OIL CROPS: SESAME AND SUNFLOWER SUBNETWORKS

PROCEEDINGS OF THE JOINT SECOND WORKSHOP HELD IN CAIRO, EGYPT,
9–12 SEPTEMBER 1989
The International Development Research Centre is a public corporation created by the Parliament of Canada in 1970 to support research designed to adapt science and technology to the needs of developing countries. The Centre's activity is concentrated in six sectors: agriculture, food and nutrition sciences; health sciences; information sciences; social sciences; earth and engineering sciences; and communications. IDRC is financed solely by the Parliament of Canada; its policies, however, are set by an international Board of Governors. The Centre's headquarters are in Ottawa, Canada. Regional offices are located in Africa, Asia, Latin America, and the Middle East.

Le Centre de recherches pour le développement international, société publique créée en 1970 par une loi du Parlement canadien, a pour mission d'appuyer des recherches visant à adapter la science et la technologie aux besoins des pays en développement; il concentre son activité dans six secteurs : agriculture, alimentation et nutrition; information; santé; sciences sociales; sciences de la terre et du génie et communications. Le CRDI est financé entièrement par le Parlement canadien, mais c'est un Conseil des gouverneurs international qui en détermine l'orientation et les politiques. Établi à Ottawa (Canada), il a des bureaux régionaux en Afrique, en Asie, en Amérique latine et au Moyen-Orient.

El Centro Internacional de Investigaciones para el Desarrollo es una corporación pública creada en 1970 por el Parlamento de Canadá con el objeto de apoyar la investigación destinada a adaptar la ciencia y la tecnología a las necesidades de los países en desarrollo. Su actividad se concentra en seis sectores: ciencias agrícolas, alimentos y nutrición; ciencias de la salud; ciencias de la información; ciencias sociales; ciencias de la tierra e ingeniería; y comunicaciones. El Centro es financiado exclusivamente por el Parlamento de Canadá; sin embargo, sus políticas son trazadas por un Consejo de Gobernadores de carácter internacional. La sede del Centro está en Ottawa, Canadá, y sus oficinas regionales en América Latina, África, Asia y el Medio Oriente.

This series includes meeting documents, internal reports, and preliminary technical documents that may later form the basis of a formal publication. A Manuscript Report is given a small distribution to a highly specialized audience.

La présente série est réservée aux documents issus de colloques, aux rapports internes et aux documents techniques susceptibles d'être publiés plus tard dans une série de publications plus soignées. D'un tirage restreint, le rapport manuscrit est destiné à un public très spécialisé.

Esta serie incluye ponencias de reuniones, informes internos y documentos técnicos que pueden posteriormente conformar la base de una publicación formal. El informe recibe distribución limitada entre una audiencia altamente especializada.
OIL CROPS:
SESAME AND SUNFLOWER SUBNETWORKS

Proceedings of the Joint Second Workshop
held in Cairo, Egypt, 9–12 September 1989

Edited by
Abbas Omran
Technical Adviser, Oil Crops Network

Organized by
Agricultural Research Centre, MOA, Giza, Egypt
and
International Development Research Centre, Canada

Sponsors
Food and Agriculture Organization, Industrial Crops and European Office, Rome
International Bureau of Plant Genetic Resources, Rome
International Development Research Centre, Canada

Scientific and Organizing Committee
Dr Abbas Omran
Dr Badr A. El-Ahmar
Dr Eglal Rashed
Material contained in this report is produced as submitted and has not been subjected to peer review or editing by IDRC Communications Division staff. Unless otherwise stated, copyright for material in this report is held by the authors. Mention of proprietary names does not constitute endorsement of the product and is given only for information.
In September 1989, the Sunflower and Sesame subnetworks held their bi-annual meetings in Cairo, Egypt. The meetings were well attended and papers, presented in these proceedings, provide a very informative overview of some of the cropping systems, management practices, production constraints and research highlights for both crops in several countries.

Chronic edible oil deficit is a major problem facing many developing countries in Africa and Asia where most countries are forced to import large quantities to satisfy the requirements of their growing populations. With the present rates of population increase and the improvement of nutrition standards it is likely that the consumption of edible oil will rise over the years, increasingly drawing on scarce foreign exchange for the importation of this vital food staple. For this reason, several countries have opted to increase self-sufficiency in edible oil.

