GERMPLASM PROGRAM

Annual Report for 2000

ICARDA

About ICARDA and the CGIAR

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is governed by an independent Board of Trustees. Based at Aleppo, Syria, it is one of 16 centers supported by the Consultative Group on International Agricultural Research (CGIAR).

ICARDA serves the entire developing world for the improvement of lentil, barley and faba bean; all dry-area developing countries for the improvement of on-farm water-use efficiency, rangeland, and small-ruminant production; and the Central and West Asia and North Africa region for the improvement of bread and durum wheats, chickpea, and farming systems. ICARDA's research provides global benefits of poverty alleviation through productivity improvements integrated with sustainable natural-resource management practices. ICARDA meets this challenge through research, training, and dissemination of information in partnership with the national agricultural research and development systems.

The results of research are transferred through ICARDA's cooperation with national and regional research institutions, with universities and ministries of agriculture, and through the technical assistance and training that the Center provides. A range of training programs is offered, from residential courses for groups to advanced research opportunities for individuals. These efforts are supported by seminars, publications, and specialized information services.

CGIAR

The CGIAR is an international group of representatives of donor agencies, eminent agricultural scientists, and institutional administrators from developed and developing countries who guide and support its work. The CGIAR receives support from many country and institutional members worldwide. Since its foundation in 1971, it has brought together many of the world's leading scientists and agricultural researchers in a unique South–North partnership to reduce poverty and hunger.

The mission of the CGIAR is to promote sustainable agriculture to alleviate poverty and hunger and achieve food security in developing countries. The CGIAR conducts strategic and applied research, with its products being international public goods, and focuses its research agenda on problem-solving through interdisciplinary programs implemented by one or more of its international centers, in collaboration with a full range of partners. Such programs concentrate on increasing productivity, protecting the environment, saving biodiversity, improving policies, and contributing to the strengthening of agricultural research in developing countries.

The World Bank, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), and the International Fund for Agricultural Development (IFAD) are cosponsors of the CGIAR. The World Bank provides the CGIAR System with a Secretariat in Washington, DC. A Technical Advisory Committee, with its Secretariat at FAO in Rome, assists the System in the development of its research program.

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International Center for Agricultural Research in the Dry Areas
P.O. Box 5466, Aleppo, Syria

This report was written and compiled by program scientists and represents a working document of ICARDA. Its primary objective is to communicate the season's research results quickly to fellow scientists, particularly those within the Central and West Asia and North Africa (CWANA) region, with whom ICARDA has close collaboration.

From 1986 to 1993 this report was published under the title "Cereal Improvement Program Annual Report." Starting with the 1994 and until the 1999 issue, it changed its title to "Germplasm Program: Cereals Annual Report." Its companion volume for legumes during the same period (1994 to 1998) was published under the title "Germplasm Program: Legumes Annual Report."

Starting with the 1999 issue, this report combined the "Germplasm Program: Cereals Annual Report" and "Germplasm Program: Legumes Annual Report," and took a new title "Germplasm Program Annual Report."

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1. GENERAL INTRODUCTION

Crop improvement research on cereals and legumes at the International Center for Agricultural Research in the Dry Areas (ICARDA) is conducted within the Germplasm Program. Among the cereals, it covers barley, durum wheat and bread wheat, while amongst the legumes it covers lentil, chickpea, faba bean and forage legumes. ICARDA has a global mandate for the improvement of barley, lentil and faba bean, and a regional mandate for the improvement of durum wheat, bread wheat, chickpea and forage legumes. The improvement of durum and bread wheat is done jointly with the International Maize and Wheat Improvement Center (CIMMYT), Mexico, which has a global mandate for wheat improvement. Similarly, chickpea improvement is done jointly with the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), India, which has a global chickpea mandate. Integrated Pest Management research at ICARDA is also within the Germplasm Program.

To fulfill the global mandate for the improvement of barley, ICARDA has posted a barley breeder in CIMMYT-Mexico to address the needs of barley improvement for Latin America. CIMMYT has placed a durum breeder and a spring bread wheat breeder at ICARDA with a regional responsibility for West Asia and North Africa (WANA). Winter and facultative bread wheat breeding is based in Ankara (Turkey), where ICARDA has posted a breeder in 1997, with backup at headquarters.

The overall objective of the Germplasm Program is to increase the productivity and sustainability of the farming systems which include barley, lentil, faba bean, durum wheat, bread wheat, chickpea, grasspea, pea and forage legumes in partnership with NARS, NGO and farmers.

This objective is being pursued through methodologies emphasizing specific adaptation through decentralized breeding, gender-sensitive participatory approaches, use of biotechnology, use of inputs compatible with the preservation and improvement of the resource base, maintenance and enhancement of agricultural biodiversity, and ultimately alleviation of poverty.

The base for most of the research work is at Tel Hadya, where ICARDA's headquarters are located and where additional environments are created by different planting dates and plastic houses. However, research is also conducted in other sites in Syria (Breda, Bouider, Lattakia and farmers' fields) and Lebanon (Terbol and Kfardan). All these sites are directly managed by ICARDA. High elevation sites of the national programs of Syria, Turkey, Central Asia and Caucasus, Iran and Maghreb countries are used, in a collaborative mode, for developing improved winter and facultative barley, bread and durum wheat, lentil, chickpea and forage legumes adapted to cold environments. The research sites and facilities of the national programs of about 50 countries in the five continents, are used jointly for developing breeding material with specific resistance to some key biotic and abiotic stress factors because of the presence of ideal screening conditions and/or expertise there. The process of decentralization of breeding work is being continued and extended with the help of national programs.

The weather conditions during the 1999/2000 season are shown in Figure 1.1 for two dry sites (Bouider and Breda), and in Figure 1.2 for relatively wetter sites (Tel Hadya and Terbol). The total precipitation during the season was lower than the long term average in all locations.

On average, mean monthly maximum temperatures were higher, whereas mean minimum monthly temperatures were lower than the long term average over 23 growing seasons.

At **Bouider,** the total precipitation was 10% below the long term average (201 mm versus 224 mm). The highest monthly precipitation deviations from the long term average during cropping season occurred in October (+21 mm)and December (-27 mm). The temperature during the 1999/2000 cropping season was 1°C above the long term average maximum and minimum temperatures, respectively. The monthly mean maximum temperature during the cropping season ranged from 10 to 42°C, and the minimum from 0 to 21°C.

At **Breda,** the total precipitation was 9% below the long term average (230 mm versus 252 mm). The highest monthly precipitation deviations from the average occurred in November (-20 mm) and in January (+28 mm). The temperature during the 1999/2000 cropping season was 2°C above the long term average maximum temperature, and 1°C above the average minimum temperature. The monthly mean maximum and minimum temperatures during the cropping season ranged from 11 to 38°C, and from 1 to 21°C, respectively.

At **Tel Hadya,** the total precipitation was 22% below the long term average (260 mm versus 331 mm). The highest monthly precipitation deviations from the average occurred in November (-37 mm) and in January (+44 mm). From May to August no precipitation was received and overall precipitation in spring was about 20 mm below average. The average maximum and minimum temperature during the 1999/2000 cropping season was 2°C above the long term average, whereas the minimum temperatures matched the long term average. The monthly mean maximum temperature during the cropping season ranged from 11 to 41°C, and the minimum from 0 to 22°C.

At **Terbol,** the total precipitation was 35% below the long term average (339 mm versus 516 mm). The highest monthly precipitation deviations from the average occurred in November (-58 mm), December (-61 mm), January (+85 mm), February (-41 mm), and March (-65 mm). The average maximum temperature during the 1999/2000 cropping season was 1°C above the long term average, while the minimum temperature was 1°C below the average during spring. The monthly mean maximum temperature during the cropping season ranged from 9 to 38°C, and the minimum from -2 to 12°C.

During the year the following changes in senior staff occurred:

a. The Program Leader, Dr W. Erskine has been appointed as A/Assistant Director General.
b. Dr K. Makkouk, Virologist has been appointed A/Leader Germplasm Program

More than 75 scientists from 20 different countries spent between few days and few months in the Germplasm Improvement Program. Their activities varied from discussions with staff members to research projects in collaboration with specific scientists. Their contributions to the achievements of the Program are reported in details in the specific sections.

The following special projects were operational during 2000:

1. **DNA-Marker assisted breeding and genetic engineering of ICARDA mandated crops**, supported by BMZ and in collaboration with University of Hannover, Prof. Dr.H.J. Jacobsen and University of Frankfurt, Prof. Dr. G. Kahl (scientist in charge: M. Baum)
2. **Improving yield and yield stability of barley in stress environments**, supported by the Government of Italy (scientist in charge: S. Grando)
3. **Resistance to nematodes in lentil and chickpea** in collaboration with the Institute of Nematology of Bari (scientist in charge: R.S. Malhotra)
4. **Fusarium wilt in chickpea**, supported by the Government of Spain and in collaboration with INIA, Spain (scientist in charge: R.S. Malhotra)
5. **Durum evaluation and utilization**, supported by the Ministry of Foreign Affairs of Italy, (scientist in charge: M. Nachit)
6. **Collaborative Research Project in Durum Grain Quality**, supported by the Ministry of Foreign Affairs of Italy, (scientist in charge: M. Nachit)
7. **Drought tolerance in Durum**, supported by Ministry of Foreign Affairs of France, (scientist in charge: M. Nachit)
8. **Adaptation of durum to dryland**, supported by the National Institute of Agronomic Investigation (INIA) of Spain, (scientist in charge: M. Nachit)
9. **Breeding of durum for dryland**, supported by CIMMYT,

(scientist in charge: M. Nachit)

10. **Coordinated improvement program for Australian lentils,** supported by GRDC, Australia (scientist in charge: A. Sarker)
11. **Improvement of drought and disease resistance in lentils,** in Nepal, Pakistan and Australia supported by ACIAR, Australia (scientist in charge: A. Sarker)
12. **Central and West Asia rusts network-enhanced regional food security through the development of wheat varieties with durable resistance to yellow rust,** (scientist in charge: A. Yahyaoui)
13. **Kabuli chickpea,** supported by ACIAR, Australia (scientist in charge: R.S. Malhotra)
14. **Development of high yielding, long spike bread wheat cultivars possessing high tiller, number, rust resistance and heat tolerance facilitated by microsatellite DNA-markers,** supported by Agricultural Technology, Utilization and Transfer Project-ATUT (scientist in charge: O. Abdalla)
15. **Genetic transformation of barley for improved stress resistance,** supported by CGIAR (scientist in charge: M. Baum).
16. **Adaptation of barley to drought and temperature stress using molecular markers,** supported by USDA, Texas Tech University, U.S.A. (scientist in charge: S. Ceccarelli).
17. **Inheritance and linkage of winter hardiness in lentil,** supported by USDA, Washington State University, U.S.A. (scientist in charge: A. Sarker)
18. **Use of entomopathogenic fungi for the control of Sunn pest,** in collaboration with University of Vermont, U.S.A, supported by USAID. (scientist in charge: M. El-Bouhssini)
19. **Integrated Pest Management of Sunn Pest in West Asia,** supported by the Department for International Development (DFID), UK.
20. **Legume resistance to Luteoviruses supported by GRDC, Australia,** (scientist in charge: K. Makkouk) (started in October 1998)
21. **Development of biotechnological research in the Arab States,** supported by Arab Fund for Economic Social Development (AFESD) (scientist in charge: M. Baum)
22. **Improvement of lentil and grasspea in Bangladesh,** supported by ACIAR (scientist in charge: A. Sarker)
23. **Collaborative Molecular Biotechnology Integrating Network (COMBINE),** supported by EU, (scientist in charge: M. Baum)
24. **Decentralized barley breeding with farmers' participation in North Africa,** supported by OPEC (scientist in charge: S. Grando)

25. **Village-based participatory breeding in the terraced mountain slopes of Yemen**, supported by SWP PRGA (scientist in charge: S. Ceccarelli)
26. **International Collaboration in barley research between ICARDA and Waite Campus Institutions**, supported by GRDC, Australia (scientist in charge: S. Ceccarelli)
27. **Improving the yield Potential and Quality of Grasspea (lathyrus sativus L)**, supported by DFID, U.K (scientist in charge: Ali M. Abd El-Moneim)
28. **From Formal to Participatory Plant Breeding: Improving Barley Production in the Rainfed Areas of Jordan**, supported by IDRC (scientist in charge: S. Ceccarelli)
29. **Barley Improvement in Eritrea**, supported by DANIDA (scientist in charge: S. Grando)

In addition, the program is actively involved in the activities of the six Regional Programs and in the following special projects:

- Mashreq and Maghreb (M&M) Project
- Mediterranean Highland Project
- Barley Improvement Project in Ethiopia
- Problem-solving Regional Network Project in Egypt Ethiopia, Sudan and Yemen
- Matrouh Resource Management Project in Egypt

This report is published in seven sections, as per the projects described in ICARDA's Medium Term Plan.

Most of the results reported in the seven sections were obtained during the 1999-2000 season, although work done in earlier years is also reported when considered important. The training and network activities, the scientific publications of the program's staff and an updated list of varieties released by national programs are also reported.

As mentioned earlier, much of the work reported here has been done in collaboration with our colleagues in the national programs in WANA and other developing countries and in some institutions in the industrialized countries. Names of all our collaborators are mentioned in a special section under each project, and to all of them goes our most sincere appreciation. Eventually, the program is greatly indebted to the support staff at the headquarters as well as in various substations: without their hard work, competence and dedication none of the work reported here would have been possible.

