OIL CROPS: SESAME AND SUNFLOWER SUBNETWORKS

PROCEEDINGS OF THE JOINT SECOND WORKSHOP HELD IN CAIRO, EGYPT, 9–12 SEPTEMBER 1989

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

Edited by
Abbas Omran
Technical Adviser, Oil Crops Network

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International Development Research Centre, Canada

Scientific and Organizing Committee
Dr Abbas Omran
Dr Badr A. El-Ahmar
Dr Eglal Rashed

FOREWORD

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 diagnosis 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 Rached,
Senior Program Officer,
IDRC, Cairo

CONTENTS

Part 3. GENERAL

Part 4. DISCUSSIONS AND RECOMMENDATIONS

LIST OF PARTICIPANTS

AUSTRIA

1. Dr. Amram Ashri
FAO/IAEA Division,
International Atomic Energy
Agency, Wagramerstrasse 5,
P.O. Box 100, A-1400 Vienna

BANGLADESH

2. Dr. M.A. Khaleque
Project Director Oilseeds,
Bangladesh Agricultural
Research Institute,
Joydebpur, Gazipur

CHINA

3. Dr. Tu Lichuan
Henan Academy of Agric.
Sciences, No. 1 Nongye Road,
Zhengzhou, Henan
(Sent paper but could not
attend)

EGYPT

4. Dr. Eglal Rashed
IDRC, P.O. Box 14, Orman,
Giza

5. Mr. I. Benard
EEC, 9 Kamel Mohamed st.,
Zamalek, Cairo

6. Mr. Etian Pilorg
EEC Consultant, 9 Kamel
Mohamed St., Zamalek, Cairo

7. Mr. Volker Loch
GTZ Project, 4 Gezira
Street, Zamalek, Cairo

8. Dr. Badr A. El-Ahmar
Head, Oilcrops Section,
Agricultural Research Center
12619, Giza
Tlx: 20332 FCRI UN
Fax: (2002) 722609
Tel: 723000 ext 39

9. Dr. Nessim Riad Guirguis
Oilcrops Section, Field Crops
Institute, Agricultural
Research Center, 12619, Giza

10. Dr. Ahmed M. El-Wakil
Oilcrops Section, Field Crops
Institute, Agricultural
Research Center, 12619, Giza

11. Dr.(Mrs) Salwa I. El-Mohandis
Oilcrops Section, Field Crops
Institute, Agricultural
Research Center, 12619, Giza

12. Dr. Mohamed Ali Madkour
Oilcrops Section, Field Crops
Institute, Agricultural
Research Center, 12619, Giza

13. Mr. Marzouk El-Emam
Oilcrops Research Section,
Agricultural Research Center
12619, Giza

14. Mr. Mohamed El-Sofey
Oilcrops Research Section,
Agricultural Research Center,
12619, Giza

15. Mr. Wahid Abdel Aziz El-Sawy
Oilcrops Research Section,
Agricultural Research Center,
12619, Giza

16. Dr. Mohii El-Din El-Mandouh
Oilcrops Research Section,
Agricultural Research Center,
12619, Giza

17. Mr. Mostafa El-Samanody
Oilcrops Research Section,
Agricultural Research Center,
12619, Giza

18. Dr. Said Tawfik
Field Crops Research
Institute, Agricultural
Research Center, 12619, Giza

19. Dr. Arafa A. Hilal
Plant Pathology Institute,
Agriculture Research Center,
12619, Giza

20. Dr. Abdel Rahman A. El-Deeb
Plant Pathology Institute,
Agricultural Research
Center, 12619, Giza

21. Mr. Abdeen Ahmed El-Shimy,
Agricultural Research
Center, Shandaweel Research
Station, Sohag

22. Dr. Samy Attia
Agricultural Research
Center, Ismailia Research
Station, Ismailia

23. Mr. Samir Taha El-Srogy
Agricultural Research
Center, Mallawi Research
Station , El-Minia

24. Dr. Khaled M. Hammad
Agricultural Research
Center, Nubaria Research
Station, El-Naser Post
Office, Alexandria

25. Mr. Kamal Riad Demian
Agricultural Research
Center, Nubaria Research
Station, El-Naser Post
Office, Alexandria

26. Dr. Ahmed El-Kafory
Agricultural Research
Center, Nubaria Research
Station, El-Naser Post
Office, Alexandria

27. Mr. Maaty Kishta
Agricultural Research
Center, Serw Research
Center, Demiat

28. Mr. Mohamed Abou Gazala
Agricultural Research
Center, Sakha Research
Station, Kafr El-Sheikh

29. Dr. Samir El-Kalla
Faculty of Agriculture,
El-Mansoura University,
El-Mansoura

30. Dr. El-Sayed A. Raouf Sadik,
Faculity of Agriculture,
El-Mansoura University,
El-Mansura

31. Dr. Abdel Wahab Abdel-Fattah
Prof. of Agron., Vice
President, Suez Canal
University, Ismailia

32. Dr. A.F. Ibrahim
Professor of Agronomy
Faculty of Agriculture
Cairo University, Giza
(Sent paper but could not
attend)

33. Dr. Reda Shabana
Professor of Agronomy
Faculty of Agriculture,
Cairo University, Giza
Tel: Off. 897677 Giza
Res. 864106 Giza

34. Dr. H.S. Salame
Director, National Research
Center, Dokki, Cairo

35. Mr. Wageh Kadry
Agricultural Research Center,
Bahteem Research Station,
Bahtim, Cairo

ETHIOPIA

36. Dr. Hiruy Belayneh
Holetta Research Center,
Institute of Agric. Research,
P.O.Box 2003, Addis Ababa

37. Dr. Abbas Omran
Coordinator, Oilcrops Network
P.O. Box 23464, Addis Ababa
Tlx : 21548 IAR ET
Tel : 513776
Cable : MERMIRU ADDIS

INDIA

38. Dr. S. Thangavelu
Professor of Oilseeds, Tamil Nadu Agric. University, Regional Research Station, Vridhachalam-606 001, Tamil Nadu

39. Dr. Mangala Rai
Asst. Director General (Seeds), ICAR, Krishi Bhawan, Dr. Rajendra Prasad Road, New Delhi 110 001
Tlx: 0316224 ICAR IN
Tlg: AGRISEC NEWDELHI
Tel: Off. 382146, 388991/561
Res. 6410876

ITALY

40. Dr. C.R. Pineda
FAO, Industrial Crops, Via delle Terme di Caracalla, 00100, Rome
Tel : 57971
Tlx : 610181 FOODAGRI.

KENYA

41. Dr. Carlos Zulberti
IDRC Consultant, Vegetable Oil/Protein System, P.O. Box 53433, Nairobi

MOROCCO

42. Dr. Said Quattar
Institute Agronomique et Veterinaire Hassan II, Box 6202, Rabat, B.P.

PAKISTAN

43. Dr. Masood A. Rana
National Agricultural Research Center, G.P.O.Box 1785, Islamabad.

PHILIPPINES

44. Dr.(Mrs) Nenita M. Tepora
Agricultural Technology Research, Research and Development Center, Central Luzon State University, Munoz, Nueva Ecija 2320

SPAIN

45. Dr. J. Maria F. Martinez
Centro De Investigation Y Desarrollo Agrarios, Apartado, 240-14071-Corolado,

SUDAN

46. Mr. Mohamed El-Hassan Ahmed
Kenana Research Station, Abu Naama, Blue Nile Province

TANZANIA

47. Mr. J.Y. Chambi
Officer In charge, Sugarcane Research Institute, 30031, Kibaha

YUGOSLAVIA

48. Dr. Dragan Skoric
Sunflower Dept., Inst. of Field and Veg. Crops, Faculity of Agric., M. Gorki St., 21000 Novi Sad,

ZAMBIA

49. Mr. Benson Chimbwe
Mt. Makulu Res. Station
P.O.Box 7 Chilanga

INTRODUCTION

The Oilcrops Network for East Africa and South Asia extended as far east as the Philippines. We are trying to coordinate the expanded activities through the four sub-networks (Brassica, Sesame, Sunflower, and Other Oilcrops).

The sesame and sunflower subnetworks were established together during the fourth Oilcrops Network workshop held in Kenya during January 1988. Again the two sub-networks were called to this second meeting in Cairo, Egypt, 9-12 September, 1989, extending to 15 September for a field trip to research stations and Pioneer research farm.

The objectives of this meeting were:

1. To get together scientists working on sesame and/or sunflower from participating network countries to exchange ideas and experiences.

2. To discuss specific ways in which sesame and sunflower research could be strengthened through the exchange of information and genetic material, collaborative projects, training and scientific visits.

The objectives were achieved by the aggregation of 15 foreign scientists from three continents: Europe, Africa and Asia in addition to 32 scientists from Egypt. The constructive discussions they were involved in and the recommendations they arrived at show the closeness of the individuals and the responsibilities they are assigned and ready to carry.

The Government of A.R. Egypt allowed and hosted the workshop. His excellency Dr. **Youssef Wali**, Deputy Prime Minister and Minister of Agriculture and Land Reclamation of A.R. Egypt, deputized Dr. **Ahmed Mumtaz**, Director of Agricultural Research Center to open the workshop.

The Food and Agriculture Organization, FAO, generously supported the participation of Dr. **C.R. Pineda, Dr. J. Maria. F. Martinez** and Dr. **D. Skoric (shared with IDRC)**, in addition to contributing to the core budget of the workshop. We really appreciate the way these scientists lead the discussions of the sunflower group.

The International Bureau of Plant Genetic Resources (IBPGR) supported the participation of **Dr. Amram Ashri**. The editor/coordinator is grateful to Dr. Ashri for his constructive criticisms and for leading the sesame group towards global cooperation.

The International Development Research Center (IDRC-Canada) supported all other participants through the Oilcrops Network and Oilseed projects. Regional offices in New Delhi, Singapore, Nairobi and specially Cairo administered participant expenses and made every effort to ensure a 100% participation. Local expenses were born by the IDRC-supported oilseed project in Egypt. **Dr. Fawzy Kishk**, Regional Directory of IDRC Regional Office for the Middle East in Cairo represented IDRC in the official opening of the workshop and hosted a dinner for the workshop participants. The Senior Program Officer for Crops and Animals, Dr. Eglal Rashed, was a vital force in organizing the workshop.

The Oilcrops Network coordinator/editor is grateful to **Dr. Badr El-Ahmar and all the staff of the Oilcrops Section** for their assistance in coordinating and organizing the workshop; **Mr Abdel-Aziz Yunus**, in charge of the Agricultural Club, for allowing us to use the meeting hall for the workshop sessions and the excellent catering facilities of the club; **Mr. Kavaleri Kibinad**, Chief Ticket Agent of NTO (National Tour Operations and Travel Agency Corporation), Addis Ababa, Ethiopia, for his efforts with **Mr. Muna Abebe** of the **Ethiopian Airlines** to route and re-route the particpants to and from Cairo.

Special thanks go to **Mr. Seid Ahmed**, **Mr. Nigussie Alemayehu**, **Mrs. Seada Ali**, **Miss Elizabeth Baslyos** and **Miss Raei Melesse** for their assistance in editing/proof-reading, typing and retyping this manuscript.

Abbas Omran
Coordinator/Editor
IDRC, Addis Ababa

Part 1

SESAME SUBNETWORK - II

SESAME GENETIC RESOURCES: COLLECTION, EVALUATION AND CONSERVATION

Amram Ashri

Abstract

Several expert consultations and various researchers dealing with sesame (*Sesamum indicum* L.) concluded that the existing germplasm collections of sesame should be expanded. This paper describes the germplasm collection of about 1650 accessions assembled by the author under the IBPGR grant and the data bases obtained from other investigators. The descriptors and states adopted are described and several new ones were added. The findings were computerized and the analysis of the data bases within and between locations is in progress.

Issues involved in the collection, evaluation, utilization, rejuvenation, and conservation of the sesame germplasm collections are discussed.

Germplasm resources constitute the evolutionary library of the species and are very important in plant breeding, evolutionary studies, botanical research, etc. Introduction has played a significant role in crop improvement since ancient times and still is; directly when introduced cultivars prove to be successful in a new region and are released to the farmers, or indirectly by hybridizing the introduced materials with local ones, transferring desired genes into the latter. This has been the case also with sesame (5).

Sesame germplasm collections have been assembled and studied over the years in several locations. Some were more comprehensive while others were more limited in scope. It should be noted that the first sesame germplasm collection was established in India in 1925 (14). Shortly after, a large world collection was assembled in the USSR (23). The very large sesame germplasm collections in India were described recently (22,19).

A very large collection has been studied and is maintained in the USA (17, 24, personal communication - G.A. White). Another very large collection has been assembled in Venezuela and is now being evaluated (personal communication - Ing. Agr. Helena Mazzani). Sizable collections of local and some introduced materials have been established and studied in R. of Korea. A large amount of collections were assembled and studied, mainly from evolutionary aspects by various workers (8,9,10).

Two FAO expert consultations (2,3) and the IDRC Workshop in 1985 (4) identified a pressing need to make a more comprehensive collection of sesame genetic resources, evaluate, utilize and conserve them. They recommended that the sesame germplasm collection, evaluation and exchange should be much enhanced, and appropriate arrangements for their long-term conservation be made. The IBPGR and FAO have acted accordingly and the IBPGR gave the author, in 1986, a grant to assemble the germplasm collection of cultivated and wild sesame species.

This paper is a progress report on the project. In 1988, 1645 accessions were sown in Rehovot (Israel) and data were collected for 14 traits. The analyses of the Israel data in the computer are in progress. Additional data were obtained from Dr. J.I. Lee on 600 lines for 38 traits and some data were obtained from the USDA (Dr. J.D. Mowder). These bodies of data will be analyzed separately and in comparison with each other when possible.

Materials and Methods

Assembling the germplasm collection

A large collection of germplasm was assembled, mainly in 1987 through an extensive effort including personal contacts, written requests and the assistance of investigators, national bodies - especially the USDA and the RDA of R. of Korea - and international ones especially the IBPGR, FAO and the IDRC Oil Crops Network. The germplasm collection was planted in the spring of 1988 at Rehovot, Israel (34° 5° E, 31° 5° N). The sources and numbers of the accessions are presented in Table 1.

Table 1. Sources of the sesame germplasm collections studied in 1988.

Source Country	No. of Accessions	Hebrew Univ. Nos.	
R. of Korea	407	1-401,	1581-1586
Bulgaria	25	402-424,	15779-1580
U.S.S.R.	5	425-429	
South Africa	5	430-434	
Kenya	5	435-438,	1643
India	6	439-444	
Thailand	15	445-450,	1628-1636
Sri Lanka	13	451-463	
Egypt	60	464-523	
Turkey	15	524-538	
Philippines	12	539-550	
Namibia	2	551-552	
Venezuela	22	553-568,	1637-1642
Burkina Faso	1	569	
Mexico	8	570-575,	1602-1603
Greece	32	576-607	
USA	937	608-1542,	1577-1578
F.A.O.*	51	1543-1576,	1611-1627
Japan	15	1587-1601	
Burma	5	1604-1609	
Nepal	1	1644	
Taiwan	2	1645-1646	
Total	1645		

*Includes 11 superior selections (8 non-shattering and 3 shattering) of Dr. D. Yermanos of the Univ. of California, Riverside, Central America, and materials from at least 8 countries.

In some cases, the contributing countries supplied only local materials, improved cultivars, and/or landraces and/or breeding lines. Often though, the source countries sent both local materials and accessions introduced into them. Thus, certain cultivars appear several times, e.g. the well known Venezuela and the U.S. varieties were obtained from their countries of origin as well as from several other countries. All were maintained as separate entities and will be compared to see if they are truly duplicate or if they have diverged over the years due to genetic shift or local selection pressures, out crossing and/or mixtures.

An examination of Table 1 shows that certain major sesame producing areas such as India, China, Burma and the Sudan are poorly represented. Actually, much of the Indian and Sudanese germplasm was included in the USDA collection, thus the representation of these gene-pools is better than that which appears in Table 1. The materials from mainland, China are poorly represented since not too many were included in the collections from other countries. Repeated requests for materials from other countries failed to secure shipments of seeds.It is hoped that the genetic resources of the countries that are poorly represented will be made available for international research cooperation soon.

Certain contributions of germplasm were received too late for inclusion in the 1988 nursery, notably a large collection from Dr. D.G. Langham and Mr. R. Langham of the Sesaco Corp. These are stored until another germplasm nursery will be grown.

So far, only the following wild species were obtained: *S. radiatum*, *S. alatum*, *Ceratotheca triloba* and four unknown entries (collected by contacts in Kenya and South West Africa). Much effort has been devoted to obtain wild species from their natural areas of distribution, mainly in West and East Africa. Unfortunately, the combination of lack of detailed information about the wild species and their maturation time and distribution, and of botanists, collectors, etc. made it very difficult to make progress.

Nursery and harvest procedures

The materials were sown in the spring of 1988, One 5 meter row per accession. The rows were spaced 1m apart, and plants were thinned to 20/m. At times the spaces were larger due to poor germination. The nursery was trickle irrigated throughout the season. Notes were taken as the desired traits became visible and/or at the appropriate phases during the season. The plants were let to flower and mature under open-pollination conditions. The extent of cross pollination is not known. Branches with mature capsules were harvested from all plants in each row, placed in large paper bags, allowed to dry and threshed. Seed characters were recorded on the cleaned seed samples.

Results and Discussion

General

The analysis of the data is in progress and the findings will be published when completed. Several more general points will be discussed here.

Descriptors and states

The descriptors and states developed under the auspices of the FAO and IBPGR (1) and the comments (7) served as a basis for the characterization of the germplasm collection. However, in several cases, they proved inadequate or too labor-consuming. The descriptors and states utilized in the 1988 nursery are described below; modifications are shown where such were made:

1. Date of first flower - later converted also to number of days from planting to flowering.

2. Plant height (cm)- mean of 3 measurements of typical plants per row.

3. Branching - a fourth state was added to those published (1): 1= None, uniculm, 2 = Basal branching (lower part of plant), 3= Top branching (upper part of plant) and 4= Basal and top branching (added).

4. Exterior corolla color, as in (1): 1 = White, 2 = White with violet / purple shading, 3 = White with deep violet / purple shading, 4 = Violet, and 5 = purple.

5. Number of flowers/leaf axil, a third state was added to (1): 1 = One, 2 = Three, and 3 = More than three (added).

6. Capsule shape, as in (1): 1 = Tapered, 2 = Narrow oblong, 3 = Broad oblong, and 4 = Square.

7. Number of carpels/capsule, as in (1): 1 = Two, 2 = MOre than two.

8. Capsule hairiness, changed from (1). It proved difficult to score separately the density and the length of the capsule hair as in the above. The following states combining length and density were utilized: 1 = Glabrous, 2 = Light, 3 = Medium, and 4 = Heavy.

9. Capsule length - Visual scores were used rather than measurements as recommended by (1) to reduce labor, as follows: 1 = Short, 2 = Medium, 3 = Long, and 4 = Very long.

10. *Alternaria* leaf spot:
1 = Immune, no symptoms,
3 = Resistant, very light infection, 5 = Medium,
7 = Susceptible, and
9 = Very susceptible.

11. Seed coat color - Examination of the seed coat color of all the accessions led to a revision of the available descriptors and states (1, 7). See Table 2.

12. Seed coat texture, as in (1) : 1 = Smooth, and 2 = Rough.

13. Seed size - To reduce labor, visual scores were used rather than weighing (1): 1 = Small, as HU No. 446 (Montalang from Thailand), 2 = Medium, as HU No. 700 (USDA PI No. 167343, origin - Turkey), and 3 = Large, as Ashri Line 1988-4127.

14. Seed lenght/width ratio, visually scored, as an approximation of seed shape: 1.0 = Ratio of 1.0, round, 1.5 = Ratio of 1.5, intermediate, and 2.0 = Ratio of 2.0, elliptic.

Forecasting performance and ranking

The traits studied can be divided into two groups regarding their response to the environment and/or the growing conditions: a) Unaffected - as corolla color or number of capsules/axil; b) Affected - as flowering time and plant height affected by day length and temperature, or degree of branching, which is affected by stand density and season.

For the characters which are not affected by the environment, a single entry in the data base should suffice. However, for those affected by the environment, multiple entries are required, denoting also the location, season, conditions, etc. Still, for the latter characters it is important to assess the forecasting value of the data from one location on the performance in another. This could be very important in breeding. For instance, can earliness or lateness in one test location be used to forecast flowering time in another? Or, if the oil content is affected by the locations' conditions, do the different accessions retain their relative ranking under different environments?

To investigate whether the oil content ranking is affected by the location, seeds of several hundred accessions from Korea, which were produced in Israel in 1988 were sent to Dr. J.I. Lee in Suweon, R. of Korea, for oil and protein content analysis. They will be analyzed with the same equipment and procedures that were used a few years ago to determine these values for seeds of the same accessions produced in Korea.

Preliminary findings indicate that the ranking of the accessions with regard to the length of period from planting to flowering is very location dependent, as would be expected. Therefore, evaluation inone location apparently cannot serve to pre-select a certain groupof "more promising" accessions for testing in a different region.
This point is being checked in detail for time of flowering, plant height and branching.

For environmentally-affected characters, comparisons of data from different locations and seasons could perhaps be aided by the establishment of an internationally agreed list of accessions which could serve as standards. The value of such standards will be examined by checking the data from Israel and S. Korea, and other data that may be available in relation to various reference groups of accessions. These groups can vary in number and make up.

Naturally, the analysis will be more valid if the data will be collected under the same conditions for all the accessions. It follows then, that for characters which show environment x accessions interaction; the data should be obtained in one season for

Table 2. Descriptors and states for sesame seed coat color.

		Ashri Reference Accession				Bartel & Goldberg**	
Code	Color	HU No.	Origin*	Source	Name or No.	Color	Reference Ac.
10	White	22	ROK	ROK	Gaesan	White	T-85
	Yellow						
21	Very light	87	ROK	ROK	Suweon 99	Very light yellow	Adi
22	Light	1258	Nepal	USA	PI 288854	Dark yellow	D-7-11-1
23	Medium	137	ROK	ROK	Yongan-1	Medium yellow	Zirra
24	Dark	107	Turkey	ROK	Anthalya-1	Very light brown	Margo short
25	Very dark	134	ROK	ROK	Gaeum	Light brown	Exute
	Grey						
31	Very light	60	Japan	ROK	Japanese black	Medium gray	Oro 9/71
32	Light	1587	Japan	Japan	No. 76, BON	--	--
33	Medium	618	Mexico	USA	PI 154, 300	Dark grey	Morada 67-11
34	Dark	648	China	USA	PI 158,056	--	--
35	Very dark	648	China	USA	PI 158,056	--	--
	Brown						
41	Very light	679	China	USA	PI 158,941	--	--
42	Light	700	Turkey	USA	PI 167,343	Medium brown	A-1-10
43	Medium	390	Japan	Japan	Black Wasegoma-2	Dark brown	A-5-13
44	Dark	633	China	USA	PI 158,038	--	--
45	Very dark	631	India	USA	PI 157,162	--	--
55	Black	239	NI	ROK	Tainan White		
				1-3-a	--	--	
	Reddish-rust (anthocyanin)						
61	Very light	892	Burma	USA	PI 202,726	--	--
62	Light	902	Japan	USA	PI 223,411	Very dark brown	X-30/46
63	Medium	--	--	--	--	--	--
64	Dark	--	--	--	--	--	--
65	Very dark	441	India	India	TMV 5	Anthocyanine	Gomi
	Green						
81	Very light	--	--	--	--	--	--
82	Light	1232	Venezuela	USA	PI 280, 809	--	--
83	Medium	--	--	--	--	--	--
84	Dark	--	--	--	--	--	--
85	Very dark	--	--	--	--	--	--

*Abbreviations, NI = Not indicated, ROK = Republic of Korea. **Their paper of 1985 (7).

all accessions, since conditions vary from year to year.

Differential geographical distribution of alleles

For breeding, it is important to identify geographical areas in which the frequencies of certain alleles are higher, e.g. alleles for resistance to a given disease. To this end, the frequencies of the different states of certain descriptors will be related to the areas of origin of the accessions. This study, though , is made more difficult by errors in recording the origins, mechanical admixtures or outcrossing.

Firmer answers to the above questions can hopefully be obtained from analysis of the Israel 1988 data and the data collected elsewhere.

Further collection needed

In a followup program to this project, much effort should be devoted to close the gaps in the germplasm collection of the cultivated species. These should include exploration and collection in poorly represented centers of diversity and obtain seeds from all existing collections. At the same time, the duplications in the collection should be eliminated. Thus, the collection could be enriched and still kept within a manageable size.

The obvious gap in the germplasm collection is the lack of wild species. There are 35 wild species in the genus (6, 12), most of them in Africa. The work carried out in Africa (20) concluded that it has limited genetic diversity in the cultivated species but it can be a good source of wild *Sesamum* germplasm. Special efforts should be devoted to the exploration, collection, evaluation and conservation of the wild *Sesamum* resources. This is important both from the breeding point of view and for evolutionary - systematic studies. It has been shown even by limited research that the wild species contain useful genes (13) which can be used to breed improved cultivars.

Long-term maintenance of the collection

Arrangements for the long-term maintenance of the collection are being made by the IBPGR and the author. The newly established and well equipped gene bank of the Rural Development Administration, Suweon, R. of Korea (Dr. Wan-Sik Ahn, Director) has been designated by the IBPGR as the first base collection for sesame. The author sent 30 of open-pollinated seeds (6000 - 7500 seeds) of each of the accessions to the Korean gene bank. The IBPGR is exploring other sites in order to identify a suitable location for a second base collection.

The long-term maintenance of the seeds may be supported by the finding that sesame seeds retain their germinability for about 5 years if kept in a well ventilated, dry room with ambient temperatures (21). It was also found that with lower temperatures sesame seeds remain viable longer; however, freezing temperatures were harmful. Research on optimal sesame seed storage conditions should be initiated without delay.

Rejuvenation of the collections posses problems too. Cross-pollination in sesame can sometimes reach 60% (6), depending mainly on insect activity. Thus, in periodic plantings of the collections to produce fresh seed supplies, precautions should be taken. Since insect elimination is impossible, selfing may be advisable. However, selfing by bagging is laborious and expensive and sometimes the seed obtained are few in number and poor in quality. Selfing may also contribute to genetic shift in the accessions, especially since many of them are not uniform and they should be kept that way.

Another possible avenue is to form pools from accessions which are genetically close and originated from the same region. This would reduce the number of collections to be maintained. Thus, it will be easier to grow them in isolation.

Still another approach to maintain the genes and alleles would be to create a few very large composite-cross gene pools, each adapted to specific conditions. This would be done by grouping many accessions, crossing them with a male sterile line and growing the bulked mixture of the hybrids for successive generations under the desired environmental conditions allowing them to intercross. This will be supported by segregation of male sterile plants. In this way, the alleles will be maintained and much new genetic variability will be generated, many new gene combinations will be formed. However, established genotypic combinations excelling in their performance may be lost.

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SESAME RESEARCH IN THE SUDAN

Mohamed El-Hassan Ahmed

The primary objective of the oil crops network is the improvement of oil crops which could be achieved by improving the yield per unit area and expanding the area under production. The yield per unit area can be increased by both developing high yielding varieties and improved cultural practices leading to better weed control, seed-bed preparation and good stand establishment.

During his visit to the Sudan in October 1988, Dr. A. Omran, the Network Coordinator advised to collect more information on the reported gap between the recorded research station's yields and the farmers' yields. Accordingly, a survey of the central rainfed lands of the Sudan including the most important sesame producing areas such as Blue Nile and Kassala, was conducted during the period April-July 1989 to obtain information needed to describe the farming systems, methods used and production constraints as well as local germplasm.

From the survey, it was found that in all rainfed areas of the central rainlands of the Sudan, the farming systems are similar. In these areas sorghum and sesame are the two major crops cultivated by the farmers. The survey and meetings with the farmers revealed many constraints to production. However, the following are considered as the major ones which formed the basis for the plan of work:

1. Low soil fertility: Soils of the central rainlands of the Sudan are inherently low in nitrogen which severely limits the productivity of cultivated crops. Since the two major crops; sorghum and sesame are non-leguminous, their production tends to further deplete the soil fertility. The trend is sorghum-monocropping. Sesame and other crops are grown less extensively. Consequently sorghum, a shallow rooted crop planted in monocropping pattern will result in continuous depletion of nutrients from the top soil, thus reducing yield correspondingly. In addition to severe depletion of nutrients, the fields become heavily infested with noxious weeds.

2. Poor cultural practices: Crop husbandry practices in these areas are generally poor, which adversely affect crop yields. Most farmers depend on hired tractors for land preparation and usually miss the optimum sowing dates. Broadcasting, practiced by the majority, results in uneven plant distribution, inefficient weed control and consequently poor stand establishment.

3. Poor seed supplies: Although the research centers have released several improved varieties of sorghum and sesame, which possess many desirable characters in addition to their higher yielding ability, the majority of the farmers still use the old, familiar, and traditional types. The seeds used by most of the farmers are usually selected from the previous crop or purchased from the local markets. These seeds are not pure, lack uniformity in size and colour, and may be damaged and have low viability.

4. Other constraints: Erratic rainfall is another major factor detrimental to yield. Also severe damage caused by diseases and pests are often extremely high. At the present time no effective control measures are used against these diseases and pests by the farmers. From the information gathered by the

survey and group discussion with the scientists at Abu Naama Research Station and other centers, it was evident that the present farming systems practiced in the central rainlands of the Sudan are similar which resulted in:

- depletion of soil fertility,
- severe infestation of fields by noxious weeds, and
- inefficient utilization of land due to cultural practices that result in low plant population, poor plant stand establishment and consequently low yield per unit area.

These factors acting together have resulted in low yields of the cultivated crops. Therefore, in order to improve the yielding ability of any crop, pressures from the above constraints must be reduced. Programs to develop and extend to the farmers ways and means of overcoming some of the basic constraints should be formulated to cater for: lack of improved seeds, ineffective weeds, diseases and pests control, low maintenance of soil fertility levels, poor stand establishment, uneven distribution, and low plant population. The plan of work will be based on agronomy, breeding and technical production package to be developed through experimentation and trials. Findings of the previous research will be tested and applied.

In order to intensify the research efforts for more precision, the breeding and agronomic programs started earlier at Kenana Research Station will be extended to the testing sites to test the breeding materials under the prevailing conditions for adaptability across environments through multi-location trials as well as on-farm trials to identify the best suited lines for release to farmers.

The agronomic program aiming at the improvement of the traditional husbandry practices is also extended. The promising lines are tested under different sowing dates, inter-row spacing and foliar fertilization.

The recommended cultural practices such as optimum sowing date, use of healthy (treated) seeds, planting in rows to allow for inter-row cultivation and efficient weeding and consequently improving stand establishment will be applied. The experimental nursery can be used as demonstration plot for the farmers around the research station.

Sesame Research

In recent years, the pattern of rainfall distribution has changed dramatically. The annual rainfall varies from season to season and from region to region in the same season and the rainy season becomes shorter. Consequently, area and production of sesame fluctuated due to erratic rainfalls.

The present study was initiated in 1986/87 on the feasibility of developing early maturing or drought resistant high yielding varieties for short and marginal rainfall conditions.

The long-term objective of the study was to screen/breed varieties for the drought stricken areas and those with sufficient rainfall.

The techniques used include:

1) Collection and evaluation of local and introduced sesame germplasm.

2) Developing desirable genetic recombinants through single, multiple and backcrosses among the promising lines.
3) Induction and selection of mutations for earliness and responsiveness in the improved local types, and

4) Testing elite cultures for adaptability across environments

through multi-location trials for initial release as varieties.

The genetical variability developed by hybridization and irradiation using improved varieties showed good recombinations and single plant selection is practiced in F_2 and M_2 generations.

The collections (local and introduced) grown in observation nurseries during 1986/87 showed wide variability of duration to maturity, plant height, branching and yielding ability. The promising lines were selected and advanced to the preliminary variety trials conducted at three testing sites over two seasons, 1987/88 and 1988/89. The data on yield and its main components were analyzed to assess the magnitude of variability.

The results showed that there was a wide variation for yielding ability, duration to maturity, plant height and branching.

Considering duration to maturity, there is a wide range of variation and accordingly the varieties could be classified into extra-early, early and medium maturing. The early and extra-early maturing lines mature during the wet rainy days of September. The medium maturing varieties showed high yielding potential coupled with disease resistance and escaping the attack of sesame seed bug that appears at the last week of October attacking the late maturing local types.

When the lines were tested for adaptation or yield stability, the early maturing (from high latitudes) showed low and consistant yields indicating that they are poorly adapted to the prevailing environments.

The medium maturing lines (from Africa or similar regions or latitudes) showed high yields of considerable stability, indicating that they could adapt to the prevailing and/or improved environments. This suggests that direct selection for yield should be practiced within introduced materials of similar environments, temperature and day length. Eight varieties which combined relatively high yield (responsive varieties) and considerable stability of performance are selected and advanced for further yield testing (multi-location and on-farm trials) for initial release as commercial varieties.

PROGRESS IN SESAME RESEARCH IN ETHIOPIA

Hiruy Belayneh, Bulcha Weyessa and Elias Urage

Abstract

Sesame is one of the oil crops in the lowlands of Ethiopia that fills the need for a cultivated crop with great tolerance to high temperature and low demand for water. Though this labour- intensive crop is likely to succeed as peasant crop under rainfed condition, it has also tremendous potential under irrigated conditions in the Awash Valley. As a result of multi-locational testing, five varieties have been released. The agronomic practices have also been worked out. Improved variety, sowing date and crop protection measures are the critical factors for increasing the yield of sesame. Future strategies of sesame research are described.

Accurate statistical data on area, production and yield of sesame are not generally available. The crop is found growing in many regions of the country notably in the northern, north-western, western and eastern plains either as a mixed or sole crop. These traditional sesame growing areas are located at altitudes of 500- 1700 m.a.s.l., having rainfall of 350-1200 mm during the growing period. The low average yield of sesame in most of these regions is a result of uncertain weather and inadequate plant protection measures.

In Ethiopia, selection of improved varieties has been underway since the late 1960's and five varieties (Kelafo 74, T-85, E, S and Mechado-80) have been made available for cultivation. The optimum cultural practices for the varieties have also been established. It is the intention of this presentation to focus on what has been achieved during the last two years on the improvement of the genetic potential of sesame, to give a brief account of the results obtained on agronomy and crop protection studies and to develop breeding and selection strategies that will allow an increase in sesame production.

Varietal Development

Within the sesame growing areas, three major zones were distinguished on the basis of weather particularly the amount and duration of rain during the growing period. Consequently, the sesame trial sites were divided into irrigated, marginal and high rainfall areas. The grouping was relevant to selection of varieties to fit specific region.

In the past, more than 350 accessions were characterized at Melka Werer (eastern zone). In addition, 64 indigenous sesame collections were grown in 1988 and their morphological characteristics were studied. Most of the lines were characterized by profuse branching, even maturity, one to two capsules per leaf axil, broad leaves at the bottom, short internode length, etc. As a result of three years multi-locational testing, SPS 111518 (Mechado-80) has been released in 1989 for the irrigated zone after fulfilling the pre-release requirements. Another selection, SPS B/M sel. #2(81)(82) is a candidate for release in 1990. The latter selection is a high yielding variety primarily suited for those growers in the high rainfall regions. It is known to be tolerant to blight. Of the varieties released earlier, E showed a higher yielding potential and adaptability to the marginal areas, Tables 1 and 2.

Agronomy

Agronomic practices suitable for different regions have been worked out. Sowing time varied in different regions depending upon temperature and availability of soil moisture. The fertilizer trials conducted, so far showed no response to different levels of nitrogen and phosphorus. A seed rate of 5 kg/ha has been recommended with row width of 40 cm and plant spacing of 10 cm. Result of the harvesting stage study showed that sesame should be harvested when 1/3 to 2/3 of the plant parts turn yellow. The irrigation studies at Melka Werer and Gode indicated that the crop requires an irrigation regime of 10 cm applied every 10-15 days based on evaporation loss.

Crop Protection

As the crop is vulnerable to weed in the early stage of growth, weeding 4-5 weeks after sowing is very critical. The result of the herbicide trial showed good control of both broad leaves and grasses with the application of Alachlor at 3.5 kg/ha.

Recent survey on the importance of diseases in sesame growing areas indicated that bacterial blight and Phyllody are the most prevalent diseases. A range of sesame varieties is being screened for their resistance to both diseases. Out of the entries screened in 1988, 25 showed considerable level of resistance against bacterial blight. On the other hand, no satisfactory results were obtained in the screening effort against phyllody since the vector (Jassids) was not uniformly distributed in the field.

Sesame webworm (*Antigastra catalaunalis*) and the green peach aphid (*Myzus persicae*) are the main insect pests. A range of varieties is being screened for their resistance to sesame webworm.

Future Research Strategies

Climate has an important influence on the type of sesame varieties that can be grown and the development of diseases and insect pests. Hence, identification of cultivars with specific adaptation to an agro-ecological zone will be emphasized rather than searching for a wide adaptation. Such grouping will help in the introduction of sesame to non-traditional but potential areas, Table 3.

Screening of the local collection and introduction in preliminary screening stage for the major diseases, pests and drought will be mandatory so as to eliminate the undesirable material right at the beginning of the testing program.

Keeping in view the success of the program on variety development, it is proposed to extend the hybridization work to develop non-shattering, high yielding and disease resistant sesame lines.

Table 1. Summary of seed yield (kg/ha) of improved sesame varieties in the national variety trials grown at 13 sites.

Area	Agricultural Development Zone	Site		Seed yield (kg/ha)
Irrigated	Eastern	Melka Werer	(3)*	1990
	"	Tendaho	(3)	2230
	"	Gode	(2)	820
		Mean		1680
Marginal	Eastern	Besidimo	(3)	540
	"	Measo	(2)	270
	North-eastern	Harbu	(2)	618
	"	Kobo	(2)	590
		Mean		505
High rainfall	North western	Pawe	(2)	850
	"	Beles	(3)	1250
	Western	Dedessa	(3)	1550
	"	Fincha	(3)	1090
	"	Abobo	(3)	580
	Central	Tedelle	(3)	720
		Mean		1008

*Number of trials.

Table 2. Crop environment characteristics at sesame trial sites.

Area	Site	Days to Maturity of Improved Varieties	Altitude (m)	Rainfall (m)	Mean Temp ^0C min	Mean Temp ^0C Max.	Soil Analysis pH in H_2O	Soil Analysis N (%)	Soil Analysis P_2O_5 (ppm)
Irrigated:									
Eastern	Melka Werer	98	750	269	18.4	34.2	8.00	0.09	20.0
"	Tendaho	103	380	80					
"	Gode		315	146	22.1	34.4			
	Mean	100.5	481.7	165.0	20.2	34.3	8.00	0.09	20.0
Marginal:									
Eastern	Besidimo	113	1450	398			8.1	0.06	13.1
"	Measo	99	1320	457					
North eastern	Harbu	116	1540				7.4	0.13	V.high
"	Kobo	127(?)	1470	438	12.9	29.3	8.2	0.12	15.0
	Mean	113.8	1445	431	12.9	29.3	7.9	0.10	>14.0
High rainfall:									
Northwestern	Pawe	120	1200	1128	17.0	35.0	6.0		69.9
"	Beles	121	1200	1224	17.0	35.0			
Western	Fincha	119	1660	762			5.9		10.4
"	Dedessa	125	1280	1216	14.9	29.3	4.9	0.19	46.1
"	Abobo	113	500	1045	20.3	33.0	6.4	0.15	22.9
Central	Tedelle	143	1670	865					
	Mean	123.5	1251.7	1040	17.3	33.1	5.8	0.17	37.3

Table 3. Environmental requirements of sesame.

Environmental and soil	Range of Suitability: Highly suitable	Moderately suitable	Marginal	Sensitivity to hazard
Altitude (m.a.s.l)	500-1250	350-500/1250-1600	0-350/1600-2000	
Min. temp. for growing period (^0C)	16-21	13-16/21-22		
Max. temp. for growing period (^0C)	30-35	27-30/35-38		
Mean temp. for growing period (^0C)	23-28	20-23/28-30	30-32	
Length of growing period (days)	120-180	100-120	70-100	
Rainfall during growing period (mm)	500-700	400-500/700-1200	300-400/1200-1500	sensitivie to water logging
Soil Type	Sandy loam			
• Texture	light			
• Colour	brown, red			
• pH		6.0-7.3	5.5-6.0/7.3-8.0	

A BRIEF OUTLINE OF SESAME (SESAMUM INDICUM L.) RESEARCH IN TANZANIA

J.Y. Chambi and E.M. Kafiriti

The traditional edible oil crops in Tanzania include: sesame, groundnut, sunflower, coconut and to a limited extent palm oil. In recent years, procurement of groundnut has limited its use for crushing in oil mills while a non-traditional source, cotton seed has attained prominence accounting for about 40% of the total installed crushing capacity in the country. During the early 70's, Tanzania was a net exporter of oilseeds after satisfying the domestic demand. However, in the mid 80's there was an acute shortage of edible oils and fats partly because of increased demand in the fast growing urban centers and declining production of the traditional annual oilcrops.

The main problems that account for the stagnation of the annual oilseeds industry in the country may be summarized as follows:

i) Lack of high yielding varieties - farmers are still using traditional cultivars which are adapted to their conditions, but which are inherently low yielding with poor response to improved management practices.

ii) High incidence of diseases and insect pests and lack of effective control methods.

iii) Poor husbandry practices such as late sowing, sub-optimal plant populations and poor weed control, and

iv) Poor post-harvest handling and storage facilities leading to additional loss of yield, quality and lack of good quality seed for the following season.

In many cases, official policies such as low producer prices of oilcrops in relation to other crops and lack of support from extension services have also contributed to the poor performance of the oilcrops industry in Tanzania.

Recognizing the limitations of the annual oilcrops, the Tanzanian government in collaboration with the United Kingdom through ODA initiated the Oilseeds Research Program in 1978. ODA's support ceased on December 1986.

The program was set up with the following broad objectives:

i) To identify the major factors that limit the production of oilseeds (i.e. sunflower, sesame, and groundnut).

ii) To develop and recommend appropriate and improved production packages for oilseed crops.

iii) To develop high yielding varieties of oilseeds with high oil contents and adapt them to the main areas of production.

iv) To identify the major insect pests and disease problems and to develop effective control measures suitable for the small-scale farmer, and

v) To investigate the role of oilseeds in the existing (traditional) and improved farming systems and to determine how improved varieties of oilseeds can best be fitted into these systems.

This report presents a brief outline of sesame research in Tanzania.

Agronomy

Sesame (*Sesamum indicum* L.) is predominantly grown by peasant farmers using complex traditional systems of intercropping where more than two crops may be found in the same field. In these systems, sesame is broadcasted while the other crops are sown at random, thus sesame is rarely grown in pure stand.

Because of the complexity of these systems which are difficult to simulate under experimental conditions, the oilseeds research program embarked on developing packages for the "conventional" sole crop system inorder to attract medium-scale producers so as to speed up production of this crop. Therefore, a range of recommendations based on the sole crop system have been developed and compiled in the form of a booklet covering, land preparation, spacings, weed control, time of sowing, varieties and pest management. During the mid-60's, a set of improved varieties, the first ever for sesame in Tanzania were recommended and seed issues made (1). These varieties were significantly higher yielding than the traditional varieties but they were not taken up by the farmers for long presumably because they were not easily adapted to the prevailing management conditions, such as described above. However, in recent years, the management practices of food crops which are intercropped with sesame have undergone radical changes including sowing in rows, use of improved seeds and to a limited extent use of fertilizer and pesticides.

The oilseeds program has, therefore, attempted to develop better methods of intercropping sesame and sorghum, the main staple in the dry areas of the country. The results obtained so far have demonstrated that intercropping sesame with sorghum was superior to growing either crop in pure stand, Table 1. Furthermore, the best intercropping combination was involving an improved sorghum cultivar with a high yielding sesame genotype. Also, incase of crop failure of one component crop, in this case sorghum; intercropping with a more branching sesame cultivar could be beneficial because such a cultivar has a greater ability to compensate for the space made available by producing a high number of productive branches when there is no competition for space and light.

Because of the importance of the intercropping system, the breeding program has attempted to develop genotypes of sesame which fit in well in the intercropping system. Results from a study designed to select a large number of genotypes suitable to the intercropping system have shown that intercropped sesame yields were positively and significantly correlated to their corresponding sole crop yields which indicated that selection for a large number of materials could be based on their sole crop yields initially inorder to reduce work load.

Crop Protection Problems

Insects and diseases are among the major factors that reduce yields of sesame in Tanzania (2). Due to the potentially low yields of sesame caused by various factors other than insects and diseases; it is not practical to recommend the use of pesticides for the control of these pests. Therefore, the only alternative, though difficult to develop is the use of natural methods of control including tolerance/resistance to pest attacks, cultural methods and integrated pest management. This implies detailed studies of the biology and ecology of these pests.

The following is a list of the most important insects and diseases of sesame and their status in Tanzania.

Table 1. Sesame - sorghum intercropping trial conducted at Naliendele, 1985-86.

Genotype Combination*	Yield kg/ha Sesame	Yield kg/ha Sorghum	LER	Value of system** (TShs)	Value of Inter crop Advantage*** (TShs)
	Intercrop Yields				
SSBS9(2) + Local	225	188	1.31	3812	902
Bora + Local	280	157	1.24	3988	772
SSBS9 (2) + Tegemeo	245	886	1.38	6484	1785
Bora + Tegemeo	316	1079	1.74	8108	3448
	Sole crop Yields				
SSBS 9 (2)	532	-	-	6384	-
Bora	510	-	-	6120	
Local	-	227	-	908	-
Tegemeo	-	963	-	3852	-

* SSBS9 = High branching sesame genotype, Bora = Less branching sesame improved genotype, Local = Local sorghum cultivar, Tegemeo = Improved sorghum cultivar

** Assuming sorghum is valued at TSHS. 4.00 / kg of grain and sesame at Tshs. 12.00/ kg of seed.

*** Advantage of intercropping compared to the same area devoted to separate sole crops to produce the same ratio of yields.

Insects:

- Sesame flea beetle (*Alocypha bimaculata* Jacoby) (*Halticidae*) is the most important insect pest in SE Tanzania causing considerable loss of stand and finally seed yield.

- Sesame Worlworm (*Antigastra catalaunalis*) - wide spread, causes severe damage during dry spells.

- Aphids, wide spread, cause severe damage particularly on drought-stressed crops.

- Spider mite (*Hermitasonemus* sp.) status not yet determined but may cause severe damage on certain genotypes.

- White flies (*Bemisia tabaci*) wide spread, suspected to be vector of Leaf Curl Virus (LCV).

- Gall midge (*Asphondylia sesami*) - wide spread, but most severe on late sown crops.

Diseases:

- *Cercoseptoria sesami* - wide spread, causes substantial loss of yield.
- *Corynespora cassiicola* - status not yet determined.
- Root and stem rots-undetermined, cause rotting associated with heavy soils subject to water logging.
- Seedling wilts and damping off - causal agents undetermined but mostly associated with water-logged conditions. The severity can be effectively reduced by the use of seed dressing.
- Powdery mildew *Oidium* sp? - Mostly in NE Tanzania, status not yet confirmed.

Bacterial diseases

- Bacterial blights caused by *Xanthomonas campestris* patho variate *sesami* and *Pseudomonas sesami* cause infrequent damage on the crop.

- Leaf Curl Virus's (LCV) suspected vector is *Bemisia tabaci*. Source of inoculum is also suspected from a semi-perenial weed, *Sida* sp. This is potentially dangerous but does not occur every season.

- Phyllody is sporadic, generally less than 0.01% but considered as potentially dangerous.

- Few sesame genotypes with tolerance to *Cercoseptoria sesami* have been identified but the genetic mechanism of this tolerance has not been determined. One genotype, SPS 80.8 has been found to have some amount of tolerance to *Xanthomonas sesami.*, Table 2.

Germplasm

The germplasm available for the sesame program at Naliendele is still very inadequate to meet the challenges of developing varieties with high and stable yields, which are suitable for specific management requirements, ecological adaptation and possessing resistances to the wide range of insect pests and diseases. Because of the past history of this near forgotten crop, it has not been easy to expand the germplasm collection. Furthermore, because of financial and transport limitations, very few locally available land races have been collected

Table 2. Performance of cv. SPS 80.8 Under High Incidences of Bacterial Blight *sesami*) at Naliendele: Seed yield (kg/ha).

	Year		
Entry	1985	1986	1987*
SPS 80.8	706	600	780
Bora	390	397	789
SSBS 7	188	187	426
Trial Means**	368	295	550
Range	129-706	62-600	206-1150

*The disease was late in this season.
**Mean of 16 cultivars from 3 replications except 1987 which was a mean of 78 cultivars with two replications.

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SCOPE OF SESAME (*SESAMUM INDICUM* L.) IN PAKISTAN

Muhammad Aslam, Masood A. Rana and M. Siddique Mirza

In Pakistan, sesame (*Sesamum indicum* L.) is grown as a minor oilseed crop. However, the growing area is increasing, Table 1. During 1977-78, the area was 31,600 ha with the production of 12,600 MT, while in 1986-87, it rose to 33,000 ha with the production of 12,500 MT, giving 40% increase in area and 0.8% decrease in production compared to 1977-78. About 53.3%, 37.3, 7.3%, and 2.1% of the total area under sesame are located in the provinces of punjab, Sind, Baluchistan and in North West Frontire province, respectively.

Yield potential

The yield potential of sesame varieties in Pakistan ranges between 1,850 and 1,899 kg/ha, but the average yield obtained during 1986-87 was very low, 375 kg/ha. The yield potentials of the varieties progeny 19-9, S-17 and P37-40,for example, are 1,899, 1,852 and 1,850 kg/ha, respectively.

Other sesame growing countries obtain greater yields than Pakistan, the maximum average yield being 1,083 kg/ha in Saudi Arabia, followed by Iran, Peru, Egypt, Mexico and Colombia with average yields of 1,000, 938, 932, 632, and 563 kg/ha, respectively. Sesame can be planted when the land is fallow, and does not disturb any major crop like wheat because it is planted during July after the harvest of wheat and harvested before planting of wheat. Therefore, farmers can get extra income from the same piece of land.

In pakistan, the occurrance of severe attack of root rot and bacterial blight disease and nonadoption of improved cultural practices by the farmers are the main reasons which cause low yield. Therefore, to get optimum yield from the existing varieties, the following cultural practices are needed:

Soil and seed bed preparation

Sesame is adapted to a wide range of soils but usually fertile and loamy soils are preferable. The crop grows well in the regions of limited rainfall on deep soils that store water in their profiles.

As the sesame seed is small, it should be planted on a firm but mellow seed bed with good moisture condition. The land should be well prepared before sowing by 2-3 ploughings, followed by planking (sohaga).

Fertilizer

The sesame crop responds to fertilizers as the seed has high contents of the elements supplied by fertilizers. Nitrogen and phosphorus are the important elements to obtain higher yields. About 57/23 kg/ha of N/P_2O_5 is sufficient to get good yield of sesame. The fertilizer should be applied during seed bed preparation.

Sowing date and method of planting

The best sowing date of sesame is first to last weeks of July. Delay in sowing decreases yield and exposes to greater possibility of disease attack.

Sesame seed should be sown about 2 cm deep in moist soil to foster rapid germination. The row spacing should be 45 cm with plant to plant distance of 10 cm. A seed rate of 5 kg/ha should be used, but if the soil is heavy the rate might be increased to get good germination.

Before sowing, the seed should be treated with Vitavex or any other fungicide to control the incidence

Table 1. Sesame area ('000 ha), production ('000 tons) and yield (kg/ha).

Year	Punjab	Sind	NWFP	Baluch-istan	Pakistan
		Area			
1977-78	10.2	13.3	1.9	6.2	31.6
1978-79	10.4	16.9	3.3	15.3	45.9
1979-80	15.1	17.5	0.9	12.7	46.2
1980-81	22.6	8.2	1.2	12.1	44.1
1981-82	23.8	11.8	1.6	5.6	42.8
1982-83	14.7	10.7	0.7	2.4	28.5
1983-84	13.0	6.1	0.9	2.4	22.4
1984-85	20.4	10.6	0.9	2.3	34.2
1985-86	25.5	8.9	0.7	2.4	37.5
1986-87	17.7	12.4	0.7	2.4	33.2
		Production			
1977-78	3.9	5.0	0.6	3.1	12.6
1978-79	4.1	6.1	0.9	7.6	18.7
1979-80	6.2	6.5	0.2	6.4	19.3
1980-81	9.1	2.7	0.4	6.1	18.3
1981-82	9.7	3.7	0.5	2.7	16.6
1982-83	6.1	3.3	0.2	1.2	10.8
1983-84	5.4	1.9	0.3	1.2	8.8
1984-85	8.8	3.3	0.3	1.1	13.5
1985-86	10.7	2.8	0.3	1.1	14.9
1986-87	7.4	3.8	0.2	1.1	12.5
		Yield			
1977-78	385	379	297	495	399
1978-79	389	365	279	498	409
1979-80	410	372	283	504	419
1980-81	405	326	302	503	414
1981-82	410	311	303	480	388
1982-83	418	307	337	483	379
1983-84	416	312	327	501	394
1984-85	431	313	354	495	397
1985-86	420	313	355	487	398
1986-87	417	296	360	458	375

of seed borne fungal diseases.

Thinning, weeding and hoeing

Thinning should be done 10-15 days after sowing, and the diseased plants should be removed.

Like other crops, weeding is essential in sesame production as the yield reduces because of competition of weeds for soil moisture and nutrients. For this purpose, hoeing should be done with the help of tarphali or rotary hoe when the weeds are small. Two hoeings are sufficient.

Disease

Root rot disease is very common in sesame and causes wilting; as a result the yield decreases substantially. Sometimes the disease attack is so severe that the whole crop is wiped out. Root rot can be controlled to some extent by changing the sowing date as early planting reduces the disease incidence.

Bacterial blight is also serious after rainy season. The attack of this disease can be controlled by two methods: i) planting disease resistant varieties and ii) field sanitation. The latter includes crop rotation i.e. sesame should not be grown on one field in successive seasons, and also the removal of all crop residues after harvest is necessary as these nourish disease organism for the future. By this practice, the crop can be saved from disease, thus, yield increases considerably.

Insect pests

In general, sesame is not seriously attacked by insect pests. However, the two main insects which attack the crop are:

i) Leaf roller *(Antigastra catalaunalis)*: By the attack of this insect, the leaves start curling and ultimately rolled and the growth of the plant is stunted which causes decrease in yield. To control the attack, spray of Dimecron 100% @ 1.0 lb/ha should be applied.

ii) Till hawk moth *(Herse convolvlii L.)*: This insect is of large size and eates leaves of the sesame plants with a great speed. In case of its severe attack, all the leaves are eaten up by the insect and the plant dies due to non-availability of food material. To curb this insect, spraying should be done with Gusathion at @ 1.0 lb/ha.

Harvesting and threshing

Sesame matures in 100-120 days. Timely harvesting is very important, as delay causes shattering and the yield decreases considerably. Harvesting should be started promptly as soon as the 1st pod (capsule) begins to burst. The plants have to be cut at ground level, tied in bunches or sheaves and stacked upright for complete drying. When all the pods burst open at the tip, the bunches should be inverted carefully over a canvas or threshing floor. Then, the seed is to be winnowed, cleaned and packed in bags. Care should be taken that seed may not contain more than 10% moisture.

Varieties

1. S-17: This improved variety was recommended for irrigated areas of Sind during 1974. It is a white seeded variety, with medium-tall stature, matures in 100 days, high yielding and resistant to insect-pest and diseases. The yield potential of S-17 is 1,852 kg/ha.

2. Progeny 19-9: This variety has been identified for cultivation in Sind province. It is white seeded, medium-tall, and medium in maturity taking about 110 days. It has a yield potential of 1,899 kg/ha and is also moderately resistant to insect-pests and diseases.

3. P 37-40: This is an improved variey selected at Oilseed Research Institute, Faisalabad, for general cultivation in the Punjab. The seed is white in colour. The plant is medium-tall with profused branching habit. The capsules are bold and matures in about 110-115 days. The yield potential of this variety is about 1,850 kg/ha.

4. Local Black: This variety is being grown in NWFP on large scale cultivation. The seed is black in colour, the plant is erect with non-shattering capsules, resistant to insect-pest and diseases to some extent and the crop matures in 110-120 days. The yield potential is 594 kg/ha which is very low as compared to other improved varieties.

STATUS OF SESAME AS OILSEED IN BANGLADESH

M.A. Khaleque and Hasina Begum

Sesame (*Sesamum indicum L.*) is the second oilseed crop in Bangladesh after rapeseed and mustard, both in area and production. It is an important crop, which is utilized in preparation of different palatable snacks and food recipes in addition to oil purposes. It is the major oilseed growing in summer (kharif) season, usually sown in spring (early kharif) when the temperature is 25-27°C. It is grown in highland areas where rain water does not stand. It is also grown in winter in some parts of the country. But when the temperature falls below 20°C the crop growth is delayed. Moreover, the growth is checked at temperature below 10°C (4). It is reasonably drought resistant and grows well with average rainfall of 500-650mm, and can stand extreme conditions of 300mm or 1000mm (2). But the crop is highly susceptible to water logging and acidic soil (3).

Growing Area and Region

Based on the average of five years, ending 1987-88, sesame growing area was about 89,319 ha with production of about 50,939 tons (@ 572 kg/ha only), Table 1. Its area has been constantly declining, possibly due to lack of high yielding variety (HYV) and the priority given to cereals. It is largely grown in the greater districts of Barisal, Faridpur, Pabna, Rangamati and Khulna and covers more than 50% of the total area and production, Table 2. In other districts it is grown with less intensity.

Cropping Pattern

Normally, sesame is grown as a sole crop. Mixed crop of sesame with Foxtail millet, Aus rice and even with groundnut is also practiced by the farmers. Cropping patterns are practiced as in Table 3 (1).

Table 1. Area, production and yield of sesame in Bangladesh, 1983-84 to 1987-88.

Year	Area (ha)	Production (MT)	Seed yield (kg/ha)
1983-84	102,340	56,634	558
1984-85	85,602	46,251	541
1985-86	92,039	53,716	583
1986-87	84,586	49,059	580
1987-88	82,021	49,027	598
Average	89,318.	50,937.	572

Table 2. Average area, production and yield of major sesame growing areas of greater districts of Bangladesh (1983/84 - 1987/88)

District	Area (ha)	Production (M. tons)	Yield (kg/ha)	Remarks
Barisal	11,282	7,343	651	Coastal area
Faridpur	9,727	4,919	506	-
Pabna	8,256	4,830	585	Drier region
Rangamati	8,008	4,409	550	Hilly area
Khulna	7,776	4,780	614	Coastal area
Dhaka	6,735	4,004	594	Central region
Total	51,784	30,285	583	

Source: Bangladesh Bureau of Statistics.

Varietal development

The local variety T-6, now under cultivation covers about 80% of the total area. It is characterized by one pod/leaf axil. Pods are medium long and narrow in shape. It contains black colored seeds with 43-44% oil. It is highly susceptible to *Macrophomina phaseolina*. This variety cannot compete with 'Aus' rice and jute. Some other types having brown or red seeds are also grown in some localities. Several materials of different kinds from various sources like USA and India in addition to the local ones, are already under study. Some of these materials are now under advance

Table 3. Cropping patterns.

Spring (Kharif I)	Autumn (Kharif II)	Region
A. Sole crop (Sesame)	Transplanted Aman rice	Barisal, Khulna, Faridpur, and Dhaka.
B. Mixed crop		
1. Aus rice + sesame	Transplanted Aman rice	Pabna
2. Foxtail millet + sesame	Transplanted Aman rice	Tangail, Comilla and Pabna
3. Aus rice	Groundnut + Sesame	Gazipur
C. Intercrop		
1. sugarcane/sesame (early stage)	Sugarcane (Contd.)	Northern district
2. jute or Aus rice	Cotton/sesame	Gazipur.

trials of selection, Table 4. Among those, UCR 9 and UCR-7-1 of USA origin are prominent. But none of these are tolerant to water logging and stem rot (*Macrophomina*). Moreover, adequate number of germplasms are not available.

So, it is highly essential to collect some good materials from different sources to test the suitability under Bangladesh condition inorder to select high yielding varieties capable to compete with Aus rice.

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Table 4. "Comparative performance of different sesame lines" at BARI, Joydebpur, Gazipur of Bangladesh.

Characters	T-6 (check)	UCR-9	UCR-7-1	local
1. Plant height (cm)	114	105	104	119.4
2. Stem stiffness	Narrow, weak	Narrow, weak	Narrow weak	Narrow weak
3. Number of primary branches/plant	3	3	4	4
4. Number of pods/plant	44	40	40	33
5. Pod bearing habit	Single, alternate	Double, opposit	Triplicate opposite	Single alternate
6. Number of chambers/pod	4	4	6-8	6
7. Pod shape	Medium long and narrow	Long and semi broad	Short and broad	Medium long and narrow
8. Number of seeds/pod	56	74	86	83
9. Seed colour	Black	Grey	Brown	Redish
10. Tolerance to heavy shower/ water logging	Moderately tolerant	Highly susceptible	Highly susceptible	Susceptible
11. Disease reaction (stem rot)	Moderately susceptible	Susceptible	Moderately resistant	Moderately resistant
12. Maturity period (days)	86	80	88	90
13. Yield/plant (g)	2.7	2.7	3.5	3.0
14. Yield/ha (kg)	485	668	710	688

Source: Bangladesh Agric. Research Institute.

PROBLEMS AND PROGRESS OF SESAME PRODUCTION IN INDIA

S. Thangavelu, G. Kandasamy, M. Sivanandam and R.K. Murali Baskaran

There is a wide gap between the demand and supply of edible oils and fats in India. With a view to reduce this gap, the Planning Commission set out a target of 18 million tons of oilseeds production by the end of 7th plan (1989-90)and 26 million tons by turn of this century. To attain the target level, an annual compound growth rate of 6.5% in production has to be achieved to reduce the import bill, which was 10 billion rupees during 1986-87.

Eventhough, area under oilseeds occupies a major share in India, production remained isolated from the green revolution which made more impact in Indian agriculture in the late 60's and in early 70's.

Sesame is the most ancient oilseed crop of India. The crop covers the largest cultivated area of 2.5 million ha with 0.5 million tons of production. Sesame ranks third among oilseeds in India after groundnut and rapeseed/mustard and occupies 11.4% of the total area under oilseeds, Table 1. The major sesame growing states are: Uttar Pradesh, Rajasthan, Madhya Pradesh, Maharashtra, Andra Pradesh, Orissa, Tamil Nadu, Gujarat and West Bengal. Among the states, Uttar Pradesh, Madhya Pradesh, Rajasthan and Orissa account for about 65% of the area and 55% of the production. The average productivity in India is 221 kg/ha.

The compound growth rates in area, production and productivity for the periods 1956/57 - 1965/66 (phase I, pre-green revolution) and from 1966/57 - 1985/86 phase II, (post-green revolution) are presented in Table 2. The data show that the area under sesame increased negligibly with 0.06 every year during the entire period. In the same period, production and productivity have increased at the rate of 0.47 and 0.61% per yer, respectively. The productivity contributed more to production than to area.

Table 1. Average distribution of area and production of oilseeds in India, 1980/81-1986/87.

Crops	Area (%)	Production (%)
Edible oilseeds	89.9	93.4
a) Groundnut	40.8	54.1
b) Rapeseed/Mustard	20.7	21.9
c) Sesame	11.4	4.5
d) Soybean	5.8	5.8
e) Safflower	4.3	3.9
f) Sunflower	4.2	2.1
g) Niger	2.7	1.1
Non-edible oilseeds	10.1	6.6
a) Linseed	7.2	3.5
b) Castor	2.9	3.1
Total	(19264.13)*	(12029.85)*

* Total area and production in thousand hectares and tons, respectively.

Table 2. Growth rate of sesame area, production and yield (%/year)in India.

Particulars	Period I 1956/57-1965/66	Period II 1966/67-1985/86	Periods I&II 1956/57-1985/86
Area	0.48	-0.39	0.06
Production	-1.38	1.43	0.47
Yield	-1.90	1.68	0.61

The analysis indicated that during phase I, the area under sesame increased at the rate of 0.4% per year against the decreasing trend in the production and productivity of -1.38 and -1.90% per annum, respectively. In respect of phase II, the trend was completely different. The area decreased by 0.39% though the production and yield showed a good compound growth rate of 1.43 and 1.68% per annum, respectively. It is interesting to note that though area was decreasing the production and productivity increased probably due to good production technology developed and adopted during the post-green revolution period.

At present, attempts are underway to bridge the gap between the potential and average yields obtained in the farmers' field by actually demonstrating in the farmers'field the viable technologies for increasing the production of sesame by scientists of the Agricultural Universities. This has been given high priority in the transfer of technology.

To co-ordinate the different ministries to involve in the production of oilseeds from sowing to oil extraction, the Oilseeds Technology Mission started functioning from 1986 onwards. To the satisfaction of every one, against the target of 18 million tons by March 1990, 17.8 million tons have been attained one year ahead by 30th June 1989. Now there is a great scope to exceed the target.

The main objectives in sesame production are:

1) to increase the yield to 1000 kg/ha,
2) to breed early maturing varieties of 70-75 days,
3) to evolve varieties with high oil contnet (52%),
4) to develop varieties resistant to leaf roller,
5) to evolve varities resistant to phyllody,
6) to evolve varieties with delayed dehiscence, and
7) to develop nutrient management strategies to maximize yield.

The season and weather conditions during the year 1988 were satisfactory for sesame in most parts of India resulting in increased yield.

Crop Improvement

In many places, research programs are being carried out and one variety, RT 46, a white-seeded high yielding type has been identified for northern parts of India. This variety also displayed tolerance to macrophomina root rot. Another culture, "Improved Selection 5" has also been identified as a high yielding one for different parts of the country. Two varieties, ACV-1 and ACV-2 were released in Kerala state.

At a number of places common co-ordinated trials were conducted with a view to identify location- specific varieties for different agro-climatic zones. The emphasis is also placed for developing varieties resistant/tolerant to major pests and diseases of sesame. Attempts are also being made to produce hybrid seeds manually as the standard heterosis for yield was found to be about 50%. The production techniques on commercial basis have been perfected and are being attempted in small scale. Further more, the breeders'seed production of improved varieties of sesame is also taken up by different State Agricultural Universities to cover the entire area under improved varieties.

Crop Management

In general, the sesame crop responded to 50 - 60 kg/ha of nitrogen at different locations.

The intercropping studies conducted at various centres have revealed that the following intercrops were found to give highest monetary return:

Madhya Pradesh	=	Sesame + Green gram	1:1
Tamil Nadu	=	Sesame + Green gram	8:2
Gujarat	=	Sesame + Pearl millet	2:1
Uttar Pradesh	=	Sesame + Pigeonpea	1:1

The spacing trial at Vriddhachalam (Tamil Nadu) has indicated that 220,000 plants per hectare is the optimum plant population to get the maximum yield.

Studies conducted at Vriddhachalam, revealed that Thiram treatment followed by Azospirillum registered highest yield of 435 kg/ha which is 29% more than the control and 15.4% more than Azospirillum treatment. Azospirillum alone increased the sesame yield by 11.9%, Table 3.

Table 3. Combined effect of fungicides and Azospirillum on the yield of sesame.

Treatments	Yield (kg/ha)	Percent of control
Captan + Azospirillum	377	111.9
Thiram + Azospirillum	435	129.0
Carboxin + Azospirillum	382	113.3
Captan alone	337	-
Thiram alone	369	108.15
Carboxin alone	364	108.0
Azospirillum alone	377	111.9
Control	337	100.0
SE	24.3	
CD	73.8	

For storing the sesame seeds upto 8-10 months, the moisture content should be reduced to 5-10% then dry-dressed with Bavistin @ 2 g/kg of seeds and packed in HD polythene 700 gauge thick bags and heat-sealed. Instead of Bavistin, treating the seeds with Thiram 75% wettable powder 2g + activated clay 10 g/kg of seeds may also be done.

To overcome the decline in germination during the early period of storage the following procedure may be adapted. The seeds may be cleaned and soaked for two hours doubling the volume of Disodium phosphate solution (3.5 g for 100 litres of water). If this salt is not available, potable salt-free water can be used. After removing the floating seeds, the soaked seeds may be spread over a clean gunny air-dried under shade & then in the morning or evening sun until they are dried to the original weight and then stored as usual.

