrids in castor; a white revolution with high yielding crossbred strains, namely, Karan Swiss (Brown Swiss x Red Sindhi or Sahiwal), Karan Fries (Friesian x Tharparkar) and Frieswal (Friesian x Sahiwal), having first lactation yield of more than 3,000 litres, and improved Murrah, Surti and Nili-Ravi buffalo breeds; and, a blue revolution with *inter alia* scientific management of inland, freshwater fisheries particularly faster growing Jayanti Rohu stock developed through genetic selection (ICAR, 2000), clearly highlight the appropriate extensive use of genetic resources made in the country to generate public good in the public sector research.

III. The free availability of genetic resources

8. The importance of diversity for agriculture and the world's food supply has been unmistakingly highlighted. The genetic resources are of paramount importance among the earth's resources. Evolved as the product of domestication, intensification, diversification and improvement through conscious and unconscious selection by countless generations of farmers, the man-guided diversity in the form of landraces and farmer' cultivars provided the basic and strategic raw materials for crop improvement the world over.

9. Realisation for the value of crop germplasm was obvious, which has been increasingly observed with the enhanced food requirement for ever-growing human population together with the narrowing limits of agricultural land that had constrained required foodgrains production at the same level of productivity. Facing various forms and degrees of threat, the primary genetic resources, which evolved under agricultural systems over the millennia, are vulnerable and irrecoverable if once lost. Their recognition at the inter-governmental platform under the umbrella of the Food and Agriculture Organisation of the United Nations (FAO) as 'Common Heritage of Mankind' which should be made 'available without restriction' had proved to be a shot in the arm for the systematic efforts of cooperation for conservation and harnessing of these invaluable resources for sustainable gains (FAO, 1983).

10. There was a definite foresight on the part of the intergovernmental body, guided by the scientific principles, in using the free exchange of genetic resources as the main steering force, under the FAO leadership that enabled masterminding and realisation of more and more production and

availability of food over the time in terms of both quantity and quality. The coherence was so strong that despite a humble membership (111 UN member nations) and also reservations by certain developed nations, the International Undertaking continued to be the lighthouse of genetic resource utilisation and free exchange.

IV. Conscious breeding and genetic enhancement

11. Plant breeding, as also breeding of domesticated animals and avians, in the initial phase has been through isolated individual efforts. The basic human requirement for food and fibre had mainly led to the domestication for agriculture. However, it was the sheer esthetic taste and curiosity that resulted into first recorded artificial plant hybrid between two flowers, carnation and sweet william, by Thomas Fairchild in 1719. This recorded origin of plant breeding in the 18th century in Europe was shortly followed by the opening up of commercial ventures in fancy seed business. Similarly, the principles of heredity, which later on turned out to be the fundamental bases of systematic plant breeding, were discovered by the private eye of Gregor Johann Mendel in 1865, without the organised, institutional efforts. Nevertheless, when once value was added to a product, its commercial worth was bound to be unearthed in the civilised society and the barter agriculturist had surely to turn out to be an enterpriser!

12. This private investment in and expected profits from genetic resources has also led to significant transformation, by choice, in plants particularly in terms of canopy, threshability of grains, response to various agricultural inputs and semi-mechanisation. Naturalised over the time, these types have also contributed to the evolution of genetic resources over the past few centuries although the magnitude may be much smaller, like just a few drops in an ocean, when compared with the origin and diversity of crop plants over the millennia.

V. Evolution of rights

(i) Intellectual property and proprietary rights

13. Private involvement meant stimulation for private investment and the realisation to exclude or include others in business! Issues of private ownership surely overpowered those of the community custodianship. Imminently, therefore, community legal systems were designed over the generations to recognise ownership of individuals and/or the village or the community in respect of particular improved materials out of the community owned genetic resources.

14. In the modern era, this was followed by the evolution of formal legal systems differentiating raw genetic resources and improved varieties or the finished products. Plant breeder's right (PBR) mooted under the International Convention by Union for Protection of New Varieties of Plants (UPOV) in 1961 is surely one such major front-runner development at trans-national level although legal protection (patent) to varieties of asexually propagated plants was provided in the US law as early as in 1930.

15. Use of intellectual property rights in public or international research centres has been viewed as the future incentive for R&D by protecting inventions of cooperative research under joint ownership rights, licensing for the use of proprietary materials, and sharing royalty on equal/equitable basis among public sector research units and private companies, as well as the national and international research institutes/centres. This is bound to lead to a state of complacency and put enormous strain if not disequilibrium in national and international agricultural research. Obviously, a greater cooperation, understanding and patience is required till some degree of equilibrium is restored from actual results.

16. Earlier, with the recognition of PBR in Europe, the trends in public-private research had changed and several well-established plant breeding institutes and laboratories were privatised ! And lately, cooperative research agreement between a trans-national company, Merck & Co., and Costa Rica's Instituto National de Biodiversidad, is also projected as novel means for reviewing public-private relationship in use of genetic resources *vis-à-vis* IPR (Lamola, 1992).

(ii) Farmers' rights

17. Looking from a broader perspective, the threat to extinction of the traditional genetic resource and the heritage seed by the high yielding monocultures appeared to have drifted the equilibrium of agrobiodiversity. Initially, the treatment of genetic resources as the resource meant for free access by anyone and everyone had provided endless opportunity and high probability of improvement through intervention/selection both between and within the landraces, being the genetic resources evolved with human intervention, and wild related species, being the genetic resources identified *in situ* by the village communities and tribals. In this process, the value of the contributions made/being made by farmers in harnessing and conserving genetic resources had become well understood.

18. But, ironically, the farmers had to pay the price, encompassing royalties in the cost of seed of those improved varieties the cultivation of which itself

threatened extinction of their traditional genetic resource! On the other hand, no compensation was ensured to them for the genetic material accessed and utilised for developing the improved, and protected, varieties from such invaluable traditional genetic resources fostered and conserved by them over the generations.

19. Hence, for the first time in 1989, the term Farmers' Rights was brought out with the majority voice of the developing countries and interpreted under the International Undertaking on Plant Genetic Resources (IUPGR), perhaps to counter the efforts of developed countries to privatise genetic resources of protected varieties under plant breeders' rights! The agreed interpretation (Resolution 5/89) defined Farmers' Rights as the 'rights arising from the past, present and future contributions of farmers in conserving, improving and making available PGR, particularly those in the centers of origin and diversity...' The Undertaking further agreed (Resolution 3/91) to acknowledge sovereignty rights of states over the plant genetic resources occurring within their national territory although the implication was that these rights were limited to only those countries which adhered to the Undertaking (Keystone Dialogue, 1991).

(a) The logic and the legal basis of farmers' rights

20. In logical terms, the rationale to establish farmers' rights under the agreed interpretation of the International Undertaking was derived from natural rights and incentive theories of intellectual property for the valuation of *inter alia* the products of informal innovation (Posey, 1991; Shand, 1991; Lamola, 1992).

21. The term 'undertaking' is, however, not a legal term in contrast with the other terms, such as, 'convention' or 'agreement' in international law. The terms of the undertaking are binding only on those nations that choose to adhere to it. According to some opinions (Bordwin, 1985; Lamola, 1992), the 'Undertaking' path was purposefully chosen to develop/implement intergovernmental opinion on plant genetic resources so as not to convey any legal significance of the issue! A relatively thinner adherence, that too with certain reservations, further indicated that there was hardly any international pressure to forcefully implement the issue of rights over genetic resources.

22. Moreover, plant genetic resources (PGR) conservation, access and utilisation could also face several policy constraints, besides the legal framework at the national and international levels, in linking the informal sector, including the non-profit/non-governmental organisations, farmer communities/groups or individuals, and the formal sector, including government/public sector agencies, international centres, and business companies for the purpose (Lamola, 1992). Nevertheless, an adequate global realisation continued to be there that in order to meet future needs for food and other agricultural commodities, genetic resources held on farm under traditional agricultural systems would continue to play the pivotal role in crop improvement programmes.

(b) Equity perspective in farmers' rights

23. Over the time, there have been number of dialogues and other attempts to develop Farmers' Rights vis-à-vis rights over genetic resources into a substantive legal right but in most cases it was observed rather difficult or even impossible to implement such provisions in legal terms. Therefore, the only clear alternative to handle this scenario was to view such rights of farmers from the perspective of equity! According to the theory of equity, the farmers deserved compensation for the commercial use of their genetic resources for which the Undertaking had clearly recognised them as the 'Trustee'. The concept of benefit sharing thus arose albeit with little practical input for its modalities. As a policy, nevertheless, such approach would require giving appropriate value and special protection to genetic resources made available by the farming communities so that appropriate compensation can be reasonably ascertained whether in monitory or developmental terms.

(c) Equity for the farm women

24. The protection of farmers' intellectual property on the principles of equity has been extended to the recognition/protection of the role of women. Most notably, the legally binding CBD has clearly recognised in its Preamble '...the vital role that women play in the conservation and sustainable use of biological diversity', and affirms '...the need for the full participation of women at all levels of policy-making and implementation for biological diversity conservation'. Similarly, Agenda 21, the Action Programme adopted by UNCED, also recommended in Article 15.4 that, 'Governments should recognise and foster the traditional methods and knowledge of indigenous people and their communities, emphasising the particular role of women, relevant to the conservation of biological diversity and the sustainable use of biological resources, and ensure the opportunities for the participation of those groups in the economic and commercial benefits derived from the uses of such traditional methods and knowledge'.

VI. Legitimising rights over genetic resources

25. The last decade of the twentieth century has witnessed climax to the genetic resource management scenario. The Earth Summit held in 1992 in Rio de Janeiro and the Convention on Biological Diversity (CBD) adopted at that conference have legalised conservation, access and sustainable use of genetic resources. The countries, according to the CBD, have sovereign rights over their biological resources and the authority to regulate access to these resources through national legislation. Countries have also been charged with the responsibilities of conservation of their biological resources and sustainable use of their components wherein farming communities have also been given the ownership rights! Thus, genetic resources under this new regime have been transformed legally rather than genetically, from essentially free resource to a resource on which claims of ownership are developing. This essentially would require new rules and regulations to protect the interests of such owners, whether farming communities or countries.

26. For the legal enforcement of sovereign and community rights over genetic resources it is important that the identity and origin of these resources can be established. Extensive efforts in *ex situ* conservation of genetic resources in the international, regional and national gene banks and development of intensive databases in respect of their passport and characterisation data have added more complexity rather than rational solutions to these problems. More voices are heard indicating that such disputes should be resolved but hardly few would be able to interpret or even understand as to how it could be resolved in cases of dispute? Before, such questions are actually posed, let us understand a bit further about the international scenario on legalising intellectual property protection particularly in relation to the genetic resources.

VII. International agreements on IPR

27. The establishment of the World Trade Organisation (WTO) in 1995 following the final (Uruguay) round of the General Agreement on Trade and Tariffs (GATT) negotiations marked the beginning of a new era of legally binding, regulated intellectual property protection, explicitly linked to trade in agriculture. The Trade Related Aspects of Intellectual Property (TRIPs) Agreement under the WTO established multilateral rules on IPR, based on uniform minimum standards. Article 27.1 of the TRIPs provided that 'patents shall be available for any inventions, whether products or processes, in all fields of technology, provided that they are new, involve an inventive step, and are capable of industrial application.' In further elaboration of the Article 27, patent protection for microorganisms, and protection to plant varieties by either patent or some effective *sui generis* system or a combination of the two has been made mandatory. Linking of the *sui generis* system with the provisions of plant breeders' rights under the Convention of the Union for Protection of New Varieties of Plants (UPOV) was largely implied although not binding due to absence of its mention in the TRIPs.

28. The UPOV Convention, 1961/1972, 1978, and 1991, provided and harmonised rules governing plant breeders' rights (PBR), which differed in nature from patent. The provision of breeders' exemption, which permitted the use of a protected variety to breed and sell other, new varieties (including the essentially derived varieties as per the UPOV 1961/1972 and UPOV 1978 provisions), and a farmers' exemption, which allowed farmers to save and re-use seed of protected varieties for future crops. The UPOV 1991 Convention, however, substantially revised its provisions, allowing right holders to prohibit the multiplication, selling and export of both reproductive and harvested materials, including processed goods. It also extended protection to essentially derived varieties (EDV) and narrowed down the farmers' privilege to save seed as optional and subject to the stakes of right holder's interest. The UPOV, no doubt, provided the model Act, a procedure and a multilateral platform to implement plant variety protection but, nevertheless, the *sui generis* options that can be admissible under the TRIPs may clearly exceed, beyond the provisions of UPOV, depending upon the national requirements and opportunities in different countries.

29. The Convention on Biological Diversity (CBD), which emerged in 1992 from environment led negotiations, focused on conservation and sustainable use of biodiversity, encompassing ecosystems, species and genetic material. It also addressed *inter alia* issues of access to genetic resources for utilisation, technology transfer, IPR, and environmental damage. The CBD Articles 15 (Access to Genetic Resources), 16 (Access to and Transfer of Technology), and 19 (Handling of Biotechnology and Distribution of its Benefits) are particularly relevant to IPR. Article 15.1 recognised the sovereign rights of States over their biological resources. This provision itself challenged the major international agreements on IPR protection of plants, animals and microorganisms. Further, Article 15.7 provided for legislative, administrative and policy measures by country parties with the aim of sharing, upon

mutually agreed terms and in a fair and equitable way, the results of research and development and the benefits arising from the commercial and other utilisation of genetic resources with the Contracting Party providing such resources.

30. Further, Article 16.1 recognised the transfer of technology, including biotechnology, as an essential element for meeting the objectives of the Convention. Article 16.3 also has implications for IPR as it clearly required contracting parties to take legislative, administrative or policy measures to provide access to and transfer of technology including technology protected by patents and other intellectual property rights, on mutually agreed terms, particularly to developing country parties which provided these resources. Article 16.5, in clear words required the contracting parties that recognised patents and other intellectual property rights, which may influence the implementation of CBD, to cooperate subject to national legislation and international law in order to ensure that such rights are supportive of and do not run counter to the objectives of the Convention. Although CBD has clearly preceded the TRIPs Agreement, the US position to this article was that only GATT TRIPs agreement would be acceptable to them as adequate and effective standard of IPR protection at the international level. The conflict in the ideology and acceptability of IPR protection had thus clearly surfaced in the developed world.

31. Article 19.2 of the CBD reiterated the importance of mutually agreed terms in terms of transfer of the products of biotechnology whereas the Article 19.3 called upon parties to consider a binding protocol on the safe transfer, handling and use of biotechnological products. Hence, the CBD obligations under Articles 15.7, 16.3 and 19.2 have left considerable discretion of the parties to ascertain the commodity value of biodiversity.

32. The issue of access to genetic resources that remained unresolved under the CBD had been further referred to the FAO International Undertaking 1983 for seeking a solution in harmony with the Convention. This Undertaking was sought to enable all countries to make full use of plant genetic resources for the benefit of agricultural development. Free exchange, albeit not free of cost, of the 'Heritage of Mankind' had been the masterpiece, which was revised in interpretation thrice. The two 1989 resolutions (4/89 and 5/89) changed the Undertaking to the extent that, (i) it should be consistent with plant breeders' rights, and (ii) it should recognise the farmers' rights, being the 'rights arising from the past, present, and future contributions of farmers in conserving, improving and making available plant genetic resources', and the third 1991 resolution (3/91) *inter alia* affirmed the sovereign rights of nations over their plant genetic resources. After the establishment of the CBD, member states agreed (resolution 7/93) to renegotiate the Undertaking in order to harmonise it with the provisions of the Convention and to provide for/implement in particular farmers' rights and access to *ex situ* collections held prior to the CBD.

33. The renegotiated IUPGR has been adopted as the International Treaty on Genetic Resources for Food and Agriculture in November 2001, as a legally binding instrument, with 116 votes in favour and two developed country abstentions – the USA and Japan (ETC group, 2001). The treaty has created a legally binding international agreement after seven years of inter-governmental negotiations. However, this will enter into force when 40 States ratify it. The Agreement is expected to stretch the multilateral environment for access of, use and benefit sharing from genetic resources of at least an agreed list of crops thereby ensuring the growing world population with *inter alia* more food from public good.

VIII Regional position on IPR

34. ASEAN member countries had collective position in the revision of the International Undertaking that the issues of sovereign rights, access to genetic resources, benefit sharing and international funding mechanism should not be seen in isolation but resolved in conjunction with each other. Also, similar position was maintained by this regional group on the provision of TRIPs Article 27.3(b), relating to patentability of plants and animals, other than micro-organisms, and the right/duty of countries to put in place a system on plants and animals through a *sui generis* system. The ASEAN workshop had clearly recommended preference for a *sui generis* system of the protection of plant varieties, and that each country should be fully independent to develop an appropriate system (Raghavan, 2000). A PGR workshop at the SAARC level held at New Delhi in 1999 also took initiative and recommended that the country of origin of genetic resources should be treated as the provider country so as to ensure equitable sharing of benefit at the right place.

35. African and the Latin American group of countries had somewhat similar common stands on issues concerning IPR and genetic resources. Nevertheless, the inter-governmental negotiations are concluded only when a consensus or near-consensus is arrived on common issues across the developed and the developing world.

IX A developed country position

36. The US passed the Plant Patent Act as early as in 1930, extending patent protection to new and distinct *asexually* propagated varieties. This Act marked the gradual separation of the farmer from control of seed and the making of seed a commodity. Those who first took advantage of the law were not for the most part farmers and occasional breeders, but nurseries and seed companies. Similarly when the Plant Variety Protection Act of 1970 extended certain monopoly rights over new varieties of *sexually* reproducing plants to plant breeders , the latter generally meant seed companies and not individual farmers (Fowler, 1994). This Act facilitated the growth of agri-business but the concomitant disappearance of the small, seed-saving farmer. Further, an amendment to the Plant Variety Protection Act of US in 1994, does not permit farmers to save seed for future harvests or to trade varieties among themselves in conformity with UPOV 1991.

37. It is believed that patents granted for genetically engineered cotton in the US may profoundly influence the future of a $20 billion crop critical to many national economies in the South. However, on the other hand, farmers' organisations in Andean countries also believe that patents granted for two varieties of coloured cotton do not recognise the major contribution to the new product by indigenous communities in South and Central America. This developed-developing divide on the issue is imminent and the unequal legal position of right to royalty and right to benefit sharing further widens the gap.

X Indian legislative and regulatory scenario on IPR and PGR

38. Some legislative and regulatory measures have been either taken or are in the process of being taken in India to cope up with the existing/emerging situations. The Patents Act 1970 along with Patents (Amendment) Act 1999 are in force which, however, do not cover the subject matter in question. The patentable subject matter in agriculture according to Patents Act, 1970 includes a device/machine, a process (but not agricultural or horticultural process), a product/article, composition of matter or any improvement thereof. Any process for medicinal, surgical, curative, prophylactic or other treatment of animals or plants to render them free of diseases or to increase their economic value or that of their products or plant varieties, strains of animals or birds, or microorganisms *per se* are not patentable as per the Act in vogue. Second amendment of the Patents Act is also in progress to further harmonise it with the TRIPs provisions.

39. Under the Indian law protection for plant varieties is not provided by patent but by a *sui generis* system, covered under the Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act 2001, which is yet to be enforced. Some unique features of the PPV&FR Act 2001 are that protection is available for extant varieties, including farmers' varieties, in addition to new varieties; a farmer is recognised as breeder, conserver and preserver of traditional varieties of crops and wild species in addition to cultivator; any plant variety having genetic use restriction technology (GURT), like terminator gene, is not protectable under law; a National Gene Fund shall be established in order to *inter alia* support conservation of genetic resources; and, an extensive farmers' right as farmer-breeder, farmer-conserver and farmer-holder of genetic resource is ascertained.

40. A Geographical Indications (Registration and Protection) Act 1999 is similarly in place but not enforced so far. The salient features of the Act are that goods, including agricultural and manufactured goods, shall be protected as originating, or manufactured in a territory, region or locality of the country where the given quality, reputation or other characteristic of such goods are essentially attributable to the geographical origin. Such protection shall be from any act of passing off, unfair competition, etc.

41. A Biological Diversity Bill 2000 is waiting enactment once cleared from a Joint Committee of the two Houses of Parliament. In practice, after the enforcement of the CBD, a setback to the international germplasm exchange has been experienced in most cases in the absence of a congenial environment for confidence building. This has occurred despite a moratorium by the CGIAR centres, holding their *ex situ* collections in 'Trust' for the world community under the auspices of the FAO. The revised International Undertaking (IU) is hoped to revoke confidence building under the multilateral system of exchange and benefit sharing for germplasm of an agreed list of crops.

XI IPR and non-governmental viewpoint

42. Attempts to hammer out ideas and recommendations on intellectual property, identifying trends, concerns, and opportunities in intellectual property issues related to plant breeding and plant genetic resources were made in several informal groups besides the formal inter-governmental developments. In contrast with the formal inter-governmental negotiations, these groups have been attempting to distill various viewpoints on issues related to the impact of intellectual property rights (IPR) on farmers, rural society and biodiversity and to make appropriate recommendations to the formal negotiating bodies.

Such diverse informal groups were formed at the collective initiative of a few international agencies and NGOs, consisting of participants from the developed as well as the developing world, including agricultural research scientists, science managers, intellectual property specialists, trade diplomats and agricultural policy analysts.

43. The impact of intellectual property on trade, agrobiodiversity, and rural society, the major issues involved thereof and of the range of policy alternatives have been a little better understood in such informal group meetings from the social and the legal points of view. One such informal NGO group, namely the Crucible Group, although recognised the protection of species and ecosystems as a moral obligation, nevertheless, it also advocated, at the same time, that the development of any sound conservation strategy must be done only in conjunction with the protection of interests of the people who depend upon diversity most immediately. Quite naturally, artificial barriers between conservation and sustainable utilisation must be broken down by acknowledging rural communities as the effective and economic conservers of biological diversity (The Crucible Group, 1994).

44. The non-governmental sector can recognizably play an important role in at least dissemination of public awareness and increasing IPR and PGR literacy. It has greater informal access to both public and private sectors and, therefore, provides an important link between them for several issues of social and economic concerns. There are several NGOs at the international and national levels, which have made recognisable contribution to the genetic resources conservation and intellectual property protection. The World Wide Fund (WWF) for conservation of nature and natural resources, the Global Environmental Facility (GEF) among others have made significant funding contributions for the purpose and have further potentials to do so. Even the Convention on Biological Diversity has recommended the GEF to function as an interim fund provider for pursuing the purposes of the Convention till some sustainable Funding and Financial Mechanism is established by the CBD. Some NGOs are major think tanks, for example, Genetic Resources Action International (GRAIN), Working Group on Traditional Intellectual, Cultural and Scientific Resource Rights (WGTRR), The Crucible Group, the Rural Advancement Foundation International (RAFI), and several others.

45. With such non governmental perception and perseverance, the term Traditional Resource Rights (TRR) has emerged to define rights which can be utilised to protect and conserve genetic resources and also ensure compensation in an attempt to build upon the concept of 'IPR protection and compensation', while recognising both tangible and intangible traditional resources. In contrast, the term 'property' has not been preferred, since for indigenous people property often implies intangible, spiritual manifestations and beliefs, which although belongings worthy of protection, do not have proprietary nature for individuals and families. Thus, privatisation of these traditional resources or considering them equivalent to commodity is alien to their culture, incomprehensible and even unthinkable. Nevertheless, indigenous and traditional communities over the time have been increasingly involved in local market economies and a number of their traditional resources are traded in those markets (Posey *et al.*, 1995). The interpretation and implication of these terms is bound to vary at large for the local communities, which may not be effectively expressed/applied to their benefit by the formal sector or the private interest. The local level small NGOs by themselves or in collaboration with the medium sized national and trans-national NGOs can essentially play their positive role in reaching the people with the awareness ideas and also the implementable solutions in collaboration with the respective national systems.

XII The private face of IPR

46. Closer examination reveals that intellectual property rights have no necessary relation with invention, innovation or ingenuity. Typically, the economic systems based on competition are guided by the theory that incentive is responsible for innovation. People are thought to gain and lose at each other's expense, and reward is associated with advantage (Lamola, 1992). Accordingly, the industrial circles, unlike the public sector, clearly recognise the IPR only to gain advantage over the economic competitors. Beside the recoupment of the R&D costs, further R&D is done by the business houses for *inter alia* the status symbol and academic pride of the company for which the economic cost is recovered from the market, excluding others to enter into competition by resorting to protection of intellectual property, for at least the term for which such protection is granted, say 20 years for patents.

47. Nevertheless, the monopoly use of IPR belies the free market, creating a sharp divide between the developing and the developed economies. It is not unexpected that in making attempts to strengthen the export sector or to get their economic houses in order the developing world is likely to fade or wipe out in the market due to export competition from the developed countries.

XIII Biotechnology, PGR and IPR

48. Biotechnology is being considered to have the potential to reorganise large sections of the agricultural sector, like microelectronics for the industrial sector. This is particularly made possible because of some complementarities of advances in biochemical and molecular technology with the conventional plant breeding. An easy although costly reference is made to modern techniques involving molecular markers that would allow for discriminating plants and plant populations based on detailed description of their heritable material. Nevertheless, such discriminant function is likely to be of practical use only when other proprietary and sovereignty issues are resolved.

49. The potentials of biotechnology have raised the utilisation limits of biodiversity to the level of infinity! As a matter of fact, under these circumstances, the definition of genepool may be expanded beyond any limits. Moreover, the general notion that biodiversity is receding is clearly arguable, simply based on the theory of geometrical progression of living forms, and also particularly when there were so many reports of fast evolution of virulent forms in pathogens/pests following the deployment of resistance genes in the widespread monocultures of host varieties in the green revolution era and the possible exponential thereof. The diversity of higher plants and animals is although under a considerable degree of threat due to several factors, such as urbanisation, environmental pollution, competition, replacement of low yielding traditional types, by widespread monocultures of improved types, etc., yet the overall increase in the biodiversity of the microbial world and also that at the micro level is not ruled out. Even at higher level far more gene flow is taking place and many varieties are really genetically broad based than ever before. Thus a dual expectation from growth in biotechnology, on one hand, and the expanding biodiversity within a 'common' and reachable genepool, on the other hand, reposes brighter prospects of growth in agriculture through extensive use of biotechnology as well as biodiversity in the years to come.

50. Industrialised countries clearly recognise biotechnology and intellectual property as two important elements of industrial policy aimed to increase overall national productivity in terms of growth, technological development and/or capital formation in various sectors of the national economy. These elements are clearly vital for gaining a competitive advantage over others provided there is equal respect for *inter alia* fair trade practices, regulatory climate and, above all, market and social acceptance of the commodity.

XIV Biosafety and IPR

51. It may have to be appreciated that as a normal course, climate in routine business and foreign investment would highly depend on the general economic and commercial policies of a country And, such policies being liberalised under the WTO Agreements, investments in agricultural biotechnology would have been welcome by both investors and the recipients. But, free negotiations on the matter are definitely and obviously constrained in both developed and developing world because of ethics and the apprehensions for biosafety or food safety of the end products or the strict regulatory requirements as in Europe.

52. It is understood that a biotechnology policy framework developed for international business would allow genetically engineered products to be imported/exported into various country/transitional markets but as per the rule of the game, domestic legislation of the importing country would ultimately has to be respected. This obviously calls for strengthening the techno-legal institutional mechanism of the importing country, which may have been pre-empting many developing and least developed countries to a state of indecision at the first place! Specific policies required to be developed by all countries with respect to use of genetic resources through biotechnology shall have to simultaneously focus on the areas of intellectual property rights and biosafety and food safety regulations for novel foods.

XV Public research and commercialisation

53. Generation of funds from research programmes, particularly in areas having potential for commercial agriculture, is relevant but in order to establish such a policy, a number of critical questions, particularly those concerned with public and private sector relationships and/or legitimacy of each one in particular circumstances, may have to be faced. The following cases may provide a few examples to this effect:

- research, the sale of whose products is feasible and profitable. A logical incentive mechanism for researchers may have to be established, which may raise issues of equity and incentives for public sector employees
- sale of non-research products by research units where this course of action may reduce research outputs
- technologies to be protected by intellectual property rights (IPR), wherein the cost of collecting revenues from contracts and royalties may outweigh the funds generated. It

is obvious that any research unit in order to pursue IPR protection and negotiations for commercialisation would have to establish/hire for specialised services of legal and business experts

- crop-, ecological-, and resource-management research aimed to focus the requirements of small-scale farmers and more marginal areas, where there is little opportunity to earn revenues from the sale of its products

In conclusion, a balance would have to be arrived at between pressing public/social needs and legitimate private sector interests.

XVI Removing the parallax

54. Perhaps an answer to at least some of the following questions may help in providing basis for resolving issues of ownership, intellectual property right, sovereign right, benefit sharing, and equity:

- ? Which course of legal protection has been adopted and what legal requirements made essential for protection of intellectual property rights (IPR)
- ? What types of materials can be essentially protected? What are the additional provisions, if any
- ? What can be considered as the *prima facie* evidence for identity and ownership of the materials
- ? Are the genebank and international databases adequately resolute and fairly placed so far as essential passport data are concerned
- ? Is DNA fingerprinting, or related molecular techniques, capable for identifying landraces and their origin? If so, at what cost and what are the limitations
- ? What can be the relevance of and what can be various modalities of exercising sovereign rights for access to genetic resources
- ? What can be the legal implications of enforcing sovereign rights using molecular techniques of germplasm identification
- ? What can be the feasibility and degree of correctness or unambiguity in determining the country of origin or the providing country
- ? Is there enough jurisprudential awareness/ preparedness on genetic resources, access, benefit sharing, equity and intellectual property claims
- ? Is there any provision for arbitration? If so, how can arbitration be made more feasible and quicker
- ? What can be the extent of feasibility and acceptability to modify/reform legal systems to be able to protect wider range of genetic resources, such as community owned landraces

55. New and complex problems are expected to keep on emerging, which have to be faced while efforts to develop workable rules and regulations have to continue following the respective enactment of each national law, in the global interest of cooperation for higher food production and more nutrition for the ever growing billions of humans.

XVII Growing needs

56. By the year 2050, world population is expected to cross 11 billion mark. To meet the growing needs, at least 185% increase in food grains production is estimated. During the period, as gains through area expansion would be limited, productivity will have to be got essentially doubled. As the Indian population is estimated to be around 1.5 billion, ours would be the most populous nation on the earth surpassing China and every 5th or 6th human being would thus be an Indian. In such a situation, it would be Himalayan task to feed the people as we have only about 4% of the global land and 2.5% of the water. Also, as economy is expected to grow further, it is quite likely that there would be substantial change in the food habits involving far more animal based proteins despite vegetarianism being advocated. In such a situation, for achieving food, nutritional and environmental security, one will have to address to the challenges of productivity declining, soil eroding and degrading, biotic and abiotic pressures increasing, and problems associated with climatic change surmounting.

57. Far greater efforts on natural resource management and judicious use of inputs would, hence, be essentially called for in order to enhance efficiency, effectiveness and relevance. New innovations would be required in effective land-use planning, crop modeling and genetically architecturing plants, animals and fish to be far more productive. With the advent of biotechnology as a powerful tool, there is likely to be no barrier to the gene flow across kingdoms. And, thus, the 1.7 million documented species, including plants, animals and microbes, can be useful source for genetic enhancement in each of the sectors. Far more input in terms of working expenses, infrastructure and first rate human resource development would be called for. The crux of the whole problem would, nevertheless, lie for making far more resources available to agricultural sector for research and development efforts.

58. Capital formation in agriculture is essentially required to go up if we have to keep pace with growth and accelerate it further. From where these resources would come? Public, private, or both? Private sector would be interested in those areas where returns on investment are likely to be more and assured! Then, who will address the concerns of fragile eco-systems such as the arid, coastal, hilly and rainfed? Who is going to invest in crops and commodities like groundnut, chickpea, etc. where seed requirement per hectare is quite high and crops are likely to be a gamble of the moisture and monsoon?

59. Hence, public sector will have to definitely invest more and more if equity, social justice, balanced and harmonised growth are required to be attained. If public sector investment commensurate with the dimension of the problem are not likely to flow in, then incentive will have to be built in for accelerated investment by the private sector for propriety private goods and services with exclusive marketing rights. Recent developments in GATT-WTO-TRIPs and in a number of national legislations have provided some incentive in this direction. Let us analyse as to how this would affect the Indian agriculture in decades to come and what paradigm shifts would take place in the foreseeable future.

XVIII Paradigm shifts

60. Poultry, piggery, goatery, dairy, aquaculture, floriculture, tissue culture, protected cultivation, seed and planting material production, precision farming, hybrid research and development etc., would be moving far more in an organised way in private sector in tune with the National Agricultural Policy, Patent Regime and Protection of Plant Variety and Farmers' Rights Act passed in 2001.

61. Due to conflict in interest of major donors who also happen to be from the developed economies, far more investment in natural resources management through CG institutions would flow in, in contrast with their earlier thrust on seed development through IRRI on rice; CIMMYT on maize and wheat; ICARDA on lentil, chickpea, barley; and, ICRISAT on groundnut, pigeon pea, chickpea, pearl millet and sorghum. In such a scenario, donor driven CG institutions may like to define seed as a private goods. Hence, to ensure that researches in seed sector are further continued and accelerated, developing nations will have to own far more than ever before these CG institutions by enhancing their contributions for genetic enhancement of crop plants lest the flow of semi-finished materials in crops like rice, wheat, maize, chickpea, pigeonpea, etc. would dry down in the foreseeable future.

62. There is expected to be a shift from public to private sector in hybrid crops such as sunflower, maize, pearl millet, sorghum, cotton, vegetables, etc. In these crops, the onus of basic and strategic researches to augment the needs of the private sector efforts is likely to be there in public domain. The investment in self pollinated crops is not likely to flow much from the private sector as farmers can retain the seed, use the seed, exchange the seed and sell the seed except the branded seed as per the Protection of Plant Variety and Farmers' Rights Act 2001. Hence, the margin of profit would obviously be low and private sector would certainly be looking to the green pastures first. Crops like groundnut, chickpea, minor millets, under-utilised crops, etc., which are grown in fragile eco-systems, would particularly be the area domain of operation of public sector at least in a few decades to come.

63. The extension system for propriety products will go a sea-change. As exclusive marketing rights would operate, the routine Government extension system will have to give way to far more professionalised private extension systems. There would be every likelihood of tie-ups of public-private, private-private and public-public sector institutions right from basic research to technology generation and its transfer. As the transfer would directly be related with the return on the investment made, far more innovative ways would be seen on ground as we go along. Also, as the technology will have to move in a systems perspective, far more re-orientation in technology generation, its evaluation, on course correction and transfer would be required. The extension system will be far more knowledge demanding and far more higher understanding of the different components of the technology in a systems perspective would be essential for ensuring impact of the technology in terms of net monetary return per unit area, time and input in a system context.

64. Consultancy, contract research, contract service, incentive and reward systems in the public sector would be far more pronounced. In many of the areas, shift will take place on the utilisation of resources created in the public sector by the private sector. Many of the complimentary researches will have to be got done including arrangements on production, processing, storage and marketing of finished products/technologies developed as proprietary item in public sector institutions. Such a tie-up in some of the cases would even be required with multi-nationals if one wants particularly the technology transfer beyond the national boundaries. Improved Indian crop varieties in crops like sugarcane, rice, wheat, maize, groundnut, chickpea, etc., do have and are likely to have far more commercial value in a number of countries on a continued basis.

65. To derive benefit, an elaborate awareness campaign about potential of technologies and stipulations of IPR regime will have to be brought about and must be integrated as part of research and development efforts of various institutions. Effective generation of information, their documentation and ensuring fulfillment of all the likely requirements of IPR regimes will have to be brought in place. In case of crops, testing procedure concentrating on DUS and assessing the value of varieties for their cultivation and use will have to be established.

66. The very basic approaches to varietal development, parental line development, and genetic enhancement of material to be used as potential donors will go a sea change. It will have to be market oriented and demand driven. At the same time, the public sector institutions will have to strike a balance between the social needs and commercial value of their technologies. Hence, structural adjustments would call for far greater innovation, not only in technology generation but also for its dissemination and management.

67. Because of the sovereign rights on the genetic resources, far more research activity would be essentially called for in collection, conservation, evaluation, documentation, utilisation and protection of these materials in the Intellectual Property Regime. Community Rights, Breeders' Rights, Farmers' Rights, etc., will have to be effectively balanced in such a way so that developmental efforts could continue. Globally, gene rich nations are seed poor. In other words, gene rich are technology poor or technology rich are gene poor. In such a situation, various stipulations of the Convention on Biological Diversity, such as, the facilitated access to genetic resources, the fair and equitable sharing of benefit accruing therefrom, technology transfer and capacity building, and patenting mechanisms agreed in TRIPs of WTO, will have to be harmonised by developing and implementing appropriate Code of Conduct. How can there be a Facilitated Access when patenting of microorganisms, and even higher organisms is permitted under TRIPs? The contradictory situations will have to be assessed and ways and means thought of.

68. Due to changing paradigm shifts, far more technologies are likely to be developed which are efficient, effective and need based on a changing time scale. In this endeavour, it is quite likely that fertilisers such as nitrogenous, phosphatic, potashic, or their combinations, could be fortified with essential elements such as zinc, boron, sulphur, etc., depending on their efficiency in soils of different regions and in varying situations. Incentives would help such ventures which would be useful for the health of the soil and addressing the concerns of declining factor productivity.

69. There is every possibility that accelerated investment would lead to designer crops. Be it the fatty acid profiles of the oil or amino acids in the protein, essential micronutrients, vitamins and even vaccines in some cases, products could further be fortified. Hence, even quality based pricing, segregated marketing and commensurate trade arrangements will have to be thought of.

70. There is every likelihood that researches would lead to conversion of the C_3 crops like rice or wheat to C_4 crops like maize that can use far more CO_2 and in the process not only yields can be enhanced but increased CO_2 associated problems of environment and climatic change could also be addressed to. There could be also rice varieties that could emit very little or no methane and, hence, address the concerns of ozone layer depletion. Plants can be evolved that could take selectively from the soil, toxins, heavy metals and other materials injurious to the soil and plant health. Similarly, there is great possibility of developing bacteria and viruses that could be used for efficient production of different value added products. Such a situation would lead to far more re-orientation of the entire production, processing, storage, marketing, trade and consumption pattern.

71. Through effective use of genic power, shelf-life of perishable products could be enhanced, heat or cold tolerance in plants could be brought about, and moisture, salinity, alkalinity tolerance could be inbuilt. Similarly, tailor-made crops and their varieties could be developed. And, all this would essentially change the cropping and the farming systems perspective. Hence, with potential based re-orientation in the entire set-up, technology led growth commensurate with the needs could be made possible.

72. As we go along, transgenics would be the order of the day. Products never thought of in the past would be available in the market. For all this to happen, risk assessment based releases for commercialisation would essentially be called for.

73. Botanical pesticides would be growing far more faster. Biological fertilisers would be much more pronounced. Biological pest control measures would be in good use and integrated pest and nutrient management will have to be essentially promoted. This would require change in the mind set.

74. Propagule production, marketing and trade would be for more organised and much would be addressed to through private investments. Tissue culture industries would be proliferating in various crops and commodities in providing disease free planting

materials. This all would require a positive change in Seeds Act 1966 and commensurate rule, regulation and guidelines thereof.

75. Researches and technology generation will be going a sea change and they will have to address the very basic issue of efficiency, which would be so essential to be effective and relevant to complete in terms of cost and quality. In this endeavour, integrated gene management and harnessing the genic power will hold the key.

IX Epilogue

76. It is believed that far more innovation in biotechnology would lead to genetically architect desired plants/animals/microbes/products with far greater precision and speed. With the vast genetic wealth available, cutting across the kingdoms, far many new products would be witnessed. In such a scenario, risk assessment based commercialisation would be the order of the day. This would bring a sea change in the production, processing, storage, marketing, trade and consumption patterns. As we go along, many proprietary items with exclusive marketing rights in intellectual property regimes would prevail. If competition is not brought to bear, exclusive marketing rights would lead to monopolistic tendencies. Due to shrinking public resources for R&D efforts, the IPR regimes would be far more stringent and would be driven by IPR holders. To derive benefit, it would be desirable to bring far more shifts in positive direction where competition should be the key word.

77. Plain level field is essential for a fair play. Although, it is talked about but such a field is not likely to be there at least for another decade or so. Hence, India will have to re-orient the national policies and programmes so as to ensure a plain level field by far more accelerated R&D efforts in the foreseeable future. If that happens, we would be able to attain and sustain advantages in agricultural sector at the global level. One must realise that we have hardly 0.6% of the global agricultural trade. At the most, and at the best, it could be enhanced to about 2.0% in the next 10 years. Even at that point of time, external market would continue to be a peripheral market. Our real greatest strength lies in internal market. This market will have to be essentially got protected by bringing much needed commerce in Indian agriculture.

78. Through effective coordination and cooperation, capitalising on complimentarities and harnessing synergies of institutions, organisations, sectors and disciplines would be essential. It is hoped that those who will change, and change for the better while analysing the strengths, weaknesses, opportunities and threats on the changing time scale, and re-orient/re-adjust their policies and programmes commensurate with the changes, would be able to attain and sustain advantages locally, regionally and globally.

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Genetic variability for seed yield and seed parameters in sunflower

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Abstract

Sunflower genotypes consisting 80 inbreds and five checks for 11 different characters revealed considerable amount of variability for all the characters except for kernel proportion in achene. All the characters were less influenced by environment showing a close correspondence between GCV and PCV. Test weight, kernel to hull ratio, number of filled seeds per head, hull content, seed yield per plant, number of unfilled seeds per head, total number of seeds per head, hull weight, kernel weight and oil content recorded high heritability coupled with high genetic advance as per cent of mean, while kernel proportion in achene recorded high heritability with moderate genetic advance as per cent of mean. Path analysis revealed that seed yield was dependent mostly on the number of filled seeds per head, test weight and kernel weight.

Key words: Genetic variability, correlation, path analysis, sunflower

Introduction

Information on variability and heritability of seed yield is essential for crop improvement. Yield is a complex character and can not be improved by direct selection as it is influenced by a set of other characters, known as yield components. Thus, association of various characters with yield and among themselves would provide criteria for indirect selection through components for improvement in yield. In sunflower (*Helianthus annuus* L.) majority of the studies are based on phenological, yield and yield components. However, studies based on seed parameters and yield components are limited. Therefore, a study was undertaken to find out the extent of variability, correlation and path analysis for 11 important traits in sunflower.

Materials and methods

The experimental material consisting of 80 inbreds and five checks was grown during summer, 2000 in a randomized block design with two replications at Directorate of Oilseeds Research, Hyderabad. Each genotype was grown in two rows of 4 m length with distance of 30 x 60 cm between plants and rows, respectively. Data were collected on ten randomly selected plants in each genotype for total number of seeds per head, number of filled seeds per head, number of unfilled seeds per head, test weight (g), oil content (%), hull weight (mg), kernel weight (mg), hull content (%), kernel to hull ratio, kernel proportion in achene (%) and seed yield per plant (g). The phenotypic and genotypic coefficients of variation were calculated as per Burton (1952). Heritability and expected genetic advance were estimated according to Johnson *et al.* (1955) and Allard (1960). Phenotypic and genotypic correlations were worked out according to Al-Jibouri *et al.* (1958) and path analysis as per Dewey and Lu (1959).

Results and discussion

The analysis of variance revealed highly significant differences among the genotypes for the 11 characters studied which indicated the presence of considerable amount of diversity in the material selected. The range of variation was maximum for number of seeds per head followed by number of filled and unfilled seeds per head, while it was lowest for kernel to hull ratio and test weight. It indicated that there is better scope for selection and improvement for former characters and was confirmed through phenotypic and genotypic coefficient of variations. Still, the magnitude of variation was maximum for number of unfilled and filled seeds per head, seed yield per plant, hull weight, kernel to hull ratio, seeds per head, kernel weight, test weight and hull content (Table 1). Higher estimates of these coefficients indicated wider diversity for these characters. Further, narrow difference between PCV and GCV was observed for all traits and it implied that they were less influenced by environment. High PCV values were reported for total number of seeds per head by Sridhar (1999), number of filled and unfilled seeds per head, test weight and seed yield per plant by Reddy (1999) and hull content by Chikkadevaiah *et al,* (1998). Moderate PCV and GCV values were observed for oil content. These results are in agreement with the reports of

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Table 1 Mean and variability parameters for eleven characters in sunflower

Character	Mean	Range	Coefficient of variation		Heritability broad sense (%)	Genetic advance	Genetic advance as per cent of mean
			Genotypic (%)	Phenotypic (%)			
No. of seeds/head	597	230.0-1075.3	30.75	31.25	96.83	372.04	62.34
No. of filled seeds/head	452	148.9-878.3	32.48	32.78	98.20	299.65	66.31
No. of unfilled seeds/head	144	25.1-500.4	56.08	56.97	96.90	163.71	113.73
Test weight (g)	4.0	1.9-6.1	22.97	23.06	99.27	1.88	47.15
Oil content (%)	32.9	22.2-41.1	13.89	14.30	94.37	9.16	27.79
Hull weight (mg)	134.4	52.5-229.7	31.09	31.74	95.96	84.38	62.75
Kernel weight (mg)	293.7	139.0-506.5	24.60	25.34	94.31	144.58	49.22
Hull content (%)	31.4	20.1-46.2	20.30	20.49	98.11	12.99	41.42
Kernel to hull ratio	2.3	1.2-4.0	31.16	31.30	99.14	1.49	63.91
Kernel proportion in achene (%)	68.7	53.8-79.9	9.38	9.43	98.97	13.20	19.22
Seed yield/plant (g)	16.4	7.1-31.1	31.83	32.17	97.88	10.62	64.87

Patil *et al.* (1996) and Sridhar (1999). Low PCV and GCV values were recorded for kernel proportion in achene, which indicated less variation in the material and less scope for improvement of this trait.

However, the coefficient of variation indicated only the extent of variability existed for different characters and did not indicate heritable portion of a character. The heritability estimates indicated the effectiveness of the character in phenotypic selection. In the present investigation, high heritability estimates were obtained for all the traits. Johnson *et al.* (1955) reported that heritability and genetic advance as per cent of mean together were more useful for predicting the resultant effect of selected genotypes than heritability or genetic advance as per cent of mean alone. Among the traits, majority of the characters recorded high heritability coupled with high genetic advance as per cent of mean except kernel proportion in achene, which recorded high heritability with moderate genetic advance as per cent of mean. Similar results of high heritability coupled with high genetic advance as per cent of mean were reported for total number of seeds per head by Sridhar (1999), seed yield per plant and number of filled and unfilled seeds per head by Reddy (1999); test weight by Madrap *et al.* (1998), oil and hull content by Chikkadevaiah *et al.* (1998). Therefore, selection for these traits, which possessed high PCV and GCV, high heritability and high genetic advance as per cent of mean is expected to result in considerable genetic gains.