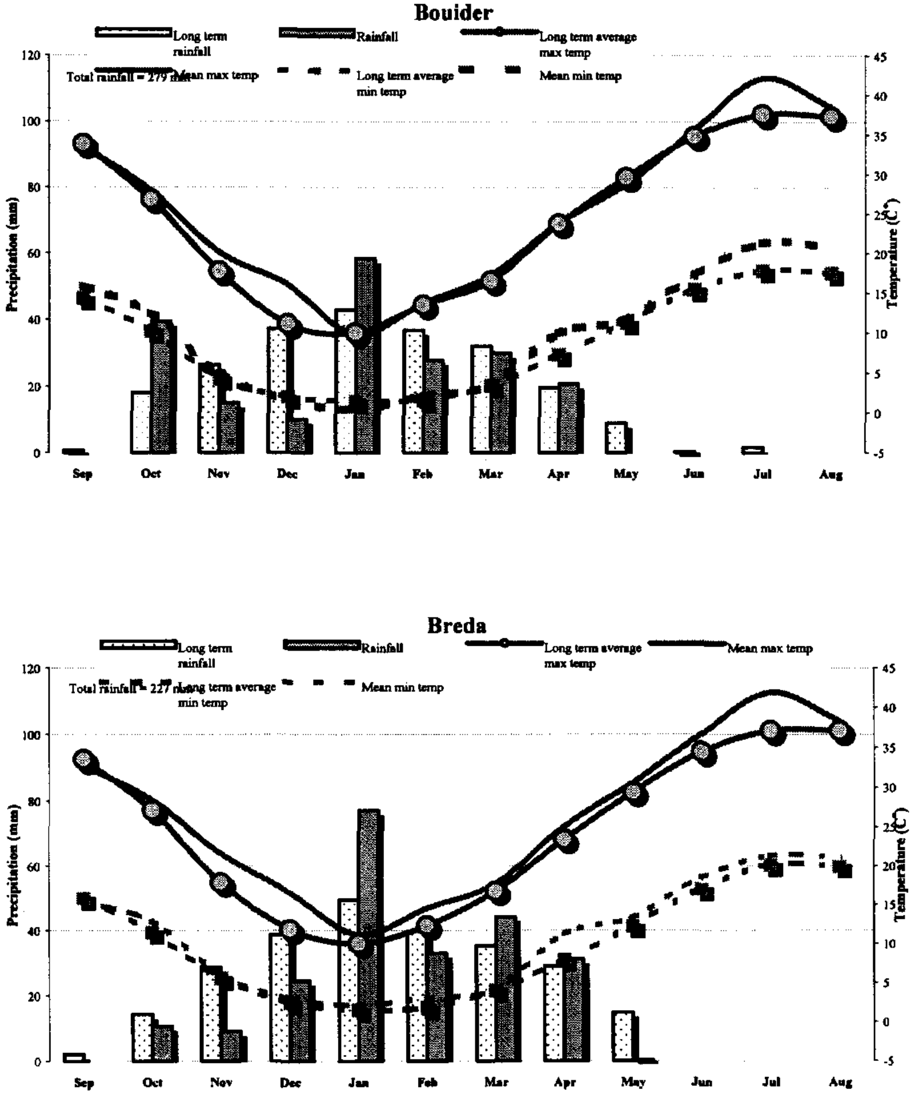
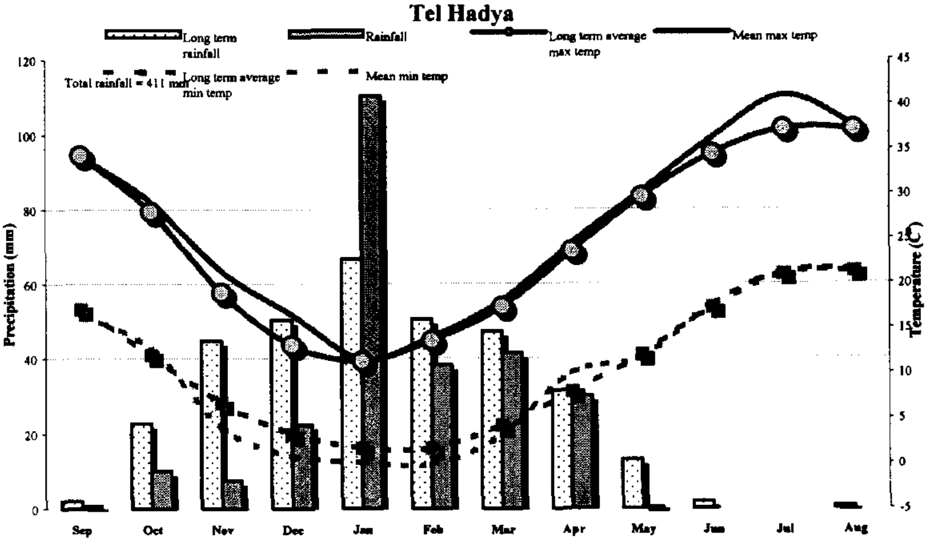


Figure 1.1. Weather conditions at Bouider and Breda during 1999-2000.



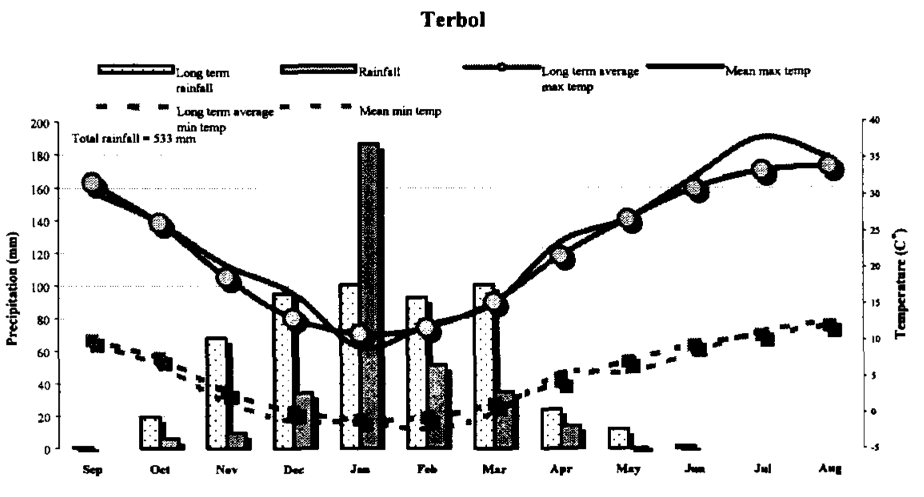


Figure 1.2. Weather conditions at T. Hadya and Terbol during 1999-2000

I. PROJECT TITLE: BARLEY GERMPLASM IMPROVEMENT FOR INCREASED PRODUCTIVITY AND YIELD STABILITY 1

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I. PROJECT TITLE: BARLEY GERMPLASM IMPROVEMENT FOR INCREASED PRODUCTIVITY AND YIELD STABILITY

II. EXECUTIVE SUMMARY

This year, the annual report is presented in a new layout that follows the structure of the ICARDA's Medium Term Plan of ICARDA. Therefore, the activities and the achievements of the cropping season 2000/2001 are organized according to the five outputs that the barley improvement project is expected to produce.

During 2001, new varieties have reached the final stage of testing in Libya, Jordan, Tunisia, Kyrgyzstan, Kazakhstan, and Armenia, the seed of the variety Sararood is being multiplied in Iran, and several new promising lines have been identified in several countries of Central Asia, Latin America and the Near East.

The severe drought that affected Syria has lead to the identification of new barley lines, able to survive and to produce some yield (in grain and dry matter) with only about 100 mm rainfall.

Considerable progresses have also been made in developing both six-row and two-row cold tolerant genotypes. The germplasm development continued to rely on screening of large amount of breeding material for resistance to biotic stresses. Screening of breeding material for a number of diseases is routinely conducted both in Aleppo and in Mexico. Resistance to Russian Wheat Aphid (RWA) has been successfully incorporated into North African material and is being incorporated into Ethiopian germplasm. A similar approach is being used with resistance to Barley Yellow Dwarf Virus (BYDV). Through the collaboration with Australian scientists, we have tentatively identified new sources of resistance to Cereal Cyst Nematodes (CCN).

Progresses have been made in the data analysis, and all data are now analyzed using REML (residual Maximum Likelihood Method) and the best linear unbiased predictors (BLUPS) are used for the selection of entries.

Participatory breeding continued to receive considerable attention, and while some special projects ended, a new project started in Jordan, and the projects in Egypt, Syria, Eritrea and Yemen are on going.

Four populations are currently being mapped with molecular markers to find suitable markers for marker-assisted selection. Other two populations are being mapped in

collaboration with Australian scientists.

The work of the project has been disseminated though 18 new publications, visits to National Programs and participation in conferences, workshops and meetings.

More than 80 scientists from over 30 countries (including Latin America, China, and South East Asia) attended individual non-degree training or training courses in barley improvement, while three students continued their degree training. More than 15 scientists, both from developed and developing countries visited the project.

The assistance and the contributions of scientists from the National Programs, of the research and secretarial support staff at the Headquarters and in Mexico, and the financial support of several donors are gratefully acknowledged.

III. INTRODUCTION

Barley is grown on more than 70 million hectares, about 42 of which in the developing countries including those of Central Asia and the Caucasus. Barley is grown for animal feed, human food, and malt, and in many different types of environments. However, most barley is grown in marginal environments, often on the fringes of deserts and steppes, or at high elevations in the tropics, receiving modest or no inputs.

Because barley is grown in unfavorable environments and by resource-poor farmers, comparatively little progress has been made through conventional breeding approaches. Therefore, the barley project at ICARDA has developed an approach to germplasm enhancement based on direct selection in the target environment and with farmers' participation. This approach provides varieties with specific adaptation to both biotic and abiotic stresses and the specific uses. The aim is to achieve sustainable increases in barley productivity by adapting the crop to the different farming systems of developing countries, with special emphasis to those areas where the crop is grown by resource-poor farmers.

The apparent contradiction between ICARDA's global mandate for barley improvement and the emphasis on specific adaptation is resolved by a process of decentralized breeding through selection in the target environment. This involves NARS scientists being equal partners in the entire breeding scheme, from the selection of parents, to the design of crosses, to the choice of selection and breeding methods, to the selection between and within segregating populations in each individual country. Therefore, there has been a gradual reduction of conventional breeding work at headquarters, with a reallocation of resources and support to NARS in the decentralized selection and testing. A major new direction in the last five years has been the participation of farmers, both men and women, in early selection of segregating populations to better exploit specific adaptation.

The goal of the project is to increase the productivity of barley in marginal areas and the purpose is the adoption of improved varieties by farmers in marginal areas.

Barley improvement at ICARDA has a global perspective aiming to address the problems that limit the production of the crop in all developing countries. The target areas of the project have been divided in the following six geographic regions, which are dealt with by six sub-projects:

1. Near East and West Asia
2. North Africa
3. East Africa and Yemen
4. Central Asia and the Caucasus
5. Far East
6. Central and Latin America

The development of germplasm pools is the responsibility of four barley breeders as follows (Fig. 2.1):

1. The breeder for Latin America is responsible for Mexico, Ecuador, Peru, Colombia, Bolivia, and Chile
2. The breeder for CAC is responsible for CAC, Russia, Turkey, and Iran
3. The breeder for Africa and Yemen is responsible for Mauritania, Morocco, Algeria, Tunisia, Libya, Egypt, Ethiopia, Eritrea, and Yemen
4. The breeder for Near East and West Asia is responsible for Syria, Jordan, Palestine, Iraq, Afghanistan, and Pakistan

At the moment the breeder for Near East and West Asia is also responsible for India, Nepal, Bangladesh, China, Korea, Vietnam, and Thailand. The work of the four breeders is supported by six specialists who spend between 35% and 8% of their time in the project (Fig. 2.1).

The project deals with a wide range of germplasm, from spring to winter, and from the wild progenitor, *Hordeum spontaneum* to landraces and modern cultivars. The major role of ICARDA's barley breeders is to generate useful genetic variability through targeted crosses, to distribute segregating populations, and to coordinate the analysis of data and the utilization of the information. The role of the national barley breeders, in turn, is to identify parental material (for example sources of resistance), to design suitable crosses, and to perform the selection in the target environments.

The project aims to achieve five types of output, namely

1. Germplasm with higher and stable yield, better biotic stress resistance and better quality identified
2. Methodology to enhance adoption developed
3. Breeding methodology for stress environments developed
4. New methodologies disseminated
5. NARS Research capabilities improved

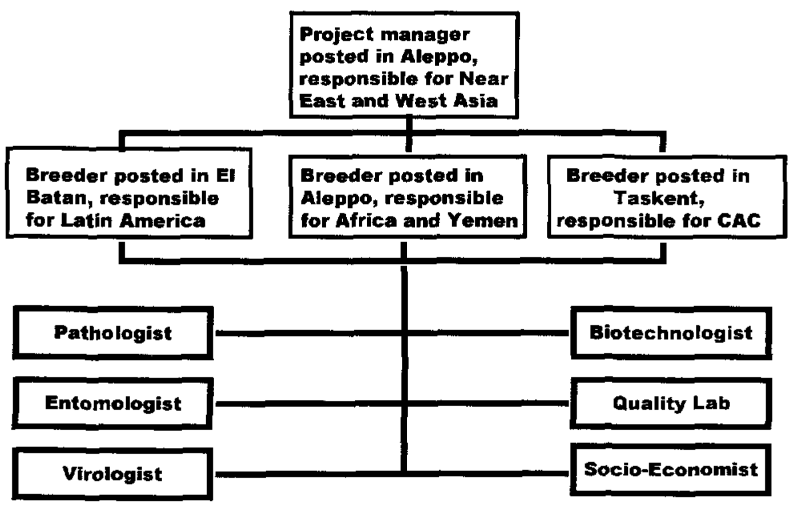

Fig. 2.1. The structure of the barley project at ICARDA.

The activities conducted during 2000 will be presented according to these five different outputs.

IV. ACHIEVEMENTS

Output 1: Germplasm with higher and stable yield, better biotic stress resistance and better quality

The main activities to achieve this output are related to the development of germplasm with higher yields in specific environments, with resistance to biotic and abiotic stress, and with improved quality (food, feed, malting) characteristics.