Crop Protection

The leaf webber (*Antigastra catalaunalis*) incidence was found to occur in most part of the country and the dusting of Endosulfan 4% or Methyl parathion 2% or BHC 10% @ 25 kg/ha was found to control this pest. The Neem oil @ 5 litres in 500 litres of water (1%) was found to highly reduce shoot webber incidence upto 90% and this is the cheapest plant product that can be used without any pesticide residue as well as environmental pollution problems. Spraying of chemical at vegetative phase as well as flowering period will be highly useful to control this pest.

The three genotypes viz., Es 12, Es 22 and SI 250 were found to be moderately resistant to leaf webber as per the trial conducted under bombarded condition, Tables 4a and 4b. This moderate resistance continues to be exhibited even upto 90 days. So, these could be good donors for shoot webber resistance. The wild species *S. alatum* was also found to be highly resistant to this pest both in the vegetative as well as pod stages.

The highest percentage of shoot webber and phyllody was recorded in kharif season as compared to other seasons. The yield loss due to shoot webber/pod borer was 41.8 - 58.9% depending on the genotypes and season.

Table 4.a Screening for sesame shootwebber incidence.

Entry	Shoot webber damage (%) 1985 Summer	1985 Kharif	Mean
SI 250	7.5	4-3	5.9
ES 22	2.6	0.0	1.3
ES 12	4.3	0.0	2.2
TMV 4 (Check)	21.4	34.0	27.7
SED	12.87±1.4	15.87±2.8	

Table 4b. Shoot webber incidence, 1988 Rabi.

	Trial I			Trial II			
	Shoot webber damage %			Shoot	Seed fed		
Entry	40 DAS	60 DAS	90 DAS	webber damage (%)	by larva (%)	Grade	Remark
ES 22	2.3	8.7	12.4	10.8	4.3	3	R
SI 250	7.4	10.7	15.3	11.1	5.9	3	R
TMV 3	15.1	25.9	29.2	29.9	31.9	7	S
S.alatum	12.5	5.8	0.0	6.1	0.9	1	HR

* R = Resistant, S = Susceptible, HR = Highly resistant.
DAS = Days after sowing.

Sesame intercropping with pearl millet or groundnut reduces the incidence of shoot webber/pod borer resulting in increased grain yield and land equivalent ratio (LER). The incidence of pest was high in pure crop of sesame while the sesame intercropped with pearl millet or groundnut showed lower incidence, Table 5. The LER was also high. In the varietal screening for shoot webber/capsule borer, three more entries PDK-31, 020-3-1 and SI-810 were moderately resistant even under controlled conditions.

Table 5. Influence of intercropping on *Antigastra catalaunalis* infestation.

Cropping pattern	Inter-crop ratio	Rainy season '87 Shoot webber damage (%)	LER	Rainy season '88 Shoot webber damage (%)	LER
Sesame + Groundnut	4:1	19.2	1.60	5.5	1.39
Sesame + Pearl millet	4:1	13.1	1.49	3.4	1.21
Sesame alone	-	34.8	-	11.2	-

The survey of the diseases indicated that the leaf curl virus was found to be high in the northern parts of India ranging from 35 to 95%. Phytopthora blight, bacterial leaf spot, Macrophomina, Alternaria and Cercospora were also found to occur in one or other parts of India.

Early sowing of sesame immediately at the onset of south west monsoon was found to reduce the incidence of shoot webber as well as other diseases.

In the screening for resistance to powdery mildew, two genotypes viz., SI 3315/11 and VS-112 were found to have low grades of incidence, Table 6.

Table 6. Powdery mildew incidence, 1988 Rabi, (0-5 grade).

Entry	Natural condition	Artificial condition	Remark*
SI 3315/11	1.67	1.90	MR
VS 112	1.47	1.83	MR
TMV 3	3.80	4.53	HS
TMV 4	4.17	4.57	HS
TMV 5	4.23	4.37	HS
TMV 6	3.97	4.40	HS
CO 1	2.07	2.73	MS

* MR = Moderately resistant, HS = Highly susceptible, MS = Moderately susceptible.

It is important to note that phyllody symptoms were observed at Coimbatore on different crop plants besides sesame: Sunhemp 22%, Parthenium 32%, Pigeonpea 4%, *Petunia hybrida* 1%, Green gram 5%, Bengal gram 5%, Fenugreek 3% and Sword bean 9%. It was also found that these crop plants act as host for the phyllody vector *Orocius albicintus* under natural condition along with Alfalfa.

PESTS OF SESAME AND THEIR CONTROL[1]

S. Thangavelu

Common Sesame Pests

I. Seed and Seedling

Scientific name	Common name	Where found
Agrotis spp.	Cutworms	Cosmopolitan
Amsacta moorei	Tigermoth	India
Aphthona sp.	Flea beetles	Africa
Chrotogenus spp.	Grasshoppers	Asia
Systena sp.	Flea beetles	S. America
Zonocerus variegatus	Grasshopper	Africa

II. Stem:

Baris helleri	Weevil	Africa
Oberea sesami	Borer	

III. Foliage:

Acherontia styx	Eastern Deoth's head hawk moth	Europe-Asia Far East.
Aleyrodidae	White flies	Africa-Asia
Amsacta moorei	Tiger moth	India
Antigastra catalaunalis	Sesame leaf-roller	Cosmopolitan
Aphis gossypii	Aphid	Africa
circulifer opacipennis	Leafhopper	Europe-Asia
Crytopeltis tenuis	Tomato bug	Cosmopolitan
Deltocephalus spp.	Jassids	Africa-Asia
Diacresia obliqua	Tiger moth	Asia, Far East
Myzus persicae	Aphid	Cosmopolitan
Spodoptera spp.	Leafworms	Cosmopolitan
Taylorilyqus vosselevi	Cotton lygus	Africa

IV. Flower and Fruit:

Acrosternum hilare	Green stink bug	America
Agonoscelis pubescens	Andat bug	Africa
Aphanus sordidus	-	Africa-Asia
Asphondylia sesami	Gall midge	Africa-Asia
Calidea sp.	Shield bug	Africa
Nezara viridula	Shield bug	Cosmopolitan

V. Storage:

Carpophilus obsoletus	Dried fruit beetle	Asia
Corcyra cephalonica	Rice moth	Cosmopolitan

[1] This paper is a response to recommendation No.10 of the first meeting (Oilcrops: Sunflower, Linseed and Sesame. IDRC MR205e, A.Omran ed.1989:311).

Ephestia cautella	Tropical warehouse beetle	Cosmopolitan
Tribolium castaneum	Red flour beetle	Cosmopolitan
Trogoderma granarium	Khaprabeetle	Cosmopolitan

Important Pests of Sesamum in India:

Common name	Scientific Name	Nature of damage
	Key Pests	
Shoot and leafwebber	*Antigastra catalaunalis* (Duponehel)	Leaves webbed and eaten seed on flowers.
Sesamum sphinx	*Acherontia styx* (Estwood)	Defoliation.
Sesamum gallfly	*Asphondylia sesami* (Felt)	Larvae feed on flowers.
	Potential Pests	
Jassid	*Orosius albicinctus* Distant	Vector of phyllody
Pod-Suking bug	*Elasmolomus sordidus* Fabr.	Sucks pods.
Green peachaphid	*Myzus persicae* (Sulzer)	Sucks Sap.
Red hairy caterpillar	*Amsacta moorei* (Butter)	Defoliation.
Bihar hairy caterpillar	*Diacrisia obliqua* (Walker)	Defoliation
Tobacco caterpillar	*Spodoptera litura* (Fabr.)	Defoliation.

Sesame is subject to attack by a wide range of insect pests, but there is considerable variation in the relative importance of various insects in different countries. In some, those species attacking flower heads and young fruit assume greatest economic importance, while in others foliage eaters cause the major loss.

In East Africa for instance, list of some thirty species feeding on sesame was found, but only half a dozen are of any importance. In other countries longer list has been compiled, but the proportions are similar (45). Insects are major causes of yield reduction in sesame and a world-wide average of 25% of the potential yield can reasonably be assumed.

In general, chemical control of sesame pests is uneconomical, but the extent of potential yield loss must be realized and offset as far as possible by cultural techniques. For instance, high seed rates can compensate for seed-bed losses, branching varieties produce more flowers than non-branching types. Planting dates that avoid the main outbreak of a major insect pest are established, and destruction of crop residues assists in reducing succeeding infestations. Screening within local varieties and strains can be very useful in selecting for resistance to a local pest (56).

Insect attacks may influence traditional planting and cultivation methods and their control requires a change in techniques. For instance, late thinning may compensate for gaps caused by mole crickets or cut worms, but if these pests are controlled, plant populations may be too high and early thinning or lower seed rates become necessary. Losses occur not only in the fields, but also during storages which are usually primitive and inefficient under peasant conditions.

Foliage eaters are of major importance in the main sesame growing regions, although the particular species concerned may differ from area to area.

<u>Shoot and leaf webber, *Antigastra catalaunalis*</u>:

It is a major pest in all sesame growing areas in India. Newly hatched larvae mine the young leaves and shoot tips and at a later stage they fasten leaves and shoots together with silk and feed inside. The caterpillars destroy tips of the plants, including flowers, pods and seeds.

The pest is active from August to November. Early (June) sown Kharif crops are less infested than late sown kharif crops, but semi-rabi crop is more infested than the kharif crop (12).

Antirrhinum majus and *Duranta* act as alternate hosts. The moth lays small greenish eggs singly on the tip of the growing shoots and flowers and fecundity is 86-232 during oviposition period of 5 days. Egg period lasts about 2 days, larval period 10-15 days and pupal period 4-19 days. Pupation takes place inside webbed leaves and in fallen leaves or soil crevices. The pupa is green and is generally covered with whitish silken threads. The pest is reported to pass 14 generations in a year. The adult moth is with brownish yellow forewings decorated with indistinct zigzag lines. The hind wings are pale yellow almost transparent and the moth looks cream colored.

Destroying volunteer sesame plants and alternate hosts like *Antirrhinum majus* prevent early infestations.

Some tolerance in sesame lines B-67, C-1036 and E-8 and moderate resistance in *Sesamum prostratum*, a wild species, has been reported. *Inchneumonids, Temelucha biguttula, Campoplex* spp. and *Trathala flavo-orbitalis* have been reported to parasitise the larvae of this pest.

Carbaryl 0.15% and Endosulfan 0.07% were reported to be economical and effective insecticides against *Antigastra*.

More details about this pest appears in Appendix I.

<u>*Sesamum sphinx, Acherontia styx*</u>:

The Sesamum Sphinx is a major pest in West Bengal and of minor importance or occasionally becomes major in other areas.

The Shining eggs are laid singly, on the underside of the leaves and the larvae feed on the leaves and pods. If te infestation is high, it may completely defoliate the entire crop. Fully grown caterpillars are 7mm long, green with oblique yellow body streaks, and with a recurved horn on the posterior segment. Normally, the pest is active from March to November and the infestation is maximum in September, caterpillars pupate in the soil in September-October and remain in pupal stage until March-April.

Ploughing of cropped fields after harvest will expose the pupae and reduce the incidence of the pest in the following season.

A Braconid, *Apanteles acherontiae* parasitizing the larvae and an Eupelmid, *Anastatus acherontiae* parasitising eggs have been reported.

Carbaryl 0.15% or Endosulfan 0.07% sprays are effective in controlling the pest.

<u>Sesamum gallfy, *Asphondylia sesami*:</u>

Sesamum gallfly is a major pest in Andhra Pradesh and Maharashtra.

The adult is a mosquito-like fly with long antennae and the maggots are greyish cream. Eggs are inserted in young flower buds and maggots feed on the floral parts, particularly ovary. The irritation caused by the feeding of the larvae results in the formation of gall like buds which do not develop into seed capsules. The maggots pupate in the galls. The adult emerges through an exit hole, leaving the pupal case protruding.

Avoiding late sowings and application of Dimethoate or BHC at 15 days interval during flowering period are found to be effective in reducing the pest incidence.

Jassids, *Orosivs albicinctus*:

The Jassid is the vector of phyllody which is a major disease of sesamum caused by MLO. The jassid is infective for life after latent period of 10-11 days.

Time of planting may influence the severity of attack. For instance, in Kanpur, mid-July sowings were found to greatly reduce the incidence. In Madras, early planting is recommended, while in Uttar Pradesh, it is late planting. The incidence of the disease and the jassid prevalence seem to be correlated. Those varieties flowering in 41-50 days were less affected by phyllody. Breeding or selection of strains resistant to the jassid within this group would appear to offer the greatest opportunities of increasing resistance to phyllody.

Insecticidal control of the jassid with Dimethoate can substantially reduce the incidence of the disease.

Storage pests:

The damage caused by insects attacking sesame seed and cake is substantial, but there is little published information on the actual degree or amount of damage in a specific region. Almost all official publications on the crop make reference to this loss and to the necessity of providing insect-proof storage for the following season's seed. The extent of this loss can be judged from official estimates of the Ministry of Agriculture, Pakistan, which quotes the amount of seed stored from one season to the next as 1,200 tons or some 2.3% of the total production. Heavy loss can also occur in India (45).

The most common pests of sesame seed and cake are *Tribolium castaneum* Hbst. and *Ephestia cautella* Lep. Both are cosmopolitan and attack a range of stored products. They are also the most frequently noted as infesting ship cargos. Other insects recorded on sesame seed and cake are *Corcyra cephalonica* St. in India, Africa and Brazil, *Cryptolestes pusillus* Schon, *Oryzcephilus mercator* F. in Africa, *Carpophilus* spp., *Ephestia cautella* Wlk in India and Pakistan, *Tribolium confusum* Dun. in Uganda and the Central African Republic.

The effect of using the fumigant Phosphine on the viability of some oil seeds including sesame, has been investigated in India. The USA official tolerance level for post-harvest fumigation of sesame seed with hydrogen cyanide is 25 ppm.

The hygacid *Spilostethus pandurus* (scop) was reported as a pest os sesame (48). *Diacrisia oblique* a polyphagous pest was also found to cause severe damage to sesamum (16, 55).

Sprays (0.1%) of Chloropyrifos, Monocrotophos, Leptophos, Methamidophos, Permethrin, Quinalphos and Endosulfan applied at a rate of 520 l/ha had a strong knock down effect on third-instar larvae (15).

Melanagromyza azawii Spencer was reported to infest sesame for the first time (39).

Larvae of *Holotrichia consanguinea* were found feeding on the sesamum plants (6).

It was found that 3 applications of BHC dust at 22 kg/ha at 35 (flowering stage) 50 and 65 days after sowing reduced the incidence of gallfly *Asphondylia sesami* to 7.1% and increased seed yields to 283 kg/ha compared with 12.4% and 185 kg/ha respectively for untreated control (30).

In pakistan, the leaf hopper *Empoasca sesame* was reported as a new pest on sesame at Karachi (31).

Biological control of gingelly blossom midge:

The parasitization of *Dasineural sesami* Grover & Prasad a common pest of sesame by the Pteromalid *Pteromalus fasciatus* (Thomas) was studied (40). The results showed that the second instar larvae were the most susceptible to parasitism, which ranged between 26.66 and 45.55%. However, the average rates of parasitism of the third and fourth instar larvae were 20.57 and 2.36%, respectively, and it was further reported that *P. fasciatus* is a biological control agent of *D. sesami*.

Aphid:

Aphis croccivora Roch was reported as a pest of sesame (34).

In Rajasthan, India, *Amsacta moorei* was found attacking sesame (36).

A study on the parasites of larvae of the noctuids *Acliothis zea* Boddie and H. eliothis virescens F. collected from cotton and inter planted sesame, showed that *H. virescens* was found more on sesame than on cotton and more often parasitised (35). The braconid *Apanteles marginiventris* Cress and the ichneumonid *Camplotis jonorensis* Cam were the most abundant parasite species reared for *Heliothis* larvae on sesame (54.8%).

It was reported that Lygaide *Nysius inconspicuus* Distant severely damage sesame in Tamil Nadu, Karnataka and Kerala (47). It was further reported that *Aerra tomentosa, Amaranthus bengalensis, A. viridis, cebosia argentea (Ageratum conyzoides), Euphorbia pilulifera and Mullugo* sp. are alternate hosts for this pest.

The following pests of sesame were reported in Tanganika (42):

- Pentatomid (*Phrycodus hystrix* Germ), Puncturs the seed capsules,
- Halticid (*Aphthona bimaculata Jac),* attacks the folliage,
- Aphid (*Myzus percicae* Sulz), sucks the growing tips.
- Leafwebber (*Antigastra catalaunalis* Dup), binds the growing tips and causes terminal distortion of the plants.

APPENDIX I

Shoot and leaf webber (*Antigastra catalaunalis*)

Description and Biology

A. catalaunalis is described as a leaf roller of sesame in a report to the government of Bengal (22). It was also reported as a major pest of sesame from Travancore (38). A report from Rangoon described this pest as rolling the top leaves and also boring in the pods of sesame (14). The pyralid *A. catalaunalis* which is a native of South Africa was recorded as a pest on sesame in Transvaal (18). The caterpiller feed on the tender shoots and leaves in a sort of nest made by webbing the leaves together and also bore into the green pods of the plant, thus wholly or partly destroying the seeds for which this crop is grown. 30% of the pod were observed to be damaged by this pest. In nature pupation probably takes place in the soil. In May the moths emerge in 2-3 weeks and though no eggs were found it is probable that they are laid on the tender parts of the sesame plant. The caterpillars were fairly heavily parasitised by two small *Braconids*.

This pest was described as binding the growing tips and causing terminal distortion of the plants (42). It was also indicated that the pyralid *A. catalaunalis* damages the tops including the pods of the plants (20, 44). The pest was recorded from two localities in the Belgian as injurious to sesame (44). It was also described that no external injury is caused to the pods by the larvae suggesting that the eggs are laid on the flowers and that the larvae after hatching reach the ovary and grow with it (5). Each pod is usually seen to be fed by single larva. On reaching maturity, the larvae bore out of the pod and pupate in the ground. Oviposition on sesame may perhaps be the result of infestation by aphids, the moths being attracted to plants by the aphids' honey-dew.

In an annual report (21), *A. catalaunalis* was mentioned as a pest of sim-sim (sesame) and the first June-August sown crop was much more severely infested than the second (Oct.-Dec) sown crop and thus, it was recommended that serious damage may be avoided by sowing during the later rains. The indigenous *Sesamum angustifolium* was found as an alternate host of *A. catalaunalis*.

Other reports also strongly stress that A. catalaunalis is an injurious pest on sesame (10). The larvae infest all the parts of the plant and most damage was caused by destroying the buds, flowers, seeds and immature seed capsules and the damage ranged from 10 to 30%.

A. catalaunalis was also recorded as injurious to sesame in Russia (13), New Delhi (23), and Turkey (58) where the larvae were found webbing the leaves or flowers which they feed and bore into the young shoots and enter into the pods and feed on the seeds. He further mentioned that infestation on pods can reach upto 87% (58).

Seasonal incidence

A report from Cyprus (29) indicated that the larvae of *A. catalaunalis* severely damage the pods of *Sesamum orientale* during August and September.

Investigations on the effect of sowing time of sesame on the occurrence of *A. catalaunalis* revealed that the incidence of the pest was highest (16.0-23.0%) in crops sown in February and September - November and lowest (8%) in those sown in June-August in Tamil Nadu, India (1).

Effect of weather factors

Studies on the effect of some climatic factors on the fluctuation of population of *Antigastra catalaunalis* revealed that the pest incidence was higher in dry sunny weather than in wet weather, and out-break occurred when a long dry spell had been preceded by heavy rains (7). Further, the plants kept under artificial shade were always attacked less severely than those kept open. There was a positive correlation between the abundance of the moth and the number of hours of sunshine, a higher proportion of larvae died in the wet season than under dry weather conditions and their activity was found high when the maximum and minimum temperatures were high and the rainfall was low.

Chemical control

The relative toxicity of dried film of 10 insecticides to full-grown larvae of *A. catalaunalis* under laboratory condition was investigated (46). The results indicate that Lesor after 24 hrs showed that Parathion was the most toxic, followed by Malathion, Fenitrothion, Mevinphos, Diazinon, BHC (Lindance, the standard), Endrin, Carbaryl, Carbophonothion and Dimethoate.

Sprays of Monocrotophos 0.5% applied 5 times at 10 day intervals starting from 21 days after sowing gave effective control of phyllody and shoot webber (2).

It was also reported that 0.6 kg Furadan 3 g (3% Carboforan) ai/ha applied to the soil in 2 split dressings at 30 days interval beginning 10 days after sowing or 0.28 kg Metasystox 25 EC (Methyldemeton) ai, 2.5 kg Ambithion 500 E (Malathion and Semitrothion in 1:1 ratio) ai or Metasystox + Ambithion applied in 3 foliar sprays at 15 days intervals beginning 35 days after sowing gave effective control of *Achrontia styx*, *A. catalaunalis* and *Cyrtopeltis tenuis* and resulted in seed yields of 510, 840, 692 and 831 kg/ha, respectivley, compared with 364 kg/ha without insecticides (38). It was further reported that application of Metasystox and Ambithion gave a wide spectrum of pest control.

A chemical control trial against sesame pod borer *A. catalaunalis* was reported that Phosphamidon (0.04%) followed by Endrin (0.04%) and Carbaryl (0.20%) gave the best result both in respect of lowering the pest infestation and giving higher yields (56). Further, it was reported that each of these chemicals can be applied as a spray.

Investigations on 4 field pests on sesame in Nigeria in 1940-72 revealed that 0.2-0.8% suspensions of powdered seeds of Neem tree *(Azadirachta indica)* applied in sprays at 250 lit/ha 6 times at weekly intervals acted as a feeding inhibitor against larvae of *A. catalaunalis* reducing infestation and increasing the yield (7). The reulsts compared favourably with those obtained when Carbaryl and a mixture of BHC with DDT were used.

Investigations on the effectiveness of some insecticides against *A. catalaunalis* on sesame showed that at a rate of 0.26 kg/ha Permethrin Quinalphos, Monocrotophos, Endosulfan and Leptophos reduced the larval population on the young sesame plant by 97.9, 95.7, 90.0, 86.3 and 79.9%, respectively (17). At the advanced stage of the crop, Quinalphos and Endosulfan at 0.52 kg/ha reduced the larval population by 93.9 and 89.7% 2 days after spraying. Monocrotophos at 0.52 kg/ha had a delayed action and reduced the larval population by 91.5% 5 days after spraying. Phoxian, Phenthoate, Chlorpyrifos and Methamidiphos were relatively ineffective (17).

A spray containing 0.1% Carbaryl or a dust containing 5% DDT was recommended against *A. catalaunalis* (51). It was also reported that Monocrotophos at 200g ai/ha was most effective compound against the pest, followed by Carbaryl and Endosulfan at 1.0kg and 350 g ai/ha, respectively (57). Spray applications were made on 45th and 60th days of crop growth.

Among the insecticides tried, 0.05% Monocrotophos, 0.05% Chorphyrifos, 0.05% Endosulfan, 0.05% Fenitrothion, and 0.15- Carbaryl, the Monocrotphos, Chlorpyrifos and Endosulfan were the most effective against *A. catalaunalis* (37). The yield of sesame from Monocrotophos treated plots was significantly greater than those plots treated with the other insecticides. The lowest incremental cost-benefit ratio was obtained in plots treated with Monocrotophos (1:8.68) followed by Chlorphyrifos (1:4.98) and Endosulfan (1:4.27) but all the insecticides were significantly superior to the untreated control.

Two spray applications (20 and 55 days after sowing) of 0.2% Carbaryl, 0.07% Endosulfan, 0.05% Quinalphos, 0.05% BPMC (Fenobucarb), 0.02% Phosphamidan, 0.02% FMC (of unsaturated compound) or 0.05% Phasalone reduced infestation of sesame in Maharashtra by A. catalaunalis (24). The best results were obtained with Carbaryl for which infestation averaged 3.58% as compared to 14.38% of untreated check.

<u>Bio-control</u>

It was mentioned that *Bracon kitcheberi* was reared from *A. catalaunalis* (3). *Camplothlipsis antigastrae* and reported on the pyralid *A. catalaunalis* from Anglo-Egyptian Sudan, (52) and the braconide *Apanteles aethiopicus* on the pyralid from Uganda and Sierraleone. Also, *Apantely aethiopicus* was reported from the pyralid *A. catalaunalis* (53).

Microbracon hebetor was found parasitising the caterpillars of *A. catalaunalis* in large numers from August till the end of November (49). This parasite is also found on the Lepidopteran which is predaceous on the lae insect *Laccifer lacca*.
The species of Microbracon parasitising larvae of A. catalaunalis were identified in Delhi as *M. hebetor* Say and *M. brevicornis* (41). In the mass breeding of Braconid, *Bracon hebetor* naturally parasitises different lepidopheran pests including

A. catalaunalis (33).

The nematode Mermis sp was found for the first time attacking larvae of *A. catalaunalis* in India (25). The parasite appeared in late June or early July (the start of the monsoon period) and was present until October and the parasitisim reached a maximum of 85% in 1970 and 78% (in the second half of August) in 1971.

Four parasites namely, Euplectrus sp (Hym: Eulophidae), Bracon sp (Hym: Bracomidae), Spilochalas sp and Brachymaria sp (Hym: Chelcididae) were reported from Coloumbia (19).

Nine natural enemies of the pyralid i.e., *Bracon gelechiae* Ashm, *B. hebetor* Say, Agathis sp., Eriboros sp, Diadegma sp (Nythobia sp), *Tratha flavoorbitalis* (Corn) Cremastus flavoorbitalis) the nematode Mermis sp and the predator *Canthoconida furcellata* (Wolff) were reported from Jabalpur, India (26).

Varietal resistance

Early maturing varieties having relatively sparse branching habit showed lower susceptibility than more profusly branching types (4). Hairy plants on the whole were comparatively disease free, however, they were proven to be more susceptible to larvae of *A. catalaunalis* than glaborous plants.

Sixty four different varities of sesame were sown in July during the rainy season of 1970-1971, in india (27). Capsule infestation varied from 0.2 to 3.9% in 1970 and from 6.1 to 24.4% in 1971. The webbed plants amounted to 3.5 - 26% in 1971. No relationship was observed between the time of flowering or seed ripening and the degree of infestation. The varieties N 66-276 and N 66-250 had the fewest infested plants, while N 66-4 showed the least capsule infestation.

Among a number of varieties screened, line 3-2 was the least susceptible on the basis of percentage of damaged capsules (54). It was also found that 13 Indian varieties were identified as sources of resistance to *A. catalaunalis* and the breeding line X173 derived from ICA Pacande combined high yields with resistance to *phaseolina* (11).
The comparative incidence of *A. catalaunalis* in 11 cultivars of sesame was studied (34). The lowest number of larvae was observed on TC 289, follwed by Punjab Till No. 1, and the most susceptible cultivars were TC 103, TC 151, TC 160 and TC 135. TC 289 had the lowest proportion of infested plants (12.8%) closely followed by Punjab Till No. 1 (15.4%). Infestation of plants of the other cultivars varied between 25.8 and 42.2%. However, these differences were not significant. The rate of pod infestation was lowest in Punjab Till No. 1. (11.8%) and highest in TC 167 (24.9%). On the basis of these results, the least infested cultivars were TC 289 and Punjab Till No. 1 (9).

Investigations on nine varieties of sesame in India showed that damage varied from 3.35% to 8.39% and that 128, TMV 2, B14 and T4 were the least damaged (28).

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REVIEW AND PROSPECTS ON SESAME PRODUCTION IN CHINA[1]

Tu Lichuan

Review

Sesame (*Sesamum indicum* L.) has been cultivated in China for more than 2,000 years, and it remains to be a major oilcrop in the country. Sesame is rich in oil and other nutrient ingredients. Its oil possesses a pleasant flavor and is regarded as a superior grade vegetable oil. Besides extracting oil, sesame is also broadly used in food, confectionery, medicine, perfume and other light industries. In comparison with other major oil crops, however, its yield is lower and more unstable, and owing to its shattering characters it can not be harvested by machine.

Sesame production in China passed through the periods of decline (1956-1977), recovery (1978-1984) and development (1985-) over the past four decades. In 1955, the sesame area in China had reached as much as 1,147,000 ha, but was reduced continuously afterwards. In 1975, it dropped to the lowest point, only 534,000 ha. In the mean time, production also dropped from 521,000 MT in 1953 to 151,000 MT in 1960. A reduction of 70% occurred within this period. In more than 20 years, 1956-1977, the area and production of sesame in China remained rather in a low level, Figure 1. This is because, China is a developing country with huge population, it has to give priority to develop high yielding cereals and oilcrops to meet the demands of the people.

Since 1978, along with the growth of the nation's economy, and progress of the scientific research in sesame itself, the production has then turned to a recovery stage. In 1985, the sesame area again expanded to 1,052,000 ha, almost equal to the area of 1955, Figure 1. The sesame production of that year was 691,000 MT, 32.6% higher than the historic record in 1953. In the recent 10 years, from 1976 to 1985, sesame area increased by 87.5%, and the production increased from 229 to 691,000 MT, almost tripled. Figure 1 shows that the yield is very unstable. This is because sesame is very susceptible to any undesirable weather conditions such as drought, too much precipitation, low temperature, etc., and the irrigation and drainage facilities in fields are not sufficient. On a grand scale, however, the yield has improved steadily in every decade: 370 kg/ha in 1950s, 388 kg/ha in 1960s, 434 kg/ha in 1970s and 502 kg/ha in 1980s, Table 1. The average yield of 1981-1987 was 49.2% higher than that of the 1950s. In 1985, the sesame production in China reached a record high of 660 kg/ha. This achievement was made mainly due to:

1. New varieties with characteristics of high yield, disease resistance and tolerance to water-logging were bred and released.

2. Extension to the farmers, of improved agronomic approaches, such as optimum sowing date, proper rotation of crops, rational close planting and prevention and control of diseases and pests,

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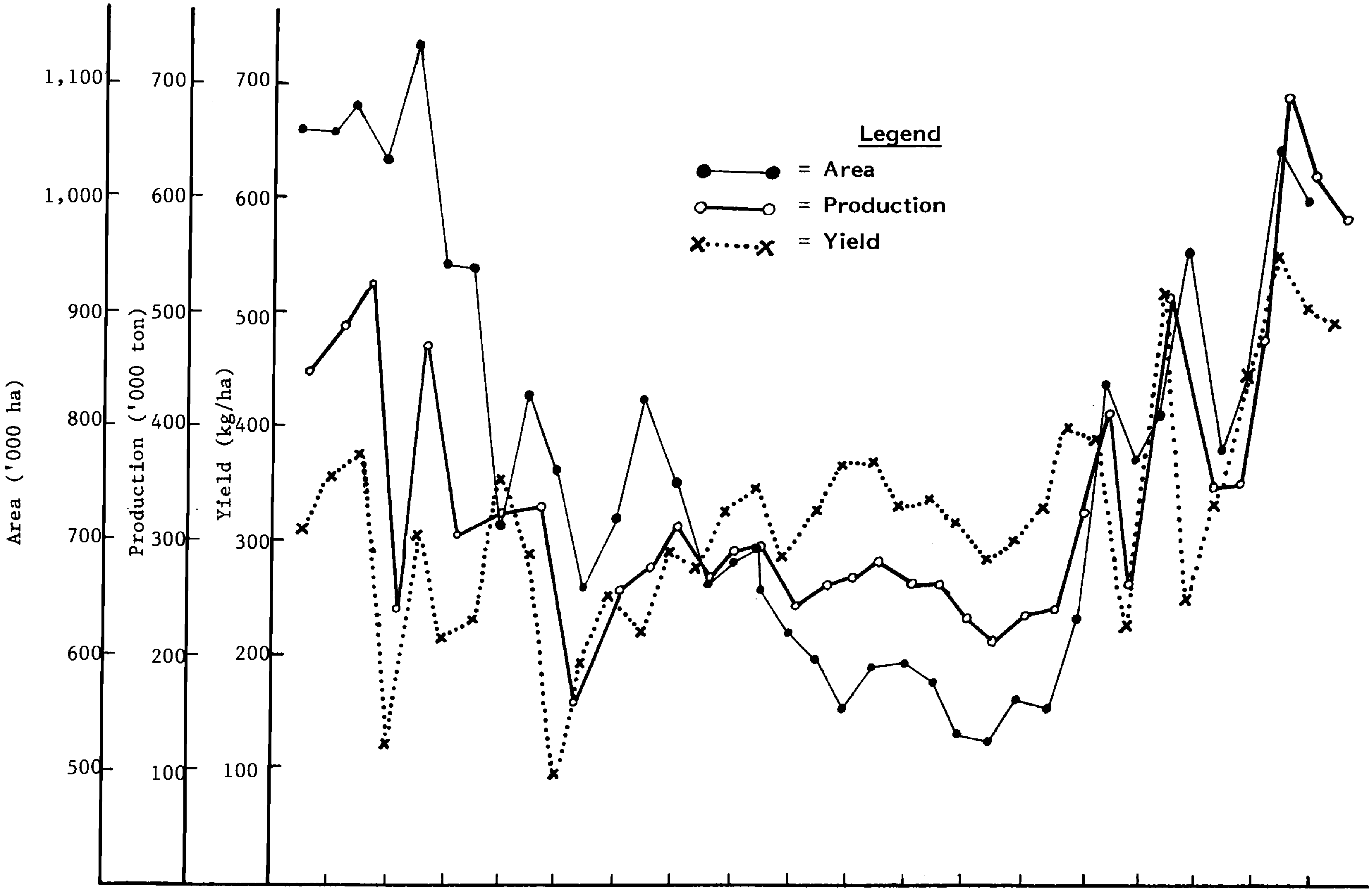

Figure 1. Area, Production and Yield of Sesame in China.

3. Improvement of basic conditions, such as irrigation-drainage engineering and fertilizer application.

4. Encouraging policy of the government for developing oil crops, and

5. The international scientific consultation and cooperation in sesame research and production.

Prospects

Although we have made some progress in sesame production in recent years, and have the confidence in its further development, we are still facing a series of tough tasks to be solved. As to our consideration, a minimum yield of 900 kg/ha is required to make sesame competitive with other crops, and this target might be reached through:

1. Reinforcing the breeding programs: It seems the most actual way to improve the sesame yield. If the cooperation in exchange of germplasm, breeding stocks and advanced breeding methods can be strengthened, it will speed up the breeding of new desirable and high yielding varieties.

2. Improving agronomic approaches: Many demonstrations showed that sesame yield in a small plot may be as high as 1,500 kg/ha or even higher. This indicates that great potentialities exist in sesame production. Applying advanced agronomic approaches is an important way to raise the yield.

3. Using heterosis and male-sterile strains: Experiments showed that heterosis in sesame do exists. The yield of a hybrid can surpass the best local variety by 50-60%. Although it is not practicable at present it is very promising in the future. The recessive genetic male-sterile strains in sesame have been selected. If these strains can be turned into dominant, they will hopefully be used in hybrid production.

4. Improving the field construction, especially the irrigation and drainage systems.

5. Encouragement of government policies, and

6. International cooperation: FAO and the IDRC's Oil Crops Network have done a series of admirable efforts to push forward the development of sesame research and production and the cooperation among scientists around the world. These efforts are effective and productive. They promote the improvement of sesame in many countries, and so also in China. We are looking forward to a close cooperation with our colleagues who are interested in this field.

Table 1. Average Area, Production and Yield of Sesame in China during 1950s, and 1980s.

	Area		Production		Yield	
Period	000 ha	% of (1)	000 MT	% of (1)	Kg/ha	% of (1)
(1) 1951-60	959	100.0	354	100.0	370	100.0
(2) 1961-70	679	70.6	263	74.3	388	104.9
(3) 1971-80	622	64.9	270	76.3	434	117.3
(4) 1981-87	908	94.7	502	141.8	552	149.2

SESAME IRRIGATION IN EGYPT

Ahmed Mohamed El-Wakil

Abstract

For best seed production, sesame should be irrigated when the available soil moisture depletion in root zone reaches 50-60%. The differences in water quantities consumed by the same sesame entries (1550, 2276 and 2676 m^3/fed.) grown at Bahtim (South Delta), Fayoum (Middle Egypt) and Shandawil (Upper Egypt) might be attributed to variation in soil and meteorological factors. Water use efficiency was 0.30-0.32 kg/m^3 at Bahtim and Fayoum, while at Shandawil it was 0.10 kg/m^3 due to the more water consumption. No significant difference was found in water quantities consumed by sesame entries in all experiments.

Sesame (*Sesamum indicum* L.) is one of the oldest crops known to man and might be the oldest cultivated oilseed crop. The leading countries in the production of sesame are: India (2.5 million ha), China (one million ha) and Burma (about 400,000 ha). The Sudan ranks third as world producer and first as exporter (1).

In Egypt, 30% of the present oil consumption comes from domestic raw materials, mainly from cotton seed. The remaining is imported to compensate the shortage of edible oils. To fill the gap, oil crops should be given great attention by research workers and crop growers. In this respect, sesame is one of the main promising crops. Its seed is a rich source of oil and protein.

Irrigation management is very important nowadays in Egyptian farms due to the shortage in water resources and the expansion of agriculture in the newly reclaimed areas. Further, too much or too little watering causes serious crop damage. Therefore, it is necessary to determine the optimum water requirement and to plan the best irrigation schedules for maximum crop production. Studying evapotranspiration (consumptive use) either emperically or by developing formulae has been given a great attention, to meet the above purpose for all crops. In Egypt, little information is available about sesame water requirements. Therefore, three field experiments were conducted with major objectives to:

I. determine the best schedule of irrigation application(2),
II. determine the critical growth stage as affected by drought (3), and
III. study the effect of two various locations and three sesame varieties on water consumptive use and water use efficiency (4).

Experiment I

Field work and laboratory techniques were carried out at Bahtim Agricultural Research Station during 1980-1982 seasons. The first aim of this study was to determine its consumptive use under four soil available moisture depletion (ASMD) viz., 30, 50, 70 and 90% ASMD, and the best schedule of irrigation application as well as water use efficiency. The white seeded variety, Giza-25 was used in the three seasons. The results, Table 1,could be summarized as follows:

1. Plant height was significantly decreased with increasing ASMD before irrigation.

2. Height to first capsule decreased with increasing ASMD level.

3. Branch number, capsule number, seed yield per plant, 1000-seed weight and seed yield decreased with increasing ASMD levels.

4. Oil content was significantly decreased by increasing ASMD levels.

Table 1. Effect of irrigation treatments on sesame characters, water consumptive use and water use efficiency at Bahtim.

Irrigation treatments (ASMD)	Plant height (cm)	Height to 1st capsule (cm)	No. of branches/ plant	Capsule number/ plant	Seed yield/ plant (g)	Seed index (g)	Seed* yield/ fed. (ardab)	Seed oil content (%)	Water consumptive use (m^3/fed.)	Water use efficiency (kg/m^3)
30%	157.92	71.66	4.83	87.31	10.81	3.11	5.14	52.86	1903	0.32
50%	133.42	65.50	4.47	60.88	9.07	3.51	4.79	52.31	1621	0.34
70%	125.75	63.67	3.88	43.96	7.71	3.23	3.69	51.24	1524	0.29
90%	125.25	64.25	3.79	41.35	6.25	3.07	3.23	50.65	1384	0.27
Mean	135.59	66.27	4.24	59.63	8.45	3.23	4.21	51.77	1608	0.30
L.S.D.(.05)	13.67	4.85	0.60	7.34	-	0.13	0.46	0.47		

*One feddan (fed.) = 4200 m^2, One ardab = 120 kg.

5. Water consumptive use (WCU) was increased as the ASMD decreased in the root zone.
6. The highest water use efficiency (WUE) WUE was obtained from irrigation at 50% ASMD.

Experiment II

Two field experiments were carried out at Bahtim Experiment Station during 1984 and 1985 crop seasons to study the effect of drought at different growth stages, Table 2, on sesame characters, consumptive use and water use efficiency, Table 3. The resuts could be summarized as follows:

1. Seed yield and its components: Table 3, indicates that treatment (d) gave the highest plant height, height of the first capsule, number of branches, capsule number, seed yield/plant and seed yield/feddan. The highest seed index was obtained from the third treatment (c). Treatment (b) gave the lowest average of these characters, indicating that, drought during flowering stage was very dangerous, because drought in that time caused abrupt drop in yield and its components. It was found that treatments (a) and (c) did not differ significantly in yield and its components, although the two treatments were given different amounts of water. Therefore, it could be concluded that, treatment (a) was economical under water deficient conditions.

Table 2. Irrigation system in different treatments.

Irrigation treatment	Date of Irrigation: at planting	at germination	15 days after germination	Beginning of flowering	15 days after flowering	at maturity
a	/	/	X	/	X	X
b	/	/	/	X	/	X
c	/	/	/	/	/	X
d	/	/	/	/	/	/

/ = The treatment was irrigated. X = The treatment was not irrigated.

2. Oil content decreased with drought at flowering stage.

3. WCU increased by increasing number of irrigations.

4. The highest values of WUE were observed with treatment (d), while the lowest were obtained

Table 3. Effect of drought on sesame growth stages on yield and its components, oil content, water consumptive use and water use efficiency at Bahtim.

Irrigation treatments	Plant height (cm)	Height to 1st capsule (cm)	No. of branches/ plant	Capsule number/ plant	Seed yield/ plant (g)	Seed index (g)	Seed* yield/ fed. (Ardab)	Seed oil content (%)	Water consumptive use (m^3/fed.)	Water use efficiency (kg/m^3)
a	136.4	65.0	4.1	55.2	8.2	3.42	3.79	53.10	1306	0.35
b	117.6	64.6	3.4	41.2	5.9	2.68	3.25	50.90	1420	0.27
c	136.2	66.0	4.1	57.2	8.2	3.32	4.49	53.10	1533	0.35
d	155.8	72.4	4.3	63.0	9.6	2.88	5.38	53.80	1714	0.38
Mean		67.0	4.0	54.2	8.0	3.08	4.23	52.80	1493	0.34
LSD 0.05	10.5	5.3	-	7.0	1.0	0.19	0.48	1.2		

*One feddan (fed.) = 4200 m^2, One ardab = 120 kg.

with treatment (b). The data in different treatments took the following order: d > c = a > b.

From economic point of view, it could be concluded that the best irrigation schedule for WUE (saving irrigation water as well as yield production) is to irrigate plants every 15 days up to maturity, as in treatment (d).

Experiment III

Three sesame entries i.e., two mutant lines (No. 8 and 48 and a local variety ("Giza-25") were examined under three available soil moisture depletions (ASMD) 40, 60and 80% ASMD at Fayoum (Middle Egypt) and Shandawil (Upper Egypt) during 1985 and 1986 crop seasons.

Data in Table 4 indicates that the first treatment of irrigation (40% ASMD) gave, in most cases, the highest means for growth characters as well as seed yield and its components. Although Giza 25 produced higher number of branches/plnat, the two mutant lines surpassed its seed yield due to their superiority in number of capsules/plant.

Sesame consumptive use of water was positively affected by the available soil moisture in the root zone. The differences in water quantities consumed by the same entries grown at both Fayoum and Shandawil might be attributed to variation in soil and meteorological factors, Table 5. WUE was increased under drought conditions at Shandawil and soil moisture at Fayoum. Mutant line 8 was the most efficient entry in making use of water.

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Table 4. Effect of irrigation treatments and varieties on sesame characters, water consumptive use and water use efficiency at Shandawil.

Treatments	Plant height (cm)	Length of fruiting zone (cm)	No. of branches/ plant	No. of capsule/ plant	No. of yield/ plant (g)	Seed index (g)	Seed* yield/ fed. (ardab)	Seed oil content (%)	Water consum- ptive use (m^3/fed)	Water use efficiency (kg/m^3)
Irrigation treatments (ASMD)										
1. 40%	228.25	121.33	4.33	241.08	42.60	3.45	2.28	56.03	3119	0.08
2. 60%	188.08	121.33	4.27	186.92	34.60	3.59	2.12	53.77	2629	0.10
3. 80%	178.92	114.33	3.97	156.92	32.70	3.05	1.88	51.90	2275	0.11
LSD at (.05)	29.21	8.10	-	-	5.00	0.32	0.21	2.11		
Varities or lines										
1. Giza-25	185.67	116.33	5.47	154.92	28.40	3.45	1.84	54.32	2622	0.10
2. Mut. 8	195.42	122.42	2.97	190.83	39.50	3.38	2.20	53.98	2665	0.10
3. Mut. 48	214.17	144.58	4.13	239.17	41.90	3.25	2.25	53.40	2736	0.90
LSD (.05)	16.29	10.29	0.55	52.28	8.75	-	0.33	-		
Irrigation treatments (ASMD)										
1. 40%	162.80	131.97	4.15	183.73	32.67	3.87	7.25	55.50	2473	0.35
2. 60%	152.98	124.15	4.12	159.21	28.99	3.76	5.90	55.25	2250	0.32
3. 80%	133.95	98.68	3.61	102.29	16.92	3.74	5.22	52.25	2097	0.30
LSD at 0.05	10.83	12.81	-	43.33	7.32	-	1.32	-		
Varieties or lines										
1. Giza 25	159.95	140.07	5.71	135.88	21.54	3.97	5.45	55.42	2223	0.30
2. Mut. 8	143.33	105.63	4.42	152.21	27.42	3.68	6.43	54.08	2239	0.34
3. Mut. 48	146.45	109.10	3.75	157.13	29.62	3.82	6.49	53.50	2361	0.33
LSD (.05)	4.56	1.02	0.66	18.09	6.35	-	0.95	-		

*One feddan (fed.) = 4200 m^2, One ardab = 120 kg.

Table 5. Mechanical analysis and some physical properties of the soil at Bahtim, Shandawil and Fayoum experimental sites.

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Bulk density	Field Capacity	Wilting (%)	Available water
Bahtim (Clay loam)							
0-20	21.99	29.95	40.71	1.16	47.76	25.95	21.81
20-40	23.74	28.80	41.22	1.29	35.48	19.28	16.20
40-60	22.13	28.50	39.54	1.33	34.49	18.74	15.75
Shandawil (Sandy loam)							
0-20	40.80	30.30	28.90	1.29	28.30	11.20	17.10
20-40	33.30	39.20	27.50	1.32	24.50	9.30	15.40
40-60	49.40	30.70	19.90	1.60	22.80	8.40	14.40
Fayoum (Clay)							
0-20	20.02	29.02	45.96	1.22	42.75	20.05	22.70
20-40	29.28	28.18	42.54	1.26	36.15	17.20	18.75
40-60	34.69	28.36	38.95	1.28	35.40	17.00	18.40

AGRONOMIC STUDIES ON GROWTH, YIELD AND YIELD COMPONENTS OF SESAME (*SESAMUM INDICUM* L.) IN EGYPT

Samir Taha Mohamed El-Srogy

Two separate but related experiments were conducted during the summer seasons of 1986 and 1987 at Mallawi, Agricultural Research Station, to study the effect of some cultural practices on growth, yield, yield components and quality of sesame seeds.

Experiment I

This experiment was designed as a split-split plot design with four replications to study the response of two different local varieties namely: Giza-25 and Hybrid-38, randomly assigned to the main plots in three plant spacings of 10, 20 and 30 cm between hills, assigned randomly to the sub-plots with plant distributions of one, two and three plants/ hill which were assigned randomly at the sub-sub-plots. The sub-sub-plot consisted of six ridges of four meters in length and 50 cm in width. The results obtained from this experiment, Tables 1 and 2, could be summarized as follows:

1 Hybrid 38 was taller than Giza-25. Sowing sesame at a spacing of 20 cm between hills tended to produce the shortest plants compared to the other two spacings. Plant height was increased remarkably with increasing number of plants per hill.

2) The narrowest space (10 cm) between plants gave the tallest height to first capsule while increasing number of plants/hill decreased the height of the first capsule.

3) Hybrid-38 produced greater number of branches, capsules and seed weight per plant than Giza-25. Widening the spacing between plants increased number of branches and capsules and seed weight per plant. But increasing number of plants per hill decreased all the characters in both seasons.

4) The maximum seed yield (kg/feddan) was obtained from Hybrid-38. Spacing of 20 cm between hills gave the highest seed yield while the seed yield decreased remarkably with increasing number of plants/ hill.

5) Increasing the spacing between hills resulted in increased 1000-seed weight. The heaviest weight resulted from two plants/ hill.

6) Planting sesame at 20 and 30 cm spacings increased protein and oil contents, respectively. Number of plant per hill had no significant effect on oil content but significantly affected protein content.

Experiment II

This experiment was designed to study the effect of combinations of nitrogen (0, 20, 40 and 60 kg/feddan) and phosphorus (0, 20 and 40 kg/feddan) on the characters of Hybrid-38. Ten NP treatment combinations were randomly assigned in a randomized complete block design with four replications. The results obtained, Tables 3 and 4 could be summarized as follows:

Table 1. Effect of varieties, plant spacing and number of plants/ hill on growth characteristics of sesame, 1986 and 1987 seasons.

Treatments	Plant height (cm)		Height of 1st capsule (cm)		No. of branches/ plant		No. of capsules/ plant	
	1986	1987	1986	1987	1986	1987	1986	1987
A. Varieties								
a_1 - Giza 25	155.92	166.08	67.11	67.78	5.91	5.45	105.59	98.07
a_2 - Hybrid 38	166.33	157.47	72.53	51.50	6.01	5.61	109.86	112.02
LSD 5%	N.S.*	5.55	N.S.	7.06	N.S.	N.S	N.S.	2.37
1%	N.S.	N.S.	N.S.	12.86	N.S.	N.S.	N.S.	4.32
B. Plant spacing between hills								
b_1 - 10 cm	161.29	168.88	72.75	64.42	6.01	5.45	98.20	79.40
b_2 - 20 cm	160.63	162.08	67.79	59.50	5.85	5.55	107.81	111.43
b_3 - 30 cm	161.46	152.38	68.92	55.00	6.02	5.58	117.17	129.31
LSD 5%	N.S.	N.S.	N.S.	7.10	N.S.	N.S	4.00	4.45
1%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	5.61	6.23
C. Number of plants/hill								
c_1 - one plant	154.58	149.38	75.50	56.04	7.60	7.00	130.79	130.06
c_2 - two plants	161.63	162.29	70.00	56.96	5.79	5.34	101.32	104.99
c_3 - 3 plants	167.17	173.67	73.96	65.92	4.50	4.24	91.07	80.09
LSD 5%	8.33	12.47	5.09	6.12	0.33	0.24	3.09	4.62
1%	11.17	16.76	6.82	8.32	0.45	0.32	4.13	6.20

*N.S. = Not significant.

Table 2. Effect of varieties, plant spacing and number of plants/hill on yield characteristics of sesame in 1986-87 seasons.

Treatments	Seed yield/ plant (g)		Seed yield (kg/fed.)		1000 seed weight (g)		Oil (%)		Protein (%)	
	1986	1987	1986	1987	1986	1987	1986	1987	1986	1987
A. Varieties										
a_1 - Giza 25	8.79	8.20	399.40	411.98	3.54	3.72	56.61	57.26	14.44	12.79
a_2 - Hybrid 38	9.49	8.34	428.93	422.04	3.52	3.34	58.43	58.90	14.02	13.62
LSD 5%	N.S*	N.S	9.03	N.S	N.S	0.23	1.40	0.59	0.35	0.29
1%	N.S.	N.S.	16.47	N.S.	N.S.	N.S.	N.S.	1.08	N.S.	0.53
B. Plant spacing between hills										
b_1 - 10 cm	8.05	7.37	298.36	286.85	3.55	3.80	58.80	58.18	13.78	12.85
b_2 - 20 cm	8.98	8.34	510.42	518.00	3.57	3.30	57.81	58.05	14.49	13.46
b_3 - 30 cm	10.38	9.10	453.70	447.09	3.47	3.50	57.94	58.01	14.42	13.31
LSD 5%	1.50	1.36	12.10	13.15	N.S	0.20	0.58	N.S	N.S	0.36
1%	2.11	N.S.	16.96	16.43	N.S.	0.29	0.82	N.S.	N.S.	0.50
C. Number of plants/hill										
c_1 - one plant	10.85	10.22	474.78	491.70	3.53	3.41	57.58	58.08	14.09	13.26
c_2 - two plants	9.27	7.71	410.63	411.29	3.51	3.67	57.54	58.23	14.58	13.36
c_3 - three plants	7.30	6.87	357.09	348.96	3.56	3.51	57.43	57.49	14.01	13.00
LSD 5%	1.42	0.76	16.43	N.S	N.S	N.S	N.S	N.S	N.S	N.S
1%	1.90	1.02	24.58	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

* N.S = Not significant.

Table 3. Effects of NP fertilization level on some sesame growth characteristics in 1986-87 growing seasons.

Characteristics Treatments (kg/fed)		Plant height (cm)		Height of 1st capsule (cm)		No. of branches/ plant		No. of capsules/ plant	
N	P_2O_5	1986	1987	1986	1987	1986	1987	1986	1987
0	0	129.50	108.25	75.75	53.25	2.83	2.18	37.75	40.00
20	0	162.75	142.75	62.00	56.25	4.10	4.73	105.70	96.50
20	20	155.50	142.25	64.75	48.00	3.90	5.48	121.00	102.50
20	40	158.50	144.50	64.25	55.00	4.58	5.13	93.75	100.08
40	0	175.50	160.00	58.50	55.75	4.70	6.15	128.25	142.93
40	20	164.25	158.13	56.50	46.25	4.95	4.93	129.50	149.25
40	40	135.50	168.00	56.25	54.50	4.78	4.77	184.00	158.48
60	0	175.00	204.00	61.50	62.75	7.55	6.28	156.75	175.75
60	20	186.25	200.33	62.00	56.00	6.15	5.80	146.00	173.30
60	40	183.00	189.50	57.25	53.75	6.55	6.40	134.25	138.00
LSD	5%	42.49	17.64	9.52	13.87	1.08	1.18	49.33	43.25
	1%	N.S.	23.82	12.85	N.S.	1.46	1.60	66.60	58.39

Table 4. Effect of NP fertilization level on yield characteristics of sesame in 1986-87 seasons.

Treatments (kg/fed)		Seed yield/plant (g)		Seed yield (kg/fed)		1000 seed weight(g)		Oil (%)		Protein (%)	
N	P_2O_5	1986	1987	1986	1987	1986	1987	1986	1987	1986	1987
0	0	5.42	2.72	228.3	201.0	2.97	2.91	57.46	55.58	13.34	13.41
20	0	13.96	8.39	370.2	411.8	3.28	3.70	57.48	56.58	13.82	13.56
20	20	12.51	12.18	375.0	538.72	3.16	3.87	57.11	57.13	13.53	13.65
20	40	8.96	8.32	397.5	413.4	3.19	3.35	58.48	57.06	13.81	14.03
40	0	16.03	13.83	584.7	696.0	3.27	2.99	56.98	57.23	13.95	14.27
40	20	22.04	12.77	647.0	724.5	3.29	3.39	58.73	57.87	14.25	14.46
40	40	18.95	16.19	669.6	665.1	3.39	3.38	57.67	57.13	13.97	14.62
60	0	14.73	13.79	577.8	608.4	3.36	3.60	57.65	57.20	15.12	14.73
60	20	8.00	11.26	563.4	229.8	3.34	3.98	57.54	58.07	14.83	15.29
60	40	10.42	12.14	491.1	532.2	3.32	3.70	58.59	57.40	15.34	15.30
LSD	5%	3.66	3.86	133.98	142.97	0.43	0.415	1.62	1.55	0.54	0.72
	1%	4.64	5.22	180.92	193.05	0.58	0.560	2.19	2.05	0.79	0.98

1) Plant height was increased progressively with applying NP fertilizer. The application of N at 60 kg/feddan alone or combined with 40 or 20 kg/feddan of P_2O_5 tended to produce the heaviest 1000 seed weight and the tallest sesame plant.

2) Number of fruiting branches/plant was affected significantly by NP fertilizer in both seasons, but the highest number of branches/ plant was obtained by the application of 60 kg N alone or combined with 40 kg P_2O_5.

3) Height of the first capsule was affected highly significantly by NP fertilizer. The minimum height was produced by the application of 40 kg N combined with 20 kg P_2O_5.

4) In both seasons, increasing NP fertilizer levels tended to increase number of capsules/ plant, the highest number being obtained from the application of N and P_2O_5 combined at a rate of 40 kg/feddan each.

5) The application of 40 kg N combined with 20/40 kg of P_2O_5 gave the highest seed weight/ plant, 1000 seed weight and seed yield/feddan in both seasons.

6) No definite trend could be observed with respect to oil content.

7) Protein content was affected highly significantly by NP fertilizer levels in the two growing seasons.

SESAME RESEARCH AND PROGRESS IN EGYPT

Nessim R. Guirguis

Sesame is considered as one of the important food crops because it is the main ingredient in preparing local food, Halawa Tehenia, which is a good source of valuable protein for a large sector of Egyptians. The total consumption is estimated to be about 45,000 tons annually, while, the national production fluctuated from year to year. However, it is about 10,000 tons in the last five years depending on the area devoted to this crop, which is about 25,000 faddans, Table 1.

Table 1. Sesame area, yield and production in Egypt, 1979-86.

Year	Area (Faddan)*	Seed yield (kg/faddan)	Total production (metric tons)
1979	37120	314	12658
1980	36635	442	16004
1981	40223	401	16131
1982	45651	436	20346
1983	25833	438	11341
1984	26062	415	10815
1985	21571	425	9137
1986	22000	444	9768

*1 faddan = 4200 m^2

Sesame is planted as a summer crop during April/May in rotation with the winter crop, sugarcane, in small holdings of 1-5 faddans under surface irrigation so that it can give high yield.

The main constraints confronting sesame production can be summarized as follows:

1) Low income compared with other competitive summer crops such as corn and sugarcane.

2) Susceptibility to root and stem rot and wilt diseases. The most prevalent causal organisms are: *Rhizoctonia solani, Sclerotia bataticola Macrophomina phaseoli, Fusarium oxysporum* and *Phytophthora parasitica*.

3) The crop management (sowing, cultivating, harvesting, threshing, and cleaning) is labor intensive.

The principal goal of the sesame breeding program is to maximize production through: release of high yielding and disease· resistant varieties, improvement of agronomic practices and transferring recommended practices to the growers through on-farm trials.

Breeding nursery

Breeding nurseries have been cultivated in two sites, Giza and Shandaweel Research Stations; representing the main sesame growing areas of the Middle and upper Egypt, respectively.

These nurseries include more than 700 lines from different genetic sources: landraces, introductions and hybrid derivatives. The main economic characters which include plant height, height of first capsule, number of branches and seed yield per plant are recorded.

Crossing program

About 30 crosses are made each year to obtain a wider genetic variability in F_2 generations to serve the selection procedures. The parents are chosen to represent the two extremes of each economic characters.

Diseases nursery

About 100 sesame strains were tested in the disease nursery under artificial infection by *R. solani, S. bataticola (M. phaseoli), F.*

Oxysporium and *parasitica* together with the commercial variety Giza- 32, to find a source of tolerance/resistance. Some of the strains exhibited a high tolerance to these fungi.

Comparative yield trials

The first evaluation for yield potential of promising breeding materials is usually conducted on state farms. Thirty two branched and 15 non-branched varieties were tested in two locations last season.

The final stage of evaluation took place in farmers' fields under normal production condition and following recommended agronomic practices. The data of the advanced yield trials of branched and non-branched varieties during 1985, 1986 and 1987 seasons are presented in Tables 2 and 3.

Data presented in Table 2 indictes that all branched hybrids gave 4-9% higher yield over the control Giza 25 with an average increase of 26-56 kg/faddan.

Table 3 shows that the non-branched varieties N. A 261-1, B-10 and H87-12 outyielded the commercial variety Giza-32 by an average yield of 31-60 kg/faddan by (5-10%).

On-farm trials

Sesame is planted on small holdings of 1-5 faddans. Most of the farmers follow their own methods of production. To achieve higher yield, which is a major target, new techniques have been transferred to the farmers. In this regard, 12 on-farm trials are conducted every year in upper Egypt, (Assuit, Sohag, and in Quena governerates) which were the most important sesame producing areas during 1986-1988, Table 4. Each trial was carried out in an area of 1/2 faddan in two replications, with 1/4 faddan. for recommended and 1/4 faddan. for farmers techniques. The package included:

Table 2. Seed yield (kg/faddan) of branched varieties of sesame in the advanced yield trials, 1985-87.

Varieties	Mean			Overall	
	1985 (12 trials)	1986 (14 trials)	1987 (14 trials)	mean	Index
Giza 25*	693	592	686	657	100
H38-2	758	692	690	713	109
H59-4-5	767	615	698	693	105
H66-2	636	656	757	683	104
H71-9	708	661	672	710	108
H93-12	728	616	719	688	105

* control (commercial variety).

Table 3. Seed yield (kg/faddan) of non-branched varieties of sesame in the advanced yield trials, 1985-87.

Varieties	Mean of six trials			Overall	
	1985	1986	1987	mean	Index
Giza 32*	631	670	562	621	100
B-10	693	702	587	660	106
B-16	622	645	563	610	98
B-35	605	632	652	629	101
H87-12	714	688	616	681	110
N.A261-1	818	606	534	652	105

*Control (commericial variety).

Table 4. Yield of recommended practices compared with farmers' technique, 1986-88.

Governorate	Year	No. of trials	Yield (kg/faddan) farmers' technique	Yield (kg/faddan) recommended practice	Increase kg	Increase %
Assiut	1986	4	581	784	109	19
	1987	4	530	620	90	17
	1988	4	315	497	185	59
Sohag	1986	3	503	553	50	10
	1987	3	444	536	92	21
	1988	4	492	596	104	21
Quena	1986	5	552	660	108	20
	1987	5	636	715	79	12
	1988	4	612	774	162	26
Overall mean			518	637	129	25

1) Variety Giza-32,
2) Plant density (50 x 10 cm, two plants/hill = 168.000 plants/faddan),
3) Fertilization (30 kg P_2O_5 + 30 kg N + 24 kg K_2O/faddan), and
4) Irrigation intervals (12-15 days).

The trial show that the recommended practices gave remarkable increases in yield (129 kg/faddan) compared with farmers technique. Consequently, it is possible to increase the average seed yield by 25% through transferring recommended practice to the farmers.

REPORT ON ROOT-ROT AND WILT DISEASES OF SESAME IN EGYPT

A.A. El-Deeb

Sesame is one of the oldest oil seed crops in Egypt and many countries of the world. It is attacked by root-rot and wilt diseases, which are now wide spread especially in Quena, Sohag, Sharkia and Ismaelia Governorates. Root-rot caused by *Macrophomina phaseolina* and *Rhizoctonia solani* and wilt caused by *Fusarium oxysporum* f. sp. *sesami* and *Verticillium albo-atrum* were recorded on sesame in different countries.

Attempts were made to control root-rot and wilt diseases of sesame by selecting disease resistant genotypes treating the seed and/or soil with fungicides, and using different levels of NPK fertilizers.

Seed treatments

In general, seed dressing with some tested fungicides decreased infection percentage of sesame root-rot and wilt diseases when compared with the non-treated control, Table 1. Sumisclex (5g/kg seed), Benlate (5 g/kg seed) and Quinolate (6 g/kg seed) significantly reduced root-rot and wilt of sesame compared to the control and other treatments.

Also, seed yield was significantly increased over the control when the tested fungicides were applied in two doses. The highest seed yield was obtained with Sumisclex (5g/kg seed) followed by Benlate (5 g/kg seed) and Quinolate 15 CTS (6 g/kg seed).

Table 1. Effect of seed dressing on infection percent of root-rot and wilt and on yield of sesame under field conditions.

		Sohag*								Sharkia*							
	Dose	1984				1985				1984				1985			
Fungicides	g/kg seeds	R	W	R+W	Y	R	W	R+W	Y	R	W	R+W	Y	R	W	R+W	Y
Benlate	2	8.3	7.5	16.3	567	6.4	9.1	15.0	436	6.2	7.9	17.1	523	6.3	8.4	14.6	421
"	5	5.8	5.1	14.8	615	4.9	8.9	13.0	548	4.4	5.6	15.8	525	4.4	8.4	13.6	554
Sumisclex	3	7.5	6.7	15.0	576	6.6	9.0	15.6	491	6.2	6.8	16.3	573	6.3	8.9	15.3	464
"	5	5.0	5.8	14.2	654	5.5	7.5	12.4	588	4.2	5.8	15.4	625	4.3	7.9	13.3	615
Quninclate 15 CTS	3	7.1	7.1	14.6	581	7.9	7.3	17.9	491	5.0	7.5	14.2	553	7.6	8.5	18.0	440
"	6	4.2	6.3	13.8	845	7.0	5.6	15.7	540	5.0	5.0	14.2	615	7.3	7.6	14.3	509
V/captan	2	10.8	8.8	17.5	495	9.1	18.9	23.7	395	7.1	5.6	17.5	456	8.5	16.0	23.5	393
"	5	5.2	8.8	15.8	509	7.1	16.0	20.4	405	5.8	9.2	17.1	485	7.5	17.3	21.4	393
Quin. V 4x	3	12.9	9.6	18.8	440	10.6	20.6	23.6	381	10.0	10.4	17.1	438	10.3	19.6	23.0	370
"	6	11.3	9.2	18.8	486	9.9	18.1	21.5	369	8.8	10.4	17.1	514	9.4	16.9	21.1	405
Vitox	3	12.5	10.8	18.8	503	12.8	21.9	23.9	359	10.8	10.8	17.9	491	11.9	21.8	23.8	319
"	6	11.7	10.4	18.3	521	11.1	19.1	21.3	376	9.6	10.4	17.5	516	11.3	19.8	21.8	335
Homi	3	14.6	12.9	19.5	499	14.1	21.0	23.1	335	12.5	12.5	20.8	473	12.9	20.9	22.4	323
"	6	14.2	12.5	19.2	534	11.9	17.9	21.0	384	11.7	12.9	20.4	525	12.3	19.8	20.6	371
Rovral TMTD	3	16.7	13.3	19.2	429	15.3	22.0	23.6	331	12.9	13.8	20.8	468	14.8	22.5	24.0	313
"	6	16.3	12.9	19.6	446	12.8	20.5	22.8	361	12.5	13.3	20.4	480	13.4	21.6	23.4	314
Rezolex	3	10.0	11.3	16.7	563	8.4	14.1	19.8	396	9.2	10.8	17.1	586	7.5	15.4	19.8	395
"	5	9.6	7.5	15.4	573	7.1	13.3	16.9	426	8.3	10.0	15.8	584	6.6	14.0	16.1	421
Control	0	25.8	23.8	27.9	359	23.9	22.0	30.5	260	23.3	20.3	30.8	366	23.1	23.3	30.5	284
L.S.D. 5%		1.4	1.3	1.6	041	0.7	2.2	1.5	035	1.4	1.5	1.2	039	0.7	1.0	1.7	027

* R = Root rot, W = Wilt, Y = Yield in g/plot.

Results in Table 2 indicate that increasing the doses of Benlate, Sumisclex and Quinolate 15 CTS from 2 to 5 g/kg seed significantly reduced root-rot and wilt infections and increased seed yield. While the increase to 7 or 10 g/kg seed resulted in different reactions. Benlate at 10 g/kg seed showed some phytotoxicity effect, yellowed leaves and stunted plants. Generally, among the four tested rates, 5 g/kg seed was the best in reducing root-rot and wilt diseases.

Table 2. Effect of four rates of three fungicides as seed dressing on the infection percent of root-rot and wilt and on yield of sesame under field conditions.

		Sohag*								Sharkia							
	Dose	1985				1986				1985				1986			
Fungicides	g/kg seeds	R	W	R+W	Y	R	W	R+W	Y	R	W	R+W	Y	R	W	R+W	Y
Benlate	2	6.3	10.0	17.1	544	6.1	8.0	14.5	499	6.2	7.9	15.6	519	6.4	8.4	14.8	500
"	5	4.2	7.9	14.6	630	4.1	7.5	13.5	549	4.2	6.7	12.9	623	4.3	7.3	13.9	549
"	7	4.2	7.9	15.0	835	3.8	8.0	13.4	566	4.2	6.3	12.5	850	4.2	6.7	13.3	557
"	10	3.8	8.3	14.6	846	0.9	7.0	12.8	582	4.6	6.7	15.5	825	4.0	6.4	13.1	550
Sumisclex	2	5.8	9.8	17.5	595	6.0	9.0	15.6	512	6.3	7.1	16.3	561	4.8	9.3	16.4	491
"	5	3.8	7.5	15.0	670	4.5	7.8	14.5	574	4.3	6.5	14.2	859	4.0	7.3	13.2	532
"	7	4.2	7.9	14.2	646	3.8	4.7	13.3	619	3.8	5.0	13.8	645	3.8	7.2	15.2	547
"	10	3.8	7.9	14.2	646	3.9	7.4	12.6	618	4.2	6.7	14.2	625	3.7	6.8	15.4	545
Quinolage																	
15 CTS	2	6.7	10.4	17.7	580	7.0	9.2	17.8	445	6.2	7.9	14.2	574	7.2	8.3	17.4	448
"	5	4.2	6.3	15.0	674	6.2	6.3	14.5	509	4.2	7.1	11.3	680	6.2	7.4	18.0	535
"	7	4.6	7.5	15.4	674	6.6	7.8	13.0	518	4.2	7.1	11.3	676	6.0	7.3	13.5	554
"	10	4.6	8.3	14.6	669	6.2	6.9	12.5	520	4.2	7.1	12.1	660	6.2	7.3	13.5	554
Control	0	22.9	17.1	22.5	341	23.5	23.0	24.6	355	24.6	23.9	24.2	305	22.2	22.7	24.8	354
L.S.D. 5%		1.6	2.2	1.7	197	0.7	0.8	0.9	41	1.9	1.9	1.2	52	0.5	0.6	0.8	27

* R = Root rot, W = Wilt, Y = Yield g/plot.