In general, the genotypic correlation coefficients were higher than phenotypic correlation coefficients indicating the masking effect of the environment (Table 2). Seed yield was significantly and positively correlated with total number of seeds per head, number of filled seeds per head, test weight and kernel weight both at phenotypic and genotypic levels. This indicated that simultaneous selection for these traits might bring an improvement in seed yield. These results are in conformity with Teklewold *et al.* (2000) for total number of seeds per head, number of filled seeds per head and test weight. Further, number of filled seeds per head recorded positive association with total number of seeds per head, while test weight recorded positive significant correlation with hull weight and kernel weight. Oil content recorded positive significant correlation with test weight and kernel weight. Similar association of oil content with test weight was reported by Mandal and Singh (1993). Hull content had negative association with oil content, kernel weight, kernel to hull ratio and kernel proportion in achene. It indicated that selection for thin hull type would enhance oil content. Similar association of hull content with oil content was reported by Dedio (1982). Kernel to hull ratio recorded positive significant association with oil content and kernel weight. It indicated that higher kernel to hull ratio led to higher kernel yield thereby resulting in higher oil accumulation in seed. Similar association of kernel to hull ratio with oil content was reported by Mandal and Singh (1993). Kernel proportion in achene recorded positive association with oil content, kernel weight and kernel to hull ratio, indicating that evaluation for kernel yield may bring increase in oil content in seed. Similar association of kernel proportion in achene with oil content was reported by Marinkovic (1992).

As the seed yield was influenced by several factors, selection based on simple correlation without taking into consideration the interaction between the component characters can be misleading. Therefore, the correlations were partitioned into direct and indirect effects and presented (Table 3). Number of filled seeds per head exhibited maximum positive direct effect on seed yield followed by test weight. The association of these characters with seed yield was also positive and significant indicating the importance of these traits for improving seed yield. These results are in agreement with Punia and Gill (1994) and Teklewold *et al.* (2000). Kernel weight had positive significant association with seed yield, however,

its direct effect was very low. This may be attributed due to its high positive indirect effects through test weight and total number of seeds per head. Number of unfilled seeds recorded negative and non-significant association and large positive direct effect on seed yield indicating the utility of restricted selection model for exploitation of their direct effects (Singh and Kakar, 1977). In contrast total number of seeds per head recorded negative direct effect on seed yield, however, its association with seed yield was positive and significant indicating the ineffectiveness of direct selection for this trait. Indirect selection for this trait via number of filled seeds per head, number of reduced unfilled seeds per head, kernel to hull ratio and kernel proportion in achene is recommended. Hull weight and oil content recorded low positive direct effects on seed yield reveled low priority in selection for high seed yield.

Kernel to hull ratio and kernel proportion in achene had negative direct effect on seed yield also showed non-significant association with seed yield, which indicated that selection based on these traits, would not be effective. Marinkovic (1992) also reported negative direct effect of kernel proportion in achene on seed yield. It is therefore, suggested that for improving the seed yield and oil content of sunflower, emphasis is to be laid on the number of filled seeds per head and test weight.

Table 2 Phenotypic (r_p) and genotypic (r_g) correlation coefficients among seed yield and yield components in sunflower

Character		No. of filled seeds/ head	No. of unfilled seeds/head	Test weight	Oil content	Hull weight	Kernel weight	Hull content	Kernel to hull ratio	Kernel proportion in achene	Seed yield/plant
No. of seeds/ head	r_p	0.8979**	0.6340**	-0.4981**	-0.3401**	-0.3033**	-0.4922**	0.0770	-0.0386	-0.0715	0.4902**
	r_g	0.8970**	0.6233**	-0.5114**	-0.3686**	-0.3290**	-0.5268**	0.0770	-0.0363	-0.0708	0.4934**
No. of filled seeds/head	r_p		0.2337*	-0.3877**	-0.2272*	-0.2615*	-0.3847**	0.0257	0.0430	-0.0172	0.6827**
	r_g		0.2182*	-0.3951**	-0.2451*	-0.2790*	-0.4078**	0.0253	0.0451	-0.0167	0.6896**
No. of unfilled seeds/head	r_p			-0.4121**	-0.3410**	-0.2146*	-0.3980**	0.1049	-0.1454	-0.1076	-0.0974
	r_g			-0.4234**	-0.3692**	-0.2371*	-0.4275**	0.1045	-0.1444	-0.1063	-0.1103
Test weight	r_p				0.3179**	0.6214**	0.8539**	-0.0308	0.0123	0.0261	0.3150**
	r_g				0.3281**	0.6363**	0.8819**	-0.0306	0.0115	0.0257	0.3193**
Oil content	r_p					-0.1263	0.4572**	-0.5079**	0.5099**	0.5067**	0.0601
	r_g					-0.1303	0.4972**	-0.5276**	0.5300**	0.5273**	0.0666
Hull weight	r_p						0.4291**	0.6870**	-0.6640**	-0.6906**	0.1345
	r_g						0.4172**	0.7032**	-0.6739**	-0.7031**	0.1239
Kernel weight	r_p							-0.3259**	0.2925**	0.3249**	0.2634*
	r_g							-0.3412**	0.3041**	0.3337**	0.2563*
Hull content	r_p								-0.9570**	-0.9961**	-0.0820
	r_g								-0.9633**	-1.0029**	-0.0832
Kernel to hull ratio	r_p									0.9657**	0.1248
	r_g									0.9667**	0.1273
Kernel proportion in achene	r_p										0.0851
	r_g										0.0858

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

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Table 3 Phenotypic (P) and genotypic (G) path coefficient analysis for seed yield and yield components in sunflower

Character		Total No. of seeds/ head	No. of filed seeds/ head	No. of unfilled seeds/head	Test weight	Oil content	Hull weight	Kernel weight	Hull content	Kernel to hull ratio	Kernel proportion in achene	Seed yield/ plant
No. of seeds/ head	P	-0.6958	1.3617	0.1725	-0.2793	-0.0049	-0.0318	-0.0185	-0.0193	0.0038	0.0018	0.4902**
	G	-0.7995	1.4546	0.2127	-0.3291	-0.0178	-0.0513	0.0410	0.0213	0.0064	-0.0448	0.4934**
No. of filled seeds/head	P	-0.6247	1.5166	0.0636	-0.2174	-0.0033	-0.0274	-0.0144	-0.0064	-0.0042	0.0004	0.6827**
	G	-0.7172	1.6216	0.0744	-0.2543	-0.0118	-0.0435	0.0317	0.0070	-0.0079	-0.0106	0.6896**
No. of unfilled seeds/head	P	-0.4411	0.3544	0.2720	-0.2311	-0.0049	-0.0225	-0.0149	-0.0262	0.0143	0.0027	-0.0974
	G	-0.4983	0.3538	0.3413	-0.2725	-0.0178	-0.0369	0.0332	0.0289	0.0254	-0.0674	-0.1103
Test weight	P	0.3466	-0.5879	-0.1121	0.5608	0.0046	0.0652	0.0320	0.0077	-0.0012	-0.0006	0.3150**
	G	0.4089	-0.6408	-0.1445	0.6435	0.0158	0.0991	-0.0686	-0.0085	-0.0020	0.0163	0.3193**
Oil content	P	0.2366	-0.3445	-0.0928	0.1783	0.0143	-0.0133	0.0171	0.1270	-0.0502	-0.0126	0.0601
	G	0.2947	-0.3974	-0.2160	0.2111	0.0482	-0.0203	-0.0387	-0.1459	-0.0933	0.3341	0.0666
Hull weight	P	0.2110	-0.3966	-0.0584	0.3485	-0.0018	0.1050	0.0161	-0.1718	0.0653	0.0172	0.1345
	G	0.2631	-0.4524	-0.0809	0.4095	-0.0063	0.1558	-0.0324	0.1944	0.1187	-0.4454	0.1239
Kernel weight	P	0.3424	-0.5834	-0.1083	0.4789	0.0066	0.0450	0.0375	0.0815	-0.0288	-0.0081	0.2634*
	G	0.4212	-0.6613	-0.1459	0.5675	0.0240	0.0650	-0.0777	0.0943	-0.0535	0.2114	0.2563*
Hull content	P	-0.0536	0.0389	0.0285	-0.0173	-0.0073	0.0721	-0.0122	-0.2501	0.0942	0.0248	-0.0820
	G	-0.0616	0.0411	0.0357	-0.0197	-0.0254	0.1096	0.0265	0.2764	0.1696	-0.6354	-0.0832
Kernel to hull ratio	P	0.0269	0.0652	-0.0396	0.0069	0.0073	-0.0697	0.0110	0.2393	-0.0984	-0.0240	0.1248
	G	0.0290	0.0731	-0.0493	0.0074	0.0255	-0.1050	-0.0236	-0.2663	-0.1761	0.6124	0.1273
Kernel proportion in achene	P	0.0497	-0.0261	-0.0293	0.0146	0.0073	-0.0725	0.0122	0.2491	-0.0950	-0.0249	0.0851
	G	0.0566	-0.0271	-0.0363	0.0165	0.0254	-0.1095	-0.0259	-0.2773	-0.1702	0.6335	0.0858

Residual effect (phenotypic) = 0.23369
Residual effect (genotypic) = 0.18440

Bold = Direct effects
Normal = Indirect effects

* significant at 1% level
** significant at 5% level

Agriculture, Hyderabad during kharif, 1998. Eight crosses were made between the CMS lines and the restorers to generate F_1 seed. During the *rabi*, 1998 the F_1 plants were studied for fertility reaction and the plants with complete male fertility (100%) based on visual observation were selfed to produce the F_2 seed. In summer *1998-99*, the parents, F_1 and F_2 were planted. The parents and F_1s were raised in single row, while the F_2 plants were grown in 40 rows of 5m length with a spacing of 60 cm between the rows and 30 cm between plants within a row. Necessary package of practices and plant protection measures were taken to produce a healthy crop. The F_2 plants were classified as male fertile and male sterile based on anther development and amount of pollen production and the data was subjected to χ^2 analysis. Pollen fertility was confirmed in the laboratory by using 2% acetocaramine staining.

Results and discussion

The results pertaining to fertility restoration in F_1 from eight crosses utilizing three diverse CMS sources and three restorer lines are presented in Table 1. The male fertility of CMS 7-1A was fully restored by DRS-5. In DCMS-6, fertility was fully restored by DRS-2 and DRS-3, while DRS-5 could not restore the fertility. In DCMS-1, the fertility was fully restored by DRS-2 while DRS-5 and DRS-3 could not restore fertility. These results indicated that the cytoplasmic sources inducing male sterility were diverse and need different fertility restorer genes for fertility restoration. The crosses, which showed complete fertility restoration in F_1 generation, were selfed to produce F_2 generation for inheritance studies.

Table 1 Male fertile plants (%) in the F_1 generation of crosses between three CMS sources and three maintainer/restorer lines

Inbred line	Cytoplasmic male sterile source		
	CMS 7-1A (PET-1)	DCMS-6 (PET-2)	DCMS-1 (GIG-1)
DRS-5	100	0	0
DRS-2	0	100	100
DRS-3	Not studied	100	0

The F_2 generation data for male sterility and male fertility is presented in Table 2. The segregation analysis of F_2 data from the crosses CMS 7-1A x DRS-5, DCMS-6 x DRS-2 and DCMS-1 x DRS-2 showed a ratio of 3 fertile : 1 sterile indicating a single dominant gene for fertility restoration. Similar results of single dominant gene control of fertility restoration for PET-1 source has been reported by Leclercq (1971), Guo and Meng (1989) and Seiler and Jan (1994). In the cross DCMS-6 x DRS-3, a 9:7 segregation for fertility and sterility was observed indicating two complementary dominant genes for fertility restoration. This necessitates the requirement of at least one dominant allele at each locus for fertility restoration. These results are in agreement with that of Kural and Miller (1992) and Meghale *et al.* (1992), who reported two complementary dominant genes for fertility restoration of PET-2 cytoplasm. The line DRS-3 restored complete fertility of DCMS-6 source, however, the same line did not restore fertility in DCMS-1. These results indicated cytoplasmic diversity among the two sources.

Table 2 Segregation for male fertile and sterile plants in F_1 and F_2 generations of the crosses between the diverse male sterile sources and restorer lines

Crosses	F_1	F_2 populations				
		Fertile	Sterile	Total	Expected ratio (F : S)	χ^2 at 1 d.f.
CMS 7-1A x DRS-5	Fertile (273)	438	158	596	3:1	0.725
DCMS-6 x DRS-2	Fertile (196)	377	142	519	3:1	1.524
DCMS-6 x DRS-3	Fertile (207)	260	188	448	9:7	0.580
DCMS-1 x DRS-2	Fertile (148)	399	157	556	3:1	3.008

F : male fertile; S : male sterile; Figures in parenthesis are the number of plants

The results of the present investigation clearly indicated the existence of cytoplasmic diversity among the three different cytoplasmic male sterile sources used. It is also evident that the single dominant gene restoring fertility of CMS 7-1A is different from that which restored fertility in DCMS-6 and DCMS-1. A single dominant gene present in DRS-2 restored fertility in DCMS-6 and DCMS-1. The fertility in DCMS-6 was restored by a single gene contributed from DRS-2 and two complementary genes present in DRS-3. These findings indicated existence of diverse mechanism for fertility restoration. Further studies are needed to know the precise mechanism of fertility restoration using different CMS sources and fertility restorers.

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Growth analysis of rainfed groundnut (*Arachis hypogaea* L.) in Manipur valley under polymulch condition

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Abstract

The field experiment was conducted at ICAR Research Complex for N.E.H. Region, Manipur centre, Lamphelpat farm, Imphal during *rabi* season as rainfed. Polymulched flat bed and broad-bed-furrow (BBF) system of sowing revealed the production potential of JL-24 variety (2180.7 kg/ha and 1618.0 kg pod yield/ha respectively) in *rabi* season over unmulched condition (1063 kg and 875 kg pod yield/ha), respectively. Significantly higher number of pods/plant (28), pod weight/plant (105g) and 100-kernel weight (43g) were obtained in flat bed system with polymulch over unmulched condition. Further, plant height, dry matter accumulation, LAI, LAR, CGR, RGR and NAR were found significantly higher in flat bed with polymulch and was followed by BBF system with polymulch over all the treatments. The vegetative and reproductive phase also differed under polymulched and umulched condition. Germination was recorded 8 days earlier while, maturity was delayed by 15-20 days under polymulched condition. Flat bed system along with polymulch provided highest net return with benefit : cost ratio of 2.93.

Key words: Groundnut, mulch, economics

Introduction

In India, groundnut ranks first both in area and production among oilseeds with an area of 6.88 m ha and a production of 6.41 mt (Directorate of Economics and Statistics, New Delhi, 2001). Still, there is a wide scope to increase its area and production in India by introducing it in the areas especially in North-Eastern states. Manipur, which occupies 178 thousand ha land under food grains can come forward in its cultivation as valley possesses fertile soil but due to low temperature and scarcity of moisture in *rabi* season the valley lands are usually kept fallow after rice. Polythene mulch conserves soil-moisture, maintains soil-physical condition, controls weed population as weeds can not emerge out from polythene film and their growth is restricted. It also reduces the cost because no intercultural operations are required as plots are fully covered with polythene sheets in flat bed system while only beds are covered in BBF system and furrows remain opened. So, it can be well used in moisture deficit as well as sub-temperate areas. Use of polysheets in agriculture may not be hazardous to the environment as after use, *polysheets may be collected from the crop fields and* mixed with coaltar during construction of pucca roads which may provide an additional strength to the roads. Keeping above points in view, the present investigations was aimed at with the objectives of increasing cropping intensity of Manipur and to study the growth and yield performances of groundnut under polymulch.

Material and methods

The field experiment was conducted during 1997-98 and 1998-99 at ICAR Research Complex for N.E.H. Region, Manipur centre, Lamphelpat farm, soil was clay-loam with *6.2 pH, 2.12% organic carbon and available N:P:K 167.43* kg, 6.87 kg and 190.6 kg/ha, respectively. The experiment was carried out in Randomised block design with five replications and four treatments (Table 1). The net width of each bed for BBF system was 60 cm with a furrow width of 30 cm. In both the systems, an additional space of 15 cm was kept in each bed to cover the polysheets edges and thus the gross width of each bed was 75 cm in BBF system. After covering both types of beds (BBF as well as flat bed) from white transparent polysheets (eight micron thickness, round holes were made with the help of bamboo poles at 15 cm interval and 30 cm row spacing). Two seeds of variety, JL-24 were sown in each hole at about 5-6 cm depth to ensure better germination and to avoid gap filling. Net plot size in BBF and flat bed system was 6.3 and 7.2 m^2, respectively. The recommended doses of plant nutrients at 20 kg N, 25.8 kg P and 49.8 kg K/ha were applied as basal. Application of 2.0 t lime/ha was

* Scientists transferred to ICAR Research Complex for Eastern Region, Patna (Bihar).

also made as basal for amelioration of soil. After germination, leaves and branches were brought out from the holes with the help of fingers where required. Growth parameters like plant height, LAI, LAR, CGR, RGR and NAR were recorded at 30, 60, 90 DAS and at harvest by following standard procedures on the basis of five randomly selected plants while, yields were recorded at maturity on the basis of net plot yield. Soil-moisture was recorded at 0-30 cm soil depth with the help of soil moisture meter by using gypsum blocks and soil temperature by soil thermometer respectively at seven days intervals. Lux meter and anemometer were used for recording illumination and wind speed from/on the soil surface and polymulched surface. The net income and benefit : cost (B:C) ratios were calculated for each system. Correlation between dry matter production and pod yield was also studied.

Results and discussion

Polymulching had influenced the pod and oil yield of groundnut on account of their pronounced effect on growth and yield attributes. Germination was found eight days earlier in polumulched groundnut in both the flat bed and BBF system of sowing. May be because of better soil-moisture and optimum soil-temperature which had favoured the early emergence of polymulched groundnut seeds. In morning hours (6.00 AM) soil-temperature was recorded around 3.0 - 3.7°C higher but was found 1.0-1.8°C lower in the afternoon (2.00 PM) under polymulched plots over unmulched plots. The results got confirmed with the findings of Hu Wenguang *et al.* (1995). It was observed that average soil-moisture at 0-30 cm soil depth was 42% throughout the crop season under polymulch while, it was only 28% in unmulched plots.

Plant height was recorded significantly higher in flat bed and BBF systems with polymulch over unmulched condition at each growth stages. Further, plant height in BBF system with polymulch was found at par with flat bed system under polymulch (Table 1). In general, plant had attained maximum dry matter accumulation at maturity. Dry matter accumulation/plant was found higher in both the systems of sowing under polymulch over unmulched treatments. DMA/plant was significantly higher in flat bed system at 90 DAS and at maturity followed by BBF system with polymulch. The same trend was also reported by Werminghausen *et al.* (1981).

LAI, LAR, CGR and RGR were also found significantly higher in flat bed system with polymulch at each growth stages followed by BBF system of sowing with polymulch over unmulched treatments. The similar trend was also reported by Ravindranath *et al.* (1974) in sorghum under mulched condition. LAI had reached to its maximum value upto 90 DAS and thereafter, it tends to reduce due to senescence, resulted in reduction of functional leaf area available for photosynthesis and lower production of photosynthates. The result also confirmed the finding of Rao and Das (1981). Leaf area ratio was found higher between 30-60 DAS in all the treatments.

Biomass duration was highly correlated with pod yield (Rao, 1979). NAR was also found significantly higher in flat bed system with polymulch and was found higher between 60-90 DAS due to more LAI at this stage in all the treatments (Table 2). At initial growth stage (30 DAS), 1, 26, 984 plants/ha in BBF and 2,22,22 plants/ha in flat bed system were maintained but due to lack of sufficient soil moisture in unmulched plots a number of plants dried up resulting into low LAI, LAR, CGR and NAR. NAR was positively correlated with LAI, LAR and CGR (Rao, 1979).

The highest pod, kernel and oil yields were found in flat bed system with polymulch (2180.7 kg, 1618.0 kg and 782.7 kg/ha) over all the treatments and was followed by BBF system (1602.0 kg, 1127.9 kg and 553.0 kg/ha) with polymulch (Table 3). This higher pod yield/ha under polymulch might be due to better soil-moisture availability and optimum soil-temperature during crop season. Daulay *et al.* (1979) also reported the similar finding in case of potato under mulched condition. There was positive correlation between dry matter production and pod yield (0.583*). Bhattacharya and Sarkar (1977) also observed increased pod yield with the increased number of branches and dry matter accumulation in groundnut.

Germination, flowering and pegging started 8-10 days, 15-20 days and 10-14 days earlier respectively while, maturity was delayed by 15-20 days under polymulch over unmulched condition (Fig 1). May be that polymulched groundnut had got longer reproductive period which favoured the yield attributing characters like higher number of pods/plant, 100-kernel weight and ultimately pod yield (Table 3). Reddy and Venkatachari (1980) also reported the similar findings in different field crops under mulched condition.

The reflection of sunlight 30 cm above the soil-surface was 5.3 - 13.0% when polyfilm was used but only 2.4 - 4.0% without it. The accumulated temperature by polymulched groundnut from 0600-1400 hrs was 3.7°C higher but some what lower from 1400-2000 hrs and wind speed with polymulched groundnut rows was 0.01-0.03 m/s faster as compared to unmulched plots. Faster wind speed had favoured air exchange and CO_2 movement. All these interlinked factors increased NAR and resulted into higher yields of polymulched groundnut. Duan Shufen *et al.* (1998) also reported the same results from their poly film groundnut experiment.

Table 1 Growth parameters at different growth stages of groundnut under polymulch (pooled data of year 1997-98 and 1998-99)

Treatment	Days after sowing														
	Plant height/plant (cm)				Dry matter accumulation/plant (g)				Leaf Area Index (LAI)				Leaf Area Ratio (10^{-2}) (LAR) cm^2/g		
T_1	11	14	22	32	5.8	7.2	23.1	139.0	0.8	3.3	3.8	1.8	184.9	68.7	30.9
T_2	8	12	17	34	1.5	3.6	15.3	118.3	0.7	1.6	2.2	1.5	112.0	57.2	20.6
T_3	13	15	23	37	6.2	8.7	34.6	152.9	1.0	4.1	4.9	2.4	207.8	87.2	34.3
T_4	10	12	18	35	1.7	4.4	19.7	132.1	0.8	2.7	3.3	1.7	146.2	63.4	27.2
CD (P=0.05)	2.9	3.3	5.1	5.3	1.5	3.3	6.9	13.6	0.1	0.2	0.5	0.2	10.4	3.8	2.8

T_1 : Broad bedded furrow (BBF) with poly mulch; T_2 : Broad bedded furrow without poly mulch; T_3 : Flat bed with poly mulch; T^4 : Flat bed without mulch

Table 2 Growth parameters at different growth stages and yield at harvest of groundnut under polymulch (pooled data of year 1997-98 and 1998-99)

Treatments	Days after sowing (DAS)								
	Crop Growth Rate (CGR) $g/m^2/day$			Relative Growth Rate (RGR) g/g/day			Net Assimilation Rate (10^{-4}) (NAR) $g/m^2/day$		
	30-60	***60-90***	***90-Mat.***	***30-60***	***60-90***	***90-Mat.***	***30-60***	***60-90***	***90-Mat.***
T_1	0.485	0.787	0.525	8.56	3.95	1.25	7.34	9.61	7.88
T_2	0.217	0.464	0.349	6.78	1.78	0.22	4.30	4.76	4.58
T_3	0.610	0.934	0.741	9.36	4.83	1.81	7.90	10.5	8.82
T_4	0.392	0.658	0.498	7.60	2.48	0.55	5.21	6.25	5.70
CD (P=0.05)	0.022	0.084	0.137	0.43	0.33	0.29	0.44	0.89	2.01

Table 3 Yield and yield attributing characters of groundnut under polymulch (pooled data of year 1997-98 and 1998-99)

Treatments	No. of pods/plant	Pod wt./ plant(g)	100-kernel wt.(g)	Pod yield (kg/ha)	Kernel yield (kg/ha)	Oil yield (kg/ha)	C:B ratio
T_1	21	73	38	1602	1128	553	2.27
T_2	12	44	34	875	569	212	1.26
T_3	28	105	43	2181	1618	783	2.93
T_4	*18*	*63*	*38*	*1063*	*735*	*310*	*1.48*
CD (P=0.05)	5.2	27.2	4.5	427	339	157	

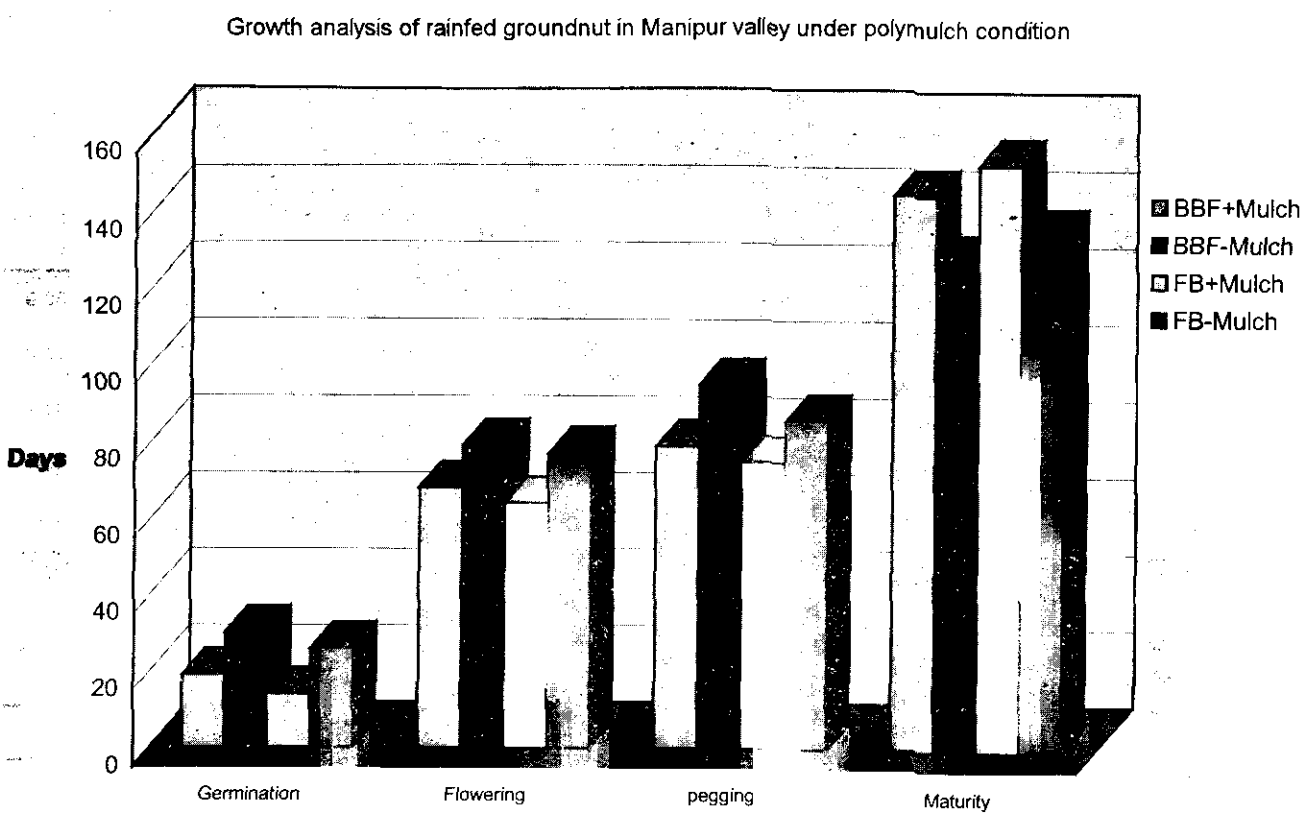

Fig 1 Days taken to germination, flowering, pegging and maturity

It was further observed that flat bed system with polymulch had shown better soil-moisture (47.2%) throughout the crop season as compared to BBF system under polymulch (36.8%). The reason behind was that flat bed system had exposed lesser area to sun while, in BBF system greater area was exposed to direct sun and thus more evaporation from the bed edges had taken place and resulted in little soil-moisture availability to the crops which had shown pronounced effect on yield.

Highest gross return, net return and benefit : cost ratio were obtained under flat bed system rather than BBF system under polymulched condition (Table 3). The lowest economic was recorded under BBF system without polymulch. In general, treatment with polymulch were more remunerative than unmulched.

Thus, it is apparent that *rabi* groundnut can be grown successfully under polymulch in Manipur valley. Further, it will be more profitable if it should be grown with polymulch in flat bed system of sowing. Despite of higher productivity from above two systems it should be further tested in the farmer's field under different soil, moisture and fertility levels for more income from single crop.

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Depthwise distribution of nutrients in groundnut growing soils of Nellore district in Andhra Pradesh

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Abstract

A survey conducted to study the nutrient status of groundnut grown in the Entisols of Nellore district in Andhra Pradesh revealed that the available P status was sufficient in the surface horizons and deficient in the subsurface horizons of all the pedons. The available P and K decreased with soil profile depths while the exchangeable Ca, Mg, available S, Fe, Zn, Cu and Mn increased with depth. In general, the soil was sufficient in available P, exchangeable Ca and Mg and available Me and Mn while deficient in available K, S, Zn and Cu contents.

Key words: Distribution, macro and micronutrients

Introduction

Detailed information regarding the vertical distribution of macro and micronutrients status in groundnut growing soils of Nellore district (AP) is lacking, though sporadic micronutrient deficiencies were reported (Pillai *et al.*, 1982). However, for efficient nutrient management the depth wise distribution of nutrients in soil profiles is highly essential (Ramalakshmi ad Seshagiri Rao, 2000). By keeping the above facts in view the present survey was conducted to study the depthwise distribution of nutrients in the groundnut growing soils.

Material and methods

Six typical pedons namely Suravayapalem profile (P_1-coarse loamy, isohyperthermic, Typic Ustipsamment), Anagaripalem profile (P_2-coarse loamy, isohyperthermic, Typic Ustipsamment), Ramanthirtham profile (P_3-coarse loamy, isohyperthermic, Typic Ustipsamment), Balijapalem profile (P_4-coarse loamy, isohyperthermic, Typic Ustipsamment), Kolladinne (P_5-coarse loamy, isohyperthermic, Typic Ustipsamment) and Diguvamerlapaka (P_6-fine loamy, isohyperthermic, Typic Haplustepts) of Kavali, Nellore and Gudur divisions covering, entire groundnut growing area of Nellore district of Andhra Pradesh were selected. The horizon wise soil samples were collected for detailed analysis. The pedons P_1, P_2, P_3, P_4 and P_5 belonged to Entisol while P_6 belonged to Inceptisol order. The soil samples were processed and analysed for available macronutrients, available and total micronutrients using standard methods as described by Jackson (1973).

The critical limits proposed by Patel and Savani (1987) for available P (13 kg P/ha), Aulakh *et al.* (1988) for available K (150 kg K/ha), Tandon (1991) for exchangeable Ca (1.5 cmol (p+)/kg), Mg (1.0 cmol (p+)/kg) and available S (10 mg/kg), Anon. (1977) for Zn (0.75 mg/kg and Tandon (1993) for available Fe (4 mg/kg), Cu (0.5 mg/kg) and Mn (2 mg/kg) were followed for classifying profile samples into sufficient or deficient with respect to above nutrients.

Results and discussion

These soils were slightly acidic to neutral in reaction, loamy sand to sandy clay in texture, non-saline and low in organic carbon. The CEC of these soils varied from 3.6 to 16.8 cmol (p+)/kg.

Macronutrients: The available P content of soil profiles varied from 2.0 to 24.1 kg/ha with a mean of 7.8 kg/ha (Table 1). Taking 13 kg P/ha as critical level, the available P status was sufficient in the surface and deficient in subsurface horizons of all the profiles except P_3 (Ramathirtham profile) where in both the surface and subsurface horizons showed deficiency. In all the profiles the available P content decreased with depth. High organic matter content in the surface and addition of phosphatic fertilizers may be the cause for the P content in surface soils (Ramalakshmi and Seshagiri Rao, 2000).

The available K content ranged from 82 to 212 kg/ha with a mean value 116 kg/ha. Based on 150 kg/ha as a critical limit, the available K was deficit in the surface and subsurface horizons of all the profiles except P_6 (Diguvamerlapaka profile) where in both the horizons

(surface and subsurface) showed adequacy level. The available K content was higher in the surface soil where as it decreased with depth. This could be ascribed to more weathering of the potassium bearing minerals, application of potassium fertilizers and upward translocation of potassium from lower depths along with capillary raise of ground water. Srinivasa Rao *et al.* (1997) also reported similar results.

The exchangeable Ca ranged from 0.1 to 8.8 cmol (p+)/kg with a mean of 3.8 cmol (p+)/kg of soil. Similarly the exchangeable Mg was found to vary from 0.5 to 6.5 cmol (p+)/kg with a mean of 2.6 cmol (p+)/kg of soil (Table 1). Taking 1.5 cmol (p+)/kg for Ca and 1.0 cmol (p+)/kg for Mg as critical limits, the exchangeable Ca and Mg in both the surface and subsurface horizons of all the profiles were found to be sufficient except P_4 (Balijapalem profile), where in surface horizon showed deficiency and subsurface horizons showed sufficiency level. Increase in the contents of Ca and Mg in the profiles with depth might be due to migration of these to the lower depths, which result in increased pH. These results are in agreement with the findings of Sahu *et al.* (1990).

The available S content showed a variation from 6.2 to 20.2 mg/kg with a mean of 10.9 mg/kg (Table 1). Taking 10 mg S/kg soil as critical value, the available sulphur was deficient in the surface horizons whereas it was sufficient in subsurface horizons of all the profiles except P6, where in all the horizons showed adequate levels. S content also increased with depth in all the pedons. This might be due to the translocation of sulphate sulphur to lower horizons by heavy rainfall along with other exchangeable bases and depletion from the surface layers by crop removal (Balanagoudar and Satyanarayana, 1990).

Micronutrients: The total Zn content in profile samples varied from 10.2 to 43.7 mg/kg with a mean of 20.1 mg/kg while the available Zn contents varied from 0.32 to 1.84 mg/kg with a mean of 0.6 mg/kg (Table 2). Further, by taking 0.75 mg Zn/kg soil as critical limit, both surface and subsurface horizons in all the profiles under study were deficient. The available Zn content decreased with depth. Less available Zn in deeper layers was due to the low amount of organic carbon. The available Zn was significantly and positively correlated with organic carbon (r=0.76) and negatively correlated with pH (r=-0.25) and $CaCo_3$ (r=-0.21). Patil and Malewar (1998) also reported similar results.

The total Fe status of all the profiles found to vary from 1.0 to 1.8 % with an average of 1.4% while available Fe ranged from 6.0 to 35.6 mg/kg with a mean of 12.3 mg/kg (Table 2). However, based on 4 mg/kg available Fe as a critical value, all the profiles were found to be adequate. The available Fe showed decreasing trend with depth. It might be due to accumulation of organic carbon and prevalence of reduced conditions in surface layers. The organic carbon due to its affinity to influence the solubility and availability of Fe by chelation effect might have protected the Fe from oxidation and precipitation, which consequently increased the availability of Fe (Prasad and Sakal, 1991). The results were supported by a positive correlation of available Fe with organic carbon (r=0.67).

Total Cu content varied from 5.2 to 24.7 mg/kg with a mean of 14.6 mg/kg while available Cu content ranged from 0.25 to 1.98 mg/kg with an average of 0.73 mg/kg. Based on the 0.5 mg Cu/kg soil as a critical limit, the available Cu was sufficient in all the horizons of P_3 (Balijapalem profile) and in the surface horizons of P^4 (Kolladinne). The available Cu content decreased with depth. The higher content of available Cu in surface soils might be due to accumulation of more organic carbon which fixed more content of Cu. Similar results were also reported by Singh *et al.* (1990). The results were further supported by the positive correlation between available Cu and clay (r=0.62).

Total Mn in the profiles varied from 70 and 230 mg/kg with a mean f 150.2 mg/kg while available Mn varied from 7.2 to 62.4 mg/kg with a mean of 18.4 mg/kg. However, the available Mn content in all the profiles was found to be adequate as per the critical limit of 2 mg Mn/kg soil. The available Mn decreased with depth, which might be due to comparatively higher amount of organic carbon as reported by Ranganayakulu (1981). It was further supported by a significant positive correlation between Mn with organic carbon (r=0.65). Singh *et al.* (1990) also reported similar results.

In conclusion, the study revealed that the groundnut growing in Entisols i.e., Typic Ustipsamments and Inceptisols i.e., typic Haplustepts of Kavali, Nellore and Gudur divisions in Nellore District of Andhra Pradesh are sufficient in available P, exchangeable Ca and Mg and available Fe and Mn while deficient in available K, S, Zn and Cu. Hence, for getting higher yields in groundnut application of K, S and Zn will be highly essential in order to boost the yields in these soils.

Table 1 Macronutrient status of groundnut growing soils of Nellore district

Depth (cm)	Horizon	Available		Exchangeable c mol (p+)/kg		Head Soluble 'S' (mg/kg)
		P (kg/ha)	K (kg/ha)	Ca	Mg	
Profile 1 : Survayapalem, coarse loamy, isohyperthermic, Typic Ustipsamment						
0-14	A_p	20.1	104	2.1	1.3	7.8
15-45	A_2	10.0	101	2.4	2.0	9.4
46-84	A_3	5.2	88	3.8	2.0	11.2
85-121	A_4	3.5	82	4.1	2.5	13.8
122-149	A_5	2.8	82	5.0	3.0	12.4
150-178	A_6	2.2	88	5.3	3.0	12.4
Profile 2 : Anagaripalem, coarse loamy, isohyperthermic, Typic Ustipsamment						
0-10	A_p	18.7	113	1.8	0.5	8.4
11-49	A_2	8.8	98	2.3	1.3	10.0
50-81	A_3	4.3	98	2.8	1.8	12.8
82-122	A_4	4.1	96	4.8	3.0	10.4
123-159	A_5	2.2	94	4.8	3.2	10.8
160-178	A_6	2.0	96	4.8	3.0	11.2
Profile 3 : Ramanthirtham, coarse loamy, isohyperthermic, Typic Ustipsamment						
0-20	A_p	12.6	87	3.2	2.0	7.8
21-62	A_2	3.5	94	3.8	2.2	6.2
63-104	A_3	2.2	82	3.8	3.6	11.2
105-156	A_1	2.2	82	4.1	2.4	10.4
Profile 4 : Balijapalem, coarse loamy, isohyperthermic, Typic Ustipsamment						
0-11	A_p	20.1	108	1.0	0.5	7.5
12-59	A_2	7.8	100	1.2	0.8	9.4
60-80	A_3	6.1	100	2.1	2.0	9.4
80-111	A_4	5.4	98	2.3	2.0	10.4
112-151	A_5	2.2	96	2.5	1.8	10.4
152-168	A_6	2.0	94	5.4	3.3	12.8
Profile 5 : Kolladinne, coarse loamy, isohyperthermic, Typic Ustipsamment						
0-11	A_p	21.3	109	1.3	1.2	8.4
12-38	A_2	8.0	107	1.5	1.2	10.0
39-86	A_3	5.4	100	4.1	3.8	12.2
87-131	A_4	5.0	100	4.1	4.1	10.4
132-158	A_5	2.2	98	4.5	4.1	10.4
Profile 6 : Diguvamerlapaka, fine loamy, isohyperthermic, Typic Haplustepts						
0-12	A_p	24.1	212	3.2	2.0	10.5
13-21	A_2	16.4	210	4.5	2.4	11.2
22-46	B_1	9.4	210	5.0	3.3	10.8
47-69	B_2	7.5	196	8.4	3.3	12.8
70-104	C_1	5.4	196	8.4	6.5	17.6
105-137	C_2	4.0	196	8.8	5.1	20.2
Mean		7.8	116.0	3.8	2.6	10.9
Range		2.0 - 24.1	82-212	1.0-8.8	0.5-6.5	6.2-20.2

Table 2 Micronutrient status of groundnut growing soils of Nellore district

Depth (cm)	Horizon	Zn (mg/kg)		Fe (%)		Cu (Mg/kg)		Mn (Mg/kg)	
		Total	Available	Total	Available	Total	Available	Total	Available
Profile 1 : Survaypalem, coarse loamy, isohyperthermic, Typic Ustipsamment									
0-14	A_p	13.2	0.74	1.3	24.0	13.5	0.82	140	36.4
15-45	A_2	14.2	0.70	1.3	17.7	14.2	0.61	160	31.2
46-84	A_3	18.4	0.68	1.4	12.0	18.8	0.54	175	24.6
85-121	A_4	26.3	0.54	1.4	10.9	18.2	0.56	210	19.8
122-149	A_5	28.3	0.68	1.4	8.1	20.5	0.60	220	19.0
150-178	A_6	26.3	0.58	1.4	6.0	20.5	0.38	220	18.1
Profile 2 : Anagaripalem, coarse loamy, isohyperthermic, Typic Ustipsamment									
0-10	A_p	12.3	0.68	1.2	10.9	12.2	0.64	120	17.4
11-49	A_2	13.2	0.64	1.3	13.5	12.8	0.58	120	24.2
50-81	A_3	14.7	0.64	1.4	8.5	14.2	0.50	160	10.4
82-122	A_4	22.3	0.60	1.4	8.2	18.0	0.52	160	10.0
123-159	A_5	23.2	0.66	1.4	10.6	18.0	0.62	180	12.6
160-178	A_6	25.2	0.52	1.40	8.0	18.4	0.50	170	8.8
Profile 3 : Ramanthirtham, coarse loamy, isohyperthermic, Typic Ustipsamment									
0-20	A_p	11.2	0.68	1.2	12.2	6.0	0.48	80	14.3
21-62	A_2	12.2	0.68	1.2	10.4	10.2	0.50	70	20.6
63-104	A_3	18.8	0.68	1.3	10.4	10.2	0.50	120	17.8
105-156	A_1	20.0	0.32	1.3	6.5	10.2	0.25	120	16.4
Profile 4 : Balijapalem, coarse loamy, isohyperthermic, Typic Ustipsamment									
0-11	A_p	10.2	0.52	1.0	12.2	5.2	0.55	105	18.0
12-59	A_2	10.2	0.52	1.0	9.6	10.5	0.55	105	17.0
60-80	A_3	10.8	0.50	1.1	8.7	9.2	0.50	110	14.4
80-111	A_4	11.2	0.42	1.1	7.5	10.5	0.50	115	9.0
112-151	A_5	11.7	0.44	1.1	7.0	10.7	0.46	120	9.0
152-168	A_6	20.8	0.42	1.3	11.2	11.5	0.40	120	14.4
Profile 5 : Kolladinne, coarse loamy, isohyperthermic, Typic Ustipsamment									
0-11	A_p	12.2	0.62	1.2	10.3	11.2	0.68	110	10.4
12-38	A_2	12.2	0.60	1.3	16.9	11.2	0.64	120	18.2
39-86	A_3	20.5	0.60	1.3	13.8	13.5	0.62	125	10.0
87-131	A_4	24.2	0.42	1.4	8.7	14.2	0.64	140	8.2
132-158	A_5	23.2	0.36	1.3	6.5	14.2	0.46	140	7.2
Profile 6 : Diguvamerlapaka, fine loamy, isohyperthermic, Typic Haplustepts									
0-12	A_p	22.2	1.84	1.4	35.6	20.0	1.42	180	62.4
13-21	A_2	26.2	1.68	1.4	30.7	20.0	1.48	165	42.2
22-46	B_1	28.2	1.42	1.6	19.2	18.2	1.52	180	20.3
47-69	B_2	43.7	0.82	1.8	11.2	20.8	1.62	225	18.2
70-104	C_1	38.2	0.70	1.4	9.4	20.2	1.74	230	14.5
105-137	C_2	38.2	0.6	1.5	8.6	24.7	1.98	220	10.2
Mean		20.1	0.69	1.4	12.3	14.6	0.73	150.2	18.4
Range		102-43.7	0.32-1.84	1.0-1.8	6.0-35.6	5.2-24.7	0.25-1.98	70-230	7.2-62.4

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Sunflower growth and yield as influenced by evapotranspiration deficits

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Abstract

A field study was conducted during 1995-96 and 1996-97 on a sandy loam soil to study the response of sunflower to evapotranspiration deficits imposed at specific crop-growth subperiods. The crop in fully irrigated control (W-W-W) treatment recorded maximum seed yield (2762 kg/ha). The evapotranspiration deficits in all the crop growth subperiods significantly reduced the seed yield except in vegetative subperiod, relative to the yield in fully irrigated control. Yield reduction coefficients indicated that vegetative subperiod is insensitive to evapotranspiration deficits. Whereas flowering-seed formation and seed filling crop growth subperiods were 219 and 119 %, respectively more sensitive to evapotranspiration deficits than vegetative period provided the crop has experienced no evapotranspiration deficits in the preceding growth subperiods. However, the susceptibility of crop to evapotranspiration deficits at flowering-seed formation and seed filling periods has found to be greatly reduced if the crop is conditioned by prior evapotranspiration deficits.

Key words: Sunflower, evapotranspiration deficit, seed yield, yield reduction coefficient

Introduction

Irrigation planning is commonly predicated on complete avoidance of water deficits during crop growing season. In years of deficient water supply the irrigated acreage is, therefore, reduced so that the evapotranspiration requirements of a crop can be met in full. An increase in the frequency of droughts, declining ground water table levels, and increased cost of irrigation water resource development necessitate the need to shift out objective from producing maximum yield/unit area to maximum yield/unit amount of water. The extent to which crop yield can be maximized/unit amount of water depends on how well field irrigation schedules are planned in time and quantity, considering the periods of water scarcity, to meet crop evapotranspiration requirements.

Sunflower an important crop in India, raised during winter season is often subjected to evapotranspiration deficits during crop growing season leading to heavy yield depression. The present study was, therefore, designed to find out the critical crop-growth subperiods of sunflower as to their order of relative sensitivity to evapotranspiration deficits and to suggest optimal irrigation programme to minimize yield losses under scarce water supply situation.

Materials and methods

The field experiment was conducted on a sandy loam soil during winter season of 1995-96 and 1996-97 at the College Farm of Acharya N.G. Ranga Agricultural University, Hyderabad (17^0 19'N, 78^0 23' E and 542.3 m above mean sea level).