Production deficits are due to a number of factors, among which neglect in oilcrops research, in both developed and developing countries has been a major one. This is particularly true for minor crops such as sesame. In the context of the IDRC oilcrops network, initiated in 1981, the interchange of information and the sharing of results between scientists have proved to be very useful and beneficial for the generation of scientific knowledge and the stimulation of research in this important area. It is hoped that conclusions and recommendations of this meeting will stimulate further research and development in the future.

A second important reason for limited national production has been the exceptionally low levels of world prices for oils and fats in the 1980’s and the comparative advantage of importation over production for developing countries. The description of a case study using a system’s approach to analysis the Vegetable Oil/Protein System of Kenya has stirred much interest during the Cairo meetings and it is hoped that similar work can be carried out in other countries in the future.

The Cairo meetings will also unfortunately be remembered as the one which has witnessed the diagnostic of the fatal disease of late Dr. Hiruy Belayneh, Chairman of the Brassica Subnetwork. We will all regret his absence.

On behalf of IDRC and of all participants, I would like to thank the Government of Egypt for its hospitality, the organizers for the excellent arrangements and all those who contributed to the success of these meetings by their presentations and discussions.

Eglal Nached,
Senior Program Officer,
IDRC, Cairo
CONTENTS

PAGE

Forward ................................................................. iii
List of Participants ..................................................... vi
Introduction ............................................................. ix

Part 1. SESAME SUBNETWORK - II

Sesame Genetic Resources: Collection, Evaluation and conservation.
AMRAM ASHRI .......................................................... 2
Sesame Research in the Sudan.
MOHAMED EL-HASSAN AHMED ........................................ 10
Progress in Sesame Research in Ethiopia.
HIRUY BELAYNEH, BULCHA WEYESSA AND ELIAS URAGE ........ 13
A Brief Outline of Sesame (Sesamum Indicum L.) Research in Tanzania.
J.Y CHAMBI AND E.M. KAFIRITI .................................. 17
Scope of Sesame (Sesamum Indicum L.) in Pakistan.
MUHAMMAD ASLAM, MASOOD A. RANA AND M. SIDDIQUE MIRZA.. 21
Status of Sesame as Oilseed in Bangladesh.
M.A. KHALEQUE AND HASINA BEGUM ................................ 24
Problems and Progress of Sesame Production In india.
S. THANGAVELU, G. KANDASAMY, M. SIVANADAM AND R.K.
MURALI BASKARAN ....................................................... 27
Pests of Sesame and their Control.
S. THANGAVELU ......................................................... 31
Review and Prospects on Sesame Production in China.
TU LICHUAN .............................................................. 41
Sesame Irrigation in Egypt.
AHMED MOHAMED EL-WAKIL ......................................... 44
Agronomic Studies on Growth, Yield and Yield Components of Sesame.
SAMIR TAHA AND MOHAMED EL-SROGY ............................ 48
Sesame Research and Progress in Egypt.
NESSIM R. GUIRGUIS .................................................. 52
Root-Rot and Wilt Diseases of Sesame in Egypt.
A.A EL-DEEB ........................................................... 55
Highlights on Improving Production of Sesame in Egypt.
A.F. IBRAHIM ............................................................ 59
Evaluation of Some Cultivars and Promising Strains of Sesame (Sesamum indicum L.).
A.A. EL-SHIMY AND M.Z. EL-HIFNY ................................. 61