Soil treatments

Sumisclex was the best in reducing root-rot and wilt diseases followed by Daconil 2787 and Benlate as compared to other treatments, Table 3. Generally, all the fungicides reduced infection and increased yield as compared to the control. When Sumisclex as a soil treatment is combined with Benlate 5g/kg seed as a seed dressing, the lowest infection and highest yield is obtained.

Varietal reaction

The ten tested sesame cultivars varied in their reaction to root-rot and wilt diseases under naturally heavily infested field conditions, Table 4. Mutation-48 was the least infected with root-rot and wilt diseases followed by Giza-32 and Mutation- 8 as compared to other cultivars. On the other hand, the highest percentage of infection was recorded on Giza-25 and Mutation-14.As regards to seed yield, Mutation-48 gave the highest yield followed by Giza-32, while Giza-25 and Mutation-14 gave the lowest yield.

Fertilization

Results in Table 5 indicate that percentage of root-rot and wilt diseases of sesame differed for the different levels of fertilizers. The highest yield and the least infection with the diseases were obtained with 30-30-48 followed by 30-30-24 NPK levels. On the contrary, the highest infection and the least yield levels were obtained when no fertilizers were added preceded by 15 unit N only. Adding 15 P only reduced percentage of infection but yield remained low compared with other treatments.

Table 3. Effect of fungicidal soil treatment on the infection percent of root-rot and wilt and on yield of sesame under field conditions.

	Sohag**								Sharkia**							
	1985				1986				1985				1986			
Fungicides	R	W	R+W	Y	R	W	R+W	Y	R	W	R+W	Y	R	W	R+W	Y
Daconil 2787																
(5 kg*)	4.6	4.6	6.3	759	4.6	4.9	8.4	769	4.2	4.6	8.3	0.775	3.8	4.5	8.3	770
Benlate (2 kg)	4.2	5.0	5.8	764	4.5	5.3	7.4	765	4.6	4.8	7.5	0.750	3.9	4.5	7.5	767
Sumisclex																
(4 kg)	4.2	3.8	5.4	790	4.1	5.0	7.3	779	3.8	4.2	7.5	0.775	3.4	4.5	6.9	785
Vitavax 3p																
(1.5 lit.)	4.9	5.0	6.7	743	4.4	6.3	8.6	689	4.2	6.7	8.3	0.783	4.4	6.5	7.5	759
Ronilan (4 kg)	5.0	5.0	6.7	734	5.0	6.1	11.1	677	5.4	5.6	7.5	0.772	5.3	6.5	12.1	640
Botren (5 kg)	5.4	9.2	11.3	655	5.1	8.8	12.0	629	5.8	10.4	12.5	0.648	5.6	10.5	12.4	636
Control 0	21.7	20.8	31.3	376	24.5	21.8	30.8	320	22.5	21.3	31.3	0.366	22.5	22.0	30.8	335
L.S.D. 5%	1.5	1.4	1.9	40	2.1	0.5	0.6	44	1.2	1.6	1.8	0.073	0.4	0.5	0.6	18

*Formulated material per faddan., ** R = Root rot, W = Wilt, Y = Yield g/plot.

Table 4. Percentage of infection with root-rot and wilt diseases and yield of ten sesame cultivars under field conditions.

	Sohag*								Sharkia*							
	1985				1986				1985				1986			
Cultivars	R	W	R+W	Y	R	W	R+W	Y	R	W	R+W	Y	R	W	R+W	Y
Hagen 88/10	10.7	12.0	14.3	570	10.8	12.8	14.3	602	10.7	12.3	14.3	455	10.3	11.2	14.3	498
Mutation 48	6.0	7.8	9.2	788	6.0	7.8	7.5	734	5.4	7.2	7.3	740	4.3	6.0	8.7	713
" 5	12.0	13.2	15.3	520	12.2	11.2	12.3	525	10.8	12.2	14.2	423	11.3	13.0	14.7	475
Giza-32	5.8	10.5	12.7	734	5.5	8.0	10.7	707	5.8	10.0	11.0	672	6.3	8.3	13.5	700
Local 36	13.5	13.2	16.0	604	13.2	13.5	13.0	560	14.2	12.5	12.2	530	13.5	11.6	13.5	403
Giza-25	18.5	20.3	22.0	429	18.0	16.5	21.0	467	22.2	18.0	17.3	393	20.2	18.0	17.3	404
Mutation 14	17.50	19.7	21.2	492	16.2	15.7	17.8	498	21.0	15.5	19.8	395	18.0	15.2	21.8	412
Hagen 01/10	9.0	11.7	17.8	595	10.8	13.0	15.8	598	6.8	11.7	15.2	322	6.5	8.7	15.2	565
Mutation 8	7.5	12.5	17.3	622	8.3	11.5	16.3	640	8.0	17.3	17.3	520	6.7	15.3	16.3	554
Local 270	13.2	28.3	18.7	537	14.3	18.0	17.8	343	12.2	16.5	17.8	442	10.3	12.3	16.7	494
L.S.D 5%	1.9	1.7	2.1	787	2.5	1.9	2.4	72	2.0	1.7	2.7	73	2.2	2.4	2.9	61

*

R = Root rot, W = Wilt, Y = Yield g/plot.

Table 5. Effect of different levels of fertilizers (NPK) on the infection percent of root-rot and wilt and on yield of sesame under field conditions.

Treatments			Sohag 1985				Sharkia 1986			
N	P	K	Root-rot	Wilt	Root-rot and wilt	Yield g/10 m^2	Root-rot	Wilt	Root-rot and wilt	Yield g/10 m^2
0.0	0.0	0.0	28.5	32.3	27.2	296	28.3	24.8	28.8	286
15	0.0	0.0	23.2	24.3	22.3	363	22.3	24.2	23.5	335
30	0.0	0.0	24.2	22.8	24.0	400	23.0	23.7	23.7	390
0.0	15	0.0	17.5	21.0	18.5	371	18.5	22.7	23.3	346
30	15	0.0	17.5	20.0	19.0	418	18.8	18.8	23.2	410
30	30	24	18.7	20.3	19.3	431	16.0	18.0	23.5	453
30	30	48	16.8	13.3	17.3	475	16.3	15.8	22.8	481
45	30	24	19.7	22.3	21.8	460	19.5	22.0	22.5	461
45	30	48	18.7	21.2	20.5	471	18.7	21.3	21.8	481
L.S.D. 5%			1.6	2.7	2.1	29	1.5	1.8	1.8	27

HIGHLIGHTS ON IMPROVING PRODUCTION OF SESAME IN EGYPT[1]

A.F. Ibrahim

Sesame (*Sesamum indicum* L.) is an ancient oil crop in Egypt. The area, productivity, and production over the last decade are presented in Table 1. The regional distribution by provinces is presented in Table 2. The crop drew the attention of breeders and agronomists at Cairo University in the last decade for the following reasons:

1) Local cultivars are low yielding, branched type, late maturing with dehiscent capsules which cause high seed loss during harvest.

2) Local cultivars are highly susceptible to wilt pathogens, particularly under excess use of irrigation and their growth is suppressed by the accompanied weeds.

3) Local cultivars are not suited to mechanical harvesting and can not compete with other crops with relatively high cash return like vegetables and sugar cane.

Integrated research on sesame in the last 10 years

An integrated research work has been carried out mainly by the Agronomy Department in collaboration with of Plant Pathology Department and Central Laboratory of Biochemistry of Faculty of Agric., Cairo Univ., Giza, and specialists of Field Crop Research Institute and Soil Research and Water Management Institute, Agricultural Research Center of Ministry of Agriculture.

Table 1. Area, productivity and production of sesame in Egypt during 1979-87

Year	Area (1000 ha)	Yield (kg/ha)	Production (MT)
1979/81	16.0	996.0	16.0
1985	9.0	974.0	9.0
1986	23.0	1043.0	24.0
1987	19.0	1053.0	20.0

Source: Year Book of production (FAO, 1988).

Table 2. Regional distribution and productivity of sesame in Egypt in 1987 crop season.

Governorate	Area (ha)	Seed Yield (kg/ha)
Lower Egypt		
Behira	91.1	468.9
Kafr El-Sheik	23.6	825.0
Sharkia	132.0	705.0
Ismalia	1366.8	1029.0
Suez	67.2	1050.0
Total	1680.7	$\bar{x}$ 969.0
Middle Egypt		
Giza	154.0	1191.0
Beni Suef	564.4	888.0
Fayoum	594.8	1323.0
Minia	1208.4	1332.0
Total	2521.6	$\bar{x}$ 1221.0
Upper Egypt		
Assuit	1284.8	1263.0
Sohag	680.0	1380.0
Quena	4702.4	1164.0
Aswan	784.4	1014.0
Total	7451.6	$\bar{x}$ 1185.0
Grand Total	11653.9	$\bar{x}$ 1161.0

Source: Agricultural Statistics Year Book, Dept. of Agric. Economics, Ministry of Agric., Egypt, 1988.

[1] Paper sent but not presented.

This work includes:

1) Breeding program aimed at selecting potential seed yield and better quality i.e. high seed oil and protein contents through:
   a) Screening germplasm,
   b) Induced mutations by seed irradiation of local varieties,
   c) Crossing exotic high yielding lines with local varieties,
   d) Crossing exotic high yielding lines with mutant lines,
   e) Back crossing of superior mutant lines,
   f) Selection of lines tolerant to wilt pathogens under artificial infection, and
   g) Crossing wilt tolerant lines with high yielding ones.

2) Propagation of superior lines that surpass the local cultivar, Giza-25.

3) Yield trials, small- and large-scale experiments and on-farm trials conducted by the farmers are carried out in sesame growing governorates; Quena, Sohag, Ismalia, Sharkia, El-Fayoum, El-Tahrer and Behira.

4) Cost-free distribution of seeds of the best matching lines in the D-yield trials to sesame growers at the rate of 2.5 kg/feddan. Farmers are also provided with package recommendations to ensure high seed yield. Farmers contribute to the project, twice the amount of seeds they receive to be redistributed to new farmers in the next season. Table 3 shows the amount of seed distributed, number of farmers received and total area cultivated with superior lines.

Selection was practiced for the following characters:

1) Reduced stem height to the first fruiting node,
2) Non-branched type,
3) Increased fruiting zone length on the main stem.
4) Increased no. of capsules/plant (3 capsules/each leaf axil).
5) Increased seed yield/plant (more than 35 g/plant).
6) Oil + protein contents of seed (75% or more), and
7) Semi-dehiscent capsules.

Table 3. Distribution and cultivation of superior lines of sesame, 1985-88.

	Season			
Discription	1985	1986	1987	1999
Distributed seed (kg)	250	400	600	600
No. of recipient farmers	26	42	62	54
Cultivated area (feddan)*	100	150	250	250

* 1 feddan = 4200 m^2.

Based on the results obtained from on-farm trials for three successive seasons, the following package is recommended to achieve potential seed yield:

1. Population density of 45 to 50 plants/m^2, (50 and 10 cm between rows and plants, respectively) of non-branched type.
2. Fertilization at the rate of 60, 45 & 30 kg/fed. of N, P_2O_5 and K_2O, respectively.
3. Irrigation after depletion of 40 or 60% of available water.
4. Elimination of weeds with one of the following pre-emergence herbicides:

   a) Linuron @0.75 kg/fed + Imex @1.5 1/fed.
   b) Stomp @1.5 1/fed. + Linuron @0.75 kg/fed.
   c) Stomp @1.5 1/fed. + Diuron @ 0.5 kg/fed.

EVALUATION OF SOME CULTIVARS AND PROMISING STRAINS OF SESAME *(SESAMUM INDICUM L.)*

A.A. El-Shimy and M.Z. El-Hifny

Abstract

Evaluation of 25 sesame genotypes including three local, three introduced cultivars and 19 promising strains were carried out at three locations during 1984 and 1985 seasons. The results showed that: 1) The combined analysis revealed significant differences among genotypes for all traits except 1000 - seed weight, with 6, 13, 5 and 3 genotypes significantly exceeding the check cultivar Giza-25 in plant height, height to the first capsule, capsule breadth and yield/plot, respectively, 2) The years effect was significant for all the studied traits except for height to first capsule, number of branches/plant and seed oil content, whereas, the locations effect was significant for all traits, 3) The genotype x year interaction was significant for all traits except 1000 - seed weight. The genotype x location was also significant for all traits except capsule length and 1000 - seed weight. Moreover, the second order interaction was also significant for all traits except number of capsules/plant, capsule length and 1000 - seed weight, 4) Sesame genotypes responded differently with changes in environment for most of the studied traits, and 5) Capsule length, plant height and height to first capsule were positively correlated with seed yield.

Evaluation is an important and necessary step in the development of improved sesame cultivars. Because of genotype x environment interaction, the evaluation of the promising breeding strains requires repeated testing in both seasons and locations. The decision to release, a strain should usually depend on the basis of whether the strain performance is "satisfactory" in comparison with the performance of one or more "standard" cultivars over a period of two or more years.

After evaluating 40 sesame genotypes, selection based on branches/plant, capsules/plant and seed yield/plant was recommended (22). Environmental effects of years and locations on yield of sesame varieties and crosses were substantial (14). The highest yielding variety had largest number of seeds/pod high seed weight and possessed multilocular capsules (1). Lack of consistency in variation from plant to plant in seed weight, oil content and oil composition was reported (15). The maximum and minimum values for different traits were distributed in different varieties (5).

The relationship between traits provides the basis for planning more efficient selection programs. Many investigators emphasized the importance of path analysis and correlations. Seed yield was positively and significantly correlated with number of capsules, primary branches, 1000- seed weight (24, 23, 20), plant height, capsule length (4) and length of fruit-bearing branch (11).

The objective of this work was to study the genetic variability and the performance of three local and three introduced cultivars of sesame along with 19 promising strains at three locations for two seasons. Phenotypic and genotypic correlations among traits were also discussed.

Materials and Methods

This study was carried out at the Agricultural Research Stations, Shandaweel, Mallawi and Al-Tahreer during 1984 and 1985 seasons as follows:

Location	Planting date	Soil Type
1. Shandaweel	20-5-84	Sandyloam
2. Shandaweel	20-5-85	"
3. Mallawi	15-6-84	Clay
4. Mallawi	2-6-85	"
5. Al-Tahreer	25-6-84	Sandy
6. "	20-6-85	"

The materials used in this study were obtained from the Oil Crop Research Section, Agric. Res. Center, MOA, Egypt, composed of 25 cultivars and strains of sesame (*Sesamum indicum* L.), Table 1.

A randomized complete block design was used with four replications plot size was 4, rows, 4m long and 50cm. apart. The recommended distances between hills were 20 cm for the branched, 15 cm for rarely branched and 10 cm for the branched types. After full emergence, the seedlings were singled, and the recommended cultural practices of sesame were adopted throughout the growing season. At maturity, plant height, height to the first capsule, number of branches/plant, and capsule length, and capsule breadth, were recorded on 10 random guarded plants in each plot. Whereas, 1000-seed weight, seed oil content which was determined by Carver Laboratory Press Instrument and seed yield/plot were measured on plot mean basis (1 plot = 8 m^2).

The combined analysis of variance, genotypic and pheno-typic correlations were calculated (12,13). The genotypic and phenotypic coefficients of variation were estimated (3).

Results and Discussion

A. Morphological traits

The combined analysis of variance is presented in Table 2. The years main effect was significant for plant height. The three morphological traits were significantly affected by locations. The average plant heights were 204.2, 193.1 and 154.6 cm at Shandaweal, Mallawi and Al-Tahreer locations, respectively, Table 3. Eventhough, Al-Tahreer location showed the lowest height to the first capsule (29.89 cm) and the highest number of branches/plant compared to the other two locations. However, the length of the reproductive zone was still larger at Shandaweel which resulted in higher yields compared to Mallawi and Al-Tahreer. This could be due to large differences in both edaphic and climatic conditions prevailing in these locations.

With respect to the effect of location x year interaction plant height and height to the first capsule showed significant differences.

The genotypes differed significantly in the three traits. Six genotypes significantly exceeded the check cultivar Giza-25 in plant height, and 13 genotypes were significantly lower than the check cultivar in height to the first capsule, Table 4. However, the check cultivar was the best of all genotypes in branching habit.

The first and second order interactions were significant for the three traits indicating that sesame genotypes responded differently when they are grown under different environments. Consequently, it is essential to test sesame genotypes under a wide range of environments to identify the best genotypes for particular environment. These results are in general agreement with those reported before (1,17,21).

B. Yield components

The combined analysis of yield components is presented in Table 2. Significant differences were obtained between 1984 and 1985 seasons. The mean of number of capsules/plant, capsule length and capsule breadth of 1985 crop season was higher than that of 1984. While the reverse trend was obtained for 1000- seed weight , Table 3. This could be due to differences in edaphic and climatic conditions prevailing in these years.

Significant differences among locations were observed; such as, Mallawi gave the highest number of capsules/plant, Shandaweel recorded

Table 1. Description of some varieties and strains of sesame.

Code No.	Variety or strain*	No. of capsules /leaf axil	Seed color	Shattering	Days to maturity
1	H_{61} F_{10}	single	Yellow	Shattering	120-125
2	H_{64} F_{1}	"	White	"	"
3	H_{70} F_{28}	"	Brown	"	"
4	H_{72} F_{5}	"	Yellow	"	"
5	H_{72} F_{8}	"	"	"	"
6	H_{74} F_{16}	"	Brown	"	"
7	H_{80} F_{9}	"	Red-yellow	"	"
8	H_{80} F_{25}	"	Waxy white	"	"
9	H_{80} F_{25}	"	White creamy	"	"
10	H_{81} $F_{1.1}$	"	Waxy white	"	125-128
11	H_{81} F_{15}	"	Yellow-red	"	"
12	H_{82} F_{7}	"	White	"	"
13	H_{82} F_{14}	"	Waxy white	"	"
14	H_{84} F_{17}	"	" "	"	"
15	H_{88} F_{10}	"	Yellow-red	semi-shatt.	130-135
16	H_{89} F_{26}	three	Yellow	"	125-130
17	H_{93} F_{12}	single	White-creamy	"	"
18	B_{24}	"	white	"	"
19	B_{24}	"	"	"	"
20	$I_{370-23-2}$	three	creamy	"	130-135
21	Giza-25	single	brown	shattering	110-115
22	Giza-23	"	waxy white	"	120-125
23	Giza-24	"	white-yellow	"	"
24	$I_{379-11-1}$	three	white creamy	semi-shatt.	125-130
25	I_{270}	"	white	"	"

* H and B = Originated by hybridization and selections were selfed for more than five generations. I = Introduction.

Tables 2. Combined analyses of variance for the studied traits in sesame after evaluation at three locations in 2 years.

Source of variation	d.f	Mean Squares: plant height	Height of first capsule	No. of branches /plant	No. of capsules /plant	No. of capsule length	capsule breadth	100-seed weight	Yield/ plant	Yield/ plot	Seed oil %
Years (Y)	1	119970**	85	12.79	44572**	7.27**	1.31**	7.89**	238**	1.41**	50.9
Location (L)	2	125446**	73228**	429.57**	272763**	118.87**	6.92**	15.37**	9635**	10.49**	614.3**
Y x L	2	37292**	3484**	16.41	33240**	0.59**	.24**	.34	310**	.18	50.9
Error (A)	18	1035	229**	5.04	2254	0.12	.01	1.74	35	.099	59.6
Genotypes(G)	24	1734**	939**	41.99**	2500**	.94**	.28**	1.03	92**	.18	38.6**
G x Y	24	648**	386	10.59**	2922**	.18**	.07	1.87	64**	.10**	16.7**
G x L	48	297*	107**	2.95**	1814**	.10	.03**	1.57	75**	.09**	19.6**
G x L x Y	48	351**	142**	3.17**	1395	.11	.03**	1.39	49**	.12**	15.7**
Error (B)	432	190	62	1.12	1104	0.08	.01	1.59	22	.04	5.8

* and ** = Significant at .05 and .01 levels, respectively.

the highest mean capsule length and 1000- seed weight. While Al-Tahreer showed the highest capsule breadth, Table 3.

Highly significant differences among genotypes were obtained for number of capsules/plant, capsule length and breadth. None of the studied genotypes significantly exceeded the check cultivar in number of capsules/plant, Table 4. The genotypes 8, 18 and 19 which were superior in capsule length and capsule breadth were also superior in seed yield. These results are in agreement with those reported before (5,21).

The first order interactions indicated that the genotypes were not consistent under different locations and years. The second order interaction was significant only for capsule breadth, Table 2. Lack of significance of the second order interaction for the other yield components may not actually mean that there was no environmental interactions effect on the genotypes. The reason could probably be due to less number of locations and few years which are needed to identify statistical differences, in addition to the large experimental errors obtained for number of capsules and capsule length.

C. Seed yield/plot

Seed yield/plot was significantly affected by growing season. The general mean of the 25 genotypes over locations was higher in 1985 than 1984, Table 3. Significant differences among locations were also observed. The highest seed yield/plot was obtained at Shandaweel location followed by Mallawi and Al-Tahreer, Table 4.
The studied genotypes differed significantly in yielding ability over the two seasons. Three genotypes, 18, 13 and 19, significantly exceeded the check Giza -25 which yielded 0.678 kg/plot, Table 4. The superiority of such genotypes could be due to their adaptation and high values of some yield components. These results are in line with those reported before (5,10,16,17).

The first and second order interactions revealed that the genotypes responded differently from year to year and from location to another.

D. Seed oil percent

The combined analysis of variance revealed significant differences among locations, Table 2. However, the effects of year x location interaction was not significant. Al-Tahreer location gave the highest while Shandaweel gave the lowest oil percent.

Significant differences among genotypes in seed oil percent were observed , such as Genotype-24 which gave the lowest (48.79%). While Giza-25 recorded the highest. The five superior genotypes were: 11, 17, 19, 20 and 21. It must be noted that genotype 11 and 19 were also superior in seed yield. First and second order interactions weresignificant, indicating differences in seed oil percent in different years and locations.

E. Estimates of variance components

Estimates of the variance components, genotypic and phenotypic coefficients of variability are presented in Table 5. The relative magnitudes of these components indicate the relative importance of the corresponding sources of variation. The large magnitude of the second order interaction indicated that the different genotypes responded differently when grown under different environments. The genotypic variance for number of branches/plant was large compared to 6^2 and 6_e^2 reflecting the importance

Table 3. Means of the studied agronomical yield traits at three locations in two seasons.

Trait		Shanda-well	Mallawi	Tahreer	Mean	Revised L.S.D.
Plant height,	1984	194.65	143.58	151.23	163.15	
(cm)	1985	213.70	202.59	158.01	191.43	1.14
	Mean	204.18	173.09	154.62	177.29	5.05
Height to the	1984	65.79	58.35	30.66	51.60	
first capsule,	1985	59.59	68.36	29.11	52.35	4.15
(cm)	Mean	62.69	63.36	29.89	51.98	2.83
Branches/plant	1984	3.25	4.14	5.59	4.32	
	1985	2.96	4.45	6.44	4.62	0.69
	Mean	3.10	4.29	6.02	4.47	0.42
Capsules/plant	1984	75.51	121.04	113.73	103.43	
	1985	66.12	163.13	132.76	120.67	13.02
	Mean	70.81	142.08	123.24	112.04	8.88
Capsule length	1984	3.51	2.80	1.72	2.57	
(cm)	1985	3.51	2.91	1.95	2.79	0.10
	Mean	3.51	2.86	1.83	2.68	0.06
Capsule breadth	1984	0.75	0.41	0.75	0.55	
(cm)	1985	0.88	0.54	0.88	0.65	0.03
	Mean	0.82	0.47	0.81	0.59	0.02
1000-seed	1984	4.00	3.63	3.54	3.73	
weight (g)	1985	3.86	3.32	3.31	3.49	N.S
	Mean	3.93	3.47	3.43	3.61	0.27
Yield/plot	1984	0.76	0.66	0.31	0.58	
(kg)	1985	0.89	0.69	0.44	0.68	0.11
	Mean	0.83	0.67	0.38	0.63	0.56
Seed oil	1984	50.17	52.26	52.51	51.65	
(%)	1985	49.76	52.80	54.13	52.23	2.04
	Mean	49.97	52.53	53.72	52.07	1.49

of the genetic variability among the tested genotypes. With respect to capsule length and capsule breadth, the genotypic 6_g^2 and 6_e^2 were comparable and sufficient genotypic coefficients of variability were obtained.

Generally, it could be concluded that the sesame genotypes behaves differently with changes in environment. Therefore, it is essential to evaluate sesame genotypes under a wide range of environments. These results are in line with those reported before (5,9,10,14,17).

F. Genotypic and phenotypic correlation

Genotypic correlations among traits are listed in Table 6. The genotypic correlation between seed yield/plot and each of the other traits indicated that the highest correlation (0.749) was between yield and capsule length followed by

Table 4. Means of the studied agronomical yield traits of different genotypes of sesame at three locations in two seasons.

Geno-type	Plant height (cm)	Height of first capsule(cm)	No. of branches /plant	capsules /plant	capsule length (cm)	capsule breadth (cm)	100-seed weight (g)	Yield/ plot (kg)	Oil (%)
1	173.95	52.46	5.15	98.45	2.64	0.58	3.66	0.502	52.95
2	176.71	44.98	4.89	116.47	2.46	0.59	3.39	0.714	51.60
3	161.69	50.00	4.75	102.33	2.59	0.53	3.50	0.641	51.56
4	180.00	50.48	5.52	107.36	2.68	0.58	3.54	0.696	50.68
5	172.52	60.17	4.94	102.96	2.69	0.58	3.35	0.601	50.62
6	166.60	54.65	4.85	107.02	2.84	0.55	3.51	0.544	51.95
7	175.79	59.04	3.73	104.45	2.59	0.64	3.56	0.619	52.97
8	178.08	51.29	5.75	127.09	2.77	0.81	3.56	0.668	52.27
9	172.65	52.19	5.04	104.13	2.67	0.94	3.61	0.523	51.53
10	179.63	61.10	4.96	102.63	2.58	0.52	3.46	0.664	52.14
11	177.83	52.38	4.30	116.25	2.61	0.54	3.49	0.693	53.18
12	186.50	55.94	5.03	125.06	2.59	0.59	3.69	0.602	52.09
13	184.23	59.25	6.07	111.08	2.69	0.62	3.70	0.750	52.59
14	171.42	53.02	4.29	102.41	2.61	0.49	3.52	0.618	51.86
15	168.23	51.56	4.75	109.91	2.64	0.62	3.51	0.662	50.31
16	161.63	37.77	5.51	106.93	2.70	0.56	3.55	0.507	52.73
17	179.49	50.54	5.99	125.06	3.04	0.61	3.58	0.604	53.08
18	189.27	54.63	3.03	99.74	3.27	0.90	3.67	0.806	52.68
19	197.75	56.04	3.42	113.49	3.24	0.95	3.86	0.741	53.09
20	185.59	44.60	2.44	128.61	2.72	0.61	3.38	0.591	53.09
21	175.50	57.92	5.78	126.26	2.59	0.60	3.62	0.678	54.18
22	171.50	53.79	4.68	97.64	2.61	0.58	3.70	0.559	52.33
23	182.92	55.08	4.45	114.79	2.63	0.56	3.50	0.670	50.87
24	175.39	41.08	1.29	113.99	2.50	0.76	3.64	0.443	48.79
25	187.48	39.46	1.07	125.89	2.37	0.57	3.26	0.599	49.35
Revised LSD(.05)	7.61	4.15	0.54	18.80	0.16	0.05	N.S.	0.058	1.27

* Check variety Giza-25.

plant height (0.737) and height to the first capsule (0.667). The other traits exhibited low correlations with seed yield/plot. Genotypic correlations were in general higher than phenotypic ones reflecting the relatively large error variances and covariances. If the environmental error variance and covariance had been reduced to zero, the phenotypic and genotypic correlation coefficients could have been identical (7).

The correlations between capsule length and breadth were positive and high, whereas, capsule length showed intermediate correlations with plant height and oil percent. Capsule breadth showed a large genotypic correlation with plant height (0.878), and slight negative correlation with number of branches/plant (0.376). Number of branches/plant gave intermediate correlations with height to the first capsule and oil percent.

These results indicated that the important traits which were positively correlated with seed yield were: capsule length, plant height and height to the first capsule. These traits should be considered in any program for yield in such materials. These results are in line with those reported before (2,6,8,19, and 20).

Table 5. Pertinent variance components, genotypic (GCV) and phenotypic (PCV) coefficients of variability and yield traits in sesame

Trait	σ^2_g	G.C.V. %	σ^2_p	P.C.V %	σ^2_{gy}	σ^2_{gl}	σ^2_{gly}	σ^2_e
Plant height	47.4826	2.89	72.2674	4.79	24.79	-8.88	40.04	190.42
Height of the first capsule	24.4823	9.52	39.1100	12.03	20.34	-5.88	20.11	61.79
Branches/plant	1.31766	25.68	1.74989	29.59	0.62	-0.04	0.51	1.12
Capsules/plant	-35.023	-	104.1771	9.11	127.24	69.80	72.81	1103.87
Capsule length	0.03186	6.66	0.03904	7.37	0.01	-0.002	0.01	0.08
Capsule breadth	0.00901	15.79	0.01184	18.11	0.003	0.00	0.01	0.01
1000-seed weight	0.04206	-	0.048712	6.11	0.04	0.03	-0.05	1.59
Yield/plant	0.021742	0.009	3.813449	11.94	1.31	4.44	6.63	22.16
Yield/plot	0.00453	10.72	0.007345	13.65	-0.002	0.0	0.02	0.04
Oil (%)	0.75271	1.67	1.6081	2.44	0.08	0.64	2.48	5.82

Table 6. Genotype "upper" and phenotype "lower" correlations as calculated from the combined analysis of variance for some agronomic and yield traits in sesame.

Trait	Capsules /plant	Capsule length	Capsule breadth	Plant height	Branches /plant	Height 1st. caps.	Oil %
Yield/plot	*	0.749	0.470	0.737	0.026	0.667	0.206
	0.167	0.472	0.429	0.513	0.168	0.423	0.285
Capsules/plant		*	*	*	*	*	*
		0.115	0.069	0.452	-0.059	-0.248	0.065
Capsule length			0.885	0.529	0.029	0.344	0.594
			0.837	0.408	0.027	0.329	0.427
Capsule breadth				0.878	-0.376	0.100	0.012
				0.589	-0.201	1.055	0.188
Plant height					-0.403	-0.155	0.170
					-0.356	0.017	0.106
Branches/plant						0.678	0.593
						0.441	0.455
Height 1st capsule							0.676
							0.380

* Negative genotypic variance was obtained for capsules/plant.

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Part 2

SUNFLOWER SUBNETWORK - II

USE OF WILD SPECIES IN SUNFLOWER BREEDING

Dragan Skoric

The domesticated sunflower has narrow genetic variability, especially regarding important agronomic characters. High-oil varietal populations and hybrids are distinguished for the narrowness of their genetic variability. The situation is similar with local populations only, in addition, they have inferior agronomic characters.

The large number of wild *Helianthus* species and pronounced variability within them offer opportunities of increasing genetic variability of the domesticated sunflower by interspecific hybridization. The validity of this assumption is confirmed by the fact that there exists a large number of natural interspecific hybrids among wild sunflowers.

The inclusion of wild sunflower species in sunflower breeding programs is not a simple but complex and long process. Differences in chromosome number (tetraploid and hexaploid species) and incompatibility render interspecific hybridization difficult, if possible at all. Fortunately, these obstacles have recently been made surmountable by the development of embryo culture and other techniques of tissue culture.

Interspecific hybridization is further burdened by insufficient knowledge of the genomic character of *Helianthus* genus. Consequently, we may lose characters in the course of hybridization. Furthermore, we introduce both desirable and undesirable characters into the domesticated form in the process of hybridization, especially the linked characters. It is therefore a must to gain more knowledge about the characters of the genus *Helianthus* in order to be able to set clear cut targets of interspecific hybridization which would ultimately ensure success in sunflower breeding.

The studies conducted so far on wild sunflowers, have not provided sufficient information from the aspect of breeding, especially for certain important characters, e.g., resistance to diseases and pests. The job on the collecting of wild sunflower species from natural populations has not been completed yet. That work should be maximally accelerated because, the rapidly spreading urbanization threatens the existing natural populations of wild sunflowers with extinction.

The use of wild sunflower species in breeding programs has been insufficient and yet it invariably produced very good results, especially in breeding for resistance to certain diseases (*Plasmopara helianthi* and *Puccinia helianthi).* It should be mentioned at this point that the domesticated sunflower is poorest in disease resistance. Wild sunflowers were also invaluable as sources of cytoplasmically male sterile (cms) and restorer (Rf) genes which practically enabled the use of heterosis in the development of sunflower hybrids.

The future uses of wild sunflowers in breeding should be directed towards the discovery of sources of resistance to the major diseases and insects, which are the dominant limiting factors of sunflower production. The work on the discovery of new sources of cms and Rf genes should be continued.

Furthermore, wild sunflowers are irreplaceable in the programs of breeding for resistance to drought and high soil salinity. It may be expected that the future breeding programs for oil and protein contents and seed quality will largely depend on certain wild sunflower species. The increase of heterosis for yield components is possible only if based on wild sunflowers.

To successfully use wild sunflowers in breeding programs, breeders should be thoroughly acquainted with all their characters, problems related to interspecific hybridization and breeding techniques.

Basic Characters of Wild Sunflower Species

Helianthus, a genus of the family *compositae (Asteraceae)* has a disjunct distribution, some 50 or so species being found in Canada, the United States, and northern Mexico, and the remaining 17 species limited to the Andes from southern Colombia to Peru (20).

Helianthus species fall into four sections and a number of series based on genetic and morphological characteristics. Section Fructicosi contains 17 South American perennial species that are only distantly related with North American sunflowers. The South American species have been transferred to genus *Helianthopsis* (53), and will not be considered further here.

The North American species of *Helianthus* occupied a variety of habitats (66). Several could be classed as desert species and a few somewhat paludose at least in the early stages of growth. Most species are found in fully open habitats and a few will be grown in rather dense shade, Table 1. A number of species can be classed as weeds. *Helianthus annuus* which has the most extensive distribution of any species apparently grows only in areas distributed by man. Many of the other species both annual and perennials, have distributions that have probably been enlarged by man. At least one from the densely pubescent race of *H. nuttallii* subsp. *parishii*, has become extinct as the result of man's activities and others may have suffered a restriction in range. Several species are intentionally cultivated by man, either for ornamental purposes or for food as *H. annuus* and *H. tuberosus* (21).

Helianthus genus is a polyploid complex consisting of diploids, tetraploids and hexaploids, all with the basic chromosome number of x=17 (55).

North American *Helianthus* species fall into three sections and a number of series based on genetic and morphological characteristics.

- I. Section Annui
- II. Section Ciliares
    - A. Series Ciliares
    - B. Series Pumili
- III. Section Divaricati
    - A. Series Angustifolii
    - B. Series Atrorubentes
    - C. Series Divaricati
    - D. Series Gigantei
    - E. Series Microcephali

I. Section Annui

Section Annui contains 14 or 15 species, nearly all of which are annual species occurring in the western half of the United States (21). Species of this section are nearly always annual, or rarely, taprooted perennials. Except for *H. agrestis H.=(Viguiera) ludens* and *H.=(Viguiera) similis*, all species are closely related and may intercross to produce hybrids with reduced fertility (51).

In most species the majority of the leaves are alternate, commonly ovate, and with few exceptions long petiolate. Disks of this section are mostly flat. The disk flowers are mostly reddish or purplish, but some species have yellow disk flowers.

Table 1. Collection and habitat information for helianthus species (Thompson et al., 1981).

Helianthus Species 1	Subspecies 2	Number of Collections 3	Where collected 4	General habitat 5	Estimated annual rainfall (cm) 6
niveus	niveu	1	Mexico	Sand dunes	<12
	tephrodes	1	CA	Sand dunes	<12
	canescns	6	TX, NM, AZ	Sand	12-50
debilis	debilis	15	FL	Sandy coast	125
	vestitus	1	FL	Sandy	125
	tardiflorus	1	FL	Sandy coast	125-140
	silvestris	3	TX	Sand	75-115
	cucumeriflolius	2	TX, CA	Sand	64-90
praecox	praecox	2	TX	Sand	120
	runyonii	5	TX	Coastal prairies	50-100
	hirtus	4	TX	Sand	50
petiolaris	petiolaris	50	Central U.S.	Sand	38-127
	fallax	15	South west U.S.	Sand	25-80
neglectus		9	TX	Sand	25-50
annuus		483	U.S. Mexico	variable	25-100
argophyllus		18	TX	Sand	50-100
bolanderi		1	CL	Valleys	25-150
exilis		5	CL	Rock outcrop areas	50
deserticola		1	UT	Sand	12-25
anomalus		1	UT	Sand	25-50
paradoxus		1	TX	Wet places	25
agrestis		1	FL	Wet places	125
gracilentus		2	CA	Dry stopes	25-50
pumilus		1	CO	Rocky soils	25-65
cusickii		2	OR,CA	Dry hills	20-75
arizonensis		1	AZ	Light soils	25-50
lociniatus		1	NM	Stopes	25-60
ciliaris		5	TX, NM	Variable	50-75
mollis		19	TX, OK, KS,AL,MT	Variable	90-140
occidentalis	occidentalis	4	TX,MT,AR	Dry sandy areas	65-140
	plantagineus	2	TX	Variable	100-125
divaricatus		3	TX,OK, MT	Dry areas	75-140
hirsutus		4	TX,OK	Dry open areas	63-140
decapetalus		4	TX,IN,IL	Shaded woodlands	60-140
x multiflorus[a]		1	IN	Cultivated only	Much
eggertii		11	TN	Barrens	127
strumosus		7	OK,NC,AL,TN	Variable	65-140
tuberosus		11	TX,IA,IL,OK,SC.AL	Variable	50-140
rigudus	rigidus	7	TX,OK,NC,IC,CO	Prairies	63-100
	subrhomboideus	1	CO	Dry prairies	38-90
x laefilorus[a]		6	TX,NE,KS,NC	prairies	75-115
giganteus		1	MN	Wet areas	50-140
grosseserratus		16	TX,KS,NE,IN,OK	Prairies	50-127
nuttallii	nuttallii	5	CO,UT	Wet areas	12-76
	rydbergii	1	ND	Sand	50
	parishii			Swampy areas	25
maximiliani		30	TX,NM,KS,NE,AL,AR	Prairies	25-127
salicifolius		5	TX,KS	Alkaline soils	76-115
californicus		2	CA	Wet areas	25-127
resinosus		1	MS	Variable	127-178
schweinitzii		2	NC	Sand	115

Table 1 contd.

1	2	3	4	5	6
microcephalis		2	SC	Variable	76-180
glaucophyllus		1	NC	Semishade	115-152
laevigatus		1	VA	Shale-barrens	90-127
smithii		1	NC	DRy areas	127-200
longifolius		1	AL	Variable	127-150
angustifolius		10	TX,AL,GA	Wet areas	90-175
simulans		1	FL	Variable	140-150
floridanus		2	FL	SAnd	127
silphioides		2	OK,FL	Variable	114-140
atrorubens		6	MS,GA,SC,NC	Variable	114-127
heterophyllus		1	MS	Wet sand	127-152
radula		3	FL	Wet sand	127-152
carnosus		2	FL	Wet sand	127
imbaburensis		1	Equador	?	0

[a] Hybrids common enough to be recognized.

Annual species of this section usually occupy open habitats.

Section Annui contains:

1. *H. annuus* L., common annual sunflower (n=17),
2. *H. agrestis* Pollard, rural sunflower (n=17),
3. *H. anomalus* Blake, anomalous sunflower (n=17),
4. *H. argophyllus* Torrey and Gray, silver-leaf sunflower (n=17),
5. *H. bolanderi* Gray, Bolanders sunflower (n=17),
6. *H. debilis* Nuttall, weak sunflower (n=17),
   - *H. debilis* Nuttal subsp. *cucumarifolius* (T. and G.) Heiser, cucumber-leaf sunflower (n=17),
   - *H. debilis* Nuttall subsp. *debilis* Nuttall, beach sunflower (n=17),
   - *H. debilis* Nuttall subsp. *tradiflorus* Heiser, slow-flowering sunflower (n=17),
   - *H. debilis* Nuttall subsp. *vestitus* (Wutson) Heiser clothed sunflower (n=17),
   - *H. debilis* Nuttall subsp. *silvestris* Heiser, forest sunflower (n=17),
7. *H. deserticola* Heiser, desert-inhabiting sunflower (n=17),
8. *H. exilis* Gray. Thin (serpentine) sunflower (n=17),
9. *H. (=Viguiera)* ludens Shinners, playing sunflower (n=17),
10. *H. neglectus* Heiser, Neglected sunflower (n=17),
11. *H. niveus* (Benth.) brandegee, snowy sunflower (n=17),
    - *H. niveus* (Benth.) Brandegee, subsp. *canescens* Heiser, gray sunflower (n=17),
    - *H. niveus* (Benth.) Brandegee, subsp. *niveus* (Benth.) Brandegee, snowy Sunflower (n=17),
    - *H. niveus* (Benth.) Brandegee, subsp. *tephrodes* (Gray) Heiser, ash-Colored sunflower (n=17),
12. *H. paradoxus* Heiser, paradoxical sunflower (n=17),
13. *H. petiolaris* Nuttall, petioled (prairie) sunflower (n=17),
    - *H. petiolaris* Nuttall, subsp. *fallax* Heiser, deceptive sunflower (n=17),
    - *H. petiolaris* Nuttall, subsp. *petiolaris* Nuttall, petioled sunflower (n=17),
14. H. praecox Engleman and Gray, premature sunflower (n=17),
    - *H. praecox* Engleman and Gray subsp. *hirtus* Heiser, premature rough sunflower n=17),
    - *H. praecox* Engleman and Gray subsp. Praecox Engleman and

Gray, (n=17),
- *H.praecox* Engleman and Gray subsp. *runyonii* Heiser, javelin sunflower (n=17),

15. *H.* *(=Viguiera) similis* (Brandegee) Blake, similar sunflower.

II. Section Ciliares

These are Western North American perennials of low stature. Plants lack rhizomes and develop from tap roots or long lateral roots. Leaves are mostly or all opposite (21,51).

A. Series Ciliares

This series is composed of 3 species of western perennials. Plants develop from long, abundant lateral roots. Leaves are usually bluish or grayish nearly hairless, and either lack or have very short petioles (51).

1. *H. arizonensis* R.Jackson, Arizona sunflower (n=17),
2. *H. ciliaris* DC, Hair-lik sunflower (n=34),
3. *H. laciniatus* Gray, Jagged-edge sunflower (n=17),

B. Series Pumili

Series Pumili is composed of 3 western perennials, taprotted sunflower species. New plants grow from buds at base of old stem. Leaves usually have rough or stiff hairs (21, 51).

1. *H. cusickii* Gray, Parsnip-root sunflower (n=17),
2. *H. gracilentus* Gray, Slender sunflower (n=17),
3. *H. pumilus* Nuttall, Dwarfish sunflower (n=17),

III. Section Divaricati

Species are perennials (except *H. porteri*), primarily from eastern and central United States and Canada. New plants grow from rhizomes, tubers or crown buds. Leaves are mostly lance-to egg-shaped. Disk corollas with yellow lobes except for seven species (21, 51).

A. Series Augustifolii

Species of this series have resemble fibers or thick roots or well developed rhizomes. Stems are hairy and have mostly alternate, linear to lance-shaped leaves with rolled-under margins. Disks are small to medium-sized, with yellow or purple-lobed corollas. Bracts are narrow. Seeds are from 2-3 mm long. Species are found primarily in south eastern states (52).

1. *H. angustifolius* L., Narrow-leaf sunflower (n=17),
2. H. floridanus Gray ex Chapman, Florida sunflower (n=17),
3. H. similans Watson, Lmitative sunflower, (n=17).

B. Series Atrorubentes

Species of this series have fibrous or cordlike roots that usually lack rhizomes. Basal rosette leaves are well-developed, while stem leaves may be few and small disk lobes are almost always purple. Seeds are from 3 to 5 mm long and are often black. Species occur mostly in south eastern states, and all are perennial (51).

1. *H. atrorubens L.*, Dark-head sunflower, (n=17),
2. *H. carnosus* Small, Fleshy sunflower (n=17),
3. *H. heterophyllus* Nuttall, Different-Leaf sunflower, (n=17),
4. *H. radula* (Purch) Torrey and Gray, Scraper sunflower, (n=17),

C. Series Divaricati

Series Divaricati has roots fibrous to coarse, with tubers mostly lacking. Rhizomes usually long and slender, sometimes becoming terminally enlarged. Leaves are usually lance-shaped to ovate, 3-veined, and mostly opposite. Stem leaves well developed except in *H.*

occidentialis and sometimes in *H. rigidus*. Disk flowers are variable in size and have yellow lobes, except in *H. rigidus*. Achenes are from 3-6 mm long (21, 51).

1. *H. decapetalus* L. Ten-Petals sunflower, (n=17 or n=34),
2. *H. multiflorus* L. Many-flowers sunflower (All plants are sterile triploids),
3. *H. divaricatus* L., Divergent sunflower (n=17),
4. *H. eggertii* Small, Eggert's sunflower (n=51),
5. *H. hirsutus* Rafinesque, Rough sunflower (n=34),
6. *H. mollis* Lambert, Soft sunflower, (n=17),
7. *H. occidentalis* Riddel, Western sunflower, (n=17),
   - *H. occidentalis* Riddell, subsp. *occidentalis* Riddell, Western sunflower, (n=17),
   - *H. occidentalis* Riddell, subsp. *plantagineus* (T. and G.) Heiser, branching Western sunflower (unknown),
8. *H. rigidus* (Cass.) Desf., Stiff Sunflower (n=51),
   - *H. rigidus* (Cass.) Desf., Subsp. *rigidus* (Cass.) Desf., Stiff sunflower (n=51),
   - *H. rigidus* (Cass.) Desf., subsp. subrhomboideus (Rydb.) Heiser, Nearly 4-sided sunflower, (n=51),
9. *H. xlactiflorus* Pers., Cheerful sunflower (n=51?),
10. *H. strumosus* L., Swollen sunflower (n=34, N=51),
11. *H. tuberosus* L., Tuberosus sunflower (Jerusalem Artichoke), (n=51).

D. Series Gigantei

The tallest sunflowers occur among species of this series. Roots usually become enlarged, often tuber-like, and produce short, stout rhizomes less than 15 cm long. Stem leaves are well developed. Leaves are mostly alternate, usually lanceolate and single-veined. Disk small to large. Lobes of disk-corolla are yellow, except in *H. salicifolius*. Seeds are 4-5 mm long. All species of series Gigantei are perennial (21,51).

1. *H. clifornicus* DC., California sunflower, (n=51),
2. *H. giganteus* L., Gigant sunflower (n=17),
3. *H. grosseserratus* Martens, Thick-tooth sunflower, (n=17),
4. H. maximiliani Schrader, Maximilian sunflower, (n=17),
5. *H. nuttallii* Torrey and Gray, Nuttall's sunflower, (n=17),
   - *H. nuttallii* Torrey and Gray, subsp. *nuttallii* Torrey and Gray, Nuttall's sunflower (n=17),
   - *H. nuttallii* Torey and Gray, subsp. *parishii* (Gray) Heiser, Parish's sunflower, (n=17),
   - *H. nuttallii* Torrey and Gray, subsp. rydbergii (Britton) Long, Rydberg's sunflower (n=17),
6. *H. resinosus* Small, Resinosus sunflower (n=51),
7. *H. salicifolius* Dietr., Willow-leaf sunflower (n=17),
8. *H. schweinitzii* Torrey and Gray, Schweinitz's sunflower, (n=51).

E. Series Microcephali

This series contains 5 perennial and 1 annual species of sunflower. Roots fibrous to coarse, not tuberous. Rhizomes lacking, poorly developed or short and thick.
Stems are usually glabrous, but sometimes they may be covered with a whitish bloom. Stem leaves are well developed except in *H. longifolius*, becoming alternate above. Disks are small. Lobes of disk corolla yellow. Seeds are 2-4 mm long (21, 51).

1. *H. glaucophyllus* Smith, White leaf sunflower, (n=17),
2. *H. laevigatus* Torrey and Gray, Smooth sunflower, (n=34),
3. *H. longifolius* Purch, Long-Leaf sunflower, (n=17),
4. *H. microcephalus* Toprrey and Gray, Small-headed sunflower, (n=17),
5. *H. porteri* (A. Gray) Heiser, Porter's sunflower. (n=17),

6. *H. smithii* Heiser, Smith's sunflower, (n=17).

Seed Germination of *Helianthus* Species

The seeds of cultivated species usually germinate more readily and more evenly than those of the most nearly related wild type(21). The germination of seeds of the cultivated strains of *H. annuus* approaching 100%, and generally all of them germinate readily. Under the same conditions, seeds of wild *Helianthus* species usually do not germinate or rarely do as much as 20%. To secure better gemrination, various methods have been attempted. Successful method for annual species was to plant the seeds in pots which are then set outside for 3-4 weeks where they are exposed to varying temperatures, including alternate freezing and thawing. Germination was still very irregular. This method has not proved very successful for the desert annuals *(H. anomalus and H. deserticola)*. For them, various other methods including wetting and drying, washing in several changes of water and soaking for several days have been tried, but germination has seldom reached 10%. Germination of perennials shows considerable variability. *H. grosseserratus* and some other give rather high percentages after a three weeks cold treatment, but most of the other species give very low percentages of germination (21).

Pollination Biology

With the exception of *H. agrestis*, one strain of *H. argophyllus* and certain cultivated strains of *H. annuus*, all species are self-incompatible with obligate cross-pollination (21). The method for determining self-incompatibility was not discussed. From observations in the field and in the experimental garden it is obvious that bees, including the honey bee, are the principal pollinators. Butterflies visit *Helianthus* only occasionally.

Hybridization and Cross-Compatibility Relationships

Interspecific hybridization between the cultivated sunflower *(H. annuus)* and other *Helianthus* species has been of considerable interest because of the potential for utilizing the immense diversity in the genus. The great diversity of the interspecific hybrid progenies with regard to morphological, genetical, physiological, biological, immunobiological reactions, as well as of other properties, represent a most valuable source of germplasm to be used in the individual crop breeding (14).

Among the annuals, only *H. annuus* is known to hybridize to a great extent with other species. The reason is that, most of the other species are allopathic with each other. All of the artificial hybrids between annual species show reduction in fertility, probably resulting from the structural differences in chromosomes so that one might consider that structural rearrangement of chromosomes has played an important role in the speciation. The reduced fertility is seen both in pollen stainability and seed set, with the latter generally running lower than that of the pollen stainability. Pollen stainability is probably the more direct indication of the degree of structural differences in the chromosomes of the two parents. Pollen production directly follows meiosis (21).

Sterility is not the only barrier to gene exchange in the annuals, since many species have their peak of blooming at different seasons and also show ecological differences (21, 14). These two barriers are also prominent among many of the perennials, but strong sterility barriers are poorly developed in the perennials.

Obviously, in the annuals good seed set would be a necessity, whereas in most perennials there would be less selective value of good seed set since the rhizomes provide an efficient means of survival and increase.

Relationships of *Helianthus* species based on crossing results were reported (55), Fig. 1.

Many of the species in the genus, particularly the perennial species, have never been successfully hybridized with the cultivated sunflower. Abortion of the hybrid embryos during early developmental stages has been one of the important barriers preventing interspecific hybridization.

Cultivated *H. annuus* has been successfully hybridized with 12 annual species and more with 7 subspecies (14,21,51,66). The 10 perennial species have been hybridized with *H. annuus*, Table 2.

<u>Sunflower Interspecific Hybridization Using Embryo Culture</u>

The wild *Helianthus* species are potential sources of germplasm for improving the cultivated sunflower (*Helianthus annuus* L.), but many have never been artificially hybridized with the cultivated sunflower, particularly the perennials. Abortion of the hybrid embryos during early developmental stages is an important barrier. The classic solution to this problem is the use of embryo culture, excising the embryo before it has aborted and placing it on nutrient media to grow "in-vitro"

into a seedling capable of supporting itself. Using embryo culture techniques hybrids have obtained between the domestic sunflower as the pollen parent and *H. angustifolius*, *H. argophyllus*, *H. exilis*, *H. gracilentis*, *H. hirsutus*, *H. maximiliani*, *H. niveus* ssp. *tephrodes*, *H. petiolaris* ssp. *fallax*, *H. strumosus*, *H. bolanderi*, *H. giganteus*, and *H. grosseserratus* *(5,6)*.

Embryo culture system using two modifications of Gamborg's B5 medium to produce interspecific *Helianthus* hybrids was developed (6,7). Embryos were successfully excised and cultured 3 to 7 days after pollination. Embryos initial ly developed on a solid medium containing inorganic components, vitamins, amino acids, and 12% sucrose. For embryo germination and seedling growth the cultured embryos were transferred to a liquid medium containing only the inorganic components and 1% sucrose.

Table 2. *Helianthus* species successfully hybridized with cultural annuus.

Helianthus Species	Subspecies	Habit
niveus	canescens	a*
debilis	debilis	a
	vestitus	a
	tardiflorus	a
	silvestris	a
praecox	praecox	a
	runyonii	a
	hirtus	a
petiolaris	petiolaris	a
	falax	a
neglectus		a
annuus		a
argophyllus		a
bolanderi		a
exilis		a
deserticola		a
anomalus		a
paradoxus		a
divaricatus		p
hirsutus		p
decapetalus		p
strumosus		p
tuberosus		p
giganteus		p
maximiliani		p
angustifolius		p
grosseserratus		p
rigidus		p

* a= annual, p = perennial

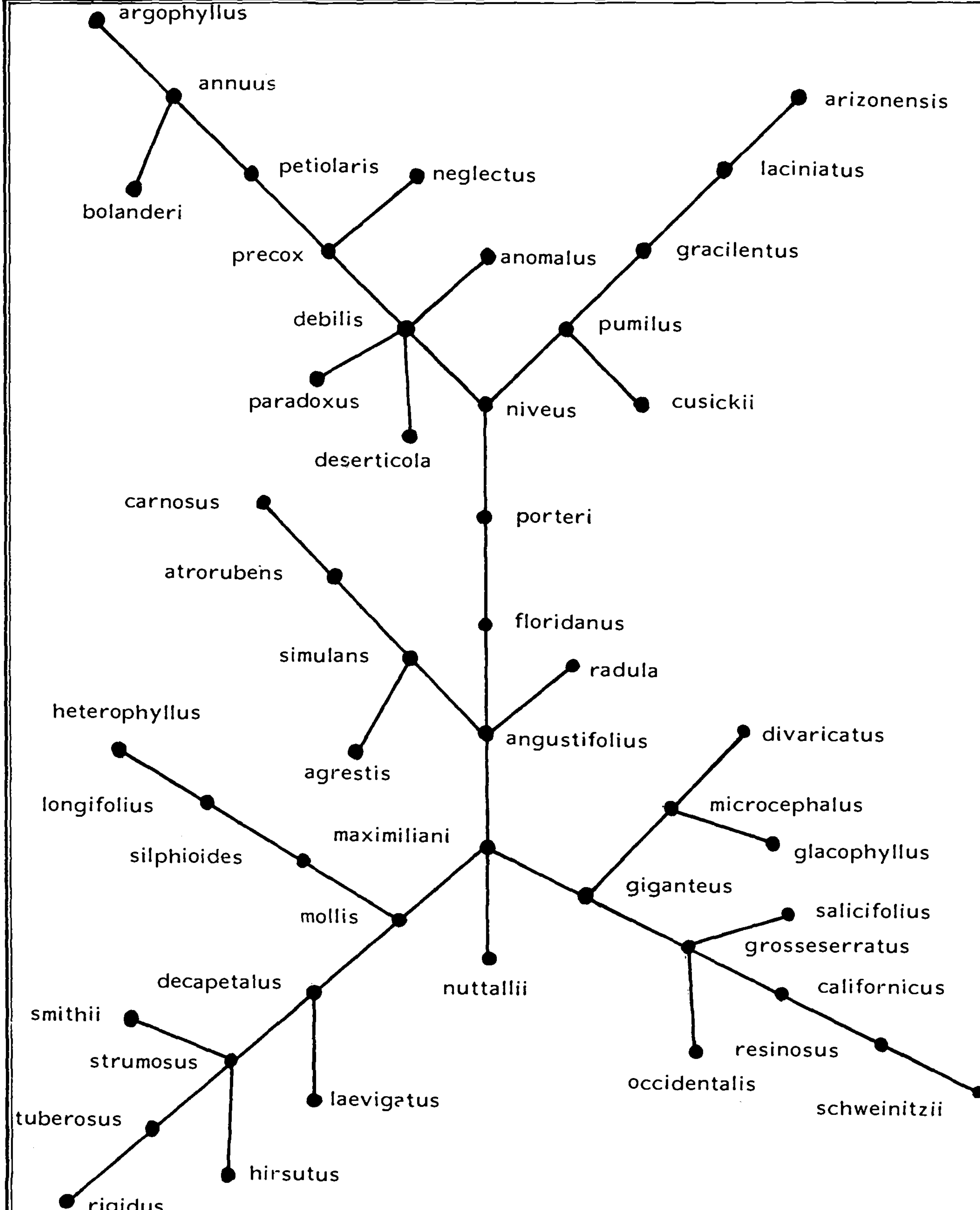

Figure 1: PRIM NETWORK SHOWING RELATIONSHIPS OF HELIANTHUS SPECIES BASED ON CROSSING RESULTS (55).

Experiments have been done using tissue culture techniques on sunflower (18), Table 3. Formation of callus seems feasible, and plants have been regenerated from stem callus.

Vegetative propagation of shoots provides a means of rapid increase of desired genotypes. Developing seeds have been cultured "in-vitro" and embryo culture has greatly facilitated interspecific hybridization.

Table 3. Summary of progress in the tissue culture of *Helainthus annuus* L. (18).

Author	Source tissue	Response
White and Braun, 1931	Secondary grown gall	Isolated bacteria free gall Callus
Hildebrant et al., 1945	- do -	Effect of temp., pH, and sugar
Hildebrant et al., 1974	- do -	Effect of growth hormones
de Roop, 1947	- do - Stem	Root from stem callus
Rogers et al, 1974	Stem	Root from stem callus
Sadhu, 1974	Stem	Plants from stem callus
Chandler and Beard, 1978	Embryo	Culture to plants
Georgieva et al., 1980	Stem	Plants from stem callus
Binding et al., 1981	Apex, leaf	Protoplasts, callus, roots from apex
Silver et al., 1981	Seed	Pest-pollination seed culture
Trifi et al., 1981	Apex, leaf node	Rapid vegetative propagation

The Chromosome Doubling in Sunflower

Wild *Helianthus* species have contributed valuable genes to the improvement of the cultivated sunflower (*H. annuus)*. The large genetic variability preserved in them should continue to play an important role in the future improvement of this crop. Utilization of some of these species is very difficult because of their low crossability with the cultivated sunflower and the high degree of F_1 sterility when hybrids are obtained.

All the interspecific hybrids that have been produced have lower fertility than their parents. The problem apparently revolves around differences in chromosome structure between the various species. This condition disrupts the orderly pairing and segregation of chromosomes during the cell division process. The cultivated sunflower is very different in chromosome structure from most other species. It has been explained (7) why fertility is so low in those hybrids produced by crossing the cultivated sunflower with most of the wild species. Sterility is one obstacle to interspecific hybridization which is not easy to overcome (7). One possible answer lies in artificially doubling the number of chromosomes in the hybrid, which would give each chromosome an exact copy to pair-with so that meiosis can occur in an orderly fashion.

Techniques for doubling chromosomes in sunflower were developed (27). These techniques for doubling chromosomes can be beneficial in two ways. First, doubling the chromosomes of one or both parents have improved interspecific crossability. Second, chromosome doubling of the hybrids is effective in improving the fertility in hybrids where sterility is associated with meiotic abnormalities (interspecific sunflower hybrids). The most effective technique is: young seedlings at two true- leaf stage were inverted, and their apical meristems were submerged in a colchicine solution of either 0.25% or 0.15% concentration at PH=5.4 with 2% DMSO for five hours. Treated seedlings were then washed and planted in pots in the greenhouse and later transplanted into the field.

Size of pollen is then best criterion for discriminating doubled from undoubled plants since pollen grains from tetraploid heads are substantially larger than from the diploids. Meiotic chromosome examinations on side buds from doubled branches have positively confirmed chromosome doubling.

Using Wild *Helianthus* Species in Breeding for Resistance to Diseases and Pests

Diseases are limiting factors of production in the majority of sunflower-growing countries. Different diseases are dominant in different regions on account of various agro-ecological conditions. The cultivated sunflower has a narrow genetic base and it is deficient in resistance genes. So far, sources of resistance have been sought and found in wild sunflowers. Certain wild species have contributed genes of resistance to *Plasmopara helianthi*, *Puccinia helianthi*, *Verticillium albo-atrum*, and *Verticillium dahliae*. There is yet a large number of diseases for which resistance sources remain to be found. Among those, the most important ones are *Sclerotinia sclerotiorum*, *Phomopsis-Diaporthe helianthi*, *Macrophomina phaseoli*, *Phomopa sp.*, *Alternaria helianthi*, *Botrytis cinerea*, *Rhizopus spp.*, etc. The diversity of *Helianthus* offers possibilities of discovering resistance sources to all diseases.

To accomplish that, breeders should include all available wild species in their programs of sunflower breeding for resistance to pathogenic fungi. This is the only solution to the problem of sunflower diseases since the cultivated sunflower lacks genetic sources of disease resistance. It has been noticed that pathogenic populations undergo genetic change developing new races. It means that the use of wild sunflower in breeding for disease resistance should be considered as continual process. An illustration of this is the occurrence of new races of *Plasmopara helianthi* and *Puccinia helianthi* and successful use of wild sunflowers in discovering new Pl and R genes.

Wild sunflowers are effectively used in breeding for resistance to *Orobanche cumana* which frequently develops new races.

Although insects impose serious problems in sunflower production in North and South America and Africa, the use of wild sunflower in breeding for insects resistance has been insufficient. Best results have been achieved in breeding for resistance to sunflower moth (*Homeosoma nebullella).* In recent years only American breeders have intensified the use of wild sunflower in breeding for resistance to several insect species.

Breeding for Disease Resistance

In the previous paragraphs we mentioned pathogens which have successfully been fought against by means of breeding based on wild sunflowers. In this chapter, we shall review several sunflower pathogens, the extent of wild sunflower use in breeding for resistance to them, and further prospectives in breeding opened up by wild sunflowers.

Plasmopara helianthi: A great break thorough in the breeding for resistance was the discovery of Pl genes which bring genetic resistance to downy mildew. The line AD-66 was the first source of Pl_1 genes. The line was derived from Canadian material (Advent) which had been developed on the basis of wild sunflowers(69). The sources of Pl_2 gene were also wild sunflowers (81), as well as the sources of Pl_3 and Pl_4 genes (71,74).

A possibility of developing new varietal populations on the basis of *H. tuberosus*, which are resistant to downy mildew (Pl_2 and Pl_5 ?) was found (42). The new varieties (Yubilejnaya 50, Progress and October), developed by interspecific hybridization, enlarged the genetic variability of the domesticated sunflower.

A new race of downy mildew discovered in the U.S. in 1980 was found to be widespread (11). Selected lines with known genes for world in-breeding resistant cultivars were all susceptible to the new race. Three sources of resistance were identified among more than 400 diverse sources of germplasm. These sources originated from the Soviet cultivar Progress, an NS hybrid from Romania and a cross of an ornamental sunflower possessing red ray flowers and ligulate disk flowers (12).

Progress and NS hybrids, which are downy mildew resistant have been derived from *H. tuberosus*.

Puccinia helianthi: Rust is the most extensively studied sunflower disease. Breeding for resistance has been successful in spite of the changes in the pathogen's population. Sunflower resistance to the discovered four races of rust is controlled by four independent dominant genes (R_1, R_2, R_3 and R_4. It was reported that all lines having resistance to rust have been derived form wild sunflowers (28,39). A large number of wild species possesses genes of resistance to rust (41). These species are diploid, tetraploid, or hexaploid. Although several genetic sources of resistance to rust are available, the disease inflicts considerable damages in North and South America, Africa, and Australia because of genetic changes in the pathogen population and the appearance of new races.

Phomopsis (Diaporthe) helianthi: Stem canker is a new sunflower disease which displays a tendency of rapid spreading in a large number of sunflower-growing countries, threatening to jeopardize the sunflower production as a whole. Only few years ago, the pathogen has been outside the scope of interest and work of sunflower breeders. It perhaps explains why the entire assortment of presently grown sunflower varieties and hybrids lack sources of resistance to stem canker. It was reported that the cultivated sunflower does not possess resistance to stem canker (63).

Sources of resistance to the pathogen should be searched for in wild sunflowers. A study of Cuk, which is still in due course, showed that stem canker was not found in the following wild species: *H. tuberosus*, *H. resinosus*, *H. decapetalus*, *H. divaricatus*, *H. eggertii*, *H. giganteus*, *H. grosseserratus*, *H. hirsutus*, *H. mollis*, *H. salicifolius*, *H. nuttallii*, *H. radula*, etc.

There are some indications that sources of resistance to stem canker may be expected to be found in *H. tuberosus*.

Alternaria helianthi: Studies conducted so far have indicated the lack of genetic sources of resistance to this pathogen in the cultivated sunflower. Resistance should thus be searched for in wild sunflowers. A total of 21 annual and 37 perennial *Helianthus* species and subspecies and a closely related annual taxon *Tithonia rotundifolia* have been tested for resistance to *A. helianthi* in the greenhouse (32). All the annual species were susceptible. The perennial *Helianthus spp.* were susceptible except for *H. hirsutus Ref.*, H. rigidus subsp. *Subrhomboideus* Heiser, and *H. tuberosus* L. which were moderately resistant. This resistance is transferable to the cultivated sunflower (*H. annuus)* by backcrossing of inbred lines with the resistant perenial species. C u k arrived at similar results which have not been published yet.

The testing of wild sunflowers, especially perennial ones, for genetic sources of resistance to *A. helianthi* should be accelerated, making use of the largest possible genetic variability within each wild species. Besides determining sources of resistance to *A. helianthi*, it is also necessary to design the most suitable methods of incorporating resistance genes in the cultivated sunflower since the resistance genes appear to be present in wild hexaploids.

Sclerotinia sclerotiorum: Sclerotinia stem-and head-rot is one of the most widespread and destructive diseases of vegetable and field crops. It has a very wide host range including Brassicas, legumes, and many vegetable and weed species.

The currently grown sunflower varieties and hybrids are not genetically resistant to *S. sclerotiorum*. Nevertheless, a number of reports has appeared in recent years indicating the existance of differences in the degree of susceptibility among the varieties and hybrids.

The variety Yubilejnaya 60 should be resistant to *S. sclerotiorum* (42). However, the variety performs otherwise when grown in field. The same authors reported the following wild species as suitable materials for breeding for resistance to *Sclerotinia* stem- and head-rot: *H. tomentosus, H. lactiflorus, H. scaberimus, H. divaricatus, H. tuberosus, H. macrophyllus* and *H. rigidus*.

Dr. C.A. Thomas (USDA-ARS, Beltsville, MD) informed the author of these pages in personal contact to have found a source of resistance to *S. sclerotiorum* (basla stem infection) in *H. tuberosus*, controlled by three dominant genes.

It is evident that, of all sunflower diseases Sclerotinia rot will be the most difficult to find genetic sources of resistance.

Verticillium wilt: The first source of genetic resistance developed to *Verticillium albo-atrum*, discovered in the line CM-144, came from an interspecific hybrid (37). The existance of sources of resistance to *Verticillium dahliae* in *H. tomentosus* was reported (42).