The weekly mean maximum temperature for the crop period ranged from 28.3 ^{0}C to 34.6 ^{0}C with an average of 30.0 ^{0}C in the first year (1995-96) and from 26.8 ^{0}c to 31.9^{0}C with an average of 29.2 ^{0}C in the second year (1996-97). The weekly mean relative humidity ranged from 29 to 93.0% with an average of 68.6% in 1995-96 and 21 to 88% with an average of 63.3% in 1996-97. Evaporation from (USWB Class A Pan evaporimeter) during the crop period 1995-96 ranged from 2.8 to 3.8 mm/day and from 2.1 to 4.9 mm/day in 1996-97 with a wind velocity of 1.5 to 3.6 Km/hour and 1.6 to 4.2 Km/hour in 1995-96 and 1996-97, respectively. A total rainfall of 144 mm spread over two rainy days in 1995-96 was received during the vegetative period i.e., 20 days after sowing. Since the rainfall occurred during the establishment – vegetative stage, the effective rainfall (Dastane, 1974) was deducted from the net irrigation requirement, while scheduling irrigations in different treatments.

The treatments consisted of seven variable water supply levels designed to allow moderate to severe Eta (water) deficits to develop in one or more three specific crop-growth sub-periods *viz.*, vegetative (0 – 30 DAS), flowering and seed formation (30 – 60 DAS) and seed filling (60-105 DAS) sub-periods including a fully irrigated control treatment (Eta = Etm) as shown in Table 1. In any given growth sub-period, the crop in a given treatment was either irrigated (W) based on soil-crop-climatic data (Table 2) to ensure Eta proceeded at the potential rate (Etm) or it was

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not irrigated (D) at all. For instance the crop in D-W-W was not irrigated during vegetative growth sub-period i.e., from 0 – 30 DAS and was irrigated during the latter two crop growth sub-periods by supplying the water equivalent that lost in Eta. Likewise the crop in treatments W-D-W, W-W-D, D-D-W, W-D-D and D-W-D, if the crop was irrigated (W) in a given crop growth sub-period, the schedule followed in W-W-W was duplicated. Following an Etd in water deficit treatment at the end of the crop growth sub-period the root zone depth of the crop was replenished to field capacity moisture content. The details of field water supply are given in Table 3. A 50 mm water meter was installed to deliver the required quantity of water in each plot. The gross and net plot size was 7.5m x 4.5m and 6.3m x 2.7m, respectively.

Table 1 Details of irrigation treatments

Treatment			Description
GS_1	GS_2	GS_3	
W	W	W	Irrigation at Eta/Etm = 1 throughout the crop growing season
D	W	W	Withholding of irrigation/s (Eta deficit) at vegetative period (0-30 DAS)
W	D	W	Withholding of irrigation's (Eta deficit) at flowering - seed formation period (30-60 DAS)
W	W	D	Withholding of irrigation's (Eta deficit) at seed filling period (60-105 DAS)
D	D	W	Withholding of irrigation's (Eta deficit) at vegetative plus flowering - seed formation period (0-60 DAS)
W	D	D	Withholding of irrigation's (Eta deficit) at flowering - seed formation plus seed filling period (30-105 DAS)
D	W	D	Withholding of irrigation's (Eta deficit) at vegetative (0-30 DAS) and seed filling period (60-105 DAS)

Table 2 Determination of irrigation requirement for sunflower (1995-96 and 1996-97) in W - W - W treatment based on soil-crop-climate parameters

Crop growth sub-period	Duration	Eto (mm/day)	Kc	Etm (mm/day)	Rooting depth (D)(m)	Sa.D (cm)	P fraction	$i = \frac{(Sa.D.P)}{Etm}$	IRR
Vegetative	25.0	4.22	0.75	3.17	0.45	6.34	0.64	13.0	40.6
Flowering-seed formation	33.0	4.22	1.125	4.73	0.60	8.50	0.57	11.0	48.5
Seed filling	47.0	4.00	0.75	3.00	0.60	8.50	0.66	19.0	57.0

Sa.D = Available soil moisture in the root zone; Eto = Reference crop evapotranspiration; Kc = Crop coefficient
Etm = Maximum evapotranspiration; P = Readily available soil moisture; IRR = Irrigation water depth
i = Irrigation interval

The seven treatments were laid out in randomized block design with four replications. "MSFH-8" sunflower hybrid was sown on 30th October both in first (1995-96) and second year (1996-97), respectively by adopting a spacing of 45 x 30 cm to achieve a desired plant population of 74,100 plants/ha. Other recommended agronomic practices *viz.*, a fertilizer dose of 75 kg N + 90 kg P_2O_5 + 30 kg K_2O/ha and need based plant protection measures were followed. The crop was subjected to Eta deficits by withholding water at different crop-growth subperiods. The ground water table was below six meters during the crop-growing season hence; it was assumed that there was not any contribution from ground water table towards crop water needs.

The experimental soil had N, P_2O_5 and K_2O at 270, 18.2 and 508 kg/ha, respectively, with pH 7.5, bulk density 1.66g/cm^3 and EC 0.13 dS/m. The available soil moisture determined as difference between moisture held at –0.03 MPa and –1.5 MPa was 84.4 mm in 60 cm soil profile.

For determination of crop Eta the soil moisture was monitored by gravimetric method at four locations and at various depths in each treatment from surface to 60 cm soil depth before and after each irrigation and on intermediate dates as necessary. The reference crop evapotranspiration (Eto) was estimated at specific crop growth sub-periods based on Hargreaves method (Hargreaves and Samani, 1982). The crop was harvested on 12th February in both the years (1995-96 and 1996-97) The water use efficiency (kg/ha-mm) was calculated as a ratio between seed yield and seasonal evapotranspiration. To quantify the effect of Eta deficits on yield the relationship between relative yield reduction and relative evapotranspiration deficit was worked out by regression analysis as suggested by Stewart *et.al.* (1977).

$(Ym - Ya)/Ym = Bo\ (Etm - Eta)/Etm)$

Where,
Ym = Maximum seed yield in fully irrigated crop i.e., W-W-W treatment
Ya = Actual seed yield of the crop as affected by Eta deficits
Etm = Seasonal evapotranspiration of fully irrigated crop
Eta = Seasonal evapotranspiration in water (Eta) deficit treatments
Bo = Yield reduction coefficient

Table 3 Field water supply at various crop-growth subperiods

Treatment	Irrigation water supply - Crop growth subperiods								Effective rainfall (mm)		Available water at planting (mm)		Field water supply	
	Vegetative		Flowering-seed formation		Seed filling		Total season							
GS_1 GS_2 GS_3	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
W - W - W	40.6	81.2	145.5	145.5	114.0	114.0	300.1	340.7	49.1	0.0	84.4	84.4	433.6	425.1
D - W - W	0.0	0.0	145.5	208.7	114.0	114.0	259.5	322.7	61.2	0.0	84.4	84.4	405.1	407.1
W - D - W	40.6	81.2	0.0	0.0	201.9	198.6	242.5	279.8	45.8	0.0	84.4	84.4	372.7	364.2
W - W - D	40.6	81.2	145.5	145.5	0.0	0.0	186.1	226.7	47.6	0.0	84.4	84.4	318.1	311.1
D - D - W	0.0	0.0	0.0	0.0	198.5	207.0	198.5	207.0	58.6	0.0	84.4	84.4	341.5	291.4
W - D - D	40.6	81.2	0.0	0.0	0.0	0.0	40.6	81.2	46.8	0.0	84.4	84.4	171.8	165.6
D - W - D	0.0	0.0	145.5	208.7	0.0	0.0	145.5	208.7	58.8	0.0	84.4	84.4	288.7	293.1

Results and discussion

Yield as influenced by Eta deficits: Scheduling of irrigation's at Eta = Etm throughout the crop growing season (W-W-W) recorded the mean highest seed yield (2762 kg/ha) which was significantly superior over other treatments, but it was statistically on par with D-W-W (2624 kg/ha) (Table 4). On an average the W-W-W and D-W-W treatment registered 113.1% and 102.4%, 30.9% and 24.4%, 213.8% and 198.1%, 364.2% and 341.0% and 46.6% and 39.2% more yield over W-D-W, W-W-D, D-D-W, W-D-D and D-W-D treatments, respectively. This could be attributed to a favourable soil water balance in W-W-W and D-W-W as was evident from mean Kc values (Eta/Eto ratio) (> 1.00 at flowering and seed formation period in both years of study) an indicator of soil water deficit (Ritchie, 1981). Further the regression of seed yield versus plant water stress parameters and seasonal Eta deficit were significant (P=0.01) with R^2 varying between 0.814 to 0.985 on pooled basis as shown below:

Seed yield (kg/ha) = -5684.6425 + 113.3214 Relative water content; R^2 = 0.961

Seed yield (kg/ha) = 5127.7433 + 1973.7907 Leaf water potential; R^2= 0.817

Seed yield (kg/ha) = 6032.4423–61.6609 Diffusive resistance; R^2 = 0.814

Seed yield (kg/ha) = -1863.5528 + 265.5113 Transpiration rate; R^2 = 0.985

Seed yield (kg/ha) = 2735.8969 – 4054.3013 Eta deficit; R^2 = 0.960

Table 4 Yield, water use efficiency, seasonal Eta and yield reduction ratios of sunflower as influenced by evapotranspiration deficits

Treatment	Seed yield (kg/ha)			Water use efficiency (kg/ha-mm)		Seasonal Eta (mm)		Yield reduction coefficient		
GS_1 GS_2 GS_3	1995-96	1996-97	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	Mean
W - W - W	2675	2850	2762	6.88	7.34	377.56	388.38	-	-	-
D - W - W	2560	2688	2624	7.24	7.61	349.66	353.40	0.6565	0.7579	0.6080
W - D - W	1280	1311	1296	4.59	4.70	277.70	278.60	1.9585	1.9008	1.9396
W - W - D	2075	2142	2109	6.28	6.48	325.25	330.50	1.6205	1.6235	1.6994
D - D - W	855	905	880	4.20	4.44	253.85	203.70	1.4620	1.4339	1.4482
W - D - D	580	610	595	3.35	3.53	168.20	172.89	1.4039	1.4159	1.4068
D - W - D	1828	1940	1884	5.86	6.22	300.25	311.65	1.5266	1.6203	1.5604
SEm±	95.9	80.5	87.4	0.48	0.50	-	-	-	-	-
CD (P=0.05)	285.7	240.6	257.9	1.15	1.50	-	-	-	-	-

Adequate soil moisture balance in W-W-W and D-W-W promoted the plants to produce significantly more plant height, which in turn put-forth more leaf area contributing to more dry matter (Table-5). Venkanna *et.al.* (1994) opined that the plant height and leaf area were the growth characteristics which limited the dry matter accumulation of sunflower under soil water deficits. In the present study too the dry matter showed significant (P=0.01) positive relation with plant height (r = 0.97) and leaf area (r = 0.90). Thus the accumulated photosynthates (leaf area) in turn might have been responsible for higher capitulum's diameter with higher seed filling percentage contributing to more number of filled seeds per plant (Table 6).

The higher seed test weight was associated with W-W-W and D-W-W when compared to other treatments (Table 6). These results emphasize the importance of adequate (Eta = Etm) water supply for sunflower during flowering-seed formation and seed filling periods for obtaining large heads with more number of well developed seeds that contributed to higher harvest indices and seed yield. The dependence of seed yield on these growth and yield components was apparent from significant (P=0.01) association between seed yield and plant height (r = 0.942), leaf area (r = 0.880), dry matter (r = 0.980), *capitulum diameter (r = 0.920), filled seeds (r = 0.940), test* weight (r = 0.800) and harvest index (r = 0.970). Unger (1990) reported that the potential number of seeds per plant is determined during flowering and anthesis and seed filling period. A study conducted by Chamundeshwari and Praveen Rao (1998) also revealed that application of adequate water following seed setting period did not improve the number of effective seeds per plant.

On the other hand withholding of water spanning from flowering to the end of seed filling period induced soil water deficits in the crop root zone. This caused Eta o fall below Etm in W-D-W, W-W-D, W-D-D and D-W-D treatments, which affected the plant water status. This unfavourable soil moisture and plant water balance not only reduced plant height, leaf area, dry matter but also brought significant reduction in yield contributing characters like capitulum diameter, filled seeds per plant, test weight and harvest index (Table 5 and 6). All of these effects finally reduced the seed yield in stress treatments except D-W-W.

Water use efficiency: The water use efficiency values registered in W-W-W, D-W-W, W-W-D and D-W-D were on par and significantly superior over W-D-W, D-D-W and W-D-D treatments in both the years. The differences in water use efficiency values of the later three treatments were not significant. The variation in water use efficiency values can be traced to the variation in seed yield and seasonal evapotranspiration in different treatments.

Relative yield deficit versus relative Eta deficit: The relationship between relative yield deficit and relative Eta deficit was established by adopting linear regression and the resultant Bo values are presented in Table 4 for both the years and on pooled basis. The slope of the regression i.e., yield reduction coefficient (Bo) reflects the sensitivity of crop to Eta deficits. The higher the Bo value, the more the sensitive the crop to Eta deficits at a given growth subperiod.

Comparison of Bo values for treatment D-W-W (Eta deficit at vegetative period alone), W-D-W (Eta deficit at flowering-seed formation period alone) and W-W-D (Eta deficit at seed filling period alone) indicated that the relative yield decrease for a given level of Eta deficit was least in D-W-W, intermediate in W-W-D and maximum in W-D-W treatment. It follows that the sunflower crop is 2.19 (or 219%) and 1.79 (or 179%) times more sensitive to Eta deficits in flowering-seed formation and seed filling period, respectively than vegetative period. Likewise the flowering-seed formation period is 0.141 times (or 14.1%) more sensitive than seed filling period.

Table 5 Growth attributes of sunflower as influenced by evapotranspiration deficits

Treatment	Plant height (m)		Leaf area (cm^2/plant)		Drymatter (g/plant)		Capitulum diameter (cm)	
GS_1 GS_2 GS_3	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
W - W - W	1.862	2.015	1783	1965	102.1	112.7	18.8	20.6
D - W - W	1.853	1.965	1685	1969	99.5	109.0	18.6	20.7
W - D - W	1.297	1.445	1720	1795	73.2	83.7	11.7	11.4
W - W - D	1.763	1.922	1415	1437	90.5	97.2	17.7	20.4
D - D - W	0.972	1.297	1225	1497	62.7	72.5	11.6	10.7
W - D - D	0.950	1.103	1375	1677	52.6	62.9	9.5	10.2
D - W - D	1.772	1.930	1455	1427	85.5	96.2	18.5	20.0
SEm±	0.023	0.041	79.2	64.0	2.7	3.1	1.3	1.4
CD (P=0.05)	0.068	1.220	236.1	191.4	8.3	9.4	3.9	4.1

Table 6 Yield attributes of sunflower as influenced by evapotranspiration deficits

Treatment	Total seeds/capitulum		Filled seeds/capitulum		Test weight (g)		Harvest index (%)	
GS_1 GS_2 GS_3	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97	1995-96	1996-97
W - W - W	1135	1235	78	80	46.6	47.4	42.2	43.9
D - W - W	1122	1230	77	80	46.4	47.5	43.2	44.7
W - D - W	685	754	76	78	44.5	46.6	35.7	34.9
W - W - D	1126	1185	695	70	37.5	37.0	39.0	38.8
D - D - W	630	725	75	76	40.8	41.0	34.0	35.6
W - D - D	538	587	61	63	32.3	30.6	32.1	33.4
D - W - D	1060	1085	68	67	38.0	38.8	37.8	38.6
SEm±	39.1	30.9	1.2	0.6	0.7	0.7	0.7	0.6
CD (P=0.05)	116.1	92.1	3.7	1.8	2.2	2.1	2.0	1.9

However when there had been an Eta deficit in the preceding growth subperiod (for instance in D-D-W treatment) the negative effect of flowering-seed formation period Eta deficit was greatly blunted (as evident from the Bo value of 1.4482). This happened because the earlier water deficits reduced the plant size and "conditioned or hardened" the crop so that following flowering-seed formation period Eta deficit had less negative effect on plant performance i.e., yield (Stewart *et.al.*, 1977). Similar trend can also be observed in case of W-D-D and D-W-D treatments.

It can be concluded that adequate water supply (Eta = Etm) to sunflower at all the crop-growth subperiods resulted in the maximum seed yield. Seed yield reduction due to Eta deficit at vegetative period was insignificant. Whereas Eta deficits at flowering-seed formation and seed filling period caused significant reduction in seed yield relative to the fully irrigated control treatment. Yield reduction coefficients indicated that the sunflower crop is highly sensitive to Eta deficits at flowering-seed formation and seed filling period and insensitive to Eta deficits at vegetative period. Hence, under limited water supply situation priority for water allocation be given to flowering-seed formation and seed filling periods of sunflower to minimize yield loses.

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Effect of phosphorus, sulphur and phosphate-solubilizing bacteria on growth and productivity of soybean [*Glycine max*. (L.) Merrill.]

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Abstract

Field studies were carried out on soybean cv. JS-335 in clay loam soil of Chhindwara (MP) during rainy seasons of 1998 and 1999 to evaluate the optimum levels of P and S application with and without PSB inoculation. Results revealed that growth parameter (plant height, branches/plant), yield attributes (pods/plant, 100-seed weight, harvest index) and seed yield (kg/ha) increased up to 60 kg P_2O_5/ha. The crop responded significantly to S application at 30 kg/ha. Seed inoculation with PSB 10 g/kg seed significantly improved the growth, yield attributes and seed yield over uninoculated treatment. Application of 60 kg P_2O_5/ha, 30 kg S/ha and PSB inoculation proved economically viable in terms of net profit and benefit cost ratio.

Key words: Soybean, phosphorus, sulphur; PSB monetary returns

Introduction

Soybean is widely grown in Satpura plateau of MP. Generally, S-free N and P fertilizers are being used by the farmers resulting in a wide spread S-deficiency in the region. Application of adequate P and S improves both quantity and quality produce (Kumar *et al.*, 1981). Inoculation with PSB has been reported to lead to low input P-management in chickpea (Alagawadi and Gaur, 1988). In view of above an effort was made to evaluate optimum levels of P, S and PSB to enhance the yield of soybean.

Material and methods

A field experiment was carried out during the rainy seasons of 1998 and 1999 at Zonal Agricultural Research Station, Chhindwara (MP). The soil of site was clay loam with pH 7.1 and contained 413, 8.8 and 600 kg/ha available N, P and K, respectively. Sixteen treatments consisted of four levels of P_2O_5 two levels of S and two levels of PSB were tested in randomized block design with three replications (Table-1). Soybean (JS-335) was sown at the rate of 100 kg/ha at 30 cm row to row after treating seeds with PSB. The crop was sown on July 3rd and 5th and was harvested on October 10th and 13th during 1998 and 1999, respectively. P was applied through DAP and S through elemental sulphur as per treatments as basal. A uniform does of 30 kg N/ha was also adjusted through urea. Data on various growth parameter and yield attributes were recorded at harvest, while physiological parameters *viz.*, LAI, CGR and NAR were recorded at 30-45, 45-60, 60-75 and 75 DAS to harvest.

Results and discussion

Growth parameters: An increasing trend in the values of plant height branches/plant, LAI, CGR and NAR was observed with increasing levels of phosphorus up to 80 kg P_2O_5/ha. Although application of P at 40 kg P_2O_5/ha was not significantly different from control with respect to these parameters. Among P level, the differences were not statistically significant (Table 1). Similar results were reported by Singh and Bajpai (1990). Application of S at 30 kg/ha also resulted in significant improvement in branches/plant, LAI, CGR and NAR over control. These results are in conformity with Singh and Ram (1990) and Hemantaranjan and Trivedi (1997). Significant positive effect of seed inoculation PSB 10 g/kg on above growth parameters was observed over uninoculated treatment confirming the finding of Alagawadi and Gaur (1988). Yield attributors like pods/plant, 100 seed weight and HI showed a significant improvement over control consequent to the application of 60 and 80 kg P_2O_5/ha. Rajput *et al.* (1991) also reported similar results. Application of sulphur, 30 kg/ha and seed inoculation with PSB, 10 g/kg resulted in increased yield attributes respective control. These results are in conformity with Pannase *et al.* (2001).

Seed yield: Application of increasing levels of P upto 80 kg P_2O_5/ha significantly improved the seed yield. The results are in agreement with by Rajput *et al.* (1991). Likewise, incorporation of S and PSB resulted in significant increase in yield over respective control. The involvement of P in energy transfer reaction and S being the constituent of protein, their application has resulted in enhanced growth and subsequent higher yield. The

interaction effect of P levels x PSB was found significant. Levels of P influenced the seed yield, when the seed was inoculated with PSB. However, difference between 60 and 80 kg P_2O_5/ha with seed inoculation were at par. The interaction between P and S as well as S and PSB showed non-significant differences.

Economics: Maximum additional net return (Rs. 4848/ha) was observed at 80 kg P_2O_5/ha which was at par to 60 kg P_2O_5/ha (Rs. 4564/ha). Through net profit increased up to 80 kg P_2O_5/ha, benefit cost ratio did not increase beyond 60 kg P_2O_5/ha. As regards S, 30 kg/ha showed additional net return (Rs. 1432/ha) with increased cost benefit ratio (4.58) over control. The highest cost benefit ratio (26.2) was obtained with PSB @ 10 g/kg seed (Table-2).

Thus, soybean (JS-335) with application of 60 kg P_2O_5/ha, 30 kg S/ha and seed inoculation with PSB 10 g/kg for medium black soils of Satpura plateau of Madhya Pradesh was productive and economically viable technology.

Table 1 Effect of phosphorus, sulphur and PSB on growth parameters and seed yield in soybean (mean of two years)

Treatment	Plant height (cm)	Branches/ plant (No.)	LAI 45-60 DAS	CGR (g/m^2/day) 45-60 DAS	NAR (mg/cm^2/day) 30-45 DAS	Pods/plant (No.)	100-seed weight (g)	Seed yield (kg/ha)	Harvest index
P_2O_5 (kg/ha)									
0	57	3	4.8	20.6	0.2	38	13.7	2036	41.2
40	58	4	5.1	21.3	0.4	40	14.1	2340	42.0
60	61	5	5.9	22.0	0.6	43	14.4	2734	44.2
80	61	5	6.2	22.7	0.7	44	14.5	2812	44.8
CD (P=0.05)	2.5	1.2	0.9	1.2	0.2	1.9	0.6	310	2.0
Sulphur (kg/ha)									
0	58	4	5.3	21.0	0.4	39	13.9	2546	43.1
30	59	5	6.2	22.2	9.8	44	14.1	2775	44.8
CD (P=0.05)	NS	1.1	0.5	0.9	0.3	2.6	NS	190	1.5
Phosphate - solubilizing bacteria (g/kg seed)									
0	60	4	5.2	20.9	0.4	40	14	2560	43.0
10	60	4	6.1	22.1	0.8	45	14.4	2764	44.9
CD (P=0.05)	NS	NS	0.7	1.0	0.3	2.5	NS	170	1.7

Table 2 Economics of P, S and PSB application in soybean (mean of two years)

Treatment	Seed yield (kg/ha)	Additional seed yield over control (kg/ha)	Additional income (Rs/ha)	Additional cost (Rs/ha)	Net returns (Rs/ha)	Cost : benefit ratio
P_2O_5 (kg/ha)						
0	2036	-	-	-	-	-
40	2340	304	2432	680	1752	3.57
60	2734	698	5584	1020	4564	4.47
80	2812	776	6208	1360	4848	3.56
Sulphur (kg/ha)						
0	2546	-	-	-	-	-
30	2775	229	1832	400	1432	4.58
Phosphate-solubilizing bacteria (g/kg seed)						
0	2560	-	-	-	-	-
10	2764	204	1632	60	1572	26.20

Cost of soybean = Rs. 8/kg

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Influence of sowing date on the performance of rapeseed and mustard varieties under rainfed situation of southern Assam

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Abstract

The effect of sowing dates on the performance of *toria* (*Brassica campestris* L.) sub sp. *oleifera* (Sinsk.) Metzger var. *toria*) and Indian mustard [*B. juncea* (L.) Czernj. & Cosson] varieties grown under residual moisture conditions was studied after the harvest of *kharif* rice in Assam (India). Studies revealed that early sowing resulted in significantly better crop growth, yield and yield attributing characters in rapeseed-mustard crops. Among the varieties, M-27 (*Toria*) , TM-2 and TM-4 (Indian mustard) were found promising. Indian mustard varieties outyielded *toria* varieties when sown on 17th or 26th November, while in later sowing dates the *toria* variety M-27 showed better performance.

Key words: Indian mustard, *raya*, sowing date, *toria*

Introduction

Rapeseed mustard crops are sown in mid-October to mid-November in Assam. But due to late cessation of retreating monsoon, which sometimes extend even up to the first week of November and high clay content of the soil in the Barak Valley Zone comprising with three southern most districts *viz.*, Cachar, Hailakandi and Karimganj of Assam, it is not practicable to prepare the land for sowing of these crops within the stipulated period. Thus, sowing of rapeseed mustard in time is delayed. The information on late sowing of these crops and their yield in a multiple cropping system under such situations is meager. Therefore, the field investigations were undertaken to evaluate the performance of four varieties of rapeseed-mustard crops under different sowing dates after the harvest of *kharif* (winter) rice with a view to find out any possibility of utilization of medium rice lands in *rabi* season which otherwise remain fallow.

Material and methods

A field experiment on rapeseed-mustard was conducted in medium land under two situations *viz.*, S_1 (land used for cultivation of mid duration *kharif* rice varieties like Mahsuri where water stagnation does not generally occur after September) and S_2 (land used for raising seedlings of *kharif* rice and subsequently occupied by traditional long duration late planted rice varieties). In this particular situation, the land was kept fallow after uprooting of the seedlings during September. The soil was clayey in texture having pH 5.2, organic carbon 0.85% available P_2O_5, 7.3 kg/ha and available K_2O 89.7 kg/ha, respectively. Four varieties of rapeseed-mustard were sown on four dates adopting a split plot design with three replications, keeping the sowing dates in main plots and varieties in sub-plots. A spacing of 30 cm between rows and 10 cm between plants was maintained by thinning the crop after germination. A uniform basal dose of 40 kg N, 35 kg P_2O_5 and 15 kg K_2O/ha was applied one day before sowing.

Results and discussion

Seed yield and all the growth as well as yield attributing characters were significantly affected by sowing dates with the exception of number of branches and siliquae/plant and number of seeds/siliqua in second situation (Table 1). In other cases also the parameters recorded in first two sowing dates remained at par and declined significantly thereafter. Seed yield, however, decreased markedly with each delay of sowing in the first situation, but in second situation the significant difference was observed only in between first and last sowing of the crop. Pooled data also showed non-significant decrease in seed yield between 26th November and 5th December sown crop (Table 2). The reduction in seed yield in crop sown on 26th November, 5th and 14th December was 29, 46 and 68%, respectively over first sowing in 17th November. The lower yield of the crop sown under delayed situation was attributed to poor plant growth in terms of plant height, reduced number of branches and siliquae/plant as well as seeds/siliqua due to comparatively shorter crop duration. Similar results have also been reported by Kurmi and Kalita (1992) for *toria* and Shastry and Kumar (1981) for Indian mustard.

Effect of variety

Mustard varieties exhibited better performance than *toria* in all the cases except number of siliquae/plant and seed yield under situation (S_1), when these two parameters were maximum in the *toria* variety M-27 and was closely

followed by mustard variety TM-4. The latter variety registered highest seed yield in second situation (S_2) and remained at par with TM-2 and *toria* M-27. Superiority of TM-4 was also confirmed by the pooled yield data (Table 2). This occurred due to better growth and development which may be attributed comparatively to longer duration. However, for delayed conditions M-27 was found to be more remunerative provided other management practices are adequately manipulated. Rajput *et al.* (1991) and Sarma and Sarma (1994) also reported about the yield superiority of *raya* over *toria* varieties.

Interaction effect of sowing date and variety

Yield performance of mustard varieties was better than that of *toria* in first two dates, while in the latter two dates *toria* variety M-27 outyielded all other varieties (Table 2) except TM-2 in third (December 5) and TM-4 in fourth (December 14) sowing dates. *Toria* variety TWC-3 resulted significantly lowest yield in all dates.

Table 1 Effect of sowing dates on growth, yield and yield attributes of *toria* and *raya* varieties

Treatment	Maturity/duration (days)		Plant height (cm)		Branches/plant		Siliquae/plant		Seeds/siliqua		Seed yield (kg/ha)	
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
Date of sowing												
November 17	89	90	96	97	4	9	101	104	13	17	759	826
November 26	88	87	80	87	4	8	80	100	12	15	474	653
December 05	85	86	65	77	4	7	45	94	10	15	245	606
December 14	83	85	51	77	3	6	30	86	9	14	73	438
CD (P=0.05)	NS	NA	24	18	0.6	NS	55	NS	2.5	NS	111	242
Variety												
M-27	84	80	63	77	4	7	74	88	9	15	440	668
TWC-3	76	79	67	70	2	7	57	87	9	13	333	380
TM-2	93	96	78	95	4	7	60	110	13	16	355	706
TM-4	91	94	83	102	4	7	66	110	13	17	423	770
CD (P=0.05)	-	-	8.6	13.6	0.4	NS	NS	NS	1.5	NS	23	112

Table 2 Pooled seed yield (kg/ha) of *toria* and *raya* varieties under different sowing dates

Sowing date	Variety				
	M-27	TWC-3	TM-2	TM-4	Mean
November 17	780	611	855	924	793
November 26	523	390	626	714	563
December 05	531	332	429	410	426
December 14	383	91	211	339	256
Mean	554	356	530	597	

CD (P=0.05) for
(1) Sowing dates = 162
(2) Varieties = 56
(3) Varieties within a sowing date = 113
(4) Sowing dates within a variety = 168

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Evaluation of seasonal crop water production functions for Indian mustard [*Brassica juncea* (L.) Czern. & Coss]

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Abstract

Field experiments were conducted on Indian mustard, *Brassica juncea* (L.) Czern & Coss during winter season of 1995-96 and 1996-97 to develop and evaluate various seasonal crop water production functions without considering time of water deficit during crop growing season for both seed and dry matter yields. Seed and dry matter yields had a significant correlation with seasonal evapotranspiration and evapotranspiration deficit. The R^2 value in *various seasonal water production functions varied* from 0.82 to 0.99 for seed yield and 0.92 to 0.99 for dry matter yield in two years (pooled basis). The F-value for testing R^2 values was highly significant in all the functions. However, in view of simplicity and from practical point of view the linear functions as expressed by linear, Stewart's S_1 and S_2 functions were suggested for predicting mustard yield under Hyderabad conditions.

Key words: Water production function, evapotranspiration, mustard

Introduction

Knowledge on response of crop yield to water (water production function) is desirable for both irrigation scheme planners and farm managers. Irrigation scheme planners need such information to estimate the likely demand for water and to carryout economic analyses of the proposed irrigation schemes. Farm managers also need this information in order to maximize returns from the available irrigation water. Such information is scarce for mustard in Andhra Pradesh. This non-traditional oilseed crop was found to be potentially profitable under minor irrigation schemes of Telangana region of Andhra Pradesh. Hence, an experiment was conducted to develop and evaluate various crop water production functions for mustard.

Materials and methods

A field experiment was conducted at the College Farm, Rajendranagar, Hyderabad (17.19^0 N, 78.23^0 E and altitude 543m above msl) in winter season of 1995-96 and 1996-97 on a sandy loam soil. There were seven irrigation treatments designed to allow moderate to severe Eta (water) deficits to develop in one or more crop growth sub-periods *viz.*, vegetative (0-27 days after sowing), flowering *pod initiation and addition (27-63 DAS) and pod filling (63-*96 DAS) sub-periods including a fully irrigated control treatment. In any given growth sub-period, the crop was either irrigated (W) based on soil-crop-climatic data (Praveen Rao, 1993) to ensure Eta proceeded at the potential rate (Etm) or it was not irrigated (D) at all. For instance the crop in D-W-W was not irrigated during vegetative growth sub-period i.e., from 0 – 27 DAS and was irrigated during the later two crop growth sub-periods by supplying the water equivalent that lost in Eta. Likewise the crop in treatments W-D-W, W-W-D, D-D-W, W-D-D, D-W-D, if the crop was irrigated (W) in a given crop growth sub-period, the schedule followed in W-W-W was duplicated. Following an Etd at the end of the crop growth sub-period in water deficit treatment, the root zone depth of the crop was replenished to field capacity moisture content. The seven treatments were laid out in randomized block design with four replications. A 50 mm water meter was installed to deliver the required quantity of water in each plot. The total rainfall received was 14.4 cm spread over two rainy days during 26 – 28 DAS in the first year. Since the rainfall occurred during transition period of vegetative to flowering-pod initiation and addition, the effective precipitation was deducted from the net irrigation requirement while scheduling irrigation's in different treatments.

Mustard variety, TM-4 was sown on 2nd November during 1995-96 and 29th October in 1996-97, respectively by adopting a spacing of 30 x 10 cm to achieve a desired plant population of 3.33 lakh plants/ha. For determination of crop Eta the soil moisture was monitored by gravimetric method at four locations and at various depths in each treatment from surface to 60 cm soil depth before and after each irrigation and on intermediate dates as necessary. The seasonal water production functions of the following types were developed and evaluated:

$Ya = a + b\ (Eta)$ ..... (1)

$Ya = a + b\ (Eta) + c\ (Eta)^2$ ..... (2)

$Ya = a + b\ (Eta) + c\ (Eta)^2 + d\ (Eta)^3$ ..... (3)

$Ya = a(Eta)^b$ ..... (4)

Where, 'Ya' is seed yield or dry matter yield in kg/ha; 'Eta' is seasonal evapotranspiration in mm; 'a' is intercept on the Y-axis, and 'b', 'c' and 'd' are regression coefficients indicating the magnitude of yield variation (kg/ha) per unit increase in Eta. Stewart (1972) replaced Eta in equation (1) by seasonal relative Eta deficit (stress factor) and proposed the following S_1 relationship:

$Ya = a + b\ (Etd/Etm)$ ..... (5)

Where, 'Etd' is seasonal evapotranspiration deficit i.e., Etm – Eta and 'Etm' is maximum evapotranspiration in mm associated with maximum yield (Ym). The equation (5) was later further modified into a dimension less form to increase the scope of transferability. The dimension less form function (S_2) as reported by Stewart *et.al.* (1977) was of the following form:

$(1 - Ya/Ym) = b\ (1 - Eta/Etm)$ ..... (6)

Where 'b' is the yield sensitivity coefficient to Etd. However Singh *et.al.* (1987) assumed that the marginal physical product of Eta in the relationship between Ya and Eta decreased after certain value, consistent with most agronomic studies. Hence, he proposed a non-linear function of the following form:

$Ya = a + b\ [1 - (1 - X)^2]$ ..... (7)

In which, 'X' is relative 'Eta' i.e., Eta/Etm.

The water production functions explained through equation (1) to (7) were verified by regression analysis both for seed yield and dry matter yield of mustard.

Results and discussion

The seasonal water production functions presented in Table 1 and 2 do not account for the timing of Eta deficits during the crop growing season i.e., optimal sequencing of Etd is assumed. The seasonal crop water production functions as expressed by linear, quadratic, cubic, power, Stewart's S_1, Stewart's S_2 and Singh *et.al.* (1987) performed well for both seed yield and dry matter yield of mustard in both the years as well as on pooled basis (Table 1 and 2). The explained total variation in crop yield as indicated by values of coefficient of determination (R^2) varied from 0.76 to 0.99 in 1995-96 and from 0.82 to 0.99 in 1996-97 and on pooled basis for seed yield and from 0.82 to 0.99 in 1995-96, 0.91 to 0.99 in 1996-97 and 0.90 to 0.99 on pooled basis for dry matter yield. The variance ratio (F-value) for testing R^2 were statistically highly significant in all the cases both for seed and drymatter yield.

The production function as expressed by quadratic form though had higher R^2 value of 0.99 for dry matter yield in both the years and on pooled basis the regression coefficients were not significant. Therefore, it can be inferred that the non-linear function expressed by quadratic form did not represent the dry matter yield data well. However, the regression coefficients of non-linear quadratic, cubic and power functions for seed yield and cubic and power functions for dry matter yields were highly significant and thus found to represent the data well.

The Stewart's S_1 and S_2 function may be expressed and written in the form of linear function. Thus, R^2, F-value and t-value both for Stewart's S_1 and S_2 and linear function were similar both for seed and dry matter yield in a given year and on pooled basis. The regression coefficients for these linear functions under both seed and dry matter yield were highly significant. The R^2 value for these functions was 0.95 for both seed yield and dry matter yield in both the years and on pooled basis.

The R^2 values for the function proposed by Singh *et.al.* (1987) modifying the stress factor in Stewart's function assuming a non – linear relationship between seed yield and dry matter yield versus seasonal Eta, though represented the data well, it had lower R^2, F-value and t-value when compared to linear, quadratic, cubic, power, Stewart's S_1 and S_2 functions both for seed yield and dry matter yield (except quadratic) in both the years and on pooled basis.

It was concluded that the linear functions expressed by equation (1), (5) and (6) may be considered more useful from simplicity and practical point of view for mustard under Hyderabad conditions.

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Table 1 **Empirical estimates for testing seasonal water production functions for mustard seed yield** (Pooled for 1995-96 and 1996-97)

Water production function	Regression constants, coefficients and test statistics								F-value for testing R^2
	a	b	t(b)	C	t©	d x 10^{-6}	t(d)	R^2	
Linear	-893.6	71.65287**	9.465					0.95	89.5
Quadratic	2.4	-19.67600**	5.952	2.07028*	18.713			0.99	201.7
Cubic	21.8	3798.81982**	6.211	-349.69784**	6.149	7.561**	6.050	0.96	23.2
Power	-0.6	2.27438**	18.592					0.98	159.9
Stewart's S_1	1536.7	-2431.03101**	9.462					0.95	89.5
Stewart's S_2	0.02	1.54720**	9.462					0.95	89.5
Singh *et al.*	-2465.0	3766.38792**	4.749					0.82	22.5

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

Table 2 ***Empirical estimates for testing seasonal water production functions for mustard dry matter yield*** (Pooled for 1995-96 and 1996-97)

Water production function	Regression constants, coefficients and test statistics								F-value for testing R^2
	a	b	t(b)	C	t©	d x 10^{-6}	t(d)	R^2	
Linear	-2302.7	226.82647**	9.854					0.95	97.1
Quadratic	35.1	57.70686 NS	2.368	2.86508 NS	2.297			0.99	86.3
Cubic	30.4	10307.36425**	7.094	-948.74261**	7.043	20.601**	6.906	0.97	33.7
Power	0.80	1.92845**	13.877					0.97	192.6
Stewart's S_1	5390.9	7696.30824**	9.856					0.95	97.1
Stewart's S_2	-0.09	1.55848**	9.856					0.95	97.1
Singh *et al.*	-7796.3	12495.73532**	6.810					0.92	46.4

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

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Response of Indian mustard [*Brassica juncea* (L.) Czern & Coss.] to nitrogen under saline water irrigation in semi-arid region of Rajasthan

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Abstract

Effect of three qualities of irrigation water having average electrical conductivity 2.85, 7.88 and 15.32 dS/m and four levels of nitrogen (0, 40, 80 and 120 kg/ha) were studied on growth, yield, oil and protein content of mustard on clay loam soil during *rabi* 1998-99 and 1999-2000 at National Research Centre on Rapeseed and Mustard, Sewar, Bharatpur, Rajasthan. There was decrease in mustard yield with increase in salinity of irrigation water mainly due to decrease in siliquae/plant. Plant height, primary branches and seeds/siliqua also decreased with the increase in salinity. Nitrogen levels significantly increased the seed yield which was mainly contributed due to plant height, branching and siliquae/plant. Interaction of water salinity and nitrogen levels showed that higher doses of nitrogen were able to overcome the adverse effect of salinity upto salinity level of 7.88 dS/m. Saline water irrigation increased the salt build up in soil more so with salinity water at the time of crop harvest.

Key words: Electrical conductivity, siliquae, saline water irrigation, mustard

Introduction

Rajasthan contributes about 42.3 and 44.5 % of total area and production of Indian mustard, respectively in India. Arid and semi-arid region of Rajasthan, which comprises of the majority of mustard area are having ground water mostly of saline nature. Out of total ground water available in the state, 68 % is of poor quality (Minhas and Tyagi, 1998). Due to limited availability of good quality water the farmers are bound to use saline water for irrigation purposes. Poor quality of irrigation water is an important factor in reducing the growth, yield and nutrient uptake by mustard (Kumar and Malik, 1983; Chauhan *et al.*,1988). It is rather not practical and economically feasible to change the quality of irrigation water. Nitrogen is one of the most sensitive element in such problematic situations, due to its high mobility in soil and thus the response becomes highly unpredictable. The objective of this study was to investigate the effect of levels of irrigation water salinity and nitrogen on the seed yield of mustard and their interaction effects.

Materials and methods

Field experiment was conducted during *rabi* season of 1998-99 and 1999-2000 at National Research Centre on Rapeseed and Mustard, Sewar, Bharatpur, Rajasthan. The soil was clay loam in texture, low in organic carbon and average in soil salinity . The organic carbon was 0.36% and 0.33% in 0-15 and 15-30 cm depths, respectively. The experiment was conducted in split plot design with three replications using three qualities of irrigation water (W_1, W_2 and W_3 having electrical conductivity 2.85, 7.88 and 15.32 dS/m and pH 7.86, 8.47 and 7.54, respectively) in main plots and four levels of nitrogen (0, 40, 80 and 120 kg/ha) in sub-plots. The mustard variety PCR-7 was sown on 25th and 27th October during 1998 and 1999, respectively. Seeds were sown in rows 30 cm apart and plant-to-plant distance was maintained at 10 cm by thinning at 25 days after sowing. Half of nitrogen and whole phosphorus (40 kg/ha) was applied as basal and remaining nitrogen was top-dressed after first irrigation (35 DAS). Second irrigation was applied to the crop at 65 DAS. Soil samples were collected from 0-15 and 15-30 cm depth at the time of sowing and at crop maturity. Data on seed yield and yield attributing characters (Table 1) were recorded from five randomly selected plants. Mean agronomic efficiency of nitrogen was calculated by taking difference of mean seed yield from that of control. The data were statistically analysed by using standard procedure. During the crop season 17.8 and 40.2 mm rainfall was received during 1998-99 and 1999-2000, respectively.

Results and discussion

Effect of saline water irrigation: There was decrease in mustard seed yield with increasing salinity of irrigation water and interaction effect was also significant with all three levels of salinity. The decrease in seed yield was mainly due to significant decrease in seeds/siliqua and siliquae/plant during the first year. In the second year also the decrease in siliquae/plant was significant but the effect on seeds/siliqua did not reach to the level of significance. Thousand seed weight was unaffected possibly because

during later stage, the crop might have overcome the stress and the effect of seed filling was minimized. Plant height normally decreased with increasing salinity, however it was significant only during second year. The reduction in plant height with the use of saline water irrigation has been reported earlier by Shannon *et al.* (1993). Primary and secondary branches and also oil and protein content were normally unaffected due to salinity.

Effect of nitrogen levels: Nitrogen levels significantly affected the seed yield and number of siliquae/plant. The yield increase was mainly contributed by increased siliquae/plant. Seeds/siliqua increased with nitrogen levels but it was significant only during first year. Plant height and secondary branches also increased significantly with nitrogen, however, seeds/siliqua and protein content was increased significantly only during the first year.

Interaction effect: Higher doses of nitrogen were able to withstand the adverse effects up to the salinity level of W_2 (EC_{iw} = 7.88), but when the salinity of irrigation water increased to the level of 15.32 dS/m, the adverse effect could not be compensated and there was no proportionate increase in seed yield with increasing nitrogen levels. Similar inference may also be obtained from perusal of agronomic efficiency data (Table 2). There was increase in seed yield/kg nitrogen up to irrigation water salinity of W_2 may be due to some stimulus effect of low salinity water which might have been resulted into increased availability of essential nutrients (Kumar, 1995).

Soil properties: Irrigation with saline water has tended to increase the salt accumulation in the soil. This was generally more in top 15 cm as compared to 15-30 cm soil depth at the time of harvest. The reason being long dry spell before harvest of the crop has favoured upward movement of salts. The build up of salt increased with increasing salinity level of irrigation water and was maximum in plots irrigated with W_3. These results are in agreement with earlier findings of Sinha (1991).

Table 1 Effect of irrigation water quality and nitrogen levels on yield attributes, yield and oil content of mustard

Treatment	Plant height (cm)		Primary branches/plant		Secondary branches/plant		Siliquae/ plant		Seeds/ siliqua		1000-seed weight (g)		Seed yield (kg/ha)		Mean	Mean agronomic efficiency of N (seed/kg of N)	Oil content (%)		Protein content (%)	
	98-99	98-00	98-99	99-00	98-99	99-00	98-99	99-00	98-99	99-00	98-99	99-00	98-99	99-00			98-99	99-00	98-99	99-00
Irrigation water																				
W_1	165	134	5	5	5	5	146	129	14	12	5	5	1712	815	1263	8.9	40	41	20.8	20.0
W_2	155	123	5	5	5	5	128	112	13	12	5	5	1555	737	1146	10.4	40	41	21.3	20.2
W_3	152	124	5	5	4	6	111	107	13	12	5	5	1330	620	962	9.0	40	41	21.2	20.5
CD (P=0.05)	NS	12	NS	NS	NS	NS	29	16.2	0.2	NS	NS	NS	80	180	85	-	NS	NS	NS	0.4
Nitrogen levels																				
0	141	122	4	5	1	3	87	96	12	12	5	5	809	336	573	-	40	40	20.5	20.2
40	156	119	5	4	3	4	111	96	13	12	5	5	1419	527	973	10.0	40	41	20.9	20.0
80	163	132	6	5	6	5	164	115	13	12	5	5	1788	918	1336	9.5	40	41	21.3	20.2
120	168	135	5	6	8	8	172	156	14	13	5	5	2112	1115	1613	8.7	40	41	21.7	20.5
CD (P=0.05)	10	10	0.6	NS	2.0	2.9	39.0	19.4	0.7	NS	NS	NS	166	121	98	-	NS	0.6	0.5	NS

Table 2 Interaction of nitrogen levels with irrigation water salinity

Irrigation water salinity level	Nitrogen levels (kg/ha)				Mean
	0	40	80	120	
W_1	7.3	10.9	14.0	18.3	12.6
W_2	5.4	9.7	14.4	16.2	11.4
W_3	4.5	8.6	11.6	13.8	9.62
Mean	5.7	9.7	13.4	16.1	11.2

CD (P=0.05) for water - 1.61 CD (P=0.05) for nitrogen - 1.62

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Influence of sowing date and irrigation levels on hybrid seed production and oil quality of sunflower (PSFH-67)

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Abstract

Field experiment on sunflower (*Helianthus annuus* L.) hybrid was conducted during spring seasons of 1998 and 1999 at Crop Research Centre, Pantnagar with 3 sowing dates and 4 levels of irrigation. The effects of date of sowing and levels of irrigation were observed. The results showed that crop sown in March had significantly higher oil content while, oil yield was highest from 20th February sown crop. Protein content was higher in 5th February sowing. Oil composition did not change by dates. Irrigation scheduling did not show significant variation in oil content. However, irrigation at all growth stages produced significantly higher oil yield. While, protein content and oil composition remained unchanged.