Part 2. SUNFLOWER SUBNETWORK - II

Use of Wild Species in Sunflower Breeding.
DRAGON SKORIC .......................................................... 70
Sunflower Breeding: General Objectives and Recent Advances.
JOSE FERNANDEZ MARTINEZ ......................................... 95
Progress in Sunflower Research in Ethiopia.
HIRUY BELAYNEH ..................................................... 102
Sunflower Adaptation in Morocco.
S. QUATTAR, T.E. AMEZIANE AND A. BAIDADA ..................... 106
Effect of Maturity Stages and Desiccant Application on Yield, Oil Content and Oil Quality of Sunflower.
MASOOD A. RANA, CHAUDHRY A. OZAIR, M. AYUB KHAN AND SHAFIUULLAH .................................................. 114
Trends and Strategy of Sunflower Production in Pakistan.
MASOOD A. RANA .................................................................. 125
Sunflower Production in India - Problems and Prospects.
M. RAI AND P.S. BHATRANGAR ............................................ 128
MANGALA RAI ....................................................................... 135
Status of Sunflower as Oilseed in Bangladesh.
M. A. KHALEQUE, AND S.H. MIRZA .......................................... 142
Some Aspects Towards Overcoming Vegetable Oils insufficiency in Egypt: Production of Sunflower and its Improvement in Suez Canal Region.
ABDEL-FATTAH MOHAMED ABDEL-WAHAB .............................. 144
SALWA I. EL-MOHANDES .................................................... 155
Sunflower Research and Production in Egypt.
BADR A. EL-AHMAR .................................................................. 158
Performance of a New Synthetic Sunflower Stock Developed From Local and Introduced Germplasm and Further Improvement Via Population Improvement Method.
R. SHABANA ........................................................................ 163
Response of Sunflower and Associated Weeds to Some single and Tank Mixed Herbicides.
A.F. IBRAHIM, Z.R. YAHIA, H.R. EL-WEKIL AND E.D. ABUSTEIT ................................................................. 167
Report on Sunflower Production In Dakahlia Governorate, Egypt.
S.E. EL-KALLA ........................................................................ 168
Studies of Diallel Cross in Sunflower (Helianthus annuus L).
KHALED HAMMAD .................................................................. 171
Effect of Some Intercropping Patterns of Sunflower/Soybean on Yield, Yield Components and Land Usage in Egypt.
M.A. MADKOUR ..................................................................... 175
Sunflower Diseases in Egypt.
ARAFA A. HILAL .................................................................... 180

Part 3. GENERAL

The Vegetable Oil/Protein System Program: The Kenyan Experience.
CARLOS ZULBERTI .................................................................. 184
Microbial Control of Lepidopterous Pests of Oilseed Crops.
H.S. SALAMA ......................................................................... 203
Sunflower and Sesame Research in the Philippines.
NENITA M. TEPORA .............................................................. 206

Part 4. DISCUSSIONS AND RECOMMENDATIONS

Discussions and Recommendations ........................................ 213
I. Sesame .............................................................................. 213
II. Sunflower ......................................................................... 218
III. General ............................................................................. 223
India is probably the only country in the world where as many as nine annual oilseeds are under cultivation in different regions and seasons, with diverse soil conditions and varying cropping systems. The total area under oilseeds is around 20 million ha with annual production of about 13 million tons. During 1988-89, production of nearly 17.5 million tons is estimated from 22 million ha under nine annual oilseeds.

The edible oil demand-supply estimates indicate that by the end of the century the production of 26 million tons of oilseeds would be required to maintain the parity. This amounts to doubling of the production in a decade or so. This appears to be a stupendous task. But, considering the production potential of available technology on a realistic basis, there is hardly a room for scepticism in achieving the targets. Researches on oilseeds have covered many milestones in the last two decades to come out with fairly well established farm-worthy technology capable of doubling the yields of cultivated annual oilseeds. Recent research results on real-farm situations have established the merits of the new technology substantiating its capabilities in boosting oilseeds production. In this background, sunflower has a great potential in years to come in bridging the gap between demand and supply to a significant extent.

Sunflower cultivation in India started in 1972. By 1975-76 sunflower area rose to 0.34 million ha from a base level of 500 ha in 1972-73. It is steadily increasing and has exceeded 1.6 million ha with a record production of 0.61 million tons in 1987-88. The important sunflower growing states are Karnataka, Tamil Nadu, Maharashtra and Andhra Pradesh.

The acreage in other states of Bihar, Orissa, Rajasthan, Uttar Pradesh, Punjab and West Bengal is marginal.