Phoma sp.: It was reported that the resistance to *Phoma sp.* appears to exist in the following wild sunflowers: *H. gigantheus, H. argialis, H. tomentosus, H. tuberosus, H. macrophyllus, H. rigidus,* and *H. subcanescens*, (41,42), Table 4. The newly developed variety, Yubilejnaya-60 was reported to be resistant to *Phoma sp* (42). According to unpublished data of Skoric, only certain genotypes within the variety Yubilejnaya-60 display resistance to *Phoma sp.*

Resistance to Phoma sp. in wild sunflower has been insufficiently studied. Studies carried out presently in several countries should give a more complete picture on the resistance of wild sunflowers to *Phoma sp.* and on the possibilities of wild sunflowers use in the development of resistant varieties and hybrids.

Rhizopus head-rot: It is one of the most important sunflower diseases, especially in arid regions. The pathogens of *Rhizopus* head-rot are *R. arrhizus* Fischer, *R. oryzae* Went. and *R. stolonifer* Vuill. *Rhizopus arrhizus* is more prevalent and virulent than *R. oryzae* or *R. stolonifer*.

The cultivated sunflower genotypes do not possess genetic resistance to *Rhizopus* head-rot. Resistance of wild *Helianthus* species to *Rhizopus* spp. has not been sufficiently studied. It was found that four of 32 tested wild species and subspecies were resistant when inoculated separately with *R. arrhizus* and *R. oryzae (H. divaricatus, H. hirsutus, H. laetiflorus,* and *H. resinosus) (80).* Studies of wild sunflower resistance to Rhizopus head-rot should be continued in order to find sources of resistance to this group of pathogens.

Erysiphe cichoracearum: Although the disease caused by this pathogen, powdery mildew does not bring economic damages to sunflower at present, it is nevertheless desirable to work on the determination of resistance genes in wild sunflowers and their introduction in the cultivated sunflower.

Three annual species or subspecies (*H. bolanderi, H. debilis subs. silvestris, H. praecox subsp. praecox)* and 14 perennial species of sunflower were resistant to *E. cichoracearum* which causes powdery mildew of sunflower in file and greenhouse tests (56). *H. grosses-serratus* and *H. maximiliani* collected from some location were resistant but from other locations were susceptible to *E. cichoracearum.*

Obviously, there exist several sources of resistance in annual and perennial wild species. In breeding for resistance to powdery mildew, however, preference should be given to the annual species because they are more easily crossed with the cultivated sunflower.

We have limited knowledge of the genetic base of resistance to powdery mildew in wild sunflowers. We know that we deal with dominant genes but we do not know their number.

Orobanche cumana: The genetic sources of resistance to *O. cumana* were derived mostly from wild sun flowers.

Table 4. Phytopathological estimates of wild *Helianthus* species (41).

Species	2n	*Plasmopara helianthi* (%)	*Puccinia helianthi* (%)	*Phoma* sp. (%)	*Orobarche cumana* (%)	Armour layer (%)
H. debilis Nutt.	34	100	100	90	100	100
H. lenticularis Doug.	34	100	100	70	100	100
H. arhophyllus T.et C.	34	100	100	90	100	100
H. petiolaris Nutt.	34	100	100	20	100	100
H. mollis Lam.	34	0	0	30	0	100
H. giganteus	34	16.60	0		0	100
H. grosseserratus Mart.	34	35.70	10		0.45	100
H. maximiliani Schard	34	0	0	50	0.5	100
H. nuttalli T.E G.	34	0	0	10	0.4	100
H. trachelioflorus Miller	34	0	0	100	100	
H. californicus D.C.	34	0	0	400	100	
H. multiflorus Hook.	34	0	0	30	0	100
H. arhialis D.C.	34	14.20	0		0	100
H. divaricatus	34	11	0	10	0	100
H. tomentosus Mich.	68	15.50	0		1.9	100
H. leatiflorus Pers.	68	25	0	10	1.3	100
H. scaberimus Elt.	68	22	0	20	0	100
H. tuberosus L.	102	0	0	0	0	100
H. macrophyllus Wild	102	0	0	0	0.56	100
H. rigidus (Coss) Desv.	102	0	0	0	0	100
H. subcanescens Gray	102	0	0	0	0	100

Several varieties were developed (42) on the basis of *H. tuberosus* which were resistant to the new population of broomrape, Yubilejnaja-60 being the most prominent among those varieties. Five different genes which bring resistance to the popualtion of *O. cumana* which are presnet in Romania were determined (68). Some of the genes originated from interspecific hybrids.

Breeding for Insect Resistance

Several hundreds of insect species are associated with sunflower. Only a few insect species are economically important as pest to the cultivated sunflower (61). Although host resistance has played a major role in the management of diseases in sunflower (83), there has been little emphasis on resistance as a management tactic for insect pests. *Homeosoma* species are serious pests of cultivated sunflower in four continents. *Homeosoma nebulella* (Hubner) attacks sunflower in Europe and Asia. Sunflower in South America is damaged by *H. heinrichi (Pastrana)*. In Mexico, the U.S. and Canada, *H. electellum* (Hulst) is a major pest nearly everywhere the crop is grown.

Resistance of sunflower varieties to the European sunflower moth (*H. nebulella)* was obtained 40-45 years ago in the USSR by interspecific hybridization of *H. annuus* cultivars with *H. tuberosus var. purpurellus*, Cockerell. The resistance mechanism giving protection against *H. nebulella* is a phytomelanin (armor) layer in the wall of the achenes. This resistance is controlled by a single dominant gene.

The North American sunflower moth, *H. electellum* appears to be more virulent toward cultivated sunflower than *H. nebulella*, and American sunflower breeders have largely discounted the importance of the phytomelanin layer as an effective resistance mechanism.

It was shown (51) that 20% of the larvae *(H. electellum)* were recovered after 5 days on *H. arizonensis*, *H. ciliaris*, *H. decapetalus*, *H. grosseserratus*, *H. maximiliani*, *H.microcephalus*, *H. pumilus*, *H. resinosus*, *H. rigidus x laetiflorus*, *H. silphioides* and *H. smithii* than on hybrid 896. Also, larval growth was more significantly reduced on *H. arezonensis*, *H. ciliaris*, *H. decapetalus*, *H. grosseserratus*, *H. maximiliani*, *H. pumilus*, *H. resinosus*, *H. rigidus x laetiforus*, *H.silphioides* and *H. smithii* than on hybrid 896. Floral injury was significantly lower on *H. arizonensis*, *H. ciliaris*, *H. decapetalus*, *H. divaricatus*, *H. grosseserratus*, *H. maximiliani*, *H. mollis*, *H. nuttallii*, *H. occidentalis* subsp. *Plantagineus*, *H. pumilus*, *H. rigidus x laetiflorus*, *H. silphioides*, *H. smithii* and *H. strumosus* than on hybrid 896.

Two annual and 10 perennial *Helianthus* species were significantly more resistant to the aphid *Masonaphis masoni* (Knowlton), (47,50). These were the other species or the hybrid 896-control (43,46). After 1 month, mortality of *M. masoni* was 100% on *H. carnosus* Small, *H.exilis* Gray, *H. floridanus* Gray ex Champan, and *H. radula* Torrey and Gray.

Adults of the carrot beetle (*Bothynus gibbosus*, Dr. Gear) did significantly more damage to roots of hybrid 896 than to roots of *H. tuberosus*, *H. maximiliani*, *H. niveus*, *H. x laetiflorus*, *H. salicifolius*, *H. mollis*, *H. grosseserratus*, *H. argophyllus* or *H. ciliaris* (47).

Wild sunflowers may successfully be used for the determination of sources of resistance to pests, Tables 5 and 6 (44,45,47). The results indicate some wild species to be resistant to *Zygogramma exclamations*, *Bothynus gibbosus*, *Masonaphis masoni* and *Empoasca abrupta*. *H. tuberosus*

Table 5. Relative resistance of *Helianthus* species, Section *Divaricati* to four species of insects in laboratory feeding tests (45).

Helianthus species	Cross compatible w/annuus	Insect species** *Zigogramma exclamation*	*Bothynus gibbosus*	*Masonaphis masoni*	*Empoasca abrupta*
Angustifolii					
angustifolius	no	++	0	++	+
floridanus	no	+++	0	+++	++
simulans	no	+++	+	++	+
Atrorubentes					
atrorubens L.	no	+++	+	+++	+
carnosus	no	+++	+	+++	+
heterophyllus					
nuttall	no	+++	++	++	
radula	no	+++	+	+++	++
silphioides	no	+++		+	
Divaricati					
divaricatus L.	no	+++	++	+	
molis	no	+++	++	++	+
occidentalis					
occidentalis	no	++	++	++	
occidentalis					
plantagineus	no	+	++		
rigidus + laetiflorus	no	+++	+++		
strumosus	yes	+++			
tuberosus	yes	+++	+	+++	+
Gigantei					
californicus	no	0			
giganteus	yes	0			
grosseserratus	no	+++	++	++	+
maximiliani	yes	+++	++	+	++
nuttallii nuttallii	no	++	++	++	+
risnosus	no	+++	++		
salicifolius	no	+++	++	++	
Microcephali					
glaucophyllus	no		+		
longifolius	no	+++	+++	+	
porteri*	no	+++	++	++	
Hybrid 896 (check)	0	0	0		0

* Annual, all other species are perennial;
** +++ Plants immune to attack or caused 100% mortality to insect;
++ Plants significantly mor resistant than the hybrid check at 1% level;
+ Plants significantly more resistant than the hybrid check at 5% level;
0 Plants no more resistant than the hybrid check.

and *H. maximiliani* displayed the widest spectrum of resistance to the above pests of all wild sunflower which may be crossed with domesticated sunflower.

Utilization of Wild Sunflower Species for Discovering New Sources of Cytoplasmic Male Sterility and Restorer Genes (Rf)

Compared with corn, the practical utilization of heterosis in sunflower started much later because of its bisexual flowers. First CMS hybrids were developed by using interspecific hybridization. The major contribution in this field was the discovery of the first source of cytoplasmic male sterility in a cross of *H. petiolaris* and the domesticated sunflower (29). All sunflower hybrids available have been developed on the basis of this CMS source. More recently another CMS source was discovered coming from *H. lenticularis* (3). A comparative study of these two CMS sources was undertaken and confirmed that those were two separate CMS sources (31).

Having succeeded in discovering CMS sources on the basis of interspecific hybridization, attention was turned to the discovery of Rf genes in wild sunflowers. The existance of restorer genes in *H. petiolaris was reported (30)*. The restorer genes in population of wild *H. annuus*, and *H. petiolaris* were found (10).

Different sources of restorer genes were discussed (70), and restorer lines derived from H. tuberosus were mentioned. H. tuberosus-based restorer lines resistant to downy mildew (pl_2 gene) were developed (64).

Restorer genes were found in wild *H. exilis* and *H. argophyllus (8)*, and in *H. argophyllus*, *H. rigidus* and *H. bolanderi* (54).

The work on the determination of restorer genes in wild sunflower species is in due course in a number of research centers around the world. It may be expected that restorer genes will be found in a large number of wild sunflower.

Table 6. Relative resistance of *Helianthus* species, Section *Annui*, to four species of insects in laboratory feeding tests (45).

Helianthus species*	Insert species***			
	Zigogramma exclamation	*Bothynus gibbosus*	*Masonaphis masoni*	*Empoasca abrupta*
agrestis Pollard	+++0	0	0	
annuus	++	0	0	0
argophyllus	++	+	-	-
bolanderi	+++0	++		
debilis debilis				
nuttall			-	
debilis silvestris	0	+	0	
deserticola Heiser		-		
exilis	+++0	+++	+	
neglectus	++	+	-	+
niveus canescens	+++++	0		
*niveus tephorodes***			++	+
paradoxus	++		-	0
petiolaris fallax Heiser		0	0	
petiolaris petiolaris	++	0	-	
praecox hirsutus	++	0	-	+
praecox praecox			-	
praecox ranyonii		+		
Hybrid 896 (check)	0	0	0	0

* All these species are cross compatible with *annuus* cultivars
** Perennial all other species and subspecies are annuals.
*** +++ Plants immune to attack or cause 100% mortality to insects;
++ Plants significantly more resistant than the hybrid check at 1% level;
+ Plants significantly more resistant than the hybrid check at 5% level;
0 Plants no more resistant than the hybrid check.

A new source of male-sterile cytoplasm in a cross of *H. giganteus* and *H. annuus* was found (77). Crosses between an inbred tester line without genes for pollen fertility restoration as the pollen parent and the existing source of male-sterile cytoplasm or four putative male-sterile backcross lines as the female parents, failed to restore pollen shed in 15 F_1 families evaluated. In similar crosses, using three pollen fertility restorer sources as the pollen parents, pollen shed was restored in male-sterile backcross lines by only one of the three pollen restorer sources, suggesting that the backcross substitution lines from *H. giganteus* are a new source of male-sterile cytoplasm which has been designated as CMS_3.

Another new source of cytoplasmic male sterility from *H. petiolaris* was obtained (80). Crosses between seven sources of pollen fertility restorer and the existing source of CMS, resulted in a high frequency of plants with normal pollen shed in all F_1 progenies. However, no normal pollen shed was evident in F_1 progenies for similar crosses between BC_5 male-steriles and three of the seven restorer sources, nor for the simple wild *H. annuus* evaluated. The foregoing suggests that the backcross substitution lines are a new source of CMS. The inheritance of restoration of pollen shed was complex and not fully elucidated. Some data suggested that two independent, complementary, dominant genes were required, but others indicated two to three independent, dominant genes.

Another source of cytoplasmic male sterility from *H. maximiliani* was obtained (76), while new sources of CMS from *H. petiolaris, H. giganteus* and *H. maximiliani,* as germplasm composite crosses CMG-1, CMG-2, and CMG-3 were registered (78).

Another new source of CMS from cross of *H. annuus* subsp. *lenticularis* and *H. annuus* L. cv. Commander was reported (22). Crosses of the male sterile plants to HA 89, known to be a maintainer of Leclercq's cytoplasmic male sterile sunflower restored pollen production. Crosses with RHA 265, known to be a restorer of Leclercq's CMS sunflower gave an F_1 male sterile plants. In addition to RHA 265, RHA 266 also serves as a maintainer of the line, designated indiana-1. Genes for pollen restoration are found in Hopi, Outlook, Perecovic, P.1. 176576, Record and Seneca, as well as in HA 89 and the original wild type. A suggestion was given for the use of CMS_1 to designate Leclercq's line and CMS_2 and CMS_3 to designate the lines developed by him; accordingly, Indiana-1 may be tentatively designated CMS_4 (77).

The determination of new CMS sources is very important, because all institutions engaged in the development of sunflower hybrids use the same source. There exists a possibility of mutual dependence between sterile cytoplasm and genes carrying susceptibility to a disease. Since all hybrids grown have the same CMS source. The pathogen's population may increase and cause devastating yield reductions. It is therefore a must to intensify the work on the determination of new CMS sources and new sources of restorer genes in wild sunflower species.

Utilization of Wild Sunflowers in Changing the Ideotype of Cultivated Sunflower

The previous chapter discussed the use of wild sunflowers in breeding for resistance to diseases and insects, which are limiting factors in sunflower production. The existing variability within the cultivated sunflower does not allow the development of ideotypes for different agro-ecological conditions. Fortunately, the variability observed in wild sunflowers opens new ways to designing different sunflower ideotypes.

The existing variability within the cultivated sunflower allows the development of inbred lines with insufficient heterotic effect for grain yield. Analyzing results of the long-term FAO trial on sunflower varieties and hybrids, it was noticed that there were no cultivars which would significantly outyield the conventional varieties, e.g., Peredovic. The problem revolves around narrow genetic variability for grain yield in the cultivated sunflower. A breakthrough can be made only by increasing genetic variability of the cultivated forms by means of wild *Helianthus* species.

One of the principal targets in sunflower breeding is a change in the architecture of the photosynthetic apparatus. It is desirable to shorten the period of attaining the maximum leaf area in parent lines and hybrids alike, to prolong leaf area duration (LAD), and to increase the efficiency of net assimilation rate (NAR). It is necessary to optimize the foliar orientation towards the sun, CO_2 uptake from the air, and aeration of the crop by altering the number and position of leaves on the stem. High genetic variability in wild sunflowers warrants the desired changes of the photosynthetic apparatus feasible. If we consider the differences in the photosynthetic apparatus of *H. mollis, H. argophyllus, H. salicifolius, H. radula, H. maximiliani*, etc., we may get an idea of the extent of genetic manipulations with leaf number, form, activity, and other characters.

Sunflower crop spreads rapidly in arid regions. The cultivated sunflower does not ensure profitability of such production in all cases. There are, however, wild sunflowers which grow in extremely dry conditions and which could be used to step up drought resistance in the cultivated sunflower. Drought resistance is a complex character including resistance to soil and air drought. Breeding for drought resistance implies improvements in the efficiency of the root system, architecture of the basic plant parts, time of maturation, resistance to *Sclerotinia bataticola (M. phaseoli)*, water uptake from the soil, and utilization of taken-up nutrients.

Wild sunflower species have recently been included in a number of research programs dealing with the determination of sources of drought resistance in sunflower. The use of *H. argophyllus* in sunflower breeding for drought resistance was recommended (54). *H. argophullus* and *H. deserticola* are also used by Spanish and Romanian breeders as sources of resistance to drought.

Sunflower crop spreads also in saline soils. Wild sunflowers could again be used to increase resistance, to high PH, of the cultivated sunflower. A study conducted presently in the US has indicated *H. paradoxus* as the most resistant to increased salinity. There are several wild sunflower species that still remain to be tested for this character.

It is well-known that a system of self-incompatibility contributes to the high level of cross-pollination in open-pollinated cultivars of sunflower (*H. annuus* L.). It was reported that a sporophytic incompatibility system was present in the cultivated sunflower (19) with the conclusion that at least two multi-allelic loci governed self-incompatibility and expression was influenced by physiological factors. It was concluded that self-incompatibility in the cultivated sunflower is complex in both expression and inheritance (67).

Crosses and reciprocals were made between wild sunflower (*H. annuus* L. and the cultivated line P-21 which is self-compatible and consists of equal numbers of the genotypes *msms* and Msms (34). Results indicated that the self-incompatibility is determined sporophytically, and that at least five different "S" alleles were involved. Dominance of allels was expressed in the pollen and in dependent action in the style.

Taking into account the foregoing results and the fact that sunflower production in a number of countries shifts to stress regions, attempts should be made to reduce self-incompatibility and increase self-compatibility in future sunflower hybrids and varieties by including wild sunflowers in breeding programs.

Several authors indicated that *H. agrestis*, *H. radula* and some other wild species should be used for introducing high degree to self-compatibility in the cultivated sunflower (21).

The cultivated sunflower is an open-pollinated crop and insects, primarily bees, play an important role as pollinators. Wild sunflowers may help in increasing the nectar content and attractiveness of the cultivated sunflower. They may also be used for increasing the resistance of pollen to stress conditions. For the later purpose we may use wild sunflowers from dry regions which are well adapted to a variety of stresses.

Wild sunflower species may also play part in increasing oil and protein contents and qualities in the cultivated sunflower.

It had been reported that *H. niveus* and *H. salicifolius* are potential sources of genetic variability to increase oil content in the cultivated sunflower (65,66). Also, the wild annual species may be the best sources of genes to utilize in a breeding program to alter fatty acid composition of sunflower oil (66). Some entries of both subspecies of *H. petiolaris* appear to be valuable genetic resources to increase linoleic acid content, while lowering oleic. *H. paradoxus*, *H. argophyllus*, *H. annuus* and all subspecies of *H. praecox* appear to be good sources of genetic variability to increase the level of palmitic acid if desired.

A current study conducted in Yugoslavia indicated that *H. anomalus* has the largest achenes and the highest oil content. *H. porteri* has the highest content of linoleic acid and *H. arizonensis*, of oleic acid. A detailed analysis of wild sunflower species revealed significant differences in oil content, oil quality, and higher content of fatty acids among them (51) were found (40). High protein contents in seeds of *H. tuberosus* and *H. macrophyllus* were found (40). These two species should be used in breeding. Several authors have found differences in amino acid composition among wild sunflower species.

Utilization of Wild *Helianthus* Species in Breeding for Whole Plant Utilization of Sunflower

The diversity of wild sunflower species and genetic differences in the composition of their seeds, heads, leaves, stems, rhizomes, and tubers offer chances of improving genetic variability of the cultivated sunflower for a number of characters, turning to better use of all parts of the plant.

Interspecific hybridization allows the transfer of favorable characters for different plant parts from wild into the cultivated sunflower. In that way, sunflower plant would be so improved that the whole plant could be turned into economically profitable products. The sunflower stands chances of being not only an oil and protein crop but a versatile crop used for the production of a line of products. The following concise and incomplete review of the diversity of wild sunflowers regarding their chemical composition gives an insight in the possibilities of enriching the cultivated sunflower by means of interspecific hybridization.

Natural rubber from sunflower

Rubber production from sunflower could be an economic bonus. The residue from the plant extraction might also be a useful commodity, since residues of sunflower plants are ranked near the top for btu value. Thus, a facility for processing rubber from sunflower might also be an ideal site for energy production from biomass.

It was reported that *H. hirsutus* contains natural rubber with a molecular weight of 2.79×10^5 and polydispersity factor (3.1) which indicates a potential as a source of natural rubber (57), while two wild species, *H. agrestis* and *H. occidentalis* contain 1.6% rubber in their foliar parts (58). Also, *H. radula, H.californicus, H. resinosus* and *H. annuus* gave the highest rubber contents by the gravimetric method (1.45-1.93%), (60). This result indicates that there is a high potential for increasing the rubber content of cultivated sunflower on the basis of wild species.

Special carbohydrates

The sunflower may be a promising source of commercial pectin. Several wild sunflower species are promising as sources of commercial pectin.

H. tuberosus and its hybrids with *H. annuus* are used, world wide, as a source of food. The tubers are rich in starch and sugars, and are being investigated as a biomass crop for ethanol production. They also contain insulin, which is converted in the body to fructose, a sugar which is suitable for use by diabetics.

Phytochemicals

Phytochemical studies on *Helianthus* species to date have led to the isolation and characterization of acetylenes, flovonoids, sesqiterpenoids and diterpendoids. Six new sesquiterpene lactones based on the endesmanolide, transgermacradienolide and heliangolide skeletons from *H. grosseserratus* Mortens were reported (23,24). The diterpenes grandifloric, 17-hydroxy-ent-isokaur-15-enic and ciliaric acid and the flavones hispidulin and pectolinarigenin were also found in *H. grosseserratus*. They have also found four known and the new germacradien-olides and one known heliangolide from *H. pumilus*. The isolation of tifruticin, acetylfructicin, deaxytifruticin, acetyldeoxytifruticin and orizabin analogue and three heliangolides from *H. maximiliani* was also reported (23).

Chloroform extract or *H. rigidus* was found to give ciliaris acid and 16-hydroxy-11-kuren-19-oic acid of *H. salicifolius* (25). It was also reported that sesquiterpene lactones and diterpenoids were found in *H. argophyllus* (73). Three germacranolide sesquiterpene lactones, three diterpenoids, and one flavonoid were isolated and characterized from a chloroform extract of *H. argophyllus*.

Two diterpene carboxylic acids, one new kaurenoid deribative and one previously characterized labdane, (-)cis-ozic acid, as well as a known heliengolide, budlein A, and a known flavonoid hymenoxin from extract of *H. angustifolius* were found (35). The new kanrenoid-type carboxylic acid has been isolated from *H. ciliaris* and *H. salicifolius*.

Two diterpenoids were isolated from the wild sunflower species *H. occidentalis (59). H. occidentalis* is resistant to sunflower insect pests and various diterpenoid acid have shown antibiotic activity to several insect species (59). The presence of cis- and trans- ozic acid contributes perhaps to host plant resistance.

Structurally related sesquiterpene lactones from phylogenetically related taxa have been shown to exhibit antimicrobial activity against Gram-positive bacteria.

Livestock feed

In addition to phytochemicals, natural rubber and special carbohydrates, the extracted residue may be utilized as animal feed. Sunflower silage was compared with alfalfa haylage, and found that dairy steers gained as much weight when fed on sunflower silage, as with alfalfa haylage (33). A feed with a protein content of 16% is normally required for dairy cattle feed. Several samples (*H. arizonensis, H. simulans, H. grosseserratus, H. petiolaris,* and *H. neglecuts*) had greater than 16% protein. They should be included in future breeding programs.

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SUNFLOWER BREEDING: GENERAL OBJECTIVES AND RECENT ADVANCES

Jose Fernandez Martinez

Abstract

In many countries, sunflower breeding in terms of generation of cultivars, is movng from public to the private sector. However, sunflower improvement has important limitations, most of which are related to the narrow genetic bases of cultivated materials due to the extensive use of oil-rich germplasm and development of hybrid cultivars.

This problem makes it difficult to achieve important objectives as yield improvement and development of resistance against major pests and diseases. For that reason, there is a need of long-term projects in basic plant breeding aimed at: a) collection, preservation and evaluation of germplasm, b) development of germplasm with special characteristics (drought, disease resistance, new sources of cms, etc.) and c) basic studies in genetic and breeding methods.

Two examples of different approaches of basic breeding research have been described. Enhancing cooperation and exchange of information and breeding material between public institutions will increase the possibilities of quicker results in sunflower breeding and cultivation.

Sunflower is an important plant among the oil crops, Table 1. At present, it ranks third at the world level after soybean and oilpalm. Historically, the improvement of sunflower breeding has made two important leaps with the development of high oil germplasm by Russian researchers, between 1930 and 1960, and in the last twenty years after the discovery, in 1969 of the cytoplasmic male sterility (13) and restorer genes of fertility. Since then, it was possible to develop hybrids taking advantage of heterosis which made possible the increase of yield up to 25% over the open pollinated cultivars. Obviously, yield increases were due in part to improved cultural practices, although the availability of hybrid cultivars has played a major role. Other improvements were made with hybrids, such as disease resistance, tolerance to stress, improvement of self compatibility and adaptation. The high oil content of Russian germplasm has also been increased in the recent cultivars and a great deal of advance has been made in oil quality.

In this presentation, I shall cover mainly major objectives and strategies in sunflower breeding, emphasising on major problems limiting yield as drought, diseases, etc., or specific needs as oil quality. For example, in Europe there are two main sunflower areas with different problems: In the rainfed cropping system of Mediterranean climate, sunflower yield was low (0.5 - 1.5 tons/ha) caused by drought and high temperatures. In France and Eastern Europe, with high precipitation and humidity; sunflower yields are over 2 tons/ha; the main limiting factor being the increasing incidence of diseases.

In the areas covered by IDRC Network (Eastern Africa and South Asia), both situations are present. Therefore, I shall refere to research programs with both types of situations, especially the program of the Research Center in Cordoba, Sapin, the main objective of which is breeding for drought resistance, and to the FAO Sunflower Network which covers a more general spectrum of objectives.

General objectives in sunflower breeding

As in other oil crops, general breeding objectives in sunflwoer breeding can be grouped under:

Table 1. World production (MT) of main oil crops, 1980-87.

	Years							
Oil crop	87/88	96/87	85/66	84/95	83/84	92/83	81/82	80/81
Soybean	15350	14585	14132	13730	13270	13980	13177	13027
Cotton	3120	3253	3558	3864	3116	3064	3234	2969
Peanut	3260	3296	3038	3137	3065	2806	3257	2442
Sunflower	7100	7177	6986	6339	6010	5242	4991	5129
Rapeseed	7070	6609	6267	5783	5065	4960	4486	4106
Coconut	3200	3191	3292	2373	2212	2668	2795	2776
Palm (seed)	1160	1097	1066	912	770	768	673	608
Palm	8410	7912	7728	5512	5853	5594	5535	4711

. High seed yield.
. High oil content and improved oil quality.
. Improved protein quantity and quality of the meal.

As seed yield is influenced by the local environment, most of the efforts of research carried out by agronomists and breeders are directed to improve adaptation as a means of enhancing yield. The following modifications of adjustments are open to:

. Improving seasonal adaptation.
. Developing optimum production practices.
. Tolerance to adverse environmental conditions.
. Protection from pests and diseases.

A strategy to improve seasonal adaptation of sunflower in the Meditranean areas can be achieved extending the growing season by winter planting within the limits imposed by the environmental conditions. This extension of the growing period has been found to increase the total biomass and harvest index, and hence, the seed yield. Yield increases achieved by this strategy has been shown highly significant, Table 2 in winter planting experiments carried out during four years using three commercial varieties which had not been previously selected for these conditions. This improvement is expected to be even higher if genetic adjustments improving the adaptation to winter planting are made, especially selecting for tolerance to low temperatures.

In other environmental conditions where the growing period is limited by low temperatures at planting and harvesting time, genetic adjustments are directed to reduce the period of cultivation by selecting for earliness.

Depending on the environment, the development of optimum production practices related with date of seeding, plant population, etc., has to be taken into account by the breeder to increase yield. For example, if moisture stress is not very severe; higher densities in sunflower can increase yield even under rainfed conditions. Genetic adjustments are neccessary since some genotypes has been found more suitable for high densities (4).

Tolerance to adverse environmental conditions

Adverse environmental conditions as drought, high or low temperature are defects of climate that prevent the realization of potential yield

Table 2. Grain yield (kg/ha) of sunflower planted in winter and spring, 1982-86.

Planting	Year*			
date	1982	1983	1984	1986
15 Dec.	2059+254	2709+488	2357+475	2507+233
15 Feb.	1854+226	2077+331	1832+375	1980+306
15 March	1653+235	1288+144	1574+503	1684+114

*Data indicates the average of the three hybryds ± the calculated standard deviation.

in crops. Spring crops, like sunflower, grown in dry conditions in Meditranean climates are affected by drought and high temperatures which are the main causes of low yields. Breeding for drought resistance is an alternative to increase yields under these environments. Several breeding strategies are open to breeders. Drought escape is a mechanism that has been used in the semi-arid conditions of Southern Spain (11) by developing early hybrids. Earliness continues to be a valuable strategy for sunflower breeding. Another way of escape, in conditions with mild temperatures in winter, is winter planting which also allows earlier flowering when still there are moisture reserves in the soil. This technique, on the other hand, permits the use of longer cycle hybrids with higher accumulation of biomass and seed yield (10).

Other mechanisms of drought tolerance are less understood although there exists genetic variation within sunflower genotypes in the capacity to withstand water stress (3) and some characters have been shown to confer adaptation to drought as root development (2).

Besides adaptative mechanisms, the ratio between yield under dryland and potential yield has been adopted as a measure of resistance to drought. This index is not correlated with yield potential (8) which indicates that the best strategy in breeding for drought tolerance is to incorporate relevant drought tolerance factors to high yielding genotypes.

Other factors as high temperatures are closely associated with drought although differences exist in sunflower genotypes for tolerance to high temperatures. Genetic differences to germination under low temperatures and tolerance to frosts have been also found (9).

Resistance to pests and diseases

Sunflower, native of North America, shows more problems of pests in this area, in Europe and Asia also *Homoesoma* species is a serious pest. In general, losses from pests are less important than diseases.

Diseases are major limiting factors of production in many sunflower countries, especially in those agro-ecological regions with more favorable conditions for higher yields which usually favor most of the important diseases. The main strategy to control diseases in sunflower, as in other crops, is genetic resistance which is a major feature in breeding programs. The cultivated sunflower has a narrow genetic base and it is deficient in resistance genes for pests and diseases. Most of the sources of resistance have been found in wild species. Resistance to European moth (*Homeosoma nebulella*) was found in Russia in the 40's by interspecific hybridization of cultivated sunflower with *H. tuberosus*. Wild species seem to be also a good source of resistance to pests in North America. In relation to diseases, wild species have rendered major genes of resistance to *Plasmopara helianthi*, *Puccinia helianthi*, *Verticillium albo-atrum*, *V. dahliae* and *Orobanche Kumana* (7). There are still a large number of important and destructive diseses, as *Sclerotinia sclerotiorum*, *Phomopsis/Diaporthe helianthi*, *Macrophomina phaseoli*. Phoma spp., *Alternaria helianthi*, *Botritis cinerca*, Rizopus spp. etc., for which there are no good sources of resistance. Wild species offer possibilities to discover sources of resistance for these diseases and for new races of diseases with known resistance. The FAO subnetwork in wild species maintain a working group to evaluate them for disease resistance.

Oil content and oil quality

In oil crops, an obvious way of increasing oil yield per hectare is increasing oil content. In sunflower, this can be achieved by reducing the amount of hull and raising the oil content of the embryo. Most of the progress made in the past by the Russian workers was achieved by reducing the proportion of hull from 41% to 20%, although oil content of the embryo was also increased. It permitted to increase the oil from 32% to 50%. The progress in selection after using high oil germplasm in crossing programs is rapid because of the high heritability of this character. Although, it is biologically possible to raise the oil content of cultivars by selection to very high limits, it may not be suitable from technological point of view because of the exccessive reduction in hull.

In relation to oil quality, high oleic mutants were obtained by mutagenesis (17) and the studies of inheritance revealed that the high oleic character was controlled by several dominant genes (5,14). The introduction of the character is very easily made by backcrossing (5) and high oleic hybrids have been obtained elsewhere.

Increasing protein quantity

The selection of high protein in the embryo maintaining low hull content has permitted the release of lines with about 35% protein, but decreasing the oil to 35%, compared to the normal values of 20% and 50%, respectively (12). This could open a new type of sunflower with high protein.

Breeding Strategies

The strategies used to achieve the breeding objectives in sunflower are not unique although depending on the approaches of the breeding programs some strategies have to be emphasized. The following points should be considered in relation to breeding strategies:

- Germplasm collection and evaluation.
- Hybrid cultivars as open pollinated varieties.
- Population management.
- Use of mutagens.
- Use of wide crosses.

Germplasm collection and evaluation

In sunflower breeding programs, the extensive use of germplasm with high oil content directly or to develop inbred lines to make hybrids, has narrowed the genetic base of populations. Many local populations which decreased the possibility of improving seed yield were replaced. However, sunflower is rich in variability. The genus *Helianthus* has about fifty species being found in Canada, United States and Northern Mexico, and the remaining 17 are limited to South America (15). In countries where modern high oil cultivars have not yet been introduced widely, land races with low oil content still remain. It is imperative that this germplasm and related wild species be collected and preserved. Since 1984, the IBPGR and FAO have been assembling important collections of cultivated and wild species.

Hybrid cultivars vs open pollinated varieties

The discovery of cytoplasmic male sterility provided the basis for hybrid cultivars in sunflower with a capacity to provide much of the production in Europe, USA and almost elsewhere. However, open pollinated cultivars may be of interest to some countries. There is scarce activity in breeding for open pollinated cultivars. Some research institutions have recurrent selection programs for population improvement. Although, the main objective of these programs is to extract inbred lines from improved populations some of them could be used as open pollinated cultivars. However, these populations have the inconveniency of being self-compatible because, most of the material used to form them were selected for self-compatibility. Other recently released popualtions, improved for drought tolerace in Cordoba (6) were derived from old Russian open pollinated cultivars, and could be of interest for programs interested.

Population management

The immediate objective of a breeding program is either to release a variety for production or to develop improved germplasm used to extract inbred lines for hybrid development. Recurrent selction methods used in sunflower in many breeding programs are the same as those used in corn. Improvements for one cycle selection are built depend upon in subsequent cycles of hybridization and selection. Recurrent selection has been successfully used in Cordoba to increase oil content in early material. In three cycles of selection, oil content was increased from 42.3 to 47.9% in a maintainer populaiton and from 43.3 to 48.5% in a restorer population (1). Two cycles of reciprocal recurrent selection for drought resistance increased the yield of hybrids derived from improved populations in 11% compared with the ones derived from original populations.

Use of mutagens

When the natural sources of genetic variation are not sufficient to meet a given objective, mutagenesis may come into consideration. Some valuable mutants have been produced in sunflower using irradiation and chemical mutagens. The most relevant for its extensive use in breeding programs has been the high-oleic mutant controlled by dominant genes obtained in Russia (17). Hybrids with oleic levels of higher than 90% are being grown in Europe and USA. Mutation breeding has produced other useful mutations as early ripening and short stature (7).

Use of wide crosses

Many desirable traits are found in the wild species of the genus *Helianthus* especially resistance to pests/deseases, drought and salinity (16). More than eight new sources of male sterility have been also found in the wild species (16) in addition to the *Petiolaris* source actually used in the commercial production of hybrids.

A great activity in the field has been carried out by the genetics and breeding subnetwork on colletion and evaluation of *Helianthus* wild species of and ther use in breeding programs within the FAO sunflower network. Specific working groups within this subnetwork study the cytogenetics of wild species and interspecific hybrids and the evaluation for pests, diseases, drought and biochemcial characters. Another working group deals with the use of biotechnology in interspecific hybridization.

Research Approches in Spain and FAO Sunflower Network

The biggest effort in sunflower breeding in Spain in terms of generation of cultivars is carried out by the private seed companies which commercialize either cultivars released by public institutions or developed in their own breeding programs and provide the seed to the farmers.

In the public sector, with a declining involvement in cultivar development, emphasis is given to basic plant breeding directed to germplasm collection, evaluation and preservation, development of basic germplasm with special characteristics (drought, pest and disease resistance, changed fatty acid composition, development of new cms sources, etc., as well as the use of breeding methods and strategies. A conventional breeding program aimed at the release of inbred lines with the characteristics mentioned is maintained. These lines are transferred to the private sector. The sunflower cultivation in Spain (one million ha) is characterized by low yield caused mainly by drought. So, the main effort of public sunflower breeding research is the development of drought resistant populations to be used in the development of drought resistant hybrid cultivars.

The program is based on a multi-disciplinary approach using a recurrent selection as the main frame for breeding base populations for improved yield potential and drought resistance. Winter planting is a strategy for increasing yield, while avoiding drought is taken into account as a selection criteria for improving adaptation. An important physiological component is included leading to the identification and screening for specific adaptive characters to drought, which is incorporated to improved populations. Biotechnologies are used to identify and accelerate the intermediate breeding processes. The released improved germplasm and the obtained information may be of interest for sunflower growing areas of some IDRC network countries under arid conditions.

The FAO Sunflower Network was established in October, 1975 within the framework of FAO, European Regional Programs, and important number of institutions from developing countries joined the multilateral cooperation. The main purpose of the research network is to undertake joint applied research in sunflower with division of tasks and adequate methodology. An additional task is to undertake an exchange of experience, information and germplasm among participating institutions.

Research subnetworks have changed since 1975, although with different approaches. The topics of diseases and their control, plant physiology, breeding/genetics and experimentation of cultivars have been maintained. In the last consultation in Szeged (Hungary) four subnetworks were established:

1. Experimentation of cultivars.
2. Sunflower genetics and breeding.
3. Sunflower diseases.
4. Ecophysiology of sunflower production.

Each sub-network has several working groups.

In the last consultation this year in Istanbul, it was decided to give more emphasis to the sunflower genetics and breeding subnetwork. This subnetwork comprises five working groups, whose main general objectives are genetic studies of important agronomic, physiological, and biochemical traits as self incompatibility, drought tolerance, fatty acid composition and evaluation of wild species for morphological and agronomic characters, and for resistance to diseases. This wide array of objectives directed to different situations and problems should be applicable to research problems and production of IDRC network countries.

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PROGRESS IN SUNFLOWER RESEARCH IN ETHIOPIA

Hiruy Belayneh

Abstract

Sunflower is a non-traditional oil crop which seems to be adapted in Ethiopia from below 800 to over 2400 m.a.s.l. Fairly large tracts of this crop have been grown in recent years in three state farms. Out of the three late maturing varieties recommended for commercial production, only "Russian Black" is under production at present time. Two short and early maturing types are considered for release in the near future. The cultural practices and crop protection measures have been perfected and made available to users. Future trends of sunflower production are described.

Sunflower has become the third most important annual oil crop in the world due in large part to the efforts of plant breeders in improving seed yield, seed oil content and the adaptability of the crop to a wide range of climatic conditions. The crop seems to be adapted in Ethiopia from below 800 to 2400 m.a.s.l. At present, it is the most important oleaginous crop in Awassa (southern) region. It is also showing a sign of positive trend in growth rate of productivity in Beles and Dedessa (north-west) state farms.

Though the crop has the potential to become an important crop in some parts of Ethiopia, the breeding programme which is undermanned in high calibre staff is struggling to survive. As a result, the sunflower group failed to show as much progress as the other highland and lowland oil crops groups. It is the purpose of this paper to give a brief account of the research results obtained and the future production trends on this crop.

Variety development

In Ethiopia, improvement of sunflower started in the late 1960's. At present time, three varieties (Russian Back, Hesa and Pop-158) are recommended for general cultivation at national level. These varieties are tall, late maturing types which often run out of moisture or are damaged by frost before they mature.

In recent years, efforts have been made to select early and intermediate varieties. From the mass and recurrent selection program, two early synthetics (Synth-NSH-2 and Synth-NSH-25) have been identified as better performing varieties and advanced to verification trial for release. Two other intermediate types (Argentario and improved Russian Black) are also candidates for release in 1989/90.

Agronomy

At several sites, the best time of sowing, plant density, weed control measures, etc., have been identified. The time of sowing varied in different regions depending on variety, availability of moisture and temperature. In sowing date trials conducted at Awassa, the highest yields from early, medium and late cultivars were obtained when sown in June than in July or August. The June sowing reduced the incidence of downy mildew resulting in better yield.

The studies on plant density have shown that 44,000-53,000 plants/ha i.e. 75 x 25 cm spacing, was optimum for long cycle cultivars. On the other hand, the highest seed yields with short cycle cultivars were obtained at population densities of 53,000 - 88,000 plants/ha i.e. 60 - 75 X 25 cm.

The national variety trials (NVT) and extension yield trials (EYT) were conducted both with and without fertilizer. Higher response to fertilizer was obtained at Tefki (central) and Woldya (north-eastern). Most of the trials showed little or no response to nitrogen and phosphorous fertilizers, Table 1. In the fertilizer trials conducted at Awassa, response of Herero and Sheneka to added nutrients was also not large.

Crop protection

Two hand weedings, with more emphasis at seedling stage, were found to be optimum. Two herbicides, namely, Alachlor at 5 kg pro/ha and Pendimethalin at 3 kg pro/ha were tested for their efficiacy as well as appropriacy under large-scale conditions at Awassa. Both herbicides gave good control of weeds in sunflower and are recommended for release.

Downy mildew, stem and head rot, rust and leaf blight are the most prevalent diseases of sunflower in Ethiopia. A part of the local collections and introductions has been screened for downy mildew resistance on a developed sick plot and some of the introductions appeared to possess high levels of resistance. However, the disease incidence at Awassa was low in 1988 and failed to provide a good base for further screening. Metalaxyl at the rate of 2.19 ai/kg seed was found effective in controlling downy mildew.

African bollworm is the most serious insect pest of sunflower in Ethiopia. In 1987 and 1988, a range of varieties have been screened for their resistance to this insect pest. The variety, "Eliodoro" showed tolerance to this pest.

Future trends

Sunflower research in Ethiopia has been limited, primarily due to the lack of trained manpower compared to

Table 1. Summary of seed yield (kg/ha) of sunflower varieties in the national and extension trial grown at 24 sites in 5 Agricultural Developmnet Zones (ADZ) with 41/46 kg/ha N/P_2O_5 (F_1) and with out fertilizer (F_0) 1982-1985 crop season.

		Mean seed yield in kg/ha		
(ADZ)	Site	F_0	F_1	Mean
Central	Debre Zeit (3)*	1868	1779	1824
	Tefki (4)	1710	2210	1960
	Tedelle (4)	1605	1531	1568
	Shashemene (1)	2331	2569	2450
	Mean	1879	2022	1951
Southeastern	Kulumsa (4)	1835	2222	2029
	Herero (3)	1428	1432	1430
	Sheneka (3)	764	1010	887
	Robe (2)	1275	1348	1312
	Sinanna (1)	3198	3552	3375
	Harawa (1)	2327	2447	2389
	Assasa (2)	810	1003	907
	Mean	1662	1859	1761
Northwestern	Mota (4)	2992	3278	3135
	Burie (4)	2308	2291	2300
	Upper Birr (3)	2572	2933	2753
	Mean	2624	2834	2729
Northeastern	Harbu (3)	2729	2412	1571
	Woldya (2)	1796	2248	2022
	Mean	2263	2330	2297
Western	Bako (4)	1544	1759	1652
	Jimma (3)	1928	2069	1999
	Hurumu (1)	2124	2438	2281
	Anger Gutin (2)	1365	1078	1222
	Assosa (3)	1451	1451	1451
	Dedesa Dimutu (4)	1570	1554	1562
	Mean	1664	1725	1695
Eastern	Wacho (2)	3462	3899	3681
	Melka Werer (3)	3035	-	3035
	Mean	3249	-	3358
Southern	Awassa (3)	2119	1996	2058

* Number of trials.

the staff position in the other important oilseeds research programs. It is hoped that the future manpower situation would improve and help as a means for increasing sunflower production in the shortest time possible.

Sunflower did not find its way into

the traditional agriculture of Ethiopia. On the other hand, there are state farms where agriculture is practiced in an extensive scale and there is a need for oil crops suited to large-scale production such as sunflower and rapeseed. The multi-locational trials have indicated that sunflower has very high potential in different agro-ecological zones, Tables 1, 2 & 3. Therefore, areas under this crop are expected to increase in different zones, provided that varieties suited for mechanization as well as for traditional farming practices are available. In fact, sunflower production has been increasing in three of the state farms (Awassa, Beles and Dedessa) over the past three years. It could be stated that the future research efforts and the national agricultural development goals will help to increase sunflower production and alleviate the shortage of edible oil in the country.

Table 2. Crop-environment characteristics at sunflower trial sites.

Agricultural Development Zone	Site	Days to maturity	Altitude (m)	Rainfall (mm)	Mean temp. °C Min.	Mean temp. °C Max.	Soil Analysis pH in H_2O	Soil Analysis N (%)	Soil Analysis P_2O_5 (ppm)
Central	Tefki	169	2050	655	9.3	23.7	6.6	0.40	20.9
	Shashemene		2020	-	-	-	-	-	-
	Debre Zeit		1900	598	9.3	24.9	6.8	0.13	64.5
South eastern	Robe		2480	482	6.7	21.0	5.6	0.16	27.5
	Sinana		2400						
	Herero		2390	430			6.3		
	Sheneka		2350	397			7.0	0.13	14.9
	Assasa		2300				6.0	0.19	42.4
	Kulumsa		2200	527	10.2	22.1	5.8	0.16	48.7
	Harawa	153	2000						
North western	Mota		2400	1100	9.6	23.6	4.9	0.16	6.5
	Burie		2150	845	-	-	5.4	0.19	10.7
	Upper Birr		1690				5.1	0.21	18.5
North eastern	Woldya		1720	707	9.3	25.6	6.5	0.09	7.5
	Harbu		1542				7.4	0.13	V.high
Western	Hurumu		1840						
	Jima		1750	1000	11.3	25.4	5.3	0.16	7.7
	Bako		1650	922	12.2	25.8	6.6	0.15	5.0
	Assosa	142	1550	935	14.9	25.9	5.9	0.34	?
	Anger Cutin		1400						
	Didessa Dimutu		1280	1216	14.9	29.3	4.9	0.19	46.1
Eastern	Wacho		1750						
	Melka Werer		750	269	18.4	34.2	8.0	0.09	20.0
Southern	Awassa		1700	617	11.6	25.4	6.0	0.21	103.9

Table 3. Crop environmental requirements for sunflower.

	Range of Suitability			
	Highly Suitable	Moderately Suitable	Marginal	Sensitivity to Hazard
Altitude	1300-2400 & 2400-2600	750-1300 & 2600-2800	0-750	
Min. temp. for growing period (°C)	10.5-18.0	6.5-10.5 & 18.0-20.0		
Max. temp. for growing period (°C)	22.5-32.0	18.5-22.5 & 32.0-34.0		
Mean temp. for growing period (°C)	16.5-25.0	12.5-16.5 & 25.0-27.0	27-30	
Length of growing periods (days)	130-169	100-130	80-100	
Rainfall during growing period (mm)	500-750	400-500 & 750-1200		Sensitive to water logging and fairly drought tolerant.
Soil Type	clay loam			
• Texture	medium			
• Colour	brown, red			
• pH	6.0-7.3	5.5-6.0 & 7.3-8.0		

SUNFLOWER ADAPTATION IN MOROCCO

S. Quattar, T.E. Ameziane and A.Baidada

In Morocco, oilcrops are important sources of humanfood and animal feed. The main oil crops that are currently cultivated on more than 160,000 ha, include sunflower, rape seed, safflower, groundnuts, cotton and soybean.

Soybean was introduced in 1981 and is grown under irrigation. The cotton seed, mainly grown for fibre, is also used in oil seed industry. The other crops are cultivated under rainfed conditions where annual rainfall ranges between 300 and 600 mm.

Sunflower is one of the main oil crops and is undergoing tremendous development. In 1988, 110,000 ha were planted to sunflower by small and large scale farmers, using both traditional and modern cultural practices. Yields obtained were generally low and variable, due to socio-economic, environmental and management constraints (5). Adequate research is also lacking. In the first and second parts of this paper, we will discuss some of these issues, taking sunflower as a case study, and ways of adjusting the crop to its environment, using simulation models.

Materials and Methods

In part one, the success of sunflower was analyzed using field data and statistics. In part two, as water deficit is the main limiting factor to sunflower crop production, we have used the modelling approach to address the problem of crop adaptation to drought prone environments.

The modelling approach was carried out based on the principles developed earlier by different scientists (8,9,2,7,4), also as described elsewhere (10,6). We have developed a model to simulate the effects of contrasting crop management strategies on the crop water deficit. Three sowing dates and three genotypes differing in maturity period were then tested. The Genotypes had 1300, 1600, and 1900 growing degree days (GDD) from sowing to physiological maturity. Date of sowing was 20 November for the autumn planting, 20 February and 20 March for spring plantings. The latter sowing date is most commonly used by farmers.

Results and Discussion

Part one : Success and limitations of sunflower production in Morocco

Sunflower is grown mostly in the North Western part of the country where it was introduced in the sixties. The development of the crop acreage shows two distinct periods, Fig. 1. From 1960 to 1980, the total area devoted to sunflower (2000-40,000 ha) remained fairly low and highly variable. After 1980, the acreage dramatically increased to reach the current level. It is projected that some 300,000 ha will be planted to sunflower in the next 10 years. Seed yields basically followed a similar pattern.

The recent success of sunflower is explained by a shift in the role and function it has in the cropping systems. The crop evolved from an insurance crop to a cash crop. Up to 1980, the observed erratic variability in acreage is related to the extent of failures in winter crop. The sunflower crop is then planted in spring to insure a minimum income. After 1980, sunflower became a cash crop, as a result of changes in government policies and farmer's attitude. Policy changes included loans to sunflower producers for input acquisition, reasonable prices and guaranted public market, Fig. 2. In spite of these progresses, environmental constraints and poor management practices still limit production.

Part two: Crop adaptation to environment

Sunflower is grown under rainfed conditions in the North Western region. The climatic conditions including rainfall (P), evapotranspiration (ETP) and water deficit, (P-ETP) of this area are shown in Figures 3. The data in Figure 6 represent a typical Mediterranean climate having a rainy winter season with low ETP followed by a spring period with a rapid increase in ETP and a decrease in P. Since sunflower is traditionally planted in spring, most of its cycle is out of the rainy season. Therefore, sunflower usually suffers from severe water stress conditions as the season progresses towards crop maturity. The following simulations illustrate the environmental constraints to sunflower production and the possibilities that agronomists and breeders may have to adjust the crop to its environment.

1. Analysis of sowing date effects

The effects of early, intermediate and late plantings on crop water use are shown in Fig. 4. The results indicate that the severity of water deficit increased as the planting date was delayed. Actual water deficit reached a maximum of 10, 55 and 70 mm per decade for early, intermediate and late sowings, respectively, Fig. 4a. The corresponding cumulative water deficit followed a similar pattern and was 40, 200 and 240 mm, Fig. 4b. For the early sowing, the crop water deficit index never exceeded 40%, i.e. at least 60% of the crop water requirements were met at any given time during the growing season, Fig. 4c. By contrast, for the intermediate and late sowings, the crop water deficit indices were above 40% during most parts of the growing season. This severe water deficit could be detrimental to seed formation and yield.

This became evident by exploring the research work executed with 23 genotypes to compare autumn and spring plantings, Fig. 5. The results clearly indicated that matching the crop cycle with the rainy season by early planting increased yield by 33%. Further, comparing the four water regimes to a rainfed control, as means of correcting the effect of late water deficits, the seed yield was greatly increased by irrigating the crop at various growth stages, particularly at late flowering, Table 1. In addition, a single irrigation applied at flowering stage yielded as much as the fully irrigated crop which produced 2.8 against 1.4 tons/ha for the rainfed control.

Similarly, three genotypes of rapeseed were compared at five planting dates. As a result, early sowing yielded 3.2 against 0.4 tons/ha with delayed sowing, Fig. 6. Therefore, choosing the appropriate sowing date, is critical to fit as much as possible the crop to a favourable environment. This is also a key factor to improve crop yields without increasing the levels of inputs.

2. Analysis of genotype effects

The model was also used to test the effects of three genotypes differing in maturity, with autumn and spring plantings. For autumn sowing, early and intermediate genotypes were able to grow under favorable conditions. In contrast, the late genotypes experienced increasing water deficit as the season progressed. This is illustrated by the data in Fig. 7. For spring planting, all genotypes were exposed to water deficit, but early maturing cultivar was least affected, Fig. 8.

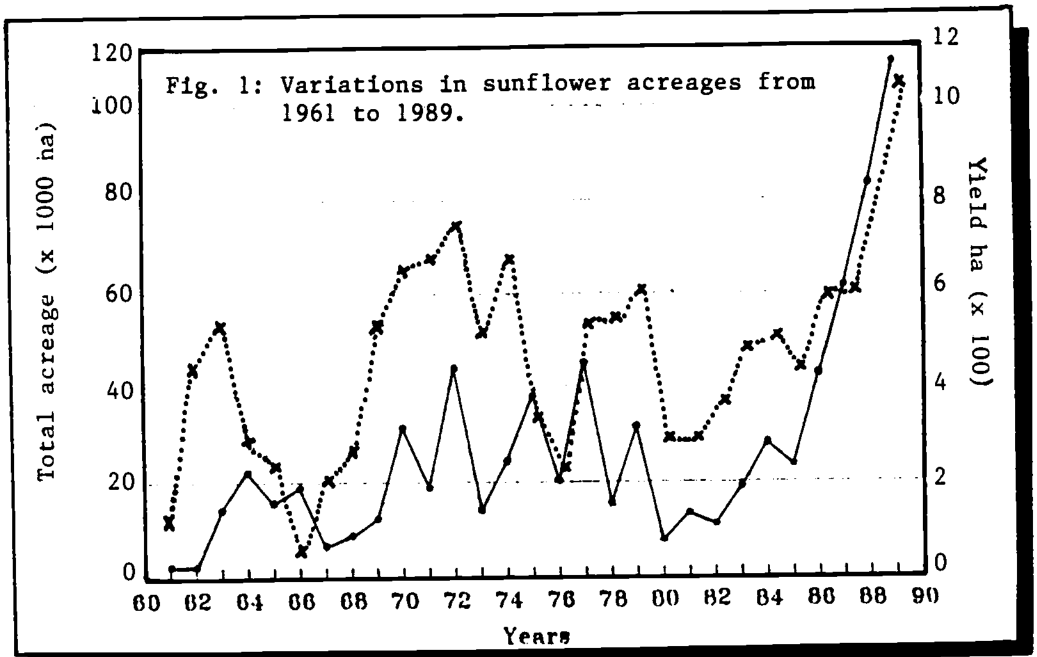

Fig. 1: Variations in sunflower acreages from 1961 to 1989.

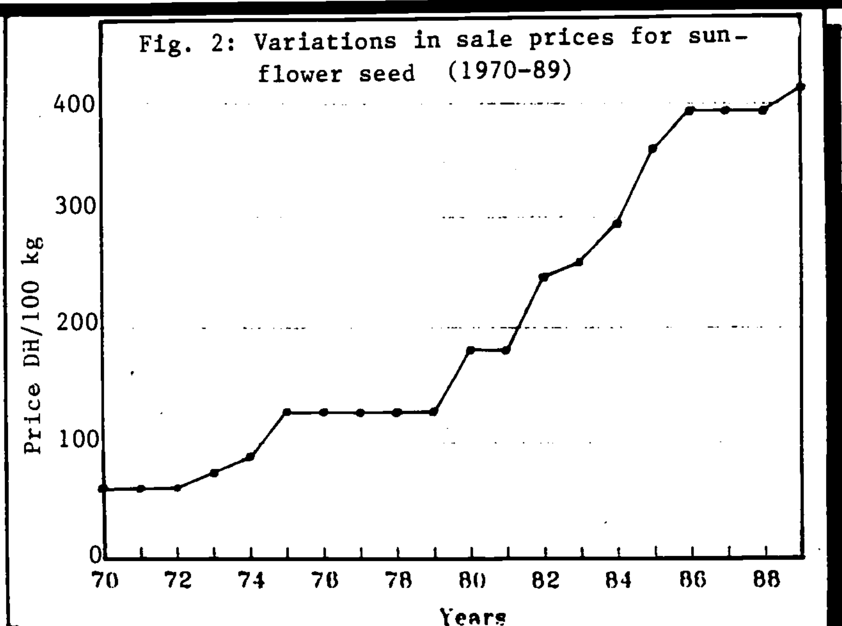

Fig. 2: Variations in sale prices for sunflower seed (1970-89)

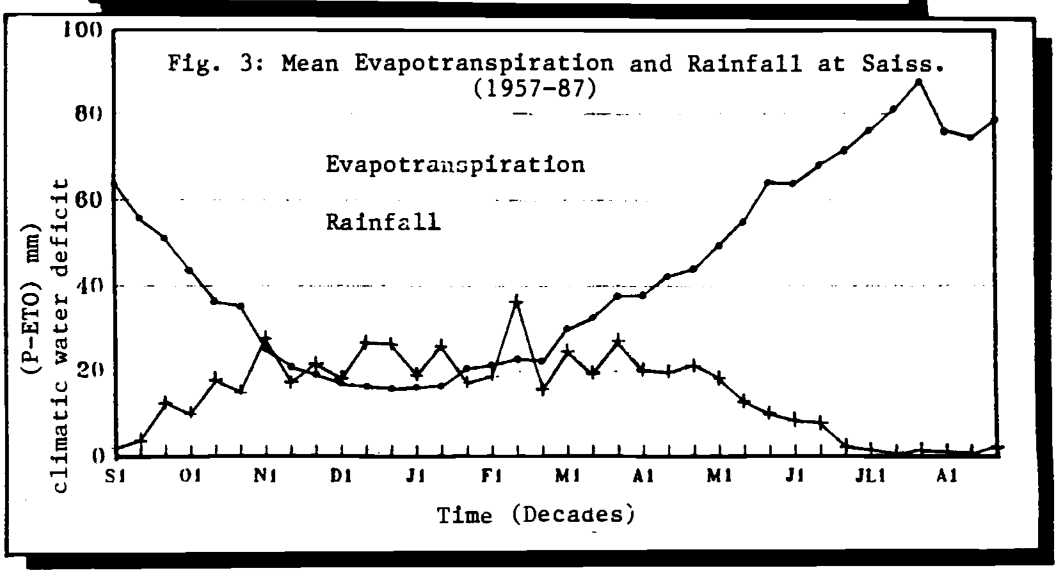

Fig. 3: Mean Evapotranspiration and Rainfall at Saiss. (1957-87)

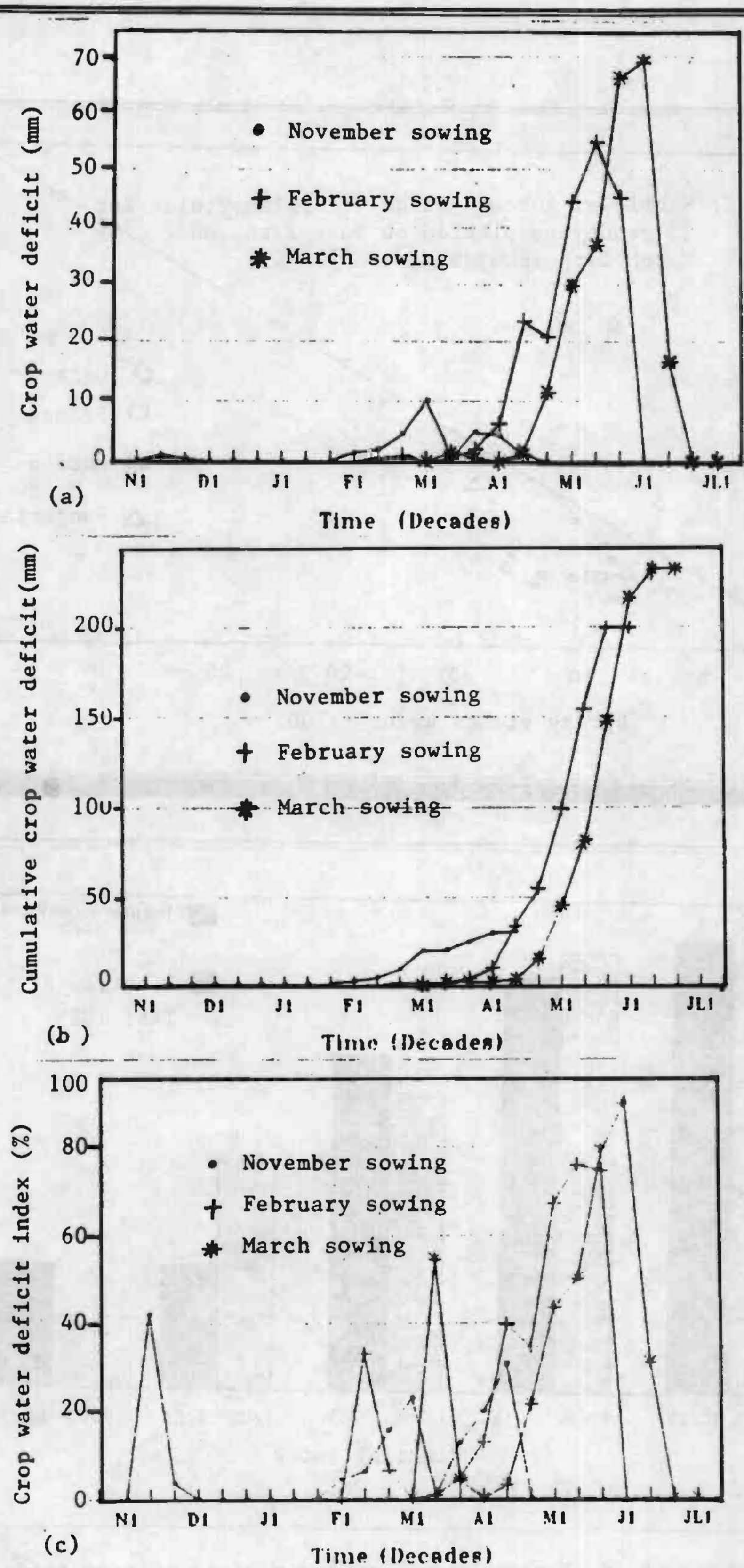

Fig. 4: Effect of three sowing dates on the simulated crop water deficit, cumulative and index during the growing season for three genotypes differing in maturity. Saiss(1957-87)

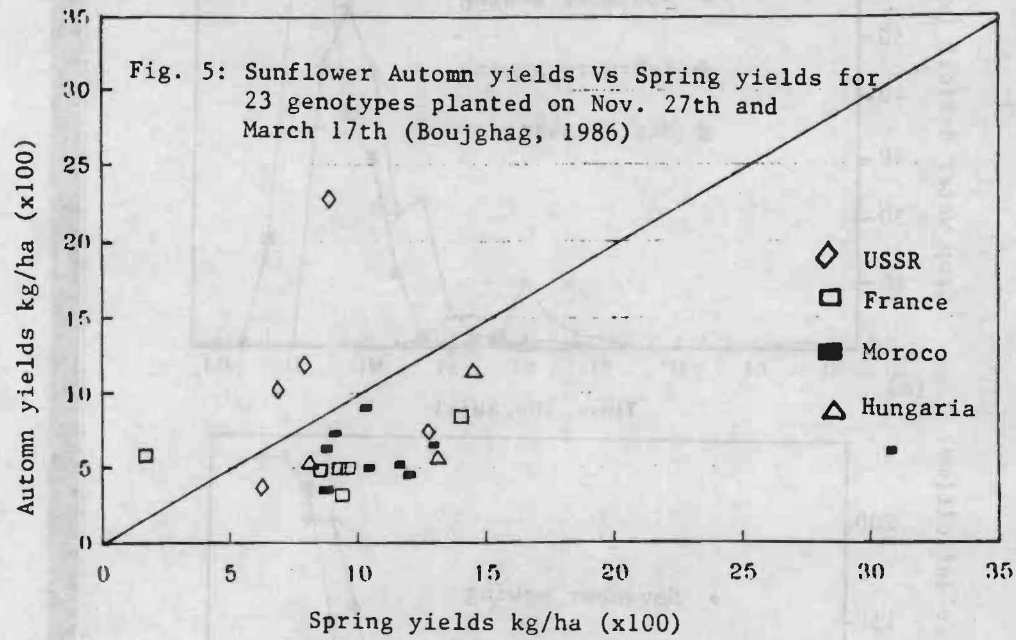

Fig. 5: Sunflower Automn yields Vs Spring yields for 23 genotypes planted on Nov. 27th and March 17th (Boujghag, 1986)

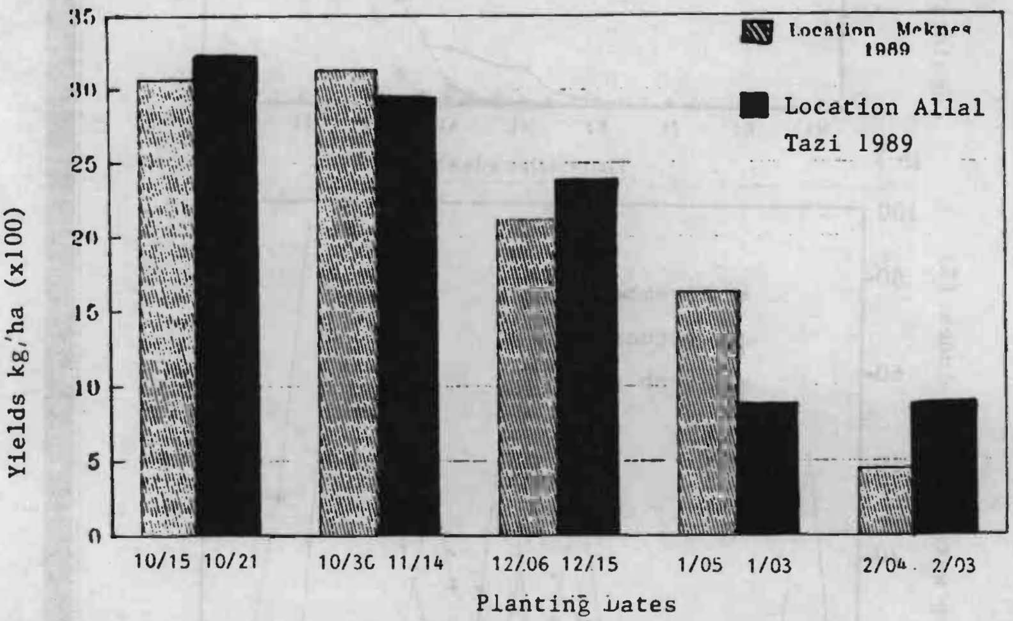

Fig. 6: Effects of planting dates on grain yield of rape seed (mean of 3 genotypes) planted at Meknes location. (Fezzaz, 1989)

Table 1. Effects of four water regimes on sunflower biomass production, seed yield and water use in the Gharb, 1989.

Water regimes	Crop yield (tons/ha)		Water use
	Biomass	Grain	(mm)
1. Rainfed control	47.13c*	13.68b	237.00c
2. Fully irrigated (4 applications)	95.70a*	28.13a	440.90a
3. One irrigation at early bud	65.84b	17.88b	354.90b
4. One irrigation at early flowering	82.58a	29.40a	330.23b
5. One irrigation at late flowering	64.21b	20.05b	339.62bc

* Values in a column not followed by the same letter are significantly different at 5% level.

These results suggest that with an autumn planting, the intermediate genotype (1600 GDD) is preferable to the early and late ones. It offers higher yield potential (longer cycle) and experiences an acceptable level of water deficit. However, the early maturing cultivar should be preferred in the case of spring sowing.