Key words: Oil content, oil composition, sowing dates

Introduction

The significant transformation of the Indian oilseeds scenario from a net importer status during eighties to the status of self-sufficiency and net exporter during nineties has been witnessed. The oilseeds production has gone up to 25.6 million metric tonnes during 1998-1999. The area under oilseeds cultivation has increased upto 27.0 million ha with a productivity of 948 kg/ha during 1998-1999 (Agriculture Situation in India,, 1999). Area under sunflower has gone up to 2 m ha with a production of 1.17 million metric tonnes in 1998-1999.

The high oil content (40-50%), high quality cooking oil because of low saturated and high poly unsaturated fatty acids which helps in lowering down the level of harmful serum cholesterol, short crop duration and wider adaptability further favour the possibility of cultivation of this crop on large scale. Sunflower is a photo and thermo insensitive crop. However, the influence of temperature on germination, growth and development has been reported. The temperature variation is documented to modify the plant activities and growth process to a large extent (Chandra, 1974). Sowing at optimum time ensures better yield relationship between the crop and weather. To set up the production and realize maximum benefit in a short period, it is imperative to schedule need based irrigation. Proper use of irrigation water demands its application at the appropriate stage which leads to maximum seed and oil yield and better quality. Prevailing temperature during spring season is more suitable to grow sunflower hybrid in mollisols of *tarai* with rational water use. Since, information on spring sunflower for north-west part of Uttar Pradesh, particularly in *tarai* belt (now in Uttaranchal) for hybrid oilseeds production of PSFH-67, is not available. Keeping this in view, present investigation was planned.

Material and methods

The field experiment was conducted during the two spring seasons (February-June) in 1998 and 1999 in Crop Research Centre, G.B. Pant University of Agril. & Tech., Pantnagar, Uttaranchal. The Crops Research Centre is located at 29°N latitude, 79.3°E longitude and at an attitude of 243.8 m above the msl.. The soil of site was sandy loam, high in organic carbon and available phosphorus and medium in available potassium, with soil (Mollisols) pH-7.2, BD-1.58 g/cubic cm, FC 23.4% and PWP 10.4%.

The experiment were laid out in split plot design, keeping dates of sowing as main plot and levels of irrigation as sub plot treatment with four replications. The plot size was 5 m x 5 m (net 4 m x 4 m with 4 female and 1 male lines). The parental line (23A and 35R) in 3:1 female and male ratio with 20 x 60 cm planting distance having 8 kg seed/ha were planted in the experiments to carried out the study of performance of sunflower hybrid (PSFH-67) as influenced by 3 dates of sowing under 4 levels of irrigation. Full dose of P (60 kg/ha) and half dose of recommended N (100 kg/ha) was applied as basal application and remaining half dose of N was top dressed after first irrigation. All other recommended practices were followed for raising the crop. Samples of seeds from each treatment were taken out for quality analysis of seed and oil by standard techniques. The oil content was estimated by Soxhlet Apparatus and Nuclear Magnetic Resonance (NMR) methods. For analysis of fatty acids composition easters were prepared.

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Easters were injected into gas chromotography. Chromotogram in percentage of individual fatty acid was calculated by the instrument automatically. Then the observed acids were recorded as saturated and unsaturated fatty acids, separately.

Results and discussion

The mean minimum (4.6 to 26.3 °C) and maximum (19.6 to 39.8 °C) temperature and relative humidity (32.5 to 73.7%) were recorded during crop growing seasons. The minimum pan-evaporation 2.3 mm in 6th week and maximum in 18th week were observed during first and second years of experimentation.

Seed yield: The maximum seed yield was obtained when planting was done on 20th February and followed by 5th February date of planting. Maximum significant reduction in yield was found in 7th March sown crop. Crop planted on 7th March bloomed and harvested 3-4 days early than the 5th February sown crop. Increased temperature in April month hasten the crop growth and maturity of the crop. Might be due to increase in temperature shorten the crop growth period of 7th March sown crop which led to reduction in yield. Irrigation at all growth stages (4 nos.) produced significantly higher seed yield. One irrigation missed at pre-flowering or flowering or grain filling stage led to significant reduction in seed yield. However, the difference between I_3 and I_4 treatments was found to be at par. The reduction in yield might be due to loss of turgidity in plant cell and unable to recover photosynthetic/ physiological losses even after next irrigation.

Oil content: Oil content as affected by date of sowing and irrigation is presented in table 1. The oil content was significantly influenced by date of sowing in first year only. There was an increase in oil content as date of sowing was advanced. There was a 30 days gap between first and third date of planting, temperature gradually increased 10°C to 40°C during February to April months. Increased temperature hasten the plant growth and seed development. The maximum oil content (40.7%) was recorded when planting was done on 7th March. However, minimum oil content (38.8) was recorded when sunflower was planted on 5th February. The value of oil content of sunflower planted on 20th February, was 39.7%. Higher oil content in 7th March, sown crop might be due to higher temperature and sunshine hours during flowering phase which led to bold seeds of sunflower. These results are in agreement with Habbeebullah *et al.* (1993), who reported that oil content was positively correlated with maximum temperature and bright sunshine hours during flowering phase. Irrigation treatments did not influence oil content of sunflower significantly in both the years. Nagavani *et al.* (1997) also reported the same. Stress created by one missed irrigation at botton or flowering or grain filling stage could not change seed composition. However, 7th March sown crop bloomed 2-3 days earlier than 5th February sown crop and produced higher oil content seeds.

Oil yield: A perusal of data in table 1 showed that oil yield was higher in 20th February, sown crop. The lowest oil yield was recorded when the crop was sown on 7th March. This reduction was 13.8% in 1998 and 14.4% during 1999. The values of oil yield of crop planted on 5th February, were in between of these two dates. The difference (13.8 - 14.4%) in oil yield was due to fact that oil yield is a product of oil content % and seed yield. Since, more seed yield was recorded from this 20th February, sown crop than that of first and third sowing dates i.e., 5th February and 7th March, respectively. The highest seed yield was recorded in 20th February sown crop while, lowest in 7th March planted crop which ultimately converted in oil yield kg/ha. Well developed seeds produced higher amounts of oil. Similar results were reported by Chandra (1974).

Irrigation treatments influenced oil yield significantly during both the years. The maximum oil yield was recorded in the treatment where no irrigation was missed at any critical stage. While minimum oil yield was observed where one irrigation was missed at flowering in 1998 and grain filling in 1999. This worked out to be 12.4% and 15.9% less oil yield. Minimum reduction in oil yield was when one irrigation was missed at pre-flowering while, I_3 was at par with I_4. The yield of oil was higher due to higher seed yields in control treatment where no irrigation was missed. Irrigation at all growth stages produced bold seed and higher yield.

Protein content: The protein content was significantly influenced by date of sowing during both years. The maximum protein (17.0% in 1998 and 16.9 in 1999) was recorded when planting was done on 5th February followed by third planting followed by second date planting in 1998 while, during 1999 first date value of protein content was followed by second date, followed by third date sowing. Protein content was found maximum in first date of sowing might be due to simultaneous decrease in oil content when protein content was increased. Irrigation levels had no significant effect on protein content in both the years.

Fatty acid composition: The data regarding fatty acids composition as influenced by date of sowing and irrigation levels are summarized in table 2. An individual analysis for fatty acid was done with the help of Gas Chromatography, the individual fatty acids in oil were : palmatic acid (16-0 Carbon) saturated, stearic acid (18-0 Carbon) saturated, oleic acid (18-1 Carbon) mono unsaturated, lenoleic acid (18-2 Carbon) poly unsaturated, linolenic acid (18-3 carbon) poly unsaturated. The fatty acids composition was not significantly influenced by date of sowing. Saturated (10.8% in 1998 and 10.5% in 1999) and unsaturated fatty acids (88.4% in 1998 and 88.1% in 1999) remained unchanged due to dates of sowings. It might be due to the fact that composition of sunflower oil was dependent on genetic make up of cultivar (Salera and Baldini, 1998). Composition of sunflower oil as a ratio of saturated and unsaturated fatty acids also did not change significantly with change in irrigation levels also.

Table 1 Effect of date of sowing and irrigation levels on oil content, oil yield and protein in sunflower

Treatment	Oil content (%)		Oil yield (kg/ha)		Protein content (%)	
	1998	1999	1998	1999	1998	1999
Date of sowing						
5th February (D_1)	38.7	39.7	826	850	17.0	16.9
20th February (D_2)	39.7	39.8	908	902	16.5	16.7
7th March (D_3)	40.7	40.2	782	772	16.6	16.6
SEm±	0.1	0.2	0.5	9.2	0.1	0.1
CD (P=0.05)	0.5	NS	17.9	32.1	0.2	0.2
Irrigation levels						
Irrigation at all growth stages (I_1)	39.9	40.1	913	946	16.7	16.7
One irrigation missed at botton stage (I_2)	39.4	39.7	836	826	16.7	16.7
One irrigation missed at flowering (I_3)	40.0	40.0	799	799	16.7	16.8
One irrigation missed at grain filling (I_4)	39.6	39.8	808	795	16.7	16.7
SEm±	0.3	0.3	10.5	16.5	0.1	0.1
CD (P=0.05)	NS	NS	30.6	48.1	NS	NS

Table 2 Effect of date of sowing and irrigation levels on composition of fatty acids in oil and yield of sunflower

Treatment	Saturated fatty acids (%)		Unsaturated fatty acids (%)		Seed yield (kg/ha)	
	1998	1999	1998	1999	1998	1999
Date of sowing						
5th February (D_1)	10.9	10.6	88.1	88.3	2130	2140
20th February (D_2)	10.7	10.5	88.3	88.4	2280	2260
7th March (D_3)	10.7	10.5	88.1	88.3	1920	1920
SEm±	0.1	0.1	0.5	0.3	10	20
CD (P=0.05)	NS	NS	NS	NS	30	30
Irrigation levels						
Irrigation at all growth stages (I_1)	10.8	10.8	88.3	88.7	2280	2350
One irrigation missed at botton stage (I_2)	10.8	10.6	88.0	88.3	2120	2080
One irrigation missed at flowering (I_3)	10.7	10.7	88.2	88.3	1970	1990
One irrigation missed at grain filling (I_4)	10.7	10.2	88.2	88.1	2040	1990
SEm±	0.1	0.3	0.8	0.9	20	20
CD (P=0.05)	NS	NS	NS	NS	30	40

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Assessment of yielding ability of Trombay Groundnut (*Arachis hypogaea* L.) varieties through growth analysis

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Abstract

Two groundnut varieties, TAG24 and TG 26, developed at Bhabha Atomic Research Centre were released for commercial cultivation in India. Using growth analysis, the different traits for the high yielding ability of these varieties were studied in comparison with popular cultivars, TMV 2 and JL 24. Enhanced source capacity by way of increased number of leaves, leaf weight and leaf area/plant was observed in TAG 24 and TG 26. They recorded superior pod yield at all stages of crop growth, which was due to maximum number of pegs, pods and seeds and increased seed weight. They registered greater growth rate, pod, seed and oil accumulation and oil yield. Estimates indicated that TAG 24 and TG 26 had enhanced partitioning efficiency as well as higher harvest index, which facilitated them for better diversion of photo-assimilates towards final economic product, seed weight and oil content.

Key words: Groundnut, *Arachis hypogaea*, partitioning efficiency, growth rate, harvest index, oil accumulation

Introduction

For increasing yield in self-pollinated crops, it has been suggested to select plants with superior biomass accumulation, high harvest index (HI) and optimum crop maturity (Wallace *et al.*, 1993). In groundnut (*Arachis hypogaea* L.), differences in yielding ability among cultivars were attributed to (I) differences in photosynthetic efficiency of leaf canopies as assessed through crop growth rate, (ii) partitioning efficiency and (iii) duration of pod filling (Duncan *et al.*, 1978). Further, studies indicated four aspects that promote higher yields, namely, (I) a rapid expansion phenophase, (ii) a sort podding phenophase, (iii) a long filling phenophase and (iv) a high partitioning of assimilation to pods (McCloud *et al.*, 1980). As the yield accumulation process is dynamic, its potential can be assessed by comparing recent varieties with old varieties through crop growth analysis (Mc Cloud *et al.*, 1980). New groundnut cultivars in the USA have higher reproductive efficiency, more number of flowers, pods, seeds and total dry matter than older ones (Coffelt *et al.*, 1989; Seaton *et al.*, 1992). Major genotypic yield differences were related primarily to partitioning of assimilates to pod, seed growth rate and timing of seed filling (Williams *et al.*, 1975; Duncan *et al.*, 1978; McCloud *et al.*, 1980; Pixely *et al.*, 1990; Wheeler *et al.*, 1997).

In India, TMV 2 and JL 24 are popular cultivars. Two varieties, TAG 24 (Patil *et al.*, 1995) and TG 26 (Kale *et al.*, 1997) developed at this centre were released for cultivation during 1991 and 1996, respectively. TAG 24 produced higher yield over JL 24 and TMV 2 and other popular checks over the years and locations (Kale *et al.*, 1999). The objective of the present experiment was to study the high yielding ability of TAG 24 and TG 26 through growth analysis by comparing with JL 24 and TMV 2.

Material and methods

A field experiment was conducted in a randomized complete block design with five replications at this centre during summer (January-April) 1999 under irrigation. Weather conditions were warm and humid. Four varieties i.e., TAG 24, TG 26, TMV 2 and JL 24 were planted in six rows of 7.5 m length with 30 cm inter and 10 cm intra-row spacing. One meter segment of a row from each replication of each variety was harvested at 30, 53, 65, 73, 86, 95, 108 and 118 days after sowing (DAS), to take observations on vegetative (VDM), pod (PDM) and total dry matter (TDM). Three plants per replication at each harvest were selected randomly in each variety and plant height, leaf area and number of leaves, pegs, pods and seeds were recorded. Leaf area was calculated by Biovis Image Plus software of digital analysis (M/s Expert Vision Labs Pvt. Ltd., Mumbai). To arrive at mean leaf area for each variety, leaf area at different growth stages from 30 to 118 DAS was pooled.

Crop growth rate (CGR), vegetative growth rate (VGR) and pod growth rate (PGR) were calculated by linear regression of TDM, VDM and PDM curves, respectively,

when they were in their corresponding linear phases (Duncan *et al.* 1978) between 65 to 108 DAS. Similarly, plant height increase rate 4 (PHIR) was estimated between 30 to 73 DAS. Seed growth rate (SGR) was derived by multiplying PGR and shelling %. Time to rapid pod growth initiation was computed as the intercept of the linear regression of PDM with the time axis (Pixely *et al.*, 1990).

Partitioning of photo-assimilates to pod growth was estimated using glucose equivalent (GEQ) values of VGR and PGR. The GEQ values are 1.44 g/g synthesis of leaf, stem, peg and shell tissue and 2.47 g/g of seed (Hang *et al.*, 1984; Pixely *et al.*, 1990). VGR and PGR were measured between 65 to 108 DAS. Harvest Index (HI) was calculated as per Dwivedi *et al.* (1998). The equations for the above calculations were as follows:

1. GEQ of VGR = VGR x 1.44
2. GEQ of PGR = [(PGR-SGR) x 1.44] + (SGR x 2.47)
3. Assimilate partitioning = GEQ of PGR / (GEQ of VGR + GEQ of PGR)
4. HI = (PDM at 118 DAS x 1.67) / [(PDM at 118 DAS x 1.67) + (VDM at 118 DAS)]
5. Effective filling period = PDM/PGR

Seed oil estimation was made by Nuclear Magnetic Resonance spectrometer (Oxford MQA 6005 Model, Oxford Instruments UK Ltd., Oxa, UK) at 65, 73, 86, 95, 108 and 118 DAS. Oil yield was determined by converting seed weight with respective oil % at different growth intervals. Oil accumulation rate (OAR) was estimated by linear regression of oil yield curve between 65 to 108 DAS. All computations for CGR, VGR, PGR, EFP, OAR, PHIR, partitioning and days to rapid pod growth initiation were done on individual replicate values, which were subjected to analysis of variance.

Results and discussion

TDM accumulation: Significant varietal differences were noticed for TDM at different stages of growth. From 65 to 118 DAS, TAG 24 recorded the highest TDM followed by TG 26 (Fig 1C). On the other hand, TMV 2 produced the lowest TDM throughout the growth period. The maximum TDM by TAG 24 (2471 g/m^2) and TG 26 (2235 g/m^2) was produced at 108 DAS while, JL 24 (1881 g/m^2) and TMV 2 (1674 g/m^2) at 118 DAS. Increased TDM has been attributed to higher photosynthetic rate as well as increased nutrient acquisition and utilisation efficiency (Lodha *et al.*, 1985).

It is known that enhanced capacity of "source" components coupled with better diversion of photosynthates is important during pod initiation and filling stages leading to rapid pod growth. At different stages of crop growth, there were no significant differences among the varieties for VDM (Fig. 1B). During 65 to 95 DAS, higher values were recorded in TAG 24 and TG 26 over TMV 2 and JL 24 for number of leaves (36-111% higher in TAG 24; 31-78% in TG 26), leaf weight/plant (0-113% higher in TAG-24; 0-73% in TG 26), leaf area/plant (0-40% higher in TAG 24; 4-40% in TG 26), indicating their superior "source" capacity. Leaf area/plant in TAG 24 and TG 26 was more due to increased number of leaves/plant than leaf size since they had smaller leaves. Leaf area index (LAI) increased upto 86 DAS in TG 26 and 95 DAS in TAG 24, followed by a drop, while in JL 24 and TMV 2, it continued to increase until final harvest (Fig 2A). This early completion of leaf development in TAG 24 and TG 26 is an indication of their determinate habit and better translocation of photo-assimilates to the "sink".

TAG 24 and TG 26 had shorter plant height (Table 1) due to their shorter internodal length (TAG 24: 1.26 ± 0.03; TG 26 : 1.28 ± 0.04; JL 24 : 1.62 ± 0.04 and TMV 2 : 1.61 ± 0.04 cm). Further, PHIR in TAG 24 was much slower than TMV 2 while, TG 26 and JL 24 were at par (Table 1). The determinate habit and shorter plant height in TAG 24 and TG 26 appear to assist in increased photosynthate mobilisation towards pod growth.

Pod yield: In addition to greater capacity of "source", it is essential to have greater "sink" capacity to result in final higher economic product. Pod yields f TAG 24 and TG 26 were superior to TMV 2 and JL 24, registering 101-110% and 53-65% increase, respectively (Table 1) at 118 DAS. Higher pod yield in TAG 24 and TG 26 over JL 24 and TMV 2 was due to increased percentage of "sink" components (Table 1), namely number of pegs (26-52%), pods (49-73%) and seeds (38.66%)/plant and hundred seed weight (10-36%). Pod yields of TAG 24 peaked on 108 DAS, indicating its early maturity (Fig. 1A).

Significant varietal differences were noticed for PDM at different stages of growth. TAG 24 recorded the highest PDM at all stages of crop growth followed by TG 26 and JL 24. TMV 2 recorded the lowest PDM (Fig. 1A). This increased PDM was contributed at different growth stages by number of pegs, pods and seeds/plant (Fig. 2B, C and D). Since, there was a proportionate increase in both peg and pod number/plant in TAG 24 and TG 26 over JL 24 and TMV 2, there were no significant differences among the four varieties for peg to pod ratio (Table 1).

Growth rate: In the present study, there were significant varietal differences for CGR, PGR and SGR, which is in conformity with earlier reports (Pixely *et al.*, 1990; Nigam *et al.*, 1994). However, VGR did not differ significantly (Table 2). This indicated that differences observed in CGR among varieties were largely due to PGR and SGR and not due to VGR. TAG 24 and TG 26 registered significantly greater CGR, PGR, and SGR over JL 24 and TMV 2 (Table 2). Increased CGR, PGR and SGR in TAG 24 and TG 26 was also due to significantly higher PDM and

number of pods and seeds/plant (Table 1). Among these two TAG 24 had superior PGR and SGR although both had similar CGR which was ascribed to enhanced pod and seed yields and shelling % (Table 1).

Partitioning to reproductive growth: Partitioning, an important determinant of genotypic yield potential is the division of daily assimilates between vegetative and reproductive parts (Duncan *et al.*, 1978). Varieties varied significantly for partitioning of assimilates. TAG 24 and TG 26 partitioned 12 to 16% more photosynthates to pods than JL 24 and TMV 2 (Table 2). Higher partitioning in TAG 24 and TG 26 was due to increased PGR only, since differences in VGR were not significant. Pixely *et al.* (1990) reported higher partitioning due to greater PGR and lower VGR leading to greater pod yield in cv Florunner. However, in the present study, TAG 24 and TG 26 maintained VGR along with other varieties but excelled in PGR resulting in higher CGR. Thus, in true sense, for groundnut productivity, higher partitioning would be ideal if both CGR and PGR were higher. Earlier studies noted that major groundnut yield differences were associated with differences in partitioning of daily assimilates to pods (Duncan *et al.*, 1978; McCloud *et al.*, 1980; Pixely *et al.*, 1990). A stepwise genetic improvement in groundnut in Florida was achieved in 30 years mainly by increasing partitioning from 40% to 98% in new varieties (McCloud *et al.*, 1980).

EFP and days to rapid pod growth initiation did not differ significantly among varieties (Table 1). Values of EFP were comparable with the values reported earlier while, days to rapid pod growth initiation were 2-4 days earlier (Pixely *et al.*, 1990). On the other hand, Wheeler *et al.* (1997) found that genotypic differences for pod yield were primarily due to differences in the timing of seed filling rather than differences in the rate of dry matter partitioning to pods.

Harvest index: *HI being a static end season computation*, it also measures partitioning of assimilates, which in turn has greater effect on pod yield in groundnut (Duncan *et al.*, 1978; McCloud *et al.*, 1980). Hence, for genetic improvement of groundnut, genotypes with higher biomass and HI are essential (Lodha *et al.*, 1985; Dwivedi *et al.*, 1998). The differences in the HI were due to differences in the duration between flowering and initiation of seed filling which is important for groundnut yield since, longer duration was associated with smaller estimates of HI (Stirling and Black, 1991; Wheeler *et al.*, 1997). In the present study, TAG 24 and TG 26 showed 20 and 35% superior HI over JL 24 and TMV 2 (Table 2). Genotypic variation for HI had been reported in groundnut earlier (Wheeler *et al.*, 1997; Dwivedi *et al.*, 1998). Higher TDM along with higher HI in TAG 24 and TG 26 indicated better acquisition, mobilisation and utilisation of photoassimilates towards seed development.

Oil accumulation: Oil %, oil yield and OAR differed significantly among varieties. TAG 24 recorded significantly superior oil accumulation since the beginning of crop growth (Fig. 1D). It had 48.3% oil as compared to 45.0% in other varieties. At 118 DAS, oil yield in TAG 24 was superior followed by TG 26 (Table 1). JL 24 and TMV 2 were at par for oil yield. Further, TAG 24 also recorded high OAR, followed by TG 26 (Table 2). Since, 80% of Indian groundnut is crushed for oil purpose and groundnut continues to remain preferred vegetable oil, TAG 24 and TG 26 may help in contribution of oil production.

Table 1 Yield and yield components of groundnut varieties at 118 days after sowing

Variety	Plant height (cm)	Leaf area (cm^2)	Peg to pod ratio	Shelling (%)	HKW (g)	Per plant number of		Pod yield (g/m^2)	Oil yield (g/m^2)
						Pods	Seeds		
TAG 24	41	31.3	0.49	71.5	40.0	49	73	1442	440
TG 26	43	36.0	0.42	68.2	36.5	45	70	1338	345
TMV 2	62	44.6	0.39	68.8	29.3	30	44	664	174
JL 24	53	43.7	0.39	68.6	33.0	28	50	870	227
CV (%)	5.4	4.0	14.1	1.1	12.4	10	7.5	12	15
CD (P=0.05)	3.7	2.1	NS	1.4	5.9	5.5	6.1	179	60
CD (P=0.01)	5.2	3.0	NS	2.0	NS	7.8	8.5	254	84

HKW : 100-seed weight; NS : Non-significant

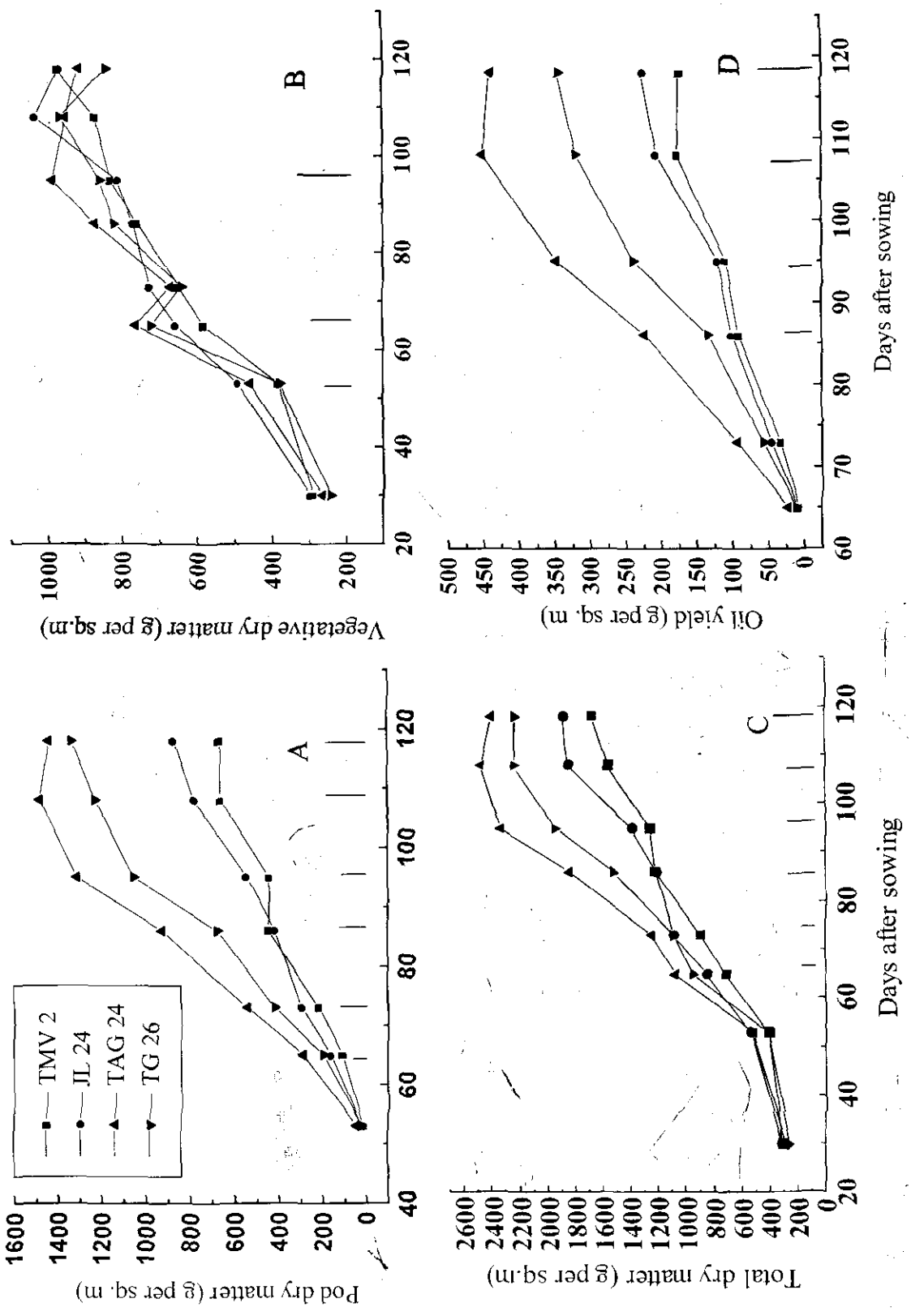

Fig 1 Pod dry matter (A) Vegetative dry matter; (B) Total dry matter (C) and oil yield (D) vs. days after sowing in four groundnut varieties. Vertical bars indicate C.D. values ($P<0.05$) for comparing varieties.

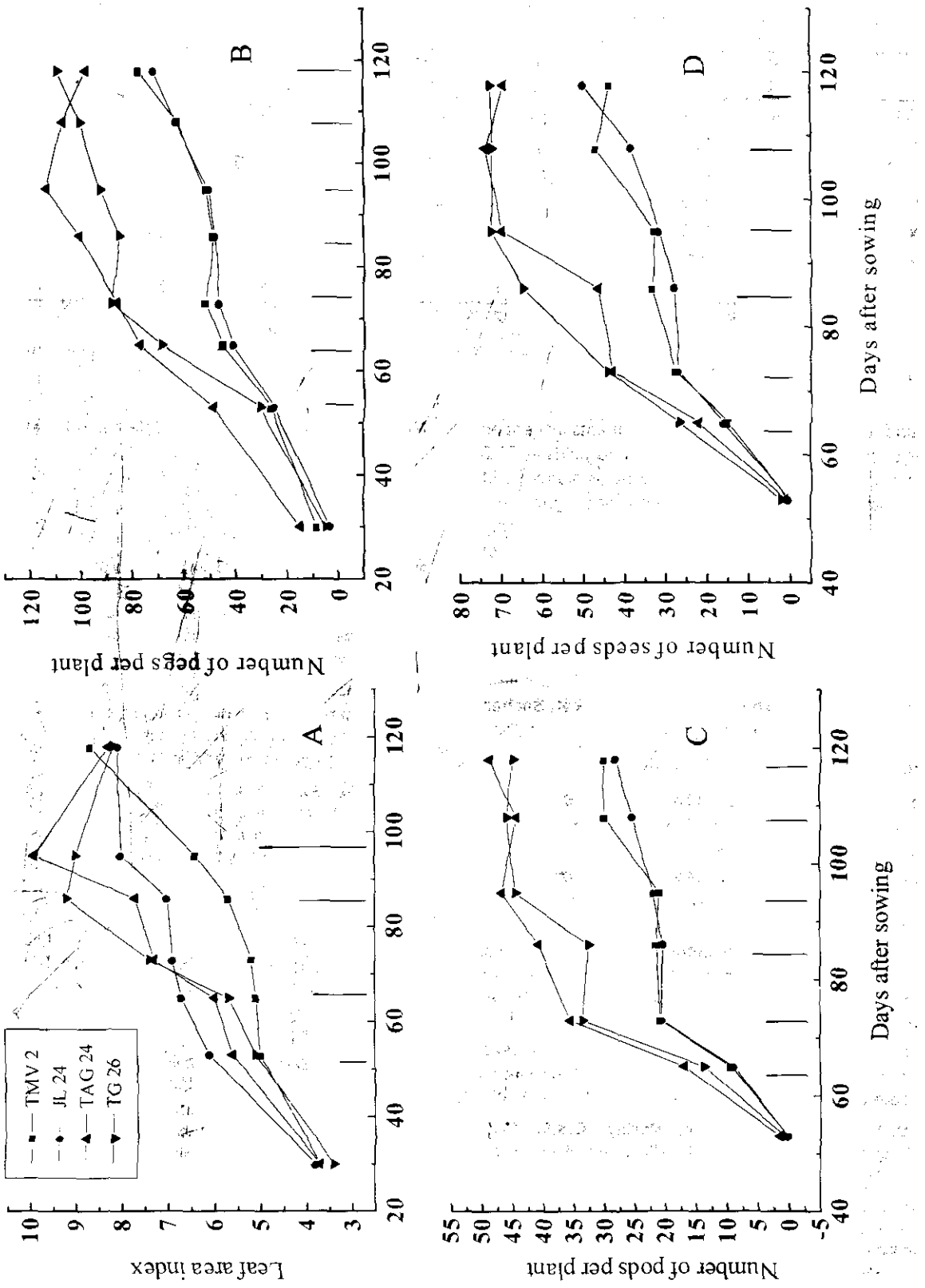

Fig 2 Leaf area index (A), Number of pegs (B), Pods (C) and Seeds (D) per plant vs. days after sowing in four groundnut varieties. Vertical bars indicate C.D. values ($P<0.05$) for comparing varieties.

Table 2 Growth analysis parameters in groundnut varieties

Variety	PHIR (cm/d)	CGR ($g/m^2/d$)	VGR ($g/m^2/d$)	PGR (g/m/d)	SGR (g/m/d)	partitioning (%)	HI	OAR ($g/m^2/d$)	EFP (d)	DRPGI (d)
TAG 24	0.34	35.4	6.5	29.0	20.7	87.4	0.72	10.27	59.8	56.0
TG 26	0.48	32.0	6.7	24.8	16.9	84.6	0.72	7.40	61.0	58.0
TMV 2	0.64	19.5	7.0	12.3	8.5	72.6	0.53	3.88	60.8	56.0
JL 24	0.49	22.0	8.2	13.7	9.3	71.3	0.60	4.37	65.4	58.0
CV (%)	15.1	12.5	18.8	10.9	11.4	6.0	4.40	10.60	5.2	3.2
CD (P=0.05)	0.10	4.5	NS	3.0	2.2	5.2	0.04	0.94	NS	NS
CD (P=0.01)	0.14	6.4	NS	4.2	3.0	7.3	0.05	1.32	NS	NS

PHIR : Plant height increase rate
CGR : Crop growth rate
VGR : Vegetative growth rate
PGR : Pod growth rate
SGR : Seed growth rate
HI : Harvest index
OAR : Oil accumulation rate
EFP : Effective filling period
DRPGI : Days to rapid pod growth initiation
NS : Non-significant

In groundnut, a wide array of yield components influenced pod yield. In the present study, superior pod yields in TAG 24 and TG 26 were mainly contributed by (i) higher PDM due to greater number of seeds and pods and higher seed weight, (ii) superior PGR and CGR, (iii) higher partitioning efficiency and HI, (iv) higher TDM, (v) more number of leaves resulting in greater photosynthetic capacity and (vi) determinate habit and shorter plant height assisting better assimilate mobilisation. Due to the above traits, these two varieties appear to possess ideal plant type for the inclusion in future groundnut breeding efforts.

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Influence of FYM and inorganic nutrition on productivity of linseed (*Linum usitatissimum* L.) under limited irrigations in Chhattisgarh plains

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Abstract

An experiment was conducted during winter seasons of 1998-99 and 1999-2000 to study the effect of organic and inorganic fertilization on linseed under irrigated conditions. Application of farmyard manure (FYM) @ 5 t/ha increased the growth, yield attributes, seed yield and economics of linseed over no FYM. The extent of increase in seed yield was calculated to be 9.6%. Application of 100% recommended dose of fertilizer (60:30:20 NPK kg/ha) significantly superior to 50% and 75% RDF by a margin of 21.4 and 11.2%, respectively with regard to seed yield. Positive increase in net monetary return was observed with increased application of RDF. A saving of 25% RDF i.e. 15 kg N and 7.5 kg P_2O_5/ha was achieved with the application of 5 t FYM/ha.

Key words : Farmyard manure, organic and inorganic fertilization.

Introduction

Linseed (*Linum usitatissimum* L.) Is an important oilseed grown during *rabi* on rainfed areas of newly born Chhattisgarh state. The productivity of linseed is low owing to input resource constraints. With the enhanced irrigation facilities, there is an ample scope for increasing its productivity and production by applying optimum levels of both organic and inorganic manures (Puste *et al.*, 1999). Cultivation of linseed, therefore, depleted the soil rapidly unless the crop is adequately manured. Adequate manuring not only improved the crop yield but also sustained the soil health and productivity (Jain and Sharma, 2000). Sustainability of higher yields could be achieved through integrated nutrient management (INM). Fertilizers are applied by farmers in a limited quantity because of the increase in chemical fertilizer cost. Though enough work has been done on inorganic fertilization to linseed, an information on organic manures in combination with inorganic fertilizer is meagre. Keeping these facts in view, the present investigation was undertaken.

Materials and methods

The field experiment was conducted at the Research farm of IGAU, Raipur during winter seasons of 1998-99 and 1999-2000. The soil of the experimental field was clay in nature (Vertisol) with neutral in reaction. It has low in available nitrogen (180 kg/ha) medium in available phosphorus (24 kg/ha) and high in available potassium (392 kg/ha). The total rainfall during the crop period from November to March was 77.8 and 43.6 mm during 1998-99 and 1999-2000, respectively. The experiment was laid out in a randomized block design with factorial concept and replicated thrice. The treatments consisted of two levels of FYM *viz.*, no FYM and FYM @ 5 t/ha and three levels of inorganic fertilizers *viz.*, 50, 75 and 100% recommended dose of fertilizer (RDF).The recommended doses of fertilizer i.e. 60:30:20 NPK kg/ha was applied through urea, single super phosphate and muriate of potash, respectively. Linseed variety Kiran with a seed rate of 20 kg/ha was sown at 25 cm apart on November 13th and 20th during 1998-99 and 1999-2000, respectively. The crop was harvested on 10th and 20th March in respective seasons. Three irrigations i.e. first irrigation, just after sowing for uniform germination and establishment, other irrigations were give at 40 and 70 DAS, respectively.

Results and discussion

Effect on growth and yield attributes : The plant height and yield attributes (branches/plant, no. of capsules/plant, no. of seeds/capsule and 1000-seed weight) increased significantly with the application of FYM @ 5 t/ha. It might have provided the better nutrition to the crop resulted in vigorous growth and yield.

Effect of farmyard Manure (FYM) : Application of FYM resulted into taller plants, more number of branches/plant and 1000-seed weight (Table 1). This might be due to improved fertility status and better utilization of nutrients by crop. On an average, FYM application resulted in 90 kg/ha additional grain yield over control (Table 2). Similar effect of FYM application was observed on straw yield, oil yield, net monetary return and economics (Table 2). The results corroborate with the findings of Santhy *et al.* (2000) stating that addition of FYM has directly added an appreciable amount of major nutrients besides micronutrients to the soil, which would contribute to the enhanced yield. The improved physical properties like water holding capacity, moisture retention would have provided a desirable soil condition for the root development, enhancing nutrient uptake, crop growth and yield (Bhriguvanshi, 1998).

Effect of inorganic Nutrition : Application of 100% recommended dose of fertilizers produced the maximum values of growth characters, i.e. plant height and branches/plant and yield attributing traits i.e., number of capsules/plant, number of seeds/capsule and 1000-seed weight (Table 1). Grain and straw yields varied significantly among different fertilizer levels (Table 2), significantly higher seed yield was recorded at 100% recommended dose of fertilizers. This was due to favourable effect of *increasing fertilizer levels on yield attributing characters*, which finally resulted in higher grain yield. Similar observations were reported by Agrawal *et al.*, (1997). They found that application of 60 kg N + 30 kg P_2O_5 + 20 kg K_2)/ha gave the highest net returns and B:C ratio with the lowest cost of production, as compared to 30 kg N + 15 kg P_2O_5 + 10 kg K_2O/ha over control. Among the fertilizer levels, oil yield, net monetary returns and B:C ratio increased with increasing level of fertilizer and maximum values were noted at 100% recommended dose of fertilizer. This was mainly due to enhanced trend of increase in grain yield.

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Table 1 Growth and yield attributes of linseed as affected by farmyard manure and inorganic nutrition

Treatment	Plant height (cm)			Average branches/plant			No. of capsules/plant			No. of seeds/capsule			1000-grain weight (g)		
	1998-99	1999-00	Mean	1998-99	1999-00	Mean	1998-99	1999-00	Mean	1998-99	1999-00	Mean	1998-99	1999-00	Mean
Farm yard manure															
No FYM	57	55	56	2.3	2.6	2.5	47	35	41	8	7	8	7.3	5.1	6.7
FYM @ 5 t/ha	60	59	60	2.6	3.0	2.8	48	43	46	9	8	8	7.5	5.2	6.4
CD (P=0.05)	0.6	1.6	-	0.3	0.1	-	1.3	2.2	-	0.1	0.3	-	0.2	0.0	-
Inorganic fertilizer															
50% RDF	57	53	55	2.2	2.4	2.3	42	34	38	8	7	8	7.4	5.1	6.3
75% RDF	59	57	58	2.5	2.8	2.7	48	39	43	8	8	8	7.4	5.1	6.3
100% RDF	60	60	60	2.6	3.1	2.9	53	44	49	9	9	9	7.4	5.3	6.4
CD (P=0.05)	0.8	2.0	-	0.4	0.1	-	1.5	2.7	-	0.2	0.3	-	0.3	0.1	-

Table 2 Seed and oil yield as well as economics of linseed as affected by farmyard manure and inorganic nutrition

Treatment	Yield (kg/ha)									Net returns (Rs/ha)			B:C ratio		
	Seed			Straw			Oil								
	1998-99	1999-00	Mean	1998-99	1999-00	Mean	1998-99	1999-00	Mean	1998-99	1999-00	Mean	1998-99	1999-00	Mean
Farm yard manure															
No FYM	1090	993	1042	1940	1924	1932	436	397	417	9991	8538	9265	2.57	2.34	2.46
FYM @ 5 t/ha	1204	1058	1131	2135	2024	2080	482	423	453	11090	8901	9996	2.59	2.28	2.44
CD (P=0.05)	52	30	-	79	74	-	36	21	-	-	-	-	-	-	-
Inorganic fertilizer															
50% RDF	1036	964	1000	1926	1678	1802	425	395	410	9151	8081	8616	2.43	2.26	2.35
75% RDF	1123	1029	1076	2030	1996	2013	449	412	431	10180	8770	9475	2.53	2.32	2.43
100% RDF	1283	1083	1183	2157	2246	2202	507	428	468	12305	9309	10807	2.77	2.34	2.56
CD (P=0.05)	64	36	-	95	91	-	28	16	-	-	-	-	-	-	-

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Morphological traits of sesame, *Sesamum indicum* L. *vis-a-vis* tolerance to leaf roller-cum-pod borer, *Antigastra catalaunalis* (Dup.)

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Abstract

Forty cultivars of sesame, *Sesamum indicum* L were sown in paired rows of 4 m length and replicated three times. Various plant morphological characteristics of plant and the *Antigastra catalaunalis* (Dup.) infestation on plant and pods were recorded. The correlation between morphological characters and the pest infestation revealed positive correlations between leaf area; days to flowering initiation, 50% flowering and maturity. However, number of hairs on leaves and flowers and number of branches and pods/plant showed negative correlation with pest infestation.

Key words: Sesame, tolerance, *Antigastra catalaunalis*

Introduction

Sesame, *Sesamum indicum* L. suffers from the ravages of an array of insect pests (Rai, 1976; Singh and Yadava, 1985), of which, sesame leaf roller cum pod borer, *Antigastra catalaunalis* (Dup.) is the most serious pest. In unattended fields, the yield losses may be as high as 67% (Kumar *et al.*, 1990). Till date, to realize good yields of this crop, one is left with no option but to control this pest with insecticides which invariably leads to many long term hazards. The best alternative to combat such a regular pest is the introduction of tolerant/resistant cultivars, which are environmentally safe, economically sound and stable. Hence, the efforts were made to screen morphologically diversified cultivars of sesame under field conditions to find out correlation between *A. catalaunalis* infestation and various morphological traits of the cultivars.

Material and methods

Forty cultivars of sesame (TC-171, JLT-9, JLT-2, TNAU-10, BS-129, RCR-4, ST-7, RT-4, AT-5, AT-7, HT-1, Kanke white, CST-783, TC-25, Pb. Til No-1, JLT-3, BS-5-18-6-G, CST-782, B-67, TC-151, PDP-2, TC-289, CST-781, AT-4, JLT-8, RCR-1, RCR-2, RAUSS-17-6, TC-229, TNAU-11, HT-1, TC-17, JLT-1, CST-785, RCR-3, AT-8, JLT-7, L-38, TC-169 and AT-3) having diversified morphological traits were grown at the research farm of the CCS Haryana Agricultural University, Hisar in randomized block design replicated thrice in paired rows of 4 m length under recommended agronomic practices. Two weeks after germination, ten plants were randomly selected and marked by tagging in each replicate of all the cultivars. The data on various morphological traits of the cultivars as mentioned in the table were recorded. Moreover per cent pod damage at maturity, plant infestation at flower initiation and maturity were recorded on the tagged plants. The number of hairs on 3079μ linear length of leaf, flower and pods were recorded with the help of binocular microscope fitted with ocular micrometer. The correlation between various morphological parameters of the plants with pod and plant infestation by the pest were worked out.

Results and discussion

The analysis of the numerical data on the morphological parameters revealed that the cultivars were significantly different for these traits. Foliage colour (green and light green), pod setting pattern (compact and sparse), pods/node (mono, bio, trio, tetra and penta) did not exhibit any appreciable influence on the pod and plant infestation by *A. catalaunalis*, except that tetra and penta poded/node cultivars suffered slightly more pod damage. It might be probably because the caterpillars could find another pod more easily after damaging the previous one. Prasad (1970) also did not notice any effect of foliage and flower colour on the incidence of this pest.

Leaf area showed significant positive correlation with pod damage on the main shoot. It might be because the large leaf surface provided more area for egg laying. Singh (1983) observed that leaves contribute for egg laying by *A. catalaunali* at full flowering stage. Initially the early flowering cultivars were infested more as compared to late flowering ones, because the pest preferred inflorescence stage of the plant (Kumar, 1985). Later on, the next generation of the pest infested the inflorescence of the late cultivars too as and when they were in flowering. At the flower initiation, none of the morphological traits i.e., leaf area, days to flower initiation, number of hairs on leaves, branches/plant and plant height, showed any correlation

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with plant infestation. However, at maturity, days to flower initiation, and number of hairs on leaves and flowers showed negative correlation with plant infestation by *A. catalaunalis* and no correlation existed with other plant morphological traits.

The correlation between pod infestation on main shoot and leaf area, days to 50% flowering and maturity were positive (Table 1). The correlation between number of hairs on leaves, branches/plant and pods/plant and pest incidence were negative but non-significant which is in tune with the observations of Prasad (1970) who did not find any difference between hairy and non-hairy surface of sesame genotypes to the incidence of *A. catalaunalis*. However, Bhattacharjee and Lal (1962) observed positive correlation between number of branches/plant and the pest incidence.

On the basis of these findings, it could be construed that smaller leaves, longer period of flowering initiation, reduced duration to 50% flowering and maturity, more hairs on the plant parts, more number of branches and pods/plant, rendered the sesame plants less vulnerable to the damage by *A. catalaunalis*. Therefore, it is suggested that breeders should consider these parameters while developing new high yielding genotypes of sesame.