Existing Research Infrastructure

Sunflower research was initiated with the establishment of five research centers at Coimbatore (Tamil Nadu), Bangalore (Karnataka), Akola and Digraj (Maharashtra) and Kota (Rajasthan) in 1972. The importance of maintaining seed yield stability and oil content in open pollinated varieties was soon recognized and five seed production centers exclusively for production of quality seeds were established at Bhavanisagar (Tamil Nadu), Bangalore (Karnataka), Hyderabad (Andhra Pradesh), Akola (Maharashtra) and Kanpur (Uttar Pradesh) in 1978. In the formative years, researches were quite broad-based covering many facets in a multi-disciplinary approach. Both basic and applied researches were carried out on a variety of problems to gain a deep insight into the genetic architecture of the crop. The importance of heterosis breeding was recognized early and a number of experimental hybrids were developed and put to test as early as 1975. The work carried out at seed production centers helped in understanding different factors influencing seed quantity and quality. Since the area under sunflower did not come up as expected in Maharashtra and Rajasthan, research centers at Digraj and Kota were phased out. Presently sunflower research is being carried out at multi-disciplinary centers at Bangalore and Raichur in Karnataka, Coimbatore and Bhavanisagar in Tamil Nadu, Akola and Latur in Maharashtra, Hyderabad in Andhra Pradesh and Kanpur in Uttar Pradesh, Fig. 1. However, varietal evaluation is carried out over 35 locations across...
the country in almost all agro-ecological zones utilizing the existing resources of All-India Coordinated Oilseeds Research Centers, depicted in Fig. 1.

**VARIETAL DEVELOPMENT**

Initially, five open-pollinated varieties namely, VNIIMK - 8931 (EC-68413), Peredovick (EC-68414), Armavirskij-3497 (EC-68415), Armaverts (EC-68474) and Sunrise were introduced from USSR. Among these, two varieties, EC-68414 and EC-68415 showed wider adaptability and are still under cultivation in different parts of the country. The initial screening and evaluation during 1972-78 resulted in the identification of the early maturing variety, "Morden" suitable for both mixed- and multiple-cropping systems. Among different open-pollinated varieties, "Surya" was evolved by mass selection using "Latur bulk" as the base material and released for Maharashtra state in 1980; "Co-1", early maturing and "Co-2", medium duration varieties were developed for Tamil Nadu state in 1986; "SS-56", super early maturing variety was released for Maharashtra state in 1988. Importance of heterosis-breeding was recognized as early as 1975 with the development of experimental hybrids at Bangalore. After multi-locational evaluation, the first sunflower hybrid, BSH-1, was released in 1980 for general cultivation in the entire country. The hybrid base was further widened with the development of three more hybrids, "APSH-11", in 1987 for Andhra Pradesh and "LDMRS-1" and "LDMRS-3" in 1988 for Maharashtra state. The latter two hybrids are resistant to downy mildew. In the private sector, three promising hybrids "MSFH-1", "MSFH-8" and "MSFH-11" have been developed and released for general cultivation after evaluation under coordinated research network system. Salient features of varieties and hybrids are presented in Table-1. The yield potential of the hybrids under irrigated and well managed conditions range between 25-30 q/ha. Cultivation of hybrids under well managed conditions in Punjab has demonstrated the worth of the crop with an average productivity of 20 q/ha as against the national average of 5 q/ha.

**PRODUCTION CONSTRAINTS**

A number of factors are responsible for low productivity and the major ones are enumerated below:

1. **Low or poor management in rainfed conditions:** Sunflower is a choice crop for rainfed agriculture, as it has a fair level of drought tolerance and rapid revival capacity after prolonged drought. In view of the uncertainties, production is associated with low level management under such situations. Sunflower being an energy demanding crop with nearly 45% oil and 25% protein in seed requires larger inputs and high level of management. Unfortunately, energy-rich crop is cultivated under energy-starved conditions resulting in poor productivity. However, under vertisols with limited irrations sunflower has proved to be much rewarding as compared to wheat and chickpea (Table 2).

2. **Poor seed filling and seed set:** Low test-weight (around 4 g/100 seeds) in sunflower as a result of partial seed filling affects not only seed yield but quality of the produce in the form of reduced oil content. One of the immediate repercussions of poor crop management is lower test-weight due to poor seed filling. Hand pollination can considerably increase seed yield and net monetary returns, Table 3.