Conclusion

Based on these preliminary results, it is important to match the crop to its environment through breeding and adequate crop management. Such strategy is more effective in improving crop production, while keeping inputs at reasonable levels. The modelling approach is useful to identify environmental constraints and to define ways of cropping with them. Further model testing using the experimental data is in progress.

Acknowledgement

The authors wish to thank Dr. Eglal Rached, and Dr. Abbas O. Omran, IDRC, for their invitation to attend this meeting.

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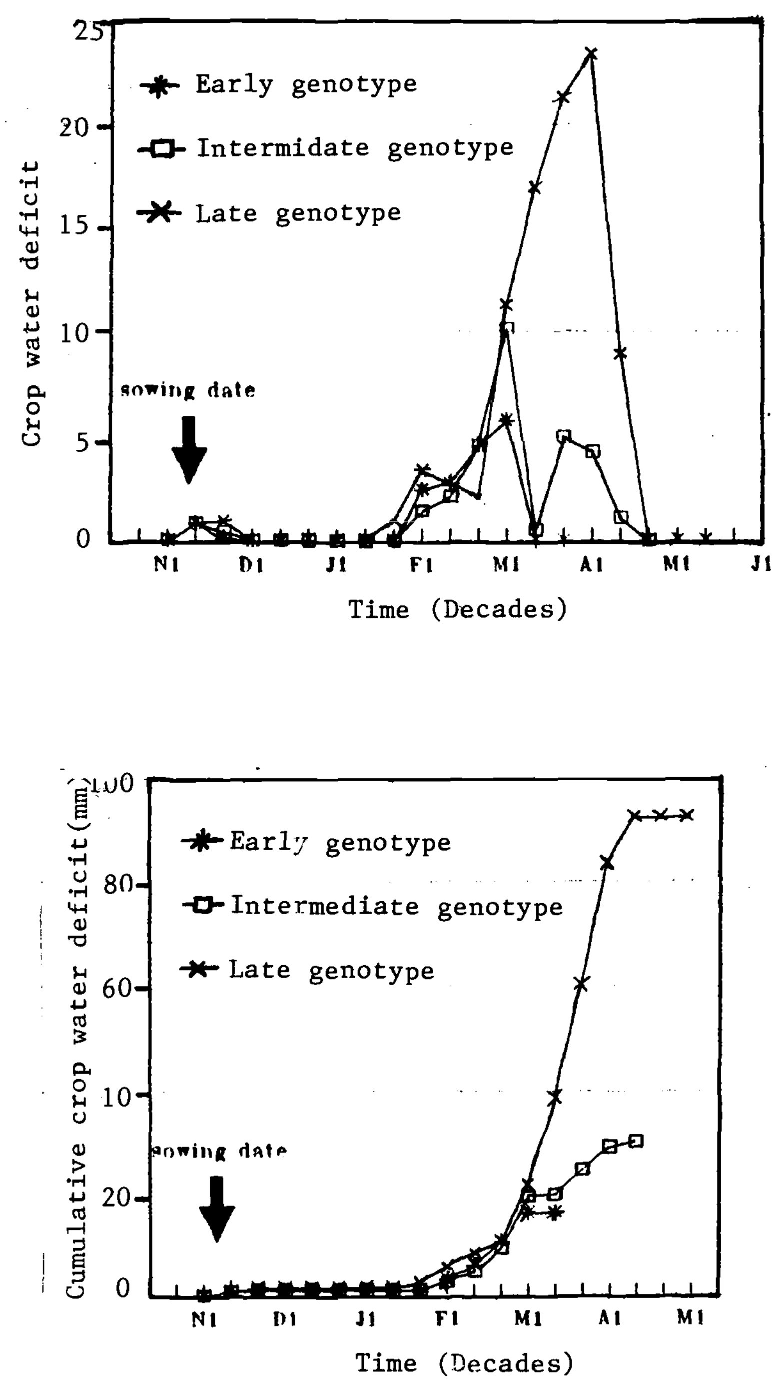
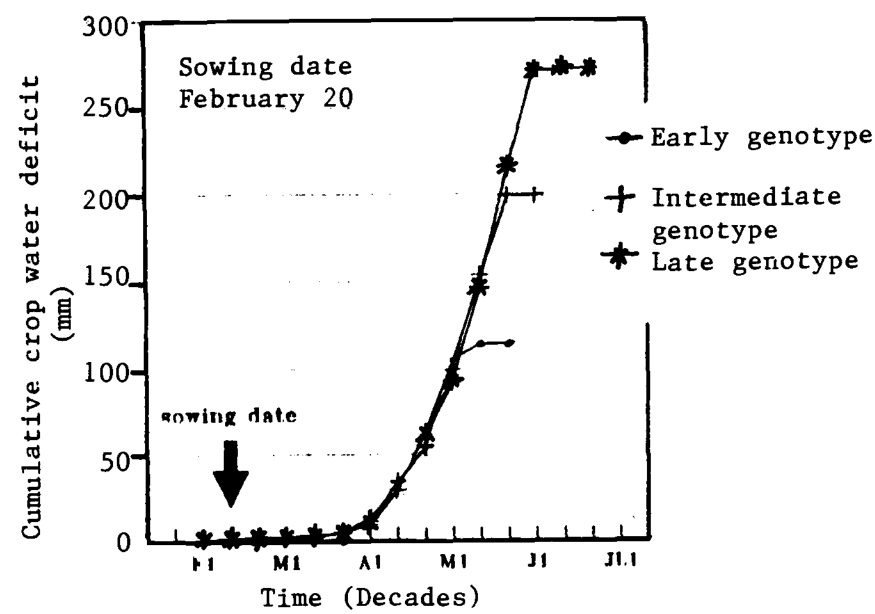


Fig. 7: Effect of Sunflower genotype on the variations of Simulated Crop Water Deficit during the growing season. November planting at Saiss. (1957-87)



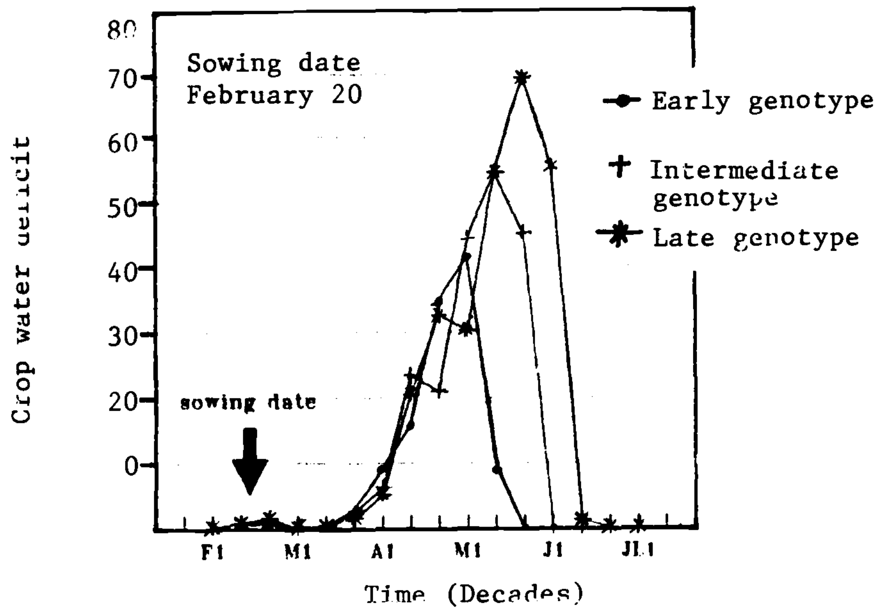


Fig. 8: Effect of Sunflower genotype on the variations of simulated crop water deficit during the growing season. February planting at Saiss. (1957-87)

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 Shafiullah

Abstract

The effect of stages of maturity and desiccant applications on the sunflower (***Helianthus annuus*** **L.**) seed yield, oil content and oil quality were studied during 1988 and 1989. Stages of maturity were maintained by five dates of harvest with 5 days interval at 25, 30, 35, 40 and 45 days after flower completion (DFC). Four desiccant treatments (Paraquat at 0.50 kg ai/ha; Paraquat at 0.25 kg ai/ha + Agral-90 at 0.02 v/v) and one control treatment (without desiccant) were studied. The desiccants were applied seven days before each date of harvest.

By delaying harvest from 25 to 35 DFC the seed yield increased significantly from 1980 to 2391 kg/ha, and from 2629 to 3279 kg/ha in 1988 and 1989, respectively. No significant increase in seed yield was obtained after 35 DFC in both years. 100-seed weight increased significantly from 25 to 40 DFC in 1988, and from 25 to 30 DFC in 1989. Between 25 and 45 DFC the seed moisture reduction was 38. 1% (51.2 to 13.1%) in 1988, and 34.8% (43.1 to 8.3%) in 1989. The seed oil content significantly increased from 36.5% to 41.1% between 25 and 40 DFC in 1988, and from 43.8 to 49.0% between 25 to 45 DFC in 1989. Oleic acid contents reduced significantly from 56.9 to 49.1% in 1988 but no significant change was observed during the same period in 1989. In 1988, linoleic acid contents increased significantly from 35.0% to 43.3% between 25 and 35 DFC, and in 1989 from 41.2 to 45.0% between 30 and 45 DFC.

The effect of desiccant treatments on seed yield and other characters were not very pronounced. In 1988, Paraquat at 0.5 kg ai/ha with Surfactant increased the seed yield by 103 kg/ha over the control which was 2283 kg/ha. Fomesafen, in 1988, at 1.0 kg/ha increased 100-seed weight significantly and reduced the seed moisture content, but the reductions were not much. Paraquat at higher dose reduced the oil contents during both years over the control. In 1989, Paraquat at both concentrations reduced the oleic acid by 4.5-5.0% and increased the linoleic acid by 4.4-4.5%.

Key words: Sunflower, *Helianthus annuus*, maturity stages, date of harvest, desiccant application, oil quality, seed yield.

In irrigated regions, attempts are being made to realize high field efficiency for making more income per unit area per annum. In order to achieve this, growers are frequently dragged into a situation where harvesting of the existing crop and planting of the next crop overlap with each other. Consequently, it results in yield losses of the preceding crop due to early harvesting, and following crop due to the delayed planting. Manipulation of appropriate crop production technology and execution of high management skills are therefore, required to handle such situations. Planting of short duration varieties, use of desiccants, mechanized harvesting and planting strategies are imperative for receiving high returns from the crops involved in the intensive cultivation systems.

Use of desiccants is an established practice in some crops where mechanical harvesting and uniform ripening is a prime desire. In situation as stated above, it has become rather more important to harvest the crop at the earliest possible date, but without taxing the yield, to allow timely planting of following crop. Such decisions would be based on the knowledge of crop maturity time coupled with the use of appropriate desiccants. In USA, different doses of Dimethipin (1,2,3-dihydro-5, 6-dimethyl-1, 4-dithin-1, 1,4, 4-tetraoxide) were used as desiccant on sunflower and found that crop maturity was enhanced (1,2) without the loss of yield, oil content and quality. Similar results were reported from France (9).

Diquat (6, 7-dihydrodiphyrido [1,2-a:2,1-c] pyrazinediium ion) has also been used successfully as harvest aid in sunflower (8). It has been reported that physiological maturity in sunflower was attained when seed moisture content ranged between 36-40% (3,7), and required 35 days after flower initiation (7) or 25 days after flower completion (6).

In Pakistan, such registered chemicals are not available in the market, except the "Bipyridinium", Paraquat, which is mainly used as non-selective herbicide in potatoes. Fomesafen is another post-emergence nonselective broad-leaf sensitive herbicide, which has a contact type mode of action and has more or less disiccation property. Fomesafen is an ICI product submitted to the Plant Protection Dept. for registration as post emergence herbicide. It is likely to be marketed some time in 1990. It was therefore, decided to initially include these two chemicals in our present study. Cost efficiency of the desiccants was also considered by reducing the rate of the chemical to half strength, and simultaneously increasing their uptake and subsequent activity by adding low cost non-ionic surfactant, Agral-90. Objectives of this study were to find out the earliest stage of maturity where sunflower could be harvested without considerable loss of yield, and to test the desiccants available in the local market for their effect to enhance the maturity, yield, oil content and quality.

Materials and Methods

The study was conducted at the National Agricultural Research Centre (NARC), Islamabad (33° 40N 73° 08E) Pakistan. The field trials were planted on February 7 and 10, in 1988 and 1989, respectively. The daily maximum and minimum temperatures and precipitation from May 1 to June 20, during 1988 and 1989 (as recorded by the Meteorology Department of NARC) along with the date of flower initiation (DFI), date of flower completion (DFC), date of first harvest (DFH) and date of last harvest (DLH) are given in Fig. 1.

The trials were maintained according to the local production recommendations. Fertilizer was applied at the rate of 120 kg N + 60 kg P_2O_5/ha at the time of seed bed preparation. The plots were irrigated twice, first at head initiation stage and later at the time of flower completion.

Stages of maturity were maintained by different dates of harvest, keeping DFC as reference point. Five dates of harvest treatments were super imposed with two desiccant applications each with two rates and one control treatment (without desiccant application) in a split plot design in which dates of harvest were arranged as main plots and desiccant application in subplots. The experiment was replicated four times. Desiccant treatments were applied in 5-days interval at 18, 23, 28, 33 and 38 days after DFC, Table 1.

Calibrated doses of the desiccants were thoroughly mixed into a known volume of water, used as diluent. The desiccants were sprayed on sunflower foliage using aluminum ladder for a uniform coverage. Solid-cone type brass nozzle was mounted on a knap-sack type manual sprayer to achieve complete wetting of the foliage. Harvesting was done seven days after each desiccant application, i.e. at 25, 30, 35, 40 and 45 DFC, Table 2. The DFC was standardized when about 95% of the floral buds/plot were opened to initiate anthesis.

Drying and burning effects of the desiccant treatments were recorded daily by visual observations after

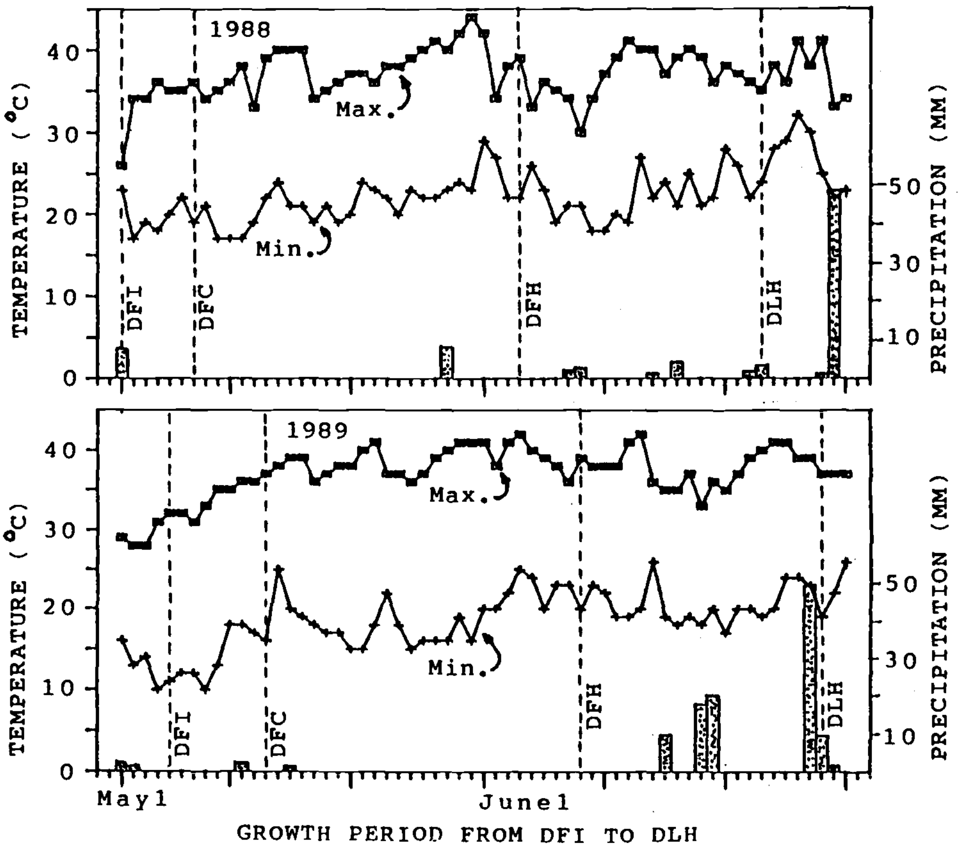


Fig. 1. Daily minimum and maximum temperature and precipitation from May1 to June30, showing date of flower initiation (DFI), date of flower completion (DFC), date of first harvest (DFH) and date of last harvest (DLH) during 1988 and 1989.

Table 1. Desiccation treatments, applicaton rates, common and chemical names of the desiccants followed by their formulated activity.

Treatment	Rate used (kg ai/ha)	Common name	Chemical name	Formulation (kg ai/ha)
Paraquat	0.50	Gramaxone	1:1-Dimethyl-4,4- Bipyridinium (cation) dichloride	20% AS
Paraquat + S*	0.25			
Fomesafen	1.00	Flex	5-[2-chloro-4-(trifluoromethyl) Phenoxy] -N- (methyl-sulfonyl) -2- nitrobenzamide	21% EC
Fomesafen + S*	0.50			
Control			No desiccant was applied	
Note: Adjuvant (surfactant)		Agral-90	[900 g/l alkyl phenol ethylene oxide condensate]	87% W/W 2% V/V

* Herbicides used as disicant, mixed with the non-ionic surfactant "Agral-90" to enhance the efficacy of the product.

Source: 1. Thomson, W.T. 1984. Agric. Chemicals-Book II. Thompson Publications, Fresno, ca 93791.

2. Agral. 90, Tech. bulletin, ICI, Plant Protection Unit, Ferhurst tasemere survey, England.

Table 2. Average of two years effect of maturity stages on yield, seed test weight, moisture contents and oil quality of sunflower.

Days after flower Completion	Yield (kg/ha)	% gain	100seed weight (g)	% gain	Seed moisture (%)	% loss	Oil content (%)	% gain	Palmitic acid (%)	% gain(+) loss(-)	Oleic acid (%)	% gain loss	Linoleic acid (%)	% gain
25	2305		6.22		47.1		40.2		5.8		51.5		39.5	
30	2645	14.8	7.12	14.5	35.3	25.5	43.1	7.2	5.8	0.0	50.3	2.3	40.6	2.8
35	2838	23.1	7.67	23.3	24.1	48.8	43.7	8.7	5.6	-3.4	48.9	5.0	43.4	9.9
40	2813	22.0	7.90	27.0	16.2	65.6	44.2	10.0	6.1	+5.2	48.7	5.4	43.2	9.4
45	2850	23.2	7.91	27.2	10.7	77.3	44.8	11.4	5.7	-1.7	48.0	6.8	43.6	10.4
LSD (0.05)	81		0.21		0.8		0.6		0.3		0.9		0.9	
CV (%)	6.85		6.46		7.1		2.9		10.6		4.0		4.5	

each application upto the day of harvest of each treatment.

The size of the sub-plot was 3x5 m (4 rows, each 5 m long and 0.75 m apart). Sunflower hybrid NK-212 was planted, and the plants were spaced 25-30 cm apart within the rows. Two central rows were harvested to assess the seed yield. The plots were harvested and threshed manually and seeds were sun-dried for 12 days before the weights were recorded for yield measurements on plot basis. The seed yields were converted and reported in kg/ha and adjusted at 9% moisture content by using a moisture meter. The 100-seed weight was obtained as an average of three samples/plot from each of the four replications. Moisture content of the seed at the time of harvest was determined by the formula (A-B)/A where A = fresh weight of seed sample drawn from each plot at harvest, and B = dry seed weight obtained by drying the same sample in a forced air oven at 70° C for 120 hours.

The oil content was reported as an average of two seed samples per plot from each of the 4 replications. It was measured by a Nuclear Magnetic Resonance (4). A Newport NMR, model: Oxford 4000 was used and oil contents were reported at zero percent moisture content. The fatty acid composition was measured by a Shimadzo Gas Liquid Chromatograph (GLC), Model GC-9A. A 2.1 m x 3.2 mm glass column packed with 3% SP 2310/2% SP 2300 coated chromosorb WAW on 100/120 mesh was used for the analyses. The column oven was operated at 230°C. Methylating solution of 4g metallic sodium prepared in 500 ml methanol was used for preparing methyl-esters of oil.

Results

Stages of maturity

The effect of stages of maturity on the seed yield was highly significant during both the years. Seed yield increased significantly from 25 to 35 DFC, Table 2 and Fig 2a. The increase of 417 kg/ha (from 1980 to 2397 kg/ha) in 1988, and 650 kg/ha (from 2629 to 3279 kg/ha) in 1989 were obtained within these 10 days. In 1988, seed yield steadily increased upto 45 DFC but the increase after 35 DFC was small and non-significant. On the contrary, during 1989, the seed yield slightly decreased after 35 DFC but it was non-significant. The mean seed yield of 3080 kg/ha for 1989 was significantly higher than the mean seed yield of 2300 kg/ha for 1988.

In 1988, the 100-seed weight increased significantly and rapidly from 6.37 to 8.53 g between 25 and 40 DFC but the increase in seed weight after 40 DFC was slow and non-significant. On the contrary, in 1989, seed development was rapid (from 6.08g to 6.96g) between 25 and 30 DFC, gradual (from 6.96 g to 7.20 g) between 30 and 35 DFC and plateaued thereafter, Fig. 2b. The 100-seed weight of 7.79g was significantly more in 1988 than that of 6.94 g in 1989.

Seed moisture reduced significantly, during both years and the moisture reduction was steady and continuous from 25 DFC to the last date of harvest (45 DFC), Fig 2c. In 1988, the moisture content of seed on 25 DFC was 51.2% which was reduced to 13.1% on 45 DFC, registering a 38.1% reduction during these 20 days. Similarly, in 1989, the moisture content of seed on 25 DFC was 43.1% which was reduced to 8.3% on 45 DFC, registering a 34.8% reduction in seed moisture was obtained during this period. On the average of both years, the seed moisture contents reduced by 23% during the first 10 days (25to 35 DFC), about 8% between 35 and 40 DFC and 6% between 40 and 45 DFC. Mean moisture content of 30.7% in 1988 was 8.0% higher than that of 22.6% in 1989.

During 1988, the oil content of seed significantly increased from 36.5% to 41.1% between 25 and 40 DFC, and thereafter reduced non-significantly. In 1989, the oil content increased rapidly and significantly from 43.8% to 47.4% between 25 and 30 DFC, and thereafter, almost no change was observed until 40 DFC. However, during the last 5 days (from 40 to 45 DFC), once again, a significant increase in oil content was obtained, Fig. 3a. Mean oil content of 39.4% in 1988 was significantly less than that of 46.9% in 1989.

Palmitic acid concentration changed significantly due to stages of maturity during both the years, Fig. 3b. However, the changes were minor and there existed no definite trend or direction in accordance to the stages of maturity from 25 to 45 DFC. Oleic acid contents reduced significantly from 56.9 to 49.1 between 25 and 45 DFC in 1988, whereas no significant change was observed in 1989 during the same period, Fig. 3c. In 1988, linoleic acid content increased significantly from 35.0 to 43.3% between 25 and 35 DFC, and reduced to 41.5% between 35 to 40 DFC and, once again, increased to 42.2% between 40 and 45 DFC. In 1989, linoleic acid reduced significantly between 25 and 30 DFC, and thereafter, it increased continuously until 45 DFC but linoleic acid content of 45.0% at 45 DFC was not significantly different from that of 43.5% at 35 DFC, Fig. 3d.

Desiccant application

Paraquat at both concentrations burnt the sunflower leaves within 2-3 days after its application, whereas Fomesafen did not dry the leaves. However, yellow speckles, leaf chlorosis and leaf brittleness was evident and such desiccating effects were unique and different from the usual plant senescence.

Desiccant treatments did not dry the plant stem or capitulum and no obvious signs of induced drying (desiccation) appeared on them. These plant parts were identical in color and appearance to the untreated check. The effect of desiccant applications on the seed yield was not pronounced. The desiccant treatments did not significantly influence the seed yield in 1989. In 1988, Paraquat when applied with Surfactant (0.5 kg ai/ha + Agral-90 0.02 v/v) increased the seed yield significantly over the check, while the seed yields obtained from all other treatments, during the same year were not significantly different from that of the control, Table 3.

In 1988, Fomesafen applied at 1.0 kg ai/ha, significantly increased the 100-seed weight over the control. However, all other desiccant treatments during the same year were not significantly different from the check.

Desiccant applications remained non-significant to affect the 100-seed weight in 1989, Table 3.
In 1989, the desiccant treatments did not reduce the seed moisture contents significantly. On the contrary, during 1988, Fomesafen applied at 1.0 kg ai/ha reduced the seed moisture contents significantly over the control. The 1.3% reduction, however, was negligible, Table 3.

The desiccant treatments affected the oil contents and fatty acids very little though the changes in both years were significant, Table 4. In 1988, Fomesafen at the rate of 1.0 kg ai/ha increased the oil contents by 0.9% while Paraquat at the rate of 0.5 kg ai/ha reduced the oil contents by 0.9%. During 1989, Fomesafen did not afect the oil contents significantly but Paraquat at both concentrations, irrespective of the added Surfactant, reduced the oil contents. Paraquat at higher concentration reduced the oil content by 2.2% and at lower concentration by 0.9% as compared to the control.

Table 3. Effect of desiccant application on yield, 100-seed weight and moisture contents of sunflower.

Disccant treatment	Yield (kg/ha)			100 seed wt.(g)			Seed moisture (%)		
	1988	1989	Avg.	1988	1989	Avg.	1988	1989	Avg.
	--------(kg/ha)------			----------(g)---------			---------(%)---------		
Paraquat	2270	3019	2645	7.67	6.64	7.16	30.6	22.8	26.7
Paraquat + S*	2386	3185	2785	7.65	6.91	7.28	31.7	22.9	27.3
Fomesafen	2334	3125	2729	8.07	7.03	7.55	29.7	22.6	26.2
Fomesafen + S*	2226	2997	2611	7.75	7.13	7.44	30.5	22.5	26.5
Control	2283	3074	2678	7.81	6.99	7.40	31.0	22.4	26.7
LSD (0.05)	66	N.S	81	0.25	N.S	0.21	0.8	N.S	N.S
Year mean	2300	3080		7.79	6.94		30.7	22.6	
LSD (0.05) for year mean	88.7			0.32			0.8		

* Agral-90 was used as Surfactant.

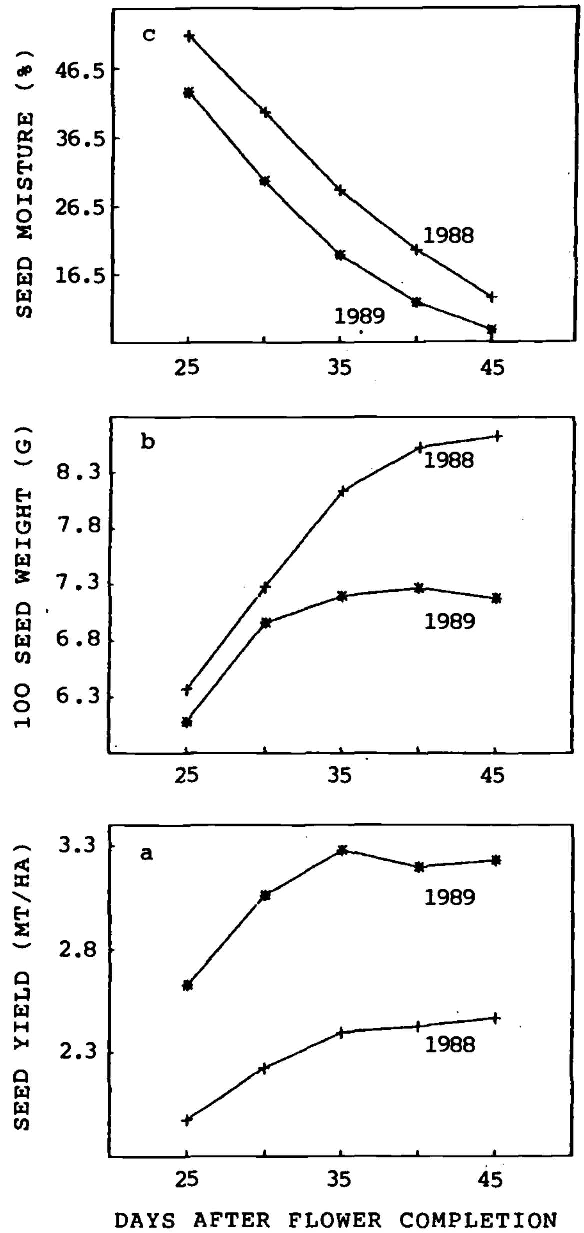


Fig. 2. Effect of stages of maturity on seed yield, 100 seed weight and seed moisture content of sunflower during 1988 and 1989.

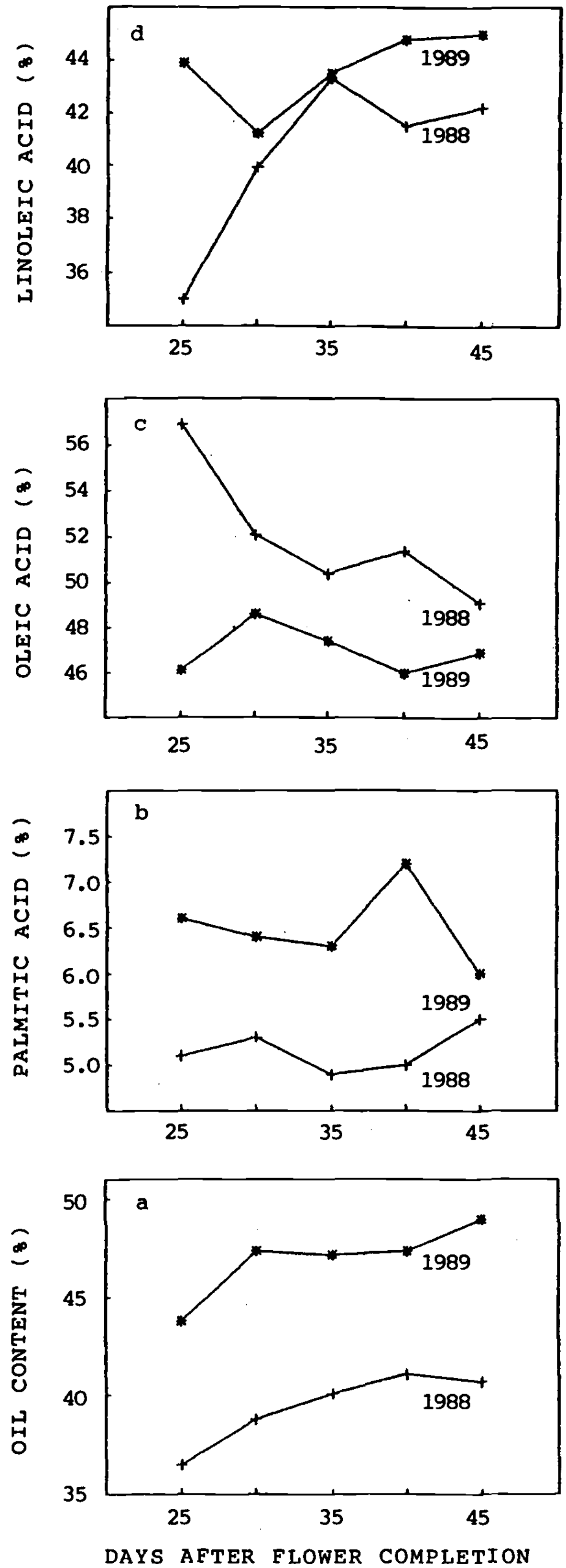


Fig. 3. Effect of stages of maturity on oil content and fatty acid composition (palmitic, oleic and linoleic) of sunflower during 1988 and 1989.

Fomesafen at the rate of 1.0 kg ai/ha reduced the palmitic acid significantly over the check and the remaining treatments reflected similar palmitic acid contents as expressed in the check, Table 4. Both the treatments of Paraquat significantly reduced the oleic acid contents during both years as compared to the check (1.3-1.0% in 1988, and 4.5-5.0% in 1989). On the contrary, both treatments of Fomesafen significantly increased the oleic acid contents (0.9 and 1.3%) over the check in 1988 while no significant increase was obtained in 1989, Table 4. Paraquat treatments increased linoleic acid contents

Table 4. Effect of desiccant application on oil contents and quality of sunflower during 1988-1989.

Disccant treatment	Oil content 1988	Oil content 1989	Oil content Avg.	Palmitic acid 1988	Palmitic acid 1989	Palmitic acid Avg.	Oleic acid 1988	Oleic acid 1989	Oleic acid Avg.	Linoleic acid 1988	Linoleic acid 1989	Linoleic acid Avg.
	%											
Paraquat	38.5	45.4	41.9	5.3	6.7	6.0	50.7	43.8	47.2	41.8	46.2	44.0
Paraquat + S*	39.6	46.7	43.2	5.2	6.6	5.9	51.0	44.3	47.6	41.4	46.3	43.9
Fomesafen	40.3	47.5	43.9	4.9	6.2	5.6	52.9	48.5	50.7	39.4	42.5	41.1
Fomesafen + S*	39.4	47.4	43.4	5.1	6.4	5.7	53.3	49.7	51.5	39.1	41.7	40.4
Control	39.4	47.6	43.5	5.2	6.5	5.9	52.0	48.8	50.4	40.0	41.8	40.9
LSD (0.05)	0.7	0.9	0.6	0.2	N.S	0.3	0.8	1.5	0.9	0.7	1.5	0.9
Year mean	39.4	46.9		5.2	6.5		52.0	47.0		40.4	43.7	
LSD (0.05) for year mean	0.8			0.3			0.9			1.1		

* Agral-90 was used as Surfactant.

significantly over the check during both years (1.4-1.8% in 1988, and 4.4-4.5% in 1889). Fomesafen at 0.5 kg ai/ha with Agral-90 reduced the linoleic acid contents (0.9%) over the check during 1988 but no evident effect of both treatments of fomesafen was observed during 1989, Table 4.

Discussion

Delaying the harvest for 10 days from 25 to 35 DFC has significantly increased the seed yield. The seed yield gains during this period were 21.1 and 24.7% in 1988 and 1989, respectively. However, no significant increase in seed yield was obtained after 35 DFC during both years, indicating the stage of physiological maturity as defined by Anderson (3). Whereas physiological maturity was reported (6) just at 25 DFC. The seed moisture contents on 35 DFC were 28.9% in 1988 and 19.4% in 1989. Suggestively, seed moisture content range of 30 to 20% can be used as a good indicator of the physiological maturity of sunflower. Contrary to our results, physiological maturity was reported (7) at 35 days after flower initiation when moisture contents of the seed was about 36%.

The 100-seed weight increased significantly upto 40 DFC. Our results are in contrary to those of (3) who obtained highest dry seed weight at 35 days after flower initiation.

Increase in seed yield, in general, corresponded to the trends of increase in 100-seed weight during both years. However, 100-seed weight in 1988 was higher than that of 1989 which was a reverse situation for seed yield. Lower seed yield, in 1988, having bigger seed size can be explained by the lower seed set per capitulum. As such, it resulted in lower competition for the allocation of photosynthates per seed per capitulum. In turn, the seeds gained larger size. For the same reason, during 1988, the seed growth was more steep and it continued to gain weight till the last date of harvest. However, it failed to influence the seed yield with the same magnitude and steepness because of lower total number of seeds per head. It was also reported (5) a negative correlations between 1000-seed weight and seed yield in two different seasons.

The lower seed set, in 1988, was expected due to the high temperature during the anthesis period. The maximum temperature on the day of flower initiation was 26°C which immediately rose to 34°C on the following day and it went upto 35 and 36°C, and prevailed up until flower completion. The minimum temperatures were also higher in 1988 and varied from 17 to 23 °C during anthesis period, Whereas in 1989, the maximum temperature was 32 °C on the day of flower initiation, and it gradually increased to 35 °C during the flower completion period, Fig. 1. During the same period the minimum temperatures were between 11 °C and 18 °C which were considerably lower than those of the previous year. Growing degree days (GDD) received within the experimental years also seemed to influence the seed yield. GDD is calculated as: [(Max.-Min. temp)/2]-3.1 °C] Total GDD received from planting to flower initiation and onwards to last harvest were more in 1988 than in 1989, Table 5.

Table 5. Dates of desiccant application and harvesting, growing degree days (GDD) from flower initiation (FI) to date of last harvest (DLH) and precipitation received from date of planting (DP) to last harvest.

Year	Date of desiccant application	Date of harvest	Growing Degree Days DP to FI	FI to DLH	Total	Precipitation PD to LDH (mm)
1988	May 27	June 3	1189	1529	2718	236
	June 1	June 8				
	June 6	June 13				
	June 11	June 18				
	June 16	June 23				
1989	June 1	June 8	1112	1382	2494	187
	June 6	June 13				
	June 11	June 18				
	June 16	June 23				
	June 27	June 28				

Most of the oil-filling (upto 40%) took place by 25 DFC, and the remaining 3-4% of oil was filled between 25-30 DFC and thereafter the increase in oil content was negligible. Our results are in agreement to (7) who obtained about 50% oil in 28 days after flower initiation (DAF) and 53% oil at 35 DAF.

Among the fatty acids, oleic acid contents changed appreciably at different stages of maturity in 1988, and did not change much during 1989. Oleic acid contents reduced by enhanced maturity whereas the linoleic acid contents changed in the reverse order of oleic acid, i.e., it increased with the enhanced maturity. Similar results were reported, (7).

Drying of the leaves due to Paraquat application is considered as an aid for the mechanical harvesting of sunflower. But, green stem and head pith at 35 DFC could still offer a considerable problem for proper threshing and cleaning of the crop during combine harvesting. Desiccant treatments did not considerably reduce the seed moisture contents either. These results are contrary to those of (2) who reported about 7% reduction in seed moisture contents as compared to the untreated check even after 10 days of desiccation with Harvade 5F.

Although the effect of desiccation on seed yield, 100-seed weight and oil contents at some treatments were significant, but they were small and unpronounced. Increase in yield due to desiccant application as compared to the control ranged from 51 to 117 kg/ha. Decrease in oil content ranged from 0.9 to 2.2% and decrease in 100-seed weight ranged from 0.08 to 0.35 g. These results are in agreement with (2) who reported that desiccant application at higher doses reduced the oil content from 0.9 to 1.2% without any effect on seed weight.

The effect of desiccant on oil content seems to be influenced by the moisture content of seed during its development and maturity process. In 1988, when seed moisture content was 6-9% higher than that of 1989, the desiccant treatments either slightly increased the oil content or when reduced, the reduction was not much. On the contrary, in 1989, when the seed moisture content was relatively lower, all the desiccant treatments reduced the oil content and the significant reduction values were more than those of 1988.

Conclusion

There was no significant increase in seed yield after 35 DFC. And since desiccant application did not reduce the seed yield, the induced maturity before 35 DFC rather than after, may help early harvest without yield loss. Harvesting at 35 DFC may reduce the oil contents by about 1.0% which could otherwise be gained by delaying the harvesting upto 45 DFC. But vacating the fields 10 days earlier is of greater interest and is desirable than harvesting the last 1.0% of the oil. No loss of oil quality was found beyond 35 DFC.

Paraqquat is a better desiccant than Fomesafen as it helped drying and burning of the leaves at both concentrations within 2-3 days of its application. Fomesafen did not induce drying or burning of the leaves. Both the desiccants failed to reduce the seed moisture contents, even when they were applied at later stages of maturity within seven days of their application. It is therefore, suggested that desiccants should be applied more than seven days before the crop is harvested.

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TRENDS AND STRATEGY OF SUNFLOWER PRODUCTION IN PAKISTAN

Masood A. Rana

As an oil crop, sunflower was introduced in Pakistan during the early 1960's and its commercial cultivation began in 1965. It persisted on a negligible area till 1970. For the first time, in 1971, its area exceeded 500 ha. As an average of 10 years (1970/71-1979/80), area under sunflower was only 312 ha and showed a negative growth rate of -1.26% per annum, Table 1.

Table 1. Area, production and average yield of sunflower in Pakistan, 1970/71-1988/89.

Year	Area ('000 ha)	Production ('000 tone)	Average Yield (kg/ha)
1970-71	670	482	719
1971-72	1250	873	698
1972-73	776	486	626
1973-74	516	246	477
1974-75	569	259	455
1975-76	483	228	472
1976-77	389	188	483
1977-78	37	35	946
1978-79	479	311	649
1979-80	592	355	600
1980-81	4679	3492	746
1981-82	7235	5855	809
1982-83	8132	6313	776
1983-84	8459	6803	804
1984-85	9592	7789	812
1985-86	19800	17600	889
1986-87	48500	37800	779
1987-88	56850	42570	749
1988-89	33387	36378	1071
Annual growth rate (AGR)*	36.6	29.9	0.05
AGR**	24.6	36.7	4.28

* Calculated on the basis of eight years, 1980/81 - 1987/88.

**Calculated on the basis of nine year, 1980/81 - 1988/89.

Source:Agricultural Statistics of Pakistan, (1987) and personal communication with the Ministry of Industries.

Realizing the increasing edible oil deficit in the country, the Government of Pakistan established a Seed Division in the Ghee Corporation of Pakistan (GCP) in 1979, with a clear cut mandate of promotion and procurement of non-traditional oil crops (sunflower, soybean and safflower). As a result, a quick increase in the area of sunflower took place upto 1987-88 and attained a high annual growth rate of 36.6%. However, in 1988-89 the area suddenly dropped to 33,980 ha as compared to 56,850 ha of 1987-88 and registered 40.2% decrease.

At present, as an average of the last 5 years, about 76.9% of the total area under sunflower is cultivated in Punjab, 23.2% in Sind and 0.9% in NWFP, Table 2. In 1984/85, about 51.1% of the total area was planted in Punjab and increased to 77% in 1988/89 showing a more rapid growth of sunflower cultivation in Punjab than other provinces. Area in Punjab and Sind is nearly equally distributed in the cotton and rice growing regions.

About 3,490 tons of sunflower were produced in 1980/81. It increased rapidly and reached to about 37,800 tons in 1986/87, with an annual growth rate of 40.5 %. It is expected to obtain about 12,000 tons of refined sunflower oil from the produce of 1988/89 (assuming 33% oil recovery) and thus, sharing 3.7% of the total national production of edible vegetable oil.

The growth rate of 0.05% upto 1987/88, Table 1, indicates that the average yield of sunflower has remained virtually stagnant. But, due to favorable climatic conditions and small acreage, the

Table 2. Province-wise area and production of sunflower, 1980/81 - 1988/89.

Year	Area (ha) Punjab	Sind	NWFP	Baluc-histan	Total	Production (tons) Punjab	Sind	NWFP	Baluc-histan	Total
1980-81	2634	1961	84	-	4679	1701	1777	14	-	3492
1981-82	4314	3655	66	-	7235	2522	3321	12	-	5855
1982-83	4324	3734	74	-	8132	2916	3382	15	-	6313
1983-84	4448	3941	70	-	8459	3214	3576	13	-	6803
1984-85	4908	4621	63	-	9592	3572	4204	13	-	7789
1985-86	13819	5911	70	-	19800	12191	5394	15	-	17600
1986-87	40575	7800	125	-	48500	30777	6942	81	-	37800
1987-88	42490	13760	600	-	56850	36153	5917	420	-	42570
1988-89	25900	6880	607	-	33387	31940	3892	546	-	36378

Source: Agricultural Statistics of Pakistan, (1987) and personal communication with the Ministry of Industries.

average yield of the country during 1989, reached to 1071 kg/ha which probably will drop down again if the area increases next year. Like all other oilseed crops, average yield of sunflower is also much lower in most of the countries. It is mainly due to:

i) lack of high yielding varieties for different agro-ecological zones,
ii) Inadequate adoption of improved agronomic practices,
iii) lack of application of necessary inputs,
iv) damage by insect, disease and birds, and
v) lack of suitable machinery for planting, harvesting and threshing which accounts a lot for obtaining high yields by incurring least cost of production.

Nevertheless, the future of sunflower in Pakistan seems to be very bright. The results of experiments indicated that average yield as high as 4,000 kg/ha could be obtained under optimum management conditions. Commercial planting, where farmers were provided proper inputs and practiced interculturing, got yields upto 3,500 kg/ha. This cofirmed the possibility that high yields of sunflower could be obtained by applying proper inputs and timely field operations such as thinning, hoeing, earthing up, etc.

The reasons for sudden drop in area of sunflower during 1988/89 were:

1. Absence/scarcity of private sector in the market for the procurement of sunflower crop.

2. Farmers had problems in selling their produce to GCP due to strict procurement standards and insufficient field staff. Mode of payment was also defective which delayed getting of cash against the cheques issued to the farmers by GCP.

3. High temperature (41-47° C) at the time of blooming results in low yield and disease spread which discouraged the farmers (our existing commercially grown hybrids are not high temperature tolerant).

4. Floods during September 1988 damaged the cotton and paddy crops in areas which were ideal for sunflower. Due to early removal of the damaged crops, the flooded areas became available for planting wheat in October. Wheat was planted on larger areas which squeezed the sunflower crop.
5. Sunflower growers opted to grow maize because of the increase in

maize procurement price from Rs. 85 to 120 per 40 kgs.

6. Other crops such as moong, mash, melons and tobacco gave a tough competition to sunflower because of its poor performance in the previous year, 1987/88.

7. In most of the cotton tract, canal water was not available at the time of seed bed preparation due to which some willing farmers also failed to plant sunflower. and

8. Decline of traditional dealing of selling the sunflower seed on credit, GCP sold the seed to the farmers on cash payment.

Strategy for the year 1990 to increase area

1. An area target of 95,000 ha has been set.

2. Seed will be sold on credit.

3. Support price of sunflower has been increased from Rs. 177 to Rs. 205 per 40 kg.

4. Short- and medium-term loans will be provided to farmers to purchase logistics, and

5. Private sector will be encouraged to operate in the market for the procurement of farmers' produce. Thus, an incentive of Rs. 5.0/ 40 kg has been announced for delivering the produce from the farm gate to the Government procurement centers.

Long-term strategy

- National Commission for Agriculture (NCA) studied the oilseed deficit situation in the country and identified oilseed production as priority area, which needs immediate attention for improvement.
- NCA set targets of 772,000 and 1,075,000 ha to increase area under oilseed crops in the 7th Five-Year Plan, 1988/92 and the year 1999/2000, respectively, Table 3.
- A seven-year (1989/90-1996/97) project on oilseed, "National Oilseed Development Project (NODP)" has been approved by the GOP to achieve a substantial increase in the production of oilseeds (particularly non-traditional oilseed crops) and reduce import of edible oil.
- Under NODP, areas of thrust would be to improve research, seed production and extension services for oilseeds.
- Credit facilities will be provided to the farmers to grow more oilseeds, and
- Existing oil extraction efficiency will be increased by rehabilitation of crushing plants.

Table 3. Oilseed targets for area, average yield, edible oil production and import.

Area Yield Production	Target Benchmark 1987-88	 7th plan	 1999/ 200	Growth rate (%) 7th plan	 1999/ 2000
Area ('000 ha)					
Total oilseeds	565	722	1075	6.4	5.6
Non-traditional oilseeds	70	227	450	26.5	16.6
Average yield (kg/ha)					
Non-traditional	900	1100	1620	4.1	5.0
Production of oil incl. cotton seed ('000 tonne)	440	660	1020	8.5	7.3
Import					
Self-sufficiency ratio (%)	37	45	51	1.6	2.1

Source: Report of the National Commission on Agriculture, MINFAC, March, 1988.

SUNFLOWER PRODUCTION IN INDIA —PROBLEMS AND PROSPECTS

M. Rai and P.S. Bhatnagar

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 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-69874) 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 "LDMRSH-1" and "LDMRSH-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 irrigations 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.

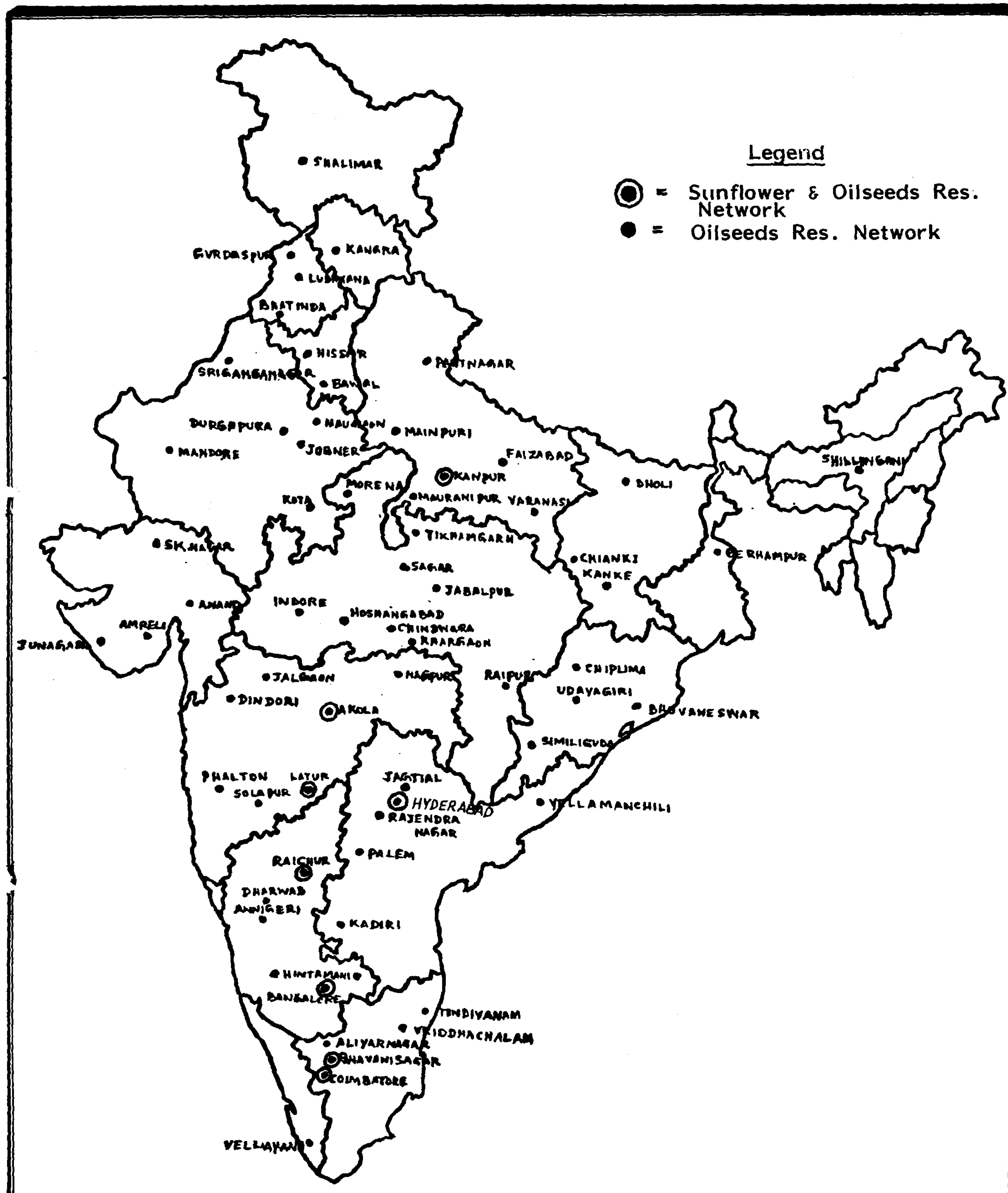

Figure 1. OILSEEDS RESEARCH NETWORK IN INDIA

Table 1. Sailent features of varieties/hybrids

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

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

Table 2. Economics of Sunflower Vs Wheat and Chickpea under irrigation in vertisols.

Crop/variety	No. of irrigations received	Mean yield	Mean returns (Rs/ha) Gross	Net	Benefit-cost Ratio
Wheat (H 2189)	5	2436	5237	2089	1.7
Chickpea (Chaffa)	3	1114	4456	2324	2.1
Sunflower (Morden)	3	1200	5400	2948	2.2

4. <u>Susceptibility to diseases and pests</u>: 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

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

* 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.

	Disease/Pest	Occurrence	Yield loss (%)
1.	Alternaria blight	Entire country	27-80
2.	Rust	Entire country	Upto 20
3.	Charcoal rot	Entire country	30-46
4.	Downy mildew	Maharashtra and Adjoining Karnataka	2-60
5.	Head borer and Jassids	Karnataka	28-33

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(are) 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 polygenically inherited.

4. Development of high yielding populations: Sunflower cultivation under input starvation and rainfed situations, may continue in India in the foreseable future. Presently, hybrids are under commercial cultivation in about 30-35% of the total area. It may go upto 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 demarkated regionalized seed production efforts. Matching agro-production and protection technologies for the production of healthy and cost effective seed required atmost 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.

TWELFTH INTERNATIONAL SUNFLOWER CONFERENCE – A REPORT

Mangala Rai

My participation in the 12th International Sunflower Conference at Navi Sad, Yugoslavia during July 25-29, 1988, was fully funded by IDRC as Chairman of the International Sunflower Sub-Network to get acquainted with: (i) the latest research informations available in the world on sunflower, (ii) germplasm status and its utility for Asian and African countries, and (iii) identification of potential institutions and resource personnel for training and consultancies in various disciplines for the development of sunflower in Asia and Africa. This mandate was vested in pursuance of the recommendations of the International Oilcrops Research Network meeting held at Kenya during January 25-29, 1988.

Participation, Deliberations and Observations

Over 500 delegates participated in the conference. The five days deliberations were directed to wide ranging topics varying from collection, conservation and evaluation of germplasm to the understanding of genetic basis of resistance to various biotic and abiotic stresses, quality and other economic considerations leading to the development of improved varieties and hybrids with in-built resistance to various diseases and pests and higher oil content in the seed. Most of the topics were addressed for hybrid development with limited efforts for the development of populations which were confined to USSR, India and certain other Asian and African countries.

Genetics and breeding

Forty five papers were presented in the genetics and breeding section. These papers may be grouped into four categories.

The first category was the use of wild sunflower as a source of genetic variability. The Conference began with the plenary paper discussing the contribution of wild species to research today, providing us with a wide range of cytoplasmic and male sterility, disease and insect resistance, oil and seed quality, and useful agronomic traits. It was felt that exploration must continue for adding new accessions to the collection. Subsequent papers described cytological studies on interspecific crosses, techniques to facilitate these crosses such as embryo culture and chromosome doubling, and the report on new restorer genes for sources of cytoplasmic male sterility.

The second category was in the field of biotechnology. This appeared as a relatively new research area for sunflower and a very interesting addition to the conference reports. Papers discussed anther culture, the application of tissue and protoplast culture, somatic embryogenesis, and the use of biotechnology for improvement of sunflower in the area of industrial and edible oils. Regeneration of whole plants from cell culture appeared positive, with transfer of genes through recombinant DNA technology, showing feasibility to add diversity in resistance to insects, diseases, and also for herbicide tolerance.

The third category described the variability of oil quality in sunflower and the use of breeding to develop high linoleic, high palmitic and high oleic sunflower hybrids and cultivars. These useful variations appeared to have potential to create alternative markets for sunflower world wide.

The fourth category covered genetic analyses and breeding methodologies. Genetic studies gave new information on the inheritance of earliness, branching pattern and morphological traits such as short petioles and head position. Also, studies on the combining ability for yield components, genetic architecture of traits of economic significance, genetic distances, and recurrent selection provided adequate ground for contemplating further improvement of the crop.

Three papers described the genetic progress and improvement of sunflower over the past few decades in Argentina, Romania and the United States. These papers were encouraging in that they documented their efforts in research, leading to increases in production through genetics, breeding, and new cultural applications.

Crop management and Production

In this section physiology, environmental effects on yield and quality, nutrition, agronomy and mechanization was deliberated. The main objective was to understand plant functioning, by itself, and also in various environments in conjunction with varying cultural practices. Greater emphasis was accorded to bio-synthesis, setting and filling of grains and other fundamental approaches all aiming at greater plant efficiency and better harvest. A critical analysis of adaptation in varying climate, soil, and water conditions and cultural practices viz. plant population, fertilization etc, was presented indicating tremendous scope for enhanced productivity and production. In crop physiology, growth analysis, leaf area development and light interception were presented and it was felt that leaf area index of about 2.5 is sufficient for light interception. The enzymatic aspects of photosynthesis were more clearly understood showing net progress in the field than ever before but a similar progress in the area of assimilates partitioning probably both dependent on enzymes and hormones was not visible. The mechanism of stress resistance was another area where little research work was observed. The water stress effects, drought tolerance, temperature tolerance and various other important fields were probably not well covered.

In the field of agronomy, the most important way appeared to adopt location specific technologies to meet yield expectations depending on the prevailing price structure. In view of the prevailing priorities and price structure, it was felt that both high physiological performances of sunflower and its robustness allow a large scale of expected yields. It was explained that although quality is important the main character will continue to be the yield. It was observed that shorter stem prevents lodging and directs more assimilates to the head and further permits greater plant population per unit area reflecting higher net monetary returns. Among C_3 crop plants, sunflower has the highest physiological performance but probably they are not skillfully exploited. One of the weaknesses appears to be the partitioning of the assimilates for the best advantages.

Crop protection

There were 73 papers in total and 3 newly reported pathogens on sunflower: *Coniellia* in Nigeria, *Stemphyllium* and *Verticillium lateritium* in Yugoslavia. Eleven articles described the distribution of diseases already known on sunflower in new growing areas and special mention was made of *Sclerotinia* and *Alternaria* in China, *Phomopsis* in Iran, downy mildew in India and *Alternaria alternata* in Greece.

Sclerotinia: There is continued

world wide interest in this pathogen, with increasing attacks in many countries, including Argentina and China. After studies in recent years in France and Yugoslavia, there were some reports of epidemiological studies in Hungary and Argentina. The reports described the modified techniques for producing inoculum and testing plants for resistance. It can now be concluded that most of the problems regarding inoculation and testing procedures have been resolved and selection for resistance is on but with relatively slow pace concerning head rot due to the problems of negative correlation with oil content. Search for improved and more rapid screening methods has led French and American teams to work on phenol contents induced by *Sclerotinia* infection. Phenols could provide both resistance markers and a better understanding of the physiology of resistance. It appears that phenolic finger prints are quite characteristic of each genotype. Another new development in resistance studies is the use of tissue culture. Differences were demonstrated in the reaction of calli to *Sclerotinia* culture filtrates related to field reaction. This method was applied for *Phoma macdonaldii*. There were several reports, mainly by French workers, of studies on improved chemical control, particularly techniques of spraying. The recent discovery of true systemic, Fenpropinorphe, opens new possibilities of chemical control of head rot.

Phomopsis: This disease, which was first discovered in Yugoslavia in 1980, was reported to be one of the most serious diseases in all countries of Europe and has been observed in the United States, Iran and Pakistan. This disease is likely to spread to other countries. Much research has been done in Yugoslavia and France on the biology, histopathology and control of the pathogen.

One of the problems complicating the work with *Phomopsis* has been the inability to produce perithecia of the *Diaporthe* stage, away from sunflower tissue. Workers in France and a combined Yugoslav-American team have produced mature perithecia on several types of media. This achievement will facilitate screening germplasm for resistance because only ascospores can infect sunflower.

From an exhaustive study of 60 different *Phomopsis* isolates of different hosts, it appears that *Diaporthe helianthii* is a distinct species. No definitive study has assessed whether the European isolates and those from North America are the same species.

Inoculation procedures to infect plants through the leaf petiole and stem have been developed. Each method has its advantages and correct identification of resistant plants may require use of more than one method. Screening of calli cultures with a culture filtrate was successful in distinguishing resistant and susceptible germplasm. This method will save much time and labour.

In the absence of complete genetic resistance, pathologists have identified several fungicides which control the pathogen. To be highly effective, chemicals have to be applied either before disease appearance or when symptoms are confined to leaves. Thus the use of genetically resistant hybrids/populations appears to be the most feasible preposition for which research efforts need to be intensified.

Plasmopara: There is renewed interest in downy mildew, particularly with the need to control new races and to identify and control the disease in new areas where it appears (India in particular). With further studies of biology, conservation of inoculum and testing methods are no longer a problem.

However, at present, all the resistance known is reported to be race-specific. Perhaps in the future, researches should be made for some horizontal form of resistance.

Rust: So far, five rust resistance genes have been identified although only four are still existant. Resistance to race 4 has been found to be governed by two dominant genes. In an effort to standardize procedure and facilitate communication between pathologists and breeders in different countries, it would be desirable to standardize the nomenclature system and the use of the same differential varieties and preferably the same inoculation and evaluation procedures to make definite dent on this vital front.

Alternaria: This appears to cause some symptoms outside its usual area in China and France. Efficient resistance tests developed by Australian and French workers can effectively be used by breeders in different countries for evolving resistant/tolerant varieties and hybrids.

Diverse fungal diseases: Epidemiological and resistance breeding studies on *Macrophomina phaseolina* and biological studies of *Septoria* and *Rhizopus* spp were reported. It was surprising to note that there was no paper on *Botrytis*, inspite of its importance in Northern and Western Europe.

Insect pests: Five articles described the insect pests present in China, Iran, Yugoslavia and Hungary. Detailed studies carried out on aphids in Yugoslavia and France were presented. There was a chinese report on the importance of the sunflower moth in their country. In fact, problems enlisted and efforts undertaken/contemplated on entomological aspects appeared limited.

Processing, utilization and marketing

The 11 presentations covered the high technology of processing as well as the use of sunflower for diverse human food. Indication in one of the papers was there to elucidate that sunflower oil apart from edible purposes could be processed for use as fuel. Nevertheless, need for studying the economic aspects of this project was emphasized. Various kinds of packing for long- and short-term storage and depending on need was emphasized.

Germplasm in the field

Yugoslavia is the center for the maintenance of FAO germplasm of sunflower. The germplasm are maintained by the Department of Sunflower of the Yugoslavian Field and Vegetable Crops Research Institute located at Novi Sad. Apart from the participation in the deliberations of the conference, with the kind gesture of Dr. Skoric, Head of the Sunflower Department and Secretary General of the Conference, a field visit was undertaken for on-the-spot assessment of the germplasm in the field .

Ten thousand germplasm lines were grown in the field showing wide diversity with respect to plant type, head type and its position, plant stature, maturity duration, resistance to diseases, drought and various other traits of economic significance. Out of about 2,000 restorer lines grown, the majority was of multi-headed type. Some of which were reported to possess as much as 64% oil in the seed. These lines may be of great interest for enhancing oil content in hybrids and may also be of use in population improvement programs. Although multi-headed trait is undesirable but, interestingly, it is controlled by recessive gene which provides an opportunity to exploit these lines in hybrid development programs. Fifty one wild species were maintained showing wide diversity in various traits and a few of them were easily crossable and the progenies were grown in the field. Some of these populations may be of considerable significance particularly for developing populations for drought resistance as well as for incorporating resistance to diseases and pests. A few stable short-statured lines with upright growing leaves were observed which may be of considerable interest for architecturing plant types for increasing plant populations per unit area under mono culture. These lines may be of great significance where the sunflower is grown or likely to be grown as mixed crop/ intercrop. Certain restorer lines with profusely base branching system which obviously will continue to flower for a wide range of time may be of interest as they may facilitate crossing programs over a wide range of time.

World Sunflower Hybrids on Display

The opportunity was availed to visit the demonstration plots where almost all the promising hybrids from all over the world developed in both public and private sectors numbering 198 (Annexure) were grown. This provided a unique opportunity to have a look and assess the relative performance/traits of all the hybrids. Depending on the plant type, maturity duration, resistance to diseases, likely yield potential, reported oil content, etc., 28 hybrids (Annexure*) were identified as probable potential materials. Instead of fragmented approaches of testing x- or y- hybrid at a time, it may be of interest to evaluate all the 28 hybrids at a time which may provide a base for further negotiations depending on the potential of the hybrids under varying agro-climatic conditions.

Resource Personnel and Training Facilities

It was felt that training of scientists in plant breeding and oil quality in the first instance would be much more rewarding and on this endeavour the Oilcrops Department of the Institute of Field and Vegetable crops, Novi Sad, would be an appropriate institution. The matter was discussed at length with Dr. Dragan Skoric and he agreed for imparting the training of about one month duration to the senior breeders/biochemists and four to five months training to junior researchers/technicians of Asian and African countries. It was felt that the expertise, experience, well equipped laboratories and-over everything - availability of the world germplasm at the Institute would provide a unique opportunity for the trainees for their development. It was further felt that expertise for different diseases and facilities for such training viz.: rust in Canada, downy mildew in UK and France, Alternaria in Yugoslavia and Sclerotinia in France may be availed as and when required. For consultancies in plant breeding and seed production, Dr. Skoric of Yugoslavia and Dr. Alex viorel Vranceanu of Romania may be resource personnels. In the field of Plant Pathology, services of Dr. Sackston E. Waldemar of Canada may be had.

General

1. It was decided to organize the 13th International Sunflower Conference at Pisa, Italy, in 1992. It was further decided that the 14th and 15th International Sunflower Conferences in 1996 and 2000 would be held in China and Mexico, respectively.

2. A perusal of the over all scenario indicated that area under sunflower will increase considerably in African and Asian countries in the years to come where, unlike Western

countries, populations would continue to play a dominant role under rainfed situations, However, under well managed irrigated conditions, hybrids would make much dent if seed supply is assured.

3. Looking to the intense and multifarious research requirements of the crop, fragmented approaches are not likely to pay much dividends. It would, therefore, be necessary to have one or tow centers of excellence preferably one national center in India where integrated approaches involving biotechnology, genetics, breeding, plant protection, biochemistry, processing and other related disciplines well supported with modern laboratory facilities can deliver the goods for this potential upcoming crop in the country.

ANNEXURE

LIST OF COMMERCIAL HYBRIDS AVAILABLE

1.	NS-H-45	39.	NS-H-7	77.	OROSOL*
2.	NS-H-43	40.	NS-H-10	78.	SC 062
3.	NS-H-44	41.	NS-H-11	79.	HYSUN 340
4.	NS-H-15	42.	NS-H-12	80.	HYSUN 354
5.	NS-H-17	43.	CONTIFLOR 3*	81.	SUNBIRD
6.	NS-H-26-RM	44.	CONTIFLOR 7	82.	DO 704 X L
7.	NS-H-27-RM	45.	CONTIFLOR 8*	83.	DO 855
8.	NS-H-33-RM	46.	CONTIFLOR 9	84.	DO 728
9.	NS-H-47	47.	CONTINENTAL P-86	85.	DO 705
10.	NS-H-HELIOS	48.	BARBARA	86.	DO 705
11.	NS-H-52*	49.	HNK-81	87.	IS 7111
12.	NS-H-53	50.	HNK-173*	88.	IS 33076
13.	NS-H-54	51.	IBH-166	89.	ISOMAX
14.	NS-H-55	52.	SUN M 20	90.	IS 320025
15.	NS-H-57	53.	S 1283	91.	HYSUN 32
16.	NS-H-58	54.	SF-100*	92.	HYSUN 33
17.	NS-H-60	55.	SF-102	93.	T-548
18.	NS-H-64*	56.	ADVANCE	94.	T-557 DW*
19.	NS-H-65	57.	CANNON	95.	T-560 A
20.	NS-H-66	58.	DYNAMITE	96.	T-565
21.	NS-H-68*	59.	SUPER 407*	97.	T-575
22.	NS-H-70	60.	SUPER 405	98.	DOBRICH
23.	NS-H-79	61.	SUPER 430	99.	ALBENA
24.	NS-H-84	62.	SUPER 530	100.	SUPER START
25.	NS-H-85	63.	SH-222	101.	OS-H-393
26.	NS-H-86	64.	NS-26	102.	OS-H-325*
27.	NS-H-87	65.	ALHAMA EXTRA	103.	OS-H-125
28.	NS-H-88	66.	SH-31	104.	OS-H-115
29.	NS-H-89	67.	SH-3322	105.	OD 128*
30.	NS-H-90	68.	SH-3822	106.	OD 123
31.	NS-H-91	69.	SH-3622	107.	OD 122
32.	NS-H-92	70.	FRANKASOL	108.	OD 106*
33.	NS-H-1	71.	ALPHASOL	109.	OD 105
34.	NS-H-2	72.	MIRASOL	110.	CMS 821/1264-1*
35.	NS-H-3	73.	CARGISOL	111.	S-335
36.	NS-H-4	74.	PARADISOL	112.	ST-349
37.	NS-H-5	75.	FLORASOL	113.	ST-330
38.	NS-H-6	76.	RIOSOL	114.	ST-314

115. SUNWHEAT 102*
116. SUNBRED 285
117. SUNBRED 281
118. SUNBRED 277*
119. PHARAON
120. SUNKING 256
121. VYP
122. TESORO 92
123. FLORIDA 2000
124. FLORAKISZ
125. DK 4020
126. C-100
127. DKS-39
128. DKS-37
129. SPS 7115
130. SPS 3094
131. SPS 3160*
132. SPS 3130
133. IS 3107
134. AG X 210 DW*
135. AG X 110
136. AG X 230*
137. SUNCROSS 60*
138. SUNCROSS 40 R*
139. NS-H-68
140. ARIFLOR
141. RUSTIFLOR
142. MAXIFLOR
143. FLORICA
144. CERFLOR
145. VERAFLOR
146. MIKAFLOR
147. MARYFLOR
148. TOPFLOR
149. EUROFLOR
150. RO-1418
151. RO-1390
152. RO-1213
153. RO-1155
154. RO-924*
155. No.17
156. No.5
157. PACHIN
158. IS 61074
159. IS 33142
160. IS 33241
161. SIGCO 375
162. SIGCO 471*
163. SIGCO 468
164. SIGCO 465 A
165. SIGCO 442
166. PACIFIC 3054
167. HYSUN 54*
168. HYSUN 44*
169. HYSUN 34
170. HYSUN 24
171. M-733
172. M-732
173. M-731
174. M-702*
175. M-701
176. CITOSOL 4
177. CITOSOL 3
178. VIKI
179. BLUMIX
180. VIGOR
181. VEGA
182. RODEO
183. PINTO
184. ELIA
185. GUADALSUR
186. TOLEDO 55
187. TOLEDO 2
188. MONRO 45
189. NS-H-53
190. NS-H-52
191. NS-H-15
192. NS-H-10
193. MULTISOL
194. SUPERSOL
195. AGRISOL
196. SOLARIS
197. NOVISOL
198. GLORIASOL

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* May be of merit to Network countries.