Table 1 Correlation coefficients between morphological traits of sesame genotypes and plant and pod infestation by *Antigastra catalaunalis*

Plant trait	Correlation with % plant infestation at		Correlation with % pod infestation at	
	Flower initiation	Maturity	Full plant	Main shoot
Leaf area	0.168	-0.234	0.019	0.389*
Days to flowering initiation	-0.130	0.452*	-0.156	0.201
Days to flower (50%)	-	-0.085	0.193	0.345*
Days to flower (100%)	-	-0.188	0.111	0.048
Days to full pod setting	-	0.033	0.091	0.305
Days to maturity	-	-0.302	0.089	0.335*
No. of hairs on leaves	-0.052	-0.315*	-0.454*	-0.195
No. of hairs on flowers	0.136	-0.324*	-0.067	-0.112
No. of hairs on pods	-	-0.113	-0.269	-0.023
Branches/plant	-0.029	-0.091	-0.324*	-0.060
Pods/plant	-	0.094	-0.519*	-0.070
Height/plant	-0.155	0.152	0.101	0.161

* Significant at P=0.05

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Toxicity of botanicals to parasitoids of castor semilooper, *Achaea janata* L.

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Abstract

Toxicity of botanicals was assayed to egg parasitoid (*Trichogramma chilonis* Ishii) and larval parasitoid (*Microplitis maculipennis* Szepligate) of castor semilooper, *Achaea janata* Linn. in *in vitro* and *in situ* conditions at the University of Agriculture Sciences, Dharwad, Karnataka. Dust and cold alcohol extract of *Clerodendrum inerme*, cold alcohol extract of *Bouganvillaea glabra*, neem seed kernel extract, neem leaf extract and commercial neem products were tested and all of them were found safe to adults of both the parasitoids except cold alcohol extracts of *C. inerme* and *B.glabra* which caused adult mortality ranging from 16.7 to 40.0 and 18.7 to 38.7 % in *T.chilonis* as well as 23.3 to 43.3 and 20.0 to 53.3 % in case of *M.maculipennis*, respectively. Cartap hydrochloride was highly toxic to adults of both the parasitoids. In all the botanicals, except *B.glabra* (58.7%) the emergence of *T.chilonis* adults was high in the laboratory (80.7 to 98.0%) and in the field(59.3 to98.7%).Dust formulation of *C.inerme* and neem leaf extracts were safer to parasitoids irrespective of the age of the developing parasitoid. The safety of botanicals to the developing parasitoids in the field parasitised eggs showed similar trends in the laboratory. More than 75% adults of *M.maculipennis* emerged from botanicals treated cocoons both under laboratory and field conditions. All the botanicals tested were safe to *M. Maculipennis* compared to cartap hydrochloride which resulted in 18.3 and 66.7 % adult emergence in laboratory and field treated cocoons, respectively.

Key words: Castor, *Achaea janata, Trichogramma chilonis, Microplitis maculipennis*, botanicals, toxicity

Introduction

The productivity of rainfed castor is low due to various production constraints, among them insect pests and diseases dominate the scenario. Castor semilooper, *Achaea janata* Linn. is a key pest of castor which is attacked by wide array of natural enemies ,among them egg parasitoids (*Trichogramma chilonis* Ishii and *Telenomus* sp) and larval parasitoid (*Microplitis maculipennis* Szepligate) were considered as potential, which parasitised 92.2 % eggs (Parasharya *et al.*, 1988)) and 77.3% larvae of castor semilooper (Gaikwad and Bilapate, 1992), respectively. All the botanicals involved in this study were evaluated against castor semilooper for their effectiveness both in the laboratory as well as in the field and were found promising (Basappa and Lingappa, 1999). However, the information on toxicity of these botanicals on bio control agents is lacking. The present investigations were initiated to study toxicity of various botanical formulations to egg and larval parasitoids *viz., T.chilonis* and *M.maculipennis.*

Material and methods

Toxicity of botanicals at field concentration was tested against both parasitoids in *in vitro* and *in situ* conditions using four dust and three cold alcohol extract formulations of *Clerodendrum inerme*, cold alcohol extract of *Bouganvillaea glabra* , Neem seed kernel extract, Neem leaf extract and four commercial neem products as well as one chemical insecticide for comparison (Table 1 and 2).

Preparation of botanicals :

***C.inerme* dust** :Shade dried leaves, flowers and tender twigs of *C. inerme* were further dried for 8-10 h at 50°C in oven and ground to 100 mesh powder. It was made in to dust of desired concentration by adding chalk powder as a carrier material.

***C.inerme* and *B.glabra* cold alcohol extract** : Cold alcohol extracts (CAE) of *C. inerme* and *B. glabra* were evaluated in the study. Forty grams of plant powder obtained as per procedure outlined above was soaked in 300 ml alcohol under intermittent stirring for 4 h and then filtered through cheese cloth and Watman No.4 filter paper successively. The extract was made up to 100 ml to get 40 % plant extract. However, neem seed kernel and neem leaf extracts were prepared following standard procedures.

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Mass production of parasitoids

The cultures of *T. chilonis*, *M. maculipennis*, *A. janata* and *Corcyra cephalonica* were maintained at 27±1° C and 60±5 % RH. Egg parasitoid, *T. chilonis* was multiplied on eggs of *C. cephalonica* cultured on broken jowar following the well laidout procedure. *M.maculipennis* adults emerged from field collected cocoons of parasitoid served as initial stock culture. Along with host leaves, 25 II instar larvae of *A. janata* were provided for parasitisation to 15 parasitoids in a glass lantern cage provided with 10 % honey. After four hours of exposure the larvae were taken out and reared in a plastic container till cocoon(pupa) formation stage of the parasitoid. Cocoons were then placed in lantern glass cage with 10 % honey for adult emergence.

Toxicity to parasitoids

Contact toxicity of botanicals (Table1) to newly emerged adults of *T. chilonis* and *M.maculipennis* was determined by dry film method. Fifty adults of *T. chilonis* and ten adults of *M. maculipennis* were used for each treatment with three replications. Mortality counts were taken at 12 and 24 h after exposure. One, 3 and 7 day old *C. cephalonica* eggs parasitised by *T. chilonis*, 5 day old cocoons of *M. maculipennis* were used to study the effect of botanicals on developmental stages of parasitoids. Fifty eggs parasitized by *T. chilonis* and 20 cocoons of *M. maculipennis* were sprayed with one ml of extract under Potters Tower sprayer with three replications. Similarly one gm of *C. inerme* dust of different strength was applied uniformly using muslin cloth. Survival of parasitoids was recorded based on emergence of adult parasitoid.

Field experiments were conducted at MRS, UAS ,Dharwad on castor variety RC-8 raised at 60 x 45 cm spacing over 3.6 x 3.6 m size treatment plots following all recommended package of practices except plant protection. Experiments were conducted in RBD with three replications. The test botanicals were evaluated for their safety/toxicity to egg and larval parasitoids by collecting parasitised *A.janata* eggs (50) and *M. maculipennis* cocoons (20) from each treatment and thus adult emergence(%) was recorded. Data were analysed after arc sine transformation and subjected to Duncan's Multiple Range Test(DMRT).

Results and discussion

Toxicity to egg parasitoid, *Trichogramma chilonis*: All the botanicals were safe and they were at par in causing mortality (5.3 to 23.3%). However, cartap hydrochloride inflicted significantly highest mortality (70%). Cold alcohol extracts from *C. inerme* caused numerically higher mortality (16.7 to 23.3%) than dust and neem based botanicals. With increase in exposure period from 12 to 24h, the mortality level increased to touch 38.7 and 40.0 % in cold alcohol extracts of *B. glabra*(30%) and *C. inerme* (10%),respectively whereas neem leaf extract and *C. inerme* (5%) dust and untreated check were on par with each other with 8 % mortality. In contrast, cartap hydrochloide knocked down all the adults. Further, the effect of these botanicals on different developmental stages of *T. chilonis* indicated that as the developmental period extended from day old to 7 day old, the per cent emergence also increased gradually (Table 1). Among the test products, *B. glabra* (30%) cold alcohol extract and cartap hydrochloride reduced the emergence to less than 70 % even at 7 day old, as compared to 98 % emergence in control. The emergence(%) in the other treatments ranged from 80.7 to 98.0% in 7 day old parasitised eggs.

The emergence of adult parasitoids from parasitised eggs treated with different treatments in field varied from 47.7 to 98.7 %, being least in cartap hydrochloride (47.7%) and highest in *C. inerme* (5%) dust and untreated check(98.7 %). The safety of botanicals to the developing parasitoid in the field parasitised eggs was similar to that in contemporary laboratory study confirming the safeness of *C inerme* dust over aqueous extracts and neem leaf extract.

Larval Parasitoid *M. maculipennis* : The toxicity to adult parasitoids at 12h exposure due to cartap hydrochloride was high with 76.7 % mortality . Next to fallow was *C. inerme* cold alcohol extract (10%) and neemguard with 23.3 % and *B. glabra* cold alcohol extract (30%) with 20.0 % adult mortality. At 24h after exposure the above trend continued with increase in mortality. Cartap hydrochloride killed all the parasitoids at 24h. Emergence of adult parasitoids, *M. maculipennis* from treated cocoons both in laboratory and field (Table 2) indicated that there was more than 75 % emergence. All the botanicals at different strength and formulations were absolutely safe to the parasitoid whereas cartap hydrochloride caused drastic reduction in adult emergence from the laboratory reared cocoons(18.3%) than in field cocoons (66.7%) of mixed ages. Because of relatively weak contact effect in insects and the unique mode of action, botanicals have not been found to be detrimental to important natural enemies of pests while cartap hydrochloride, caused cent per cent mortality of adults of both species at 24h after exposure. While information from Singh and Jalali (1994) agreed with the present findings in the case of *T.chilonis* in respect of botanicals, no comparison could be made for other parasitoid in the absence of published findings. Generally synthetic insecticides are detrimental to egg parasitoids than plant products and bio pesticides (Jhansi Lakshmi *et al.*,1997).

Table 1 Toxicity of botanicals to egg parasitoid, *Trichogramma chilonis* under laboratory and field conditions

Treatment	Laboratory					Field
	Toxicity to adults (% mortality)		adult emergence from parasitised eggs (%)			adult emergence from parasitised eggs (%)
	12 h	24 h	1 day old	3 day old	7 day old	
Clerodendrum inerme 100% dust	13.3 b	29.3 c	90.0 c	92.0 cd	94.0 bc	94.7 b
C. inerme 50% dust	15.3 b	18.7 e	90.7 c	90.0 d	96.7 ab	96.7 ab
C. inerme 10% dust	11.3 b	14.7 f	94.7 b	95.3 abc	97.3 ab	97.3 ab
C. inerme 5% dust	6.7 b	8.7 h	96.7 a	97.3 a	98.0 a	98.7 a
C. inerme 10% cold alcohol extract	18.7 b	40.0 b	59.3 h	64.0 f	83.3 d	67.3 d
C. inerme 5% cold alcohol extract	23.3 b	31.3 c	70.7 f	67.3 f	80.7 d	73.3 d
C. inerme 3% cold alcohol extract	16.7 b	23.3 d	77.3 e	66.7 f	94.0 bc	86.7 c
Neem guard 0.3%	18.7 b	30.0 c	59.3 h	66.0 f	84.7 d	64.7 d
Neem Seed Kernel Extract (NSKE) 5%	12.0 b	12.7 g	85.3 d	80.7 e	93.3 bc	88.0 c
Neem leaf extract 5%	5.3 b	8.0 h	92.0 c	94.0 bcd	95.3 abc	96.0 ab
Margocide CK 0.1%	8.0 b	21.3 d	51.3 l	62.0 g	81.3 d	75.3 d
Achook 0.3%	10.0 b	24.0 d	66.0 g	63.3 f	88.7 cd	80.0 c
Jawan 0.15%	14.0 b	22.7 d	54.0 l	57.3 f	84.0 d	59.3 d
B. glabra 30% cold alcohol extract	18.7 b	38.7 b	38.0 j	40.7 g	58.7 e	55.3 d
Cartap hydrochlorid 0.05%	70.0 a	100.0 a	38.0 j	44.7 g	68.0 e	47.7 e
Untreated check	6.7 b	8.0 h	96.7 a	96.0 a	98.0 a	98.7 a

Table 2 Toxicity of botanicals to larval parasitoid, *Microplitis moculipermis* under laboratory and field conditions

Treatment	Laboratory			Field
	Toxicity to adults (% mortality)		Adult emergence from treated cocoons (%)	Adult emergence from treated cocoons (%)
	12 h	24 h		
Clerodendrum inerme 100% dust	13.3 bc	33.3 cd	86.7 def	88.3 b
C. inerme 50% dust	6.7 cde	16.7 def	98.7 ab	98.3 a
C. inerme 10% dust	0.0 e	6.7 fg	99.3 ab	99.0 a
C. inerme 5% dust	0.0 e	3.3 gh	100.0 a	98.3 a
C. inerme 10% cold alcohol extract	23.3 b	43.3 bc	85.0 def	90.0 b
C. inerme 5% cold alcohol extract	3.3 de	23.3 de	95.0 bc	93.3 b
C. inerme 3% cold alcohol extract	3.3 de	16.7 def	98.3 ab	98.3 a
Neem guard 0.3%	10.0 bcd	23.3 de	88.3 def	91.7 b
Neem Seed Kernel Extract (NSKE) 5%	6.7 cde	16.7 def	90.0 de	93.3 b
Neem leaf extract 5%	0.0 e	6.7 fg	93.3 cd	98.3 a
Margocide CK 0.1%	3.3 de	6.7 fg	90.0 cde	91.7 b
Achook 0.3%	6.7 cde	13.3 ef	88.3 def	98.3 a
Jawan 0.15%	3.3 de	16.7 def	88.3 ef	93.3 b
B. glabra 30% cold alcohol extract	20.0 b	53.3 b	78.3 f	86.7 b
Cartap hydrochlorid 0.05%	76.7 a	100.0 a	18.3 g	66.7 c
Untreated check	0.0 e	0.0 h	100.0 a	100.0 a

Data were analysed after arc sine transformation. **In columns** the means followed by same letter do not differ significantly by DMRT

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Biochemical attributes of *Brassica* and *Eruca* cultivars grown in Punjab

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Abstract

Different *Brassica* cultivars were analysed for biochemical parameters. *Brassica napus* cultivars had higher oil content followed by *Brassica campestris, Brassica juncea, Brassica carinata* and *Eruca sativa* whereas reverse trend was observed for protein content. *B. carinata* cv. PC 5 and *E. sativa* cv. TMLC 2 had low crude fibre content and higher content of glucosinolates, phenols and flavonoids. *B. napus* cv. GSL 2 had 21% erucic acid and more content of oleic and linoleic acids.

Key words: *Brassica*, biochemical constituents, fatty acid profile

Introduction

Rapeseed-mustard are the second most important edible oilseed crops of India, next to groundnut and account for more than 25% of the total oilseeds production in the country. The major acreage is covered by *Brassica juncea* which is grown widely throughout India, followed by *Brassica napus* and *Brassica campestris*. Several workers have reported variation in biochemical constituents in rapeseed-mustard but scanty information is available on these aspects with respect to Punjab approved rapeseed-mustard cultivars approved for Punjab (Chauhan and Bhargava, 1984; Ahuja *et al.*, 1989; 1990; Davis *et al.*, 1991). The present study was therefore, undertaken to investigate the biochemical attributes of the *Brassica* cultivars grown in Punjab.

Materials and methods

Four varieties of *Brassica juncea* (*Raya*), three of *Brassica napus* (*Gobhi sarson*), two of *Brassica campestris (Toria)*, one each of *Brassica carinata* (*Ethiopian mustard*) and *Eruca sativa* (*Taramira*) were sown in the experimental area of Department of Plant Breeding, Punjab Agricultural University, Ludhiana in a randomized block design, with three replications during 1999. The crops were raised with full package of practices. Five plants from each plot were selected randomly for studying different biochemical parameters (Table 1 and 2). For biochemical analysis samples were oven dried and analysed for protein (AOAC, 1980), crude fibre (Ahuja and Bajaj, 1999), fatty acids (Ahuja *et al.*, 1998), total phenols (Swain and Hills, 1959), flavonoids (Balbana *et al.*, 1974), total sugars (Clegg, 1956) and glucosinolates (Brezenzinski and Mendelwski, 1984). Oil content was determined by wide line NMR (Newport Analyser Model MK III A).

Results and discussion

B. napus cultivars had 43.5% oil content followed by *B. campestris* and *B. juncea* varieties (Table 1). *B. campestris* varieties having oil content of 42.5% fall in the medium category. *B. carinata* cv. PC 5 and *E. sativa* cv. TMLC 2 had oil content of 37.3 and 32.6% respectively. Amount of protein content indicated that *B. juncea*, *B. carinata* and *E. sativa* had its higher content in the range of 26.8 to 27.2% whereas *B. campestris* and *B. napus* had protein content of 25.9% and 25.1% respectively. This showed that oil and protein contents might be negatively correlated. Similar pattern had been observed by Gupta *et al.* (1982). Total soluble sugar content in different varieties ranged from 11.6 to 14.7%. *B. juncea, B. campestris* and *B. napus* had relatively low sugars as compared to *B. carinata* cv. PC 5 and *E. sativa* cv. TMLC 2.Crude fibre content in *B. carinata* cv. PC 5 and *E. sativa* cv. TMLC 2 was low whereas a higher value was observed in *B. juncea* cultivars.

B. campestris and *B. napus* cultivars had 7.8 and 8.3% crude fibre, respectively. Total glucosinolates and phenols, the antinutritional factors, were found to be maximum in *B. carinata*. *B. juncea* cultivars however PBR 91 and RL 1359 (*B. juncea*) had almost similar content of glucosinolates. In general, *B. campestris* cultivars had lowest content of glucosinolates. Phenols and flavonoids content in *B. juncea* and *B. napus* cultivars were almost similar while in *B. campestris* it was the lowest. It is well known that higher content of glucosinolates, phenols and flavonoids impart resistance against diseases and pests (Brahmachari and Kolte, 1993). *B. carinata* and *E. sativa* cultivars having high content of these constituents can be utilized for developing pest resistant cultivars.

Major fatty acids of rapeseed-mustard were oleic, linoleic, linolenic, eicosenoic and erucic acids. Oleic acid is related to the stability of oil whereas linoleic acid, an essential fatty acid is nutritionally desirable. Erucic acid on the other

hand is undesirable since it leads to cardiac disorders and is associated with pathological lesions. *B. juncea, B. campestris* and *E. sativa* cultivars had very high content of erucic acid ranging from 46.8 to 51.2% (Table 2). Varieties of *B. napus* and *B. carinata* had 32.4 and 35.8% erucic acid, respectively. GSL 2 had the minimum content of erucic acid (21.8%). Oleic acid content in various cultivars varied from 9.6 to 23.7%. *B. napus* cultivars had higher content of oleic acid ranging from 17.4 to 32.7%. Hence, oil of *B. napus* cultivars had more stability as compared to other cultivars of *Brassica* species and are most suitable for cooking purposes. Range of linoleic acid was from 10.7 to 20.1% in all the *Brassica* cultivars. Oil of PC 5 having higher content of linoleic acid is better from nutritional point of view. Linolenic acid, another essential fatty acid varied from 10.4 to 12.6%. Varieties of *B. napus* and *B. campestris* were at par for this fatty acid content. Another higher chain fatty acid i.e., eicosenoic acid ranged from 7.5 to 14.5%. It was further noticed that varieties having higher content of erucic acid had lower content of eicosenoic acid. Based on fatty acid profile, *B. napus* cv. GSL 2 had better quality oil since it had higher content of oleic, linoleic and lower content of erucic acid. Since, oil is mostly used for cooking purposes, thus the oil of *B. napus* cv. GSL 2 is better than that of other *Brassica* cultivars as it provided stability and long shelf life. The results showed that none of the varieties of rapeseed-mustard except GSL 2 grown in Punjab can be considered as low erucic acid variety. The *Brassica* cultivars are poor in nutritional and meal quality in contrast to varieties raised in Europe and Canada. Substantial progress has been made in this direction and recently trials of double zero genotypes have been conducted. There is a possibility of replacing present high erucic acid and high glucosinolate cultivars with those having double zero character in the near future.

Table 1 Biochemical constituents of *Brassica* cultivars

Variety	Oil content (%)	Protein content (%)	Total soluble sugar (%)	Crude fibre (%)	Glucosinolates (μ mol/g seed)	Phenols (mg/g)	Flavonoids (μg/g)
B. juncea							
PBR 91	37.6	27.7	13.1	9.0	106	6.2	0.83
PBR 97	39.8	27.4	12.3	9.6	103	6.5	0.85
RLM 619	42.0	27.3	11.5	8.7	90	6.8	0.84
RL 1359	42.0	26.2	11.9	11.2	107	6.7	1.16
Mean	40.4	27.2	12.2	9.6	102	6.6	0.92
B. napus							
GSL 1	43.5	24.6	11.3	8.1	86	7.2	0.92
GSL 2	43.3	25.1	11.6	8.4	90	6.5	0.84
PGSH 51	43.5	25.7	12.0	8.3	96	6.7	0.95
Mean	43.5	25.1	11.6	8.3	91	6.8	0.90
B. campestris							
TL 15	42.3	26.2	12.9	7.9	72	5.1	0.83
PBT 37	42.7	25.2	12.7	7.7	74	5.3	0.87
Mean	42.5	25.9	12.8	7.8	73	5.2	0.85
B. carinata							
PC 5	37.3	26.7	13.4	7.0	124	5.0	1.23
E. sativa							
TMLC 2	32.6	26.8	14.7	7.3	98	3.0	1.95

Table 2 Biochemical constituents of Brassica cultivars

Variety	Fatty acids (%)						
	Palmitic (16:0)	Stearic (18:0)	Oleic (18:1)	Linoleic (18:2)	Linolenic (18:3)	Eicosenoic (20:1)	Erucic (22:1)
B. juncea							
PBR 91	3.1	0.8	10.7	15.4	12.9	7.6	49.5
PBR 97	3.4	0.9	9.4	14.0	13.1	7.9	51.3
RLM 619	3.2	0.9	9.1	16.4	11.2	8.1	51.2
RL 1359	3.6	0.8	9.3	15.0	12.3	6.4	52.6
Mean	3.3	0.9	9.6	15.2	12.4	7.5	51.2
B. napus							
GSL 1	3.8	0.9	17.4	13.0	9.5	12.1	43.3
GSL 2	3.6	0.9	32.7	16.5	9.3	15.2	21.8
PGSH 51	3.2	0.8	21.0	14.4	12.3	16.2	32.1
Mean	3.5	0.9	23.7	14.6	10.4	14.5	32.4
B. campestris							
TL 15	3.2	0.7	11.8	14.4	10.8	9.1	50.0
PBT 37	3.1	0.6	13.2	14.9	9.4	8.5	49.3
Mean	3.2	0.7	12.5	14.7	10.1	8.8	49.7
B. carinata							
PC 5	3.5	0.7	15.0	20.1	12.6	12.3	35.8
E. sativa							
TMLC 2	3.3	0.8	14.1	10.7	12.4	12.0	46.8

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A comparative analysis of dormancy pattern in the varietal forms of groundnut

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Abstract

A comparative analysis was made using 17 erect, 8 semi-spreading and 5 spreading varieties of groundnut to study their dormancy behaviour (both intensity and duration) in three growing seasons. The varieties showed wide range of variation for both the dormancy parameters. Most erect varieties showed short to medium dormancy period and weak to moderate intensity and most semi-spreading and spreading varieties possessed long dormancy period coupled with strong intensity of dormancy. Seeds of *kharif* showed the highest degree of dormancy, followed by *rabi* and summer.

Key words: Groundnut, seed dormancy, varietal forms

Introduction

The cultivated groundnut (*Arachis hypogaea* L.) shows great morphological diversity. The species have been classified into two subspecies and four varieties, *viz.*, ssp. *hypogaea* var. *hypogaea* (Virginia bunch and runner), var. *hirsuta* (Peruvian runner, not found in India), ssp. *fastigiata* var. *fastigiata* (Valencia bunch) and var. *vulgaris* (Spanish bunch). These botanical groups are broadly classified into three habit groups, *viz.*, erect/bunch (Spanish and Valencia), semi-spreading (Virginia bunch) and spreading (Virginia runner). The differences among these groups have botanical as well as agricultural significance because certain desirable traits occur in an associated manner in each form. Seed dormancy is considered a desirable trait in groundnut because it prevents pre-harvest sprouting of nuts. The present study was undertaken to analyse the dormancy behaviour of the seeds of the three habit groups under different seasons for effective manipulation of the trait in selecting and developing groundnut varieties possessing seed dormancy.

Material and methods

Thirty selected groundnut varieties from the three habit groups were grown in RBD with three replications at the Central Research Station, OUA&T, Bhubaneshwar during summer, 1995, *kharif*, 1996 and *rabi*, 1996. Each variety was shown in a plot of 5 rows of 3 m. Standard agronomic practices were followed. Each variety was harvested at maturity and the pods were shade dried to about 8% moisture content and stored in gunny bags under ambient conditions for dormancy test.

Seed dormancy in different varieties was detected by germination test (ISTA, 1985) and confirmed by Tetrazolium test of viability (Agrawal and Dadlani, 1992). These tests were conducted immediately after harvest and subsequently at weekly intervals till the tests gave cent per cent germination or indicated a decline in germinability.

Two parameters of dormancy, *viz.*, intensity and duration (period) were estimated for each variety. The duration of dormancy was measured as the number of days taken from the day of harvest to achieve full germinability (DG_{100}). This was estimated by probit analysis (Wardlaw, 1985) of the data from the germination test at weekly intervals. Besides DG_{100}, two other intermediate durations *viz.*, number of days taken for 70% (DG_{70}) and 50% (DG_{50}) germination were also estimated.

The intensity of dormancy was measured as percentage of non-germinated seeds in the test at harvest (NGH_0) and 7 days after harvest (NGH_7). Besides these, another parameter called dormancy index (DI) which takes into account the speed of release of dormancy was estimated by the following formula (Swain *et al.*, 2001):

$$DI = \sum \frac{ni}{di}$$

Where, ni = number of seeds showing dormancy release on the i^{th} day and di = days after harvest.

Results and discussion

ANOVA of data of individual seasons and pooled ANOVA indicated significant differences among varieties and among seasons for all the parameters of dormancy. The pattern of variation in duration of seed dormancy in the three varietal forms of groundnut (Table 1) showed that on an average, the spreading varieties had longer dormancy period than the semi-spreading varieties, though the difference was small. The erect varieties on the other

hand, had much shorter dormancy period than the other two groups. But, genotypic variation for dormancy period was more in erect type, less in semi-spreading and least in spreading group as indicated by range of variation among varieties within groups.

Based upon DG_{100}, which is the dormancy period by the most general definition, the varieties were classified into short (<45), medium (46-88) and long (>88) days dormancy period classes (Table 2). Most of the erect varieties had short to medium dormancy period, whereas, most semi-spreading and spreading varieties had medium to long dormancy period.

Table 2 **Frequency distribution of dormancy period (DG_{100}) categories in the three varietal forms of groundnut**

Varietal form	No. of entries	Dormancy period category		
		Short (<45 days)	Medium (45-88 days)	Long (>88 days)
Erect	17	5 (29.4%)	11 (64.7%)	1 (5.9%)
Semi-spreading	8	1 (12.5%)	4 (50.0%)	3 (37.5%)
Spreading	5	0	2 (40.0%)	3 (60.0%)

DG_{100} : Days from harvest to achieve 100% germination

Table 3 **Frequency distribution of dormancy intensity (DI) categories in the three varietal form of groundnut**

Varietal form	No. of entries	Dormancy intensity category		
		Weak (>9)	Moderate (3-9)	Strong (<3)
Erect	17	11 (64.7%)	4 (23.5%)	2 (11.8%)
Semi-spreading	8	1 (12.5%)	0	7 (87.5%)
Spreading	5	0	0	5 (100%)

DT : Dormancy index

The pattern of variation in intensity of seed dormancy in the three varietal forms of groundnut (Table 1) showed that intensity of dormancy was highest in spreading type, less in semi-spreading and least in the erect type. But, as indicated by the range of variation, genotypic variation for dormancy intensity was more in erect type, less in semi-spreading and least in the spreading type.

Based upon the DI, which showed maximum diversity among the intensity parameters, the varieties were classified into weak (DI>9), moderate (DI=3-9) and strong (DI<3) dormancy intensity classes (Table 3). It showed that most of the erect varieties were either non-dormant or weakly dormant, whereas, almost all semi-spreading and spreading varieties had strong dormancy intensity.

Based on a joint consideration of intensity (DI) and duration (DG_{100}), the varieties fell into five dormancy classes (Table 4). Generally, most of the erect/bunch types showed short to medium dormancy period and weak to moderate intensity, whereas most semi-spreading and spreading varieties possessed long dormancy period coupled with strong intensity of dormancy. It is encouraging that several of the erect varieties possessed varying degrees of dormancy. The presence of a range of dormancy characteristics provided scope for selection of varieties that can be used as such to prevent losses from viviparous germination or as donor parents for transfer of the character to other non-dormant cultivars. Dormancy period up to 40 days in erect/bunch varieties have been reported by Abrar and Jadhav (1991) and upto 60 days and more in semi-spreading and spreading varieties has been reported by Kapur *et al.* (1990) and Keneni *et al.* (1993).

Table 1 Pattern of variation in duration and intensity of dormancy in the three varietal forms of groundnut (mean values)

Varietal form		Dormancy duration (days)			Dormancy intensity		
		DG_{50}	DG_{70}	DG_{100}	NGH_0 (%)	NGH_7 (%)	DI
Erect	R	5-54	5-59	33-107	54-100	30-100	1.83-11.45
	GM	17.4	22.6	54.4	83.6	57.7	8.16
Semi-spreading	R	7-59	11-63	37-96	82-100	37-100	1.63-10.78
	GM	41.8	47.2	80.1	97.7	92.1	3.29
Spreading	R	43-56	48-62	79-93	-	-	1.75-2.33
	GM	48.6	54.0	86.4	100.0	100.0	2.05

R : Range of variation; GM : General mean

Table 4 Classification of groundnut varieties on the basis of intensity and duration of seed dormancy

Dormancy category	Varietal form	Names of varieties
Weak & Short	Erect	AK 12-24, Co.1, OG 52-1, POL-1 and Gangapuri
	Semi-spreading	TG 3
Weak & Medium	Erect	Girnar 1, ICGV 86094, JL 24, Jyoti, K 150 and TMV 2
Moderate & Medium	Erect	ICGS 11, ICGS 44, Kissan and NRGS (FDRS)-3
Strong & Medium	Erect	TG 22
	Semi-spreading	Kadiri-3, Kaushal, TKG 19A and TMV 10
	Spreading	K 4-11 and M 145
Strong & Long	Erect	TG 26
	Semi-spreading	ALR1, BG 3 and UF 70-103
	Spreading	M 13, M 37 and PG No.1

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Effect of levels of nitrogen and phosphorus on the performance of sunflower (*Helianthus annuus* L.) in rice fallow vertisols

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Abstract

Field Experiments were conducted during summer season of 1997 and 1998 on clay loam vertisol at Agricultural Research Station, Gangavathi, Karnataka to study the effect of nitrogen and phosphorus on the productivity of sunflower in rice fallow situation. Seed yield of sunflower increased with successive dose of nitrogen and highest yield was obtained with 100 kg N/ha (874 kg/ha in 1997 and 707 kg/ha in 1998) which was significantly superior to 50 kg N/ha and control. The oil yield showed similar trend. In both the years of study, phosphorus application at 60 kgP_2O_5/ha gave comparable yields with 90 kg P_2O_5/ha and was significantly higher over 30 kg/ha and control. The mean oil yield was similar at 60 and 90 kg P_2O_5/ha. The combined application of 100 kg N + 60 kg P_2O_5/ha was beneficial in realizing higher productivity of sunflower. The response to nitrogen was linear while it was quadratic for the phosphorus.

Key words: Sunflower, nitrogen, phosphorus, vertisols

Introduction

Sunflower by virtue of its short duration, low photo and thermosensitivity and wider adaptability to different soil types fits well into various multiple cropping systems. The crop has great potential in rice fallow situations in the tail end areas of irrigation commands where there is restriction for second crop of rice due to limitation of irrigation water.

Higher production efficiency and economic returns from rice-sunflower cropping system were reported in Orissa (Shah *et al.*, 1988), West Bengal (Sarkar *et al.*, 1995), Andhra Pradesh (Krishna and Ananda Reddy, 1997) and Madhya Pradesh (Srivastava *et al.*, 1998). The nutrient requirement of sunflower under normal soil conditions is well understood. However, the information on the nutrient needs of sunflower under altered soil conditions succeeding puddled paddy is meagre. Sunflower is grown in substantial area under rice fallow vertisols under Tungabhadra irrigation command where yields are low and there is need to work out the nutrient requirement of the crop to attain higher productivity. Hence field experiments were conducted to assess the nutrient response and requirement of sunflower under puddled grown rice system.

Materials and Methods

The field experiment was carried out during summer season of 1997 and 1998 at Agricultural Research Station, Gangavathi located in Northern dry agro-climatic zone of Karnataka on rice fallow black soil (Vertisol). The soil of the experimental site was medium deep, clayey (clay content >40%) low in available nitrogen, (Organic Carbon, 0.504%) low in available phosphorus (13.6 kg P_2O_5/ ha) and high in available potassium (291 kg K_2O/ ha) having soil pH 7.6. The treatments comprised of three levels of nitrogen (0, 50 and 100 kg N/ha) and four levels of phosphorus (0, 30, 60 and 90 kg P_2O_5 kg / ha) replicated thrice in randomized block design with factorial concept. The nitrogen and phosphorus were applied as per treatment through urea and diammonium phosphate, respectively. A uniform dose of 60 kg K_2O /ha was applied in the form of muriate of potash. Entire dose of phosphorus, potassium and half the dose of nitrogen were applied as basal and remaining half of nitrogen was applied in equal splits at 30 days after sowing and at 50% flowering. The test cultivar of sunflower was hybrid KBSH-1 which was sown on 1st week of January and after harvest of rainy season rice. The spacing adopted was 60x30 cm. The gross and net plot sizes were 5.4m x 4.8m and 4.2 m x 4.2 m respectively. The crop received seven irrigations (including one pre-sowing irrigation). Oil content in seeds was analyzed through Nuclear Magnetic Resonance. Response curves were fitted for levels of nitrogen and phosphorus in respect of seed yields.

Results and Discussion

Effect of Nitrogen: The Nitrogen levels had significant influence on the growth and yield of sunflower in rice fallow (Table 1). Seed yield increased significantly with increase in successive dose of nitrogen during 1997. The highest yield was obtained at 100 kg N / ha (874 kg/ha) which registered about 15 and 25% increase over 50 kg N/ha and no nitrogen, respectively. There was no perceptible increase in growth and yield attributes although parameters showed trend at higher levels of nitrogen. The oil content was not influenced by nitrogen application,

while oil yield increased with graded levels of nitrogen. During 1998, N levels had significant influence on plant height, stem girth, seed yield, stalk yield and oil yield. All these parameters were higher at increased levels of nitrogen. Seed yield, stalk yield and oil yields with 50 kg N/ ha and no nitrogen were similar. The percent increase in seed yield with 100 kg N / ha over 50 kg N/ ha was 32%and it was 48.5% over control. The pooled analysis of two years data also showed similar trend as seed yield increased with each increment in the levels of nitrogen (Table 2). On an average, the increase in seed yield with 100 kg N/ ha was 215% over 50 kg N / ha and 35% over 0 kg N /ha respectively. The higher seed yield with 100 kg N / ha was due to better growth of the crop as reflected in increased plant height, stem girth and head diameter. Mean oil yield was significantly higher with 100 kg N / ha mainly because of higher seed yield and oil content at this level. The response equation was worked out based on pooled yield data. Response was found to be linear ($Y = 2.09x + 571.5$; $R^2 = 0.97$).

Table 1 Effect of nitrogen and phosphorus on growth and yield attributes of sunflower in rice fallow vertisols

Treatment	Plant height (cm)			Stem girth (cm)			Head diameter (cm)			1000 seed weight (g)		
	1996-97	1997-98	Pooled	1996-97	1997-98	Pooled	1996-97	1997-98	Pooled	1996-97	1997-98	Pooled
N levels (kg/ha)												
N_1 : 0	111	124	118	3.9	4.7	4.3	8.4	8.2	8.3	30.4	31	30.7
N_2 : 50	109	128	119	3.8	4.8	4.3	8.1	8.2	8.1	32.6	29.6	31.1
N_3 : 100	111	143	127	3.9	5.5	4.7	8.4	9.1	8.8	30.9	32	31.5
SEm±	4.1	3.08	2.57	0.14	0.14	0.1	0.22	0.34	0.23	1.5	1.1	0.97
CD (P=0.05)	NS	9.05	7.3	NS	0.4	NS	NS	NS	NS	NS	NS	NS
P levels (kg/ha)												
P_1 : 0	109	124	117	3.9	3.6	3.8	6.8	8.5	7.7	30.7	29.8	30.2
P_2 : 30	109	131	120	3.8	3.6	3.7	8.2	8.1	8.2	29.8	31.0	30.4
P_3 : 60	111	135	123	3.8	3.9	3.8	8.5	8.4	8.5	33.9	30.7	32.3
P_4 : 90	113	136	125	4.0	3.9	3.9	9.5	8.9	9.2	30.9	32.0	31.4
SEm±	4.73	3.56	2.97	0.2	0.16	0.12	0.25	0.39	0.27	1.8	1.3	1.1
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	0.81	NS	NS	NS
Interaction												
SEm±	8.13	6.17	5.15	0.28	0.27	0.2	0.43	0.68	0.47	3.1	2.2	1.9
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CD (%)	12.8	8.1	10.41	12.8	11.4	12.28	9.1	13.92	13.69	17.1	12.3	15.2

Table 2 Effect of nitrogen and phosphorus on yield and oil content of sunflower in rice fallow vertisols

Treatment	Seed yield (kg/ha)			Stalk yield (kg/ha)			Oil content (%)			Oil yield (kg/ha)		
	1996-97	1997-98	Pooled	1996-97	1997-98	Pooled	1996-97	1997-98	Pooled	1996-97	1997-98	Pooled
N levels (kg/ha)												
N_1 : 0	693	476	585	1605	2081	1843	40.7	37.9	39.3	282	180	231
N_2 : 50	776	534	655	1654	2013	1834	40.2	37.6	38.9	313	200	256.5
N_3 : 100	874	707	791	1902	3269	2586	41.1	38.1	39.6	360	269	314.5
SEm±	31.34	47.3	40.93	117	340	174.3	0.96	0.48	0.54	13.76	18.55	
CD (P=0.05)	91.83	138.7	124	NS	998	494	NS	NS	NS	40.32	54.42	
P levels (kg/ha)												
P_1 : 0	649	459	554	1666	1907	1786	40.5	37.8	39.1	259	174	216.5
P_2 : 30	663	500	582	1502	2280	1891	40.9	37.9	39.4	273	190	231.5
P_3 : 60	882	676	779	1726	2704	2233	41.0	38.5	39.8	362	259	310.5
P_4 : 90	930	653	792	1951	2926	2439	40.6	37.16	38.9	379	244	311.5
SEm±	36.19	54.62	47.26	135.1	393	249	1.11	0.56	0.62	15.89	21.42	
CD (P=0.05)	106.04	160.2	119	NS	NS	NS	NS	NS	NS	46.56	62.83	
Interaction												
SEm±	62.68	94.6	81.85	234.02	681	432	1.92	0.96	1.08	27.52	37.1	
CD (P=0.05)	183.65	277.5	NS	NS	NS	NS	NS	NS	NS	80.63	NS	
CD (%)	13.9	28.64	44.14	23.56	48	30.1	8.19	4.41	6.76	14.98	29.67	

Effect of Phosphorus: During 1997, phosphorus application increased the seed yield linearly. The highest yield (930 kg/ha) was recorded at 90 kg P_2O_5/ ha which was significantly superior to 30 kg P_2O_5/ha and control. The differences between seed yield at 90 kg P_2O_5/ha and 60 kg P_2O_5/ha were not significant. Plant height and stem girth was not affected by levels of P whereas application of 90 kg P_2O_5/ha resulted in significantly larger sized heads over other levels of phosphorus. Phosphorus application did not influence the oil content. The oil yield increased with increase in levels of phosphorus and recorded maximum at 90 kg P_2O_5/ha. During 1998, seed yield differed significantly by P levels. The highest yield was recorded at 60 kg P_2O_5/ ha followed by 90 kg P_2O_5/ha which were similar but significantly superior to 0 and 30 kg P_2O_5/ ha. The percent increase in yield with 60 kg P_2O_5 /ha over 30 kg P_2O_5/ha and control was to the extent of 34.9 and 47.3% respectively. The effect of levels of P on oil yield was similar to that of seed yield. On an average, application of 60 kg P_2O_5/ ha registered an increase in yield to the magnitude of 41% and 34% over 0 and 30 kg P_2O_5/ha respectively.

The higher seed yield at increased levels of P can be attributed to the increased plant height, stem girth and head diameter. The higher seed yield and oil content was responsible for higher oil yield at 60 and 90 kg P_2O_5/ha. Virupakshappa and Somasekhara (1997) reported the response of sunflower to P levels up to 90 kg P_2O_5/ha with increase in yield ranging from 4.1-10.1 kg of phosphorus. Response equation computed for phosphorus based on pooled data was quadratic ($Y = -0.0042x^2 + 3.4117x + 536.35$; $R^2 = 0.87$).

Interaction of N and P: The interaction effect was significant in respect of seed yield of sunflower during both the years. At 0 level of phosphorus, sunflower yield increased significantly with each successive increment in the levels of nitrogen. Similar trend was observed at 60 kg P_2O_5/ha.

During 1997, the results revealed that the application of 100 kg N+60 kg P_2O_5/ha recorded the highest seed yield (1288 kg /ha), which was significantly superior to all other treatments (Table 3). During 1998, the interaction effect was significant for seed yield and the highest yield (882 kg/ha) was registered with the combination of 100 kg N and 60 kg P_2O_5/ha. However, it was similar to the seed yields obtained at 50 kg N+60 kg P_2O_5/ha. Increase in yield of sunflower hybrid with fertilizer application up to the level of 120 kg N /ha+60 kg P_2O_5/ ha was reported by Devidayal and Agarwal (1998) under Haryana conditions. The results clearly indicated the need for application of both N and P nutrients in adequate quantity to realize the higher yields. Application of 100 kg N and 60 kg P_2O_5 /ha can be recommended to achieve higher seed and oil yields of sunflower in rice fallow vertisols.

Table 3 Interaction effect of N and P on seed yield (kg/ha) of sunflower in rice fallow vertisols during 1996-97 and 1997-98

N/P (kg/ha)	1996-97					1997-98				
	P_0	P_{30}	P_{60}	P_{90}	Mean	P_0	P_{30}	P_{60}	P_{90}	Mean
N_0	774	671	480	887	693	347	511	527	521	476
N_{60}	679	668	877	881	776	493	452	635	554	534
N_{100}	534	650	1288	1025	874	538	540	868	882	707
Mean	649	663	882	930	781	459	501	676	652	
SEm±			62.68					94.61		
CD (P=0.05)			183.65					277.5		

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Short communication

Combining ability studies in castor (*Ricinus communis* L.)

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India is the first country in the world to exploit hybrid vigour in castor crop commercially. As a prelude for the commercial exploitation of hybrid vigour, combining ability analysis is employed to identify the desirable parents and to study the nature of gene action. Among several methods, line x tester analysis helps in testing large number of entries besides being comprehensive for understanding the genetical basis at population level. The present study, therefore aims to analyse the combining ability through line x tester analysis involving three lines and five testers of castor.

The experimental material comprised of 15 hybrids derived by crossing three lines and five testers in a line x tester mating design. The 15 hybrids and their parents were grown in a randomised complete block design with three replications during *Kharif,* 1999. Each entry was represented by two rows of 7.2 m length with a spacing of 90 x 45 cm. Data were recorded on five randomly selected plants in each replication for 10 characters (Table 1). The combining ability analysis was done as per Kempthorne (1957).

Analysis of variance revealed that parents exhibited significant differences for days to 50% flowering, capsules on main spike, 100 seed weight, seed yield and oil yield whereas lines and testers did not exhibit significant differences for all the characters studied except for oil content by lines. However, line x tester interaction was found to be significant for all the characters studied.

Analysis of variance components for combining ability revealed that *sca* variance was higher in magnitude over *gca* variance indicating preponderance of non-additive gene action for all the traits studied (Table 1). Similar results have been reported by Pathak *et al.* (1989) for all the characters studied except for total number of spikes/ plant. Fatteh *et al.* (1988) and Chakrabarthy (1997) for oil content and seed yield/plant.

The estimates of general combining ability (gca) effects are given in Table 2. Among lines, DPC-11 was a good general combiner for oil content, seed yield per plant and oil yield per plant while DPC-13 was better general combiner for dwarfness and total number of capsules on main spike. M-584 did not show any significant *gca* effect in the desired direction for any of the traits studied. Among testers, JI-225 was the best general combiner for dwarfness, earliness (number of nodes upto main spike), oil content, seed yield and oil yield per plant. Tester JI-240 was good general combiner for effective length of main spike, total number of spikes per plant, total number of capsules on main spike, 100 seed weight whereas, JI-260 was a good combiner for earliness(flowering), effective length of main spike and total number of capsules on main spike.

The cross DPC-11 x SKI-232 was good specific combiner for earliness, total number of capsules on main spike, seed yield and oil yield/plant. The crosses DPC-11 x JI-260, DPC-13 x JI-225, M-584 x JI-240 and M-584 x SKI-233 showed significant *sca* values for seed yield and oil yield/plant. None of the crosses showed significant *sca* values in the desired direction for total number of spikes/plant. The crosses DPC-13 x JI-260, M-584 x JI-240 and M-584xSKI- 233 were good specific combiners for total number of capsules on main spike whereas DPC-11 x JI-225, DPC-13 x SKI-232 and M-584 x SKI-233 were good specific combiners for 100 seed weight.

Among lines DPC-11 and DPC-13 were found to be good general combiners whereas among testers JI-225, JI-240 and JI-260 were good general combiners. Crosses DPC-1 x JI-260, DPC- 11 x SKI-232, DPC-13 x JI-225, M-584 x JI-240, M-584 x SKI-233 and DPC-3 x JI-260 exhibited desirable *sca* effects and can be exploited for developing superior hybrids in castor.

The study, in general, indicated the preponderance of nonadditive gene action for all the characters. Hence exploitation of hybrid vigour is the best method for improving all the characters studied including oil content and seed yield as pistillate lines are available in this crop.