3. **Lack of uniformity:** Lack of uniformity in open pollinated varieties like Morden, EC-68415 and EC-68414 has made them more vulnerable to production instability and erratic performance.
Figure 1. OILSEEDS RESEARCH NETWORK IN INDIA
Table 1. Salient features of varieties/hybrids

<table>
<thead>
<tr>
<th>Variety</th>
<th>Maturity duration [days]</th>
<th>Plant height [cm]</th>
<th>Head diameter [cm]</th>
<th>Seed yield (kg/ha) under rainfed conditions*</th>
<th>Oil content (%)</th>
<th>Salient features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morden</td>
<td>75-80</td>
<td>80-100</td>
<td>12-15</td>
<td>600-800</td>
<td>40-44</td>
<td>Highly self-fertile, suitable for all states particularly Maharashtra, Karnataka and Tamil Nadu.</td>
</tr>
<tr>
<td>EC-68414</td>
<td>100-110</td>
<td>150-200</td>
<td>15-20</td>
<td>800-1000</td>
<td>42-46</td>
<td>Suitable for late planting, drought tolerant performs well in Andhra Pradesh, suitable for Tamil Nadu, Maharashtra, Uttar Pradesh and West Bengal.</td>
</tr>
<tr>
<td>EC-68415</td>
<td>100-110</td>
<td>150-200</td>
<td>15-20</td>
<td>800-1000</td>
<td>42-45</td>
<td>Drought tolerant, suitable for Karnataka, and Tamil Nadu.</td>
</tr>
<tr>
<td>Surya</td>
<td>90-95</td>
<td>150-200</td>
<td>15-20</td>
<td>800-1000</td>
<td>30-35</td>
<td>Seeds black with white stripes suitable for Maharashtra.</td>
</tr>
<tr>
<td>Co-1</td>
<td>60-65</td>
<td>60-80</td>
<td>8-10</td>
<td>500-700</td>
<td>38-40</td>
<td>Suitable for Tamil Nadu, selection from Morden from Coimbatore.</td>
</tr>
<tr>
<td>Co-2</td>
<td>85-90</td>
<td>130-180</td>
<td>15-20</td>
<td>800-1000</td>
<td>36-42</td>
<td>Suitable for Tamil Nadu.</td>
</tr>
<tr>
<td>SS-56</td>
<td>60-70</td>
<td>80-100</td>
<td>12-15</td>
<td>500-700</td>
<td>40-42</td>
<td>Super early in maturity suitable for Maharashtra.</td>
</tr>
<tr>
<td>BSH-1</td>
<td>90-95</td>
<td>130-150</td>
<td>12-15</td>
<td>1000-1500</td>
<td>42-45</td>
<td>Highly self-fertile, rust resistant, tolerant to Alternaria leaf spot, drought tolerant, highly adaptive to wide agro-climatic zones.</td>
</tr>
<tr>
<td>APSH-11</td>
<td>90-95</td>
<td>120-150</td>
<td>15-20</td>
<td>1000-1500</td>
<td>40-42</td>
<td>Suitable for Andhra Pradesh.</td>
</tr>
<tr>
<td>MSFH-1</td>
<td>95-100</td>
<td>120-150</td>
<td>15-20</td>
<td>1000-1500</td>
<td>38-42</td>
<td>Suitable for all states.</td>
</tr>
<tr>
<td>MSFH-8</td>
<td>95-100</td>
<td>130-160</td>
<td>15-20</td>
<td>1000-1500</td>
<td>38-42</td>
<td>Suitable for all states.</td>
</tr>
<tr>
<td>MSFH-17</td>
<td>100-105</td>
<td>150-200</td>
<td>15-20</td>
<td>1000-1500</td>
<td>38-42</td>
<td>Suitable for all states.</td>
</tr>
<tr>
<td>LDMRSH-1</td>
<td>95-100</td>
<td>120-150</td>
<td>12-15</td>
<td>1000-1500</td>
<td>40-42</td>
<td>Resistant to Downey Mildew and suitable for Maharashtra.</td>
</tr>
<tr>
<td>LDMRSH-3</td>
<td>95-105</td>
<td>125-150</td>
<td>12-15</td>
<td>1000-1500</td>
<td>40-42</td>
<td>Resistant to Downey Mildew and suitable for Maharashtra.</td>
</tr>
</tbody>
</table>

*Under irrigated conditions yield may be obtained more than two tons.