STATUS OF SUNFLOWER AS OILSEED IN BANGLADESH

M.A. Khaleque, and S.H. Mirza

Sunflower is a new oilcrop in Bangladesh. A cultivar named Kironi (DS-1) has been released by the National Seed Board in 1982. It is a selection from one introduced material "Elkopolski" from poland and has been introduced in the farmers' field in 1985. Prior to 1985, it was grown as a garden flower and as research material for experimental purpose only. Now it is growing in the districts of Rajashahi, pabna, Tangail, Gazipur, Comilla, Natore, Barisal and Dinajpur, Table 1.

Table 1. Sunflower demonstration in farmers' plots of variety Kironi (DS-1), in 1987-88.

District	No. of plots	Total area	Yield (kg/ha)	Remarks
Rajshahi	86	8.6	280	Farmers are interested
Comilla	50	5.0	358	Farmers are interested to grow, but feel problems of lodging and crushing seeds.
Tangail	07	0.7	390	Boys take away flowers, crushing problem identified
Barisal	06	0.6	490	People take away flowers. Farmers' willing to grow in large scale.
Dinajpur	20	2.0	719	Farmers' opinion "oil is better than mustard oil".
Gazipur	60	6.0	809	Farmers are willing to grow
Total	229	22.9	483	-

Source: Concerned officers of relevant districts of the Directorate of Agricultural Extension (DAE).

Statistics on its growing area is not yet available with Bangladesh Bureau of Statistics (BBS). Rainfall between 300-600 mm during the main growing period upto pre-flowering stage is desirable. But flowering in full rainy season (June-August) is not desirable because it causes lodging and sterility. Under improved management the yield ranges from 1400-1500 kg/ha. Due to its insensitivity to light and temperature, it can be cultivated throughout the year particularly in spring (early kharif), Autumn (late kharif) and rabi seasons.

There is a scope for growing sunflower after harvest of transplanted Aman rice in some of the northern districts of the country where enough residual moisture or irrigation is available. It bears positive prospect to reduce the chronic shortage of edible oil in the country. The crop has been introduced in the farmers' field to supply high quality oil as well as to grow the oilseed crop in two seasons.

Now, it is being cultivated by the farmers for its oil yield and they are consuming the oil from their produce, which is crushed either in bullock driven "ghani" or electric "ghani". It is also crushed by expeller in big markets where electric power is available. The oil is free from undesirable erucic acid and is rich in linoleic acid i.e. the essential fatty acid, Table 2. The seed contains 40-45% oil, but the extracted oil yield varies from 25% by ghani to 33% by expeller. The residue oil cake, which contains about 35% normal protein. The seeds are fed to polutry, caged birds or taken by wild birds. The cake is fed to cattle, but after shelling, it may be made suitable for human food in the form of chips or breads. The cake is free from toxins.

As a highly cross pollinated crop, maintenance of pure seed and short plant type is very difficult. Sterility, loss of viability, tall plants and bird damage are the major problems so far observed in sunflower cultivation. Seed filling may be improved by encouraging visits of honey bees as well as hand pollination. By growing the crop in larger area, the bird damage is likely to be reduced considerably.

Research should be carried out for developing short duration varieties with 100-110 days of maturity to fit it in the local cropping patterns. Early maturity, dwarf plants and convex head have been fixed as criteria for selection of desirable types.

Table 2. Percent of some important constituents of major oilseeds.

Crop	Oil	Protein	Oleic acid (18:1)	Linoleic acid (18:2)	Linolenic acid (18:3)	Erucic acid (22:1)
Rape & Mustard	40-45*	22-26*	11-15**	12-16**	9-11**	48-56**
Groundnut	48-49	22-23	45-48	32-34	2-3	Nil
Sesame	44	19.7	44.4	45.2	Trace	Nil
Sunflower	41.3	27.5	37.0	55.4	Trace	Nil

Source: Oilseed Research Center, BARI,
*Percent of the whole seed,
**Percent of total fatty acids.

SOME ASPECTS TOWARDS OVERCOMING VEGETABLE OILS INSUFFICIENCY IN EGYPT : PRODUCTION OF SUNFLOWER AND ITS IMPROVMENT IN SUEZ CANAL REGION

Abdel-Fattah Mohmed Abdel-Wahab

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To overcome vegetable oil insufficiency in Egypt, it has become very urgent to expand indigenous oil production through increasing the total area under oil crops as well as the production per unit area. Sunflower is considered promising in this respect. It is the second most important source of vegetable oil in the world, second only to soybeans. It can be grown in the new reclaimed lands as well as in the low maize-yielding soils without drastic changes in the crop rotation in Egypt. The crop responds well to new techniques of irrigation. Such conditions are prevailing in Suez Canal region.

The local varieties of sunflower have only about 30% oil while the new cultivars in the developed countries have more than 50%. Therefore, high yielding, short season with high oil content varieties should be introduced or bred to grow the crop successfully.

The research project entitled "Some aspects towards overcoming vegetable oils insufficiency in Egypt" was initiated in 1985 and continued in 1986 and 1987 seasons. The period of the project was two years. The main objectives of the project were to:

1. select the most suitable cultivars to be grown in Suez Canal region on different types of soil as well as under different irrigation systems.
2. have synthetic variety of higher seed and oil yields.
3. adapt the agricultural practices for the selected varieties such as sowing date, seeding rate and plant density, fertilization and weed control.
4. recommend areas to be cultivated with sunflower about 50,000 faddans (1 faddan = 4200 m^2) in Suez Canal region and adjacent reclaimed lands.

In this paper some of the agronomic studies conducted in the new reclaimed lands as well as in areas where maize is usually grown will be demonstrated.

SEASON I (1985)

I. Evaluation of Some Sunflower Varieties at Different Levels on New Reclaimed Lands

Materials and methods

Four field experiments were conducted, two at Ismailia under surface irrigation and two at Salhia project under sprinkler irrigation (Pivot irrigation). Meanwhile, at each situation, one experiment was performed as early summer sowing and the other as late summer one. In each experiment, 10 cultivars were evaluated at two levels of fertilization and three planting distances.

The cultivars were: 2 open varieties "Giza-1" and "Maiak" (Russian variety introduced to Egypt in 1970); 4 American hybrids "H. 7000", "H. 7111", H. 7116 " and H. 7780" and 4 French hybrids - "Elia", "Topflor", "Cerflor" and "Bolero". The American hybrids are produced by Interstate Seed and Grain Company, North Dakota, USA, while the French ones were imported for Salhia project. The local cv. "Giza-1" was not included in the late summer experiment at Salhia.

The two levels of fertilization were 40 kg N + 15 kg P_2O_5 + 25 kg K_2O per faddan and 80 kg N + 30 kg P_2O_5 + 50 kg K_2O per faddan. The three planting distances were 36, 30 and 24 cm between one-plant hills within the row 70 cm in width. The split-split plot design was used where the two fertilization levels were allocated in the main plots, the three planting distances in the sub-plots and the 10 varieties in the sub-sub plots. The experimental plot consisted of 4 rows 360 cm long and 70 cm wide in the two summer experiments as well as in the late summer at Salhia while in the late summer at Ismailia the plot was three ridges only.

Sowing was carried out on 28th April and 1st May in early summer and 19th July and 29th July in late summer at Ismailia & Salhia, respectively. Hand hoeing as well as irrigation were carried out as proper.

At 75 days from sowing, data were recorded for plant height, number of leaves/plant, fresh and dry weights/plant, fresh and dry weights of stem/plant, fresh and dry weights of head/plant, and number of days to flowering as well as to harvesting. At harvesting, the following data were obtained: plant height, head diameter, seed index, seed yield and seed oil content. The data were subjected to the proper statistical analysis of variance at the Central Lab., Computer Unit, Faculty of Agric., Alexandria University.

Results

A. Effect of fertilization: (Tables 1,2)

a. The high level of fertilization caused almost insignificant increases in the seed yield and its components such as head diameter and seed index, while the reverse was true in seed oil content.

b. The high level of fertilization is not recommended for sunflower in sandy soils under Ismailia Governorate conditions regardless of the irrigation methods.

B. Effect of planting distances: (Tables 3, 4).

a. In general, head diameter as well as seed index decreased consistently as planting distance was decreased from 36 to 24 cm and the differences were highly

Table 1. Effect of fertilization levels on yield and its components.

Fertilization Levels	No. of days to harvest	Plant height (cm)	Head diameter (cm)	100-seed weight (g)	Seed yield (kg/fad.)	Seed oil content (%)
			Ismailia Summer Experiment			
40 N + 15 P_2O_5 + 25 K_2O	104.70	163.19	15.90	4.74	1000	45.15
80 N + 15 P_2O_5 + 50 K_2O	104.20	161.58	15.70	5.03	1007	43.57
L.S.D. 5%	N.S	N.S	N.S	0.09	N.S	N.S
1%	N.S	N.S	N.S	0.17	N.S	N.S
			Salhia Summer Experiment			
40N + 15 P_2O_5 + 25 K_2O	115.0	117.0	16.30	5.27	850	41.02
80 N + 15 P_2O_5 + 50 K_2O	115.60	121.32	16.90	5.29	930	39.37
L.S.D. 5%	N.S	N.S	0.60	N.S	N.S	0.47
1%	N.S	N.S	N.S	N.S	N.S	0.69

Table 2. Effect of fertilization level on yield and its components.

Fertilization Levels	No. of days to harvest	Plant height (cm)	Head diameter (cm)	100-seed weight (g)	Seed yield (kg/fd.)	Seed oil content (%)
		Ismailia late summer experiment				
40 N + 15 P_2O_5 + 25 K_2O	-	85.30	8.41	4.315	568	42.44
80 N + 15 P_2O_5 + 50 K_2O	-	87.80	8.59	5.657	667	41.92
L.S.D. 5%	-	0.52	N.S	N.S	78	-
1%	-				N.S	
		Salhia late summer experiment				
40 N + 15 P_2O_5 + 25 K_2O	-	65.89	10.91	3.77	380.0	44.33
80 N + 15 P_2O_5 + 50 K_2O	-	70.16	13.00	3.77	378.0	45.10
L.S.D. 5%	-	N.S	3.34	N.S	N.S	N.S
1%	-	N.S	9.78	N.S	N.S	N.S

significant in all experiments, except in late summer under sprinkler irrigation at Salhia. However, comparisons between the three planting distances, within each experiment, showed that the highest seed yield was obtained with 30 cm under surface irrigation and with 24 cm under sprinkler irrigation. However, the differences were statistically significant in the late summer at Salhia only.

b. It could be recommended to grow sunflower at planting distance of 30 cm under surface irrigation and 24 cm under sprinkler irrigation.

C. <u>Effect of varieties</u>: (Tables 5,6,7 and 8)

a. According to the data of earliness (number of days to flowering and/or number of days to harvesting). The results showed the differences among the open varieties, the American and French hybrids.

The delay in flowering and maturing in Salhia experiments under sprinkler irrigation as compared to Ismailia ones under surface irrigation within each planting (summer or late summer) might be attributed also to the difference in the soil type. The soil at Ismailia was pure sandy, while at Salhia it was sandy loam.

b. In the Summer experiment at Ismailia under surface irrigation, the highest seed yields were obtained for the French hybrids followed by the open varieties without significant differences among them. That was more evident with planting distance of 24 cm and under the high or level of fertilization. In Salhia Summer experiment, the highest seed yields were obtained for Giza-1 followed by H. 7116 followed by H. 7780 and Elia. In the late Summer experiments, the French hybrids, Elia and Bolero gave the highest seed yields.

c. The highest seed oil contents were obtained from the hybrids Topflor, Maiak, H. 7780, Bolero and Elia in Ismailia Summer experiment under surface irrigation. The introduced hybrids gave higher seed oil content with planting distance of 30 cm. In Salhia Summer experiment, the hybrids Topflor and

Table 3. Effect of plant distances on yield and its components.

Planting distances	No. of days to harvest	Plant height (cm)	Head diameter (cm)	100-seed weight (g)	Seed yield (kg/fad.)	Seed oil content (%)
			Ismailia summer experiment			
36 cm	105.30	167.33	16.60	5.35	969	44.04
30 cm	104.40	162.73	16.10	4.94	1065	45.22
24 cm	103.70	157.09	14.80	4.35	975	43.93
L.S.D. 5%	1.17	N.S	0.73	0.16	N.S	
1%	N.S	N.S	1.03	0.22	N.S	
			Salhia summer experiment			
36 cm	116.4	133.90	18.20	5.54	870	40.64
30 cm	114.50	117.84	16.50	5.29	870	39.96
24 cm	115.10	116.04	15.40	5.02	930	40.75
L.S.D. 5%	N.S	6.07	0.90	0.12	N.S	0.47
1%	N.S	N.S	1.30	0.17	N.S	0.69

Table 4. Effect of plant distances on yield and its components.

Planting distances	No. of days to harvest	Plant height (cm)	Head diameter (cm)	100-seed weight (gm)	Seed yield (kg/fad.)	Seed oil content (%)
			Ismailia summer experiment			
36 cm	-	90.90	8.63	5.400	623	42.05
30 cm	-	82.90	8.92	4.928	651	42.12
24 cm	-	85.90	7.93	4.929	578	42.37
L.S.D 5%	-	0.59	0.35	N.S	N.S	
1%	-	0.86	0.42	N.S	N.S	
			Salhia late summer			
36 cm	-	71.52	12.80	3.95	354	43.37
30 cm	-	67.52	12.07	3.63	381	46.0
24 cm	-	65.06	10.99	3.72	402	44.79
L.S.D. 5%	-	N.S	3.34	0.07	-	-
1%	-	N.S	9.78	0.11	-	-

Table 5. Effect of varieties on yield and its components in Ismailia summer experiment.

Varieties	Plant height (cm)	Head diameter (cm)	100-seed weight (g)	Seed yield (kg/fad.)	Seed oil content (%)	No. of days to harvesting
Maiak	214.48	17.50	5.71	1005	46.68	112.00
Giza 1	266.57	18.10	5.84	1053	33.25	113.25
Hybrid 7000	136.51	14.80	5.67	820	42.82	100.60
" 7111	135.93	14.60	4.52	856	43.80	100.30
" 7116	140.65	14.60	3.78	975	44.87	100.55
" 7780	139.96	14.20	3.90	962	46.64	103.15
Elia	165.37	14.60	4.85	1169	46.40	104.30
Topflor	138.69	15.10	4.90	1028	48.03	106.55
Cerflor	145.48	14.80	4.60	1121	43.65	99.90
Bolero	138.58	15.50	5.02	1044	46.48	104.30
L.S.D. 5%	6.80	0.89	0.24	256	2.27	3.21
1%	8.91	1.17	0.31	336	3.01	4.22

Table 6. Effect of varieties on yield and its components in Salhia summer experiment.

Varieties	Plant height (cm)	Head diameter (cm)	100-seed weight (g)	Seed yield (kg/fad.)	Seed oil content (%)	No. of days to harvesting
Maiak	164.52	19.3	6.70	1150	40.33	132.6
Giza 1	193.08	20.8	6.77	1280	28.21	130.9
Hybrid 7000	97.92	14.8	5.85	640	40.70	108.6
" 7111	97.32	15.1	4.95	780	42.55	108.0
" 7116	101.64	16.1	4.61	960	43.64	110.6
" 7780	108.24	16.1	4.36	870	42.54	112.1
Elia	111.0	16.0	4.98	870	41.65	115.1
Topflor	100.20	15.7	4.35	710	44.73	114.7
Cerflor	110.16	16.0	5.27	840	40.61	108.1
Bolero	107.64	16.2	4.97	810	39.52	113.2
L.S.D. 5%	4.87	0.9	0.27	84	1.76	2.1
1%	6.38	1.2	0.35	114	2.34	2.7

Table 7. Effect of varieties on yield and its components in Ismailia late summer experiment.

Varieties	Plant height (cm)	Head diameter (cm)	100-seed weight (g)	Seed yield (kg/fad.)	Seed oil content (%)
Maiak	126.7	11.15	5.858	570	41.31
Giza 1	118.7	9.17	5.336	651	30.56
" 7000	82.2	8.77	5.578	554	41.00
" 7111	73.4	6.93	4.847	523	43.34
" 7116	78.7	8.18	4.293	572	43.99
" 7780	79.5	9.20	4.616	595	45.36
Elia	85.9	8.93	4.650	720	43.93
Topfor	78.5	8.19	4.859	653	48.18
Cerflor	75.2	6.83	4.239	663	41.34
Bolero	66.7	7.68	5.578	672	42.76
L.S.D. 5%	1.06	0.37	0.846	36	2.52
1%	1.41	0.50	1.130	48	3.34

Table 8. Effect of varieties on yield and its components in Salhia late summer experiment.

Varieties	Plant height (cm)	Head diameter (cm)	100-seed weight (g)	Seed yield (kg/fd.)	Seed oil content (%)
Maiak	97.38	14.82	3.80	465	39.21
Hybrid 7000	62.20	10.68	4.13	237	45.25
" 7111	60.57	11.52	3.64	361	44.19
" 7116	61.08	12.07	3.68	395	43.47
" 7780	62.68	11.93	3.28	329	42.35
Elia	72.43	12.64	4.16	474	44.95
Topflor	65.59	11.70	3.67	391	47.84
Cerflor	68.02	10.79	3.67	317	46.31
Bolero	62.28	11.42	3.87	442	48.29
L.S.D 5%	5.63	1.55	0.13	46.80	1.29
1%	7.48	2.07	0.17	61.95	2.65

H.7116 had the highest seed oil content and that was more evident with planting distance of 24 cm. In the late Summer experiment at Ismailia, hybrid Topflor followed by H. 7780 had the highest seed oil content with planting distance of 24 cm. H. 7780 responded negatively to the higher level of fertilization in this respect. However, under sprinkler irrigation at Salhia in the late Summer sowing, hybrids Bolero and Topflor had the highest seed oil content and that was more evident under the higher level of fertilization as well as with planting distance of 30 cm.

d. On the basis of earliness, seed yield per faddan and seed oil content, it is recommended for sunflower producers to cultivate the French hybrids as well as the American hybrids 7116 and 7780 for the Summer sowing in Sandy soil under surface irrigation, while under sprinkler irrigation at Salhia project where the soil is sandy loam, H. 7116 followed by 7780 and Elia are recommended for the same sowing. Although the seed yield decreased markedly in the late summer sowing, generally the same afore mentioned cultivars were also the superiors.

e. The open variety Maiak gave high seed yield and almost did not differ significantly from the high yielding hybrids in yield as well as in seed oil content. That was particularly true for the summer sowings. But this variety was relatively late-maturing (by about 2 weeks at Ismailia and 3 weeks at Salhia). Therefore, a breeding program of mass selection is recommended for its purification and earliness.

D. <u>Effect of planting dates</u>

The Summer planting in May resulted in high yields under surface as well as sprinkler irrigations, while in the late summer sowing (Nily), the yields remarkably decreased. Moreover, at Ismailia region, the yield was severly subjected to the attack of birds. Therefore, it is recommended to cultivate sunflower in both locations as a summer crop. However, sowing dates should be studied further.

SEASON II (1986)

In Summer 1986 season, a series of experiments were conducted in Ismailia province in areas where maize is usually cultivated. The following exp. were carried out:

II. <u>Evaluation of Some Sunflower Varieties at Different Planting Distances and Fertilization Levels</u>

<u>Materials and Methods</u>

The same experiment (I) which was conducted on the new reclaimed lands at Ismailia as well as at Salhia project in 1985, was also performed in 1986 season at Abo-Sultan district in a special farm, the soil of which is sandy loam.

The phosphorus fertilizer in the form of superphosphate 15.5% as well as the potassium fertilizer in the form of potassium sulphate 48% were added during soil preparation, while nitrogenous fertilizer was applied twice, one half before the second irrigation and the other half before the third irrigation. The following data were recorded: number of days to harvest, plant height at harvest, head diameter, 100-seed weight, seed yield.

Table 9. Effect of fertilization levels on sunflower characters in Abo-Sultan experiment during 1986.

Fertilization Levels	No. of days to harvest	Plant height (cm)	Head diameter (cm)	100-seed weight (g)	Seed yield (kg/fad.)
40 N + 15 P_2O_5 + 25 K_2O	104.0	151.1	17.8	7.28	974
80 N + 30 P_2O_5 + 50 K_2O	104.1	153.1	18.0	7.94	1042
L.S.D 5%	N.S	N.S	N.S	N.S	N.S
1%	N.S	N.S	N.S	N.S	N.S

Results

a. Effect of fertilization: (Table 9)

The studied characteristics were found to be affected slightly but insignificantly by increasing fertilization level. The increases in 100-seed weight and seed yield amounted to 9.06% and 6.89%, respectively.

b. Effect of planting distances: (Table 10)

Table 10. Effect of planting distances on sunflower characters in Abo-Sultan experiment during 1986 season.

Planting distances	No. of days to harvest	Plant height (cm)	Head diameter (cm)	100-seed weight (g)	Seed yield (kg/fd.)
36 cm	104.1	151.1	18.2	8.02	867
30 cm	103.7	153.3	18.0	7.66	1024
24 cm	104.1	152.0	17.5	7.16	1133
L.S.D. 5%	N.S.	N.S.	N.S.	0.396	32.91
1%	N.S.	N.S.	N.S.	0.557	47.80

Decreasing planting distance from 36 cm to 24 cm did not affect significantly, number of days to harvesting, plant height at harvesting and head diameter. On the other hand, 100-seed weight was found to decrease consistently and significantly as planting distance was decreased. Meanwhile, seed yield increased consistently and highly significantly as planting distance was decreased. There were increases in seed yield of 18.11 and 30.68% by decreasing planting distance from 36 cm to 30 and 24 cm, respectively.

c. Varietal differences: (Table 11)

Number of days to harvest: Significant differences were found among varieties The American hybrids as well as the French ones matured significantly earlier than the local varieties Maiak and Giza- 1 (by about 10 days). Meanwhile, the tallest plants were recorded for Maiak followed by Giza-1 and both differed highly significantly from the introduced varieties which did not differ significantly from each other in this respect.

Head diameter: the differences among the varieties were highly significant. Giza-1 followed by Maiak had the largest heads and both surpassed significantly the introduced hybrids. Hybrid 7116 had larger heads compared with the other introduced hybrids and deviated significantly from all of them except Elia.

100-seed weight: The differences among the varieties were highly significant. The heaviest seeds were

Table 11. Effect of varieties on sunflower characters n Abo-Sultan experiment during 1986 season.

Varieties	No. of days to harvest	Plant height (cm)	Head diameter (cm)	100-seed weight (g)	Seed yield (kg/fd.)
Maiak	111.5	221.8	20.0	8.64	1603
Giza 1	111.6	191.4	21.4	8.93	1470
Hybrid 7000	102.1	136.9	16.3	8.28	691
" 7111	102.1	137.0	16.7	8.18	788
" 7116	101.7	138.2	18.5	6.90	1023
" 7780	102.5	135.7	16.7	6.45	911
Elia	102.5	152.5	17.8	7.57	977
Topflor	102.4	138.9	17.4	7.52	901
Cerflor	101.7	141.9	17.5	7.00	940
Bolero	102.3	127.2	15.8	7.13	775
L.S.D. 5%	1.339	26.74	0.966	0.803	240.20
1%	1.772	35.39	1.280	1.063	317.92

those of Giza-1 while the lightest ones were those of hybrid 7780.

Seed yield: Over the two fertilization levels and the three planting distances, the highest seed yield was obtained from Maiak followed by Giza-1. Both local cultivars, highly significantly, out yielded the introduced hybrids. H.7116 had the highest seed yield when compared with the other introduced hybrids but it deviated significantly from H. 7000 only.

The interactions among the three factors did not affect significantly, all the studied characteristics.

III. The Response of Certain Sunflower Cultivars to Planting Distances at Different Planting Dates

Materials and Methods

Three field experiments were conducted on low maize yielding soil at Abo-Swier district in 1986 season at three dates of sowing (22 May, 12 July and 5 August). In each experiment, three cultivars namely, Maiak and the American Hybrids 7116 and 7780 were tested at four planting distances: 12, 18, 24 and 30 cm. The experimental design was split-plot with four replications. The planting distances were allocated in the main plots and the cultivars in the sub-plot. The plot consisted of four rows of 60 cm width and 360 cm length. Fertilizer was applied at 60 kg N + 15 kg P_2O_5. The phosphorus fertilizer was added before sowing in the form of calcium superphosphate, while nitrogen fertilizer was added twice before the 2nd and the 3rd irrigations in the form of Ammonium nitrate. Thinning was carried out after about 7 weeks from sowing. Data were recorded in two stages:

i. At 75 days from sowing: The following data were estimated on a sample of 3 plants taken randomly from the inner rows of each plot: plant height, fresh-weight per plant, dry weight per plant, and leaf area index (LAI).

ii. At harvesting: Plant height as an average of 10 plants, head diameter as an average of 10 plants, 100 seed weight, and seed yield.

The data were statistically analyzed and Duncan's multiple range test was used for comparison among averages.

Results

Table 12 indicates the mean averages of all characters at the three planting dates for the three varieties at the four studied planting distances.

1. Plant height (cm)

Plant height decreased consistently as planting distance was increased, but at 75 days from sowing, the differences were significant in the third sowing only, while at harvesting these differences were significant in the three sowings. Meanwhile, the differences between 24 and 30 cm were not significant. Maiak, as it was expected, had the tallest plants and differed significantly from the American hybrids 7116 and 7780 which almost did not differ from each other in this respect. However, plant height was decreased evidently by delaying sowing from 22 May to 12 July as well as to 5 August.

2. Fresh- and dry-weight per plant (g)

Both characters increased consistently as planting distance was increased. The planting distance of 12 cm deviated almost significantly, from the other distances, while the differences between 24 and 30 cm were not significant. Maiak had the heaviest plants as compared to H. 7116 and H. 7780. The plants of hybrid 7780 were heavier, but the differences were significant in July and August sowings concerning fresh weight and August sowing concerning dry weight. Plants became lighter by delaying sowing from May to July or August. The plants of May sowing were, on the average, heavier by 65.4% and 77.6% in fresh-weight and by 71.3% and 68% in dry-weight compared to those of July and August sowings.

3. Leaf area index at 75 days of sowing (LAI)

LAI decreased consistently as planting distance was increased. In May sowing, the differences between 12 and 18 cm as well as between 24 and 30 cm, were not significant, while in the July/August sowings the differences among the four distances were significant. Maiak had the highest LAI and deviated, significantly, from the other two hybrids. H.7780 plants had significantly larger LAI than H.7116 in July/August sowings.

4. Head diameter (cm)

Although head diameter increased consistently as planting distance was increased, the differences among the four planting distances were significant in July/August sowings only. Maiak gave larger heads than both hybrids, which did not differ significantly from each other. That was true in the three dates of sowing.

5. 100-seed weight (g)

This trait was not affected significantly by the plating distances when sowing in May as well as in August, while the weight increased consistently and significantly as planting distance was increased. H.7780 gave the heaviest seeds in the three sowings and differed significantly with Maiak and H.7116. In May sowing, H. 7716 resulted in seeds significantly heavier than those of Maiak, while the differences between them were not significant in July/August sowings. Generally, the seeds of May sowing were heavier than the seeds of the other sowing dates.

6. Seed yield (kg/fad)

In the May sowing, the highest seed yield was obtained by sowing sunflower at planting distance of 12 cm compared to the other distances, which did not differ significantly from each other in this respect. In the July/August sowing, the yield decreased consistently and significantly as planting distance was increased. There were no significant differences among the three cultivars in May sowing as wellas in July sowing, while in August H.7116 gave seed yield less than H.7780 and Maiak, which did not differ significantly from each other in this respect. There was significant interaction between distances and cultivars concerning the effect on seed yield. All over the factors studied May sowing outyielded July and August sowings by about 37%.

Table 12. Response of some sunflower cultivars to planting distances at different sowing.

Culti-	22/5/1986 Sowing					12/7/1986 Sowing					5/8/1986 Sowing				
	Planting distances (cm)					Planting distances (cm)					Planting distances (cm)				
vars	12cm	18cm	24cm	30cm	Avg.	12cm	18cm	24cm	30cm	Avg.	12cm	18cm	24cm	30cm	Avg.
Effect on plant height (cm) after 75 days:															
H.7116	179a*	185a	184a	160a	177B	123a	134a	132a	116a	126B	126de	126de	123e	118f	123B
H.7780	176a	166a	168a	157a	167C	128a	131a	127a	110a	124B	129de	130d	124def	106g	122B
MAIAK	213a	206a	194a	203a	204A	201a	197a	205a	178a	195A	212a	197b	194bc	187c	198A
AVG.	189A	186A	181A	174A	182	150A	154A	155A	135A	148	156A	151B	147C	137D	148
Effect on plant height (cm) at harvesting:															
H.7116	178d	178d	171de	166de	173B	140	136	128	120	131B	135e	132ed	126df	116g	127B
H.7780	173d	168de	162de	154e	164B	137	132	124	116	127C	134e	137e	125f	112g	127B
MAIAK	284a	256b	232c	238c	252A	266	242	223	216	236A	245a	232b	226c	219d	230A
AVG.	212A	201AB	188B	186B	197	181A	170B	158C	151D	165	171A	167B	159C	155C	162
Effect on fresh weight per plant (g) after 75 days:															
H.7116	722a	734a	950a	1097a	876B	360a	454a	556a	555a	481C	380a	435a	502a	528a	461C
H.7780	552a	942a	917a	998a	852B	476a	529a	596a	577a	544C	410a	454a	519a	540a	481B
MAIAK	939a	1283a	1107a	1325a	1164A	596a	676a	769a	851a	723A	491a	515a	572a	593a	543A
AVG.	738B	986A	992A	1140A	964	478B	553AB	640A	661a	583	427D	468C	531B	554A	495
Effect on dry weight per plant (g) after 75 days:															
H.7116	117a	118a	139a	161a	134B	58a	77a	80a	82a	74B	70a	82a	92a	94a	85C
H.7780	93a	143a	139a	164a	135B	67a	84a	79a	81a	78B	78a	87a	96a	95a	89B
MAIAK	156a	194a	175a	198a	181A	95a	104a	124a	118a	110A8	86a	87a	104a	98a	94A
AVE.	122A	152A	151A	174A	150	73A	86A	94A	94A	87	78C	85B	97A	96A	89
Effect on leaf area index after 75 days:															
H.7116	1.21	0.76	0.82	0.55	0.83B	0.72	0.62	0.56	0.43	0.58	0.75c	0.62de	0.59e	0.49fg	0.61C
H.7780	0.92	0.91	0.67	0.50	0.75B	0.91	0.63	0.56	0.49	0.65	0.95b	0.80c	0.59e	0.44g	0.70B
MAIAK	1.64	1.46	0.96	0.94	1.25A	1.21	1.01	0.98	0.78	1.00	1.09a	0.81c	0.68d	0.55ef	0.78A
AVE	1.25A	1.04A	0.82B	0.64B	0.94	0.95	0.75	0.70	0.57	0.74	0.93A	0.74B	0.62C	0.49D	0.70
Effect on head diameter (cm) at harvest:															
H.7116	16.7a	17.3a	17.7a	18.7a	17.6B	12.3a	14.3a	14.3a	14.7a	13.9B	7.7g	8.7g	10.7f	13.3de	10.1B
H.7780	15.7a	16.0a	18.0a	18.0a	16.9B	10.7a	12.6a	14.3a	15.0a	13.2B	7.7g	9.0g	12.7cd	14.7cd	11.0B
MAIAK	19.0a	21.0a	22.7a	25.0a	21.9A	14.3a	16.7a	18.7a	22.0a	17.9A	14.0cde	15.0c	17.3b	18.3a1	16.2A
AVG.	17.1A	18.1A	19.4A	20.6A	18.8	12.4D	14.6C	15.8B	17.2A	15.0	9.8D	10.9C	13.6B	15.4A	12.4
Effect on 100 seed weight (g):															
H.7116	6.57a	5.26a	6.42a	6.21a	6.11B	4.43a	4.78a	5.39a	5.29a	4.97B	5.07a	5.64a	5.26a	5.54a	5.38B
H.7780	7.41a	6.15a	7.21a	7.24a	6.94A	5.50a	5.64a	6.27a	6.28a	5.92A	5.68a	5.96a	6.41a	6.35a	6.10A
MAIAK	5.10a	5.37a	5.64a	5.88a	5.50C	4.70a	4.82a	5.08a	5.86a	5.12B	4.96a	5.07a	5.32a	6.20a	5.39B
AVG.	6.36A	5.59A	6.42A	6.44A	6.20	4.90C	5.08BC	5.58AB	5.81A	5.34	5.24A	5.56A	5.67A	6.03A	5.62
Effect of seed yield per faddan (kg):															
H.7116	1800a	1526a	1495a	1589	1602A	1410a	1288a	1159a	1040a	1224A	1330a	1183a	1047a	905a	1118B
H.7780	1916a	1508a	1472a	1483a	1594A	1297a	1175a	1133a	1063a	1167A	1437a	1334a	1066a	949a	1194A
MAIAK2	2144a	1555a	1533a	1636a	1717A	1412a	1198a	1095a	1049a	1188A	1450a	1294a	1093a	943a	1195A
AVG.	1953A	1530B	1500B	1569B	1638	1373A	1220B	1129BD	1050D	1193	1406A	1272B	1065C	932D	1169

Values followed by the same letter for each character are not significantly different.

RESPONSE OF SUNFLOWER TO NITROGEN APPLICATION AND PLANT POPULATION DENSITY UNDER IRRIGATION AT GIZA, EGYPT

Salwa I. El-Mohandes

In Egypt, there is a severe shortage in vegetable edible oils. The majority of local oil production comes from cotton seed. However, there is no prospect to increase the area devoted to cotton cultivation. Therefore, increasing oil production depends on cultivation of the new oilcrops, such as sunflower.

Maximizing sunflower yield under Egyptian condition can be achieved by introduction of good varieties and/or application of suitable cultural treatments. Nitrogen fertilization and plant population density are the main factors affecting yield and its components in sunflower.

Materials and Methods

The experimental site of this study was at the Faculty of Agric., Cairo Univ., Agric. Research Centre (ARC) at Giza. The soil type is loamy clay; the P^H 7.8-7.9, total N 0.11 - 0.12% and organic matter 1.17%. Three nitrogen levels, 30, 60 and 90 kg N/feddan (one feddan = 4200 m^2), were applied in the form of ammonium nitrate (33% N), after thinning, just before the first irrigation. Also, three plant densities were used (17,000, 35,000 and 70,000 plants/feddan). These densities were obtained in distributions by the following hill spacing and number of plants/hill. The variety used was Mayak:

System	Plant density	Row spacing (cm)	Hill spacing (cm)	Plant/ hill
I.	17.500	60	40	1
II.	35.000	60	20	1
III.	35.000	60	40	2
IV.	70.000	60	20	2

Results and Discussion

Effect of N fertilization

Two experiments were conducted. Data in Table 1 showed that an average of both experiments showed that increasing N level from 30 to 60 kg/feddan increased plant height, stem diameter, leaf area, leaf area index, head diameter, and dry weight of leaves, stems, head and tops. However, increasing N level from 60 to 90 kg/feddan did not significantly increase these characters. Also, increasing N level from 30 to 60 kg/feddan significantly increased yield and its components, i.e. head diameter, 500-seed weight and seed weight/head, Table 2.

Thus, the present results indicated that application of 60 kg N/feddan to sunflower was enough to maximize growth of the plants, seed and oil yields under the conditions of this study.

Effect of plant populaiton density

As plant population increased leaf area, head diameter, dry weight of leaves, stems and heads were decreased but leaf area index increased in both experiments, Table 3. However, plant height (in both experiments) and stem diameter (in the second one) were not significantly affected by population density.

Seed and oil yields of sunflower and their components (head diameter, seed weight/head, 500-seed weight) were significantly affected by plant population density. However, oil content was not significantly affected.

Table 1. Effect of N levels on plant characteristics at peak flowering.

		PLANT CHARACTERISTICS								
Experiment	N Levels (kg/fed)	Plant height (cm)	Stem diameter (cm)	Leaf area (dm^2)	Leaf area index	Head diameter (cm)	Dry weight (g) of leaves	Stem	Head	Total top
1	30	198.9	1.89	35.9	2.93	9.2	26.8	59.9	13.5	100.2
	60	213.6	2.10	48.6	4.12	10.0	38.6	93.2	15.2	127.0
	LSD 0.05	N.S.	N.S.	7.96	6.49	7.6	4.66	N.S.	N.S.	N.S.
2	30	116.5	1.54	31.8	2.67	7.7	24.8	25.0	79.7	57.77
	60	121.5	1.66	35.1	3.28	7.7	32.9	32.7	7.94	72.94
	90	129.0	1.78	34.5	3.01	8.2	36.0	29.6	8.4	74.0
	LSD 0.05	N.S.	N.S.	N.S.	N.S.	N.S.	5.78	5.69	N.S.	8.80

Table 2. Effect of N levels on yield and yield components.

Experiment	N levels (kg/fed)	Head diameter (cm)	Seed Weight/ head (g)	500 seed weight (g)	Seed yield (ton/fed)	Oil content (%)	Oil yield (ton/fed)
1	30	13.7	37.7	24.81	1.09	45.52	0.48
	60	15.0	49.5	28.72	1.43	44.54	0.64
	LSD 0.05	0.89	5.95	2.02	0.214	N.S.	0.143
2	30	14.26	53.73	28.60	1.34	45.17	0.46
	60	15.15	61.47	31.60	1.58	44.75	0.72
	90	15.55	62.52	32.27	1.51	43.97	0.67
	LSD 0.05	0.67	5.06	2.12	0.14	N.s	0.08

Table 3. Effect of plant population density on plant characteristics at flowering peak.

Experiment	Plant population density	Plant height (cm)	Stem diameter (cm)	Leaf area (dm^2)	Leaf area index	Head diameter (cm)	Dry weight (g) of Leaves	Stem	Head	Total top
1	I	211.3	2.20	55.9	2.31	11.0	44.2	84.7	18.3	147.2
	II	197.0	1.98	49.6	3.88	9.2	32.6	58.0	13.7	104.2
	III	211.5	2.03	40.5	3.88	10.0	33.1	69.1	15.5	117.7
	IV	205.4	1.75	27.3	4.53	8.4	21.1	54.6	9.8	85.5
	LSD 0.05	NS	0.21	11.75	0.92	1.41	6.74	12.26	4.42	17.8
2	I	116.5	1.89	35.4	1.51	8.7	28.5	40.6	9.5	78.6
	II	117.3	1.47	32.2	2.63	8.0	26.0	24.2	7.82	58.02
	III	124.9	1.64	39.3	3.28	7.6	49.1	28.7	7.91	85.71
	IV	130.8	1.69	28.2	4.52	7.3	21.4	22.2	7.18	50.78
	LSD 0.05	NS	NS	6.198	0.657	0.67	4.375	7.25	1.073	9.849

Inspite of the reduction in yield components, such increase in seed and oil yield could be explained by the number of harvestable plants which increased from 14,875 to 28,525 to 49000 plants /feddan, when plant population density increased from 17,000 to 35,000 to 70,000 plants/feddan, respectively, Table 4.

Regarding the plant population density of 35,000 plants/feddan, the average results of treatment used by two systems (II & III), revealed that system III resulted in greater harvestable plants, seeds and oil yields by 10.2, 13.1 and 10.2%, respectively, over system II, as an average of both experiments.

Table 4. Effect of plant population density on yield and yield components.

Experiment	Plant population density	Head diameter (cm)	Seed Weight/ head (g)	500 seed weight (g)	Seed yield (ton/fed)	Oil content (%)	Oil yield (ton/fed)
1	I	16.2	60.8	29.59	1.04	44.87	0.47
	II	13.9	41.0	26.22	1.16	44.69	0.52
	III	13.9	43.2	26.40	1.35	43.93	0.59
	IV	13.4	29.4	24.86	1.48	44.64	0.66
	LSD 0.05	0.81	7.29	1.94	0.177	Ns	0.124
2	I	17.38	72.22	31.18	1.02	43.64	0.46
	II	15.38	56.62	30.93	1.43	44.75	0.65
	III	14.27	55.69	30.65	1.59	44.26	0.71
	IV	12.89	52.42	30.51	1.86	45.87	0.86
	LSD 0.05	0.46	8.92	Ns	0.24	Ns	0.104

SUNFLOWER RESEARCH AND PRODUCTION IN EGYPT

Badr A. El-Ahmar

Sunflower seed is one of the most important sources of edible oil in most of the continents due to its wide range of adaptability in addition to high percent of excellent edible oil in the seed, 45-55%.

In Egypt, due to severe shortage of edible oil, sunflower (oil type) received a great attention from the high authorities since 1987 so that the area devoted to oil type sunflower was increased from 3000 ha in 1987 with an average seed yield of 0.5 to 7000 ha in 1988 with 1.5 ton/ha. This season, 1989, the area devoted to this crop is 8000 ha concentrated mainly in Fayoum and Behera provinces. The average seed yield of the harvested area (till end of August) was 2.97 and 2.2 ton/ha in the two provinces, respectively.

The increase in the average seed yield was due to holding a field day, showing the farmers the technology of oil type sunflower cultivation and the difference between the oil type and the large-seeded confectionery type to which the farmers are more familiar.

Research Activities on Sunflower

Breeding program

The objectives of sunflower breeding program focussed on developing varieties with such characteristics as:

1. Early maturity.
2. High in seed and oil yield.
3. Resistance to bird attack.
4. Resistance/tolerance to diseases.
5. Resistance/tolerance to salinity.
6. Suitability to prevailing weather during Egyptian summer.
7. Suitability to intercropping with sugarcane as winter cultivation.

To achieve these objectives the breeding program involved the following:

A. Composite population

In order to increase our genetic resources and widen genetic variability, seven composite populations were formed since 1979 up till now, two of them namely, No. 1/79 and 2/81 were formed in 1979 and 1981, while the others were made in 1988. Those composite populations are gene pools acting as sources of new germplasm, which give us good opportunity to select the desirable plants and characters as head bending, CMS, earliness, etc.

B. Synthetic varieties

Twelve inbred lines, quite similar phynotypically, were selected. Different cross combinations were made among the inbreds without emasculation and the produced seeds (hybrid and selfed) were grouped. Each group contains, at least, six different inbreds. Each group was sown in a suitable number of rows according to the amount of seed. All plants were bagged and pollen was collected. Hand pollination was made using the mixed pollen grains.

The construction of these synthetic varieties was started in 1987. The varieties will be tested next season in comparative yield trials.

C. Hybrids program

Cytoplasmic male sterile (CMS) plants were selected from composite populations viz., 1/79 and 2/81. In 1988, one CMS plant was crossed with an open pollinated variety (pure line) in order to obtain A,B lines, as the first step to produce hybrids. One CMS plant was crossed with an open pollinated variety in 1988. The hybrid seed was sown at Giza Res. Station in 1989. All the plants produced from this seed are CMS, which means, this variety does not have restorer gene. Two to three plants of the CMS progeny were back-crossed to the original open pollinated variety to obtain BC 1.

Some other open pollinated varieties were used as parents and crossed (2-3 CMS plants) with pollen grains of each open pollinated variety collected from each plant separately.

Crosses: In order to select an early maturing and short stem genotype, ten crosses were made this season (1989) using the commercial variety Mayak (O.P.) and three inbreds (tall stem, good head shape and diameter) as male parents and very short inbred lines as females. These crosses were made without emasculation of the female parents.

D. Breeding nursery

The sunflower breeding nursery included the following:

1) 90 pure inbred lines,
2) 2 cytoplasmic male sterile populations,
3) 2 restorer gene populations,
4) 40 cytoplasmic male sterile lines, and
5) 6 segregating generations (sown at Sakha).

E. Comparative yield trial

During 1987, 19 hybrids were tested for their potential of both seed and oil yields and adaptability to the Egyptian condition. The check was the local commercial Mayak. This experiment was carried out at Sakha (Middle Delta), Serw (north-eastern region of Delta) and Sids (Middle Egypt) research stations, Table 1.

Table 1. Summary of comparative yield trial (t/ha) 1987.

Varieties	Sakha	Serw	Sids	Mean	Oil %
Mayak	1.8	3.2	4.3	3.5	42.0
G 100	1.8	3.1	4.8	3.4	40.6
G 101	1.6	2.7	4.4	3.0	33.8
DK 4021	2.5	3.2	4.4	3.5	43.4
Bloero	2.9	2.7	4.0	3.7	36.6
Rodeo	1.0	2.3	3.6	2.3	37.4
Elia	1.6	2.6	4.6	3.1	39.5
Slow	1.8	2.6	4.6	3.2	42.7
Pariow	1.0	3.0	3.7	2.7	37.1
M 5131	2.1	2.8	4.7	3.4	39.7
U 5025	1.9	2.9	4.8	3.2	39.7
5077	1.2	2.9	4.5	3.4	39.7
6480	2.2	2.6	4.6	3.4	39.2
6431	2.0	3.3	4.5	3.3	44.4
6440	2.2	2.2	4.2	3.0	43.7
6U 0001	1.2	2.5	4.5	3.3	37.4
Florom 328	1.5	2.9	4.3	2.0	38.0
Florom 350	0.7	2.6	2.7	2.3	39.9
2.6IH - 173	1.6	2.0	4.3	3.1	39.1
Jnegi HNK 81	1.4	3.0	4.5	3.1	38.4
C.V. (%)	16.89	17.5	13.7		
LSD (0.05)	0.408	-	0.986		

At Sakha, two varieties, DK 4020 and Bloero, outyielded the check by 700 and 1100 kg/ha, respectively. In Serw Research Station, however, there was no significant difference between the tested hybrids but, some hybrids such as DK 4020 and 6431 have given about the same yield as the check. In Sids, Middle Egypt, 4 hybrids. G 100, Elia, U 5131 and U 5025 , out-yielded the check by 438, 305, 400 and 670 kg/ha, respectively. Concerning oil content, the hybrids DK 4020, 6431 and 6440 had 1-2% higher oil than the check.

In 1988, 32 hybrids were tested at Sakha and Serw Research Stations. At Sakha, Seven hybrids viz. U 5087, G 98, DICS 440, DKS 610 DKS 3849, DKS 3848 and Hysun 33, outyielded the check (Mayak) by 840, 470, 800, 590, 660, 690 and 510 kg/ha respectively, Table 2. The same hybrids except G 98 had a higher seed yield than the check at

Table 2. Summary of comparative yield trial of sunflower 1988.

Varieties	Seed yield (t/ha) Sakha	Sids	Mean	Oil (%)	Husk (%)
Mayak	2.59	1.35	1.97	42.0	20
Mikaflor	2.45	1.07	1.76	37.3	20
Topfflor	1.73	0.96	1.84	38.14	20
Euroflor	2.58	0.65	1.61	38.05	22
Cerflor	2.34	1.69	2.01	39.25	23
DKS 39	2.30	1.74	2.02	38.21	24
Sigco 475	2.37	1.02	1.69	38.78	28
" 465 h	2.43	1.38	1.90	39.03	22
" 452	1.72	1.90	1.81	37.39	18
" 468	1.88	1.41	1.64	39.44	22
U 5025	1.74	1.12	1.43	37.67	32
" 6480	2.11	2.11	2.11	38.39	25
" 6431	2.41	1.22	1.81	38.01	23
XF 569	1.64	1.08	1.36	37.93	32
U 5087	3.43	1.59	2.51	38.32	25
6 40047	2.53	0.99	1.76	37.98	24
G 98	3.06	1.22	2.14	38.07	20
G 90	2.36	1.93	2.14	34.86	29
DKS 440	3.39	0.94	2.16	38.73	29
" 600	1.62	0.83	1.22	38.73	23
" 610	3.18	1.98	2.58	39.01	22
" 3849	3.25	1.95	2.62	39.80	24
" 3850	2.05	1.67	1.86	37.63	22
Viki	2.05	2.04	2.04	38.96	25
DKS 3848	3.28	2.14	2.71	38.96	24
" 937	1.90	0.94	1.42	38.57	22
" 39	1.96	0.78	1.37	37.76	21
G 100	1.75	1.25	1.50	38.65	23
G 101	2.29	1.28	1.78	37.80	26
Hysum 23	2.04	0.78	1.41	37.87	24
" 33	3.10	2.08	2.59	38.47	31
" 54	2.34	0.86	1.60	39.16	26
PAC 354	2.08	1.12	1.60	39.01	21
C.V %	15.44	14.42			
LSD (0.05)	0.33	20.212			

Serw Res. Station. G 98 produced approximately equal seed yield with that of the check.

Across locations, the hybrids U 5087, DKS 610, DKS 3849, DKS 3848 and Hysum 33 out yielded the check by 540, 610, 650, 740 and 620 kg/ha, respectively.

Some of these hybrids are being tested on a large scale this season.

Agronomic studies

Fertilization

Sunflower like other crops requires a suitable amount of NK for each type of soil to produce a maximum seed yield.

An experiment including three varieties (Mayak, Rodeo and Elia), three N levels (70, 110 and 150 kg/ha) and two levels of k_2 0(0 and 60kg/ha) was conducted at four research stations in 1988. The preliminary results indicated that at Serw, Sakha, and Sids old lands there was no response for the higher 110 and 150 kg/ha doses of N due to the high fertility of the soils of these sites. The suitable nitrogen dose was 70 kg/ha. For Nubaria region (new colcarious soil), however, the suitable N dose was 110 kg/ha, Table 3. Sunflower does not respond economically to K_2O application except at Nubaria region in which the seed yield increased by 0.8 ton/ha when the amount of 60 kg k_2 O/ha was applied, Table 4. This experiment is being repeated this season.

Effect of levels and time of N application

Three levels (70, 110 and 150 kg/ha) and three times of application of N were tested for two seasons at two locations using one sunflower variety. The time of application was designed to apply:

1) all at the time of sowing,
2) all 30 days after sowing and
3) half at the time of sowing, and the other half 30 days after sowing.

The results showed that splitting N at a rate of 110 kg/ha significantly increased seed yield meanwhile application of N at a rate of 70 kg/ha at sowing time had a significant effect on oil content in both seasons and locations, Table 5.

Table 3. Summary of seed yield (t/ha) of three sunflower varieties to different NK doses, 1988.

Variet-ies	Treatments N	K	Locations Sakha	Serw	Nubaria	Sids
Mayak	70	0	3.6	2.3	3.3	1.7
	70	60	3.3	1.8	4.2	1.8
	110	0	3.7	2.4	3.9	2.0
	110	60	4.2	1.4	5.6	2.3
	150	0	3.9	2.6	4.6	2.7
	150	60	3.0	2.0	5.6	2.8
Rodeo	70	0	3.2	1.3	2.9	1.3
	70	60	3.1	1.1	3.6	1.4
	110	0	3.3	1.5	4.2	1.5
	110	60	3.2	1.6	4.3	1.7
	150	0	3.2	1.3	2.9	1.7
	150	60	3.1	2.2	3.9	2.2
Elia	70	0	3.1	2.0	3.2	1.4
	70	60	3.0	1.7	4.1	1.5
	110	0	3.3	1.5	4.1	1.9
	110	60	3.1	1.8	4.6	1.8
	150	0	3.4	1.6	4.5	1.9
	150	60	3.4	1.8	5.0	2.3
LSD	var		0.13	0.22	0.59	0.23
	N		0.83	0.22	0.05	0.10
	k		0.06	-	0.06	0.05
	Var. x N	0.14	-	0.09	0.17	
	Var. x K	0.10	0.28	0.10	0.09	
	N x K	-	0.28	-	0.09	

Table 4. Effect of NK fertilizer on seed yield (ton/ha) of sunflower at the 4 locations

Varieties	N (kg/ha) 70	110	150	K20 (kg/ha) 0	60
		Serw			
Mayak	2.0	1.9	2.3	2.4	1.7
Radeo	1.2	1.5	1.8	1.4	1.6
Elia	1.8	1.7	1.7	1.7	1.8
Mean	1.7	1.7	1.9	1.8	1.7
LSD:Var. = 0.218, N=0.218, K_2O=0.000					
		Sakha			
Mayak	3.4	3.7	3.8	3.7	3.5
Radeo	3.1	3.2	3.2	3.2	3.1
Elia	3.1	3.2	3.4	3.3	3.2
Mean	3.2	3.3	3.5	3.4	3.3
LSD:var = 0.134, N=.084, K_2O=0.060					
		Nubaria			
Mayak	3.7	4.7	5.1	3.9	5.1
Radeo	3.2	4.3	3.9	3.6	3.9
Elia	3.6	4.4	5.1	3.9	4.8
Mean	3.5	4.5	4.7	3.8	4.6
LSD:var = 0.059, N=0.053, K_2O=0.057					
		Sids			
Mayak	1.8	2.2	2.7	2.2	2.3
Radeo	1.3	1.6	2.0	1.5	1.8
Elia	1.4	1.8	2.1	1.7	1.8
Mean	1.5	1.9	2.3	1.8	2.0
LSD:var = 0.231, N=0.097, K_2O=0.053					

Table 5. Seed yield (t/ha) and oil content (%) of sunflower as affected by levels (kg/ha) and time of N application at Sakha and Sids, 1986 and 1987.

N levels	TIME OF APPLICATION: Sakha 1986 1	2	3	Mean	Sakha 1987 1	2	3	Mean	Sids 1986 1	2	3	Mean	Sids 1987 1	2	3	Mean
								Seed yield								
70	2.7	2.4	3.1	2.7	1.8	2.9	1.6	2.1	1.3	1.4	1.6	1.5	2.2	2.7	3.6	2.1
110	3.5	3.6	3.5	3.7	1.8	1.9	1.8	1.8	1.5	1.6	1.9	1.7	2.8	3.1	4.2	2.5
150	3.3	3.4	3.4	3.4	1.6	2.0	1.5	1.7	1.8	1.9	2.1	1.9	2.3	2.7	2.9	2.3
Mean	3.2	3.1	3.4		1.7	2.3	1.6		1.5	1.6	1.9		2.3	2.8	3.6	
LSD (.05)	N=0.397, Time=NS,				N=NS, Time=NS				N=0.10, Time=0.10,				N=0.431, Time=0.431			
								Oil content								
70	40.5	41.8	43.5	41.9	41.3	42.3	42.8	42.1	39.8	41.5	42.8	41.3	40.3	41.5	41.8	41.2
110	40.5	39.5	39.5	39.8	40.8	38.3	38.5	38.5	40.5	39.0	39.0	39.5	40.3	36.0	38.3	38.2
150	39.3	36.5	37.3	37.8	39.8	38.3	37.0	38.5	39.3	36.3	36.3	37.3	38.5	36.0	35.5	36.7
Mean	40.1	39.3	40.1		40.6	39.6	39.4		39.8	38.9	39.3		38.7	37.8	38.5	
LSD	N=0.8, Time=NS,				N=1.1, Time=NS,				N=0.7, Time=0.7,				N=1.3, Time=1.3			

1=All N at sowing, 2=All N 30 days after sowing, 3=1/2 at sowing and 1/2 after 30 days, NS=Not signif.

PERFORMANCE OF A NEW SYNTHETIC SUNFLOWER STOCK DEVELOPED FROM LOCAL AND INTRODUCED GERMPLASM AND FURTHER IMPROVEMENTS VIA POPULATION IMPROVEMENT METHOD

R. Shabana

The gap between production and consumption of edible oils in Egypt, as well as in many African countries, is increasing from year to year. The failure in ceasing the gap increments has many reasons, among which the population and consumption are the two main ones.

The population has increased from about 10 million at the beginning of the 20th century to 28 million in 1960. Nowadays, it became over 55 million and is expanding at a rate of about 3% every year. Surprizingly, not only the population that increased at a higher rate, but also the consumption of edible oil per person which increased in the last decade from 9 to 12 kg. Besides, the area under cotton, which was and still is the main oil crop in Egypt, decreased from 1.9 million feddan (1 feddan = 4200 m^2) with 888,000 MT of seed in 1960 to 1.05 million with 552,000 MT in 1986. As a result, self-sufficiency decreased from 95.4% of 1960 to 34% in 1980. At present, domestic production accounts for approximately one fifth of our consumption. Thus, more attention and investments are given to oil crops including sunflower.

International experience from sunflower growing countries revealed that crossing among a limited number of chosen selfed lines to develop synthetic cultivars would be a better way for sunflower improvement in most countries. Moreover, synthetic varieties of open pollinated crops are more acceptable in many third world countries due to the price policy and the prevailing market conditions. Hybrid seed of sunflower can only be produced in Egypt under some sort of governmental support through the distribution of subsidized seeds to the farmers.

Choice of parents

For the best choice of parents, an approach was made to define the model cultivar needed in Egypt (4) by testing 120 accessions which represent local and introduced germplasm in several evaluation experiments that covered the environmental conditions prevailing in Egypt. The work Continued in co-operation between the Agronomy Departments of Cairo and Suez-Canal Universities. Through this university's linkage programs, We made a collection from farmers in Middle and Upper Egypt who used to grow their own seed for many years. Although these land races had mixed seed colors (mainly white and striped seeds) which would affect their acceptance and lower their price, they were known to have a good yielding ability (2.4-3.6 tons/ha), under conditions of small holders. They showed also vigorous growth and adaptation. However, they had some disadvantages such as tallness, late maturity and low oil content (30% or less). We aimed to combine high oil content, earliness and shortness from exotic materials with high yield potential and adaptability of our land races. Thus, we tested all the available accessions at Giza and Ismalia. The evaluated accessions included a varietal cross which I made in the previous season between the two distributed cultivars in Egypt (Giza - 1 and Maiak) and some selections from previous works (5). At Giza, I used the polycross method to test the combining ability of the accessions that showed superiority in their characteristics to fit our need. Based on the evaluation experiments and the combining ability results, three land races were selected to be used as female parents together the two distributed cultivars. As male parents, we selected VN-03, VN-04, and VN-05, as gene sources for earliness and short stems; Citosol, Drysol, and ISEA were also selected as a source for high oil content. Characteristics of male and female parents against the F_1 of the varietal cross Giza-1 x Maiak are presented in Table 1.

Table 1. Mean characteristics of parents used to form the synthetic population.

Parents	Days to flowering	Plant height (cm)	Head diameter (cm)	1000 seed weight (g)	Seed* yield (t/ha)	Seed oil content (%)
Giza-1	85.5	383.2	20.9	96.45	3.06	29.59
Maiak	75.5	362.3	15.5	67.50	1.51	38.20
Varietal cross	83.0	432.6	19.0	85.55	2.36	33.50
ISEA	75.0	304.5	19.5	85.00	2.61	42.89
VN-03	58.0	168.5	18.4	62.10	1.13	41.23
VN-04	60.0	193.0	18.0	77.5	2.07	42.24
VN-05	49.5	92.0	7.0	56.60	0.62	33.11
Citesol	68.5	216.0	17.5	85.00	1.91	42.18
Land race	82.5	453.2	21.9	91.80	4.33	23.54
Land race	81.0	453.8	23.0	91.25	3.46	22.73
Land race	83.0	410.0	23.5	98.75	3.90	25.05

<u>Formation of base synthetic population</u>

MOre than 100 healthy plants per parent were selected for selfing by inducing the plants to form two branches (6). Selfing was continued for two seasons fall and summer). Visual selection was manipulated in the field. After harvest, heads with higher seed yield and oil content in each parent were kept. S_2 of female parents were sown 15 days earlier than male parents and were treated by GA_3 as a gametocide when heads were one cm. in diameter. Crosses between males and females were done by hand. Half the seed of each cross was evaluated in two diverse locations (Giza and Ismalia) in the summer of 1986. CRosses that showed less plant height, larger heads, absence of natural disease symptoms, bird resistance and morphological characteristics such as: drooping heads, lightness of seeds, more concave heads and bracts that extend over the head, were selected in the field. Based on the harmony in flowering date, crosses with high seed yield or oil content were grouped:

Group (I): included the earlier crosses with high oil yield.

Group (II): included medium maturing crosses with high oil yield.

Equal quantities of seed from crosses selected in each group (Synthetic 0) were mixed, irrespective of their seed color, to form Synthetic-1. Syn-1 from group I was assigned to the Agronomy Department, Suez Canal Univ. while, that from group II was my responsibility for further improvements. I will restrict myself in the rest of my presentation to improvements made with respect to group II.

Data in Table 2 show the ranges among the crosses from which we selected the ones that composed Syn-1.
It is obvious that taller plants dominated the crosses. Thus, one of the objectives is to increase gene frequencies for shortness. However, it seems a difficult task from the experience with my synthetic

population so far. Table 2 shows also transgressive segregations for achene yield per plant and oil percentage.

Table 2. Range among the crosses, mode and percentages of frequencies among the sunflower crosses, below or above the mode class.

Character	Range	Mode	Percentage of frequencies below modal class	above modal class
Number of leaves/plant*	19-59	34.39	50.79	37.30
Plant height (cm.)	127-375	257.21	32.59	35.56
Head diameter (cm.)	12-27	19.46	42.31	41.02
Achene yield (g/plant)	77-307	143.36	51.13	34.47
Oil content (%)	13.3-48.5	30.00	27.47	56.04

* Ranges for number of leaves among male and female parents were 7-39 and 17-46, respectively.

To increase gene frequencies for the desired characters, I began a recurrent slection program. In Zambia, a recurrent selection program was manipulated using a composite and it was possible to increase the potential yield from 1.5 to 2.5 mt/ha and the oil content from 28-32% to 35-44% on a country wide basis (3). The experiment revealed the advantages of local breeding programs.

In my recurrent selection program, I tested the general combining ability using a weak tester for the characters in question ($p < 0.5$). Thus, to screen the population for high achene yield, I used var Maiak as a tester. By contrast, to screen for oil content in the population, I used var. Giza-1 (oil content about 30% only) as a tester. Selection pressure of performance in the field and achene yield was 10% but about 1% was retained after oil analysis.

After one cycle of recurrent selection, the synthetic population was divided into six sub-populations based on achene yield, oil content or oil yield and seed color (black, white or striped). Performance of the six sub-populations (mean of five replications) is presented in Table 3.

I hope to continue in developing

Table 3. Field performance of six sub-populations after one cycle of recurrent selection in synthetic-1, summer 1989.

Sub population	Plant height (cm)	Head diameter (cm)	Achene yield (g/feddan)
A	342.17	17.09	26.18
B	314.03	17.60	24.38
C	290.10	18.06	28.11
D	342.20	18.78	29.06
E	328.53	17.43	25.51
F	343.70	17.09	25.19

these populations via population improvement. With this procedure, populations of plants are dynamic gene pools, to which new sources of germplasm are added when feasible, in which the frequencies of desired alleles are progressively increased through recurrent selection, in which genetic recombination is enhanced by massive hybridization among selected genotypes, and from which cultivars, inbred or parental lines can be extracted at any stage (2). Indeed, it had been also suggested (1) that a breeder who wants to start a population breeding program should spend 3.5 years evaluating and selecting plant materials from locally adapted and exotic sources for inclusion in the population. These suggestions are consistent with the present breeding work.

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RESPONSE OF SUNFLOWER AND ASSOCIATED WEEDS TO SOME SINGLE AND TANK MIXED HERBICIDES

A.F. Ibrahim[1], Z.R. Yehia[2], H.R. El-Wekil[2)] and E.O. Abusteit[1)]

Read by Dr. Said Tewfik

Abstract

Two field experiments were carried out during 1985 and 1986 seasons at the Farm of Sids Agric. Res. Station, A.R.C., Ministry of Agric. (Egypt), to study the effect of six herbicides applied in a single or tank mixtures applications as well as hand-hoeing treatment on sunflower plants and associated weeds under Egyptian conditions. Pendimethalin, alachlor, linuron, prometryn, terbutryn and chlorobromuron at 2.04, 2.304, 1.2, 1.92, 2.88 and 1.2 kg a.i/ha, respectively) were applied pre emergence in single applications. Pendimethalin and alacholor were combined with linuron, prometryn, terbutryn and chlorobromuron at the same rates in the tank mixed treatments. The untreated check was left without weed removal throughout the growing season.

Pendimethalin in single or in tank mixed treatments with terbutryn, prometryn and linuron as well as hand-hoeing treatment gave the highest control of narrow weeds, while excellent effectiveness against broad-leaved weeds was obtained by terbutryn and prometryn in mixture with pendimethalin. Whereas, pendimethalin applied in mixtures with terbutryn and prometryn provided the most effective control of the total weeds and gave significantly higher seed yield of sunflower as well as other yield components.

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1) Agron. Dept., Fac. of Agric., Cairo Univ., Giza, Egypt.

2) Weed Control Res. Dept., A.R.C., Giza, Egypt.

REPORT ON SUNFLOWER PRODUCTION IN DAKAHLIA GOVERNORATE, EGYPT

S.E. El-Kalla

Sunflower (*Helianthus annuus* L.) is considered the second most important source of vegetable oil in the world, second only to soybean. There are two types of sunflower, the oil-types and non oil-types. Seeds of oil type cultivars contain 38 - 50% oil and 14 - 19% protein.

Sunflower is adapted to a wide range of soil and climatic conditions. It can be planted over a rather wide range of dates. It is considered more drought tolerant than most crops and can therefore, be grown in most drought-prone regions and performs better than such crops as corn and soybean. Sunflower can be economically grown in the newly reclaimed soils at northern parts of Egypt which can not be planted with other crops such as corn or soybean.

Sunflower is relatively a new crop in the Egyptian agriculture and production aspects are not well understood. Thus, more care should be given to this crop for increasing its productivity to minimize the gap between the production and consumption of vegetable oil. Most of high yielding oil varieties are imported and need to be evaluated under the Egyptian circumstances. The proper cultural practices also need to be well recognized through continuous researches that must be done in the newly reclaimed soils in North Delta.

Under the environmental conditions, of El-Mansoura province, little investigations were conducted during the last decade, and came to the following conclusinons:

1. The response of two sunflower varieties to plant spacing and nitrogen rate was studied (2). It was reported that adding 45 kg N/faddan, resulted in the highest seed and oil yields/faddan (1 faddan = 4200 m^2). Sowing sunflower at a space of 25 cm between hills and 60 cm between ridges gave the highest seed and oil yields/faddan, Tables 1 and 2. The treatment having 45 kg N/faddan and sowing plants at a space of 25 cm between hills was recommended for raising sunflower productivity, Table 3 and 4. Despite higher oil content of the variety Maiak, it was inferior to Giza-1 in seed and oil yields (2).

2. Raising nitrogen rates up to 40 kg N/faddan, significantly increased seed yields (1). Phosphorus showed a relatively large positive effect on all studied characters, Table 5.

3. It was also reported that early sowing (1st week of May) favoured growth parameters, seed oil content as well as seed and oil yields (3). Nitrogen application significantly increased growth characteristics, as well as seed and oil yields. The recommendation was that sunflower should be sown at the first week of May with 45, 31 and 24 kg/faddan of N, P_2O_5 and K_2O, respectively (3).