1.1. Cultivar Development

1.2. The Crossing Program

The implementation of the breeding philosophy is based on a large crossing program that is the main source of new genetic variation. Parental lines used in the crossing program include lines selected for their performance in various target environments, sources of resistance to diseases, pests and viruses identified either by ICARDA scientists or by national program scientists, lines selected for special characteristics (earliness, yield potential, resistance to drought, heat, cold or salinity, seed quality attributes, lodging resistance, etc), and cultivars produced by other breeding programs in the world. In terms of diversity, the parental lines include landraces, modern varieties, six- and two-row, early and late maturing types, spring, facultative, and winter types, hulless and hulled. Recently, malting barleys were added to the crossing block in response to an increased demand for malt to be used in baby food.

The overall crossing program consists of several groups of crosses, each targeted to a specific country, or to a group of countries, or to a specific objective, and with each group comprising between 50 and 300 crosses. While at the headquarters crosses are only made in the spring, in Mexico crosses are made during the winter at the CIANO Station at Ciudad Obregon, and in the summer at the El Batan and Toluca Stations.

The crosses made by the project in 2000 are given in Table 2.1.

Crosses with landraces and with *H. spontaneum* are not listed separately as most of the crosses for Syria, Jordan and northern Iraq (Mashreq) have a landrace and/or *H. spontaneum* as one of the parents. Most of the crosses done in 2000 to transfer, incorporate or combine resistance to diseases, pests and BYDV and to incorporate the hull-less gene were included among those targeted for specific countries. Also, those crosses made to develop mapping populations are not listed separately.

1.3. Selection and Testing

The development of new germplasm is largely done in collaboration with national programs of developing countries, and in some cases in collaboration with advanced institutions in developed countries. The process is based on decentralized selection, defined as selection in the target environment, starting from the generation of new variability based on the crossing program described above.

The segregating populations derived from the crossing program are distributed in two different ways. In the first, the F_2, or more often the F_3 bulks are sent as targeted

Table 2.1. Number and type of crosses done in 2000 in the barley project compared with 1999.

Country/Objective	2000	1999
Algeria	79	64
Egypt	79	
Iran and Iraq (irrigated areas)	102	79
Libya	69	32
Morocco	94	87
Tunisia	72	35
China	35	
Mashreq (Syria, Jordan, north Iraq)	242	201
Eritrea/Tigray/Yemen	104	11
Ethiopia	30	59
North Africa (general)	16	
Naked	324	
Iran	30	*
Russia (spring program)	41	*
Kyrgystan	48	*
Turkey	50	*
Uzbekistan	34	*
Malting quality (CAC, Turkey, Iran)	346	
CAC (Russian wheat aphid)	20	*
High yield potential (two row)	119	71
CAC cold tolerance x yield potential)	188	*
Recurrent selection	141	189
Latin America (spring x spring)	641	469
Latin America (spring x winter)	97	163
Latin America (top crosses)	606	516
Total	3607	2255

* In 1999 these were lumped in one group of 289 crosses

nurseries to the respective country or countries. Based on the selections made by the national programs in the locations where the segregating populations are evaluated, we then send nurseries that include the selected populations, and eventually country-specific yield trials. In the second, which is used in the case of countries for which we do not have sufficient information to develop targeted crosses and targeted segregating populations, we send the traditional international nurseries that are targeted to four types of environments, namely:

Low-rainfall areas with mild winters
Low rainfall areas with cool winters
Moderate rainfall areas
Cold areas with severe winters (predominantly with winter types)

The nurseries include observation nurseries and yield trials. We are also making available internationally one crossing block, one set of segregating populations, trait-specific nurseries comprising lines characterized by earliness, hulless caryopsis, cold tolerance, resistance to specific diseases, insects or viruses, etc.

The decentralization of both selection and testing has caused a progressive reduction of the number of lines that are yield-tested on ICARDA's research stations and that are mostly targeted for the Mashreq Region (Syria, Northern Iraq, Palestine and Jordan) in the Near East, and the closing of the research site at Bouider. This component of the program is now increasingly conducted in farmers' fields with the participation of farmers, and therefore most of the yield testing has been gradually shifted to farmers' fields, while seed multiplication is done on station. Therefore, during 2000, of the three types of yield trials conducted in the past in the research station, namely initial, preliminary and advanced yield trials, only the advanced yield trials were still present (Table 2.2); in 2001 the yield testing will be entirely conducted in farmers' fields (Table 2.2)

The yield trials are conducted without addition of fertilizer (Breda) or with modest amount (30 kg/ha of nitrogen and 20 Kg/ha of P_2O_5) at Tel Hadya.

1.4. Cultivar Development for the Near East

1.4.1. Syria

Advanced Yield Trials

Table 2.2. Evolution of the yield testing: total number of plots from 1993 to 2000 (in parenthesis the number of locations).

	On Station			Farmers fields[a]	Total
Year	Initial	Preliminary	Advanced		
1993	6804 (3)	4272 (3)	2240 (5)	0	13316
1994	5632 (2)	2256 (2)	912 (4)	0	8800
1995	6160 (2)	1600 (2)	1400 (5)	0	9160
1996	3520 (2)	1360 (2)	1440 (5)	0	6320
1997	3520 (2)	1040 (2)	1000 (5)	1872 (9)	7432
1998	1960 (2)	1008 (2)	900 (5)	1484 (10)	5352
1999	0	2280 (2)	500 (3)	1220 (10)	4000
2000	0	0	600 (2)	2200 (11)	2800

[a] this does include the plots in the on-farm verification trials

The advanced yield trials conducted in 2000 included 145 lines, partly repeated from the advanced yield trials of 1999, and partly selected from the preliminary yield trials of 1999, and 5 checks (Table 2.3). They were planted in two locations and in two replications with an alpha-lattice design. Yield in Tel Hadya and Breda were lower than usual (2450 and 882 kg/ha, respectively), due to the low rainfall. The highest grain yields in Tel Hadya were just above 3 t/ha and the yields of the highest yielding lines were 1 t/ha above the average of the checks. In Breda, the highest yields were about 1.1 t/ha and were more than twice the yields of the best checks and the average yields of the check. Two lines of different origin (entries 89 and 102) were among the top yielding both in Tel Hadya and Breda. This is not usual, and is likely to be associated with the yield level of Tel Hadya that is around the point where the crossover interactions start showing their effects.

Verification Trials

The On Farm Verification Trials (OFVT) represent one specific type of collaboration with the Syrian national program. These trials are important because from their results recommendations are made to release varieties in Syria.

The OFVT with barley are conducted in several locations in each of the two stability zones, namely zone B receiving between 350 mm and 250 mm of annual rainfall, and zone C receiving about 250 mm of annual rainfall, respectively.

Table 2.3. The lines in the advanced yield trials 2000 included among the top 5% for grain yield (kg/ha) in Tel Hadya (upper half) and Breda (lower half) with their row type (rt), vernalization requirement (vr), days to heading (dh), plant height in Tel Hadya and Breda (phth and phbr), grain yield in Tel Hadya and Breda (gyth and gybr) and 1000 kernel weight in Tel Hadya and Breda (kwth and kwbr)

Ent.	Name	Rt	vn	Tel Hadya				Breda		
				dh	ph	gy	kw	ph	gy	kw
	Best 5% in Tel Hadya									
9	WI2269/Line 51-11-2/5/11012-2/Impala//Birence/3/Arabi Abiad/4/5604/1025	2	1	90	48	3273	46.	30	1035	38.4
58	Zanbaka/H.spont.41-2	2	3	88	47	3177	44.	28	956	27.3
8	Cerise/Lignee 1479//Moroc 9-75/PmB	2	1	89	47	3110	41.	29	1052	34.8
16	SLB 05-96/Arta	2	3	89	44	3056	46.	26	860	34.0
89	Zanbaka/H.spont.41-2	2	3	92	40	3050	44.	27	1130	35.4
132	Lignee527/NK1272/4/Deir Alla106//DL71/Strain 205/3/Lignee 527	6	1	95	51	3050	36.	27	704	29.2
102	Arda/4/Roho//Alger/Ceres 362-1-1/3/Kantara	2	3	88	50	3047	38.	29	1108	31.1
	Best 5% in Breda									
12	SLB 39-037	2	3	91	55	2484	35.	36	1171	26.4
108	SLB 45-048	2	3	95	49	3009	44.	27	1140	33.9
89	Zanbaka/H.spont.41-2	2	3	92	40	3050	44.	27	1130	35.4
1	SLB 31-24	2	3	90	40	2842	46.	28	1122	36.5
4	Arar/H.spont.19-15//Ar	2	3	96	47	2861	38.	30	1119	31.6
85	Zanbaka/H.spont.41-2	2	3	91	46	2815	43.	30	1111	31.6
102	Arda/4/Roho//Alger/Ceres 362-1-1/3/Kantara	2	3	88	50	3047	38.	29	1108	31.1
	Checks									
146	Rihane-03	6	2	98	46	1999	35.	29	470	28.8
147	Alanda-01	6	1	97	56	2235	35.	27	405	28.2
148	Arta	2	3	97	41	2101	28.	25	396	24.5
149	Tadmor	2	3	96	40	2014	29.	25	356	25.4
150	Zanbaka	2	3	96	56	2050	39.	25	342	31.6
	Mean of the checks	-	-	97	47	2080	33.	26	394	27.7
	Trial mean	-	-	91	55	2450	36.	33	882	28.9

Lines tested in the OFVT are selected by ICARDA, DASR (Directorate for Agricultural and Scientific Research of the Syrian Ministry of Agriculture and Agrarian Reform) and ACSAD (Arab Center for Studies of the Arid Zones and Dry Lands) and are tested for a maximum of three years when they perform well. If they do not perform well they can be taken out after the first year.

The trials are conducted as RCB designs with three replications in zone B and four in zone C.

The OVFT for zone B in 1999/2000 (Table 2.4) included ten promising lines and five checks. They were conducted in 6 locations with mean yields ranging from 1010 kg/ha in Souran to 2208 kg/ha in Al Goz.

Genotype x environment interactions explained 60% of the variation of environmentally standardized data. The performance of the lines in the seven environments is shown in Fig 2.2, where the entries are indicated as G followed by the entry number, and the environments are indicated as E and are in the same sequence as in Table 2.4. Five of the six locations were closely correlated, while Izraa (E6) behaved differently and most likely caused most of the large genotype x interaction effects. Arta, Acsad 1420, Furat 2, and Furat A-5468 were the genotypes performing better across all the environments that were closely correlated. However, they performed poorly in Izraa where the best line was Mo.B1337/WI12291//Moroc 9-75, which performed poorly in all the other environments.

The OVFT for zone C in 1999/2000 (Table 2.5) included thirteen promising lines and two checks (the two local landraces). They were conducted in 7 locations, but because of severe drought, only three were harvested. The mean yields ranged from about 400 kg/ha in Batraneh, to nearly 750 kg/ha in Breda and Khabab. Genotype x Environment Interactions were small and explained slightly less than 20% of the variation of the environmentally standardized data. The three locations were correlated, particularly Breda and Khabab (Fig. 2.3). There were four groups of lines with different performance across the three locations; those performing poorly in all three locations (such as A.Abiad, Furat S-5715, and Acsad 1182), those performing very well in Batraneh, but just above the average in the other two locations (such as Acsad 1420 and WI2291/Tadmor), those performing well in Breda and Khabab, but poorly in Batraneh (such as Moroc 9-75/Arabi Aswad and Furat A-5473), and those with an average performance in all three locations (all the other entries including A. Aswad).

Table 2.4. Grain yield (kg/ha) of lines in the on farm verification trials in zone B in Syria.

Entry	Name	Abteen	Al_Goz	Mohjah	Harran	Suran	Izraa
1	A.Abiad (check)	1338	1809	1329	1094	932	2042
2	Arta (check)	1793	2509	2108	1592	1013	1712
3	A.Aswad (check)	1586	2406	1927	1346	1062	1726
4	Acsad 1182	1353	2212	1980	1347	953	2075
5	Acsad 1420	1754	2545	2120	1562	1148	1644
6	Alanda//lignee527/Arar	1397	2085	1510	1223	974	1518
7	Carina/Moroc 9-75	1219	2356	1873	1211	1015	1682
8	Clipper/Volla/3/Arr/Esp//	1524	2230	1615	1513	974	1103
9	Furat 1 (check)	577	1634	1426	796	621	1802
10	Furat 2 (check)	1744	2203	2079	1362	1125	1723
11	Furat A-5468	1555	2295	2125	1583	1155	1904
12	Furat E-5406	1509	2148	2239	1528	1033	1767
13	Furat M-5408	1727	2005	1911	1183	956	1360
14	Lignee 527//Rhn/Rhn-03	1211	2329	1435	1054	1102	1963
15	Mo.B1337/WI12291//Moroc 9-75	1328	2354	2074	1489	1087	2734
Location means		1441	2208	1850	1325	1010	1784

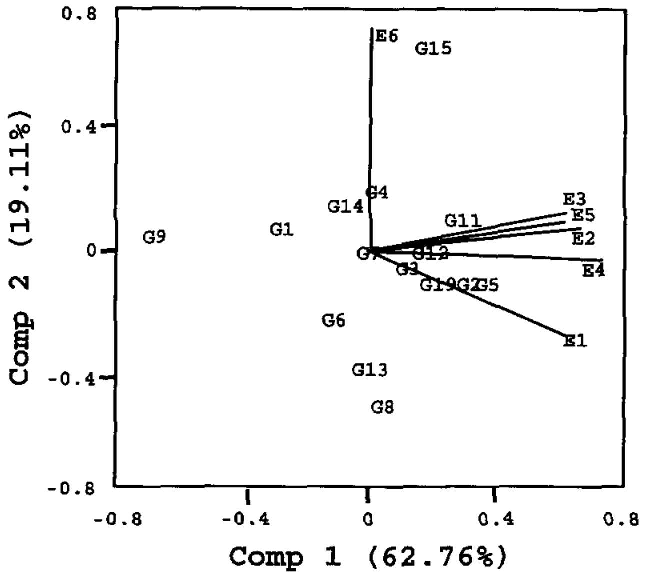

Fig.2.2. Biplot of grain yield of 15 barley lines grown in six locations (1= Abteen, 2=Al Goz, 3=Mohjah, 4=Harran, 5=Souran; 6=Izraa) in zone B in Syria. The lines' names are given in Table 2.4.