Table 1 Estimates of general combining ability effects for lines and testers for 10 characters in castor

Parent	Days to 50% flowering	Plant height up to main spike (cm)	Number of nodes upto main spike	Effective length of main spike (cm)	Total number of spikes/ plant	Total number of capsules on main spike	100-seed weight (g)	Seed yield/ plant (g)	Oil content (%)	Oil yield/ plant (g)
Lines										
DPC-11	-0.11	1.64	-0.13	-1.90*	0.02	0.68	0.37	3.89**	1.00**	2.65**
DPC-13	0.29	-4.22*	0.43	0.88	-0.17	1.37*	-1.12	-3.13*	0.49	-0.94
M-584	-0.18	2.58	-0.3	1.02	0.15	-2.04**	0.75	-0.77	-1.50**	-1.71**
SEi	0.61	2	0.26	0.91	0.14	0.6	0.62	1.38	0.3	0.62
Testers										
JI-225	-0.91	-7.23**	-1.52**	-2.09	0.21	0.25	1.3	11.77**	0.90*	6.54**
JI-240	0.98	11.71**	0.06	3.59**	0.37*	1.65*	2.20**	1.04	-0.18	0.25
JI-260	-2.02**	-0.73	-0.18	2.55*	0.19	2.83**	-3.12**	3.04	-0.95*	0.73
SKI-232	-1.13	-0.36	1.19**	-1.91	-0.47	3.08**	1.94*	-10.90**	0.56	-4.61
SKI-233	3.09**	-3.39	0.45	-2.14	-0.3	-7.81**	-2.32**	-4.96**	-0.35	-2.91**
SEj	0.78	2.58	0.34	1.17	0.18	0.77	0.81	1.78	0.39	0.8
σ^2 *gca*	-0.08	1.04	0.01	0.3	-0.01	0.35	-0.4	-11.35	0.12	-2.38
σ^2 *sca*	8.33	80.44	0.87	9.78	0.26	36.54	21.24	407.59	0.97	95.93
σ^2 *gca*/σ^2 *sca*	-0.01	0.02	0.01	0.04	0	0.01	-0.02	-0.03	0.13	-0.02

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

Table 2 Estimates of specific combining ability effects of hybrids for 10 characters in castor

Parent	Days to 50 % flowering	Plant height up to main spike (cm)	Number of nodes upto main spike	Effective length of main spike (cm)	Total number of spikes/ plant	Total number of capsules on main spike	100-seed weight (g)	Seed yield/ plant (g)	Oil content (%)	Oil yield/ plant (g)
DPC-11xJI-225	3.78**	1.25	1.40*	1.65	-0.53	-1.74	4.06**	-11.06**	0.3	-5.15**
DPC-11xJI-240	1.22	-0.15	-0.45	-3.97	-0.55	-7.21**	2.7	-15.24**	-0.45	-7.52**
DPC-11xJI-260	0.22	-1.58	-0.34	1.34	0.29	-0.79	1.01	18.83**	0.04	8.77**
DPC-11xSKI-232	-4.67**	0.79	-0.71	2.8	0.48	8.82**	-4.35**	15.07**	0.29	7.41**
DPC-11xSKI-233	-0.56	-0.31	0.1	-1.83	0.31	0.91	-3.42*	-7.60*	-0.17	-3.51*
DPC-13xJI-225	-2.29	9.11*	1.37*	-2.19	0.26	1.16	-3.25*	26.33**	0.98	13.57**
DPC-13xJI-240	-3.18	3.38	-0.54	5.06*	-0.03	2.23	-3.45*	-0.62	-0.04	-0.36
DPC-13xJI-260	2.16	3.58	0.57	0.57	0.41	4.52**	-0.07	-1.08	-0.08	-0.79
DPC-13xSKI-232	2.93*	0.63	-0.89	-0.16	-0.03	-2.14	8.14**	-9.77**	-1.90**	-6.18**
DPC-13xSKI-233	0.38	-16.98**	-0.5	-3.28	-0.63*	-5.78**	-1.37	-14.85**	1.03	-6.23**
M-584-JI-225	-1.49	-10.36*	-2.76**	0.53	0.27	0.58	-0.82	-15.27**	-1.29	-8.42**
M-584xJI-240	1.95	-3.23	0.99	-1.09	0.58	4.98**	0.75	15.86**	0.5	7.88**
M-584xJI-260	-2.38	-1.99	-0.23	-1.91	-0.71*	-3.73**	-0.94	-17.74**	0.02	-7.98**
M-584xSKI-232	1.73	-1.42	1.60**	-2.65	-0.45	-6.69**	-3.79**	-5.3	1.63*	-1.24
M-584xSKI-233	0.18	17.01**	0.4	5.11**	0.31	4.87**	4.80**	22.46**	-0.87	9.75**
SEij	1.36	4.48	0.59	2.03	0.31	1.33	1.4	3.08	0.67	1.39

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

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J. Oilseeds Res., **19**(2): **231 (2002)**

Short communication

Variability, correlation and path analysis of seed yield in *Brassica carinata*

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The Ethiopian mustard (*Brassica carinata*) has an edge over the domesticated species especially under rainfed and natural pest infested conditions. Therefore, the evaluation of different genotypes of *B. carinata* was undertaken with a view to identify a high yielding variety for Jammu region of the state.

Studies were carried out during *rabi* 1995-96 to 1997-98 at SKUA&T, Dryland Research Station, Bari Brahmna, Jammu. Sixteen genotypes of *B. carinata* were evaluated in a complete randomized block design with three replications. The soil was sandy loam in texture and low in available N (205 kg/ha), P (120 kg/ha) and K (179 kg/ha) having pH of 7.4. Recommended dose of N and P, 60 and 30 kg/ha respectively was applied. Different observations were recorded on five randomly selected plants/genotype for seed yield and physico-morphological traits. The data was subjected to analysis of genotypic correlation (Dewey and Lu, 1959).

The genotypes *viz.*, PC-5, PCC-5, NPC-2 and HC-9001 recorded highest seed yield of 1482, 1379, 1365 and 1349 kg/ha, respectively. The analysis of variance indicated significant difference among genotypes for all the traits. The pooled analysis of the data showed that varieties did not differ significantly for all the characters except secondary branches and main shoot length because of high variety x environment interaction (Table 1).

Table 1 Pooled analysis for different traits in *Brassica carinata*

Source	d.f.	Mean square							
		Seed yield	1000-seed weight	Days to maturity	Primary branches	Secondary branches	Siliqua length	Main shoot length	Plant height
Year	2	10.326**	9.926**	139.583**	14.835**	74.600**	0.640**	126.521**	4011.049**
Genotype	15	0.245	0.622	46.088	13.156	67.550**	0.117	167.94**	679.996
Genotype x Year	30	0.264**	0.596**	24.994**	6.986**	23.579**	0.123**	66.950**	673.382**
Replication within year	6	0.059	0.015	28.139	2.002	1.574	0.055	24.535	4.861
Error	90	0.013	0.007	6.183	1.337	2.560	0.051	15.712	18.980

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

The 1000-seed weight, primary branches and siliqua length were genotypically correlated with seed yield, indicating that it may be improved through selection for these traits. Since primary branches were directly and indirectly correlated with seed yield, this character may be considered for improvement of seed yield.

The negative correlation between seed yield and days to maturity indicated that early maturing genotypes were high yielding. The significant genotypic correlation between yield and pod length may be related to greater photosynthetic activity as more than 60% of photosynthesis occurred through the pods as compared to 30% by leaves in rapeseed-mustard (Hozoyo *et al.*, 1972).

Pod length, primary branches and 1000-seed weight had significant positive correlation and positive direct effects on seed yield. Although, main shoot length had shown non-significant correlation with seed yield, it had largest direct effect with negative indirect effect on seed weight and siliqua length. Considering its association, the primary branches and 1000-seed weight appeared to be most reliable indices of seed yield. Both the characters had the largest direct effects. Although the 1000-seed weight was highly correlated with seed yield, its direct effect on seed yield is relatively smaller with its largest indirect effect with siliqua length. Therefore, the primary branches may be more appropriate character to select for higher yield.

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Short communication

Seed yield and plant-water relations in sunflower as influenced by varying IW/CPE ratios

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Maintenance of suitable plant-water balance is an essential pre-requisite for favourable growth and higher yield of crops. However, plants are usually incomplete in this desirable condition due to variable water supply, particularly during summer season. The basic parameters which describe the degree of unsaturation i.e., the plant water stress are relative water content, leaf water potential, transpiration rate, diffusive resistance and leaf temperature. Such information is lacking for sunflower grown during summer season under irrigated conditions. Hence, an experiment was conducted to study the variation in plant water stress parameters under varying irrigation levels and to establish the relationships between seed yield and evapotranspiration (Eta) versus plant water stress parameters.

The field experiment was conducted during the summer season of 1997-98 on sandy loam soil of Hyderabad. The IW/CPE ratios throughout the crop life were: I_1, 0.6; I_2, 0.8; I_3, 1.0; I_4, 1.2. Their combinations at vegetative and reproductive stages were: I_5, 0.6 upto 37 days after sowing (DAS) and 0.8 later; I_6, 0.6 upto 37 DAS and 1.0 later; I_7, 0.6 upto 37 DAS and 1.2 later; I_8, 0.8 upto 40 DAS and 1.0 later; I_9, 0.8 upto 40 DAS and 1.2 later; I_{10}, 1.0 upto 34 DAS and 1.2 later; I_{11}, 0.8 upto 40 DAS and 0.6 later; I_{12}, Irrigation's of 50 mm depth each at critical growth stages *viz.*, vegetative (20 DAS), flowering (45 DAS), seed setting (65 DAS) and seed filling stages (80 DAS). The treatments were laid out in a randomized block design with three replications. The mass water percentage at field capacity and permanent wilting point was 18.5% and 8.6%, respectively. The bulk density was 1.64 Mg/m^3. The available water storage determined as total water storage at –0.03 MPa (Field capacity 18.49%) minus storage at –1.5 MPa was 97.4 mm in 60-cm deep soil profile. The 60-cm soil profile was replenished to field capacity at the time of planting. Hybrid 'MSFH – 8' was planted on 12th January 1998. Other recommended measures of production (80 + 60 + 30 kg N, P_2O_5 and K_2O/ha respectively) and plant protection were followed. The crop was harvested in the second week of April.

The plant-water stress was measured by adopting standard procedures and instruments *viz.*, relative water content as suggested by Turner (1981); leaf water potential by Pressure chamber apparatus; and diffusive resistance, transpiration rate and leaf temperature by Steady state prometer.

Average seed yield was highest (2354 kg/ha) in I_3 treatment, where irrigation's were scheduled at 1.0 IW/CPE ratio throughout the crop life. Nevertheless, it was statistically on par with I_4, I_6, I_7, I_8, I_9, I_{10} and significantly superior over other treatments (Table 1). Lowest seed yield (632 kg/ha) was recorded when irrigation's were scheduled at critical growth stages (I_{12}). The trends could be traced to favourable soil water balance as indicated by Eta/PET ratios (Table 1) and plant water balance as indicated by relative water content, leaf water potential, transpiration rate and leaf temperature (Table 2). The seed yield (R^2 = 0.933 to 0.967) and Eta (R^2 = 0.959 to 0.983) showed a significant relationship with plant water stress parameters (Table 3). Likewise the regression of seed yield on seasonal Eta ($Y = -1780.1 + 8.61Eta$; $R^2 = 0.957$) exhibited a significant positive correlation with high explained variation. Further, the results under I_6, I_7, I_8 and I_9 treatments substantiate earlier findings of Unger (1982) that through careful management and consideration of available soil water at planting in the soil profile, sunflower can be irrigated at less than full levels (0.6 IW/CPE) during vegetative period without causing any major yield decrease. This could be due to low Eta requirement of the crop during this period as the canopy cover is low and ground cover is incomplete and its remarkable ability to resume leaf production and expansion consequently assimilatory structure. Moreover, early vegetative growth may continue by using much of the stored soil water as root penetration and proliferation increased.

Plant water relations *viz.*, relative water content, leaf water potential, diffusive resistance, transpiration rate and leaf temperature measured at different crop growth periods were largely a function of irrigation schedules adopted in different IW/CPE ratios (Table 2). The crop in I_3, I_4, I_6, I_7, I_8, I_9 and I_{10} treatments maintained higher relative water

content, leaf water potential and transpiration rate and lower leaf temperature in comparison to I_1, I_2, I_5, I_{11} and I_{12} treatments.

The relative water content, leaf water potential, transpiration rate and leaf temperature is dependent upon the lag between the evaporative demand of the atmosphere and the amount of water absorbed by the plant roots. Thus the crop plants in I_3, I_4, I_6, I_7, I_8, I_9 and I_{10} treatments, where in water application was equivalent to either 1.0 or 1.2 times that of atmospheric demand (as reflected by Epan) during flowering, seed setting and seed filling periods, extracted adequate water and were able to maintain better hydration and more favourable plant- water balance. Conversely, reduced water supply in I_1, I_2, I_5, I_{11} and I_{12} treatments decreased the soil water potential (became more negative) affecting the water conductivity in the soil leading to decreased water flow into the plant system as evident from low Eta. This situation in turn leads to dehydration (reduction in relative water content and leaf water potential) of the plant affecting the opening and closing of stomata in turn the stomatal conductance and increasing the resistance to water vapour diffusion leading to reduced transpiration rate.

Table 1 Seed yield, seasonal evapotranspiration and soil moisture as influenced by varying IW/CPE ratios

Irrigation treatment (IW/CPE ratio considered for scheduling irrigation)	Seed yield (kg/ha)	Seasonal Eta (mm)	Eta/PET ratio			
			30 DAS	50 DAS	70 DAS	90 DAS
I_1 - 0.6 throughout the crop life	924	315.5	0.363	0.509	0.752	0.227
I_2 - 0.8 throughout the crop life	1428	385.0	0.320	0.642	0.978	0.207
I_3 - 1.0 throughout the crop life	2354	465.9	0.441	0.871	1.254	0.247
I_4 - 1.2 throughout the crop life	2301	489.4	0.449	1.049	1.245	0.254
I_5 - 0.6 upto 37 DAS and 0.8 later	1321	372.0	0.345	0.582	0.997	0.325
I_6 - 0.6 upto 37 DAS and 1.0 later	2129	410.5	0.363	0.849	1.151	0.325
I_7 - 0.6 upto 37 DAS and 1.2 later	2156	447.5	0.353	0.850	1.257	0.315
I_8 - 0.8 upto 40 DAS and 1.0 later	2328	465.6	0.354	0.846	1.199	0.361
I_9 - 0.8 upto 40 DAS and 1.2 later	2316	478.0	0.377	0.949	1.243	0.355
I_{10} - 1.0 upto 34 DAS and 1.2 later	2328	486.5	0.346	0.986	1.224	0.327
I_{11} - 0.8 upto 40 DAS and 0.6 later	936	342.6	0.303	0.600	0.774	0.323
I_{12} - Irrigation at critical growth stages	632	259.0	0.350	0.450	0.550	0.298
SEm±	84.2	-	-	-	-	-
CD (P=0.05)	247.5	-	-	-	-	-

Table 2 Plant-water stress parameters as influenced by varying

Treatment	Leaf water potential (MPa) Days after sowing				Transpiration rate ($\mu H_2O/cm^2/S$) Days after sowing				Leaf temperature (°C) Days after sowing				Relative water content (%) Days after sowing			
	30	50	70	90	30	50	70	90	30	50	70	90	30	50	70	90
I_1	-1.17	-1.75	-1.91	-2.15	17.58	13.77	11.90	8.95	27.7	26.7	27.8	28.6	84.5	77.8	75.5	68.5
I_2	-0.99	-1.57	-1.73	-1.90	18.20	15.75	14.00	10.73	26.8	25.6	25.8	26.9	85.0	80.1	76.4	68.2
I_3	-0.88	-1.25	-1.35	-1.42	21.24	19.80	16.60	13.23	25.0	23.4	24.1	22.3	89.5	86.3	82.7	73.9
I_4	-0.88	-1.20	-1.35	-1.45	22.50	20.22	17.00	13.55	24.5	23.6	24.1	22.3	90.1	86.0	82.5	74.0
I_5	-1.20	-1.55	-1.80	-1.95	16.77	15.95	13.50	10.60	27.6	26.3	26.9	26.6	84.5	80.0	78.9	69.5
I_6	-1.15	-1.22	-1.40	-1.50	17.34	19.00	16.35	13.00	27.9	23.5	24.0	22.9	84.5	86.0	83.0	72.8
I_7	-1.15	-1.22	-1.41	-1.49	17.5	19.10	16.20	13.00	28.0	23.5	24.2	22.1	83.9	87.0	81.8	74.0
I_8	-1.03	-1.20	-1.32	-1.42	19.00	19.60	16.65	13.60	26.5	23.6	23.9	22.8	86.0	85.8	83.0	73.5
I_9	-1.01	-1.21	-1.30	-1.42	18.00	19.60	16.52	13.44	26.6	23.6	23.1	22.9	85.8	86.5	81.7	74.1
I_{10}	-0.90	-1.23	-1.30	-1.40	22.00	20.50	16.75	13.50	24.2	23.4	23.1	21.8	89.5	87.5	85.0	75.3
I_{11}	-1.00	-1.80	-1.95	-2.12	17.95	14.12	11.50	9.60	25.9	26.4	27.6	28.5	84.9	78.0	74.8	69.0
I_{12}	-1.31	-2.11	-2.25	-2.45	14.28	12.50	10.21	7.55	28.6	27.8	28.0	29.0	84.0	74.3	70.8	94.5

Table 3 Regression of seed yield (kg/ha) and Eta (mm) on various plant-water stress parameters

Relationship	Regression constant, coefficient and test statistics						F-value for testing R^2
	a	b	SEb	Tb	R^2	SEy	
Seed yield : Relative water content	-211.61720	3.0185	0.247	12.199	0.937	2.80	148.8
Seed yield : Leaf water potential	84.91473	38.0124	2.669	14.240	0.953	2.42	202.7
Seed yield : Transpiration rate	-39.78991	4.4593	0.375	11.878	0.933	2.87	141.0
Seed yield : Leaf temperature	10950.81	-362.647	20.996	17.271	0.967	2.15	298.2
Eta : Relative water content	-1317.8264	21.6140	1.405	15.375	0.959	15.94	236.3
Eta : Leaf water potential	807.05292	273.2950	11.105	24.609	0.983	10.08	605.6
Eta : Transpiration rate	-92.94908	32.2803	1.560	20.686	0.977	11.95	427.9
Eta : Leaf temperature	1454.97701	-41.1861	2.448	16.822	0.965	2.35	282.9

Generally, the leaf temperature is less than the surrounding ambient temperature when adequate soil moisture is present to meet the evaporative demand of the atmosphere. But, when the water absorption by the root lags behind the plant transpiration requirements due to decrease in soil moisture (i.e., reduction in soil water potential) the stomata started closing and there was a rise in leaf temperature as evident in I_1, I_2, I_5, I_{11} and I_{12} treatments in comparison to I_3, I_4, I_6, I_7, I_8, I_9 and I_{10} treatments. This is because the leaf temperature is a function of the balance between the net radiation flux on plant surface and the energy loss through sensible heat and latent heat transfers.

The regressions of seed yield and Eta on relative water content, leaf water potential, transpiration rate and leaf temperature were adequately described by a linear function (Table 3). The explained variation (R^2) in seed yield and Eta by different plant – water stress parameters varied from 0.933 to 0.967 and 0.959 to 0.983, respectively. The variance ratio (F - value) for testing R^2 were highly significant (P = 0.01) in all the cases. The regression coefficient (b) with respect to relative water content, leaf water potential and transpiration rate were significant and positive suggesting that an increase in these variables increased the seed yield and Eta. The unit variation in relative water content, leaf water potential and transpiration rate caused 3.01, 38.01 and 4.46 kg/ha increase in seed yield and 21.61, 273.29 and 32.28 mm increase in Eta respectively. On the other hand, the seed yield and crop Eta was significantly and negatively correlated to leaf temperature and unit increase in this variable caused 362.6 kg/ha decrease in seed yield and 41.1 mm decrease in crop Eta.

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Short communication

Integrated nutrient management for irrigated castor (*Ricinus communis*)

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Castor is an important non edible oilseed crop of Gujarat being a long duration crop requires higher amount of fertilizers. Due to increase in fertilizers cost during recent years and their detrimental effect on the soil health, the reduction in use of chemical fertilizer and supplementing the same through organic manures i.e. FYM, castor cake and bio-fertilizers have become necessary to sustain productivity and profitability. Such information is very limited in castor crop, therefore, the present study was under taken.

The experiment was conducted during *kharif* 1995 and 1996 at Main castor-mustard Research Station, Gujarat Agricultural University, Sardarkrushi Nagar in sandy soils under irrigated conditions. The soil had 176 kg/ha available N, 43.27 kg/ha available phosphorus and 217 kg/ha available potassium and pH 7.8. Sixteen treatments combinations comprising organic [Farm yard manure (FYM)] and castor cake (CC), inorganic (100% and 50% of recommended dose of 75-50-00, NPK, kg/ha) and bio-fertilizers *Azospirillum* and Phosphorus Solubilizing Bacteria (PSB) were tested. FYM @ 5 t/ha and castor cake @ 1 t/ha were applied as band placement. Seed was inoculated with bio-fertilizer @ 50 g/kg seed (Table 1). Castor hybrid "GCH-4" was dibbled at a spacing of 90 cm x 60 cm in net plot size of 2.7 x 4.2 m and replicated thrice. During crop growth period the amount of rain received in was 582 and 349 mm in 27 and 26 rainy days respectively in 1995 and 1996.

The application of castor cake + 10% RDF + phosphorus Solubilizing Bacteria or *Azospirillum* resulted in more capsules on primary spike and more branches/plant during both the years of study (Table 1). Similar findings were also made from Andhra Pradesh (Baby Akula and Bapi Reddy, 1998). Effective branches were less in organic and bio-fertilizers applied plots without inorganic fertilizers. The conjunctive use of organic, inorganic and bio-fertilizers gave significantly higher test weight and oil content during both the years.

Table 1 Effect of organic, inorganic and biofertilizers on yield, yield contributes and net returns of castor

Treatment	Effective primary spike length (cm)		Capsules on primary spike		Branches/ plant		100 seed weight (g)		Oil content (%)		Seed yield (kg/ha)			Net returns (Rs/ha)
	1995	1996	1995	1996	1995	1996	1995	1996	1995	1996	1995	1996	Pooled	
FYM + 50% RDF	43	46	53	46	4	5	28.6	31.9	51.1	48.5	2133	2651	2392	14194
FYM + 100% RDF	47	59	52	58	5	6	29.4	30.3	51.1	47.5	2638	2906	2772	17714
FYM + *Azospirillum*	43	47	54	49	4	4	29.8	31.9	50.6	47.8	1902	2440	2201	12719
FYM+PSB	42	46	51	40	4	4	29.6	29.9	50.6	46.2	2304	2672	2488	15916
Castor cake + 50% EDF	43	52	47	49	4	5	30.0	31.7	50.5	47.5	2707	3042	2874	19063
Castor cake + 100% RDF	50	48	56	54	5	6	29.7	31.5	50.0	46.4	2678	3034	2856	18149
CC + *Azospirillum*	45	47	62	51	3	5	29.4	30.6	50.1	44.5	2524	3006	2765	18513
CC + PSB	46	45	48	52	4	5	30.1	30.8	48.0	48.3	2515	3037	2776	18625
FYM+50% RDF + *Azospirillum*	44	49	63	43	4	5	30.3	30.2	50.9	46.6	2757	2908	2833	19046
FYM+50% RDF + PSB	45	49	59	48	4	5	29.4	31.4	51.6	44.9	2417	2705	2561	16016
FYM+100% RDF	43	53	63	51	5	5	29.8	31.1	52.1	45.6	3002	3186	3096	21262
FYM+100% *RDF+Azospirillum*	48	49	65	43	4	6	28.7	31.9	52.0	46.3	3125	3156	3140	21753
CC + 50% RDF + *Azospirillum*	42	53	63	59	4	5	28.5	31.8	51.4	46.7	2671	3359	3015	20573
CC + 50% RDF + PSB	44	51	72	47	4	5	28.4	32.1	52.1	46.7	2917	3158	3037	20818
CC + 100% RDF + *Azospirillium*	51	49	78	48	5	5	31.0	32.7	52.2	47.2	3517	3356	3436	24550
CC + 100% RDF + PSB	52	51	79	50	5	6	29.3	32.6	51.9	48.2	3334	3573	3454	24750
CD (P=0.05)	6.7	NS	14.4	11.6	0.6	1.2	1.64	1.81	1.38	0.79	548.9	547.9	361.3	-

Likewise the application of castor cake + 100% RDF + PSB gave higher yield followed by *Azospirillum* at the same level of other fertilizers and FYM + 100% RDF together with PAB or *Azospirrilum* as compared to the rest of the treatments. Application of castor cake + 50% RDF together with PSB or *Azospirillum* was on par with all other treatments except FYM + 50% RDF, FYM + Azo. and FYM +PSB. The increase in yield can be attributed to more capsules on primary spike, branches and more seed weight (Anonymous, 1994, Baby Akula; Bapi Reddy, 1998). At Mandor also application of FYM or Castor cake in conjunction with recommended dose of NPK with PSB gave significantly higher yield (Anonymous, 1995). At Palem under rainfed situation use of PSB along with Neem cake + 100% RDF gave higher yield followed by *Azospirillum* at the same levels of other fertilizers (Baby Akula and Bapi Reddy, 1998). The conjunctive use of organic , inorganic and bio-fertilizers might have improved soil physical conditions and increased nitrogen uptake. Report from Sardarkrushi Nagar (Gujarat) also indicated that application of 75% N through castor cake + 25% N through urea and 50% N through mustard cake + 50% N through urea increased total nitrogen uptake under irrigated conditions Anonymous (DOR, 1992).

Lowest yield was recorded in the treatments with application of FYM + 50% RDF and FYM with bio-fertilizer (*Azospirillum* or PSB). This showed that FYM and bio-fertilizers can not completely substitute inorganic fertilizers. However, conjunctive use of these fertilizers can sustain productivity of castor.

Economic analysis showed that the maximum net return (Rs. 24750 and Rs. 24550 was obtained with application of 1 t/ha castor cake + 100% RDF (75-50-00, NPK, kg/ha) +PSB or *Azospirillum* respectively. Kumar *et al.* (1993) reported more gross and net returns in pearl millet + Castor intercropping system with *Azospirillum* seed inoculation besides application of nitrogen and phosphorus.

Thus it can be concluded that conjunctive use of 1 t/ha castor cake or 5 t/ha FYM + 100% RDF (75-50-00, NPK, kg/ha) + seed inoculation with PSB or *Azospirillum* @ 50 g/kg seed increased castor yield under irrigation conditions of North Gujarat.

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Short communication

Efficacy of different methods of zinc application in groundnut, *Arachis hypogaea*

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Groundnut is an important oilseed crop grown in soils of diverse physico-chemical characteristics. Deficiency of micronutrients especially, zinc has been reported to adversely affect the yield and significant response of Zn application on groundnut yields has been reported (Bahl *et al.*, 1986, Sutaria and Patel, 1987; Revathy *et al.*, 1997). The information about the efficacy of different methods of Zn deficiency correction in groundnut is very meagre. The present investigation reports the comparison of the performance of different Zn sources, rates and their method of application on yields, Zn concentration and uptake by groundnut.

Field experiment was conducted with groundnut (cv. ICGS-44) in *kharif*, 1999 at Ujhani to compare the performance of different Zn sources, rates and their method of application (Table 1). In the case of $ZnSO_4$ seed treatment, a 2% solution of gum acacia added at the rate of 8 ml/kg seed was used as an adhesive prior to addition and mixing of $ZnSO_4.7H_2O$ to groundnut seeds.

The experimental soil had a sandy loam texture, 7.8 pH, and 0.71% organic C and 0.91 mg DTPA extractable Zn/kg soil. The climate of the area is semiarid subtropical type with mean annual rainfall of 821 mm. The experiment was conducted in RBD with three replications. The net plot size was 5 X 3 m. A basal dose of 20 kg N and 50 kg P_2O_5 as diammonium phosphate and 30 kg K_2O as muriate of potash /ha was applied uniformly to each plot. Groundnut seeds of cv. ICGS-44 treated with chemicals as per the treatment details were sown in each plot keeping row-to-row and plant-to-plant distance as 30 and 10 cm, respectively. After drying, pod and haulm yields were recorded. Shelling (%) and thousand seed weight were also determined plot wise.

Dried seeds and haulms were finely ground in a Wiley mill *and digested in di-acid mixture* (HNO_3: $HClO_4$, 4:1 *v/v*). Zinc content in the digest was estimated by double beam atomic absorption spectrophotometry. Total Zn uptake by seeds and haulms were calculated.

The yield data revealed that soil application of zinc sulphate at the rate of 25 kg $ZnSO_4.7H_2O$/ha significantly increased the pod yield by 15.5% over control; the increase at the lower dose (12.5 kg $ZnSO_4.7H_2O$ /ha) was statistically non-significant (Table-1). Bahl *et al.* (1986) also reported a significant response to 20 kg Zn/ha on yields of groundnut grown in loamy sand. Foliar spray with 0.5% zinc sulphate heptahydrate + 0.25% lime at 30 and 45 days after emergence did not increase the pod yield significantly over control. Moraghan (1983) also noted that foliar spray of Zn was less effective than soil applied Zn in correcting Zn deficiency in flax. Seed treatment with Teprosyn- Zn at both the recommended (100%) and more than recommended (130%) doses and seed treatment with an equivalent amount of zinc sulphate using gum acacia solution as an adhesive brought only a slight increase in pod yield, which too was statistically non-*significant. Lower pod yield under seed treatment* as compared to soil application of zinc sulphate could be possibly attributed to the inability of former method of application to ensure supply of adequate amount of Zn in the plant rhizosphere as number of plants/m or pods/plant were not significantly lower under seed treatments as compared to soil application. Whitehouse (1973) also reported that application of $ZnSO_4$ to seeds was not as satisfactory in correcting Zn deficiency in linseed as its foliar spray or soil application. The haulm yields were not significantly influenced by different treatments.

The lowest seed yield (1907kg/ha) was recorded in the seed treatment with 24.0 g $ZnSO_4.7H_2O$/kg seed and could be attributed to the reason described above. Soil application of 12.5 and 25.0 kg/ha $ZnSO_4.7H_2O$ *significantly increased the seed yield by 31.9 and 30.6%* over seed treatment with 24.0 g $ZnSO_4.7H_2O$/kg seed, respectively. The shelling percentage and 1000 seed weight were not significantly influenced by different treatments.

All treatments were effective in significantly increasing Zn concentration in haulms over control (Table 1). Foliar spray of $ZnSO_4.7H_2O$ gave the highest increase (50.71%) in Zn concentration of haulm in comparison to control and

this treatment was also found effective in bringing a significant increase in Zn concentration of seeds. None of the treatments was effective in bringing a significant increase in Zn uptake of seeds. However, foliar spray of $ZnSO_4.7H_2O$ and soil application of 12.5 and 25.0 kg $ZnSO_4.7H_2O$ /ha significantly increased Zn uptake of haulms by 50.2, 51.9 and 65.0% over control, respectively.

Total Zn uptake by crop was also significantly increased by 43.1, 67.3, 54.9 and 62.9 % over control with Teprosyn- Zn seed treatment at 100% recommended level, foliar spray of $ZnSO_4.7H_2O$ and soil application of 12.5 and 25.0 kg $ZnSO_4.7H_2O$ /ha, respectively.

Thus, soil application of 25 kg $ZnSO_4.7H_2O$ /ha appeared to be the most effective method for correcting Zn deficiency and obtaining high pod yield of groundnut crop grown in Zn deficient coarse textured soils. Other methods of Zn deficiency correction like foliar spray or seed coating with zinc preparations failed to give significant response in terms of pod yield.

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Table 1 Comparison of different zinc sources, rate and method of application on groundnut yields and yield attributes and uptake in seed and haulm

Treatment	Yield attributes					Zn uptake				
	Pod yield (kg/ha)	Haulm yield (kg/ha)	Seed yield (kg/ha)	Shelling (%)	1000 seed wt. (g)	Zn conc. in seed (mg/kg)	Zn conc. in haulm (mg/kg)	Zn uptake in seed (g/kg)	Zn uptake in haulm (g/kg)	Total Zn uptake (g/kg)
Control	3366	4653	2155	64	485	13.1	16.0	28.3	74.6	102.9
Teprosyn seed treatment (8 ml/kg seed) recommended level (100%)	3399	4613	2168	64	505	13.7	19.7	29.7	90.9	120.5
Teprosyn seed treatment (10.4 ml/kg seed) recommended level (130%)	3427	4698	2233	65	477	20.7	21.0	48.4	98.9	147.3
Zinc sulphate seed treatment (24 g $ZnSO_4.7H_2O$/kg seed)	3183	4144	1907	59	464	18.4	20.7	35.2	86.4	121.6
Zinc sulphate seed treatment (31.2 g $ZnSO_4.7H_2O$/kg seed)	3516	4873	2349	64	540	14.6	20.2	34.4	98.7	133.0
Foliar spray (0.5% $ZnSO_4.7H_2O$ + 0.25% lime) at 30 and 45 days after emergence	3427	4642	2115	63	465	28.2	24.2	60.1	112.1	172.2
Soil application (12.5 kg $ZnSO_4.7H_2O$/ha)	3683	5144	2515	69	510	18.3	22.1	46.0	113.4	159.4
Soil application (25.0 kg $ZnSO_4.7H_2O$/ha)	3888	5218	2491	64	510	17.9	23.6	44.5	123.2	167.6
CD (P=0.05)	383	NS	477	NS	NS	8.0	2.3	NS	26.9	43.0
CV (%)	6.4	12.6	12.1	8.7	6.3	25.1	6.2	30.5	15.4	17.5

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Short communication

Effects of herbicides and in integration with cultural practices on weed control and yield of sunflower (*Helianthus annuus* L.)

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Sunflower is an important oilseed crop in India. Andhra Pradesh occupies third place in area under sunflower but the production and productivity are low when compared with the Northern states of Punjab and Haryana. This may be attributed to rainfall fluctuations, improper nutrition and weed management etc. Yield losses due to weed infestation up to 60 -70% were also reported (Annual Progress Report, 2000-01).

Cultural weed control is the most common practice. But incase of drought spells or excess rainfall, this is also not carried out by the farmers leading to heavy competition of weeds with the crop in the initial stages resulting in poor yields. On the other hand, chemical weed control through herbicides is rarely practiced in rain fed sunflower and may not be feasible alone. Hence integrated weed management forms a suitable and viable alternative. Keeping this in view, the present study was carried out in rain fed sunflower .

An experiment was conducted on vertisol during *Kharif* 1997, 1999 and 2000 to study the effect of integrated weed management practices (cultural and/or pre-emergence herbicide application) on the weed control and yield of rain fed sunflower. The design was Randomised Block (RBD) with 12 treatments replicated thrice. The seeds were sown with an Inter- and Intra- row spacing of 60 cm and 30 cm respectively along with a recommended fertilizer dose of 60 N : 60 P_2O_5 : 30 kg K_2O/ha . The inter-cultivation and weeding operations were carried out around 25 and 45 days after sowing (DAS) depending upon the receipt of rainfall while the herbicides were sprayed as pre-emergence application immediately after sowing. The experimental soils was heavy black with low available nitrogen (157 to 212 kg/ha N), low to medium available phosphorous (5.5 to 23.4 kg/ha P) and high available potassium (331 to 482 kg/ha K). The normal rainfall of Nandyal is 752.2 mm while the rainfall received during 1997, 1999 and 2000 was 598 mm, 370 mm and 1364 mm respectively. During 1998 , the crop failed due to heavy rains (1191 mm) especially from sowing to maturity (906 mm in 38 rainy days).

The weed counts were recorded/m^2 immediately after harvesting of crop and the weeds were collected, dried and dry weights were recorded later .Post harvest observations like number of filled and unfilled seeds/ head, 100-seed weight as well as the yield were recorded during all the three years. The net returns and benefit-cost ratio were also calculated (Tables 1).

The following predominant weed flora was observed in the experimental plots:

Acanthospermum hispidum, Achiranthus aspera, Boerhaevia diffusa, Aristolachia bractiata, Commelina benghalensis, Cyperus difformis, Dactyloctenium aegyptium, Digera arvensis, Panicum repens and Tridax procumbens.

Yield attributes and yield: The number of filled seeds per head was significantly influenced during 1997 and maximum number was recorded with Butachlor alone (593) and it was on a par with weed free (585) and 1 I.C (interculture) + 1 H. W. (hand weeding) (580) individual years data is not given. The pooled analysis (Table 1) revealed that significantly higher number of filled seeds was obtained with pendimethalin (587) and all the treatments were on par but superior to weedy check (409).

Number of unfilled seeds was significantly influenced during 1997 and 2000 and also pooled data. The lowest number of unfilled seeds was recorded with metalochlor (67). The 100-seed weight was also influenced significantly (during 1997, 2000 and was reflected in pooled analysis) with pendimethalin + 1 H. W.(4.62g).The combined effect of all these was reflected in the seed yield. The pooled analysis revealed that significantly highest seed yield was recorded with 2 I.C + 2 H.W. (907

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kg /ha) which was at par with pendimethalin + 1 H. W. (838 kg/ha) and pendimethalin alone (835 kg/ha). Beneficial effects of herbicides and integrated methods of weed control on sunflower were also reported by several workers (Poonguzhalan *et al.*,1996 and Pradeep and Sundaram 1996).

Table 1 Effect of herbicides and cultural practices on yield attributes and yield of rainfed sunflower (Pooled analysis of 1997, 1999 and 2000)

Treatment	No. of filled seeds/head	No. of unfilled seeds/head	100-seed weight (g)	Seed yield (kg/ha)	No. of weeds/m^2	Dry weight of weeds (g/m^2)	B:C ratio
T_1 : Weedy check	409	72	3.6	602	158	172	2.3
T_2 : Weed free	504	95	4.1	841	51	81	2.7
T_3 : 1 I.C. + 1 H.W.	585	75	4.3	669	95	207	2.3
T_4 : 2 I.C. + 2 H.W.	550	92	4.2	907	40	78	2.8
T_5 : Metalochlor @ 1.0 kg a.i. / ha	470	67	4.1	681	112	202	2.2
T_6 : Pendimethalin @ 1.0 kg a.i. / ha	587	89	4.1	835	61	63	2.2
T_7 : Butachlor @ 1.5 kg a.i. / ha	479	95	4.1	821	104	162	2.7
T_8 : Alachlor @ 1.5 kg a.i. / ha	525	72	4.0	710	62	89	2.1
T_9 : $T_5 + T_3$	508	78	4.3	733	53	54	2.1
T_{10} : $T_6 + T_3$	501	88	4.6	838	36	43	2.1
T_{11} : $T_7 + T_3$	528	97	4.3	832	49	95	2.5
T_{12} : $T_8 + T_3$	490	97	4.2	729	52	88	2.0
S. Em ±	55.3	9.8	0.1	29.8	8.3	21.8	-
C.D. (P= 0.05)	154	27	0.25	84	23	NS	-

IC = Inter-cultivation; H.W. = Hand weeding

Weed number and dry weight of weeds: The highest number of weeds/m^2 was recorded with weedy check during all the years as well as in pooled data (158) while the lowest number of weeds/m^2 (36) was recorded with pendimethalin + 1 H. W. which was on par with 2 I.C + 2 H. W. (40) and Butachlor + 1 H. W. (49). In case of weed dry weight also, the lowest value (43 g / m^2) was obtained with pendimethalin+1 H.W. Poonguzhalan *et al.*, (1996) also reported that pendimethalin 0.5 kg/ha + Hoeing at 30 days resulted in the lowest dry weight of weeds in sunflower. Similar results of lowest weed counts and weed dry weights with oxyflourfen and pendimethalin along with 1 HW were also reported by Rakesh Kumar *et al.* (1996).

During 1997 and 1999, the rainfall received was below normal compared to 2000 . But due to timely receipt of rain and heavy nature of soil which retains the moisture for a longer period, higher number of seeds (filled and unfilled) and 100-seed weight were obtained, during both the years, which resulted in higher yield levels compared to the year 2000. On the other hand, weed number and the dry weight of weeds were low during these years compared to the later. As such, it is evident that sunflower crop preferred and performed better only during normal rainfall while excess rainfall is harmful to yield because of heavy weed infestation besides water logging and its associated effects.

Economics: Maximum net return (Rs.7042 / ha) was obtained with 2 I.C. + 2 H.W. followed by weed free treatment (Rs. 6400/ha). Among the herbicide treated plots, Butachlor at 1.5 kg a.i./ha and Pendimethalin at 1.0 kg a.i./ha (with or without hand weeding) were better than the other two herbicides. The benefit: cost ratio also revealed the superiority of these herbicides over others. But due to the relatively higher cost, pendimethalin and Alachlor with 1 H. W. resulted in the lowest B:C ratio.

It may be concluded that irrespective of rainfall, when it is not possible to carry out only cultural operations,

integrated methods of weed control involving Butachlor @1.5 kg a.i./ha or Pendimethalin at1.0 kg a.i./ ha along with one hand weeding may be adopted for effective weed control and to realize higher yields of sunflower crop.

Field experiments conducted in rainfed sunflower during *kharif* 1997, 1999 and 2000 to find out the effective weed control method indicated that the yield differences varied significantly due to different treatments depending on the seasonal weather fluctuations. The pooled analysis revealed that the higher seed yield (907 kg/ha) was obtained with 2 inter-cultivations (I.C) + 2 hand weedings (H.W) at 25 and 45 days after sowing (DAS) followed by pendimethalin 1 kg a.i. + 1 H.W. (838 kg/ha), pendimethalin 1 kg a.i. alone (835 kg/ha) and Butachlor + one H .W. (832 kg/ha) which were on a par. The decrease in yield due to unweeded check over 2 I.C. + 2 H.W. was to the tune of 32.5%. The yield increase recorded with or without hand weeding in case of pendimethalin was 28.4% and 27.9%, while with Butachlor it was 27.6 and 26.6% respectively over unweeded check. Lowest number and dry weight of weeds/m^2 were recorded with pendimethalin + 1 H. W. (36 and 43 g respectively).

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Short communication

Performance of Indian mustard, *Brassica juncea* (L.) Czern & Coss. varieties under irrigated condition

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Rapeseed-mustard are the most important *rabi* oilseed crops of Rajasthan and are grown on about 2.47 million hectares with a total production of 2.45 million tones (1999-2000). Mustard crop covers 60% of the total area under *rabi* oilseeds in the state (Anonymous, 2000), but average productivity is low being only 965kg/ha (1998-99) mainly because of less adaptability of high yielding varieties. To assess the performance of different varieties of mustard, a field experiment was conducted during 1996-97 and 1997-98 at the NRCRM, Bharatpur. Ten varieties of Indian mustard (*Brassica juncea*) were tested in RBD with three replications. The soil was clay-loam in texture, poor in available nitrogen and phosphorus with medium available potassium content.

All the varieties were sown in the second week of October at 30cm x 15cm spacing. The dose of nitrogen and phosphorus was 80 and 40kg/ha. Full dose of phosphorus and half N was applied as basal and the remaining N was top dressed at flowering stage after first irrigation given at 40 DAS. The seed yield differences among varieties were found to be significant during both the years (Table 1). However, the varietal performance differed from year to year. During 1997-98, all varieties produced lesser yield as compared to the year 1996-97. In this year weather was congenial for diseases incidence. In 1996-97, Mustard variety RH-30 recorded highest seed yield (1740kg/ha) followed by PCR-7 (1700kg/ha) which was significantly higher over RLM-1359 and Rohini. In 1997-98, RLM-1359 recorded maximum seed yield (1310kg/ha) followed by Rohini, Varuna, Kranti, RH-819 and PCR-7 and proved superior to all other varieties. On the basis of two years average, RL-1359 resulted in significantly higher seed yield (1460kg/ha) but remained at par with PCR-7, RH-30, Kranti and Rohini. The suitability of these varieties in irrigated conditions was also reported by Kumar *et al.*, 2000. The difference in oil content among varieties was non-significant in both years. However due to variation in seed yield the oil yield per hectare was highest with RL-1359 (571kg/ha).

Thus, it can be concluded that mustard varieties RLM-1359, RH-30, Varuna, Kranti, Rohini and PCR-7 are suitable for cultivation under irrigated clay-loam soil situation of semi-arid tract of eastern Rajasthan.

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Table 1 Performance of mustard varieties under irrigated condition

Variety	*Seed yield (kg/ha)*			*Oil content (%)*			*Oil yield (kg/ha)*		
	1996-97	1997-98	Mean	1996-97	1997-98	Mean	1996-97	1997-98	Mean
RL-1359	1620	1310	1460	38.0	40.2	39.1	616	526	571
RH-819	1480	1070	1270	37.2	40.0	38.6	549	428	488
Bio-902	1670	960	1310	37.0	40.1	38.5	630	385	507
Kranti	1660	1110	1380	37.5	39.8	38.6	629	441	535
Pusa Bold	1660	980	1320	38.1	40.6	39.3	632	398	515
PCR-7	1700	1060	1380	37.8	40.4	39.1	644	428	536
Rohini	1540	1150	1340	39.2	39.8	39.5	603	457	530
Vardan	1610	860	1230	39.5	40.2	39.8	637	346	491
Varuna	1630	1120	1370	39.2	39.8	39.5	638	446	542
RH-30	1740	1030	1380	38.1	40.0	39.0	664	412	538
CD (P=0.05)	110	250	130	NS	NS	-	-	-	-

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Short communication

Intercropping of oilseed and pulse crops in castor (*Ricinus communis* L.) under irrigated conditions

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Production of oilseeds and pulses in India is quite low and there is no scope to bring more area under the plough. Also under existing situations, horizontal expansion of area of castor with grain legumes or oilseeds is not possible due to high yield potential of castor. Being a long duration, widely spaced crop, it offers a great scope for using its inter space by growing short-duration crops and thereby helps harvest the potential productivity (Singh and Singh, 1988). Hence, this experiment was carried out to find out the most suitable crops for intercropping in castor.

The experiment was conducted during *kharif* season of 1992, 1993 and 1995 on sandy loam soil, containing 0.18% organic carbon, 176 kg/ha, 29 kg/ha and 217 kg/ha of available nitrogen, phosphorus and potassium, respectively, and pH 7.75 in the top 15 cm soil. The experiment conducted during *kharif*, 1994-95 was vitiated due to continuous heavy rains. The treatments comprised eight intercropping systems and sole castor (Table 1). The experiment was laid out in a randomized block design with three replications. A recommended dose of fertilizers for all the crops was applied in all the treatments as per row ratio.