4. Susceptibility to diseases and pests: Most varieties are susceptible to a large number of foliar diseases like rust, Alternaria leaf spot, root and head rots. Since 1985, recent appearance of downy mildew in parts of Maharashtra has added to the complexity of the situation. High incidence of Alternaria leaf spot in the last 4-5 years is responsible for unremunerative yields in Kharif (rainy) season. Losses due to various diseases and pests in different parts of the country are presented in Table 4.
Table 3. Effect of hand pollination on seed yield (kg/ha) of sunflower

<table>
<thead>
<tr>
<th>Centre</th>
<th>Treatment</th>
<th>Akola</th>
<th>Digraj</th>
<th>Bangalore</th>
<th>Coimbatore</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1. Open pollination</td>
<td>1230</td>
<td>1036</td>
<td>1460</td>
<td>750</td>
<td>1119</td>
</tr>
<tr>
<td></td>
<td>2. Open + hand pollination</td>
<td>1400</td>
<td>1357</td>
<td>1725</td>
<td>1000</td>
<td>1370</td>
</tr>
<tr>
<td>Extra yields (kg/ha)</td>
<td>of (2) over (1)</td>
<td>170</td>
<td>321</td>
<td>265</td>
<td>250</td>
<td>251</td>
</tr>
<tr>
<td>Extra net returns</td>
<td>(Rs./ha) from (2) over (1)</td>
<td>700</td>
<td>1455</td>
<td>1175</td>
<td>1100</td>
<td>1107</td>
</tr>
</tbody>
</table>

* Hand pollination carried out on alternate days for a fortnight with Rs. 150 as additional cost due to hand pollination.

Table 4. Major diseases and pests causing yield losses in Sunflower in India.

<table>
<thead>
<tr>
<th>Disease/Pest</th>
<th>Occurrence</th>
<th>Yield loss (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Alternaria blight</td>
<td>Entire country</td>
<td>27-80</td>
</tr>
<tr>
<td>2. Rust</td>
<td>Entire country</td>
<td>Upto 20</td>
</tr>
<tr>
<td>3. Charcoal rot</td>
<td>Entire country</td>
<td>30-45</td>
</tr>
<tr>
<td>4. Downy mildew</td>
<td>Maharashtra and</td>
<td>2-60</td>
</tr>
<tr>
<td></td>
<td>Adjoining Karnataka</td>
<td></td>
</tr>
<tr>
<td>5. Head borer</td>
<td>Karnataka</td>
<td>28-33</td>
</tr>
<tr>
<td>and Jassids</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

5. Absence of crop rotation: Remunerative price structure prompted many farmers for continuous and successive cropping of sunflower in the same fields. It has resulted in poor yield and disease build up. Researches have amply demonstrated that cereals, pulses and millets are ideal groups of crops for rotation. Two-years’ rotation has proved desirable.

6. Genetic deterioration of varieties: Sudden increase in acreage resulted in the increased demand for seed thereby leading to the supply of sub-standard seed. Extra care and full attention is needed for open pollinated crops like sunflower where deterioration in seed quality and oil content is tremendous, if varietal renovation programes are not persued vigorously.

7. Prone to bird damage: Small holdings and fragmented cultivation lead to more pronounced damage due to birds for they especially like the crop. Lack of resistant varieties is a serious bottleneck in taking the crop to new areas. Hence, cultivation in large contiguous blocks is desirable.

8. Susceptibility to abiotic stresses: Frequent onslaught of drought results in poor productivity. The situation is compounded with the prevalence of salinity/sodicity in different regions. Here it may be worth mentioning that in India over 7.0 million ha of land is salt affected.

9. Non-exploitation of crop potential: Sunflower in India, is cultivated primarily for its oil yield. Protein-rich cake and other valuable products are not properly utilized and many times going as waste due to the lack of diversified usages as value added products. All these add up to the poor returns and a disincentive to the farmer to
afford/risk inputs required for higher yields per unit area.

10. Sowing at improper time: There is wide belief that sunflower being photo-insensitive crop, can be cultivated round the year. Sowing sunflower at a time when flower and head development coincides with heavy precipitation during rainy season leads to considerable yield losses. Adoption of well tested and widely acknowledged planting schedule(s) for different regions and seasons is recommended for harnessing full potential of the crop.

Research Thrusts

1. Development of superior hybrids: Thirty CMS lines and 20 restorer lines are available at the Germplasm Management Unit and 600 hybrids are being synthesized by crossing these lines and their evaluation may result in identification of superior hybrids.