Table 2.5. Grain yield (kg/ha) of lines in the on farm verification trials in zone C in Syria.

ntr	Name	Batrane	Breda	Khabab
1	Moroc 9-75//H. Spont. 41-1/Tadmor	441	744	826
2	Furat A-5473	302	771	827
3	SLB 34-40	417	727	777
4	Acsad 1420	547	855	777
5	Zanbaka//Hml-02/Lgnee 131	478	758	776
6	Furat S-5715	315	574	512
7	A.Abiad (check)	289	551	482
8	SLB 34-65/Arar	394	757	802
9	Acsad 1182	376	685	693
10	Local 2	419	784	799
11	Moroc 9-75/Arabi Aswad	361	816	879
12	Furat A-5475	430	736	769
13	WI2291/Tadmor	506	816	833
14	A.Aswad (check)	451	770	816
15	Furat A-5474	484	751	855
	Means	414	740	762

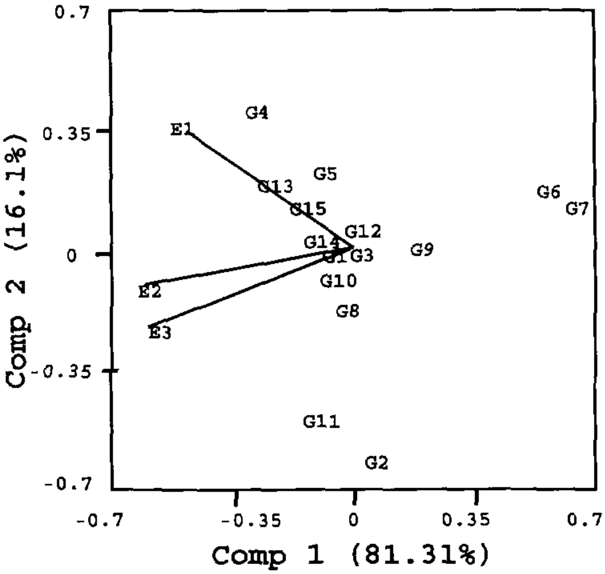

Fig. 2.3. Biplot of grain yield of 15 barley lines grown in three locations (E1 = Batraneh, E2 = Breda, E3 = Khabab) in zone C in Syria. The lines' names are given in Table 2.5.

1.4.2. Lebanon

The two ICARDA research stations in Lebanon are used for two purposes; the first is to screen breeding material for cold tolerance and high yield potential (in Terbol) and for resistance to terminal heat and drought stress (Kfardane), and the second is to develop barley cultivars specifically targeted for Lebanon. Therefore, in the last few years, both segregating populations and yield trials have been developed specifically for Lebanon.

The highest yielding lines in Terbol during the last two years are shown in table 2.6 with their yield in 1999, in 2000 and as average of the two years expressed as percent of the best check. Compared with Rihane-03 and Mari/Aths*2, the two released varieties in Lebanon. A number of lines, mostly two row, out yielded both checks in both cropping seasons by between 17 and 34%, even though the yield levels were widely different.

Table 2.6. Row type (rt) and grain yield (gy in % of the best check) in 1999, 2000 and as mean of the two years of lines in the yield trials for Lebanon tested in Terbol.

Entry	Name	rt	gy99	gy00	mean
37	Shyri-3/3/Arar//2762/Bc-2L-2Y	6	1.55	1.13	1.34
17	Hml-02/A.Abiad*2/4/Sfa-02/3/RM1508/Por//WI2269/5/H.spont.20-4/Arar28//WI2291/Bgs	2	1.22	1.40	1.31
33	Rihane-03/3/Bc/Rihane//Ky63-1294/4/Orge 905/Cr.289-53-2	6	1.36	1.21	1.28
19	Barbara/5/Api/CM67//Mona/3/DI//Asse/CM65-1W-B/4/Asl-02/6/H.spont.20-4/Arar28//WI2291/Bgs	6	1.34	1.18	1.26
18	M126/CM67//As/Pro/3/Alanda/4/Rhn-03	6	1.25	1.25	1.25
29	Bda/5/Cr.115/Pro//Bc/3/Api/CM67/4/Giza 120/6/Baca'S'/3/AC253//CI 08887/CI 05761	6	1.24	1.25	1.25
20	Rhn-03/3/Roho//Alger/Ceres362-1-1/4 /Rhn-03	6	1.11	1.30	1.20
25	Manal/3/Lignee 527/NK1272//JLB 70-63	6	1.10	1.27	1.18
22	Mari/Aths*2//Avt/Attiki/3/Aths/Lignee 686/4/Rhn-03	6	1.16	1.18	1.17
30	Bco.Mr/Avt//Cel/3/Line257-14/4/Rihane 'S'-5/5/Harmal/4/Lth/3/Nopal//Pro/11012-2	6	1.10	1.23	1.17
55	Rihane-03	6	764	1.00	4256
56	Mari/Aths*2	6	604	0.98	4170

The highest yielding lines in Kfardane the last two years are shown in table 2.7 with their yield in 1999, in 2000 and as average of the two years expressed as percent of the best check. Compared with Rihane-03 and Mari/Aths*2, the two released varieties in Lebanon. A number of lines, mostly two row, out yielded both checks in both cropping seasons by between 9 and 35%. Two lines, Mari/Aths*2//Avt/Attiki/3/Aths /Lignee 686/4/Rhn-03 (entry 22) and Rhn-03/3/Bc/Rhn-03//Ky63-1294/4/Orge 905/Cr.289-53-2 (entry 33) out yielded the best checks both in Terbol and Kfardane.

Table 2.7. Row type (rt) and grain yield (gy in % of the best check) in 1999, 2000 and as mean of the two years of lines in the yield trials for Lebanon tested in Kfardane.

Entry	Name	rt	gy99	gy00	Mean
36	Lignee 527/NK1272/3/Arizona 908/Aths //Lignee 640	6	1.15	1.55	1.35
21	Arar//Hr/Nopal/3/Alanda-01/Alanda-01	6	1.30	1.16	1.23
22	Mari/Aths*2//Avt/Attiki/3/Aths/ Lignee 686/4/Rhn-03	6	1.17	1.25	1.21
8	Alanda-01/4/WI2291/3/Api/CM67//L2966 -69/5/Rhn-08/3/Deir Alla 106//DL71/ Strain 205	6	1.21	1.20	1.21
47	Hml//Kv/Mazurka/5/WI2198/Emir/4/7028 /2759/3/69-82//Ds/Apro	2	1.05	1.31	1.18
38	Lignee 527/NK1272//Sawsan/Lignee 640	6	1.01	1.27	1.14
30	Bco.Mr/Avt//Cel/3/Line257-14/4/Rihan e'S'-5/5/Harmal/4/Lth/3/Nopal//Pro/1 1012-2	6	1.31	0.91	1.11
28	Bda/5/Cr.115/Pro//Bc/3/Api/CM67/4/Gi za 120/6/Barbara	6	1.18	1.03	1.10
4	Line 49-14 D30/IPA265	6	1.14	1.06	1.10
33	Rihane-03/3/Bc/Rihane//Ky63-1294/4/ Orge 905/Cr.289-53-2	6	1.00	1.18	1.09
55	Rihane-03	6	237	1738	0.83
56	Mari/Aths*2	6	427	1236	0.96

1.5. Cultivar Development for North Africa and Horn of Africa.

1.5.1 Selections in 1999-2000 Special Nurseries for Maghreb

During 1999-2000 the nurseries specifically targeted for North Africa were:

1. Segregating populations for North Africa, divided in two groups; SEGEL00, containing mostly early germplasm, planted in Libya and Egypt, SEGMAG00 planted in Algeria, Tunisia, and Morocco (Table 2.8).

2. Special nursery for North Africa: NUREL00, containing mostly early germplasm, planted in Libya and Egypt, and NURMAG00, planted in Algeria, Tunisia, and Morocco (Table 2.8).

3. Yield trials for Algeria, Egypt, Libya, Morocco, and

Tunisia (Table 2.9).

Table 2.8. Segregating populations (SEGMAG and SEGEL) and special nurseries for North Africa (NURMAG and NUREL) distributed for 1999-2000 cropping season with number of lines and number of sets.

Country	SEGMAG00 (SEGEL00)[a]		NURMAG00 (NUREL00)[b]	
	N of lines	N of sets	N of lines	N of sets
Libya	142	3	91	3
Egypt	142	3	91	3
Algeria	298	3	110	4
Tunisia	298	5	110	6
Morocco	298	5	110	6

[a] SEGEL00 was planted in Egypt, Libya, and in one location in Morocco.
[b] NUREL00 was planted in Egypt and Libya.

Table 2.9. Barley yield trials distributed to North Africa in 1999-2000 cropping season with number of lines, number of replications and number of locations.

Country	N of lines	N of replications	N of sets
Libya	66	2	4
Egypt	63	2	4
Algeria	60	2	4
Tunisia	90	2	8
Morocco	72	2	8

Segregating populations (SEGMAG00 and SEGEL00)

In Morocco, selection in SEGMAG00 was done in Merchouch, Jemaa Shaim, and Annaceur. On the basis of agronomic performance and resistance to major diseases, thirty-six entries were selected at Merchouch, fifty-three at Jemaa Shaim, and thirty-seven at Annaceur. In total, 135 entries were selected in Morocco. Three entries were selected in all three locations, and fifteen entries were selected in two locations (six at Merchouch and Jemaa Shaim, one at Merchouch and Annaceur, and eight at Jemaa Shaim and Annaceur). Name and pedigree of the entries selected in the three locations in Morocco are reported in Table 2.10.

Table 2.10. Entries selected in all locations in Morocco from SEGMAG00.

Entry	Cross	Pedigree
189	Lignee527/NK1272//Alanda/3/Alanda-//Ssn/Lignee640	ICB97-0933-0AP
152	Ager//Api/CM67/3/Cel/WI2269//Ore/4/Ala/Alanda/Hamra	ICB97-0889-0AP
251	Alanda//Lignee527/Arar/4/Rhn-03/5/Manal//Aths/Lignee686	ICB97-1213-0AP

In Tunisia, selection was done at three locations; Beja, Tajerouine, and El Kef. At Tajerouine and El Kef the host farmer and a neighboring farmer also did selection, respectively. One hundred and sixty entries were selected in total. Two entries were selected by the breeder in all three locations (Table 2.11).

Table 2.11. Entries selected in all locations in Tunisia from SEGMAG00.

Entry	Cross	Pedigree
182	Alanda/Hamra/3/Lignee527/NK1272//UL7aidor	ICB97-0925-0AP
53	Comp.Cr.229//As46/Pro/3/Srs/4/RWA.M5	ICB97-0730-0AP

At Tajerouine the host farmer selected sixteen entries, the breeder fourteen. Six entries were commonly selected by the breeder and the farmer. At El Kef the breeder selected fifty-three entries, while the farmer selected forty-two, thirty-six were in common. Five entries were selected by both farmers (Table 2.12), only one entry (n.182) was selected by the breeder in all three locations and by both farmers.

In Algeria, selection was done in two locations, El Khroub and Setif, seventy-three and fifty-seven entries were selected in the two locations, respectively. A total of 150 entries were promoted to further testing in NURMAG01.

Selection in SEGEL00 was done at Sofit and Azizia in Libya, and at El Hamol in Egypt. Seventy-nine entries were selected in Libya, and forty-two in Egypt. Twenty-eight entries were selected in both countries. Seventy-eight

Table 2.12. Entries selected by farmers in two locations in Tunisia from SEGMAG00.

Entry	Cross	Pedigree
8	M66-69-1/M65-94//70-22109/3/Apm/IB65/4/Glda'S'/5/CM67/Centeno//Cam/6/Api/CM67//Aths*3/7/RWA.M56	ICB97-0653-0AP
10	Man/4/Bal.16/Pro//Apm/DwII-1Y/3/Api/CM67/5/Comp.Cr.229//As46/Pro/6/Lignee527/Chn-01/5/DeirAlla106//DL70/Pyo/3/RM1508/4/Arizona5908/Aths//Avt/Attiki/3/Ager	ICB97-0656-0AP
73	Saida/6/Cita'S'/4/Apm/Rl//Manker/3/Maswi/Bon/5/Copal'S'/7/Lignee527/NK1272/6/Cita'S'/4/Apm/Rl//Manker/3/Maswi/Bon/5/Copal'S'	ICB97-0768-0AP
181	Alanda/Hamra/4/Aths/Lignee686/3/DeirAlla106/Lignee527//Assala	ICB97-0924-0AP
182	Alanda/Hamra/3/Lignee527/NK1272//UL76252/Jaidor	ICB97-0925-0AP

entries were promoted to next year testing.

El Hamol, in Kafr El Sheikh Governorate, is a site affected by a high level of salinity in the soil, therefore, the lines selected with the highest score (Table 2.13) are putative sources of tolerance to salinity.

Table 2.13. Best entries selected in SEGEL00 at El Hamol, Egypt.

Entry	Cross	Pedigree
27	Aths/Lignee686/3/DeirAlla106/Lignee27//Asl/4/Giza126	ICB97-0495-0AP
37	Aths/Lignee686/3/Ssn/Bda//Arar/4/Gia126	ICB97-0508-0AP
44	Aths/Lignee686/3/DeirAlla106/Lignee27//Asl/4/Giza126	ICB97-0515-0AP
55	Aths/Lignee686/3/DeirAlla106/Lignee27//Asl/4/Giza126	ICB97-0528-0AP
56	Aths/Lignee686/3/DeirAlla106/Lignee27//Asl/4/Acc#116134-Coll#89032-26	ICB97-0529-0AP
72	Giza126/3/Mammut//Gloria'S'/Come'S'	ICB97-0546-0AP
142	ETHIRA/B/491/4/Baca'S'/3/AC253//CI0887/CI05761	ICB97-0631-0AP

Special nursery for North Africa (NURMAG00) and for Egypt and Libya (NUREL00)

NURMAG00 comprised 117 entries (110 new lines selected from SEGMAG99 and 7 checks). Thirty-six entries were selected in Morocco, forty-seven in Tunisia, and twenty-two in Algeria. There were four entries selected in all three countries. With the lines selected from the nursery in each country, three different yield trials were prepared.