Sole cropping of castor recorded significantly higher seed yield than that obtained in different intercropping systems in 1992 and 1993 (Table 1). However, the intercropping with groundnut in 1:1 row ratio during 1995 was at par with sole castor. Similar results were observed by Anonymous (1995) and Gupta and Rathore (1993). Intercropping of different crops reduced the castor seed yield (Singh and Singh, 1988). The maximum reduction in castor seed yield was recorded when it was intercropped with cluster bean and moong in 2:1 row ratio. Conversely, the minimum reduction in castor seed yield was recorded when it was intercropped with groundnut in 1:1 row ratio followed by cowpea, green gram and cluster bean (Anonymous, 1989; Gupta and Rathore, 1993). The yield of castor showed a decreasing trend with increase in the rows of component crops possibly due to internal competition for nutrients, water and shading effect. Reddy *et al.* (1965) reported considerably lower yields of castor in mixed crop than in pure crop.

Table 1 Castor yield, economics and land equivalent ratio (LER) as influenced by different intercropping systems

Intercropping	Castor yield (kg/ha)				Net economic returns (Rs/ha)	B:C ratio	LER
	1992	1993	1995	Pooled			
Cluster bean + castor							
1:1	1870	2232	2707	2270	15967	1.24	1.20
2:1	1244	1824	1456	1508	9740	0.72	1.24
Cowpea + castor							
1:1	1388	1917	2343	1882	9058	0.70	1.02
2:1	1089	1470	2244	1601	6730	0.50	1.18
Greengram + castor							
1:1	1684	2332	2839	2285	16703	1.29	1.18
2:1	820	2137	1697	1551	11181	0.82	1.15
Groundnut + castor							
1:1	2109	2690	3130	2643	15362	0.94	1.28
2:1	1166	1894	2215	1758	7610	0.44	1.24
Sole castor	3266	3409	3573	3416	24160	2.41	1.00
CD (P=0.05)	735	427	522	352			

Table 2 Grain yield of component crops (kg/ha)

Crop	Component crops yield (kg/ha)							
	1992-93		1993-94		1995-96		Pooled	
	Intercrop	Sole	Intercrop	Sole	Intercrop	Sole	Intercrop	Sole
Cluster bean + castor								
1:1	569	-	366	-	713	-	549	-
2:1	733	941	617	704	1128	1447	826	1030
Cowpea + castor								
1:1	397	-	414	-	231	-	348	-
2:1	665	755	568	887	366	598	538	747
Greengram + castor								
1:1	357	-	649	-	463	-	456	-
2:1	557	829	626	1070	689	800	624	900
Groundnut + castor								
1:1	439	-	482	-	211	-	318	-
2:1	606	860	704	935	299	424	536	740
CD (P=0.05)	271	-	218	-	159	-	351	-

While comparing the component crops both in intercropping and sole cropping system, all the intercrops produced more yield when sown as sole crop than as an intercrop in castor. These results were in agreement with those of Desai and Goyal (1980). All the intercrops gave more yields in higher row proportion of 2:1. Among the different component crops, cluster bean recorded higher grain yield in the intercropping system (Table 2).

Economic analysis of various systems revealed significantly higher return (Rs. 24160/ha) in sole castor, followed by groundnut + castor, moong + castor and cluster bean + castor all in 1:1 row ratios. The benefit/cost ratio was higher in sole crop (2.42) followed by moong + castor (1.29) and cluster bean + castor (1.24) in 1:1 row ratio.

The land equivalent ratio (LER) is an indicator of efficient utilization for intercropping system (Jha and Chandra, 1982). For profitable intercropping, the land equivalent ratio should exceed 1.4, but in this experiment none of the systems could achieve it (Table 1). Therefore, not a single intercropping system found to be profitable over sole crop of castor.

Though, in North Gujarat maximum net return is obtained through sole castor, yet as an insurance against vagaries of weather farmers can take intercrop of either groundnut or green gram in 1:1 row ratio.

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Short communication

Response of groundnut (*Arachis hypogaea* L.) to *Rhizobium* and PSM inoculation in the acid soils of Meghalaya

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Groundnut is emerging as very promising oilseed crop in uplands of the NEH region. The crop needs proper nutrition for its higher productivity. Although nitrogen requirement in groundnut is quite substantial for its proper growth and development, major part of the nitrogen need is met through the *symbiotic* N-fixation. Under the mid and high altitude situations of Meghalaya, the status of available nitrogen is rather low as most of the organic matter remains unhumified due to low temperature conditions. Considering the high cost and less availability of nitrogenous fertilizers in the NEH region of the country, efficient utilization of fertilizer nitrogen in groundnut is very important.

Availability of phosphorus to groundnut plant is critical in acid soils. Plant absorbs phosphorus from the soil solutions mainly in the $H_2PO_4^-$ ionic form (orthophosphate) and smaller amount in the form of secondary orthophosphate ions (HPO_4^-). The acid soils of Meghalaya found to be highly deficient in available phosphorus. The soluble orthophosphate rapidly reacts in soil to form insoluble phosphorus through precipitation and absorption due to phosphate fixation in soils. When the total phosphorus in an average arable soil is approximately *0.05%* by weight (*400-2000* kg/ha), the availability of phosphorus to plant is scarce only because of this phosphate fixation. The fixed form in acid soil is Fe PO_4 and $AlPO_4$. Several research findings have established phosphorus solubilising micro-organisms (PSM) may play changing role as sustainable resources in providing phosphorus (Bhattacharya and Jain, 2000).

Keeping above factors in view, an experiment was conducted to study the response of different *Rhizobium* strains and phosphorus solubilising micro-organisms (bacteria) to groundnut yield and yield attributes in acid soils of Meghalaya.

The field experiment was conducted at the ICAR Research Complex, Umiam (980 m. msl), Meghalaya during the *kharif* seasons of 1998 and 1999 in randomized block design with virginia bunch (VB) variety ICGS 76. The soil was red laterite having pH 5.6, total nitrogen 450 kg/ha, available P 10.5 kg/ha and exchangeable potassium 430 kg/ha. Four *Rhizobium* strains *viz.*, NC-92, TAL-1000, IGR-40, IGR-6 and three PSM *viz.*, *P. striata*, *B. polymyxa* and *B. circulan* supplied by NRC groundnut, Junagadh (Gujarat) were used for seed inoculation. A control was maintained without any *Rhizobium*/PSM inoculation. Solution of 10% sugar was prepared for activating *Rhizobium* and PSM for inoculating groundnut kernel (Anonymous, 1990). The inoculated seeds were dried in shade before sowing. The inoculum-coated seeds were sown with a spacing of 30 x 10 cm between row and plant. The sowing was done in the first week of June in both the years. Phosphorus in the form of single super phosphate (60 kg P_2O_5/ha), potassium in the form of muriate of Potash (40 kg K_2O/ha) and nitrogen in the form of urea (20 kg N/ha) were applied in all the plots as common dose. The crop was harvested at maturity (115 DAS) and observations on plant height, root length, number of nodules per plant, dry biomass, yield and yield attributes were recorded.

Effect of *Rhizobium*

The *Rhizobium* strains NC-92 and TAL-1000 were found to be the better in increasing the plant height (27 cm each), number of nodules (168 and 153/plant), dry biomass per plant (37.1 and 35.6 g) and pod yield (2600 and 2420 kg/ha) over the control and other strains (Table 1). Out of the four *Rhizobium* strains, only TAL-1000 and NC-92 influenced number of pods/plant, pod weight/plant, number of kernel/pod, shelling % and 100 kernel weight (*Table 2*). However, *shelling percentage and 100* pod weight were significantly increased by these two strains. Both these strains were at par in increasing the plant height, nodules/plant, dry biomass and pod yield. The increased pod yield due to seed inoculation of *Rhizobium* strains in acid soil may be due to increased nodulation and nitrogenase activity of nodules. Naidu (2000) also reported that *Rhizobium* strains were the best in increasing number of nodules/plant, dry weight of plant and pod yield over control in virgin soil. Jain *et al.* (1988) also obtained similar results.

Effect of PSM

PSM strain *P. striata* was found effective in increasing root length and dry biomass/plant over control. But, none of the PSM strains (*P. striata, B. circulan* and *B. polymyxa*) inoculated were found effective in increasing the nodules/plant, pod yield and yield attributes over control. It showed that strains are not capable of solubilising fixed phosphorus in the acid alfisols. Although PSMs improved P-uptake and increased yield of different crops (Bhattacharya and Jain, 2000) and has the capacity to produce hormones and can stimulate growth of plants (Dubey and Gupta, 1996). However, appreciable effect on pod yield of groundnut was not obtained with these three PSMs strains.

Highest number of nodules/plant, maximum dry biomass and pod yield were obtained due to seed inoculation with *Rhizobium* strains NC-92 followed by TAL-1000. Out of the four *Rhizobium* strains (NC-92, TAL-1000, IGR-40 and IGR-6), seed inoculation with NC-92 and TAL-1000 was found to be effective in significantly increasing the nodules/plant, biomass/plant, pod weight, shelling % and pod yield over control. However, the PSM strains (*P. striata, B. circulan* and *B. polymyxa*) proved effective increasing the nodules/plant, yield attributes and pod yield over control in the phosphorus deficient, acid soil of Meghalaya.

Table 1 Effect of groundnut seed inoculation with *Rhizobium* cultures and PSM on growth and pod yield (Pooled data of *kharif*, 1998 and 1999)

Treatment	Plant height (cm)	Root length (cm)	Nodules/plant	Dry biomass/plant (g)	Pod yield (kg/ha)
Control	24	13	97	31.0	2130
NC-92	27	15	168	37.1	2600
TAL-1000	27	16	153	35.6	2420
IGR-40	25	14	146	33.9	2150
IGR-6	25	14	133	34.2	2100
P.striata	26	16	109	36.6	2130
B. circulan	25	15	112	33.3	2060
B. polymyxa	25	14	52	31.4	2110
CD (P=0.05)	1.4	1.5	28	2.9	184

Table 2 Effect of groundnut seed inoculation with *Rhizobium* cultures and PSMs on yield attributes (Pooled data of *kharif*, 1998 and 1999)

Treatment	Pods/ plant	Pod weight/ plant (g)	100 pod weight (g)	Kernel/ pod	100 kernel weight (g)	Shelling (%)
Control	10	11.6	123	2	51.3	74.3
NC-92	12	14.0	138	2	53.9	76.0
TAL-1000	11	13.1	132	2	53.5	75.2
IGR-40	10	11.4	122	2	51.3	73.5
IGR-6	10	11.3	123	2	51.4	73.7
P.striata	10	11.2	122	2	51.7	72.3
B. circulan	9	10.9	123	2	51.9	72.3
B. polymyxa	10	11.2	123	2	51.1	72.4
CD (P=0.05)	NS	NS	5.5	NS	NS	1.8

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Short communication

Studies on relationship among yield components and seed quality traits in sunflower, *Helianthus annuus* L.

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Seed yield is a complex character and the quantitative improvement in it largely depends upon the enhancement of its components and seed quality traits. It therefore, becomes essential to ascertain the association among various quantitative and seed quality traits with seed yield, oil content and field emergence and thereby to formulate guidelines for effective and stable improvement in the crop especially for seed yield and oil content. Germination, seed size and vigour were positively associated, but they had negative relationship with electrical conductivity of seed leachates (Jagadish and Shambulingappa, 1983; Parvathamma *et al.*, 1992). Seed yield was positively affected by number of filled seeds/head, head diameter, stem diameter and test weight (Mogali and Virupakshappa, 1994; Punia and Gill, 1994; Butter and Uppal, 1998).

The experimental material comprised of 72 entries (56 F_1 hybrids, 7 corresponding isogenic maintainer lines (B-lines) in lieu of each CMS line, 8 fertility restorer lines and one standard hybrid check Jwalamukhi) was grown in Randomized Block Design replicated three times to evaluate seed yield and its component traits at the research farm of Seed Technology Centre, CCS Haryana Agricultural University, Hisar during *rabi* season, 1997-98. Each replication with two rows (4.5 m length) for each of the 72 entries, which had a spacing of 60 cm between the rows and 30 cm between the hills within a row. Recommended package of practices were followed to raise to good crop. The remnant seed material of 72 entries was also used to assess seed quality traits as per ISTA Rules (1985) in Seed Testing Laboratory during same season, 1997-98.

The observations were recorded on seed yield and its component traits *viz.*, days to maturity, plant height (cm), number of leaves/plant, head diameter (cm), number of seeds/plant, 100-seed weight (g), filled seed percentage, seed yield/plant (g), biological yield/plant (g), harvest index (%) and seed quality parameters namely, standard germination (%) and oil content (%), seed viability (%), total seeding length (cm), seedling dry weight (mg), seedling vigour index-I, seedling vigour index-II, electrical conductivity of seed leachates (μmhos/cm/seed) and field emergence(%). The correlation among field and laboratory parameters was worked out as per the standard method.

The correlations (Table 1) among seed yield component and seed quality traits implied that the seed yield displayed highly significant positive association with number of seeds/plant (0.92), head diameter (0.75), biological yield/plant (0.68), 100-seed weight (0.64), plant height (0.52), number of leaves/plant (0.50), harvest index (0.48) and filled seed percentage (0.37). These results were in confirmation to the findings of Vanisree *et al.* (1988); Khan *et al.* (1989); Singh and Labana (1990); Chaudhary and Anand (1993); Mogali and Virupakshappa (1994); Punia and Gill (1994) and Gill (1996).

The seed yield was also found to have significant positive correlation with seed quality traits *viz.*, seedling vigour index-I (0.39), seedling vigour index-II (0.33), seed viability (0.28), field emergence (0.27) and standard germination (0.27). Field emergence exhibited highly significant positive relationship with standard germination (0.98), seed viability (0.97), seedling vigour index-I (0.91), seedling vigour index-II (0.87) and total seedling length (0.37), but, showed significant negative association with electrical conductivity of seed leachates (0.89), which is desirable for high seed viability. Similar results were earlier reported by Jagadish and Shambulingappa (1983); Dharmalingam and Basu (1989) and Parvathamma *et al.* (1992).

The seed quality traits as standard germination, seed viability and field emergence were ascertained to have significant positive association with seed yield and its component characters namely oil content, seed yield per plant, number of seeds per plant and number of leaves per plant.

The ultimate seed yield could be enhanced by exercising indirect selection for number of seeds per plant, head diameter, biological yield per plant, test weight, standard germination, seed viability, seedling vigour indices and lower electrical conductivity of seed leachates. The

Table 1 Correlation among seed yield components and seed quality traits in sunflower

	Days to maturity	Plant height (cm)	No. of leaves/ plant	Head diameter (cm)	No. of seeds/ plant	100-seed weight (g)	Filled seed (%)	Seed yield/ plant (g)	Biological yield/ plant (g)	Harvest index (%)	Oil content (%)	Standard germination (%)	Seed viability (T.z.) Test (%)	Total seedling length (cm)	Seedling dry weight (mg)	Seedling vigour index-I	Seedling vigour index-II	EC test (μmhos/ cm/ seed)	Field emergence (%)
Days to maturity	1.00																		
Plant height	0.05	1.00																	
No. of leaves/plant	0.24*	0.61**	1.00																
Head diameter	0.15	0.67**	0.52**	1.00															
No. of seeds/plant	0.09	0.52**	0.52**	0.70**	1.00														
100-seed weight	0.02	0.40**	0.32**	0.54**	0.47**	1.00													
Filled seed percentage	-0.05	0.16	0.14	0.26*	0.24*	0.09	1.00												
Seed yield/plant	0.06	0.52**	0.50**	0.75**	0.92**	0.64**	0.37**	1.00											
Biological yield/plant	0.28*	0.57**	0.62**	0.69**	0.70**	0.40**	0.22	0.68**	1.00										
Harvest index	-0.22	0.10	-0.69**	0.21	0.38**	0.41**	0.26*	0.48**	-0.23	1.00									
Oil content	-0.31**	0.19	0.03	0.02	0.12	0.15	0.01	0.12	-0.05	0.24*	1.00								
Standard germination	-0.15	0.21	0.26*	0.12	0.28*	0.09	0.04	0.27*	0.15	0.06	0.31**	1.00							
Seed viability (T.Z.) Test	-0.14	0.22	0.26*	0.13	0.30*	0.11	0.06	0.28*	0.18	0.05	0.29*	0.98**	1.00						
Total seedling length	-0.14	0.31**	0.25*	0.32**	0.23	0.11	-0.02	0.23	0.15	0.05	0.10	0.37**	0.40**	1.00					
Seedling dry weight	-0.07	0.03	0.01	0.21	0.14	0.11	0.02	0.20	0.09	0.05	-0.07	0.13	0.15	0.47**	1.00				
Seedling vigour index-I	-0.18	0.30*	0.32**	0.24*	0.36**	0.13	0.03	0.34**	0.20	0.09	0.30*	0.91**	0.91**	0.69**	0.29**	1.00			
Seedling vigour index-II	-0.14	0.18	0.21	0.19	0.32**	0.12	0.05	0.33**	0.16	0.09	0.22	0.89**	0.88**	0.50**	0.54**	0.89**	1.00		
Electrical conductivity test	0.20	-0.17	-0.22	-0.07	-0.24*	-0.05	-0.10	-0.24*	-0.07	-0.10	-0.24*	-0.91**	-0.90**	-0.37**	-0.13	-0.83**	-0.81**	1.00	
Field emergence	-0.17	0.20	0.26*	0.10	0.30*	0.08	0.05	0.27*	0.14	0.06	0.33**	0.98**	0.97**	0.37**	0.12	0.91**	0.87**	-0.89**	1.00

*, ** significant at 5 and 1 per cent, respectively

correlation study between seed yield contributing traits and seed quality traits implied that the performance of parent lines and their hybrids for seed yield components could be predicted indirectly by examining their performance for seed quality traits under laboratory conditions. Field emergence could be predicted through standard germination, seed viability, seed vigour indices and electrical conductivity of seed leachates.

Seventy two genotypes comprising of seven CMS lines, eight fertility restorer lines, their 56 F_1 hybrids and one standard hybrid check Jwalamukhi were studies for seed yield components and seed quality traits. The correlation analysis implied that the seed yield had strong positive relationship with number of seeds per plant, head diameter, biological yield per plant and 100-seed weight, while field emergence showed positive association with standard germination, seed viability, seedling vigour indices and lower electrical conductivity of seed leachates which is desirable. The association among seed yield components and seed quality traits also implied that the performance of parent lines and their hybrids could be predicted indirectly for seed yield components by examining their performance for seed quality traits under laboratory conditions.

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Short communication

Effect of different sources of nitrogen on yield and quality of sunflower (*Helianthus annuus* L.)

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India holds a premier position in the global oilseeds scenario accounting for 19 % of the total area and 9% of production. However, the productivity of oilseeds in India is only 935 kg/ha as compared to 1632 kg/ha in world (Hegde, 2000). Of all the oilseeds, sunflower gained importance due to its wider adaptability and a rich source of polyunsaturated fatty acids. One of the critical factors for low productivity of sunflower is imbalanced use of plant nutrients. Among major nutrients, nitrogen is the key input for increasing sunflower production. Major losses of nitrogen through volatilization and leaching are replenished by application of nitrogen through inorganic fertilizer. A fairly effective approach to increasing efficiency to applied N fertilizer will be through conjunctive use of organic and inorganic sources which help in slow mineralization of fertilizer N and its uptake by the crop. In view of the escalating costs and high demand-supply gap of chemical fertilizer, there is a strong need to adopt integrated nitrogen management by judicious combination of organic manure, inorganic fertilizer and biofertiliser to improve soil health and productivity. Hence, the present study was undertaken to know the response of vermi compost, farm yard manure, *Azospirillum* alone and in conjunction with urea on yield and seed quality of sunflower.

A field experiment was conducted during *rabi*, 2000-2001 with sunflower cv. Morden under irrigated conditions on sandy loam soil at Rajendranagar, Hyderabad. The sowing was taken up on 20th November, 2000 with a spacing of 45 x 30 cm. Harvesting was done on 25th February, 2001. The experimental soil was slightly alkaline (pH 7.8), low in organic carbon (0.45) and nitrogen (206.32 kg/ha), medium in available phosphorus (33.4 kg P_2O_5/ha) and potassium (286.93 kg/ha). The experiment was laid out in a randomized block design with three replications and 14 treatments (Table 2). Manuring and fertilization was done as per the treatments. Nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate and muriate of potash, respectively. Seed inoculation was done with *Azospirillum* @ 50 g/ha of seed before sowing. The mixture of 50 g of *Azospirillum* culture plus 150 ml starch was added to 1 kg seed and mixed thoroughly. After mixing, the uniformly coated seeds were dried under shade. All the treatments received a uniform dose of 60 kg P_2O_5/ha and 40 kg K_2O/ha. The entire dose of phosphorus and potassium were applied as basal dose. Urea was however, applied in three equal splits, half as basal and the remaining half applied in two splits at 35 and 55 days after sowing. The nutrient composition of vermi-compost and farm yard manure has been given in Table 1.

Table 1 Nutrient composition of manures used in the experiment

Nutrient	Vermicompost	Farm yard manure
N (%)	1.8	0.50
P (%)	1.5	0.38
K (%)	1.4	0.32
Fe (mg/kg)	1400.3	308.8
Mn (mg/kg)	300.5	189.2
Cu (mg/kg)	69.3	27.2
Zn (mg/kg)	130.4	50.8

The oil content in the seed was estimated by Nuclear Magnetic Resonance (NMR) spectrometer method and oil yield was also calculated. The protein content in the seed was estimated by multiplying the nitrogen content (%) with factor 6.25.

The seed yield was significantly influenced by substitution of recommended dose of inorganic fertilizer N with vermi compost and farm yard manure, seed inoculation with *Azospirillum* in combination with inorganic nitrogen (Table 2.). All the treatments receiving vermi compost in conjunction with urea(T_4 to T_6) recorded significantly higher grain yield compared to 100% RDNF through urea (T_2).

All the vermicompost combinations performed better their corresponding combinations of farm yard manure and *Azospirillum* inoculation with seed. Similar increase in seed yield due to application of vermicompost was reported by Rajkhowa *et al.*(2000), which might be due to steady and increased availability of nutrient from vermi compost resulting in increased uptake of nutrients by plants and finally augmented the seed yield. However, the combination of 50% RDNF through VC+50% RDNF through urea (T_5) recorded the higher seed yield than other

treatments. This might be due to immediate release of N through urea and the later by the mineralization of N through vermicompost resulting in steady supply of nutrients through the crop growth period. The results were in accordance with the findings of Gopal Reddy and Suryanarayan Reddy (1999).

The increases in seed yield by 50% RDNF through VC+ 50% RDNF through urea and 100% RDNF through urea was 87.7 and 25.31%, respectively over control. The lowest seed yield was recorded in control (T_1) followed by *Azospirillum* inoculation with seed (T_7) which was due to no supply of nitrogen in the control and inadequate supply of nitrogen by the *Azospirillum* to an extent of 20 to 25% in sesame as per Natarajan *et al.* (1986).

The oil and protein contents were significantly increased with application of manure and biofertilizer either alone or in conjunction with urea (Table 2). The combination of 50% RDNF through VC+ 50% RDNF through urea (T_5) recorded the highest oil and protein contents, which were comparable with the combination of 75% RDNF through VC+25% RDNF through urea (T_4). The higher protein content was due to more nitrogen content in seed.

Significantly higher oil yield was recorded by the treatment 50%RDNF through VC+50% RDNF through urea (T_5) due to higher seed yield and oil content. The increase in oil yield in 50% RDNF through VC+50% RDNF through urea over control and 100% RDNF through urea was 102.64 and 30.50%, respectively. Bachhav and Sabale (1996) have also reported the positive role of vermicompost on quality parameters in soybean. The results indicated that application of 50% RDNF through VC+50% RDNF through urea increased the yield of sunflower besides improving the quality parameters.

Table 2 Effect of different sources of nitrogen on yield and quality of sunflower

Treatment	Seed yield (kg/ha)	Oil content (%)	Oil yield (kg/ha)	Nitrogen content in seed (%)	Protein content in seed (%)
T_1 : Control	638	38.9	248	2.0	12.2
T_2 : 100% RDNF through urea	956	40.3	385	2.3	14.5
T_3 : 100% RDNF through VC	855	40.6	347	2.4	15.0
T_4 : 75% RDNF through VC + 25% RDNF through urea	1060	41.9	444	2.4	15.3
T_5 : 50% RDNF through VC + 50% RDNF through urea	1198	42.0	503	2.5	15.3
T_6 : 25% RDNF through VC + 75% RDNF through urea	1087	41.9	448	2.4	15.1
T_7 : Seed inoculation with *Azospirillum* (Az)	678	39.5	268	2.1	13.0
T_8 : Az + 25% RDNF through urea	753	39.6	298	2.3	13.8
T_9 : Az + 50% RDNF through urea	822	39.8	327	2.3	14.1
T_{10} : Az + 75% RDNF through urea	961	40.3	388	2.3	14.6
T_{11} : 100% RDNF through FYM	765	40.4	309	2.3	14.4
T_{12} : 75% RDNF through FYM + 25% RDNF through urea	839	40.5	340	2.4	14.8
T_{13} : 50% RDNF through FYM + 50% RDNF through urea	968	40.7	394	2.4	14.9
T_{14} : 25% RDNF through FYM + 75% RDNF through urea	1053	41.0	432	2.4	15.0
SEd±	40	0.2	16	0.03	0.06
CD (P=0.05)	82	0.3	32	0.06	0.12

RDNF = Recommended dose of nitrogen fertilizer; VC = Vermicompost; FYM = Farm yard manure

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Short communication

Performance of safflower, *Carthamus tinctorius* L. based intercropping under various weed management practices in vertisol

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Safflower (*Carthamus tinctorius* L.) is an important annual oilseed crop grown in many parts of world. Importance of safflower has been realized due to its capacity to withstand moisture stress, low input requirement and good average yield under adverse conditions. Being a long duration crop it can be intercropped with short duration crops like chickpea and linseed. Safflower seems to be more sensitive to weed competition than any other crop. During early growth period, weeds caused considerable damage to the crop and it envisaged that infestation of weeds is one major biotic constraints in reducing its production. Earlier findings revealed that in intercropping system weed population is not suppressed but biomass is lowered to greater extent (Kurchania *et al.*, 1996).

A field experiment was conducted at Department of Agronomy, Indira Gandhi Agricultural University, Raipur during *rabi* season of 1998-99 in vertisols. The experimental soil was natural in pH and had low nitrogen (180.25 kg/ha), medium phosphorus (24.82 kg/ha) and high potassium (392.45 kg/ha) contents. The experiment was laid out in split plot design with three replications. The treatments consisted of three intercropping systems namely safflower sole, safflower + chickpea (4:3) and safflower + linseed (4:3) in main plots and four weed management practices namely unweeded check, hand weeding (25 and 45 DAS), alachlor @ 2.0 kg/ha and pendimethalin @ 1.0 kg/ha as preemergence in subplots. Safflower (variety, JSF-1), chickpea (JG-74) and linseed (Kiran) with seed rate of 20, 100 and 30 kg/ha, respectively were sown on 10 December, 1998 with row spacing of 50, 30 and 30 cm for safflower, chickpea and linseed, respectively.

Results revealed that dry matter accumulation, number of branches/plant and capitula/plant were maximum under sole crop of safflower. Whereas, seeds per capitula and 100-seed weight did not show significant effect on safflower, which may be due to genetic character. Among treatments, significantly higher seed yield was obtained in sole safflower (1623.5 kg/ha)followed by safflower + chickpea (1025 kg/ha) and safflower + linseed (986 kg/ha). Higher seed yield in case of sole crop may be due to more number of rows. Similarly in this treatment, plant growth and yield components were also higher than other treatments that is why the yield was higher under sole crop than intercrops. Similar results were also reported by Jadhao *et al.* (1990). Tajane *et al.*, 1995. Net returns and safflower equivalent yield were maximum obtained in safflower + chickpea (4:3) as compared to other treatments whereas, highest benefit: cost ratio was obtained in safflower + linseed (Table 1). Correlation studies revealed that seed yield of safflower was significantly and positively associated with dry matter accumulation, number of branches per plant, capitula per plant and number of seeds per capitula.

Maximum dry matter accumulation and number of branches per plant and capitula per plant were found in case of pendimethalin @ 1.0 kg/ha which was found statistically at par with hand weeding. Highest seed yield was obtained in case of pendimethalin and it was found at par with hand weeding and these both were found superior over other treatments. Net returns and benefit: cost ratio were highest in hand weeding as compared to other treatments. While, correlation studies showed that seed yield was negatively correlated with weed population/m^2 (-0.6361) and dry matter production of weeds (-0.6011) which revealed that lower weed population and dry matter produced resulted in higher seed yield of safflower.

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Table 1 Growth yield attributes, yield and economics of safflower as influenced by intercropping and weed management practices

Treatment	Drymatter accumulation (g/plant	Branches/ plant	Capitula/ plant	Seeds/ capitula	100-Seed weight	Seed yield (kg/ha)	Stover yield (kg/ha)	SEY	Net return (Rs/ha)	Benefit Cost Ratio
Intercropping										
Safflower sole	21.6	13	20	18	6.0	1624	3530	1624	2481	0.49
Safflower + Chickpea (4:3)	18.8	13	19	18	5.9	1025	2563	2868	8633	1.12
Safflower + Linseed (4:3)	18.5	13	17	17	5.9	986	1983	2175	5715	0.72
CD (P=0.05)	0.36	NS	0.77	NS	NS	74	129	3.57	-	-
Weed management										
Unweeded check	15.8	11	15	15	5.2	875	2383	844	1653	0.23
Hand weeding (25 and 45 DAS)	22.7	16	20	19	6.2	1659	2917	1999	7431	0.81
Alachlor @ 2.0 kg/ha as pre-em.	18.4	13	18	17	5.9	11.10	2856	1632	254	0.03
Pendimethalin @ 1.0 kg/ha as pre-em.	23.0	16	22	20	6.5	1824	3492	2483	2989	0.34
CD (P=0.05)	0.30	0.9	0.27	1.09	0.42	173.23	280.28	7.12	-	-

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Short communication

Effect of *in situ* green manuring of intercropped legumes in maize on the performance of succeeding safflower crop

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The benefit of legumes in crop rotations has long been recognized. Green manuring helps in maintaining soil fertility and productivity particularly under intensive cropping. Since, maize-safflower sequence is one of the predominant cropping systems under rainfed conditions of northern transitional zone of Karnataka and both crops being exhaustive, organic recycling through green manuring needs consideration. The wide spacing followed in maize provides an opportunity to introduce a green manure as intercrop. With this in view, an experiment was undertaken during *kharif* and *rabi* seasons of 2000-01 at Main Research Station, Dharwad on medium deep black soil under rainfed conditions. The soil was slightly alkaline in reaction (pH 7.7), medium in organic carbon (0.53%), low in available nitrogen ($KMnO_4$-N 220.4 kg/ha), medium in available phosphorus (Olsen's P 30.5 kg/ha), medium in available potassium (323.5 kg/ha). Experiment was laid out in randomised block design replicated thrice, with eight treatments. In the hybrid maize (cv. DMH-1)-safflower (cv A-1) sequence seven legumes were grown between two rows of maize in 1:2 (maize : legume) row proportion during *kharif* and incorporated at 50 DAS. RDF (100:50:25 kg NPK/ha) was used for maize and green manures (25:50 kg NP/ha). Safflower was sown during October, 2001. For safflower treatments involving intercrops necessary reduction in fertilizer was made based on the supply of nutrients to legume components i.e., 20:0:25 kg NPK/ha. In treatment preceded by sole maize, RDF (40:50:25 kg NPK/ha) was applied. The seed yield of safflower differed significantly due to *in situ* incorporation in maize (Table 1). The maximum seed yield of safflower was obtained due to incorporation of sunnhemp (2300 kg/ha) and *dhaincha* (2272 kg/ha) in preceding maize crop as against lowest seed yield (1242 kg/ha) in non-green manured plot. Balyan and Seth (1989) observed higher grain yield of wheat grown after maize + cowpea (green manuring). Higher seed yield of safflower in green manured plots could be attributed to better expression of yield components. This may be related to increased availability of N in soil due to addition of higher biomass of green manures. The differences in yield components could be inturn related to differences in total dry matter production, which differed significantly at harvest over other treatments due to luxuriant crop growth (Table-1). Oil content of safflower did not differ significantly due to *in situ* incorporation of intercropped legumes, but significantly higher oil yield was observed with sunnhemp green manured plot followed by *dhaincha* and cowpea.

Thus, succeeding safflower crop yield was enhanced through intercropping of sunnhemp or *dhaincha* in 1:2 row proportion in maize planted using 90 x 20 cm spacing and incorporating at 50 days after sowing in a region which favour double cropping.

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Table 1 Yield and yield contributing traits of safflower as influenced by intercropping and *in situ* green manuring in preceding maize

Treatment	Plant height (cm)	Leaf area index	Branches/ plant	Total dry matter production (g/plant)	No. of capsules/plant	100-seed weight (g)	Seed yield (kg/ha)	Oil content (%)	Oil yield (kg/ha)
Maize + Cowpea	65	3	35	181.9	35	6.4	1924	29.5	572
Maize + Horsegram	61	3	31	161.2	31	6.0	1605	28.7	459
Maize + Field bean	63	3	33	171.8	33	6.2	1760	28.7	495
Maize + Greengram	61	3	30	156.5	30	6.0	1508	28.5	428
Maize + Sunnhemp	67	4	40	208.0	40	6.6	2300	30.3	699
Maize + *Dhaincha*	67	4	39	205.4	40	6.6	2272	30.0	666
Maize + Blacksoya	60	3	29	151.4	28	6.0	1350	28.2	382
Sole maize	57	3	27	138.6	27	6.0	1242	27.9	350
CD (P=0.05)	2.8	0.2	3.3	11.3	3.4	NS	171	NS	127

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Short communication

Effect of moisture stress at various physiological stages on growth, yield and nutrient uptake by groundnut (*Arachis hypogaea* L.)

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In Orissa about 50% of total groundnut area is in *rabi* season with the productivity of 1086 kg/ha. The crop is mostly irrigated, but moisture stress at different physiological stages has reported to decrease the productivity of the crop (Pathak *et al.*, 1988; Chapman *et al.*, 1993). Rational application of water will therefore increase the area and productivity of the crop.

Present experiment was conducted during *rabi* season of 1997-1998 at Bhubaneshwar to study the effect of moisture imposed at various physiological stages on growth, yield and nutrient uptake by groundnut cv. AK 12-24. The experiment comprising of seven treatments (Table 1) was conducted in a completely randomised block design with three replications. The soil was sandy loam with pH 5.7 and was low in total N (0.041%), medium in both available P (38.4 kg/ha) and K (154.5 kg/ha). The available soil moisture holding capacity of the soil was 14 cm/m depth of profile. The rainfall received during the crop growing period was 80 mm. Initially a common irrigation of 3 cm was given to all plots to facilitate germination. Subsequently irrigation of 6 cm was given through a Parshal flume at different physiological stages. Six irrigations were applied on the stress day index (SDI) basis which equals to that under non-stressed treatment. In other treatments one irrigation was withheld either at early vegetative (Sv), flowering (Sf), peg penetration, (Spp), pod initiation (Spi) or at pod development stage (Spd).

The plants under non-stressed condition were longest (41 cm) with number of branches (6), dry matter (19.0 g/plant) and leaf area index at 80 DAS (7.4). Lowest shoot height was recorded when plants were stressed at pod initiation and pod development stages, respectively (Table 1). Higher nutrient uptake and utilization with favourable moisture regime under non-stressed condition might have enhanced the growth parameters of the plant. It is in accordance with the findings of Mohan and Rao (1989) and Patra *et al.* (1998). The number of pods/plant (21) and hundred kernel weight (40.2 g) were also significantly higher under non-stressed treatment. The highest shelling percentage (77) was obtained from the treatment irrigated on the basis of stress day index which was at par with the non-stressed treatment. The pod yield was significantly higher (2158 kg/ha) under non-stressed condition. The plants stressed at peg penetration stage produced the least number of pods/plant (16) and lower hundred kernel weight (38 g), whereas, those stressed at flowering stage have the lowest shelling percentage (73.4). All these in turn resulted in the lowest pod yield of plants stressed at peg penetration stage (1642 kg/ha) closely followed by those stressed at flowering (1701 kg/ha) or pod initiation stage (1715 kg/ha). It might be due to production of more number of shrivelled and damaged seeds due to imposition of moisture stress at these stage. This was in conformity with the report of Naveen *et al.*, (1992). Oil content in seeds (46.2%) and oil yield (764.2 kg/ha) were maximum under non-stressed condition while moisture stress either at pod initiation or pod development stage reduced the seed oil content to the minimum of 41.7% compared to stress at early vegetative (45.9%) or flowering stage (43.4%). Lower oil yield of 520.4 kg/ha was obtained in plants stressed at peg penetration stage which was at par with those stressed either at pod initiation or flowering stage . It might be due to reduction in both seed oil content and pod yield under moisture stress condition.

Uptake of N, P and K by the plants receiving irrigation on SDI basis or by non-stressed ones were statistically at par with that by the plants stressed at early vegetative stage. The non-stressed plants on an average removed 67.4, 8.3 and 61.6 kg of N, P and K/ha, respectively at harvest. Moisture stress either at flowering, peg penetration, pod initiation or pod development stage significantly reduced the uptake of all the major nutrients by groundnut plants. Non-availability of optimal moisture in the root zone of differentially stressed plants might have adversely affected the availability, uptake and utilization of soil and/or applied nutrients by the plants during the dry *rabi* season receiving only 80 mm of rains. This is in conformity with findings of (Balasubramaniam and Yayock 1981; Patra *et al.*, 1998).

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Table 1 Growth, yield, yield attributing characters, oil content and uptake of nutrients by groundnut plant at harvest

Treatment	Shoot height (cm)	Branches /plant	Leaf area index at 80 DAS	Dry biomass (g/plant)	Pods/ Plant	100 Kernel Wt.(g)	Shelling (%)	Pod yield (kg/ha)	Haulm yield (kg/ha)	Oil content (%)	Oil yield (kg/ha)	Uptake of nutrients (kg/ha)		
												N	P	K
So	41	6	7.4	19.0	21	40.2	76.5	2158	2572	46.3	764.2	67.5	8.3	61.6
Sv	40	6	7.3	18.2	20	39.4	74.4	1956	2378	45.9	686.7	66.5	8.3	60.5
Sf	37	6	6.7	17.5	17	39.0	73.4	1701	2237	43.5	542.6	62.3	7.1	55.0
Spp	38	6	6.2	17.4	17	38.0	73.7	1642	2274	42.9	520.4	60.0	6.4	53.3
Spi	36	6	6.0	16.6	17	38.8	73.5	1715	2260	41.8	526.9	56.7	6.2	52.4
Spd	37	6	6.0	16.2	19	38.6	74.2	1902	2390	41.7	588.6	55.4	5.9	51.1
Irrigation based on SDI	406	6	7.3	18.7	21	39.4	77.0	2052	2524	44.9	709.5	68.8	8.9	61.1
SEm ±	0.3	-	0.1	0.2	0.3	0.9	0.56	50	30	0.3	18.4	0.6	0.2	0.6
CD (P=0.05)	1.0	-	0.5	0.7	0.9	NS	1.71	154	92	1.0	56.7	1.8	0.6	1.9

Non-stress (So), stress at early vegetative stage (Sv), at flowering (Sf), at peg penetration (Spp), at pod initiation (Spi), at pod development (Spd), Stress day index (SDI)

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Short communication

Honeybee foraging behaviour and pollination studies on niger (*Guizotia abyssinica* Cass.)

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The niger, *Guizotia abyssinica* Cass is an important cross pollinated oilseed either as a mixed or sole crop on marginal or submarginal lands in the states of Madhya Pradesh, Andhra Pradesh, Orissa, Maharashtra, Bihar, Karnataka and Tamil Nadu (Rao and Surayanarayana, 1990). Honeybees were the main pollinators of the niger and represented 91.3% of the total pollinator population, rockbee (*Apis dorsata* F.), Indian hive bee (*Apis cerana indica* F.) and little bee (*Apis florea* F.)being the efficient pollinators (Rao and Surayanarayana, 1990). Chavan (1961), Panda *et al.* (1988) and Rao and Surayanarayana (1990) reported that both open pollination and bee pollination treatments were effective in increasing the seed yield of niger i.e., upto 22-33 % compared to without insect pollination. The present endeavour is a step forward in the same direction.

The studies were carried out at Central Bee Research and Training Institute (CBRTI), Pune, Maharashtra (Lat.18 22' to 18 35' N, Long. 73 50' to 73 55' E) during 1993-94. Niger (cv. Local) was sown following all agronomic practices. Five *A. mellifera* and 20 *A. c. indica* colonies were maintained in the CBRTI apiary. The wild colonies of other *Apis* species, stingless bees (*Trigona iridipennis* L) were also present in the vicinity of the experiment. Studies on floral biology, abundance of foragers, foraging rate/behaviour formed the part of the studies. The crop was raised in plot size of 5 m and the experiment consisted of two treatments, without insect pollination (WIP) and open pollination (OP). Ten plants were randomly selected and bagged in mosquito ring bag nets (100 cm length and 70 cm diameter) just before flowering for WIP treatment taking care that no part of the plant comes in contact with the net so as to avoid any insect contact, whereas in OP the same number of plants were kept open for the visits of pollinators.

The niger plants started blooming about 60 days after sowing. The yellow 2-3 cm long flower heads developed in leaf axil, in a cluster of 2-5. Each head contained about 8 ray florets and 40-60 tubular hermaphrodite disc florets. The anthers appeared united to form the corolla tube. The style extended through corolla tube and the hairy stigma was borne above it. The florets opened and liberated the pollen early in the morning. The style emerged at about mid day and then stigma lobes got separated which curled backwards in the evening.

Apoidea was the major visitors of niger flowers at Pune, constituting 98.9 % of the total flower visitors. Other insect visitors (1.1 %) included some unidentified solitary bees, moths, butterflies, flies and few beetles. Among the apoidea, *A. florea* was the most abundant (84. %) followed by *A. c. indica* (7.9%) and *A. mellifera* (5.7%). The rockbee, *A. dorsata* was however, conspicuous by its absence on niger flowers. Stingless bee, *Trigona iridipennis* L also visited niger flowers but in very low proportions (0.9%). In the marked area (1 x 1 m), on an average, 160 flower visitors/day were recorded, *A. florea* accounted for 134 of them. Rao and Surayanarayana (1990) also reported honeybees to be the main pollinators of niger (91.3%), *A. florea* representing 51.5%, *A. c. indica* 10.3% and *T. iridipennis* very rare. They, however, also reported *A. dorsata* as important pollinator accounting for 29.5% of the flower visitors, which in our studies was not recorded to forage on niger may be due to the prevalence of more rewarding flowers in the vicinity consummate with high energy requirement of this big bodied honeybee.

Among the three Apis species, *A. florea* foraged between 0600-1820 h, *A. c. indica* from 0600 1635 h and *A. mellifera* from 0615-1630 h. *A. c. indica* and *A. mellifera* though started foraging early (0600 and 0615 h) but their foraging also terminated early (1635 and 1630 h, respectively). Honeybees spent relatively longer time in collecting nectar than pollen irrespective of the time of the day (Table 1). *A. mellifera* spent least time (5.2 seconds/flower) to collect pollen whereas, *A. c. indica* spent maximum time (5.5 seconds). *A. florea* on the other hand spent maximum time to collect nectar (7.2 seconds/flower) followed by *A. c. indica* (6.3) and *A. mellifera* (5.7). In general, honeybees visited more flowers to collect pollen (13.3 flowers/minute) than nectar (9.7 flowers/minute) from niger flowers. *A. florea* visited

maximum number of flowers to collect pollen (16.0 flowers/minute) followed by *A. c. indica* (13.0) and *A. mellifera* (11.0). However, all the honeybee species visited 9-10 flowers/minute to collect nectar.

Table 1 Foraging behaviour of honeybees on niger

Date	Time spent/flower (seconds) by					
	A. mellifera		*A.c. indica*		*A. florea*	
	N*	P	Date	P	N	P
September						
15	3.2	5.0	**	6.5	-	7.3
16	5.1	5.9	4.7	4.7	-	7.0
17	5.6	5.5	6.1	5.3	-	6.9
18	6.3	5.2	6.5	6.5	5.4	7.6
20	5.1	5.9	4.7	5.9	5.4	6.4
21	5.8	5.6	4.7	7.7	6.8	8.7
22	5.6	6.8	6.3	7.4	4.1	7.0
Mean SD±	5.2±0.92	5.7±0.55	5.5±0.81	6.3±1.00	5.4±0.95	7.3±0.68
Flowers visited/min	11.0	10.0	13.0	9.0	16.0	10.0

* N = Nectar, P = Pollen ** No observations recorded

Rao and Surayanarayana (1990) also reported honeybees to spent more time in collecting nectar (3-9 seconds/flower) than the pollen (2-3 seconds). Likewise they also reported non-significant variation in *A. florea* foraging which too is in contrast to the present studies.

The studies revealed an increase of 41.80 % in mean seed number and 15.00% in mean seed weight/plant in open pollination (OP) compared to without insect pollination (WIP) in niger crop.

It is therefore concluded that honeybees were the major pollinators of niger, *A. florea* being the most efficient followed by *A. c. indica* and *A. mellifera*. The exposure of the flowers to the honeybees and other insects increased seed set and seed weight considerably.

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Short communication

Status of castor wilt in Nalgonda district of Andhra Pradesh

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India is the largest producer of castor (*Ricinus communis* L.), a non-edible oilseed crop important for industrial uses. Out of world's 1189 thousand mt from 1290 thousand ha, 880 thousand mt is produced in India from 900 thousand ha (Damodaram and Hegde, 2000). Involvement of *Fusarium oxysporum* f. sp. *ricini* (*For*) and *Rotylenchulus reniformis* (Chattopadhyay and Reddy, 1995; Chattopadhyay *et al.*, 1996) with the disease has been reported earlier. Castor area for the district of Nalgonda is 74 thousand ha (Damodaram and Hegde, 2000). A survey of the castor growing areas of the Nalgonda district of Andhra Pradesh state of India was taken up in 19 villages spread over 14 *Mandal*s in seven divisions. The survey was done to ascertain the ground realities involving castor cultivation in general and castor wilt in particular in one of the major castor growing districts of India. Thirteen farmers singly and 20 in seven groups were interviewed during the survey.