2. Diversification of hybrid base: The hybrids developed so far in the country have been largely based on the introduced CMS and restorer lines. There is a need for a strong program to develop large number of inbred lines, their evaluation for nicking ability and converting the promising ones into CMS and restorers. Hybrids from parental lines developed indigenously will have better adaptability to varying agro-climatic conditions. Steps are under way to establish strong gene pools or composites to derive inbred lines and separate gene pools for maintainer and restorer lines. Inbreeding may be done in the gene pools to develop inbred lines and their subsequent conversion into CMS- and R-lines. B-line and R line composites have been constituted and are being distributed to sunflower breeders to develop CMS and restorer lines.

3. Breeding for resistance to diseases: As the crop is grown more and more extensively, disease and pest problems are becoming more intense. Resistance breeding should, therefore, form an integral part of the breeding program. Diseases like rust, Alternaria leaf spot and downy mildew need immediate attention. Root rot caused by *Macrophomina phaseolina* is becoming severe in parts of Tamil Nadu. Rust and downy mildew resistances are controlled by one or two dominant genes (oligo-genes). The selection and fixing of lines with resistance to these diseases is relatively easier compared to Alternaria leaf spot, which is poly-genically inherited.

4. Development of high yielding populations: Sunflower cultivation under input starvation and rainfed situations, may continue in India in the foreseeable future. Presently, hybrids are under commercial cultivation in about 30-35% of the total area. It may go up to a maximum of 60-70% in the near future. Thus, open pollinated varieties/populations may continue to cover the remaining 30% of the area under marginal and sub-marginal soil conditions during rainy (Kharif) season. Intensified efforts to step up the tempo of population improvement program are required through public research set up.

5. Breeding for high oil content: In sunflower, lines containing 60% oil in the seed are available. Hence, there is a great scope for increasing oil yield *per se*. It is hoped that with sustained breeding efforts, 10% increase in oil content can be achieved conveniently.

6. Breeding for earliness: Varying agro-ecological conditions provide ample opportunity for the cultivation of a variety of crops in different regions and situations. Sunflower being a photo-insensitive crop, its cultivation as a main crop, catch crop, sequential crop, inter crop and relay crop is of paramount
significance. Particularly under rainfed situations where the crop is frequently encountered with the onslaught of drought, earliness provides better opportunity for a bumper harvest.

7. Quality seed production: Cross pollination and the very basic nature of pollination in sunflower demands intensified research efforts for varietal renovation and quality hybrid seed production under diversified Indian situations. Identification of regions, seasons, situations and cropping systems for sustained quality seed production demands well demarcated regionalized seed production efforts. Matching agro-production and protection technologies for the production of healthy and cost effective seed required utmost attention.

Future projections

The future of sunflower lies in the popularization of hybrids under irrigated North Indian conditions from Punjab to West Bengal through Haryana, Uttar Pradesh and Bihar. The most potential cropping system in this region is likely to be potato/rapeseed-mustard/sugarcane / field pea, etc. based on spring sunflower, The command areas of Rajasthan, Madhya Pradesh, Maharashtra, Gujarat, Orissa, Andhra Pradesh, Karnataka and Tamil Nadu offer immense potential of Rabi (Winter)/Spring/Summer hybrid sunflower cultivation. Under such system, it is hoped that hybrids may occupy 90% of the sunflower area.

During rainy season, sunflower may replace some of the unremunerative crops like small millets/minor millets, upland rice, horse gram, etc., in central and peninsular India. During rainy season, hybrids would dominate under assured rainfall/irrigated situations in the years to come, while populations may continue to be cultivated in half the area under Kharif (rainy) season. With the concerted research back-up support, sunflower cultivation in Kharif (main) season may spread to the states of Orissa, Madhya Pradesh, Rajasthan, Gujarat, Uttar Pradesh, Bihar and parts of Haryana and West Bengal.

Sunflower may also fit into a number of intercropping systems with groundnut, cotton, finger millets, potato, sugarcane, etc., in different regions and seasons.

Sunflower has a great potential in India. By 2000 AD the sunflower area may go up to around 2.5 million ha with national average productivity of 10 q/ha and realization of average productivity of 20 q/ha in some of the states.