Selection in NUREL00 was done only in two locations in Libya; twenty-seven entries were selected for further testing.

1.5.2. Barley Yield Trials for North Africa

At the time of writing this report, data from the yield trials are being processed.

Due to the severe drought that affected all countries across North Africa during 1999-2000 cropping season, only some trials were harvested. In Libya no location was harvested, two locations were harvested in Egypt, three in Morocco, and two each in Algeria and Tunisia.

1.5.3. Food Barley Survey in Tunisia

A preliminary survey was conducted in Tunisia to assess the uses of food barley in different regions and to document farmers' preferences for quality characteristics.

The study indicated that the use of barley as food is very important in the rural areas of Tunisia with a large diversity of preparations, both from barley grain and flour. Malthouth (barley couscous), D'chich, Mermez, Kisra, and Frik, are the most common recipes using barley grain (whole and/or cracked).

1.5.4. Barley Traveling Workshop in Tunisia

The barley traveling workshop was organized by ICARDA/NARP in collaboration with IRESA/INRAT in Tunisia from May 2 to 5, 2000. Two barley breeders from each country in North Africa (Algeria, Libya, Morocco, and Tunisia) participated. The DG of INRAT Dr M.S. Mekni attended the whole workshop. Dr M. El Mourid, Regional Coordinator of the North Africa Regional Program and Dr S. Grando represented ICARDA.

The workshop, well planned and organized, took the participants to most of the sites (research stations and farmers' fields) used by the Barley Breeding Program in Tunisia. A particular emphasis was given to visit the Participatory Barley Breeding Project activities, conducted in collaboration with ICARDA. At each site, farmers were invited to join the participants for selection. At the end of the field visit a round table was organized with farmers, extension specialists, and breeders to discuss several aspects of participatory plant breeding. The participation of farmers in research and technology development was highly appreciated. The sites visited were:

1- INRAT station at El Kef
2- ESAK (Agricultural Faculty at El Kef)
3- On-farm trials at Tejerouine Garn El Halfaya, Farmer Amor (Mouelhi)
4- On-farm trials at Foussana, Farmer Brahim El Aïdi and his (wife)
5- On-farm trials at El Fahs, Farmer R'jeb Med Ennaoui
6- ESAM (Agricultural Faculty at Mograne)
7- INRAT station at Béja

This cropping season was characterized by favorable rainfall until beginning of January. Drought occurred for two and half months (January- February, March). Although the sites were all affected at different levels by the drought stress, several promising barley lines were identified.

At the end of the workshop, a round-table discussion was held at the ICARDA regional office and recommendations were made to strengthen barley improvement programs in North Africa in Collaboration with ICARDA.

The recommendations endorsed during the meeting were as follows:

1. In order to continue on-going PBB activities, there is an urgent need that ICARDA Barley program continue providing its support to national programs by sending nurseries and ensuring needed help and assistance.
2. To enhance regional learning processes related to PBB and pursuit this work until achieving its objectives, there is an urgent need to secure a second phase of the project where Algeria and Libya will be integrated as full partners.
3. To secure wide support to PBB at regional level, we need to summarize the findings of phase 1 and make that information available to national policy makers and to all partners including Algeria and Libya.

4. Collect and characterize local landraces and integrate them in the PBB process.
5. Associate farmers at an early stage of the PBB process (F5-F6) and continue with them till the end (seed increase and growing of selected local varieties).
6. Participatory breeding as a new approach needs in depth study and more discussion (Community and individual farmer involvement, field lay out, field days, extension services input) in order to come up with adapted appropriate ways of implementing it in the region.
7. Take into consideration farmers' interest in using barley for food and/or feed when planning PBB nurseries.
8. Plan starting 2000/2001 season for a Maghreb barley trial where already grown varieties could be grown across the region (5 varieties/2 sites/3 reps per country). ICARDA regional coordinator will initially take the lead in this activity (collect the material, approximately 3 kg/variety, and give it to Tunisian national program to prepare seed for field trials then distribute it to participating countries).
9. Include other disciplines in PBB teams (besides the breeders), in particular a social scientist.
10. Because of the importance of net blotch and stem gall midge, it is requested that ICARDA continues its support to the Moroccan specialized labs to carry out the screening for the Maghreb countries.
11. Encourage farmers' exchange of experience and information through traveling workshop, training courses, and documentation.

1.5.5. Momtaz: the First Product of the Decentralized ICARDA Barley Breeding in Tunisia.

Tunisia was one of the first countries to host the decentralized participatory barley-breeding program in collaboration with ICARDA.

Momtaz is one among thousands of lines evaluated during this period. It is tolerant to foliar diseases (net blotch, scald and powdery mildew) and drought.

In favorable years (1995-96 and 1998-99 in Beja), both Rihane and Manel out yielded Momtaz by between 5 to 30%. In dry years (Beja 1996-97 and 1997-98 and Kef98), Momtaz yielded on average 4,6 t/ha with a yield advantage of between 14% and 21% over the checks, whereas in Kef/semi-dry (1997-98), Momtaz gave 4.58 t/ha (30.30% over the check).

1.6. Cultivar Development for Latin America

A total of 732 barley advanced genotypes were tested in El Batán in the summer of 2000. From these experiments, 310 top yielding genotypes were selected to be included in the International Nurseries, mainly based on grain yield. The variety Cabuya, included as a check, was the top yielder in all experiments (8.3 t/ha), and was out yielded by only one genotype.

In the CIANO Station at Ciudad Obregon, 1200 genotypes (600 hulless and 600 hulled) were planted in the yield trials in November. The former 8x8 lattice design was replaced by an alpha-lattice design with two replications, and the genotypes to be tested were subdivided in two experiments of 300 hulled lines each and two experiments of 300 hulless lines each, both with two replications. This change is expected to increase the efficiency in the genotype and data processing, as well as save resources by reducing the number of plots dedicated to experimental checks needed in relation to the total number of advanced genotypes to be tested in the experiments.

Agronomy experiments were conducted in the Yaqui Valley with the varieties Bichy, Petunia and Tocte to test the effect of irrigation frequency (2, 3 and 4 irrigations), planting method (2 and 3 rows per bed), and seed density (60 and 120 kg/ha) on grain yield. In general, yield tended to decrease at higher seed densities, especially when combined with higher irrigation frequencies. This is likely to be associated to an increase of lodging at higher densities. There was a slight increase of yield with an additional irrigation in Tocte and Petunia. With the variety Bichy, there was a significant increase in yield whith three irrigations as compared with two. However, even though the third irrigation resulted in a significant increase in yield, a yield of about 5 t/ha could be economically viable under limited irrigation, because of the shorter growing cycle of Bichy, which can be harvested approximately one month earlier than wheat. This earliness would allow the early planting of an additional crop in the summer cycle. In the CIANO station, a soybean crop following Bichy was planted. Failure in the irrigation system precluded having yield results of this crop, but preliminary observations were possible regarding the effect of the early planting over the incidence of white fly in soybeans. No damage due to this pest was observed in the experiment. Additional yield information in the summer crop is needed before recommending this production system for this region.

Mexico State

Producers in the State of Sonora in Mexico are interested in finding new crop alternatives for their environment. Barley could be an option for producers if it can compete with durum wheat, the only cereal planted during the winter in the Yaqui Valley. Hulless barley can be an additional option for the pork feeding industry of the region because of its price, superior feeding quality, and seasonal availability. An ideal barley cultivar should have acceptable yield under high-input conditions, be resistant to lodging and to local diseases, especially stem rust. The shorter growing cycle of barley compared to wheat would be an advantage for the whole production system since it would allow the use of an additional summer crop, and would save irrigation water. The variety Bichy 2000 has been tested under those conditions and appears to be a feasible option. The release of the hulless variety Bichy 2000 depends on the results of the agronomy experiments described above. If the economic results are favorable, a niche for barley production could be found as a feed crop for that region.

Several populations were developed in the past years, with the objective of generating genotypes with short stature, resistant to lodging under irrigated conditions and resistant to stem rust. This effort is expected to continue to generate cultivars adapted to the region. The generation and number of populations are shown in Table 2.14.

Table 2.14. Pedigree, number and generation in EB 2000 of the populations developed for the target area of Sonora, Mexico.

Pedigree	Population	Generation
Brea/DL70//Cabuya	4	F_3
Brea/DL70//Tocte	4	F_3
Brea/DL70//2*Cabuya	23	$BC1F_2$
Brea/DL70//2*Tocte	23	$BC1F_2$
Brea/DL70//Tocte/3/Brea/DL70//Cabuya	22	F_2

Approximately 1000 plants were selected from the first two populations, and from these about 500 remained after post-harvest visual kernel screening.

The forage variety Capuchona, was released by ICAMEX (an Institution that works in the promotion of different crops in the State of Mexico). ICAMEX is planning to release one additional variety next year. Five forage barley varieties were given to ICAMEX for testing and are being tested in demonstration plots in the their experiment station.

Yield experiments under the environmental conditions of the state of Mexico were planted in El Batan with one supplementary irrigation and in a farmer's field at Oxtotipac without irrigation. Because of the dry conditions that occurred in Oxtotipac this year, the data generated in the experiment were useful to select genotypes adapted to these conditions. The genotypes tested were advanced lines derived from Petunia2/3/Galeras/PI6384//ESC.II.72.607.1E.4E.5E cross, where one parent has good performance under drought conditions. Twenty-eight genotypes out yielded the drought resistant parent. The five highest yielding genotypes and the genotypes selected by phenotype are shown in Table 2.15. We will continue to plant experiments in farmer's fields to generate additional data about breeding material and to identify new genotypes coming from the segregating populations.

Table 2.15. Highest yielding genotypes in the experiment of Oxtotipac in 2000, under drought conditions. (*) Indicate genotypes also selected for phenotype.

Genotype	Yield (t/ha)
Line 12*	5.0
Line 10	4.8
Line 37	4.4
Line 33	4.3
Line 52	4.2
Line 39 *	3.3
Line 64 *	3.2
Galeras/PI6384//ESC.II.72…	3.2
Weebill 1 (Wheat)	3.4

Hidalgo State

Hidalgo Foundation works in the same fashion as ICAMEX in the area of the State of Hidalgo. Five genotypes (Arupo/K8755//Mora, Tocte, Capuchona, Zig Zig and Sen) were tested in demonstration plots in five locations throughout the State of Hidalgo. Two of these genotypes (Tocte and Zig Zig) performed well across locations, and were identified by producers and extensions specialists in the field days organized in the region. The drought tolerance experiments conducted in Oxtotipac and El Batan also generated useful information to select genotypes for the environments of this State. Genotypes selected from these experiments will be extensively tested next year.

The project has a research agreement with Anheuser-Busch (BARI - Busch Agricultural Resources inc.) to incorporate *Fusarium* Head blight (FHB) resistance into their high malting quality germplasm. To reach this objective, three varieties from their program were crossed with our best FHB resistant genotypes, and the populations will be advanced through SSD to speed the breeding process. Twelve crosses were made at Toluca among genotypes provided by BARI and elite genotypes of our program with improved FHB resistance. The F_1 from these crosses were planted in the greenhouse for faster generation advancing (single seed descent), following the plan discussed with BARI researchers. Seed samples of the parents used were sent to the BARI quality lab for micro malting testing.

1.7. International Testing

In this section, we will refer the results of the International Yield Trials, which represent the main interface between the germplasm developed by ICARDA and the breeding programs of the NARS.

1.7.1. Low-Rainfall Areas with Mild Winters

The yield trial for low rainfall areas included 19 test entries, four long-term checks (entries 1, 6, 12, and 18), and the national check (Table 2.16).

The trial was planted at several locations, but data were returned from the 15 locations of the eight countries listed in Table 2.17.

Yields varied widely (Table 2.18), from less than 1 t/ha (in Faisalabad, Pakistan; in Serai Nanrang, Pakistan; and in Breda, Syria) to more than 5 t/ha (in Sakha, Egypt and in Athalassa, Cyprus). In the other locations, grain yields ranged from about 1 t/ha to about 4 t/ha. The genotype x environment interactions explained abot 80% of the environmentally standardized data. The Biplot (Fig. 2.4) shows three major groupings of the environments; in the first, which includes E3 and E5, lines G1, G7 and G10 were the highest yielding; in the second, which includes E4, E1, E6, E14, E11, E8, and E7, lines G15, G22, G13 and the long-term check G12 were the highest yielding; in the third, which includes E9, E10, E12 and E13, lines G9, G3, and G16 and the long-term check G6 were the highest yielding.

Table 2.16. Names of the lines tested in the International Yield Trial for low-rainfall areas with mild winters.