The holding size ranged between 0.4-6.0 ha, more often being 1.2-2.0 ha. Castor was found to be cultivated largely under rain fed condition, being occasionally rotated with any of the crops among green gram, horse gram, cowpea, sorghum, groundnut and pearl millet. The post-rainy season was left fallow. Sowing was done mostly with the arrival of rains between 06 and 25 June with the cv. Aruna, any local variety (75 %) or hybrid GCH-4 (25 %). Seed normally was purchased from the nearby towns or self-seed was utilized for 3-4 years. The crop was cultivated on red sandy (*alfisol*) to sandy and light black (*vertisol*) soils. Intercrop with pigeonpea was more prevalent (85%) in castor culture with 4:1 ratio being dominant (60%) while ratios of 2:1 (5%), 3:1 (5%) and 5:1 (15%) were also observed. While 15% of the farmers did not apply any manure or fertilizer, 20% applied only cattle or sheep manure, 65% applied at least di-ammonium phosphate at sowing with 25% of the latter having applied urea as well. The picking started in late December and continued till early March.

Most farmers knew occurrence of wilt. Data collected during the survey through interaction with farmers indicated that 80% of the growers noticed the incidence of wilt every year in their castor crop at different stages. The incidence ranged between 10 and 75% with 20-30% being the observation of most of the cultivators. Late wilt appeared to be more common than early wilt in general. Stunting was noticed in 45% of the castor fields surveyed and nematode infestation symptoms were seen. Even in the presence of soil moisture, patchy plant stands, yellowing of foliage or other symptoms associated with nematode infestation were seen. During field observation, 20% of the roots collected from wilt affected plots showed reniform nematode infestation. Processing of the soil and root samples collected during the survey by plating on modified Czapek's Dox Agar medium (Kalpana Sastry *et al.*, 1993) and by sieving and decantation technique (Cobb, 1918) followed by modified Baermann funnel method (Schindler, 1961), confirmed the high population levels of *For* (up to 43 x 10^3 colony forming units/g soil) and *Rotylenchulus reniformis* (*Rr*, 280/1000 cc). However, farmers attributed stunting to soil sickness problem. Farmers did not observe root symptoms except in one (5%) instance where a lady farmer at village Palwai (Gurrampode) not only described the wilt symptoms clearly on roots but also differentiated them from insect damage. However, farmers were not aware of any management technique against any fungal disease in general and wilt in particular. Due to lack of knowledge about wilt management, no measure was taken to check the disease. Only the above mentioned lady farmer showed enthusiasm in wilt management by reporting use of Gamaxene powder for the purpose. None of the farmers practiced seed treatment or summer ploughing to manage wilt disease. However, some of them believed that more application of inorganic fertilizers led to higher wilt incidence.

Available literature revealed lack of quantitative information on the seed borne nature of the fungal pathogen involved with the disease. To assess the seed borne nature of the pathogen, 400 whole seeds of castor (cv. Aruna) collected randomly from each of 25 lots were plated on modified Czapek's Dox Agar medium (Kalpana Sastry *et al.*, 1993) after surface sterilization with sodium hypochlorite. Ten seeds were placed on each of the Petri plates and were incubated at 25±1°C for 10 days. It was found that the pathogen was present in 10.91% of the seeds.

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Following the same method, seeds (cv. Aruna) collected from wilted castor plants were surface sterilized, plated on the same medium and incubated as mentioned above. Results indicated that the pathogen was present in 62% of such seeds. Components of the seeds collected from wilted castor plants were plated on the same medium following the same procedure. The pathogen was found to be present in 55.3% of cotyledons, 25.3% endosperms and 22.7% seed coats. Thus the seed borne nature of the pathogen could be established.

Using cv. Aruna, experiments were conducted to determine relationship between castor wilt disease incidence (di) and seed yield (y). Correlation analysis indicated that di was significantly ($P < 0.01$) negatively correlated to y. For predicting y, linear equation (Fig. 1) was fitted on di (y = 362.5 – 1.86**di). However, the data further indicated that soil borne population of *For* and *Rr* also influenced seed yield as they possibly provided stress and hence affected castor productivity.

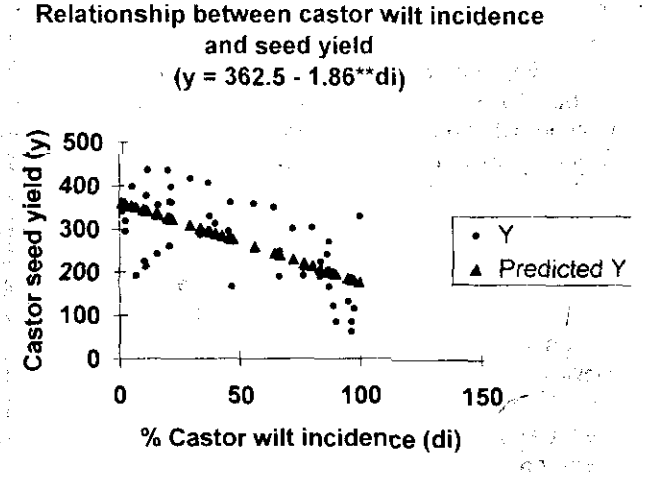

Fig 1 Relationship between castor wilt incidence and seed yield

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Short communication

Incidence of bruchid, *Caryedon serratus* (Olivier) and other insect pests on stored groundnut in Andhra Pradesh*

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Groundnut, *Arachis hypogaea* L. is one of the important edible oilseed crops grown in India. Andhra Pradesh holds second place in groundnut growing states of our country. Groundnuts are generally stored as pods and kernels, which are susceptible to attack by over 100 insect pests (Redlinger and Davis, 1982). Of these, pod borer, *Caryedon serratus* (Olivier) is well known pest of international importance of stored unshelled groundnut and tamarind pods in the world (Mittal and Gupta, 1978; Connsay, 1983). Loss in dry weight to the extent of 20 % (Dick, 1987 b) and 65 % (Kapadia, 1994) in groundnut due to this bruchid infestation has been reported in India. However, it reached up to 60-70 % in Senegal and Zambia (Metakot, 1987) and 80-100 % in Congo (Nkouka, 1991). No systematic survey on the incidence of bruchids in groundnuts has been made. Therefore, survey for the incidence of *C. serratus* and other insect pests associated with stored groundnut in Andhra Pradesh was undertaken and presented in the below endeavour.

The survey on the incidence of bruchid, *C. serratus* and other insect pests was conducted in various groundnut godowns of six districts of Andhra Pradesh *viz.*, Jeedimetla in Rangareddy district; Patancheru in Medak; Talupula and Mallepally in Anantapur; Adoni, Kurnool and Emmiganoor in Kurnool; Kesergutta and Mahboobabad in Warangal and Peddakothapally in Mehboobnagar. Five representative samples of stored groundnut were drawn from each godown by coning and quartering technique as suggested by Dick (1987a) to detect the infestation of bruchid and other insect pests. Samples were repeatedly pooled and quartered to get the final sample of 100 pod size along with the grubs of *C. serratus* and the grubs/ larvae of other insect pests like rice moth, *Corcyra cephalonica* Staint., rust-red floor beetle, *Tribolium castanium* Herbt. and saw-toothed beetle, *Oryzaephilus surinamensis* Linn. were also recorded.

The highest number of grubs (82/100 pod sample) and damage (71.7%) of *C. serratus* was recorded from the godowns of Talupula (Anantapur) while the lowest number of grubs (17/100 pod sample) and damage (16%) was noticed from Peddakothapally in Mehboobnagar. However, the other districts i.e. Rangareddy, Kurnool and Warangal had range of 52 - 77 grubs and 43.3 – 62.3 % pod damage (Table-1 and Fig. 1). Green (1959), Connsay (1983) and Pointal *et al.* (1979) reported this bruchid causing serious damage to groundnut. Dick (1987 b) also reported a total dry weight loss in groundnut kernels up to 20 % due to *C. serratus* in five months old stored groundnuts. Singh and Ansari (1991) found that the intensity of infestation by *C. serratus* on groundnut was less during the pre-harvest period of the crop, which drastically increased during post harvest season. Kapadia (1994) recorded 45 % damage by *C. serratus* in groundnut seeds resulting in 65 % loss in weight of the damaged seeds. The population of *C. cephalonica* (larvae), *T. castanium* and *O. surinamensis* (grubs) was recorded lower as compared to *C. serratus*. Maximum infestation of *C. cephalonica* i.e., 25% was recorded in Emmiganoor in Kurnool district while minimum of 2% in Mahboobabad of Warangal district. Maximum damage i.e., 39% due to *T. castanium* was noticed in Jeedimetla in Rangareddy and minimum of 3% in Peddakothapally of Mehboobnagar. In case of *O. surinamensis*, the highest infestation i.e., 11% was noticed in Adoni of Kurnool while lowest of 3% in Peddakothapally of Mehboobnagar district. However, over all, intensity of *C. serratus* and other insect pests *viz.*, *C. cephalonica*, *T. castanium* and *O. surinamensis* was observed highest in Anantapur district followed by Rangareddy, Kurnool and Warangal while the lowest was found in Mehboobnagar district of Andhra Pradesh.

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* Part of the M.Sc. (Ag.) Thesis, Acharya N.G. Ranga Agricultural University, Hyderabad.

Table 1 Incidence of *Caryedon serratus* and other insect pests associated with stored groundnut in Andhra Pradesh

District (Groundnut godown)		No. of grubs (*C. serratus*)	% damage (*C. serratus*)	No. of insect/100 pods		
				Corcyra cephalonica	*Tribolium castaneum*	*Oryzaephilus surinamensis*
Rangareddy	Jeedimetla	77 (8.7)	58.3 (49.8)	8 (2.8)	39 (6.2)	10 (3.0)
Medak	Patancheru	62 (7.8)	50.0 (45.0)	7 (2.6)	20 (4.4)	6 (2.5)
Warangal	Mahboobabad	52 (7.2)	53.3 (41.2)	2 (1.4)	15 (3.8)	4 (2.0)
	Kesergutta	70 (8.4)	62.3 (52.2)	12 (3.4)	16 (4.0)	8 (2.7)
Mahboobnagar	Peddakothapally	17 (4.2)	16.0 (23.4)	3 (1.6)	3 (1.8)	3 (1.8)
Ananthapur	Talupul	82 (9.0)	71.7 (57.9)	10 (3.2)	29 (5.4)	29 (2.9)
	Mallepally	70 (8.4)	64.0 (53.2)	9 (3.0)	25 (5.0)	6 (2.4)
Kurnool	Kurnool	67 (8.2)	59.3 (50.4)	13 (3.6)	22 (4.6)	5 (2.3)
	Adoni	65 (8.2)	58.3 (49.8)	21 (4.6)	37 (6.0)	11 (3.3)
	Emmiganoor	71 (8.4)	59.3 (50.4)	25 (5.0)	30 (5.5)	10 (3.1)
CD (P=0.05)		8.3	5.0	0.7	0.8	0.6

Figures in parenthesis are square root transformed values

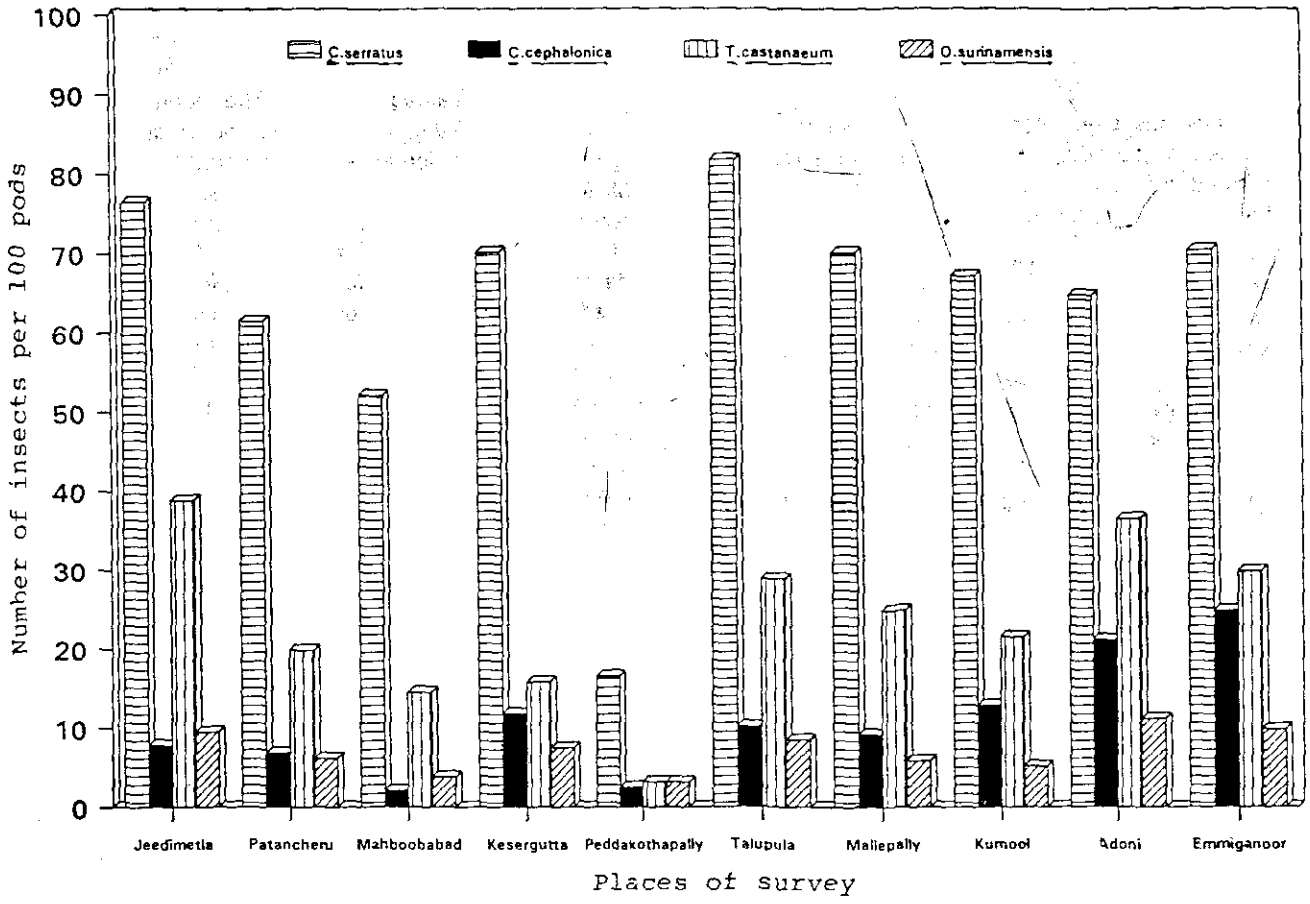

Fig.1 Survey on the incidence of C. serratus indicating other insects with C. serratus

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Short communication

Critical injury level of groundnut leaf miner, *Aproaerema modicella* (Deventer)*

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Need based application of many insecticides for the control of insect pests in an IPM programme requires prior knowledge of damaging threshold levels of pest populations and vulnerable stage of the crop. Groundnut leaf miner (GLM) *Aproaerema modicella* (Dev.) is a key pest of groundnut crop (Channabasavanna, 1957; Krishnamurthy *et al.*, 1962; Reddy, 1982; Tejkumar and Urs, 1983). Several workers conducted various chemical trials for the control of GLM (Vasudevan *et al.*, 1980; Jagtap *et al.*, 1984; Srinivasan and Siva Rao, 1985; Chandramohan and Manoharan, 1986; Muthaiah and Hussain, 1991; Somasekhar *et al.*, 1991; Chandrasekharan *et al.*, 1992). Often the insecticides are applied when the pest population does not need it at a particular stage of crop growth thus leading not only to unnecessary expenditure but creating other problems. The present investigations were, therefore, carried out to determine GLM larval threshold levels and stage of the crop if not cared for a check may bring an adverse effects on yields.

In order to create different levels of GLM populations, an experiment was laid out with varying degrees of protection and exposure of the groundnut variety (TMV-2), under a schedule of insecticidal treatments in a randomised block design during *rabi*, 1995. The number of live larvae/plant were recorded for total of ten plants at random a day before spraying and 1, 4, 7 and 14 days after treatment (DAT). In order to determine the critical time for the control of GLM, relationship between yield and infestation level was established and subjected to regression analysis. Four forms of equations *viz.*, linear, log linear, exponential and quadratic represented by a definite form and shape of the curve were used. The ordinary least square technique was employed to estimate these parameters. Economic injury level (EIL) was worked out after establishing the yield infestation relationships and the gain threshold was estimated by dividing the cost of protection by the market price of the produce.

The results of GLM infestation and yield showed that the difference between the two was not significant up to 64 days of crop age and after 82 days. Hence, the data, wherein regression coefficients were significant are presented in Table-1. The coefficient of determination factor (R^2) considerably increased suggesting that from 64 days of the crop age and onwards upto 76 days, GLM started affecting the crop yield significantly. The highest value of R^2 (0.7859) was exhibited by quadratic forms of equation at 70 days age of the crop indicating it is as the best fit equation amongst all explaining nearly 80% of total variation in the yield due to *A. modicella* attack. Other of equation such as linear, log linear and exponential forms gave marginally lower values of R^2 being 0.7832, 0.7304 and 0.6919, respectively. The regression coefficients for all the four forms of equation were significant at 5% probability.

In order to find out an optimum number of sprays required for getting maximum produce, yield data obtained with variable number of plant protection measures was analysed (Table 2). Perusal of results showed that maximum yield was obtained in the plots which received protection throughout the crop age (1939 kg/ha) and also in plots, which received monocrotophos at 45, 60, 75 DAS (1889 kg/ha). The results again thus confirmed that period between 60 to 75 days of crop growth was most vulnerable and protection was essential to obtain higher yields.

After having determined the best fit relationship with minimum number of three sprays, EILs were determined. The grain threshold value was determined to be 0.775 q/ha. The cost of pest control included cost of total insecticide (2250 ml for 4 sprays) amounting to Rs. 720 @ Rs. 320/litre of monocrotophos; labour charges Rs. 180 and equipment hire charges Rs.30/- and the price of the produce was taken as Rs. 1200/quintal. On the basis of gain threshold, EIL was determined to be 12.00 GLM larvae/plant.

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Table 1 Testing various forms of equations for yield-infestation relationships of GLM

Crop age (days)	Form of equation	Pure intercept (a)	Regression coefficient		R^2
64	Linear	1663.5155	-28.2865		0.0474
	Exponential	7.4105	-0.0252*		0.5104
			(-0.0079)		
	Quadratic	1622.5863	-20.9121	-2.6239*	0.5699
			(44.2156)	(2.2840)	
67	Linear	1694.4622	-30.8055*		0.5882
			(9.74305)		
	Exponential	7.4298	-0.0226*		0.6662
			(0.0069)		
	Quadratic	1676.8959	-14.9401	-0.0815*	0.5940
			(56.9121)	(2.8411)	
70	Linear	1764.5421	-28.34205*		0.78324
			(5.63578)		
	Log linear	7.5291	-0.1609*		0.7304
			(0.03677)		
	Exponential	7.5641	-0.0201*		0.6919
			(0.0056)		
	Quadratic	1757.5423	-24.9641	-0.1299*	0.7859
			(27.42915)	(1.0287)	
75	Linear	1757.0410	-22.2393*		0.7248
			(5.11724)		
	Log linear	7.5346	-0.15038*		0.7249
			(0.03501)		
	Exponential	7.5714	-0.0219*		0.7001
			(0.0046)		
	Quadratic	1781.1335	-34.4956*	-0.4071*	0.7383
			(35.72700)	(1.17213)	
76	Linear	1690.1092	-26.5236*		0.6452
			(5.7518)		
	Log linear	7.4842	-0.13774*		0.6474
			(0.03842)		
	Exponential	7.4326	-0.01562*		0.7249
			(0.00375)		
	Quadratic	1786.3659	-47.15047*	0.6641*	0.7077
			(24.07507)	(0.58633)	

NS = Non-significant; * = significant at 5%

Table 2 Effect of different treatment schedules on the yield of groundnut crop

Treatment with Monocrotophos (0.05%) at different crop ages (days)	Mean yield (kg/ha)
T_1 (45 DAS)	1225
T_2 (60 DAS)	1399
T_3 (75 DAS)	1136
T_4 (45, 60, 75 DAS)	1889
T_5 (45, 60 DAS)	1650
T_6 (45, 70 DAS)	1403
T_7 (60, 75 DAS)	1699
T_8 (Maximum protection) **(35, 45, 60, 75 DAS)**	1939
T_9 Control	888
SEm±	28.67
CD (P=0.05)	85.95

As the R^2 values of four forms of equations were high and significant in the yield infestation relationships at 70 days of crop age, they were used for determining economic injury levels and the results are presented in Table-3. The results showed that EILs differed greatly with the nature of relationship. EILs for linear, log linear and exponential forms of relationship were estimated to be 0.02, 4.8 and 38.6 larvae/plant, respectively. On the basis of pooled data, EIL was 12 larvae/plant. The present EIL values are in conformity with the results of Ranga Rao and Wightman (1991) who gave the arbitrary figures of 15 GLM/plant at 50 days after emergence.

Table 3 Mathematical models of regression equations estimated at 70 DAS

Forms of equation	Crop age (days)	Models
Linear	70	$Y = 1764.54 - 28.34 x$ (R^2= 0.7832)
Log linear	70	$Y = 7.52914 - 0.1690 x$ (R^2=0.7324)
Exponential	70	$Y = 7.56 - 0.02 x$ (R^2=0.6919)
Quadratic	70	$Y = 1757.54 - 24.96 x - 0.12 x$ (R^2=0.7839)

Economic injury levels (EIL) based on different types of yield *infestation relationship*

Equation	Maximum yield Y obtainable when X=1	Yield Y at EIL=Y-GT	EIL
Linear	1736.20	1735.37	0.02
Log linear	7.36	6.53	4.81
Exponential	7.54	6.71	38.55
Quadratic pooled	1732.70	1731.87	5.96
Pooled	-	-	12.00

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Short communication

Phenotypic stability for capsule damage and seed oil content in sesame under micro and macro environments*

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Sesame (*Sesamum indicum* L.) is one of the most ancient edible oilseeds crop cultivated in India. The crop is infested by a host of pests of which sesame leaf roller/capsule borer (*Antigastra catalaunalis* Dup.) and Bihar hairy caterpillar (*Spilosoma obliqua* Walk) are the key pests. A stable genotype gives an insurance against adverse environmental conditions as well as the epidemics of insect-pests and diseases. Therefore, the present study was aimed to assess genotype-environmental interaction for capsule damage and seed oil content and identifying stable genotypes of sesame for these traits.

Nine genotypes of sesame were selected on the basis of better performance in terms of seed yield and its attributes. Different micro and macro environments were created by *kharif* and *rabi* sowings at 20, 30 and 40 cm row spacings under protected and un-protected conditions against insect-pests during 1996 and 1997. The experiment was conducted in a randomized block design with three replications. Each genotype was planted in a single row plot of 3 m. All other remaining recommended agronomic practices were followed during crop period. Observations for capsule damage due to *A. catalaunalis* were recorded on ten randomly selected plants at the time of crop maturity. A representative sample of 20 g seed was drawn randomly from the bulk seed of the ten tagged plants/genotype under different environments and oil % was estimated by NMR. Analysis of mean data for genotype x environment interaction and stability was done following Eberhart and Russell (1966).

Significant g x e and env. + (geno. X env.) interactions for both the traits indicated variable response of genotype to a wide range of environments (Table 1). Significant linear portion of environments for both characters further indicated differences between environments and their considerable influence on these traits. Mandy *et al* (1988) also reported similar results for oil % in sesame. Significant predictable (linear) components and non-significant unpredictable (pooled deviation) component of the g x e interaction for oil % revealed that the performance of the genotypes with respect to oil content were entirely predictable in nature. On the contrary, non-significant linear component and significant non-linear component of the interaction for capsule damage indicated absence of linear response in most of the genotypes and the genotypes differed considerably in stability for capsule damage. Thus, the prediction of performance for capsule damage would be difficult.

Table 1 Analysis of variance for stability of capsule damage and seed oil content in sesame

Source of variation	d.f.	Mean squares	
		Capsule damage by insect-pests (%)	Seed oil (%)
Genotype	8	15.66**	23.72**
Environment	23	92.62**	5.08**
Genotype x environment	184	3.05**	0.63**
Env. + (Geno. X Env.)	207	13.00**	1.12**
Environment (linear)	1	2128.07**	125.93**
Geno. x Env. (Linear)	8	2.81	1.22*
Pooled deviation	198	2.73**	0.49
Pooled error	383	2.25	0.60

*, ** = Significant at 5 and 1% probability level.

Kharif and *rabi* sowings with protection against insect-pests appeared to be the most suitable for higher seed oil content and lower capsule damage. All the nine genotypes were stable for oil content of which TKG 21, MT 15, PTS 3 and RT 274 showed high mean performance (Table 2).

Table 2 Analysis of variance for stability of capsule damage and seed oil content in sesame

Genotype	Capsule damage by *A. catalaunalis*			Seed oil (%)		
	x̄i	bi	s^2di	x̄i	bi	s^2di
RT 274	6.9 **14.6**	1.15	0.85	50.12	1.09	0.13
MT 15	8.2 **16.2**	1.03	2.12**	50.37	0.76	0.09
NT 13-91	6.6 **14.3**	0.94	0.10	49.70	1.08	0.13
NT 8-91	6.1 **13.7**	1.07	0.91	49.22	1.14	0.05
PTS 1	6.2 **14.0**	0.83	0.50	49.50	1.62**	0.08
PTS 3	6.1 **13.5**	0.79	1.11	50.28	1.23	0.17
TKG 21	7.1 **15.0**	0.99	-0.38	50.51	1.09	0.23
Krishna	7.3 **15.0**	1.22*	0.57	47.45	0.74	0.36
Over all mean	6.8 **14.5**	-	-	49.57	-	-
SEm±	0.34	0.11	-	0.15	0.19	-
CD (P=0.05)	0.68	-	-	0.29	-	-

*, ** = significant at 5 and 1 % probability levels, respectively (**Bold** figures are angular transformed values)

Genotypes RT 274, TKG 21, NT 13-91, NT 8-91, PTS 3, MT 15 and Krishna had average stability for seed oil content, thus were found to be desirable under different environmental conditions. Genotype PTS 1 exhibited above average stability for seed oil % proved desirable specifically under un-favourable (poor) environments. While, PTS 2 was below average stable in that respect and found suitable for favourable environments only. Mahdy *et al.* (1988) reported that the introduced genotypes of sesame were stable for seed oil content and promising local genotypes gave average stability in that respect. Likewise all the genotypes except MT 15 were found to be stable due to non-significant deviation from regression, whereas MT 15 was the most unstable genotype due to significant deviation mean square in that respect. Krishna which has average damage in the capsules was below average stable and found to be suitable under favourable growing conditions only. Remaining stable genotypes were unpredictable due to non-significant regression coefficients. These genotypes namely, PTS 3 and NT 8-91 with minimum damage to the capsules and PTS 2, PTS 1, NT 13-91, RT 274 and TKG 21 with average capsule damage need to be analysed further for prediction response and stability in that respect. Earlier, Ahuja (1990) recorded minimum capsule damage due to *A. catalaunalis* in sesame variety Krishna.

Thus, the sowing of sesame during *kharif* and *rabi* seasons and following protection against *A. catalaunalis* would be ideal for both traits in the region. Genotypes TKG 21, MT 15, PTS 3 and RT 274 showed high oil content and appeared the best under fluctuating environmental conditions, whereas PTS 2 appeared better under favourable conditions. Genotype PTS 1 appeared better under less favourable growing conditions. Genotypes PTS 3 and NT 8-91 had lower capsule damage under varied environmental conditions. Krishna with average capsule damage gave considerable high stability under better environments. An improvement in stability of these genotypes through breeding programme would lead to the improvement of the productivity of the crop in the region.

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Short communication

Role of artificial ageing technique on different physiological and biochemical parameters of seed in soybean, *Glycine max* (L.) Merr.

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The life span of seeds of different plant species varies widely when stored under identical conditions. Some seeds are poor storers with relatively shorter period and some are good storers with longer storage period. A third category includes seeds having intermediate storability. However, the differences in seed longevity are not limited to species only, as several studies showed that the principles prevailing at the species level are also applicable at the genotype/variety level, at least in some crops. During storage, some physiological, biochemical and genetic changes occur in the seeds (Roose, 1980). The extent and rate of deterioration within a seed lot at the time of storage reflect the pre-storage history of the seed lot *viz.*, weathering, time of harvest, harvesting procedure, drying, handling and conveying, treating and so on. Since, the pre-storage history of seed lots differs their physiological conditions, hence suitability for storage also differs markedly. There is inverse relationship between seed vigour and seed deterioration. Vigour decreases as the level of deteriorative process is greatly increased by exposing them to very adverse levels of the two most important factors influencing the rate of deterioration: temperature and relative humidity (Delouche and Baskin, 1973). The accelerated ageing test was first developed to measure the relative storability of seeds (Delouche, 1965; Delouche and Baskin, 1973). This test has been found to be correlated with seed vigour in soybean (Byrd and Delouche, 1971). The present study was conducted to ascertain the effect of artificial ageing on different physiological and biochemical parameters of seed quality in soybean.

The present study was comprised of two varieties of soybean *viz.*, Bragg and PK 416. Further, twelve seed lots of these two cultivars were created by artificial ageing at 45 °C and 100% RH for different periods of time ranging from 0-60 hours. All the seed lots were studied for germination percentage, vigour index, respiration rate (μlO_2/seed/h), dehydrogenase activity test, electrical conductivity (μ m hos/cm/seed), pH of the seed exudates and emergence rate index.

Germination was tested in three replicates of 100 seeds in each lot as per ISTA Rules (1985). Normal seedlings were counted according to the rules for testing seeds (Association of Official Seed Analysts, 1978) and expressed as the per cent germination. The vigour index was calculated by multiplying the germination percentage with seedling length.

Respiration rate (RR) was measured by Gilson Differential Respirometer. Ten seeds were soaked in 50 ml. distilled water for six hours. Five seeds were placed in a reaction flask having two ml of distilled water outside and 0.2 ml KOH (10%) inside the central well. The reaction flasks were placed in the water bath and subjected to shaking of 78 oscillations/min for 30 minutes. Readings were taken three times at an interval of 30 minutes. Respiration rate was expressed as oxygen absorbed (μlO_2/seed/h) at standard temperature and pressure. The dehydrogenase activity (DHA) test was determined following the method of Kittock and Law (1968). For electrical conductivity test (EC), three replications of 50 normal seeds of known weights were soaked in 500 ml beaker containing 250 ml of distilled water and kept at 25°C. Electrical conductivity was measured after 24 hour with Conductivity Meter and expressed as (μ m hos/cm/seed). The pH exudate test were based on the principle that as the seed deterioration progresses, the cell membrane becomes less rigid and more water permeable, allowing the cell contents specially acidic and hydrogen ion to escape into solution with water resulting in the lower pH. One hundred seeds of each lot were allowed to imbibe in distilled water with pH 7.0 ± 0.01 for 20 hours at 25°C. After imbibition, the pH was determined using a digital pH meter. The plastic cap protector was used as the container for exudates due to the small amount of the material. For the field emergence test, 400 seeds of each seed lots were planted in the field. sowing was done in a Randomized Block Design with three replications. Emergence was recorded daily and evaluated as emergence rate index as per Maguire (1962). The observations recorded in both the field and laboratory were subjected to statistical analysis.

The results revealed that the original seed lots were of high quality as indicated by germination percentage, vigour index, respiration rate, dehydrogenase activity, electrical conductivity of seed leachates, pH of the seed

exudates and emergence rate index (Table 1). As the ageing period increased, the quality of the seed deteriorated. The respiration rate and dehydrogenase activity also decreased as the ageing period increased but it decreased more rapidly after 36 hours of ageing period. Similar results were also reported by Verma *et al.* (1997). The seed lots differed significantly for the values of conductivity. Poor membrane structure and leaky cells are usually associated with deteriorating and low vigour seed. It is interesting to observe that as the ageing period increased, conductivity also increased. Similar results were also reported by Ram and Wiesner (1988) in wheat and Verma *et al.* (1997) in berseem. The results showed that the pH of the seed exudates and emergence rate index decreased as the ageing period increased.

Results revealed that original seed lots were of high quality but it started to deteriorate as the ageing period increased. Electrical conductivity increased as the ageing period increased. The germination percentage, seedling vigour index, respiration rate, dehydrogenase activity test, pH of the seed exudates and emergence rate index decreased as the ageing period increased. The results suggested that seed vigour test is more sensitive index of seed quality than the standard germination test.

Table 1 Mean performance of different seed vigour parameters and emergence rate in soybean [*Glycine max* (L.) Merr.]

Cultivar	Ageing period (h)	Germination percentage	Vigour index	Respiration rate (μlO_2/seed/h)	Dehydrogenase activity test	Electrical conductivity (μmhos/cm/seed)	pH of the seed exudates	Emergence rate index
Bragg	12	81.5	1026.9	14.6	0.9	7.6	6.5	32.5
	24	72.8	819.0	14.0	0.9	8.2	6.0	28.5
	36	68.5	753.5	11.5	0.7	9.6	5.6	24.5
	48	60.3	590.5	8.0	0.7	12.5	4.8	20.6
	60	45.5	409.5	6.2	0.6	15.0	4.3	18.4
	Control	84.0	1075.2	14.7	0.9	7.4	6.5	35.5
PK 416	12	83.0	1070.7	15.2	0.9	7.0	6.6	34.5
	24	78.3	974.2	14.7	0.9	8.1	5.8	30.7
	36	70.0	801.5	12.3	0.8	9.2	5.9	26.5
	48	63.0	674.1	8.9	0.7	11.8	4.9	22.8
	60	49.0	480.2	6.5	0.6	14.5	4.4	19.8
	Control	86.0	1118.0	15.5	0.9	6.8	6.7	36.0
CD (P=0.05)		4.2	344.9	0.5	0.02	0.37	0.08	0.31

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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.

The Indian Society of Oilseeds Research had organized a National Seminar on **"Oilseeds and Oils : Research and Development Needs in the Millennium"** during February, 2 -4, 2002 at the Directorate of Oilseeds Research, Rajendranagar, Hyderabad. Forty lead papers presented at this seminar under twelve thematic sections are presented in the volume under review, along with the inaugural presentation "Oilseeds on a Balance" by Dr. Mangala Rai, Deputy Director General (Crop Sciences), Indian Council of Agricultural Research, New Delhi.

For setting the pace and pattern of discussions at the seminar, there could have been no better presentation than the one on "Oilseeds on a Balance" by Dr. Mangala Rai. In the spectrum of coverage of the multifaceted vegetable oil economy, or critical depth of analysis, this presentation is incomparable. Particularly, the 22-point future strategy suggested is invaluable.

The second item of strategy suggested *viz.*, horizontal area expansion of oilseeds, is rather debatable, as the expanded area is bound to be marginal and under-productive, since any intensification of inputs to oilseeds area only weans it away to more remunerative crops. While this might improve the village or rural level economy, its contribution to national vegetable oil economy is not likely to be commensurate with the efforts involved in such horizontal expansion. The author, very justifiably, is very laudatory in his comments on the achievements of the Technology Mission on Oilseeds. An added remark that the TMO operational period also coincided with favourable monsoon and market conditions, would have lent "balance" to this appreciation. Planners, programmers and project implementers in oilseeds research and development owe, Dr. Mangala Rai, a debt for *this 36 page 'tract' on "balancing oilseeds". For a long time to come it is bound to be their reference and resource* material.

The first thematic presentation is on "bio-diversity", three papers, two from NBPGR/IPGR and one from ICAR headquarters. The first two are rather narrative in nature recounting the organizational structures at the national and international levels involved in the assessment of bio-diversity and regulations in its exploitation, with particular reference to oilseeds crop species. The third paper by Dr. Prakash Tiwari has more specific reference to the major Indian oilseeds. The "pre-breeding" steps by the NBPGR to release genetic variability in *sesamum* referred to in page 78, however, does not figure on pages 41 & 42 of the first paper recounting activities of IBPGR/IPGRI. Dr. Tiwari has not included the work on the utilization of *S. prostratum* in evolving lines resistant to *Antigastra*, on page 72 para No.2, dealing with the utilization of wild species in sesame improvement. His observations on the evolution of self-compatible types in the *Brassica campestris* group is interesting. However, it is rather unlikely that a macro mutation for seed colour and its subsequent selection could change the compatibility reaction. It has already been shown that more important traits like the dehiscence pattern in the teradynamous anther whorls is more related to compatibility types. Linkages between characters involved in the mating system, and recombination suppressors like chromosomal inversions are suspected to be involved (Rajan, 1958, 1966, 1970 and 1972). It is rather surprising that except for a passing mention in Table 2 on page 58, none of these three papers refer to the significance of the collection, preservation and evaluation of land races and primitive cultivars.

The second theme deals with the diversification of production systems. One paper each is on oilseeds in rice fallows, in non-traditional areas and seasons, and the diversification of cropping sequences. As to be expected the results and recommendations are highly location and/or season specific. It is surprising that no mention is made of photo-thermo sensitivity of the oilseed crops to be exploited in rice fallows or canopy-, and root- system characteristics in intercropping systems. Concept of varietal blends as a non-traditional production system is not considered at all.

The single paper on the third theme on genetic engineering of oilseed crops for the management of biotic stress, reviews the work done mostly outside India. Its potential for the Indian situation is not evaluated, except for a table listing the major pests of oilseed crops on page 113.

The exploitation of heterosis and the development of hybrid oilseeds are discussed in four papers constituting the fourth theme. Dr. S.S. Banga deals extensively the issue of heterosis in sunflower, rapeseed-mustard and castor. The title appears to be misleading since no "quality" issues are discussed. The potential use of the self-incompatibility gene in the *Brassicas* is emphasized. "Self-incompatibility is dominant over self-compatibility" (page 123) appears to be an oversimplification of a complex phenomenon. The implication of the statement "absence of economic system to enforce selfing in inbred lines" is not clear to the reviewer. Dr. Banga critically evaluates the situation in castor improvement through hybrids. It is curious that the only oilseed crop in which hybrids are under commercial large scale cultivation, *viz.*, castor, the genetic control of the pistillate condition, whether 'N' or 'S' or 'NES', is indeed very unstable and complex attended by a spectrum of sex reversals. Dr. V.D. Patil discusses the problem of using genetic male sterility in producing safflower hybrids. Early identification of sterile plants seems to be the main bottleneck. It may be mentioned here that in sunflower the early Romanian hybrids were based on genic male sterility and seedling markers. The comparison between two safflower hybrids DSH-129 and MKH-11 against variety A-1, given in Table 2 on page 147, does not inspire confidence in hybrids. The gains appear to be marginal (10%). The two other papers one on role of private sector and the other on apomixis are of general nature are not specific to oilseeds.

Dealing with input use efficiency (Vth theme) Drs. Biswas and Das make out a well documented and substantiated case for the application of IPNS to oilseed crops. At least, in the case of groundnut with an average yield of 22.2 q/ha and cost benefit ratio of m 10.5, the significance of IPNS can not be over emphasized. But, apart from reinforcing well proven benefits, the major problem in fertilizer use, *viz.*, the resource investment needed on the part of the average farmer, has perhaps been considered out of the purview of the paper but nevertheless very important.

Likewise, Dr. Agnihotri has critically analyzed the pesticide residue problem in oilseeds. "Most of the pesticides are non-polar in nature and have tendency to partition and accumulate in the oil. Once in the oil the residues do not degrade easily". It is a pity that when pesticide recommendation for oilseeds were made under the insecticide Act of 1968, no residue data were required for registration. In soil application of insecticides to oilseed crops grown under non-irrigated conditions (which is generally the case) more residues of insecticides are to be anticipated, this is a matter of concern. The paper also reports on several residue estimates by different laboratories under national Institutes and Universities, presumably by internationally accepted and standardized analytical methods. Whether these have any legal validity, in the absence of national standards, for purpose of regulatory enforcement, is to be examined.

Weed management in oilseed crops is discussed in detail by Dr. N.T. Yaduraju. Besides conventional physical, cultural, biological and chemical weed control, the author also refers to the potential of allelopathy and evolution of herbicide resistant varieties of oilseed crops, and advocates transgenic methods to be involved. Although, mentioned only *en passant* the implications of this suggestions are to be carefully evaluated. Current public resistance to, and rejection of GM food crops is well known. If herbicide resistant weeds are a consequence of this step, then it would be most undesirable.

The sixth theme on "Biotic Stress Management" is represented by three papers, one each on integrated pest management, biological control of pests and diseases, and lastly disease and their management-new paradigm. The paper by Drs. Bakhetia, Singh and Chander is a comprehensive and exhaustive one on IPM in oilseeds. It runs to 34 pages and cities about 164 references. Nevertheless, genetically pest resistant varieties receives only a passing one sentence reference on page 185, and as a mandatory thrust area for various oil crops at the end of the paper. But, the authors themselves admit, in page 205, that "pest resurgence and insecticide resistance ---- quite alarming".

In the paper by Dr. Kolte, the reviewer is unable to comprehend what is meant by term "Breeding for disease management" on page 247. The concept of pathogen-derived-resistance is a novel one. The author does not comment on whether the resistance so derived is heritable. In the section on thrust areas mention is made of "Genetic enhancement of quantitative genes for disease *Alternaria* resistance", page 252. This is not likely to be easy since such quantitative genes are yet to be identified.

The seventh theme deals with abiotic stress management. The first of three papers, by Dr. Agarwal on model is an excellent general survey non-specific to oilseeds. An excellent review of salinity and its management in oilseed crops is given by Dr. Kumar. He lists specific growth and adaptive traits relating to salinity, tolerant cultivars and growth stages sensitive to salinity. Oilseeds can also play an important role in the cropping of reclaimed soils. His reference to *B. napus, carinata* and *tournefortii* as "amphi tetraploids" on page 268 needs to be verified (amphidiploids?).

"Increasing drought resistance in some oilseed crops - options and approaches" by Dr. Udaykumar and associates presents not only an excellent review, but a critical analyses of reaction to drought by oilseed crops. Since oilseeds are more often subjected to drought than otherwise, this paper is extremely valuable to oilseed researchers. A distinction is made between drought resistant genotypes (DRG) and genotypes that possess merely drought resistant traits (DRI), a distinction not generally recognized by the breeder. The authors believe that moderate yield gains obtained by breeding under rainfed conditions, is more by unconscious selection than by design. Intrinsic tolerance at the genetic varieties at the cellular level for abiotic stress is rather marginal at the infra-specific level and more pronounced at the inter specific level. Multigenic variability for avoidance traits appears to be significant. This is a pointer to the breeders. However, screening segregating populations could be problematical. The authors also refer to two important evaluation techniques that could be useful to the breeder. The carbon isotope discrimination technique for the estimation of water use efficiency, and induction stress technique to assess stress response (Temperature Induction Response). Since material identified as thermo tolerant by this technique also showed resistance to osmotic and drought stress attributed to protection offered by Late Embryogenerics Abundent (LEA) proteins, the relevance of this technique to breeding efforts is apparent. This nondestructive technique also facilitates advancement to segregating generations, and the seedling nature of the test enables handling of large populations. The genetic and breeding slant given this paper from a plant physiological laboratories is commendable and worth emulating. This paper is a must-reading for all oilseeds breeders.

The eighth theme of quality improvement consists of five papers. It is comforting to know from the paper of Agnihotri and Kaushik, there need be no panic from health considerations due to erucic acid and glucosenolates by the mustard oil consuming communities in India. The authors also evaluate analytical and screening methods in quality improvement. The potential and need for evolving plants with specific fatty acid composition for industrial purposes, are highlighted.

Dr. Ghafoorunnisa, in her paper on human nutritions, advises to avoid excess intake of any one fatty acid. Two or more oils could be used in cooking, not blended, but alternately. However, rice bran oil contains about 2% alpha linolenic acid and good linoleic - alpha linolenic acid ratio. At the household level the use of hydrogenated vegetable oil in cooking is not advised, due to high levels of saturated fatty acids as also trans fatty acids.

Dr. Kaimal in his paper draws our attention to some recent technological advances in the oil extraction and processing.

The paper by Dr. Nawab Ali and that by Harsh Maheswari on soybean is quite revealing. The annual production of soybean @ 5.5 million tonnes is hardly sufficient to keep the soybean processing units going with an installed capacity to handle 15 million tonnes per annum. 85% of meal is exported and of the 15% domestically consumed, 10% is used in feed industry and only 5% in food industry. Its contribution to vegetable oil pool is only 12% (8.7 lakh tonnes out of a total of 7.1 m tonnes). It would appear that soybean cultivation in India is mainly to support export trade of the meal and much less to contribute towards vegetable oil and food items. This, inspite of nearly three decades of campaigning for the use of soya products as food items.

In the paper "Quality seed production and processing : Issues and Strategies", the reviewer was looking for discussion of problems in seed production and possibilities of evolving special agronomic techniques for the production of seeds for planting. But, the paper mainly concentrates on improved implements for general crop production, a topic important by itself and deserves a separate theme section.

The tenth theme dealing with "Diversified sources of oil" has one paper each on coconut, oil palm and cotton seed. In the case of coconut, a well established traditional crop, it is the high domestic prices of oil compared to other vegetable oils, that is the bottleneck. While in the case of oil palm, a crop being attempted to be introduced, with high subsidies, it is the cheap imports that will kill any attempts at expansion. Intellectual property rights and TRIPS regulations are not going to make it easy to introduce productive germplasm from aborad.

In cotton seed, as indicated by Dr. Momin, we have a tragic case of vegetable oil being produced by the country, but not utilized. Along with rice bran, this can yield to the tune of 2 million tonnes of vegetable oil. This has the potential to totally eliminate nearly 1.5 million tonnes of oil imports (mainly palm, soybean and sunflower oils) valued at Rs. 3000 crores. The problem appears to be more organizational than technological.

In the eleventh theme on transfer of technology Dr. N.K. Sanghi has made a very forceful case for the farmer participation in the transfer of technology. The paper is not oilseed specific, but a valid for these crops also. His arguments in favour of extension work carried out by farmers themselves are impressive. The picture would have been more complete if it had considered the reciprocal situation *viz.*, "on-farm research" where the research-, not extension, workers finish their final technological recommendations by testing in the farmer's fields, not finished recommendations or packages, but those in terminal stages in the pipeline. This enables the primary producer to select the technology to suit his own requirements.

The last theme relates to policy interventions and is covered by six papers. The reviewer does not feel competent to comment on these, but would like to ask the question, "Is there a national policy for vegetable oils?".

The production values of this publication are excellent. Ten out of forty papers do not include references. In some cases the organization of the Tables included needs to be improved, particularly with reference to column and row headings. A list of acronyms and other abbreviations used, suitably expanded would have facilitated easy understanding.

The Indian Society of Oilseeds Research is to be warmly complimented for bringing out this volume which should be an invaluable addition to libraries and personal books collection of research, development and planning workers on oilseeds.

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Contents

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