Beside the bird damage, one of the major problems threatening sunflower production in Dakahlia Governorate is the ignorance of sunflower producers to use the suitable cultural practices that increase sunflower productivity under the newly reclaimed soil conditions.

The most limiting factors for sunflower production which need to be studied are:

Table 1. Mean seed yield (kg/faddan) of sunflower cultivars as affected by nitrogen levels and plant spacings, 1978 and 1979.

	Cultivars			
	Giza-1		Maiak	
Treatments	1978	1979	1978	1979
A. Nitrogen levels (kg/faddan):				
0	1048.7 a+	868.1 a	839.5 a	960.7 a
15	1308.7 b	1104.8 b	1044.9 b	819.5 b
30	1497.7 c	1296.0 c	1098.7 b	951.8 c
45	1716.5 d	1496.9 d	1257.7 c	1027.6 d
F Test	**	**	**	**
B. Plant spacing (cm):				
25	1477.5 a	1351.3 a	1180.1 a	1006.1 a
35	1366.6 a	1161.1 b	1041.2 b	854.0 b
45	1334.7 b	1061.9 c	959.4 c	757.0 c
F Test	*	**	**	**

+ Numbers followed by the same letter are not significantly different at 0.05 level. *,** Significant at .05 and .01 levels.

Table 2. Mean oil yield (kg/faddan) of sunflower cultivars as affected by nitrogen levels and plant spacings, 1978 and 1979.

	Cultivars			
	Giza-1		Maiak	
Treatments	1978	1979	1978	1979
A. Nitrogen levels (kg/faddan):				
0	328.48 a+	295.83 a	327.90 a	303.18 a
15	420.32 b	351.50 ab	408.12 b	361.43 b
30	439.53 b	387.22 bc	420.42 b	401.37 c
45	470.23 b	454.93 c	461.58 b	422.75 c
F Test	*	*	*	**
B. Plant spacing (cm):				
25	455.39 a	421.20 a	435.91 a	428.20 a
35	394.84 b	363.21 b	398.09 b	361.40 b
45	393.70 b	322.71 c	379.51 b	326.95 c
F Test	**	**	**	**

+ Numbers followed by the same letter are not significantly different at 0.05 level. *,** Sifnificant at .05 and .01 levels.

Table 3. Mean seed yield (kg/faddan) of sunflower variety Mayak as affected by the interaction of nitrogen level (kg/faddan) and plant spacings (cm between hills), 1979.

Nitrogen levels	Plant spacings (cm)		
(kg/faddan)	25	35	45
0	762.7 d+	690.5 b	618.9 a
15	922.1 hi	813.6 ef	723.0 c
30	1140.2 k	908.5 h	806.6 e
45	1199.5 l	1003.3 j	879.8 g

+ Numbers followed by the same letters are not significantly different at 0.05 level.

Table 4. Mean oil yield (kg/feddan) of sunflower var. Majak as affected by the interaction of nitrogen and plant spacing, 1978 and 1979.

Nitrogen levels (kg/faddan)	Plant spacing (cm) 1978			1979		
	25	35	45	25	35	45
0	322.9 a+	328.9 a	321.9 a	333.9 b	296.7 b	279.0 a
15	413.0 bc	402.9 bc	408.5 bc	396.2 de	359.0 bc	329.2 ab
30	501.1 d	409.9 bc	350.3 ab	489.0 f	374.4 cd	340.7 bc
45	496.7 d	450.7 cd	437.4 cd	493.8 f	415.5 e	358.9 bc

+ Number followed by the same letters are not significantly different at 0.05 level.

Table 5. Effect of nitrogen and phosphorous levels on sunflower characters, 1979 and 1980.

Treatment	CHARACTERS: Seed weight per head (g) 1979	1980	1000-seed weight (g) 1979	1980	seed yield (kg/fad.) 1979	1980	Oil content (%) 1979	1980
Nitrogen levels:								
N_0: (without N)	56.3	49.3	73.9	70.4	1049	861	32.9	33.4
N_1: 20 Kg N/fad.	68.1	60.1	78.1	74.2	1356	1115	31.8	32.2
N_2: 40 Kg N/fad.	77.8	71.3	84.0	79.0	1540	1261	30.1	31.6
F-test	**	**	**	**	**	**	**	**
H.S.D at .01 level	0.7	1.8	1.9	0.5	32	10	0.3	0.3
Phosphorus levels:								
P_0: (without Phos.)	63.6	57.8	76.8	73.3	1251	1069	31.9	32.3
P_1: 15 kg P_2O_5	67.2	60.2	78.8	74.6	1328	1079	31.6	32.1
P_2: 30 kg P_2O_5	71.1	63.1	80.4	75.8	1367	1089	31.4	31.8
F-test	**	**	**	**	**	**	**	**
H.S.D. 5%	0.5	1.4	1.5	0.4	25	8	0.2	0.2
" 01%	0.7	1.8	1.9	0.5	32	10	0.3	0.3

** Significant at .01 level.

1. Selecting the high yielding cultivars, the suitable planting dates and the proper plant population and distribution.
2. Determining sunflower requirements for N P K fertilizers as well as micro-nutrients.
3. Raising fertilizer efficiency through proper time and method of application.
4. Searching for suitable methods of weed, pest, disease and bird control.

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STUDIES ON DIALLEL CROSS IN SUNFLOWER (*HELIANTHUS. ANNUUS* L)

Khaled Hammad

The acute shortage of edible oil in Egypt leads to a great deal of concern to the production of different oil crops, especially sunflower. Increasing yield and oil content is one of the important objectives in sunflower breeding. The main objective of this investigation is to evaluate six sunflower (*Helianthus annuus*) populations per-se and their diallel crosses with respect to the type of gene action for agronomic and technological characters. The parents are: Giza-1, Mayak, Int. 763, Int. 764, Int. 797 and Int. 800, Table 1.

Table 1. Origin and major characteristics of the parental cultivars*.

No.	Cultivars	Name	Origin	Days to flowering	Plant height	Diameter Head	Diameter Stem	Yield/ plant	100-seed weight	Oil (%)	Husk (%)
1	Giza-1	Girasol white G_1	Turkey	Very late	Tall	Big	Thick	High	Heavy	Low	High
2	Mayak	Mayak	Bulgaria	Late	-	Medium	Medium	Medium	Medium	High	Low
3	Int. 763	Argent-ario	Italy	Medium	Short	-	-	-	-	Medium	Medium
4	Int. 764	Ala	-	-	Medium	-	-	-	-	-	-
5	Int. 797	Amiata	-	Early	-	-	-	-	-	-	-
6	Int. 800	Alpian	-	Medium	Short	-	Thin	-	-	-	-

*These cultivars were kindly supplied from the Oil Crops Research Sections, Field Crops Research Institute, Agricultural Research Center, Giza.

The investigation was carried out at the Nubaria Research Station and the analyses were performed using model 2 of Griffing's method. Parents and F_1 plants were grown in a randomized complete block design with 4 replications.

The results are presented in Tables 2 and 3. It is shown that the largest portion of genetic variation was due to the additive variance. For all characters, the results revealed that the additive genetic variance was the largest component of the genetic variance while non-additive was also present in small magnitude.

General combining ability (g.c.a)

Days to flowering: From Table 4, it could be seen that significant g.c.a. effects were obtained for all traits. The two cultivars, Giza-1, and Mayak have proved to possess the largest positive effect indicating that they have the longest number of days to flowering. The other cultivars possessed negative estimates, with cultivar Int. 800, possessing the largest negative estimate.

Plant height: Positive estimates were deteced for the two cultivars, Giza-1 and Mayak. The other introduced cultivars exhibited negative estimates. The g.c.a. effect for Int. 763 was not significant.

Head diameter: Significant positive effect was recorded for the cultivars Giza-1, Mayak and Int.800, negative estimates were recorded for the other cultivars, but the two estimates of Int.763 and 797 were not significant.

Stem diameter: g.c.a. effects were highly significant for all cultivars while the effect in the introduced

Table 2. Mean performance of the different parents and their crosses for the characters studied.

Entries	No. of days to flowering	Plant height (cm)	Head dia. (cm)	Stem dia. (cm)	Yield/ plant (g)	100-seed weight (g)	Oil (%)	Husk (%)
P_1	79.25	222.43	21.71	3.06	92.04	9.37	28.59	37.36
P_2	67.14	193.38	19.55	2.50	67.00	7.85	41.61	26.42
P_3	61.66	123.18	17.04	2.00	53.97	7.15	37.65	27.39
P_4	61.60	134.36	16.35	1.86	58.73	7.64	36.87	29.51
P_5	59.84	149.28	17.76	2.04	60.91	7.51	33.06	27.71
P_6	62.83	121.08	17.00	1.75	53.85	7.53	33.01	29.65
$P_1 \times P_2$	65.24	230.93	22.38	3.01	122.18	10.45	30.92	34.89
$\times P_3$	64.36	246.36	24.49	3.16	141.84	10.85	30.84	36.44
$\times P_4$	65.14	233.33	22.63	2.83	104.56	8.85	30.15	35.32
$\times P_5$	65.29	237.43	23.70	3.30	125.51	9.99	30.34	36.73
$\times P_6$	63.46	226.45	22.19	2.94	111.93	9.42	33.32	33.76
$P_2 \times P_3$	65.45	213.24	21.70	2.83	112.50	8.96	37.60	30.42
$\times P_4$	69.10	209.75	21.86	2.82	92.09	8.14	36.76	28.73
$\times P_5$	60.54	191.13	22.55	2.98	85.74	9.27	37.18	25.95
$\times P_6$	63.43	209.39	21.58	2.86	99.99	8.47	39.32	28.88
$P_3 \times P_4$	55.31	172.84	19.30	2.52	62.67	8.10	34.97	28.94
$\times P_5$	59.66	171.65	20.75	2.38	79.53	7.99	38.01	26.87
$\times P_6$	54.34	172.80	19.60	2.46	69.17	8.15	37.49	26.65
$P_4 \times P_5$	64.01	185.39	20.26	2.47	75.05	8.52	38.19	26.65
$\times P_6$	50.26	150.28	19.30	2.23	76.79	9.07	32.61	31.16
$P_5 \times P_6$	55.43	150.06	17.83	02.11	64.50	7.91	35.45	27.01
L.S.D. 0.05	2.46	21.42	2.19	0.33	19.97	0.94	4.28	3.01
0.01	3.51	28.49	2.91	0.43	26.56	1.25	5.66	3.99

P_1 = Giza-1, P_2 = Mayak, P_3 = Int.763, P_4 = Int.764, P_5 = Int.797, P_6 = Int.800.

Table 3. Mean squares for entries, combining ability and error variance for the studied characters using Griffing's Method-2.

S.O.V.	d.f	No. of days to flowering	plant height (cm)	Head diam. (cm)	Stem diam. (cm)	Yield/ plant (g)	100-seed weight (g)	Oil (%)	Husk (%)
Reps	3	96.15**	3398.72**	18.73**	0.78**	721.79**	3.197**	45.30**	16.70*
Entries	20	136.00**	6134.06**	21.58**	0.81**	2684.52**	4.09**	52.10**	57.76**
g.c.a.	5	86.78**	3983.05**	13.17**	0.50**	1493.65**	2.83**	40.52**	48.13**
s.c.a	15	16.65**	717.04**	3.66**	0.12*	396.99**	0.46	3.87	2.88*
E	60	0.87	57.36	0.60	0.01	49.86	0.11	2.26	1.13
Error	60	3.49	229.43	2.39	0.05	199.4	0.46	9.03	4.52
g.c.a.:s.c.a		5.2:1	5.6:1	3.6:1	4.8:1	3.8:1	4.2:1	10.5:1	16.7:1

**Significant at 0.01 level, * Significant at 0.05 level.

cultivars was negative and significant.

Yield: Giza-1 and Mayak possessed the highest positive effect. The other cultivars possessed insignificant or negative estimates. Also Giza-1 possessed the highest value.

100-seed weight: Significant g.c.a. effects were found for Giza-1, Int.76 and Int. 800.

Oil content: Significant negative effects were calculated for Giza-1.

Mayak and Int.763 possessed significant positive effects, while estimates for the other cultivars were not significant.

Husk percentage: Highly significant g.c.a. effect was found for Giza-1. Significant negative effects were also detected for Mayak, Int.763 and Int.797.

Finally, it could be concluded that Giza-1 and Mayak proved to possess the highest values of g.c.a. effects for most of the characters studied. These two varieties could be included in the breeding program to utilize their superior characters.

Specific combining ability (s.c.a):

Days to flowering: Table 5 shows that significant s.c.a effects were obtained for the crosses Giza-1 by each of Mayak, Int.763 and 800. The cultivar Mayak, however, has proved to be good combiner for this character.

Plant height: s.c.a. effects showed significant estimates for the crosses of Giza-1 with each of the other cultivars except Mayak.

Crosses with Mayak also showed significant s.c.a. effects except with Int.797, other crosses were of inconsistent trend.

Head diameter: s.c.a effects were significant for the crosses Giza-1 with each of Int.763, 764 and 797; Mayak with each of Int. 764, 797, 800; and Int. 797 X Int. 800.

Stem diameter: Significant s.c.a. effects were recorded for the crosses: Giza-1 with each of Int. 764, 797, and 800; Mayak with each of Int. 764, 797 and 800.

Yield/plant: Significant s.c.a. effects were found for the crosses Giza-1 with each of Int. 763, and 797; and Mayak X Int. 800.

Oil content: Negative and significant s.c.a. effects were calculated for the crosses Giza-1 X Mayak and Int. 763 X Int. 800. Positive and significant estimates, however, were calculated for the crosses Giza-1 X Int. 800 and Int.797 X Int. 764.

Husk percentage: s.c.a. effects were significant for the crosses Giza-1 with each of Int. 763 and 797 and Mayak with each of Int. 763 and 764.

Table 4. General combining ability effects for all the characters studied using Griffing's Method-2.

Varieties	No. of days to flowering	plant height (cm)	Head diam. (cm)	Stem diam. (cm)	Yield/ plant (g)	100-seed weight (g)	Oil (%)	Husk (%)
Giza-1	5.739**	38.05**	1.95**	0.915**	28.20**	0.982**	-5.48**	5.40**
Mayak	2.120**	15.79**	0.75**	0.323**	4.53	0.068	3.411**	-1.58**
Introduced 763	-1.705**	-11.46**	-0.41	-0.086**	-4.97	-0.256*	1.82*	-0.36*
" 764	-1.771**	-11.83**	-0.89**	-0.181**	-10.38**	-0.305**	0.40	-0.66
" 797	-1.433**	-10.08**	-0.32	-0.089**	-6.66*	-0.213	0.00	-1.75**
" 800	-2.951**	-20.47**	1.09**	-0.382**	-10.72**	-0.290**	-0.136**	-0.53
S.E	0.30	2.440	0.249	0.0375	2.719	0.113	0.485	0.343
C.D. (0.05)	0.592	4.780	0.486	0.0735	5.329	0.220	0.951	0.672
C.D. (0.01)	0.776	6.270	0.640	0.097	6.987	0.290	1.246	0.882

Table 5. Specific combining ability effects for the characters studied using Griffing's Method-2.

Cross	No. of days to flowering	Plant height (cm)	Head diam. (cm)	Stem diam. (cm)	Yield/ plant (g)	100-seed weight (g)	Oil (%)	Husk (%)
P_1 x P_2	-4.92**	10.76	-0.78	-0.17	5.48	0.76**	-2.77*	0.99
x P_3	-1.97**	31.92**	2.49**	0.25*	33.65**	1.49**	1.25	2.02*
x P_4	-1.13	19.25**	1.11*	0.02	1.97	-0.46	-1.94	0.40
x P_5	-1.31	21.61**	1.61*	0.40**	20.00**	0.59**	-0.63	3.21**
x P_6	-1.63	21.02*	0.87	0.20*	9.79	0.09	2.48*	-0.10
P_2 x P_3	2.74	21.05*	0.90	0.16	25.03**	0.51*	-1.27	2.27**
x P_4	1.45*	17.94**	1.55**	0.24**	10.68	-0.26	0.62	0.08
x P_5	-2.45**	-2.30	1.67**	0.31	1.41	0.78**	-0.57	-1.30
x P_6	-1.96	26.23**	1.46**	0.34**	-14.02*	-0.06	1.70	0.39
P_3 x P_4	-3.51*	9.28	0.14	9.21*	-10.24	0.03	-1.58	-0.23
x P_5	0.50	5.35	1.02	-0.02	3.52	0.17	1.86	-0.99
x P_6	-3.30**	-28.12**	-.64	0.21*	-3.30	0.07	1.47	-0.60
P_4 x P_5	4.92*	19.45**	1.02	0.16	4.83	0.41	2.76*	-1.62*
x P_6	-7.43**	-5.39	0.82	0.08	9.93	1.04**	-2.69*	-1.66*
P_5 x P_6	-2.49*	-7.23	-1.23**	-0.14	5.28	-0.22	0.55	-1.09
S.E	0.684	5.543	0.565	0.985	6.167	0.256	1.099	0.778
C.D (0.05)	1.340	10.86	1.107	0.166	12.087	0.502	2.154	1.525
C.D (0.01)	1.758	14.246	1.446	0.218	15.849	0.658	2.824	1.999

P_1 = Giza-1, P_2 = Mayak, P_3 = Int.763, P_4 = Int.764, P_5 = Int.797, P_6 = Int.800.
* = Significant at 0.05 level, ** = Significant at 0.01 level. (4)

EFFECT OF SOME INTERCROPPING PATTERNS OF SUNFLOWER/SOYBEAN ON YIELD, YIELD COMPONENTS AND LAND USAGE IN EGYPT

M.A. Madkour

In Egypt, there is a big gap between the demand for edible oils and oil production, Table 1. So, high oilseed yield per unit area becomes of prime importance to meet the increasing demand and the lack of arable land.

Table 1. Production and consumption gap in edible oil crops.

Season	Oil produc. (M.T)	Oil consump. (M.T)	Produc. gap (M.T)	% Self sufficiency
1981/82	115,000	429,000	314,000	26,8
1986/87	120,000	637,000	517,000	18,8

In the old lands, we have to plant major crops such as cotton, maize, rice, etc. The new lands ought to be planted with oilcrops and/or intercropped with the major crops.

Intercropping systems practiced by farmers generally produce more total yields per unit area than sole cropping systems. It has been pointed out, by many investigators, that a yield advantage of 20 - 50% is commonly obtained by intercropping.

Two field experiments were conducted during 1982 and 1983 crop seasons at Sids Agric. Research Station, Middle Egypt, to study the effect of eight intercropping patterns and solid planting on yield and other characters of soybean (*Glycin Max* L. Merr.) variety Calland and sunflower (*Helianthus annuus* L.) variety Maiak . Soybean was planted on May 20 and 25, 1982 and 1983 crop seasons, respectively. Three weeks later, sunflower was planted. Soybean was harvested on Sept. 22 and 25, 1982 and 1983, while sunflower was harvested on sept. 24 and 30, 1982 and 1983, respectively.

Plots were made up of 8 ridges, 4 X 4.8 m^2, arranged in randomized complete block design with four replications. Phosphorus fertilizer was added at a rate of 30 kg P_2O_5 /faddan (1 faddan = 4200 m^2 during seed bed preparation and N at 60 kg/faddan in split application; the first half at sunflower sowing and the second at thinning. The plots were irrigated every two weeks.

The experiments were planted in highly productive clay loam soil at pH 7.5 and the preceding crop was onion and wheat in 1982 and 1983 respectively. The treatments were:

1. Solid planting of soybean (140,000 plants/fad) using the optimum population for high production.
2. Solid planting of sunflower (23,333 plants/fad) using the optimum population for high production.
3. Pattern I: One side ridge of soybean (140,000 plants/fad.), alternating with one ridge of sunflower one plant/per hill (23,333 plants/fad).
4. Pattern II: Soybean on both sides of one ridge (280,000 plants/fad.), alternating with one ridge of sunflower, one plant/hill.
5. Pattern III: Two ridges of soybean on one side alternating with two ridges of sunflower, one plant/hill.
6. Pattern IV: Two ridges of soybean on two sides alternating with two ridges of sunflower, one plant/hill.
7. Pattern V: One side ridge of soybean, alternating with one ridge of sunflower, two plants/hill (46,666 plants/ha).
8. Pattern VI: One ridge of soybean on both sides, alternating with one ridge of sunflower, two plants/hill.

9. Pattern VII: Two ridges of soybean on one side, alternating with two ridges of sunflower, two plants/hill.
10. Pattern VIII: Two ridges of soybean on two sides, alternating with two ridges of sunflower, two plants/hill.

Calculation of land Equivalent Ratio (LER) has been a common practice in intercropping studies (6). LER is determined as the sum of fractions of the yields of the intercrop relative to their crop yields, as depicted in the formula below. It is usually assumed that the "level of management" must be the same for intercropping as for the solid cropping.

$$LER = \frac{Y_{ab}}{Y_{aa}} + \frac{Y_{ab}}{Y_{bb}} \; \frac{Y_{ab}}{Y_{aa}} + \frac{Y_{ab}}{Y_{bb}}$$

Where,

Y_{ab} = mixture yield of species (a) in combination with (b).

Y_{aa} = pure stand yield of species (a)

Y_{ba} = mixture yield of species (b) in combination with (a)

Y_{bb} = pure stand yield of species (b).

Relative Crowding Coefficient (RCC), assumes that mixture treatments form a replacement series (1). Each species has its own coefficient (k), which gives a measure of whether that species has produced more or less yield than expected.

$$K_{ab} = \frac{Y_{ab} \times z_{ba}}{(Y_{aa}-Y_{ab}) \times z_{ab}}$$

for species (a) (in a mixture with species (b)).

Similarly for species (b) (in a mixture with species (a)), it can be calculated as follows:

$$K_{ba} = \frac{Y_{ba} \times z_{ab}}{(Y_{bb}-Y_{ba}) \times z_{ba}}$$

Where,

z_{ab} = sown proportion of species (a) (in mixture with (b)).

z_{ba} = sown proportion of species (b) (in mixture with (a)).

Aggressivity usually denoted by 'A' also assumes that mixtures form a replacement series and gives a simple measure whether the relative yield increase in species a is greater than that of species (b)(3):

$$A_{ab} = \frac{Y_{ab} \qquad - \qquad Y_{ab}}{Y_{aa} \times Z_{ab} \qquad Y_{bb} \times Z_{ba}}$$

where, Aab is the aggressivity value of species (a) in combination with (b).

$$A_{ba} = \frac{Y_{ba}}{Y_{bb} \times Z_{ba}} - \frac{Y_{ab}}{Y_{aa} \times Z_{ab}}$$

where, Aba is the aggressivity value of species (b) in combination with (a).

The results could be summarized as follows:

1. Most intercropping patterns reduced the yield components (pods/plant, seed/plant and 100-seed weight) of soybean. The best result was obtained from pattern 5 (35 pods/plant and 74 seeds/plant) compared with soybean in pure stand, Table 2.

2. Pure stand of soybean significantly out yielded intercropped. Intercropping soybean at high population produced higher seed yields compared with soybean at low population, Table 2.

3. Some intercropping patterns recorded higher oil contents in soybean seeds than solid planting, Table 3.

4. Intercropping Sunflower/ soybean, specially at low population of sunflower increased stem and head Diameters of sunflower, but

number of leaves/plant was not affected whereas husk percentage of sunflower was reduced.

5. Intercropping patterns at low population of sunflower increased seed yield/plant of sunflower compared with solid planting and other intercropping patterns, Table 3.

6. In general, intercropping reduced seed yield significantly as a result of the reduction in actual area grown. On the other hand, the yield per unit area at dense sunflower population was significantly higher than that of lower population. At high population of sunflower plants, oil content was favorably affected by intercropping, Table 3.

7. Most intercropping patters of sunflower/soybean increased LER. The land usage has been increased in 7 patterns out of 8 depending on the tow seasons average. Best LER values were obtained when both crops were grown at higher population densities, Table 4.

8. The RCC/(K) value of intercropping was greatly influenced by population densities of both intercrop components. k value reached its maximum where both crops were intercropped at higher population, Table 5.

9. Aggressivity (A) as an average of both seasons showed that in soybean/sunflower mixture, sunflower was the dominant component in 6 out of 8 patterns, Table 6.

Table 2. Effect of intercropping patterns of Calland soybean (with Maiak sunflower) on the yield, yield components and other characters average of 1982 and 1983 seasons.

Soybean Characters	Solid planting	Intercropping patterns I	II	III	IV	V	VI	VII	VIII	L.S.D
Leaf Area Index (LAI)	4.78	4.92	7.40	5.47	7.14	5.73	6.86	5.24	6.56	0.34
Plant height, (cm.)	86.50	70.70	80.30	72.80	69.40	72.40	75.80	65.30	75.10	3.60
No. of branches/pl.	2.20	1.33	1.44	1.93	1.69	1.26	1.85	2.15	1.43	0.25
No. of pod/pl.	34.98	32.98	33.68	32.53	27.23	35.98	32.49	30.30	27.84	2.65
No. of seeds/pl.	67.15	67.41	58.23	66.43c	58.71	74.00	60.16	63.30	58.06	4.23
100-seed wt., (g).	17.14	17.19	14.09	17.50	14.34	15.69	13.62	16.68	14.48	0.50
Seed yield/pl.(g).	11.66	11.67	7.66	11.48	8.12	11.37	8.42	10.41	8.25	0.66
Seed yield, kg/fad*	1125.00	538.00	713.00	533.00	724.00	542.00	724.00	522.00	709.00	46.00
Relative yield(%)	100.00	48.00	63.00	47.00	65.00	48.00	64.00	46.00	63.00	-
Protein (%)	34.61	33.18	32.44	33.08	32.58	32.48	32.61	31.81	32.59	0.68

* Actual yield.

Table 3. Effect of intercropping patterns of Maiak sunflower (with Calland soybean) on the yield, yield components and other characters: average of 1982 and 1983 seasons.

Soybean Characters	Solid planting	Intercropping patterns I	II	III	IV	V	VI	VII	VIII	L.S.D
Leaf Area Index (LAI)	4.55	5.43	6.24	5.95	5.23	8.64	9.83	9.25	9.75	0.42
Plant height, (cm.)	180.9	178.0	173.7	177.5	176.6	174.4	171.9	169.9	181.9	5.20
Stem diameter, (cm.)	1.99	2.05	1.83	2.12	1.63	1.56	1.67	1.67	1.87	0.10
No. of leaves/pl.	28.4	27.7	27.0	28.1	29.3	26.8	27.7	26.6	28.9	1.60
Head diameter, (cm.)	19.08	20.11	19.91	19.33	20.78	16.95	16.94	16.91	16.98	0.94
Husk (%)	24.05	23.28	22.94	21.94	22.99	20.89	20.88	23.90	24.41	0.93
100-seed wt., (g)	6.98	7.52	7.15	6.76	7.99	6.88	7.04	6.64	7.54	0.58
Seed yield/pl.(g)	34.42	40.66	35.89	35.45	38.47	24.78	24.35	27.54	27.67	2.65
Seed yield (kg/fad)	782.00	462.00	408.00	403.00	437.00	563.00	553.00	625.00	629.00	49.00
Relative yield (%)	100.00	59.00	52.00	52.00	56.00	72.00	71.00	80.00	80.00	-
Oil (%)	41.90	42.91	43.38	43.12	44.07	43.73	44.48	43.13	42.97	0.55

* Actual yield.

Table 4. Land equivalent ratio (LER) for intercropping Calland soybean and Maiak sunflower in 8 different patterns of intercropping in 1982 and 1983 seasons.

Year	Intercropping patterns I	II	III	IV	V	VI	VII	VIII
1982								
L Soy.	0.48	0.63	0.48	0.66	0.48	0.63	0.46	0.62
L Sfl.	0.62	0.52	0.53	0.56	0.73	0.70	0.83	0.80
LER	1.10	1.15	1.01	1.22	1.21	1.33	1.29	1.42
1983								
L Soy.	0.18	0.65	0.47	0.63	0.49	0.66	0.46	0.64
L Sfl.	0.56	0.53	0.51	0.56	0.71	0.72	0.77	0.81
LER	1.04	1.18	0.98	1.14	1.20	1.38	1.23	1.45
2-Years average								
L Soy.	0.48	0.63	0.47	0.65	0.48	0.64	0.46	0.63
L Sfl.	0.59	0.52	0.52	0.56	0.72	0.71	0.80	0.80
LER	1.07	1.15	0.99	1.21	1.20	1.35	1.26	0.43

L Soy = Land Equivalant Ratio For Calland Soybeans in mixed stand.
L Sfl = Land Equivalant Ratio For Maiak Sunflower in the mixed stand.
LER = Land Equivalant Ratio For Calland soybean and Maiak sunflower yields.

Table 5. Relative Crowding Coefficient (RCC) resulting from intercropping Calland soybean and Maiak sunflower in 8 different patterns of intercropping in 1982 and 1983 seasons.

Year	Intercropping patterns							
	I	II	III	IV	V	VI	VII	VIII
1982:								
K Soy.	0.91	1.71	0.92	1.97	0.91	1.70	0.87	1.64
K Sfl.	1.63	1.07	1.11	1.29	2.74	2.30	4.83	4.03
K.	1.48	1.83	1.02	2.54	2.49	3.91	4.20	6.61
1983:								
K Soy.	0.92	1.75	0.88	1.73	0.97	1.92	0.86	1.77
K Sfl.	1.28	1.11	1.02	1.25	2.41	2.55	3.38	4.18
K.	1.18	1.94	0.90	2.16	2.34	4.90	2.91	7.40
2-year average								
K Soy.	0.92	173.00	0.90	1.84	0.94	1.81	0.87	1.70
K Sfl.	1.44	1.09	1.06	1.27	2.57	2.33	3.93	4.11
K.	1.32	1.89	0.95	2.34	2.42	4.22	3.46	6.99

K Soy. Relative crowding coefficient for Calland soybean in mixed stand.
K Sfl. " " " " Maiak sunflower in mixed stand.
K. Product of relative crowding coefficient ck soy. x k sfl.

Table 6. Aggressivity values of intercropped Called soybean and Maiak sunflower in 8 different patterns of intercropping in 1982 and 1983 seasons.

Year	Intercropping patterns							
	I	II	III	IV	V	VI	VII	VIII
1982								
A Soy	-0.284	0.226	-0.095	0.199	-0.513	-0.132	-0.731	-0.359
A Sfl.	0.284	-0.226	0.095	-0.199	0.513	0.132	0.731	0.359
1983								
A Soy	-0.168	-0.221	-0.080	0.152	-0.431	-0.120	-0.622	-0.359
A Sfl.	0.168	0.221	0.080	-0.152	0.431	0.120	0.622	0.359
2-year average								
A Soy	-0.226	0.224	-0.088	0.176	-0.472	-0.126	-0.676	-0.350
A Sfl.	0.226	-0.224	0.088	-0.176	0.472	0.126	0.676	0.350

A Soy = Aggressivity value of soybean.
A Sfl. = " " " sunflower.

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SUNFLOWER DISEASES IN EGYPT

Arafa A. Hilal

There are 14 known diseases of sunflower (*Helianthus annuus*, L) but only 6 are commonly observed, Table 1. We have contended with most of the diseases recorded in the sunflower growing countries. The first known disease was rust (*Puccinia helianthi* Schwu.), which was recorded in 1931. Root-rot incited by *Sclerotium bataticola*, and *Rhizoctonia solani* was reported on sunflower in 1957. Other diseases were, however, observed between 1970 and 1988.

Diseases known to be present in one area may not be found in others. Some destructive diseases in one area may be of little significance in another because of differences in environment or cultivars. Disease occurrence, prevalence, and severity may differ from year to year.

Some of the sunflower diseases; (charcoal rot, leaf spot, root-rot and rust) have been intensively studied in Egypt. Whereas, little work has been done on the other diseases. Therefore, it is important to determine the nature of these diseases, and such factors as soil and climatic conditions.Means for their control should also be established.

Table 1. List of sunflower diseases in Egypt.

Disease	Pathogen	Comment
1. Charcoal rot	*Machrophomina phaseolina*	Major disease
2. Rust	*Puccinia helianthi*	" "
3. Leaf spots (complex)	*Alternaria alternata*	" "
	Curvularia lunata	
	Drechslera rostrata	
	D. spicifera	
	Ulocladium botrytis	
	U. septosporum	
	Botryodiplodia theopromae	
4. Wilt	*Fusarium oxysporum*	*Uncommon*
5. *Southern blight*	Sclerotium rolfsii	Minor disease
6. Stalk and head rot	*Sclerotinia sclerotiorum*	" "
7. Powdery mildew	*Erysiphe cichoracearum*	" "
8. *Head rot*	Rhizopus arrhizus	Heavy damage on
	Aspergillus spp.	short cultivars.
9. Root-rot (complex)	*Rhizoctonia solani*	Minor disease
	Pythium spp.	
	Fusarium spp.	
10. Verticillium wilt	*Verticillium dahliae*	" "
11. Gray rot	*Botrytis cinerea*	Scarce
12. Black stem	*Phoma oleraceae* var.	"
	Helianthi-tuberosi	
13. Root-knot	*Meloidogyne* spp.	Heavy losses in sandy soil
14. Bacterial disease	*Pseudomonas solanacerum*	Scarce

Charcoal rot as a major disease is found in most of the growing areas in Egypt, where damage ranges between 5 and 80%. Symptoms of the disease start to appear on 35-45 days old plants and are not usually apparent until after flowering. In infested fields, dark discoloration on the outer surface of the stem basal parts is predominant, and premature ripening and drying stalks which bear poor heads are evident. Varieties Giza-1 and Giza-2 were more tolerant to the disease than the other tested ones. The disease affects plant growth and reduces head diameter, total seed yield, 1000 seed weight, and oil content. Depending on environmental conditions and cultivars, the disease can cause 10-30% yield loss. Many trials were carried out on the control of charcoal rot by applying fungicides as seed dressing. Benomyl, Thiophanate-methyl, Vitavax/Thiram and Homai at the rate of 3-5 g/kg seed gave efficient control of the disease.

Rust is one of the major diseases of sunflower in Egypt. It was frequently observed in different governorates in the Delta, Middle Egypt and as far south as Sohag. Moreover, it is prevalent in north western areas and newly reclaimed lands where the spray irrigation is widely applied. From the previously reported four Races, only Race-1 was identified in Egypt. Plantvax, Calixin and Daconil-2787 gave sufficient control to sunflower rust when applied three times at the rate of 0.25%.

Leaf spot diseases were frequently caused by *Alternaria alternata*, *Drechslera spicifera* and *D. rostrata* and to a lesser extent by *Ulocladium* spp. and *Curvularia lunata*. Head rot caused by *Rhizopus arrhizus* always followed by head wounds was severe under moist conditions on short-stem varieties.

Root rot diseases were caused by *Rhizoctonia solani, Pythium* spp. and *Fusarium* spp. Powdery mildew caused by *Erysiphe cichoracearum* occurred on late maturing sunflower. Several cases of Southern blight disease attributed to *Sclerotium rolfsii* were observed in many fields, mainly in Upper Egypt. Heavy infestation of root-knot nematodes (*Meloidogyne* spp.) was reported on sunflower grown in sandy soil.

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Part 3

SESAME AND SUNFLOWER

GENERAL

THE VEGETABLE OIL/PROTEIN SYSTEM PROGRAM: THE KENYAN EXPERIENCE

Carlos Zulberti

The purpose of this paper is to report the various steps undertaken, the different actors participating and some of the results being obtained in the process of developing and implementing the Vegetable Oil/Protein System (VOPS) program in Kenya. The description of the integrated approach being followed to characterize, analyze and generate research and policy interventions of the oil/protein Production, Processing, Marketing and Utilization (PPMU) system has as its main objective, the generation of awareness on the work being done, the appraisal of its usefulness, and the assessment of its potential for implementation in other countries of the region. It is expected that at the end of the meeting the participants will evaluate the possibilities following a similar approach in their respective countries and estimate the interest that their colleagues at home will have in carrying out this kind of work in the future.

Background

The International Development Research Centre (IDRC) is a Canadian public corporation established in 1970 by the Parliament of Canada to support research designed to adapt science and technology to the needs of developing countries. As part of its mandate, IDRC began to fund oilcrops research projects in East Africa, the Middle East and South Asia in the late 70's. After few years, the need to promote and facilitate contacts between research workers investigating similar subjects but in relatively isolated places was identified. To ameliorate the problem, partially, due to the lack of an international agricultural research centre responsible for most of the important oilseed crops, the Oil Crops Network was established with a permanent Technical Advisor to coordinate its activities. The first meeting of the Network took place in Cairo six years ago (3-8 September, 1983). Several other gatherings have taken place since then and four Subnetowrks have emerged, two of which are meeting here today.

In 1986, while the Network was strengthened by having more participants and expanding its activities, the world prices for oils and fats were following a downward trend reaching the lowest levels in 14 years. The decline in prices was mostly caused by accumulation of stocks due to the supply growing faster than the demand. It can be seen in Figure 1 that using palm oil as an example, the prices were below 300US$/MT in the years before 1972 and 1986.

Those low levels were not attained during 1973-1985 period. As a consequence of the significant price-drop, the possibility of continuous over production and the collapse of the market was felt as a real threat. As someone quite eloquently put it at that time " The rivers of palm oil from the Far East will flood the mountains of butter in Europe".

Figure 1 also shows that substantially different conclusions could be drawn depending on which length of time is used to analyze past prices. If the last 20 years are taken into consideration, the general tendency is for the price of palm oil to increase. While if the last 15, 10 or 5 years are used, the tendency is decreasing, at a rate given by the slope of the regression line; increasing as the period of analysis shortened. In other words, it was during the last few years, immediately before 1987, that the

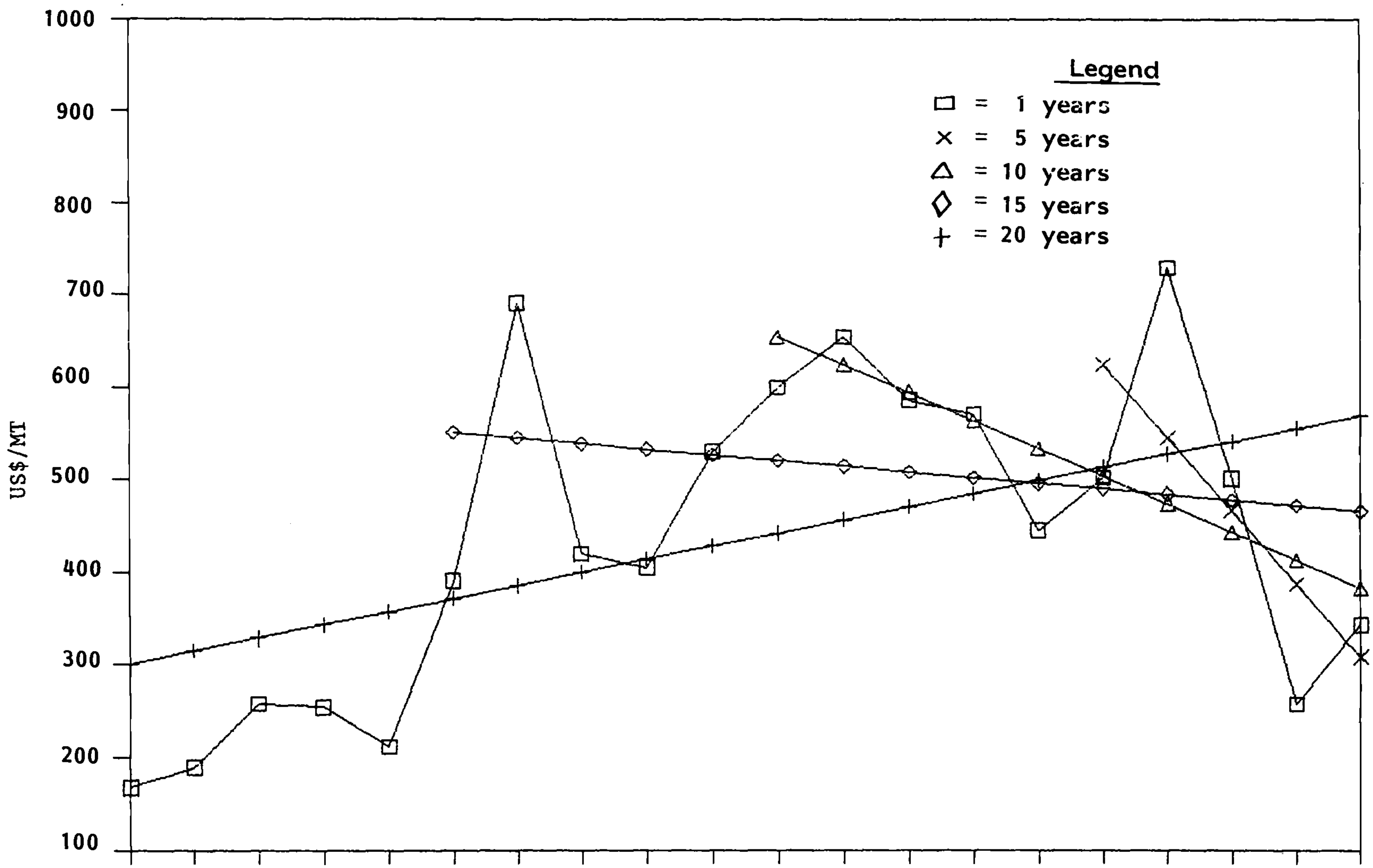

Figure 1: PALM OIL PRICES
Sum/Mal, cif N.W. Eur.

prices really decreased, reversing the previous growing tendency and significantly changing the future outlook of the sector.

Figure 2 shows that what has been said for palm oil closely applies to sunflower oil which has a very similar price change pattern while enjoying a premium due to its relatively better quality*.

A similar situation also existed for cakes. Using soybean meal prices as an example, Figure 3 shows that the tendencies were alike but gradient of the slope for soybean meal was substantially smaller than for oil's. While the price of palm oils decreased at an average yearly rate of US$ 18.01, 31.87 or 79.70 per MT depending if 15, 10 or 5 years were taken into consideration, the prices of soybean meal decreased US$2.28, 2.85 and 8.20/MT/year during the same periods. In other words, the relative importance of oil, as one of the products obtained from oilseeds, was diminishing in comparison with the cake. And, both commodities were showing the same downward trend observed in many other agricultural and non agricultural commodities.

Under these circumstances, IDRC professionals began to query if it was still justifiable to allocate limited research funds to oilcrops research when its future looks so bleak. They started to speculate to what extent the decline of fats and oil prices in the international markets would negatively affect the cultivation of oilcrops at the local level to the point of making irrelevant the generation of more productive technologies through agricultural research. Or even under decreasing oil prices to what extent the demand for protein cake for animal production could help justify the continuous cultivation of oilseeds, especially in those countries where oilcrop research has been funded or being considered for support.

A meeting to discuss the subject between the Associate Director (Agricultural Economics) and the Program Officers (Crops and Animal Production Systems and Postproduction Systems) from the Agriculture, Food and Nutrition Science (AFNS) Division and the Program Officer (Economics) of the Social Science Division took place in the East African Regional Office (Nairobi) in October 1987.

Based on the discussions held with a number of informed Kenyans from Government, research institutes, and industry and a potential international consultant, the need for a four-stage investigation aimed at establishing the economic as well as technical feasibility of oilseed production and processing with particular reference to the marketing of the meal for animal feed was identified.

The four stages were**:

a) A consultancy to formulate a project that would investigate the principal economic, technical and institutional factors determining the economic and technical feasibility of oilseed production and processing (3 months).

b) Locally based research into the principal economic, technical and institutional factors affecting the economic and technical

* Unfortunately, international price data for sesame is not available for the same periods of time but, it could be expected that, if available, will show very similar tendencies.

** The description of the four presented in its original form as they appear in the earlier document. Later on it was slightly modified to improve their presentation and understanding.

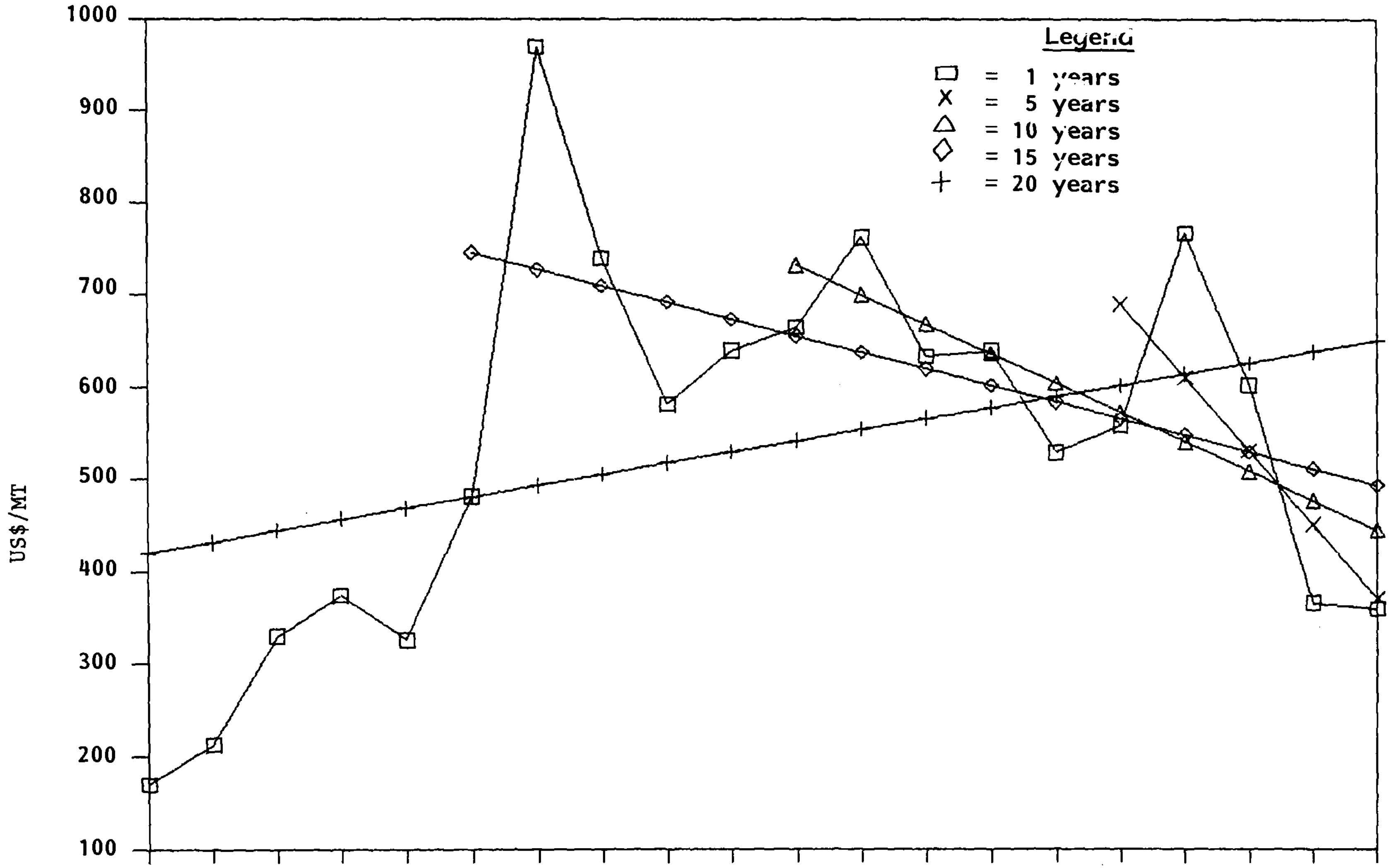

Figure 2: SUNFLOWER OIL PRICES
any orig, ex-tank Rott

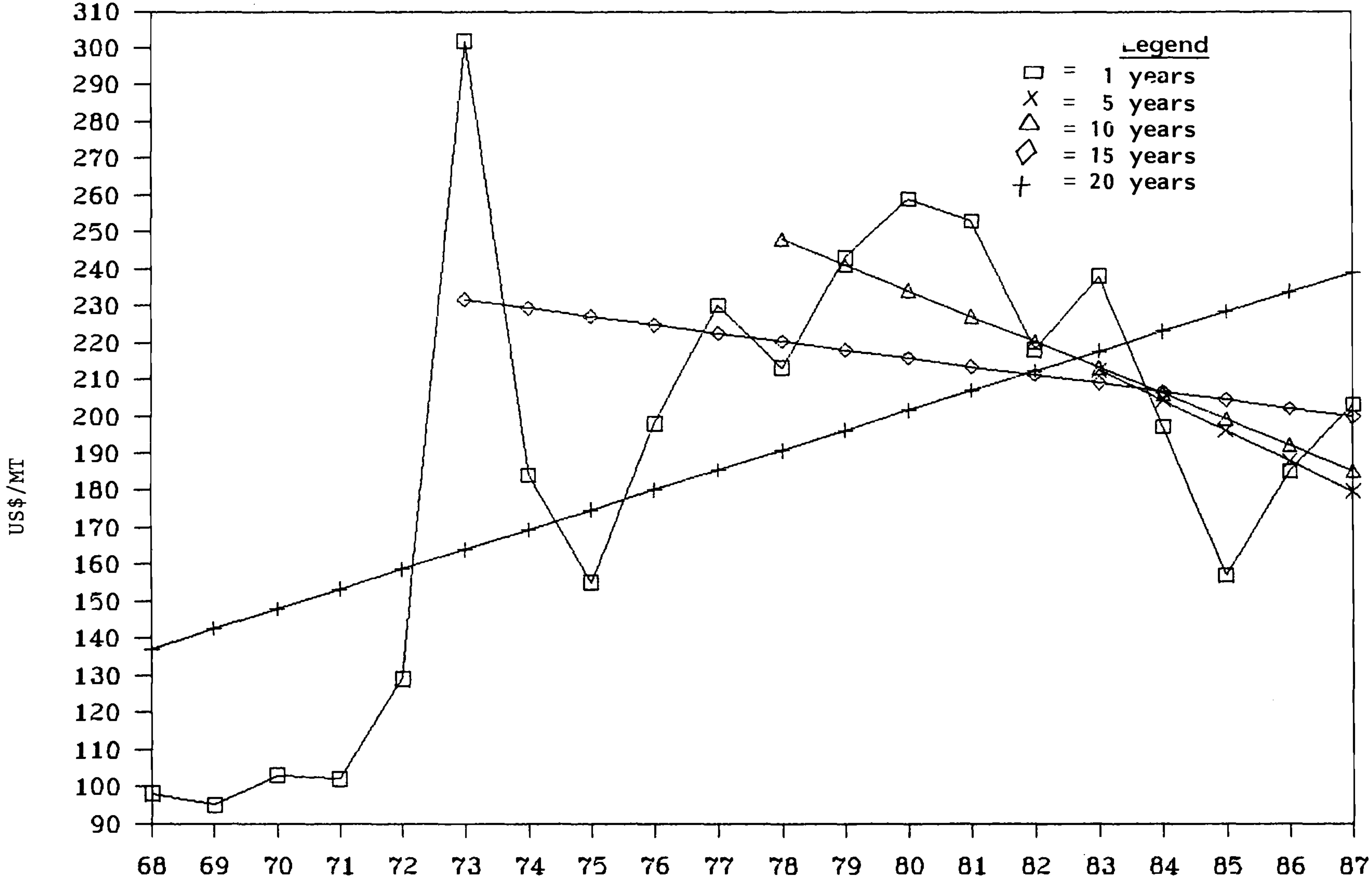

Figure 3: SOYBEAN MEAL PRICES
44% U.S., CIF Rott

feasibility of oilseed production and processing in Kenya (8-9 months).

c) Based on the results of the above mentioned study, a series of field trials related to selective aspects of oilseed production and processing, and further investigation of the marketing of oilseed cake and vegetable oil (2 years).

d) On the basis of the above mentioned research, and in conjunction with Government authorities, farmers organizations, enterprises in the food industry, and other donor agencies, specification and implementation of a program to expand Kenyan production and processing of oilseeds (2+ years).

System Approach

The oil/protein sub-sector was conceptualized as a system with several interacting components which has to be analyzed as a whole to be able to properly describe and understand it. It was envisaged that by following a system approach it will be possible to identify those research and policy interventions required to modify it to better satisfy national objectives without unexpected and undesirable effects.

Incremental Process to Research Support

From the start, the VOPS program was conceived as to follow an incremental process by which each step of the investigation is predicted on prior demonstration, from the results of the previous stage, that oilseed production and processing can not be ruled out on economic grounds. This original notion was somehow made more embracing by promoting the continuation of research based on previous satisfactory performance demonstrated by the economic criterion, the quality and relevance of the results being obtained and the commitment of the researchers involved in the exercise.

The concept of incremental process also connotes the notion that knowledge and understanding of systems, the social, economical and political environment in which they evolve must be generated sequentially, step by step, because tomorrow's research can not be properly defined until today's results are out. In other words, the investigations required to generate meaningful results and improved recommendations must be based on previously accumulated experience and the continuous assessment and improved understanding of the over changing reality.

The first step to follow the incremental process was taken, in November, 1987 by retaining the services of a consultant, through a Divisional Activity Project (DAP*), to prepare a report leading to the identification of a possible research project on the feasibility of oilseed production and processing for edible oils and protein cake in Kenya.

Table 1, represents the various steps followed initially and how the program and its financing has developed since then.

Stage I

DAP 1

The consultancy was carried out as expected and the report was discussed

* The Divisional Activity Project (DAP) is an IDRC internal mechanism for the speedy financing of relatively low cost activities leading, in most cases, to the identification and development of full fledged projects.

Table 1. The incremental process applied to the financing of the vegetable oil/protein system program in Kenya.

VOPS program terminology	IDRC terminology	Amount approved CAD $	Effective date
Stage I	DAP 1	16,400	November, 1987
	DAP 2	26,060	February, 1988
	Extension	9,555	April, 1988
Stage II	Phase I	234,100	May, 1988
	Phase 2	223,100	February, 1989
Stage III			
Core	Phase 3	641,000	September, 1989
Satellites	DAP 3	6,000	September, 1988
	DAP 4	8,000	January, 1989

on the 24 of January, 1989 and a presentation made at the Fourth Oil Crops Network Workshop at Njoro, Kenya, 25-29 January, 1988. The main output from this initial exercise was the general characterization of the oil/protein system which was represented by a diagram (Figure 4) showing seven major interrelated components, including the policy environment.

The main conclusions were:

> "The importation of palm oil at bargain prices has allowed high levels of profitability of the refining and packing activities in spite of relatively low price to consumers. The fats and oil industry has no economic encouragement to pay the prices required by the domestic producers to make a profit."

> "... the production of oilseed in Kenya does not appear to be economically feasible and the importation of oil/protein related products will continue until the existing circumstances are deliberately modified, shifted by outside forces without local control or unexpectedly changed by unforseen events."

> "Unfortunately, not enough is known about the oil and fat industry, its backward and forward linkages and the direct and derive demands for its products, which will enable us to make conclusive recommendations. A better understanding of the complex interrelationships... is required to determine where interventions are needed by identifying and predicting their outcome."

The gathering at Njoro was attended by several Kenyan professionals from Universities, Ministries, Research Institutes and the Private Sector plus a sizable representation of IDRC staff including the Deputy Director, two Associate Directors and several Program Officers of AFNS and the Regional Director for East Africa. The interest demonstrated by the Kenyan professionals in the subject made IDRC confident of the need for the continuation of the investigation, following the previously described incremental process by carrying out a comprehensive study of the various components of the system.

DAP 2 and Extension

Egerton University, through its recently created Division of Research and Extension, showed the interest and willingness to assume the leadership and coordination responsibility and became the recipient of the second DAP and its extension aimed at the generation of a project proposal for those studies.

The Deputy Vice-Chancellor for Research and Extension assumed the responsibilities of Principal Investigator and, from then on, a very close and participatory professional relationship was developed between him representing the recipient organization, the Postproduction Systems Program Officer at the IDRC Regional

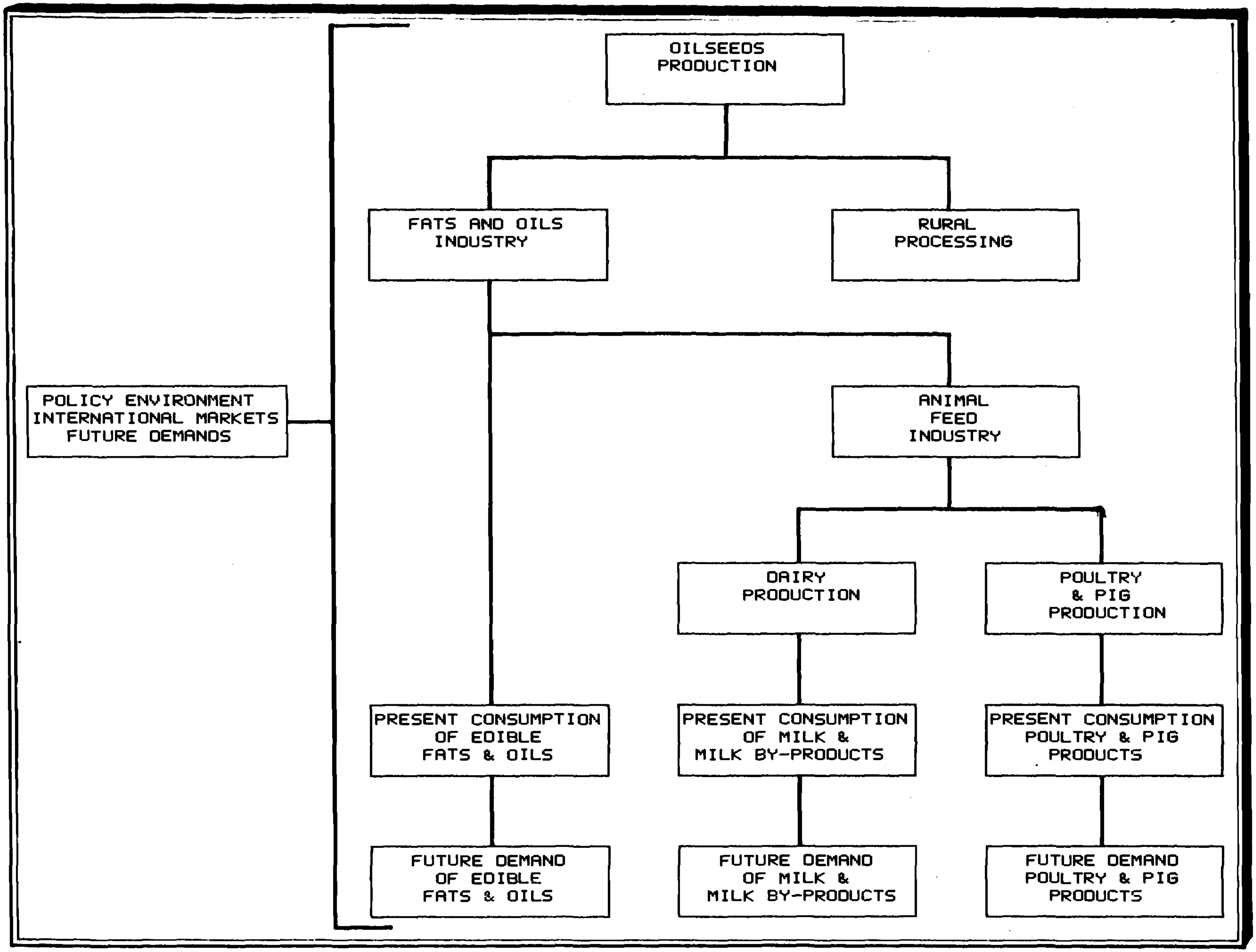

Figure 4: THE VEGETABLE OIL/PROTEIN SYSTEM IN KENYA PRODUCTIVE, INDUSTRIAL AND CONSUMPTION ACTIVITIES.

Office in Nairobi as the Officer Responsible representing the Donor Agency and the consultant. The three of them acted as partners in a team from their own institutional perspective pursuing the objectives of the program by identifying common grounds in which to operate together. That basic team actively interacted with and had the support of the Program Officers for Crops, Animal Production and Economics at the East Africa Regional Office and the Associate Director of the Agricultural Economics Program in Vancouver, Canada.

To develop the proposal for the comprehensive study of the sub-sector, two workshops were organized with the participation of about 50 Kenyan professionals. They were held on February 16 and March 15, 1988.

In the first meeting, after general presentations about oilcrops production and processing in Kenya and their relationship with the international market, the consultant presented a challenging null hypothesis:

> "Due to the importation of cheap palm oil to satisfy local demand it is not worthwhile for the country to pursue the expansion of oilseed production and, as a consequence, no more genetic, agronomic or socio-economic research on the subject is required".

Several participants, mainly the plant breeders and agronomists refused to accept that conclusion but they had a difficult time trying to justify their rejection. It became evident that not enough information was available and the system was not properly understood to arrive to meaningful conclusions. The whole assembly concluded that a much better grasp of the various components and their interactions was required.

The participants then organized in seven groups following the characterization of the sub-sector, Figure 5, under the leadership of carefully selected by the Principal Investigator, group team leaders representing a wide spectrum of institutions and professional expertises.

Each group generated a plan of work for the next month having as the main objective the preparation of a proposal and a budget to carry out the investigations related to their main area of interest.

The Principal Investigator and/or the Consultant met with every group during that month to participate and advice on the preparation of the individual proposals. They also hosted a meeting for all the team leaders to ensure consistency in the presentations.

In the second general meeting, each team leader made a presentation of his group proposal and how they were planning to execute the study. They received comments and suggestions from other participants on how to clarify the objectives being pursued and suggestion to improve the methodology to be utilized.

The draft proposals prepared by the groups were used to develop a unified and definitive proposal which was presented to IDRC for consideration on 15 April, 1988. That proposal had the benefit of the discussions that the Principal Investigator and the Consultant had with AFNS Director who visited Nairobi in March to attend the IDRC Board of Governors' meeting which took place during that period.

The objectives of the research project which became known as Vegetable Oil/Protein System (Kenya) (VOPS) Phase 1 were to:

a) specify the structural characteristics of the oil/protein production system in Kenya, the linkages between the

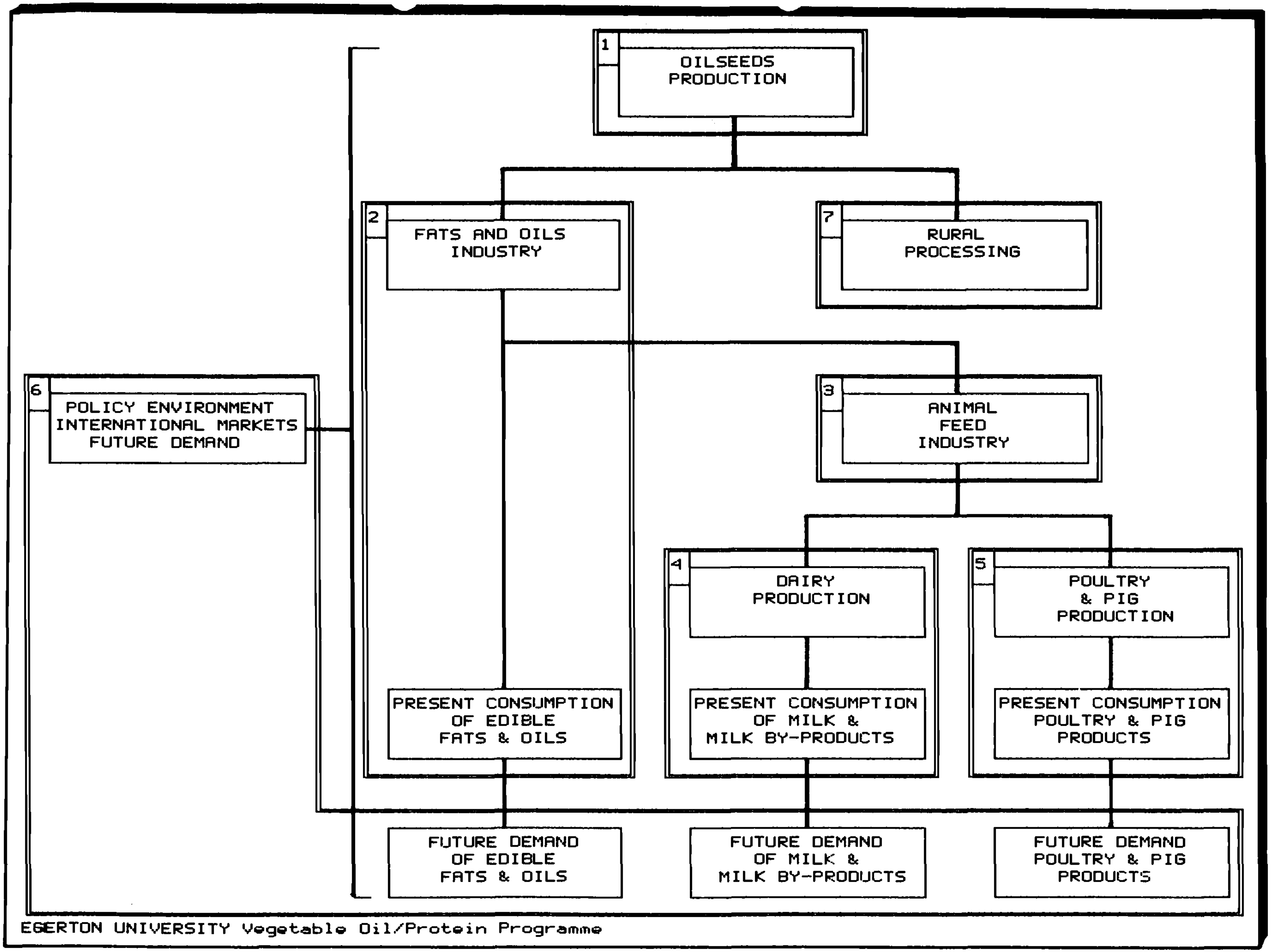

Figure 5: STUDIES OF THE VEGETABLE OIL/PROTEIN SYSTEM IN KENYA PRODUCTIVE, INDUSTRIAL AND CONSUMPTION ACTIVITIES.

various components and the quantitative flows between them;

b) determine the farming production systems which include oilseeds, and how they are influenced by the socio-economic environments;

c) describe the technological characteristics of each component in particular, its use of the factors of production and its contribution to value added;

d) find out the present level of consumption and estimate the future demand of vegetable oils, fats and protein cake as derived from dairy, poultry and pig industries;

e) define the policy instruments which influence the oil/protein system, determine their setting mechanisms and estimate their quantitative impact;

f) identify, assess and assign priorities to specific areas of research leading to the removal of constrains to local oilseed production and processing into edible oils and protein cake; and

g) prepare a project proposal for a subsequent phase which includes those areas of research with the highest priority and expected pay-off to be presented to IDRC for financing.

Stage II

Phase 1

The second stage was started by requesting each group to prepare a definitive plan of work within the budget approved for them and to develop the questionnaires that they were going to use for the collection of primary data. Those questionnaires and the methodology of data gathering would be discussed in a workshop with the participation of all team members. The third general gathering was valuable for the professionals from different backgrounds to familiarize themselves with, and comment on, the work to be done to characterize the various components of the system. It was also useful to coordinate the work of the groups dealing with related industries and to rationalize the use of resources and avoid duplications.

The various groups visited farmers, extension agents, local authorities, managers of crushing plants and refineries, feed millers, government officials, etc. They gathered primary and secondary information and by October 29, 1988 presented their preliminary results in the fourth seminar which was held in Nairobi with the participation of special guests, mostly from Government Agencies.

Those preliminary results were compiled and put together in a report which was first presented in the meetings of the Oilseeds Inter-ministerial Committee (see below) and later delivered at the International Oil Crops Workshop held at Hyderabad, India in January 1989.

The major findings included issues such as:

- the secondary data being used, and available, is apparently not consistent, and needs to be improved for planning and research;

- past attempts to increase the production of sunflower through large- and small-scale farmers indicated that the comparative advantage was with the small holders;

- for the majority of small farmers, oilseeds are of secondary importance, behind the main food and cash crops. The average smallholder plants less than 2 ha. of oilcrops together in an intercropping arrangement mostly in marginal areas and often late in the season, after labor is released from other major crops. Almost all small farmers do not use chemical fertilizers on oilcrops and only a few use manure. At present, thousands of small holders are planting sunflower and simsim (sesame) under the above circumstances with the potential for increased production not being investigated because no station or on-farm research is being carried out under those farmers' conditions. This situation partially explains why yields of oilseeds are slow. This means that scientists working at present on sunflower and those who would get involved in simsim and other oilcrops in the future would have to design their experiments to match farmers' circumstances and provide recommendation which are suitable to their environment, production system and economic situation;

- another possibility to be explored is the opportunity for some oilseeds to be a low-input, high- risk crop for the short rains in areas with bi-modal rainfall;

- the drop in world prices of vegetable oils which took place in 1986 led the major promoter of sunflower and other oilseeds to reduce its prices to the farmers. As a result many farmers have discontinued growing oilcrops;

- until recently, cotton and maize constituted the major source of raw material for domestic oil production. The fact that these oils were by-products of other primary commodities had a major effect on the oil processing industry which has not developed procurement mechanisms to be obtain raw materials directly from farmers. The significant reduction in cotton production, due mostly to lack of prompt payment to producers, has been detrimental to the smaller members of the oil expressing industry who were using cottonseed as their sole source of raw material. It has reduced their plant capacity utilization to about 50%. The smaller processors have also had difficulty in obtaining foreign exchange allocation for the import of spares to maintain equipment and/or to import raw materials. It seems expertise is lacking in fine tuning existing equipment so as to obtain optimal performance on the raw materials available to them. The solution to these problems could enhance their profitability.