Entry	Name
1	Rihane-03
2	Rhn-03/Anoidium
3	SLB15-05/4/H.Spont.96-3/3/Roho//Alger/Ceres362-1-1
4	Lignee527/5/As54/Tra//Cer*2/TolI/3/Avt/TolI//Bz/4/Vt/Pro//TolI/6/UC566/5/M64-76/Bon//Jo/York/3/M5/Galt//As46/4/Hj34-80/Astrix
5	Arar/Lignee527//Arar/PI386540
6	Harmal
7	Lignee527/5/As54/Tra//Cer*2/TolI/3/Avt/TolI//Bz/4/Vt/Pro//TolI/6/Arar//Comp.Cr.29/C63
8	Arar/Lignee527//Pyo
9	Hml/Galleon
10	Arar/PI386540//Giza121/Pue/4/Srs/3/Mari/Aths*2//Arizona5908/Aths
11	Aths/Lignee686/5/ID/CM67//Asse/Nacta/4/Zoap//Mcu3021-5D/Ben/3/BcoMr//Ds/Apro
12	Beecher
13	JLB70-01/5/DeirAlla106//DL70/Pyo/3/RM1508/4/Arizona5908/Aths//Avt/Attiki/3/Ager
14	DeirAlla106//DL71/Strain205/3/DL529
15	DeirAlla106/3/As46//Avt/Aths/5/As46/Pro//Bal.16/Api/3/Mat.Rass209/4/6/DeirAlla106/Cel/3/BcoMr/Mzq//Apm/5106
16	Lignee131/ArabiAbiad//Hml-02/Roho
17	ER/Apm/3/Arr/Esp//Alger/Ceres362-1-1/4/Moroc9-75/PmB
18	Moroc9-75
19	Roho/ArabiAbiad//ND7014/Bowman
20	Lth/3/Nopal//Pro/11012-2/4/Antares//12201/Attiki/3/RM1508/Por//WI2269
21	H.Spont.41-1/Tadmor/3/ER/Apm//Lignee131
22	Lignee527/NK1272//JLB70-63
23	Mari/Aths*3-01/5/Mzq/Ben//H272/3/DeirAlla106/4/Manker/Slr//CP
24	NationalCheck

Table 2.17. Locations and countries where the lines in the International Yield Trial for low-rainfall areas with mild winters were tested in the year 2000.

Code	Location	Country
E1	Sakha Research Station	Egypt
E2	El-Giza Research Station	Egypt
E3	El-Hamal	Egypt
E4	El-Serw	Egypt
E5	Athalassa	Cyprus
E6	El Kef	Tunisia
E7	Hisar	India
E8	Faisalabad - Uni. Agric.	Pakistan
E9	Kohart-Jarma	Pakistan
E10	Serai Nanrang	Pakistan
E11	Jaipur	India
E12	Jemma Shaim - Safi	Morocco
E13	Breda	Syria
E14	Tel Hadya	Syria

1.7.2. Low Rainfall Areas with Cool Winters

The yield trial for low rainfall areas with cool winters included 19 test entries, four long-term checks (entries 1, 6, 12, and 18), and the national check (Table 2.19).

The trial was tested in several locations, but data were returned from the 9 locations of the eight countries listed in Table 2.20.

Yields varied widely (Table 2.21), from less than 0.5 t/ha (in Sariab, Pakistan; in Shirvan, Iran, and in Ramtha, Jordan) to a maximum of 3.6 t/ha in Tel Hadya (Syria) and 4.3 t/ha in Annaceur (Morocco). In the other locations, grain yields ranged from about 1 t/ha to 2.7 t/ha. The genotype x environment interactions explained about 70% of the environmentally standardized data. The Biplot (Fig. 2.5) shows three major groupings of the environments; in the first, which includes E2, E7, E3 and E4, lines G11, G13, G14, G23, G10, G19 and G7 were the highest yielding; in the second, which includes E9, E1, and E6, lines G20 and one of the checks (G18) were the highest yielding; in the third, which includes E8, and E5, lines G21, G9, and G15 were the highest yielding.

Table 2.18. Grain yield in 14 locations of the lines tested in the International Yield Trial for low-rainfall areas with mild winters (Entry and Location names are given in the previous Tables).

Entry	RT	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14
1	6	5934	3780	4666	3750	7576	4537	3500	815	2217	733	1289	800	998	3924
2	6	5267	5367	4517	3184	6702	3922	3500	866	2734	1159	1333	978	1055	3433
3	2	5751	4977	2950	2100	7108	4168	3389	815	2634	1069	833	1578	1119	4007
4	6	5918	4934	3967	3750	7290	4042	3639	810	2611	548	945	1111	798	3424
5	6	5801	3384	4433	3409	6086	4380	2556	1020	2722	930	1295	1111	872	3644
6	2	5167	4644	3616	2666	6797	4061	3611	1253	2878	867	1511	1800	1166	3765
7	6	5101	3360	4933	2867	7466	4025	3111	1046	1434	556	695	400	698	3355
8	6	4617	3617	4900	2900	7224	3454	3139	881	2945	492	1178	1467	757	3733
9	2	5334	4194	3700	2817	6310	4589	3722	890	3667	1181	1267	1200	1200	3526
10	6	6084	2404	5500	3267	6807	4016	3028	859	2945	845	1339	933	812	3464
11	6	5668	3110	4433	3492	6609	4368	2639	950	3078	688	1611	1289	747	3803
12	6	6268	4687	3617	4033	6707	4401	4028	881	4045	452	1889	1600	939	3728
13	6	5667	4227	4316	3250	6913	3948	4389	837	4000	918	1284	1155	1062	3915
14	6	4850	4397	3983	2033	6325	3350	2222	864	3111	989	795	667	823	3722
15	6	6518	4480	4116	3533	7090	3937	3555	890	4000	1033	2167	1200	929	4056
16	2	4917	5400	3583	3175	6773	3956	3083	1066	4056	826	756	1556	1042	3232
17	2	5634	3150	4066	3750	6773	3320	3139	781	3000	982	1333	1111	1166	4303
18	2	6084	3807	4217	3217	6279	4246	2944	867	3212	911	1122	1178	1067	3792
19	2	5634	3167	4250	2366	6329	4482	3417	997	3200	911	1333	1466	1176	3602
20	2	4700	3727	2250	2833	6576	3864	2111	692	2645	548	1678	1467	950	3443
21	2	4550	3134	2600	2366	5762	2902	2083	618	3778	863	639	1089	1078	3262
22	6	6667	3250	3250	3783	7516	4222	2694	815	3334	1167	1578	1067	970	3937
23	6	5868	4734	3616	3600	6036	3273	4111	1048	2689	1139	1467	1133	848	3291
24	-	5318	4494	5583	3084	7929	4442	3417	830	3056	689	2211	1222	1181	3173
Mean		5555	4017	4044	3134	6791	3996	3209	891	3083	854	1314	1191	977	3647

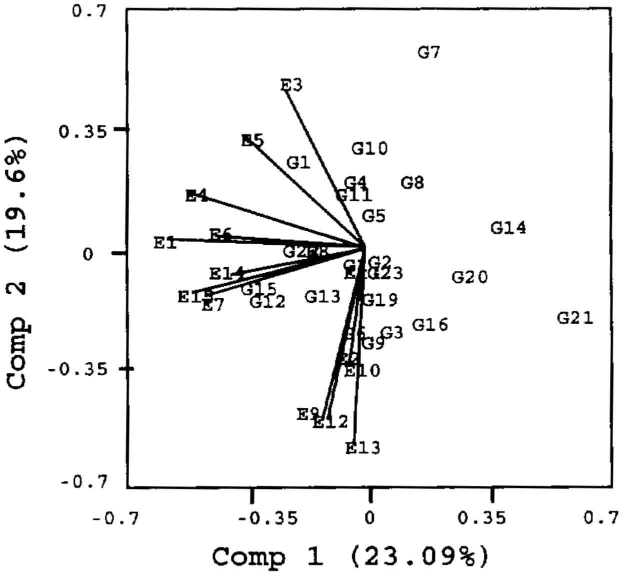

Fig. 2.4. Biplot of the 24 lines tested in the International Yield Trial for low-rainfall areas with mild winters grown in 15 locations (E1 = Sakha Res. St. (Egypt); E2 = El-Giza Res.St. (Egypt); E3 = El-Hamal (Egypt); E4 = El-Serw (Egypt); E5 = Athalassa (Cyprus); E6 = El Kef (Tunisia); E7 = Hisar (India); E8 = Faisalabad - Uni. Agric.(Pakistan); E9 = Kohart-Jarma (Pakistan); E10= Serai Nanrang (Pakistan); E11= Jaipur (India); E12= Jemma Shaim - Safi)Morocco); E13= Breda (Syria); E14= Tel Hadya (Syria).

Table 2.19. Names of the lines tested in the International Yield Trial for low-rainfall areas with cool winters.

Entry	Name
1	Matnan-01
2	Arar/PI 386540//Giza 121/Pue/4/Deir Alla 106/Cel/3/Bco.Mr/Mzq//Apm/5106
3	M64-76/Bon//Jo/York/3/M5/Galt//As46/4/Hj34-80/Astrix/5/NK1272/6/Multan/M23/4/Hop Ro/3/Md/AT//CM
4	Harma-02//11012.2/CM67/7/Mola/4/Brea'S'/DL70//Mozdosky/3/Nopal'S'/5/CI 10622/CI 05824/6/Lignee
5	Shyri-3/M83-194 Ras*32
6	Lignee 131
7	Courlis/Rihane-03
8	Eldorado/4/ROD586/Nopal'S'/3/PmB/Aths//Bc
9	Clipper/Volla/3/Arr/Esp//Alger/Ceres.362-1-1/4/Harma
10	Tipper//WI2291/WI2269
11	Tipper//ER/Apm
12	Beecher
13	Carina/WI2291
14	Arta//WI2197/Cam/3/Salmas
15	7028/2759/3/69-82//Ds/Apro/4/Arizona 5908/Aths//Arabi Abiad*2/5/Menuet/Arabi
16	JLB70-01/5/DeirAlla106//DL70/Pitayo/3/RM1508/4/Arizona5908/Aths//Avt/Attiki/3/Ager
17	80-5013/5/Cr.115/Pro//Bc/3/Api/CM67/4/Giza120/6/CI08887/CI05761//Lignee640
18	Salmas
19	80-5013/5/Cr.115/Pro//Bc/3/Api/CM67/4/Giza120/6/CI08887/CI05761//Lignee640
20	PI386540/ArabiAbiad//H.Spont.41-1/Tadmor
21	WI2291/WI2269//Stirling
22	Lth/3/Nopal//Pro/11012-2/4/Antares//12201/Attiki/3/RM1508/Por//WI2269
23	Lignee527/Rihane//Arar
24	National Check

Table 2.20. Locations and countries where the lines in the International Yield Trial for low-rainfall areas with cool winters were tested in the year 2000.

Code	Location	Country
E1	Sariab	Pakistan
E2	Konya	Turkey
E3	Shirvan	Iran
E4	Sararood - Kermanshah	Iran
E5	Ramtha Station	Jordan
E6	Tel Amara	Lebanon
E7	Annaceur	Morocco
E8	Breda	Syria
E9	Tel Hadya	Syria

Table 2.21. Grain yield in 9 locations of the lines tested in the International Yield Trial for low-rainfall areas with cool winters (Entry and Location names are given in Tables 2.19 and 2.20, respectively)

ntr	RT	E1	E2	E3	E4	E5	E6	E7	E8	E9
1	6	259	1943	211	1556	291	1563	4293	834	3338
2	6	185	3063	326	1437	302	1440	3826	853	3385
3	6	148	2856	387	1259	209	1093	3866	756	3275
4	6	148	3080	361	1126	162	1483	4293	762	3187
5	6	111	2850	449	1504	109	1131	4333	544	3149
6	2	185	2323	687	2185	335	1432	3933	1014	3664
7	6	370	3033	243	1578	172	1370	4640	808	3734
8	6	185	2180	199	1148	115	1313	4106	544	3485
9	2	130	2053	300	1423	502	1768	3453	1204	3639
10	2	259	3310	411	1482	220	1727	4506	981	3661
11	2	222	2930	581	1815	297	1777	5040	880	3969
12	6	148	2740	380	1334	382	1773	4320	962	3961
13	2	315	2950	548	1445	200	2299	5093	923	3874
14	2	111	3233	576	1741	128	2406	4373	671	3678
15	2	370	2633	406	1171	445	1473	4186	1187	4062
16	6	222	2553	634	1371	335	1605	3866	1164	3539
17	6	370	2500	236	1402	338	1969	4426	1073	3826
18	2	259	3106	692	2171	449	1756	3866	1263	4246
19	6	296	2753	508	1556	304	1546	4826	863	3461
20	2	259	3086	589	1163	363	2345	4453	1007	3721
21	2	222	1826	299	985	519	2445	3786	1154	3834
22	2	278	1993	347	1223	261	1437	4306	1048	3277
23	6	296	3226	424	1482	233	1680	4746	921	3920
24	-	370	3416	373	1593	333	1261	5640	1137	3348
Mean		238	2735	423	1465	292	1670	4341	940	3635

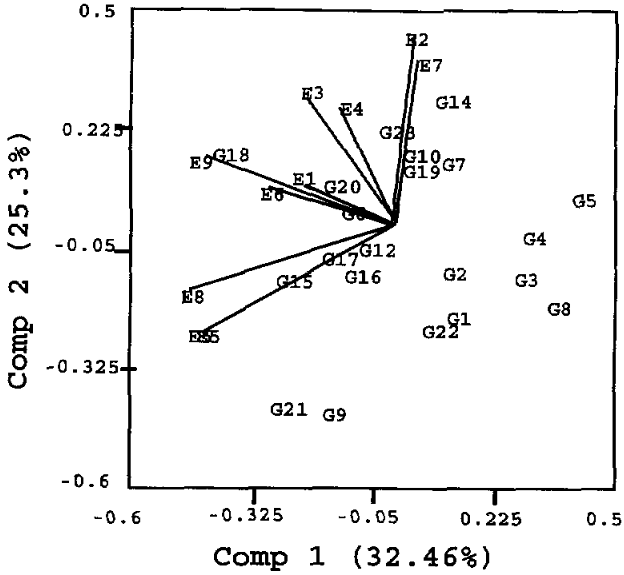

Fig. 2.5. Biplot of the 24 lines tested in the International Yield Trial for low-rainfall areas with cool winters grown in 9 locations (E1 = Sariab (Pakistan); E2 = Konya (Turkey); E3 = Shirvan (Iran); E4 = Sararood - Kermanshah (Iran); E5 = Ramtha Station (Jordan); E6 = Tel Amara (Lebanon); E7 = Annaceur (Morocco); E8 = Breda (Syria); E9 = Tel Hadya (Syria)

1.7.3. Moderate Rainfall Areas

The 19 lines tested in the International Yield Trial for moderate rainfall areas together with four long-term checks (entries 1, 6, 12, and 18), and the national check are listed in Table 2.22.

The data used for this report were received from 15 locations in 9 countries (Table 2.23). Grain yield ranged from about 0.8 t/ha in Breda to more than 4.5 t/ha in El Giza and Sakha in Egypt, and in El Kef in Tunisia. Entries 10 and 20 were the top yielding with 7 and 6.7 t/ha in El Giza, while other eight entries yielded more than 5 t/ha either in El Giza or Sakha or El-Harmal (Table 2.24).

Genotype x Environment Interactions explained 75% of the variation of the environmentally standardized data.

Table 2.22. Names of the lines tested in the International Yield Trial for moderate rainfall areas.

Entry	Name
1	Assala-04
2	M64-76/Bon//Jo/York/3/M5/Galt//As46/4/Hj34-80/Astrix /5/NK1272/6/Gerbel//Gloria'S'/Copal'S'
3	Triumph/Moroc 9-75
4	Rihane-03//Lignee 527/As45
5	Carbo/Gustoe
6	ER/Apm
7	Gustoe//80-5145/Harma-01
8	WI2737/4/Alger/Ceres//Salmas/3/ER/Apm
9	Arda/Moroc 9-75
10	Onslow/Tipper
11	CM67/3/Apro//Sv.02109/Mari/4/Carbo
12	Beecher
13	Granado
14	Comino
15	Patty-B/Ruda'S'//Aleli
16	Geranio//Matnan'S'/EH165
17	Gloria'S'/Copal'S'
18	WI2291
19	Aleli
20	Gloria'S'/Saida//Matnan'S'/EH165/3/LB Iran/Una80//Lignee 640
21	Rhodes'S'//TB/Chzo/3/Gloria'S'/Copal'S'/4/Ben-4D
22	Pye'S'/Shyri//Gloria'S'/Copal'S'
23	CI 05791/Cal607//Shyri
24	National Check

The locations formed three groups (Fig. 2.6). The first includes El-Giza (E4) and Sakha (E6) in Egypt and Kanpur (E8) in India. These were strongly correlated with each other, and poorly correlated with all the other locations. Therefore, entries yielding well in these three locations, such as entries 10, 8, 3, 15, 19 and 20 tend to perform poorly in all other locations with the exception of entries 8 and 3. The second group includes Breda (E1), Moghan (E10), Tel Amara (E11), Merchouch (E12), Sakrand (E13) Tel Hadya (E14) and El Kef (E15). Entry 8 yielded more than average both in the first and in the second group, while entries 6 (ER/Apm, one of the long term checks) and 12 (Beecher, also a long term check) yielded more than average in all locations of the second group. The third group included locations that on average yielded less than the grand mean such as Dromolaxia

(E2), El-Hamal (E3), El-Serw (E5), Faizabad (E7), and Gorgan (E9). The highest yielding entries in this group were entries 9, 22, 14, 1 and 4.

Table 2.23. Locations and countries where the lines in the International Yield Trial for areas with moderate rainfall were tested in the year 2000.

Code	Location	Country
E1	Breda	Syria
E2	Dromolaxia	Cyprus
E3	El-Hamal	Egypt
E4	El-Giza Research Station Kermanshah	Egypt
E5	El-Serw	Egypt
E6	Sakha Research Station	Egypt
E7	Faizabad, N.D. Univ. Farm	India
E8	Kanpur	India
E9	Gorgan - Aghagalla	Iran
E10	Moghan - Ultan-Parsabad	Iran
E11	Tel Amara	Lebanon
E12	Marchouch	Morocco
E13	Sakrand	Pakistan
E14	Tel Hadya	Syria
E15	El Kef	Tunisia

1.7.4. Cold Areas with Severe Winters (Predominantly with Winter Types)

The 20 lines tested in the International Yield Trial for cold areas with severe winters together with three long-term checks (entries 1, 8, and 16), and the national check are listed in Table 2.25.

The data used for this report were received from 10 locations in 4 countries (Table 2.26). Grain yield ranged from less than 0.5 t/ha in Oroumieh and Shirvan in Iran, to between 0.5 and 1.0 t/ha in Qumloo (Iran) and Breda (Syria) to over 10 t/ha in Ardabile (Iran). High yields were also obtained at Karnobat in Bulgaria and at Tokat in Turkey (Table 2.27).

Table 2.24. Grain yield in 15 locations of the lines tested in the International Yield Trial for moderate rainfall areas (Entry and Location names are given in Tables 2.22 and 2.23).

Entry	RT	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15
1	6	1122	2151	4050	3820	3517	5017	2789	2778	1606	4778	2640	1522	3996	3596	4207
2	6	687	1238	3950	5404	3734	4942	1667	3000	1034	3678	1853	1577	2167	3237	3555
3	2	966	1335	4434	5020	2817	4167	1300	3556	1206	4233	3326	2278	3222	3505	4146
4	6	952	2112	4500	4497	3234	4750	1467	2834	2362	3822	2551	1800	3334	3497	4612
5	6	487	972	4500	3360	3017	4817	994	2778	1550	3739	2023	1917	2556	2710	3678
6	2	1155	2200	3434	4330	3234	5183	1889	3167	1762	5144	4342	2544	3445	3642	4620
7	6	739	1792	2916	4330	2883	4142	1700	2667	1067	3945	3080	2189	2612	3618	4560
8	2	922	1156	3850	5374	3267	4150	889	2445	1200	4116	3083	2555	3389	3865	4192
9	2	1016	1931	5133	3110	2984	1750	2400	4222	1606	4272	3785	2231	3333	3458	3840
10	2	772	966	2516	7014	2267	4317	1867	3556	1023	3678	3341	2233	3111	3279	4167
11	6	589	1373	3334	4000	2266	3542	2533	2778	1245	2867	1556	2266	2778	3045	3776
12	6	963	1903	3800	4047	3933	5550	1717	3445	1839	4033	3547	2000	3334	3907	4430
13	6	640	1574	4683	4120	1850	5284	1950	2667	1578	4078	2297	1700	2667	3336	4012
14	2	473	2620	4767	4927	3300	3750	3044	2334	1239	3545	1956	1377	2334	3410	4068
15	2	865	1834	3550	5674	3550	5417	2022	3056	989	4111	1856	1566	3778	3389	4466
16	6	536	1280	3467	4600	2466	4484	1211	3389	1234	2811	1740	1188	2778	2317	3546
17	6	686	1545	4084	4397	3100	4717	2244	2445	1428	3861	2543	2250	2945	3725	4302
18	2	1227	2304	3900	4617	3233	4617	2511	3334	2178	3900	4353	2111	3556	3806	4554
19	2	498	1156	2250	4587	2167	5350	1372	4111	984	3056	1550	678	2778	3265	3462
20	6	563	1476	4417	6724	2400	4167	2222	3000	1495	3928	3296	1389	3556	3336	4535
21	6	381	1752	3584	4140	3767	4609	2305	3389	1100	3828	2062	1011	2389	2686	4034
22	2	795	1722	3700	3057	2600	4817	2700	3222	2339	3656	1189	2111	3333	2916	3904
23	2	688	907	3467	5407	2750	4933	2189	2667	1284	4167	2290	644	3333	2738	3360
24	-	1294	3767	4050	4537	3217	4267	3250	2556	1328	3811	3808	2198	3000	3126	4463
mean		792	1711	3847	4629	2981	4531	2010	3058	1445	3877	2669	1806	3072	3309	4104

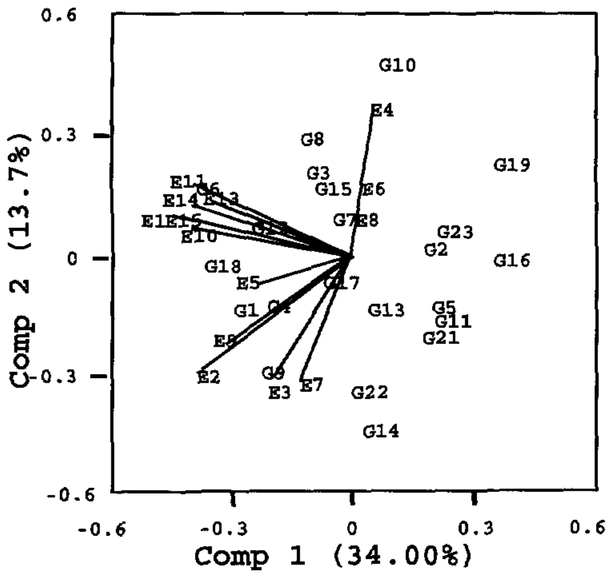

Fig. 2.6. Biplot of the 24 lines tested in the International Yield Trial for moderate rainfall areas grown in 15 locations: E1 = Breda (Syria); E2 = Dromolaxia (Cyprus); E3 = El-Hamal (Egypt); E4 = El-Giza Res.St. (Egypt); E5 = El-Serw (Egypt); E6 = Sakha Res. St. (Egypt); E7 = Faizabad, N.D. Univ. Farm (India); E8 = Kanpur (India); E9 = Gorgan - Aghagalla (Iran); E10= Moghan - Ultan-Parsabad (Iran); E11= Tel Amara (Lebanon); E12= Marchouch (Morocco); E13= Sakrand (Pakistan); E14= Tel Hadya (Syria); E15 = El Kef (Tunisia)

Table 2.25. Names of the lines tested in the International Yield Trial with winter types.

Entry	Name
1	Bulbul
2	80-5024/F3 Bulk Hip//Lignee 131
3	Grivita/Malta 1-4-3094-2
4	Alpha/Durra//Lignee 131/Arabi Abiad
5	CWB117-77-9-7//Antares/Ky63-1294
6	Obruk-86/3/Alpha//Sul/Nacta
7	YEA1819/YEA195.4/3/Alpha//Sul/Nacta
8	Rihane-03
9	YEA1819/YEA195.4//Grivita
10	YEA168.4/YEA605.5//Lignee 131/Arabi Abiad
11	ICB-102893/3/Alpha//Sul/Nacta
12	Roho//Alger/Ceres 362-1-1/3/YEA422.1/YEA455.25
13	Arabi Abiad/3/Car/Rm1508F1//Coss
14	Alpha/Durra//Antares/Arabi Abiad
15	Antares/Ky63-1294//Lignee 131
16	Radical
17	CWB117-77-9-7//BKF Magnelone 1604/Lignee 640
18	Ste/Lignee 640//Hml-02/Arabi Abiad*2
19	Alpha/Gumhuriyet//Sonate
20	Alpha/Gumhuriyet//Sonate
21	Rhn-03/3/NY6005-18/OWB70173-2H-4H F1//F1 NY6005-19/J-126
22	Zarjau/4/Rhn-05/3/Apm/HC1905//Robur
23	Radical/Precoce
24	National Check

Table 2.26. Locations and countries where the International Yield Trial with winter types were tested in the year 2000.

Code	Location	Country
E1	Tel Hadya	Syria
E2	Karnobat	Bulgaria
E3	Tokat	Turkey
E4	Zandjan	Iran
E5	Dari-Maragheh	Iran
E6	Ardabile	Iran
E7	Oroumieh, Haidarlo	Iran
E8	Shirvan	Iran
E9	Qumloo-Kurdistan	Iran
E10	Breda	Syria

Table 2.27. Grain yield in 10 locations where the International Yield Trial with winter types were tested (Entry and Location names are given in Tables 2.25 and 2.26.

Entry	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
1	276	6011	3610	1583	1542	8700	185	240	805	331
2	380	7011	4490	2112	1999	9989	359	246	708	716
3	372	6255	4453	2064	2096	9278	352	164	668	1038
4	390	7166	4503	2352	2249	10989	404	250	921	1052
5	394	7678	4807	2400	2522	10133	274	413	674	882
6	377	6178	4503	1920	1910	11022	326	264	933	516
7	408	6000	4457	1632	1954	9067	363	266	681	753
8	444	6422	5003	672	778	10422	359	194	593	1140
9	359	6678	4660	2688	2800	11800	337	435	711	854
10	423	5833	4637	2353	2366	11434	330	247	1229	1114
11	336	6344	3690	2592	2511	10167	348	246	967	951
12	328	6255	4033	1728	1720	12333	322	424	648	783
13	347	6422	4613	1699	2032	8478	396	255	534	909
14	352	7111	5937	2448	2388	11911	300	345	574	767
15	366	8744	6060	2304	2305	12844	304	260	677	769
16	311	8000	4643	1344	1684	8956	122	172	622	81
17	362	8344	5260	2064	2422	12467	115	239	677	737
18	341	5166	3807	1603	1425	10733	355	444	897	1024
19	367	8166	5460	1727	1848	12400	411	339	656	708
20	337	7500	5593	1584	1859	9322	319	320	663	761
21	370	6166	4093	1853	1820	12133	359	224	727	740
22	436	8011	5283	2160	1687	11800	274	234	637	860
23	375	7600	4763	2247	1542	8755	341	383	724	673
24	282	7755	3657	2592	2282	15245	259	262	1195	1196
Mean	364	6951	4667	1988	1989	10849	313	286	755	807

The locations formed three groups, considering that E1 and E8 were not well represented (Fig. 2.7). The first group includes two of the highest yielding locations, namely Karnobat (E2) and Tokat (E3); in these locations entries 15 and 17 were the highest yielding, but also entries 14, 22, and 19 yielded more than the mean. The second group includes Zandjan (E4), Dari-Maragheh (E5), and Ardabile (E6); in these locations the highest yielding entries were 5 and 9, but also entries 14 and 15 which were also performing well in the two locations of the first group. Of the four lowest yielding locations, three (E7, E9 and E10) were closely correlated, while E8 was not well represented. In the lowest yielding locations the best entries were 10, 11, 18 and 4. As shown in table 10, three of these entries have Arabi Abiad (one of the Syrian landraces) in the pedigree.