- the studies of the fats and oils processing industry have put together the expelling enterprises, the refining ones and the packers, assuming that all of them have the same objectives. This is far from reality. While the expelling business wants to promote local production or be authorized to import seeds and it is supportive of levies on imported crude and refined oil, the refineries want only levies on refined oil (many times impossible to identify from the crude one), while the packers aspiration is an unregulated market free for all regardless of its effects on foreign exchange use, local resource utilization, employment generation, etc.

- similar findings were made in other components of the total system which could be found in the reports of the groups which will be made available in the immediate future.

The key policy and research interventions identified are:

- the need to charge variable levies to the importation of oils and fats to stabilize prices and eliminate the negative effects of the volatile international markets. The prices will have to be set at such levels that will induce industrialists to avoid imports and pay higher and steady prices to farmers in order to promote local production. It is expected that those more remunerative prices will encourage farmers to increase the production of oilcrops;

- another important interrelated intervention will be the execution of agronomic and plant improvement research to increase the yields of oilcrops to further raise the income of the farmers. Simsim and sunflower are considered as the crops with greatest potential. Simsim (sesame) originated in the region, is already being cultivated by small holders in the coastal and western areas of the country and not enough investigation has been carried out to improve its performance. Sunflower is the oilseed most widely cultivated at present by thousands of small farmers in many areas of the country, including some marginal ones;

- to make local oils competitive with foreign ones through import price stabilization, it requires de-regulation of the price to consumers or increase of the prices at present under control. To avoid the negative effects of that measure in the most vulnerable sector of the population, small farmers in the marginal areas, rural processing of oilseeds would have to be experimentally introduced;

- the generation of rural processing technological packages adjusted to local conditions will require the participation of professionals in various subject matters i.e., agricultural engineering, agriculture, animal production, home economics, agricultural economics, etc. to insure that the dissemination process is properly designed, taking into consideration the production of the oilseeds easy to crush the rural level, the economics of processing, the utilization of the oil and cake obtained by humans and animals, respectively, the marketing of surpluses, etc.;

- industrial economics, industrial engineering and economics will be required to better describe, analyze and appraise the existing and future potential of the oil and fats, and soaps and detergents industries and how they can be encouraged and convinced to use local raw materials permanently;

- the whole VOPS should continue to be more precisely described, the data being used should be verified and improved, and the effects of various interventions assessed, monitored and evaluated;

- research planning, management and execution capacity have to be strengthened and enhanced by short- and long-term on-the-job and academic training.

Some of the interventions that have already been taken place are:

- as a consequence of the increase in price of vegetable oils in the international market during late 1987 and the beginning of 1988, the Government increased the consumer price of margarine by 17% in June 1988 and in mid-November 1988 the consumer prices for all vegetable fats and oils products were increased by 10% including margarine whose price increased by 29% during 1988.

- also in November 1988, the Government announced the formation of a senior level inter-ministerial working group, with significant participation by the fats and oils industry, to develop a strategy for strengthening national production of oilseeds. The Government took note of the research work of Phase I of VOPS project and hence invited the participation of the Principal Investigator in the working group as a full member, on the strength of potential contributions. He was requested to submit a working paper, and he did so on 13 December, 1988. The information presented has been used by the working group to generate a set of recommendations for Government consideration.

- the Government has signed an agreement with the World Bank for the implementation of the Rural Service Design Project which will be co-financed by the International Development Association and the United Nation Development Program in March 1989. One of the components of the project deals with the production and processing of oilseeds. It is intended to finance agricultural research in the major oilcrops mainly sunflower and the dissemination of rural processing technology. No implementation reports are available yet, but it is expected that the Ministry of Agriculture will subcontract with KARI; the agricultural research activities and will work together with Egerton University in the development of the dissemination process for the rural processing technology.

Phase 1 generated more interest and enthusiasm among Kenyan scientists, administrators and policy makers than expected pulling the project along faster than anticipated path. To meet this high level of interest a "bridging" phase to consolidate the achievements made and complete Stage II was conceived until Phase III was approved and fully operational.

<u>Phase 2</u>

Its general objective was to develop the institutional base and coordination capacity of Egerton University to ensure that the on-going oil/protein systems research in Kenya meets national needs in an efficient and sustainable manner. Specifically, it was devised to:

a) coordinate with the recently formed Vegetable Oils and Protein Development Committee to resolve information reliability and consistency concerns,

b) promote enhanced understanding of the oil/protein system among public and private interest groups,

c) refine proposed research intervention points and encourage the development of research proposals on the intervention point,and

d) define the structure required for the generation ad implementation of an on-going research and extension program on the oil/protein system in Kenya.

Phase 2 has been able to consolidate the research results of Phase I, hire and familiarize permanent research staff with the VOPS program and formulate the detailed work plan for the third phase which is expected to last in three years.

To achieve those objectives:

- one day workshop meetings have been held with the seven working groups of Phase I to review their draft documents, discuss ways to handle data inconsistencies and agree on their final presentation. The seven reports from the groups plus the description of the phase I project, the original paper presented by the consultant and the summary of Phase I report are all being published as part of VOPS Working Papers Series which was specially created to disseminate the results of investigations related to VOPS program;

- the project team has began to familiarize itself with the method for assessing, programing and managing integrated production/ consumption system (MEPS) and its adaptation to the Kenyan conditions. Discussions have been held with UNIDO personnel (the co-developers of MEPS) to identify their possible assistance in training project staff.

- consultations between the researchers in charge of preparing the satellite project proposals (see below) and the staff members of the core project have been taking place to ensure that those proposals are closely linked to the objectives of the VOPS program and their quantifiable goals and methodology are clearly described to facilitate implementation and follow up.

Stage III

Phase 3

A Phase 3 proposal was prepared and presented to IDRC for financing on April 1989. It was approved by the Board of Governors in June and became effective on 7th of September, 1989.

Based on the experience of the previous research stages, a two tier approach was proposed for Phase 3 for the future research process to be consistent with the Governmental objectives:

- the first tier is a core unit which includes an adequately staffed analytical group, which will facilitate the integration and co-ordination of an evolving research program, and support a continued systematic sharing of research results with policy and decision makers, researchers, and other main actors in the oil/protein system;

- the second tier consists of a collection of satellite projects which will comprise the execution of distinct, though linked, in-depth applied research each addressing itself to the intervention points identified within the seven components of the system. These projects will be separately funded and implemented under the co-ordination of Egerton University as part of an integrated national research network.

The general objective of this phase of the program is:
To develop an integrated research and development program on the vegetable oil/protein system (VOPS) in Kenya aimed at the removal of constraints to domestic oilseed production, processing and utilization of edible oils and protein cakes.

The specific objectives for the Core Unit are to:

a) characterize the VOPS model for Kenya in greater depth in order to assess, monitor and evaluate its reactions to policy land research interventions;

b) communicate VOPS's changing state to improve the understanding of the system by all concerned and, to enrich the decision making process related to it;
c) evaluate and synthesize the results of the interventions in the system in order to update the long-term integrated research, policy and extension agenda on the national oil/protein system;

d) promote, coordinate and appraise research on knowledge gaps detected as VOPS evolves;

e) establish and sustain a research management structure capable of supporting and monitoring an integrated cluster of research activities within the vegetable oil/protein system, aim at the establishment of a national VOPS research unit within the University;

f) strengthen the capacity of researchers in conducting applied research on VOPS through short and long term academic and on the job training, and

g) evaluate the usefulness of the systems approach used in this project, as a contribution to planning and execution of research.

The specific objectives for the Satellite Projects are to:

a) describe and analyze the oil and fats, and soaps and detergents industries to determine all their components and effective capacities, cost of operation and present flows so as to estimate which changes will take place, and when and by how much the crushing capacity will have to be expanded to absorb the expected increase in local oilseed production;

b) test and select for introduction small scale rural processing equipment, develop the technological packages for their local utilization and identify the dissemination mechanisms with the greatest potential of being accepted by the rural communities;

c) collect, classify and select simsim germplasm and identify by surveying growers, the most productive agronomic practices suited to the needs and abilities of small holders with the purpose of enhancing their income.

The long-term direct beneficiaries of the program in general and of this specific phase in particular, are foreseen to be the Kenyan small holders by bringing about opportunities to increase production and utilization of oilseeds based on technology generated under their own conditions and in close collaboration with them.

The expected increase in local oilseed production, its processing and the utilization of edible oils and protein cake will benefit the Kenyan economy as a whole through a stabilization initially and later a reduction in the use of scarce foreign exchange for the importation of oil/protein products. The resources so saved could be used in other areas for development.
Another potential country-wide benefit will be the strengthening of the research capacity of several professionals and the establishment of a research management capability to execute applied research of relevance to national objectives, within one of the institutions of higher learning which could well be replicated elsewhere.

Egerton University will benefit internally by establishing a knowledgeable and authoritative analytical unit of the oil/protein system and by suing the results from this research and extension program to enrich curricula and provide study opportunities for post-graduate research.

The anticipated methodological and institutional building results include:

- an effective research support program to meet the needs of researchers, policy-makers, and the extension cadre, all of whom are seeking to respond to the problems of the producers, processors, and consumers of edible oil and protein cake;

- the construction of a useful model of the interrelationships among the components of a national oil/protein system, capable of predicting changes in the systems's output in response to changes in factors such as policy, technology, demand, weather, and the international market; the critical parameters in the model will be updated annually, using data gathered and validated through strengthened national data collection mechanisms;

- an enhanced decision making by the public and private sector as a consequence of greater data availability and better understanding of VOPS. Sharing of results will provide a service to government and industry for planning and policy formulation;

- a regular publication of findings by applied researchers working on the Kenyan vegetable oil/protein system;

- a collection of formal and informal literature i.e., a library about the oil/protein food/feed system and their components, focussing particularly on Kenya, Africa and South Asia;

- a sustainable mechanism capable of contributing to national setting of research priorities, stimulating proposals and attracting research funding;

- an experience in utilizing an incremental and systems approach for goal-directed application of research resources to solving development problems relating to food/feed self-sufficiency;

It is foreseen that the previously mentioned achievements will lead to the following concrete results:

- a generation of farm income due to intensification of production;

- a creation of employment at the rural level by the introduction of local processing;

- an increased availability of animal products as a consequence of improved feeding based in locally produced protein cakes;

- an improvement in the nutritional status of the rural communities due to higher energy intake through oils and greater accessibility to protein of animal origin;

- an overall positive change in income distribution because increased oilseed cultivation and animal production will take place at the small holders level mostly in marginal areas and rural processing will be run by small operators employing landless rural population, and

- an improved capacity in utilization of existing processing plants.

DAPs 3 and 4

The first of these two DAPs was generated to finance the purchasing of a manually operated ram press and an engine driven expeller for lab.

experimentation. The second one financed the field experimentation required to start the process of designing methodology for the diffusion of the oil extraction technology at the rural level. These efforts are related to the preparation of one of the satellite project previously mentioned as part of Phase 3.

Implementations for other countries

Table 2 shows the supply and demand situation of several of the countries represented in the workshop. Unfortunately, data is not available for all of them, but for all of those for which some information is available (with the only exception of Philippines) they are net importers of vegetable oils.

While the situation is expected to be somehow different in each country, the experience being obtained in Kenya could be of use in some of them. It is important to emphasize that what is being pursued in Kenya is a system approach and an incremental process, not a fix method. This is so because each country requires the flexibility to develop the kind of information which suits its needs. Nonetheless, as it has already happened with the Oilcrops Network, the interchange of information and the sharing of results have been proven useful and beneficial for the generation of scientific knowledge. The same appears to be true for the understanding of the system and the elimination of constraints for the development of the oil/protein sub-sector.

Conclusions

The key policy and research interventions required to remove constraints to the local production and consumption of oils and fats identified in Phase 1 of Stage 2 clearly show that the problems are not limited to one area, component or subject matter.

Nonetheless, it has become evident that without Government intervention and/or the introduction of rural processing in some of those areas the probability of increasing local production and reducing imports is low. The present structure of the internal production, processing, marketing and utilization system and the international market is still such that the most profitable enterprise within the sector is to import palm oil, pack and sell it to consumers.

At present, the policy of remitting (not charging) any duty to the importation of crude or refined palm oil contradicts the Governmental objectives of reduction of the importation bill, generation of income and employment at the rural level and food security. But, which are the more appropriate measures to reverse the present situation in pursue of those objectives, are not yet properly defined. Until those answers are found and made widely known to researchers, administrators and policy makers for them to support and take action, the potential to modify the existing situation is low.

Table 2. Supply and demand of oils and fats in selected 17 countries, 1987 (000 MT).

Country	Population July 1987	Opening Stocks	Production	Imports	Exports	Disappear	Ending Stocks	Balance Exp-Imp
China	1,065.4	757	7,428	965	117	8,298	734	(848)
India	786.4	312	3,860	1,823	40	5,435	519	(1,783)
Bangladesh	102.6	25	56	346		367	49	(346)
Pakistan	102.2	224	586	769		1,478	102	(769)
Philippines	57.4	135	1,529	28	1,075	447	171	1,047
Egypt	50.8	120	134	603		865	51	(603)
Ethiopia	45.2			4				(4)
Tanzania	23.1			25		25		(25)
Sudan	22.8	6	213	44	10	249	5	(34)
Kenya	21.9	5		167	38	115	19	(129)
Nepal	17.6							
Uganda	16.5							
Sri Lanka	16.4	16	52	21	17	68	5	(4)
Mozambique	14.5			47				(47)
Zimbabwe	8.7			18				(18)
Malawi	7.5							
Zambia	7.1			9				(9)
Ruwanda	6.5							
Burundi	5.0							
Somalia	4.9			27		27		(27)
Israel	4.4			17	5	103		(12)
Bhutan	1.5							
Botswana	1.2							

MICROBIAL CONTROL OF LEPIDOPTEROUS PESTS OF OILSEED CROPS

H.S. Salama

In the present studies, a series of experiments were conducted to evaluate the potency of some fifty strains of *Bacillus thuringiensis (B.t)* against larvae of two major pests of oil crops, namely, greasy cut worm (*Agrotis ypsilon*) and cotton leaf worm (*Spodoptera littoralis*). The bacterial cultures were first grown aerobically on a rotary shaker using either fodder yeast or ground kidney beans media. The harvested Endotoxin preparations were bioassayed for their potency against 2nd and 3rd instar larvae of *A. ypsilon* and *S. littoralis*, respectively. The bioassays were carried out under standard conditions on larvae fed on castor oil leaves dipped in Endotoxin suspensions at 500 ug/ml level. Proper controls were run simultaneously.

With respect to *A. ypsilon*, several cultures of var. *Aizawai* (amongst which were HD-130, HD-128, HD-228, HD-593 and HD-865) proved to be active against this insect pest. Within the var. galleriae, HD-210 and HD-234 were effective. In addition, two strains of var. kurstaki, HD-341 and HD-263 as well as HD-703 of var. *Thuringiensis* were also highly active against the same insect pest. The most effective strains against *A. ypsilon* were HD-130, (var. *Aizawai*), HD-703 (var, *Thuringiensis*), HD-134, (var. (*Aizawai*) and HD-341 (var. kurstaki) giving LC_{50} values of 15.3, 22.6 26.0 and 46.5 ug/ml, respectively, as compared to 3640 ug/ml of the HD-1-1-1980 standard.

When the *B. thuringiensis* strains were screened against third instar larvae of *S. littoralis*, several cultures of var. *Aizawai* notably HD-134, HD-593, HD-113 and HD-282 were highly active. Furthermore, some other cultures were also effective notably HD-554 (var. *Canadensis*), HD-234 (var. gelleriae), HD-263, HD-341, HD-89 (var. *Kurstaki*), in addition to HD-110 (var. *Entomocidus*) and HD-96 (var. *Thuringiensis*). The most potent strains were HD-593, HD-110, HD-263 and HD-554 giving LC_{50} values of 22.0, 27.4, 35.7 and 37.5 ug endotoxin/ml, respectively as compared to 2160 ug/ml for HD-1-1980 standard preparation.

In the second phase of the present work, studies were conducted to search for possible biochemical means to enhance the potency of the bacterial Endotoxin preparation against *A. ypsilon* as plausible means to increase the feasibility of application and lowering the field spraying costs. Thus, a number of simple chemcial compounds were used in conjunction with low levels of endotoxin preparation of *B.t.* var. *Galleriae* HD-234 (125 ug/ml) . These groups of compounds included selected divalent salts of Calcium, zinc and Copper; some salts of Potassium and Sodium; a group of organic acid salts as well as some protein-solubilizing agents. Appropriate controls were run simultaneously, and the cotoxicity factor (CF) in each case was calculated to elucidate the type of the resulting interaction. Within the divalent cations tested, a clear enhancing effect on the potency of the Endotoxin was noted for the calcium salts with CF ranging between 43 and 72 depending on the salt tested. However, among this divalent group of salts, Zinc sulfate recorded the highest CF value reaching 84 whereas copper salts were also potentiative but demonstrated notable toxicity when tested alone against the target insect. The LC_{50} values of the Endotoxin (138.2 ug/ml was lowered to 29.7, 29.9, 37.1 and 39.5 ug/ml in the presence of Calcium carbonate (0.1%), Hydroxide (9.1%), Acetate (0.05%) and Nitrate (0.1%), respectively. Copper carbonate, Copperoxide and zinc sulfate lowered LC_{50} to 9.5, 13.8 and 18.7 ug/ml, respectively (conc. 0.05-0.1%).

Within mono-cationic salts tested, Potassium carbonate exhibited high potentiating effect with CF value of 55 and lowering the LC_{50} value of the endotoxin to 7.6 ug/ml when added at 1% concentration to the dipping solution. Among the mono-carboxylic acid salts tested, those of short-chained acids proved to be highly potentiating for the endotoxin effect on the target insect. Thus, CF values of formate and acetate were 92 and 91, respectively. The highest CF value obtained for this group of compounds was 127 recorded for acetamide added at 1% final concentration.

Some dicarboxylic acid salts exhibited high potentiative effect, e.g., malate, tartarate and fumarate yielding CF values of 96, 78 and 72, respectively. In the presence of the potentiative organic acid salts, the LC_{50} values of the endotoxin preparation were reduced drastically. Thus, the LC_{50} values in the presence of acetamide (1%), fumarate (0.5%), malate (0.5%) and tartarate (0.1%) were 7.4, 47.5, 48.4 and 49.4 ug/ml, respectively.

In addition, some protein-solubilizing agents, e.g., EDTA, urea, and sodium thioglycollate were also potentiative for the endotoxin resulting in CF values of 100, 75 and 71, respectively. In the presence of these compounds, LC_{50} values were lowered to 15.6, 80.8 and 55.3 ug/ml in the same respective order.

In the next phase of the studies, 21 amino acids and amides were tested as possible potentiators for endotoxin preparation of B.t. var. *Galleriae* HD-234 against larvae of *A. ypsilon.* The amino acids were selected to represent different classes including aliphatic, branched, aromatic, cyclic, basic as well as acidic amino acids. These compounds were incorporated in the dipping solution both alone and in conjunction with the endotoxin suspension in final concentrations of 0.05%. Proper controls were run simultaneously. A notable potentiative effect was noted for some aliphatic amino acids including DL-serine and DL-alanine where CF values amounted to 91 and 86 with LC_{50} reduced to 52.8 and 33.9 ug/ml, respectively, as compared to 240.7 ug/ml for the endotoxin preparation only. Within the branched amino acids, L-valine was the most potent activator of the endotoxin with CF value of 86 and lowering LC_{50} of the endotoxin to 33 ug/ml. Among the basic amino acids and amides, L-arginine was the most effective potentiator followed by DL-ornithine, L-asparagine and DL-glutamine with CF values of 110, 93, 91 and 88 accompanied by reduction of the LC_{50} value to 6.0, 12.0, 9.2 and 83 ug/ml, respectively. The acidic amino acids, L-aspartic and L-glutamic, were also potentiative but to a lesser extent than their amide forms. The indole-containing DL-tryptophan and the cyclic L-proline amino acids were also highly effective potentiators with CF values corresponding to 90 and 92 with a capacity to lower LC_{50} value to 14.9 and 7.7 ug/ml, respectively. On the other hand, the sulfer-containing amino acids tested could not exhibit any potentiation of the endotoxin under study. On the contrary, L-cysteine and L-cystine were antagonistic to the potency of the endotoxin and recorded negative CF values. The obtained results were discussed in the light of their scientific as well as application merits in the field of bilogical control of pests of oilseed crop.

Fifty nine cultures belonging to 12 different vars. of B.t were screened for the production of B-exotoxin. A devised medium was used for maintenance of the cultures. The activity of the B-exotoxin preparation of different *B.t.* cultures was evaluated for *A. ypsilon* *and S. littoralis,* compared to the standard preparation, thuringiensin. The results showed that some B.t. cultures were able to produce large amounts of B-exotoxin, such as vars. *Kenyae* HD-588, *Galleriae* HD-129, *Toloworthi* HD-301 and *subtoxicus.* Some field tests were carried out to assess the effect of spraying B-exotoxin against *S. littoralis* on peanuts and the results were encouraging but they need further conformation.

B.t var. Kurstaki HD-1 (Dipel 2x), as a biological insecticide was tested against *S. littoralis,* larvae infesting soybean plants either alone or combined with potassium carbonate as an adjuvant. The carbamate chemical insecticide, Lannate, was used for comparison. The materials were applied either through spraying or dusting. Results showed that potassium carbonate enhanced and significatly increased the effect of Diepl. Both techniques are suitable for use in control application. The recommendation of using a combination of Dipel at 250 gm/faddan and potassium carbonate at 150 g/faddan is advisable. This combination gave significantly high larval reduction (96.86% and 92.11% with an increase of 2.50 and 1.60 folds in yield after spraying and dust appli- cations, respectively. The data also suggested that a combination of Dipel and potassium carbonate (Dipel + K_2CO_3) might be an effect-ive component of the future *S. littoralis* IPM programs on soybeans.

Field tests were conducted to determine the effectiveness of wheat bran baits based on *B.t* var. kurstaki HD-1 (Dipel 2x) compared to the organophosphorous insecticide, Hostathion, against the greasy cutworm (*A. ypsilon*) on faba bean (*Vicia fabae).* Significant larval reductions were observed in all treated plots after one application with a significant increase in the yield (1.45-1.60 folds) compared to the control plots. The yield was not affected by varying dose of Dipel in the bait between 150 and 250 gm/f. The addition of the adjuvant, potassium carbonate, to the Dipel bait caused a significant larval reduction, 10 days after application and showed to be as efficient as baits based on Hostathion.

In the third series of experiments, application of Dipel 2x at a rate of 250 g/f was effective against the larvae of *S. littoralis* (1st to 4th instars), while larvae in older stages (5th and 6th instars) were more resistant. Lannate was highly effective against young and old larvae. The addition of potassium carbonate to Dipel increased larval mortality. In Sharkia governorate, the yield of soybean increased significantly when the infested areas were treated once by Dipel 2x or Lannate with 1.113 fold increase. In Menoufia governorate, also, when soybeans were treated three times with Dipel 2x or Lannate, yield increased 2.031-2.066 times. This difference in yield gives a higher net profit to the farmer exceeding the costs of spray applications.

SUNFLOWER AND SESAME RESEARCH IN THE PHILIPPINES

Nenita M. Tepora

Sunflower and sesame are minor oil crops in the Philippines. Sunflower is an introduced crop while sesame is grown in marginal areas by few farmers. Most, if not all, of the cultivation of these crops is in Central Luzon where the Central Luzon State University (CLSU) is located and where there is very distinct dry and wet seasons.

There is increased interest in upland crops to increase the productivity and income of irrigated and rainfed lowlands as well as uplands. This is where sunflower and sesame could fit in.

Sunflower

Continuous sunflower research has been undertaken by CLSU since 1972. Various studies have been made (Appendix A) and a complete package of production technology had been developed (Appendix B) which is now being pilot tested in three towns of Nueva Ecija. The cost and return analysis for one hectare of sunflower seed production shows a return of investment of 137% (Appendix C).

The technology has shown high potential for increasing the income of farm families, especially when the seeds are processed as cracked seeds. Sunflower crack seeds have become popular around CLSU. It is better than the common watermelon crack seeds in terms of nutritive content and palatability.

Sunflower production can be one of the potential alternative cash crops for farmers. The limitations to production are lack of quality seeds and low seed setting in the farmers' field. For high seed set, pollinators like bees are needed but normally the farmers do not engage in beekeeping.

Sesame

Sesame research in the Philippines is conducted only by CLSU and has been continuous since 1982 though in a limited scale.

At present, there are 128 accessions of sesame germplasm in the CLSU, Table 1. Duplicate seed lots of these accessions were brought to the National Plant Genetic Resources Laboratory (NPGRL), Institute of Plant Breeding of the University of the Philippines at Los Banos (IPB-UPLB) for storage.

Table 1. CLSU sesame germplasm collections.

Number of Accessions	Origin	Source
5	Thailand	Bureau of Plant Industry
1	Guatemala	Philippines
2	Sri Lanka	
5	Philippines	
8	Thailand	IRRI thru Dr. Carangal
1	Colombia	
10	Philippines	NPGRL, IPB-UPLB
7	Thailand	CLSU graduate students FAO thru Dr. Campos
14	Greece	
7	Mexico	
3	India	Bhabha Atomic Research Center thru Dr. Murthy
6	India	Tamil Nadu Agric. Univ.
5	Introductions to India	Through Dr. Thangavelu
2	China	Institute of Crop Germplasm Resources, CAAS thru Dr. Yu-Shen Dong
20	Israel	FAO through Dr. Pineda
12	Somalia	IDRC Oilcrops Network
3	Sri Lanka	Through Dr. Omran
10	Egypt	
7	Ethiopia	
128		

Last year, 78 accessions were characterized & evaluated, Table 2.

Table 2. Performance of sesame accessions evaluated during 1988 wet season.

Accession No.	Yield /plant (g)	Maturity (DAE*)	Plant Height (cm)	Branching habit	Number of pods /plant	Seed coat color	1000-seed weight (g)	Seed size	Phyllody Disease (No. of plants with disease	Cercospora leaf spot Incidence**	Powdery Mildew Incidence**
1	2	3	4	5	6	7	8	9	10	11	12
68	11	64	116	Basal	88	White	3.0	Small	2	LR**	-
69	10	64	94	Monopodial	28	White	3.0	Big	2	LR	-
43	8	65	90	Basal	60	Cream	2.75	Small	0	LR	-
46	13	65	110	Monopodial	36	Dirty white	3.0	Small	0	LR	-
50	13	65	84	Monopodial	41	Light brown	3.25	Big	0	LR	-
54	30	65	97	Monopodial	21	Cream	3.5	Small	0	LR	-
19	8	65	92	Basal	37	White	3.0	Small	0	LR	-
41	14	67	104	Basal	63	Light brown	3.5	Big	0	LR	-
45	9	67	94	Basal	52	White	3.0	Big	0	LR	LR
51	19	67	78	Basal	34	Light brown	3.75	Small	2	LR	-
21	9	67	78	Monopodial	46	Dirty white	3.0	Big	0	LR	-
20	17	68	110	Basal	68	White	2.75	Small	0	LR	-
17	21	68	159	Top	106	Reddish brown	2.0	Small	1	MR all	LR
38	14	68	130	Basal	75	Dirty white	3.25	Big	0	LR	M
42	8	68	105	Basal	61	Brown	3.5	Big	0	LR	-
44	15	72	110	Basal	112	Dirty white	3.25	Big	0	LR	-
18	11	73	96	Monopodial	60	Light brown	2.5	Small	0	LR	-
55	10	73	120	Monopodial	41	Dirty white	3.75	Big	0	LR	-
59	12	73	129	Basal	109	Dirty white	3.0	Big	0	LR	LR
6A	17	73	171	Basal	107	White	4.0	Big	1	MR all	MR
66D	15	78	140	Basal	97	White	3.5	Big	2	LR	MR
33	15	78	147	Basal	75	Dirty white	2.5	Small	0	LR	LR
35	17	78	171	Monopodial	95	Dirty white	2.75	Small	3	MR all	M
36	13	78	172	Basal	78	Dirty white	2.5	Small	0	MR all	M
37	15	78	165	Basal	96	Cream	3.0	Medium	3	MR all	M
39	22	78	180	Monopodial	38	Dirty white	2.5	Small	0	MR all	LR
05	12	80	141	Top	42	Black	3.0	Big	0	MR all	-
12	29	80	157	Basal	165	Light brwn	3.0	Small	0	LR	-
53	78	80	162	Basal	224	Light brown	3.0	Small	0	MR all	-
16	12	82	101	Monopodial	72	Brown	3.0	Small	0	LR	-
47	14	82	134	Monopodial	51	Dirty white	3.75	Big	0	LR	LR
56	10	82	141	Basal	42	Dirty white	3.25	Big	2	LR	MR
52	15	85	122	Basal	124	Light brown	3.0	Big	0	LR	M
65B	29	85	179	Basal	127	White	4.25	Big	2	MR all	-
75	30	85	105	Basal	138	Dirty white	4.0	Big	0	LR	-
76	4	85	85	Monopodial	40	Dirty white	2.5	Big	0	LR	-
01	13	87	154	Top	66	Cream	2.0	Small	0	LR	-
58	12	88	196	Monopodial	72	Cream	4.0	Big	0	LR	-
65A	16	88	163	Top	50	White	3.0	Big	0	ER all	-
60	21	92	198	Top	120	White	3.0	Big	0	LR	-
70	24	92	151	Basal	104	Purplish-black	3.25	Big	0	LR	-
71	19	92	140	Top	110	"	3.0	Big	1	LR	-
72	25	92	149	Basal	158	"	3.0	Big	0	MR all	-
73	20	92	147	Top	122	"	3.75	Big	0	LR	-Table
74	27	92	140	Basal	85	"	4.0	Big	0	MR all	-
24B	7	94	170	Top	52	White	3.0	Big	2	MR all	M

2 contd.

1	2	3	4	5	6	7	8	9	10	11	12
12	10	95	101	Basal	57	White	3.0	Small	0	LR	M
48	13	95	96	Basal	52	Cream	2.5	Small	0	LR	M
49	9	103	91	Basal	48	Cream	2.75	Small	0	ER all	M
07	82	103	187	Top	576	Black	3.5	Big	0	LR	-
101	19	103	125	Basal	99	Dirty white	2.75	Big	0	LR	-
102	25	103	147	Basal	99	Black	3.0	Big	0	LR	-
61	8	103	173	Top	76	White	3.0	Big	0	LR	-
63	12	103	187	Top	77	Dirty white	3.0	Medium	0	LR	-
77	39	103	70	Top	294	Light brown	2.5	Small	0	LR	-
78	21	103	166	Monopodial	132	White	3.0	Small	0	LR	-
06	16	103	194	Top	126	Black	1.5	Small	0	LR	-
04	8	104	149	Top	44	Black	3.0	Big	0	LR	-
27	12	188	198	Top	90	Light brown	2.5	Small	0	LR	-
10	9	105	175	Top	108	Light brown	1.5	Small	1	LR	-
29	13	105	193	Top	146	Brown	1.5	Small	3	LR	-
67B	23	105	198	Top	223	Dirty white	2.0	Small	0	LR	-
23B	10	106	178	Top	154	Purplish-Black	1.75	Small	8	LR	-
136	18	107	158	Top	120	Cream	3.0	Medium	0	LR	-
26	11	107	174	Top	52	Brown	4.0	Big	0	LR	-
34	19	107	193	Top	196	Light grey	1.75	Small	0	LR	-
30	20	107	189	Top	193	Dirty white	1.5	Small	0	LR	-
24C	12	108	179	Top	93	Greyish black	2.0	Big	0	MR all	-
62	5	108	167	Top	61	Black	3.0	Small	0	LR	-
240	16	108	177	Top	106	Greenish-brown	3.0	Big	0	LR	-
31	10	110	172	Top	66	Grey	3.0	Big	0	LR	-
32	20	110	189	Top	159	Black	2.5	Big	0	LR	-
67A	16	112	196	Top	180	Dirty white	2.0	Small	0	LR	-
28	7	113	184	Top	110	Brown	1.25	Very small	0	LR	-
02	17	123	224	Top	103	Black	3.0	Big	0	LR	-
64	9	124	182	Top	72	Brown	3.0	Big	0	LR	-
03	13	124	177	Top	82	Greenish-brown	3.0	Big	0	LR	-
64A	17	124	223	Top	140	Light brown	3.25	Big	0	LR	-

*DAE = days after emergence, **LR = late reproductive stage, ***MR = mid reproductive stage, ****M = Maturity.

The collections had wide ranges of variabilities including yield (5-82 grams per plant), maturity (64-124 days after emergence (DAE), plant height (70-224 cm), number of pods per plant (40-576), 1000 seed weight (1.25-4.00 g),and seedcoat color (white, dirty white, cream, light brown, brown, reddish brown, greenish brown, light grey, grey, grayish black, greenish black, purplish black and black).

Fifteen accessions from different origins were observed with some plants showing symptoms of phyllody, Tables 3 and 4. Diseased plants were uprooted and burned as soon as the symptoms were observed. Phyllody was more prevalent during the rainy season than during the dry season. Eighteen accessions were susceptible to powdery mildew and three to *Cercospora* leaf spot.

Ninety-seven crosses of outstanding introduced varieties with varieties previously found adapted to the Philippines were made.

Five varieties with the highest yields in a yield trial were multiplied and were programed for multilocation yield test in Northern Luzon- Region I and II.

Table 3. Performance of 23 highest yielding sesame accessions evaluated during 1988 wet season.

Accession No.	Yield /plant (g)	Maturity (DAE*)	Plant Height (cm)	Branching habit	Number of pods /plant	Seed coat color	1000-seed weight (g)	Seed size	Phyllody Disease (No. of plants with disease	Cercospora leaf spot Incidence**	Powdery Mildew Incidence
07	82	103	187	Top	576	Black	3.5	Big	0	LR	-
53	78	80	162	Basal	224	Light brown	3.0	Small	0	MR all	-
77	39	103	70	Top	294	Light brown	2.5	Small	0	LR	-
75	30	85	105	Basal	138	Dirty white	4.0	Big	0	LR	-
54	30	65	97	Monopodial	21	Cream	3.5	Small	0	LR	-
12	29	80	157	Basal	165	Light brown	3.0	Small	0	LR	-
65B	29	85	179	Basal	127	White	4.25	Big	2	MR all	-
74	27	92	140	Basal	85	Black	4.0	Big	0	MR all	-
102	25	103	147	Basal	99	Black	3.0	Big	0	LR	-
72	25	92	149	Basal	158	Black	3.0	big	0	MR all	-
70	24	92	151	Basal	104	Purplish black	3.25	Big	0	LR	-
67B	23	105	198	Top	223	Dirty white	2.0	Small	0	LR	-
39	22	78	180	Monopdial	98	White	2.5	Small	0	MR all	LR
78	21	103	166	Monopodial	132	White	3.0	Small	0	LR	-
17	21	68	159	Top	106	Reddish brown	2.0	Small	1	MR all	-
60	21	92	198	Top	120	White	3.0	Big	0	LR	-
73	20	92	147	Top	122	Black	3.75	Big	0	LR	-
30	20	107	189	Top	193	Dirty white	1.5	Small	0	LR	-
32	20	110	189	Top	159	Black	2.5	Big	0	LR	-
51	19	67	78	Basal	34	Light brown	3.75	Small	2	LR	-
71	19	92	140	Top	110	Black	3.0	Big	1	LR	-
101	19	103	125	Top	99	Dirty white	2.75	Big	0	LR	-
34	19	107	193	Top	196	Light grey	1.75	Small	0	LR	-

*DAE = days after emergence **LR = late reproductive stage ***MR = mid reproductive stage.

Table 4. Incidence of phyllody disease in 15 sesame accessions evaluated during 1988 wet season.

Accession number	Origin/ source	Number of plants with symptoms	Accession number	Origin source	Number of plants with symptoms
23	Philippines	8	68	China	2
29	Philippines	3	69	China	2
35	Thailand	3	65	India	2
37	Thailand	3	58	FAO (Mexico)	1
13	Thailand	2	10	Philippines	1
51	FAO (Greece)	2	17	Thailand	1
56	FAO (Mexico)	2	71	India	1
66	India	2			

Appendix A.

Sunflower Studies Conducted in CLSU from 1972-88.

Field	Number of studies
Varietal Improvement	4
Cultural Management	
- Planting dates, seeding rates, irrigation, harvesting and land preparation	16
- Fertilization	27
- Intercropping	10
Crop Protection	
- Insect pests	13
- Weeds	11
- Diseases	3
Seed Technology	4
Economics	3
Processing	12
Total	123

Appendix B.

Package of Technology for Sunflower Production

1. Recommended variety: Improved CLSUN-190-95 maturity days.

2. Site Selection: The area should have irrigation facilities. The basic soil requirements are moderate to well-drained soil. Soils used for corn, rice and vegetable are suited for sunflower production.

3. Growing season: The best time for planting sunflower for the first cropping is from October-January and the second cropping from February-May.

4. Land preparation: Burn the residues of previous crops and grasses to kill disease organisms prior to ploughing. Plough the field once and leave it for 2-3 days. Harrow twice to obtain good tilt.

5. System of planting: Planting should be done using single row method with rows spaced 75 cm and plants 25 cm within the row. Plant at the rate of 2-3 seeds/hill at a depth of 3-4 cm. Seeding rate is 18-20 kg/ha.

6. Thinning, off-barring and hilling-up: Thin the plants to one plant/hill 14 days after emergence (DAE).

7. Fertilizer application: Fertilizer application should be made on the basis of soil-test results. For soils with high P and K values: 90-0-0 (4 bags urea) and for soils with low P and K values: 90-30-30 (3 bags 14-14-14).

8. Irrigation schedule: First (just after planting), second (15 DAE), third (30 DAE), fourth (50 DAE), and fifth (70-80 DAE).

9. Control of pests and diseases: Insect pests and diseases of sunflower can be controlled using the following:

Insect pests/ diseases	Control measures
Cutworm leafworm Leafhopper Headworm	1) CRop rotation with a non-Leafworm susceptible host plant. 2) In small areas, collect eggs and larva and crush them. 3) Spray using any of the following: Sevin (2-3 tbs/16 l of water), Lannate (3 tbs/16 l of water), Azodrin 202R (2-3 tbs/16 l of water), Thiodan (3-5 tbs/16 l of water). Spray as soon as insect pests appear. If needed, repeat at 7-days interval. Shorten spray interval in cases of heavy infestations.
Sclerotium wilt Leaf spot Leaf blight	1) Pull out infected plants and burn them immediately. 2) Use the following fungicides: Leaf blight Arasan, Brassicol (5-10 g/kg of seed); Manzate, Daconil (3-4 tbs/16 l of water). Thoroughly mix with the seeds before planting for Sclerotium wilt control. Spray when symptoms of infection appear.

10. Bees as pollinators (optional): In sunflower production, introduction of bee colonies during the onset of blooming is important to increase seed setting. Bees as pollinators increase seed setting to as much as 20%. Wind and some other beneficial insects can also help in pollinating the crop.

11. Harvesting of heads: Harvest the head when the green back side of the flower disks turned to yellowish brown. Cut the stalk with a scythe or lingkaw just below the head. Spread harvested heads in a single layer on dry ground with their faces up. Dry for 2 or more days or until the seeds start to separate from the head.

12. Threshing: Sunflower heads are ready to be threshed when the seeds separate easily from the head. Threshing can be done using a screen board with nails laid out in squares 1 cm apart or by a self-feeding power sunflower thresher.

13. Cleaning: Clean the threshed seeds before storage to prevent heat accumulation. Clan with a winnower or a seed blower.

14. Drying: Dry the seeds to a moisture content of 8-10%.

15. Storage: Seeds should be packed in plastic bags/sacks. Store in a ventilated room or area to prevent the attack of storage pests. Seeds intended for planting should be treated with pesticides before storage.

Appendix C.

Cost-Return Analysis for One Hectare Sunflower Seed Production

Item	Rate & quantity	Value P
I. Gross Income	1,000 kg	
Yield	at P15/kg	15,000.00
II. Expenses		
A. Cash Costs		
1. Labor*		
a. Land preparation	P850/ha	850.00
b. Planting/replanting/Thinning	18 MD	540.00

Item	Rate & quantity	Value P
c. Fertilization	6 MD	180.00
d. Hilling-up (tractor)	P175/ha	175.00
e. Spraying	5 MD	150.00
f. Irrigating	12 MD	360.00
g. Harvesting/Threshing/Hauling	25 MD	750.00
h. Cleaning/Drying/ Bagging	6 MD	180.00
Sub-total		3,185.00
2. Inputs		
a. Seeds	20 kg @p15	300.00
b. Fertilizer (Urea)	4 bags @p165	660.00
c. Pesticides (Insecticides)		555.00
d. Irrigation fee		425.00
Sub-total		1,940.00
B. Overhead cost		
Interest on Capital (12% per annum)		153.00
Land rent		1,035.00
Sub-total		1,188.00
Total Expenses		6,313.00
III. Net Income		8,687.00
IV. Return on Investment (ROI)		137%
V. Production Cost per kg		6.31

*P30.00 per MD.

Part 4

DISCUSSIONS

AND

RECOMMENDATIONS

I. SESAME SUBNETWORK

The priorities of constraints were revised in consultation with the concerned countries and the priorities included for those countries which were not represented earlier (Egypt and Bangladesh), Table 1. The following is the discussions on actions taken-or to be taken- on the recommendations of the first subnetwork meeting, Kenya, January 1988. IDRC MR 205e, compiled by Dr. S. Thangavelu, the chairman of Sesame Subnetwork.

A. Insect Pests

1. Shoot Webber

- Three lines (ES 12, ES 22 and Si 250) reported to be resistant/tolerant to Antigastra were confirmed for their resistance/tolerance and data presented by Dr. Thangavelu (India) in the meeting. The mode and mechanism of inheritance will be further investigated in these lines.

- Mr. Ahmed (Sudan) will test/verify the resistance of local varieties to Antigastra and also will supply materials to India for confirmation of resistance under artificial conditions.

- There was no incidence of Antigastra in Tanzania, hence the fungus attacking the pest could not be identified. However, search will be made this year also.

- Initially the collection of literature on biological control by fungus will be done before starting a regular program. Dr. Pineda (FAO) has agreed to collect the available information.

- The information available in India on pests especially on Antigastra and control was compiled by Dr. Thangavelu and furnished to Dr. Omran to form part of the proceedings.

- Further work on Antigastra is in progress in India and Dr. Thangavelu has agreed to present results during next subnetwork meeting.

2. Aphids

- The study on biology of aphids and identifying the causes for preference in feeding was agreed to be taken up by Dr. Tepora in Philippines.

3. Storage pests

- The information on activated clay was presented in the subnetwork meeting by Dr. Thangavelu. The procedure for preparation of activated clay has been furnished and forms part of the proceedings. The studies were agreed to be continued by Dr. Thangavelu.

Table 1. Priorities* of constraints of sesame research and production.

	Countries**																			
Factors	Su	Et	So	Ke	Ug	Ta	Za	Pa	In	Ne	Sr	Th	Ch	Ph	My	Ko	Ni	Eg	Ba	Total
1. <u>INSECT PESTS</u>																				
Antigastra	2	3	3	3	-	3	?	2	3	3	3	2	3	3	?	?	1	-	1	35
Aphids	-	2	-	2	?	3	?	1	1	2	-	-	2	3	?	?	-	2	1	19
Storage pest	2	1	2	1	?	2	?	1	2	-	1	1	2	1	?	?	-	-	-	17
Seed Bug	3	1	-	-	-	-	?	-	2	-	-	-	-	2	-	-	2	-	-	10
Acherontia	-	-	-	-	-	-	?	-	-	2	3	-	2	3	?	?	-	-	-	10
Mites	-	1	-	2	2	-	?	-	-	1	-	-	1	1	?	?	-	-	1	9
Gallmidge	-	1	-	1	?	1	?	-	2	?	2	-	-	-	?	?	-	-	1	8
Cotton green bug	-	2	-	-	?	-	?	1	1	1	-	1	-	3	?	?	1	1	1	12
Flee Beetle	-	1	-	-	-	3	-	-	-	-	-	-	-	-	?	?	-	-	-	4
2. <u>DISEASES</u>																				
Phyllody	3	2	1	1	-	1	-	2	3	3	2	2	1	2	-	-	-	-	1	24
Macrophominia	2	2	-	1	1	-	-	3	3	2	3	1	3	1	-	-	2	3	3	30
Fusarium	1	2	1	1	1	1	-	2	2	3	3	2	3	2	-	-	-	3	2	29
Powdery Mildew	-	2	1	1	-	3	2	2	3	2	3	2	1	3	-	-	-	-	1	26
Phytopthera	1	1	1	1	?	1	?	2	2	1	3	2	1	2	-	-	-	-	1	19
Cercospora	1	-	2	2	?	3	?	2	2	2	1	1	1	2	-	-	-	1	1	21
Xanthomonas	2	3	1	1	-	2	-	-	2	1	-	-	1	1	-	-	1	-	1	16
Pseudomonas	2	2	-	1	-	2	-	-	2	1	-	-	2	-	-	-	1	-	-	13
Alternaria	-	-	-	1	-	-	-	2	2	3	-	-	1	-	-	-	1	2	1	13
Leaf curl	-	-	1	1	-	2	-	-	1	2	-	1	1	3	-	-	-	1	1	15
Corynespora	-	1	-	-	?	1	-	-	2	-	-	-	1	-	-	-	-	-	-	5
PMMV	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
TUMV	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
3. <u>OTHER CONSTRAINTS/NEEDS</u>																				
Seed Retention	3	3	3	3	-	3	?	3	3	3	3	3	1	3	-	-	3	-	3	40
Harvest Index	3	3	3	3	-	3	?	3	3	3	3	3	3	3	-	-	3	3	3	45
Wide Adaptability	3	3	3	3	-	3	?	3	3	3	3	3	3	3	-	-	3	-	3	42
Yield Potential	3	3	3	3	-	3	?	3	3	3	3	3	3	3	-	-	3	3	3	45
Growth Habit	2	3	3	1	1	3	?	1	2	2	3	3	2	3	-	-	3	3	2	37
Maturity	3	2	3	2	-	3	-	3	3	3	2	3	3	3	-	-	1	3	2	39
Drought	3	3	3	2	1	2	2	2	3	1	2	2	3	3	3	1	1	-	3	39
Stand Establishment	2	2	3	2	2	1	?	3	3	2	2	2	3	-	-	-	1	-	-	28
Root System	2	2	2	2	3	-	?	2	2	1	2	2	2	2	-	-	1	-	2	27
Inter Cropping	-	3	3	3	3	3	?	2	3	-	2	-	3	-	-	-	-	2	2	29
Fertilizer Response	1	1	2	1	-	3	?	2	3	2	1	1	2	2	-	-	2	2	1	26
Branching	2	2	2	1	9	3	-	2	3	2	3	1	1	1	-	-	1	1	2	27
Sequential Cropping	-	2	2	1	-	-	?	2	3	-	2	3	3	3	-	-	1	2	1	25
Relay Cropping	-	2	3	2	-	1	-	-	2	-	1	-	3	-	-	-	2	-	1	17
Mechnical Harvesting	3	3	2	-	-	-	-	-	-	-	-	-	1	-	-	1	3	-	-	13
Water logging	-	1	1	1	-	3	-	-	1	-	-	-	3	3	-	-	1	3	3	20
Salinity	-	2	-	-	-	-	1	-	1	-	-	1	2	3	-	-	-	-	-	10
Post-harvest losses	3	3	3	3	?	1	-	-	3	-	3	3	3	3	-	-	1	-	-	29
Weed Control	2	2	3	3	?	3	-	2	2	3	3	1	3	3	-	-	3	3	1	36
Hybrid Varieties	-	1	-	-	-	1	-	2	1	-	1	-	3	-	-	-	-	2	-	11
Oil/protein system	3	3	3	?	?	2	?	2	2	?	?	3	2	2	?	?	?	2	3	27

* 3 = High, 2 = Medium, 1 = Low, - = Not a priority, ? = No information.

** Su = Sudan, Et = Ethiopia, So = Somalia, Ke = Kerya, Ug = Uganda, Ta = Tanzania, Za = Zambia, Pa = Pakistan, In = India, Ne = Nepal, Sr = Sri Lanka, Th = Thailand, Ch = China, Ph = Philippines, My = Myonmar (Burma), Ko = Korea, Ni = Nicaragua; Eg = Egypt, Ba = Bangladesh.

B. Diseases

4. Phyllody

- The investigations are in progress in India and Dr. Thangavelu has agreed to present the results when available.

- Dr. Amram Ashri (Israel) has agreed to identify the donor agency for undertaking DNA probe studies on MLO causing phyllody.

5. Macrophomina

- Egypt (Dr. A. Helal / Dr. A. El-Deeb) has agreed to send the inoculation procedure for publication in the newsletter and also identify the resistant sources. In personal communication to Dr. Thangavelu. Dr. Li Lili from China has reported a few high resistant local cultivars in her studies on resistance to Macrophomina and further information will be obtained.

6. Phytophthora

- Information on reported resistance will be obtained from Sri Lanka and Korea.

7. Powdery Mildew

- All countries agreed to screen the germplasm available for resistance to powdery mildew and will present data.

- The methodologies available for effective screening will be collected and will be furnished by Dr. Thangavelu.

8. Fusarium

- Information from China and Egypt on resistance to Fusarium will be collected and furnished.

- Resistant sources will be collected and supplied to participating countries along with mode of screening.

9. Other Pests

- The information will be collected on resistant sources to all other pests from different countries and methods of control and will be presented in the next meeting.

C. Other Constraints or Needs

10. Seed retention

- Information to be collected from Korea on hormone treatment for seed retention and uniform maturity. Information from SESACO to be obtained.

  Dr. Wasana Wongyai of Thailand is working on semi-shattering capsule. It is characterized by opening of the tip of capsule. Information will be obtained on this program. Information on studies of indehiscence, strong placentation, delayed dehiscence, tip opening and upright capsules will be collected. Each country will furnish the information. The studies will be undertaken by all participating countries. Some Sudan local types were reported to have delayed shattering and further investigation will be done.

- Mutation breeding by the following countries will be continued for selecting the types for seed retention: Venezuela, Sudan, Sri Lanka, Korea, India, and Egypt.

11. Harvest Index

- Studies will be undertaken with more efficient types as indicated below for better harvest index by Phillipines, India, Sudan and Egypt.

    a. Short internode
    b. Basal capsule setting
    c. Linear leaves
    d. Longer capsules
    e. Many seeds/capsule
    f. Three capsules/axil

  The influence of fertilizer, season, irrigation and management on harvest index may be investigated wherever possible.

12. Maturity

- All countries will initiate studies and present the results in the next meeting.

13. Stability over years

- The already available information on simple method for stability analysis done in Australia will be obtained and utilized by all countries to study the stability of their available germplasm/varieties over locations/seasons/years. Dr. Wasana Wongai of Thailand is already working on this problem and information will be obtained.

14. Drought

- Information for screening by Infra-red screening for plant hydration done in Spain for sunflower (Dr. Fernandez Martinez) will be obtained and studies undertaken. IDRC is kindly requested to provide funding for the purchase of this equipment for at least two or three countries. The information on work being done in Thailand by Dr. Wongyai using the enzyme electrophorosis technique will be collected.

15. Stand Establishment

- The countries where seed planter is used will undertake studies on this aspect. The result of investigation being done in India will be presented by Dr. Thangavelu.

16. Weeds

- All countries will identify the major weed flora and screen germplasm for early vigour and growth.

- In India, Fluchloralin at 1750 ml/ha as pre-emergence spray was reported to be effective in controlling the weeds. Dr. Thangavelu has agreed to collect further information.

- It is reported that Treflan at 1500 cc/ha is effective when applied to soil after mixing with soil. Further information will be collected.

Summary Recommendations for Sesame

1. The action plan drawn based on the last subnetwork meeting after accomplishing a few, may be carried out by the scientists of the countries as agreed.

2. The group strongly recommended the consideration of the project on sesame proposed earlier to FAO/UNDP for funding as any further delay is likely to result in set back in sesame production at global level as it is considered as minor oil crop by most of the countries.

3. The member countries were requested to urge their Governments to give priority for sesame research programs for funding by outside agencies.

4. IBPGR is requested to accord priority for collection of wild species of sesame in collaboration of respective countries as any further delay is likely to result in loss of valuable genetic resources.

5. Dr. Li Lili of China in her communication to chairman of sesame subnetwork requested that academic exchanges meetings may be held every year in different countries for exchange of latest scientific knowledge and ideas. This was recommended subject to availability of funds.

6. It was requested to provide funds to chairman and co-chairman for effective collaboration and co-ordination as well as to visit to co-ordinating countries in the region. The Oilcrops Network is requested to provide funds.

7. As recommended in the last subnetwork meeting, the training for senior level scientists is proposed to have advance training opportunities on sesame breeding methodologies, new methods of statistical analysis, oil quality etc., with Dr. R.D. Brigham of Texas A & M University, Texas. The Chairman of Sesame will supply the Co-ordinator the list of recommended scientists along with priorities.

8. A training program for sesame production covering all aspects is recommended for junior level scientists in India (Tamil Nadu Agril. University, Coimbatore). The chairman will finalize the list and period of training and furnish to the Network Co-ordinator.

9. It is recommended that IDRC/Net work may provide small funds to two or three centres for the purchase of Infra Red equipment for screening for drought resistance. The cost of one equipment may be around 800-900 US$.

II. RECOMMENDATIONS FOR SUNFLOWER SUB-NETWORK

The sunflower group of 13 participants from 7 different countries (Bangladesh, Egypt, India, Morocco, Pakistan, Spain ad Yugoslavia) took part in the long and in-depth discussion and formulated The following recommendations as compiled by Dr. Mangala Rai, the chairman of the Sunflower subnetwork, and Dr. M.A. Rana.

1. Identification of Priority Constraints

The priority constraints of sunflower published in the proceedings of last meeting held in Kenya (IDRC MR 205e) was reviewed and updated, Table 2. Some new constraints such as headrot, collar rot, grey cotton bug, ideotype, economics and development of farm machinery for small farmers were identified and added in Table 1. Two new countries, Bangladesh and Morocco were listed in the Table indicating their priority constraints.

According to the total scores, priority constraints such as: leaf spot, white rot, downy mildew (diseases), cutworm, bird damage (pests), drought, plant height, earliness and oil content were identified.

It has been suggested to revise the Table 2 and include in the proceedings. In this regard, the Coordinator (Oilcrops Network) is requested to contact the countries, which did not attend this meeting, and get update on the table concerning situation in their country.

2. Development of Improved Populations

A strong need was felt to develop different diversified sunflower populations to help generate base material for the selection of elite lines leading to develop open-pollinated varieties and inbred lines having desirable characteristics such as drought tolerance, high yield, high oil content, resistance to downy mildew, earliness and short height. To achieve this, four groups have been formulated each having some sunflower varieties/germplasm lines with specific characters. The groups are as follows:

Group I: High yield, high oil group
1. New pemir (Spanish)
2. Peredovik
3. Vniimic 8931
4. Smera
5. Luch

Group II: Drought resistance group
1. Armavirsky 3492
2. Armavirsky 9343
3. Armavirsky 9345

Group III: Resistant to downy mildew
1. Yubile noyu 60
2. Progress
3. Novinka
4. October

Group IV : Mixed group
1. Mayak (Drought)
2. Zarya (Earliness)
3. Donsky (Dwarfness)

To obtain the seed of above lines (except New Pemir) the Coordinator (Oilcrops Network) is requested to approach the concerned authorities in USSR. In case the seed of some varieties are not available in USSR, other sources shall be contacted such as Dr. Dragon Skoric, Dr. Vennozi and Dr. Vranceano. Dr. Jose Fernandez Martinez promised to supply the seed of "New Pemir" on the request of the coordinator (Oilcrops Network). The seed of varieties included in group I,II, III, and IV will be used for making/developing different gene pools by India, Morocco, Pakistan and Egypt, respectively. All the seeds shall be supplied to coordinator

Table 2. Priorities* of constraints of sunflower research and production.

	Countries**																
Factors	Mo	Ph	Et	Eg	Ke	Za	Pa	In	Ug	Th	Ca	Ta	Ne	Su	Ba	My	Total
DISEASES																	
Head rot	1	2	?	?	?	?	2	1	?	1	2	3	?	?	?	?	12
Leaf spot	-	2	-	-	1	1	2	3	-	3	-	3	3	1	2	2	23
Leaf blotch	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	2
White rot	2	3	3	-	3	2	1	2	2	-	3	2	2	2	-	-	27
Leaf blight	-	-	-	-	-	-	2	2	-	-	-	-	-	-	-	-	4
Rugose mosaic	-	-	-	-	3	-	-	-	2	1	-	3	-	-	-	-	9
Yellow ring spot	-	-	-	-	2	2	-	-	3	-	-	3	-	-	-	-	10
Downy mildew	2	-	3	-	3	1	1	3	3	1	1	1	1	3	-	-	23
Rust	3	-	2	-	2	-	1	1	-	-	1	1	1	2	-	-	14
Powdery mildew	1	3	-	-	-	-	-	-	1	-	-	1	1	1	-	-	8
Wilt	2	2	1	2	1	1	2	2	?	3	1	-	2	1	2	2	24
Charcoal rot	-	2	-	2	1	3	3	-	?	-	-	3	?	2	-	-	15
Collar rot	1	2	-	2	1	3	3	-	?	-	-	3	?	2	-	-	17
INSECT PESTS																	
Cut worms	2	2	1	2	1	3	1	1	3	2	2	3	2	1	1	1	28
Boll worms	1	1	1	3	1	-	2	1	2	3	-	3	-	3	-	-	21
Hairy caterpil.	-	2	-	-	-	-	3	1	2	1	-	-	3	-	1	1	14
Tobacco " Caterpillar	-	2	-	-	-	-	3	1	2	1	-	-	3	-	-	-	12
Termite	-	-	1	-	1	3	-	1	-	1	-	1	1	1	-	-	10
Plusia semi	-	-	-	?	1	1	2	1	1	1	-	-	1	?	-	-	8
Flee beetles	3	-	-	?	-	-	-	-	?	-	-	-	2	3	-	-	8
Niscus Stinging bug	-	-	-	?	-	2	-	-	-	-	-	-	-	-	-	-	2
Blister beetle	1	-	?	-	-	-	-	-	-	-	-	-	1	-	-	-	2
Nematodes	-	1	-	?	1	1	?	1	2	-	-	-	1	-	-	-	7
Rodents	-	-	-	-	-	-	-	-	-	1	-	-	2	-	-	-	3
Birds	3	2	2	3	3	3	3	3	3	3	3	2	3	1	3	3	43
Grey cotton bug	-	-	?	?	?	?	2	?	?	1	-	-	?	?	?	-	3
OTHERS																	
Ideo type	2	1	?	?	?	?	?	2	?	1	1	-	?	?	?	?	7
Weeds/ Parasites	3	1	2	2	-	-	-	-	-	-	-	-	-	-	-	-	8
Salinity/ alkalinity	1	-	-	2	-	-	1	2	-	-	-	-	?	-	-	-	6
Acidity	1	-	-	-	-	3	-	-	2	-	-	-	?	-	-	-	6
Drought	3	2	3	2	2	3	2	3	3	1	1	1	2	3	-	2	33
Plant height	2	3	3	2	-	-	3	-	2	-	2	?	2	2	3	3	27
Earlines	3	3	3	3	2	2	3	2	2	3	2	3	3	3	3	3	43
Oil percent	3	3	3	3	3	3	2	3	3	3	2	3	3	3	3	3	46
Economics	3	1	?	?	?	?	2	3	?	1	3	?	?	?	?	2	15
Farm machinery	2	1	?	?	?	?	3	-	?	1	1	?	?	?	3	-	11

* 3 = High, 2 = Medium, 1 = Low, - = Not a priority, ? = No information.

** Mo = Morocco, Ph = Philippines, Et = Ethiopia, Eg = Egypt, Ke = Kenya, Za = Zambia, Pa = Pakistan, In = India, Ug = Uganda, Th = Thailand, Ca = Canada, Ta = Tanzania, Ne = Nepal, Su = Sudan, M = Morocco, Ba = Bangladesh, My = Mycnmar (Burma).

(OilcropsNetwork) for redistribution to member countries for selecting desirable types.

3. Distribution of Literature on "Sunflower Breeding"

To help the breeders to learn "how to develop populations, gene pools and handle the material in each population for the selection of elite/novel lines", the coordinator (Oilcrops Network) is requested to purchase 20 copies of a special issue of the Yugoslavian Journal containing valuable article entitled "Sunflower Breeding" by Dr. Dragan Skoric and distribute one copy to each member country through their contact person. Dr. Skoric will kindly supply the publication free of charge.

4. Transfer of Technology Through Exchange of Information

All the member countries are requested to supply one copy of their sunflower production/ protection technology package to the Coordinator (Oilcrop Network), who would photocopy these documents to make a complete set and redistribute them to each participating member country.

The production package document should contain brief information on at least following topics:

a. Land preparation,
b. Method of planting,
c. Time of planting,
d. Seed rate,
e. Recommended varieties,
f. Interculturing practices,
g. Fertilizer doses,
h. Seed treatment,
i. Herbicide application,
j. Insecticide recommendations,
k. Harvesting,
l. Marketing and storage, and
m. Economics (Production cost and benefit ratio).

In addition, each member country is also requested to furnish in brief the following information about the sunflower growing area in their respective countries:

a. Average monthly temperatures (maximum and minimum),
b. Monthly precipitation (mm),
c. Soil types, and
d. Sunshine intensity and duration.

5. Identification of Races of Downy Mildew

It has been suggested to identify the downy mildew races present in each country as a first step towards an integrated approach for building high resistance against this disease in sunflower. To achieve this, the Coordinator (Oilcrops Network) shall request USDA at Fargo to supply the seed of differential lines which would be distributed among the member countries to initiate the work on race identification.

6. Leaf Blight (Alternaria)

It has also been suggested to initiate screening work against alternaria disease in the countries where it is a problem. Dr. Dragan Skoric has very kindly agreed to supply enough seed of a wild sunflower species (*Helianthus tuberosus*) to the Coordinator (Oilcrops Network) who would distribute it among the member countries. The countries where the resistance to alternaria is found shall share the information and gene source with the member countries.

7. Charcoal Rot

Dr. Skoric has very kindly agreed to provide the seed of lines which are resistant to charcoal rot to the Coordinator (Oilcrops Network), who would distribute them to the interested countries on receiving a formal request.

8. White Rot

Since no proven race of resistance

is available for white rot disease, cultural practices such as crop rotation should be followed to avoid disease to the maximum extent possible.

9. Insect Pests

Looking to the other priorities, for the time being, no action is suggested on the problem of insect pests except to take appropriate chemical measure to control the insect-pest infestation wherever it is a problem.

10. Salinity and Alkalinity

Helianthus paradoxus has been pointed out as a source for resistance to salinity and alkalinity. Dr. D. Skoric has very kindly agreed to provide small quantity of seed of this wild sunflower species to India and Egypt through the Coordinator (Oilcrops Network). India and Egypt will initiate breeding work on the salinity/alkalinity problem, the findings of which (information and resistant material) will be shared among the member countries.

11. Drought Resistance

Dr. Jose Fernandez Martinez, on the request of Coordinator (Oilcrops Network), will supply the seed of two B populations and two R populations which have showed better performance under the drought conditions. The Coordinator (Oilcrops Networks) will share this material with the member countries. For the increase of seed, Pakistan is assigned to multiply the seed of B populations and Egypt the R populations and return them to the Coordinator (Oilcrops Network).

12. Earliness and High Oil

It has been pointed out that every country has some early maturing and high oil materials, which should be obtained by the Coordinator (Oilcrops Network) for developing gene pool at his level to distribute among the member countries. Dr. D. Skoric has also very kindly agreed to supply seed of some elite lines having high oil content and some early maturity lines to the Coordinator (Oilcrops Network).

Each country will exploit their gene pool for developing populations/lines with earliness and high oil content for their countries.

13. Compilation of Review on Charcoal Rot

Dr. Arafa Hilal (Egypt) has very kindly agreed to prepare a review on charcoal rot disease indicating the following:

a. Breeding techniques,
b. Selection techniques,
c. Preparation of inoculum,
d. Methods of artificial inoculation,
c. Gene sources available,
d. Effect of environments on the appearance of disease,
e. Disease symptoms,
f. Mode of infection and life cycle of pathogen,
g. Chemical control if any,
h. Alternate hosts, and
i. Other important points not being covered by above.

14. Consultancy

Since sunflower is a new crop it would be desirable to provide the consultancy services in specific disciplines and problem areas to some of the more needy countries to develop research programs on sound footings.

15. Training Needs

A strong need of training manpower in specific disciplines of plant breeding, plant pathology, seed technology and seed production has been pointed out. The recommendations made in this regard during the Kenyan meeting have also been endorsed by the sunflower group.

A specific training in plant breeding have been worked out to be undertaken during July-August, 1990 or 1991, the details of which are as follows:

a. Place of training: Institute of Field and Vegetable Crops, Novi Sad, Yugoslavia.
b. Time of training: July 10 to August 10, 1990
c. Duration: 30 days.
d. No. of Participants : 20-26 (two from each country)
e. Level of participants :
   - One junior scientist having Master's degree in plant breeding with at least 2 years experience of research.
   - One senior scientists having Master's/Ph.D. degree in (Plant breeding) with at least 6-8 years experiance of research.
f. Lectures and practical training courses: The training course should cover a diversified area in theory as well as practical so that the participants can get a comprehensive knowledge about sunflower breeding methodology. The courses should cover:

1) development, maintenance and improvement of sunflower populations.
2) Emasculation and crossing procedures.
3) Maintenance of wild species.
4) Procedures of using wild species in sunflower breeding for selection of resistent genes and transfer of these genes to cultivated species.
5) Role of embryo culture of interspecific hybridization and its practical use.
6) Development of inbreed lines and their maintenance.
7) Making new combinations (top crossing) and evaluation of their performance.

III. GENERAL RECOMMENDATIONS

1. Research on Oil/Protein System

Many countries have shown interest in the Oil/Protein system research as reviewed by Dr. Zulberti in the meeting. The interested countries are requested to write to IDRC for financial and technical assistance indicating their interest and special requirements.

2. Low Cost Oil Extraction Machines

All the countries which have developed the low cost manual- or power-operated oil extraction machines should send the information about them to the Coordinator (Oilcrops Network) for sharing the information among the member countries.

3. Establishment of an International Unit on Oil Crops

The group strongly felt that IDRC must establish a research unit on oilcrops in the region for undertaking multidisciplinary research programs on the pattern of other International Research Institutions. This is essential to provide much needed thrust to the crops which are, although important for the region, not being looked after by any International Research Organization.

4. Establishment of Centers of Excellence

It was felt absolutely essential to develope potential research centers in different countries to cater to the needs of specific priority problems of the regions. To start with, we may have centers of excellence on drought, salinity/alkalinity, oil quality, and disease resistance. These centres would be complementary or supplementary for augmenting research inputs even to the International Oilcrops Unit.

5. Establishment of Oil Quality Laboratory

The group strongly recommended strengthening of some of the oil laboratory for quick determination of oil content and fatty acid profile. IDRC should consider to provide adequate funds/equipments for strengthening laboratories in the member countries. Preferably the equipment suitable for the regions should be provided to these laboratories on priority basis.

6. Venue for Next Meeting

The network suggested to hold the next meeting in Pakistan during last week of April 1991. A formal permission will be seeked from the Pakistan Agric. Res. Counsel and Government of Pakistan for this meeting. It is also suggested to hold the full network meeting at the same time. Suggested agenda/program will be 1-2 days of steering committee of subnetworks, 4 days of presentations and discussion especially finalizing the constitution and 2 days of field trips to Lahore and Faisalabad.