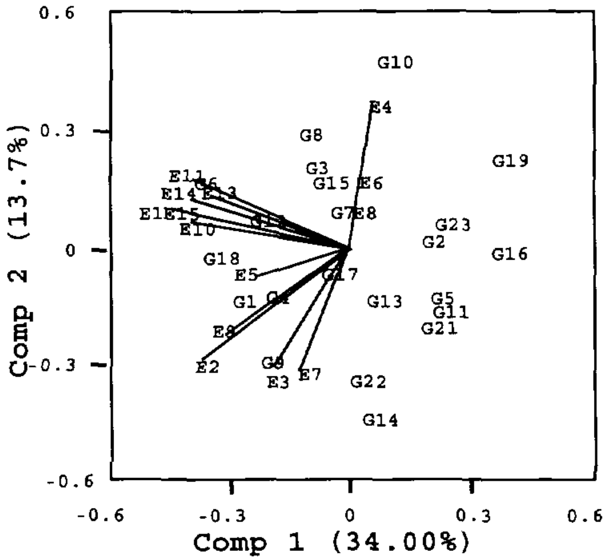

Fig. 2.7. Biplot of the 24 lines tested in the International Yield Trial for cold areas with severe winters grown in 10 locations: E1 = Tel Hadya (Syria); E2 = Karnobat (Bulgaria); E3 = Tokat (Turkey); E4 = Zandjan (Iran); E5 = Dari-Maragheh (Iran); E6 = Ardabile (Iran); E7 = Oroumieh, Haidarlo; (Iran); E8 = Shirvan (Iran); E9 = Qumloo-Kurdistan (Iran); E10= Breda (Syria).

1.8. Abiotic Stresses: Drought, Heat and Cold

1.8.1. New Levels of Drought Tolerance in Barley

During 2000 the total rainfall in most areas of Syria was below average, and crop yields were severely affected. In some areas the rainfall was so low that the crop did not even germinate, in many others the crop failed to produce grain. The trials planted in eight farmers' fields in Syria (Fig. 2.8) to begin the second phase of the participatory barley breeding program described earlier, were affected by different intensities of drought; one extreme was Melabya (Hassakeh province) with only about 50 mm rainfall in the entire season and no germination, and the other extreme was

Suran with 252 mm rainfall and an average grain yield of 1.8 t ha-1 (ranging from 1.0 to 3.2 t/ha). However, the highest yielding location was Mardabsi with an average grain yield of3.4 t/ha (ranging from 2.7 to 4.4 t/ha), even though the total rainfall was only 221 mm. This demonstrates once again that differences in total rainfall only explain part of the differences in grain or biomass yields.

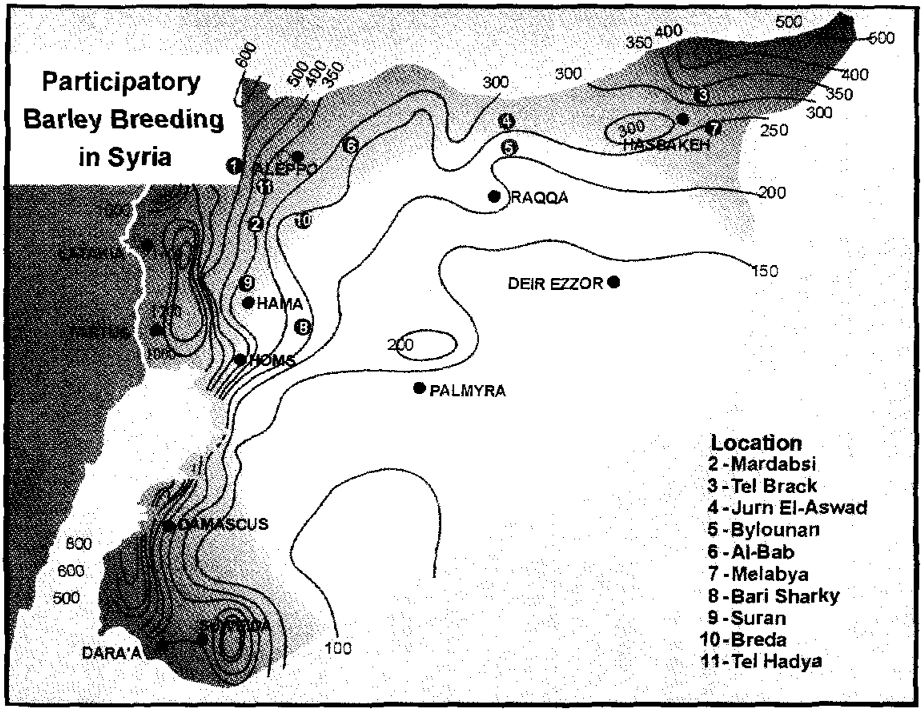

Fig. 2.8. Location of the villages involved in participatory barley breeding in Syria

The driest sites where some new barley entries were able to produce some grain and/or some biomass were Tel Brack (Hassakeh province) with 87 mm, Jurn El-Aswad and Bylounan (Raqqa province) with 121 and 87 mm, respectively, and Bari Sharky (Hama Province) with 130 mm.

In Tel Brack we were not able to measure grain yield because of bird damage. In the other three locations, even though average grain and biomass yield were very low, some lines were able to produce between 300 and 500 kg/ha of grain (Figure 2.9) and between 500 and 3000 kg/ha of biomass yield

(Fig. 2.10).

Plant height and 1000 kernel weight, two traits usually affected negatively by drought, showed a large variation both within and between sites, suggesting large differences in the response of the genotypes to the severe stress (Fig. 2.11 and 2.12).

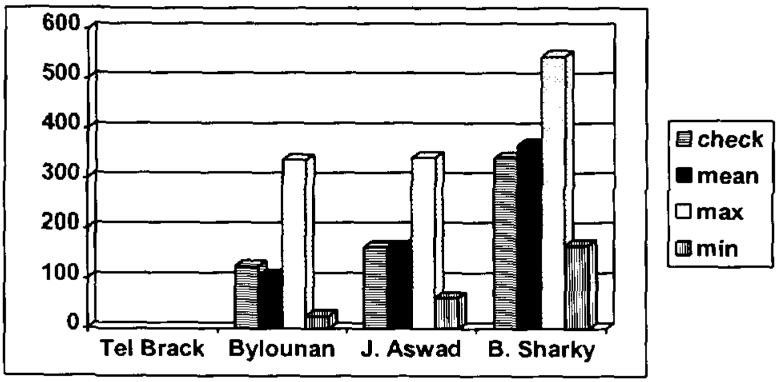

Fig. 2.9. Grain yield (kg/ha) under severe drought stress in four locations in Syria. Total rainfall was 87 mm in Tel Brack and Bylounan, 121 mm in J. Aswad and 130 mm in Bari Sharky.

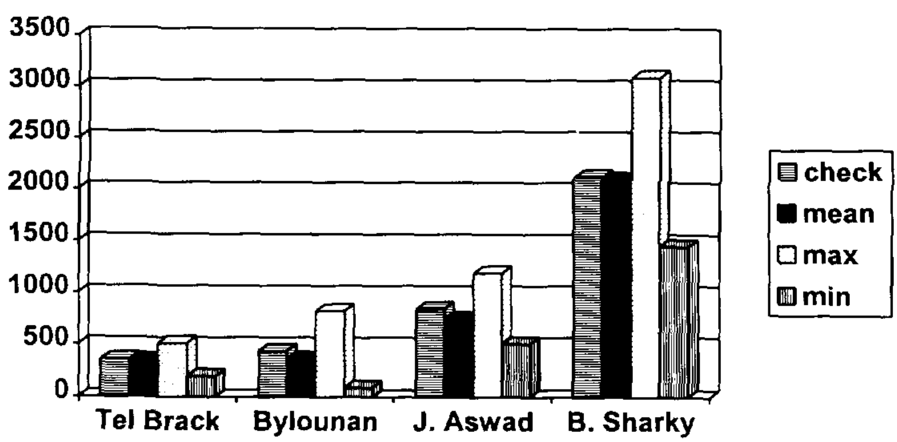

Fig. 2.10. Biomass (kg/ha) under severe drought stress in four locations in Syria. Total rainfall was 87 mm in Tel Brack and Bylounan, 121 mm in J. Aswad, and 130 mm in Bari Sharky.

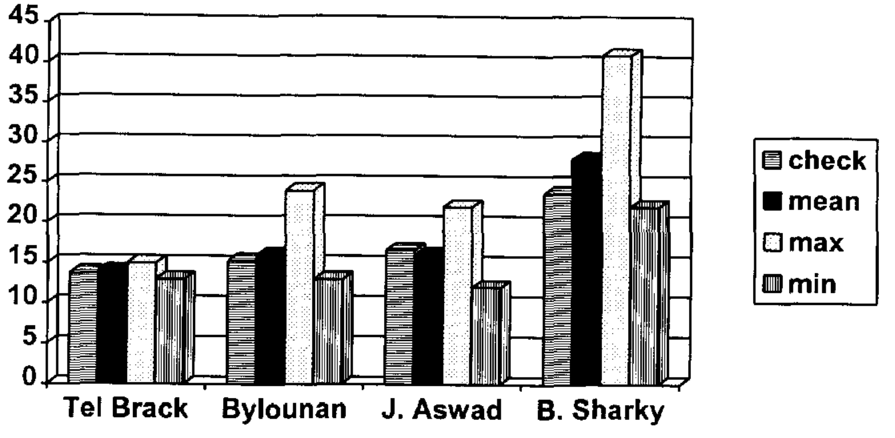

Fig. 2.11. Plant height (cm) under severe drought stress in four locations in Syria. Total rainfall was 87 mm in Tel Brack and Bylounan, 121 mm in J. Aswad, and 130 mm in Bari Sharky.

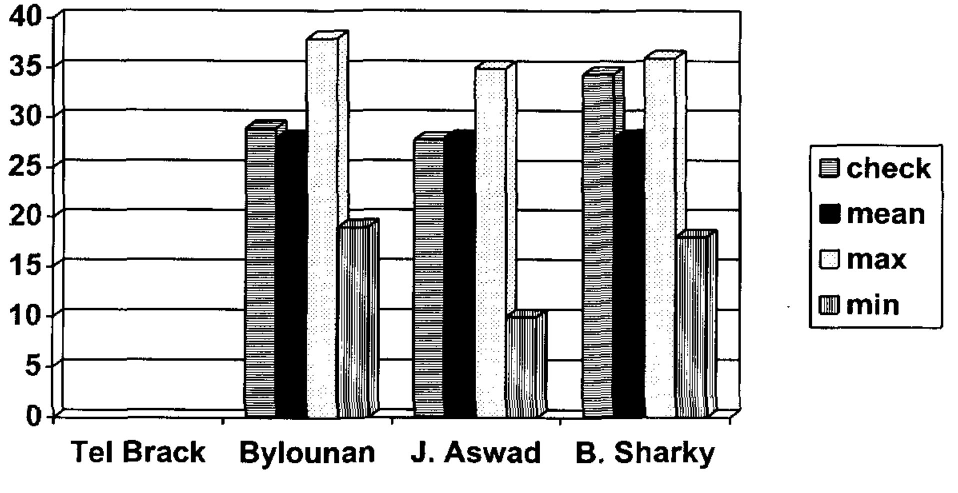

Fig. 2.12. Kernel weight (g) under severe drought stress in four locations in Syria. Total rainfall was 87 mm in Tel Brack and Bylounan, 121 mm in J. Aswad and 130 mm in Bari Sharky.

Drought tolerance was assessed in the field when the plots where close to maturity with a score from 1 (the majority of plants in a plot with a spike and seed and no symptoms of leaf rolling or wilting) to 5 (absence of spikes, leaf desiccation and/or wilting) as shown in Fig. 2.13.

The data were then classified according to five different types of germplasm, namely modern germplasm (unrelated to Syrian landraces), landraces or crosses between landraces, crosses between modern and landraces, and breeding lines obtained from *Hordeum spontaneum*; the latter was further divided in a group with crosses between *Hordeum spontaneum* 41 (which includes four lines 41-1, 41-2, 41-3 and 41-5 that have consistently shown a superior adaptation to extreme dry conditions) and landraces, and a group containing crosses with any other source of *Hordeum spontaneum* and either landraces or modern germplasm. The selections made by farmers in the four locations were also classified according to the types of germplasm described above.

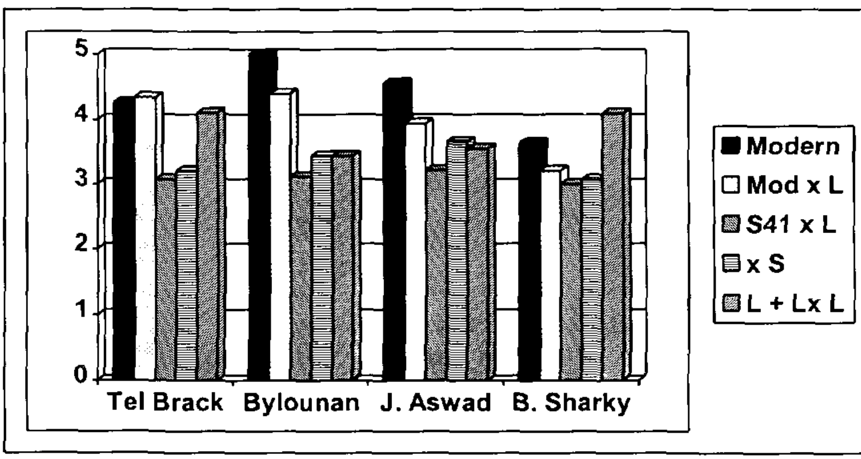

Fig. 2.13. Drought susceptibility (1=resistant, 5=susceptible) of five types of germplasm grown under severe stress in four locations in Syria Total rainfall was 87 mm in Tel Brack and Bylounan, 121 mm in J. Aswad and 130 mm in Bari Sharky.

In the four locations, the crosses between *Hordeum spontaneum* 41 and landraces were the most drought tolerant, while the modern germplasm was nearly always the least tolerant (Fig 2.13). The crosses between *Hordeum spontaneum* 41 and landraces were also the type of germplasm most frequently selected by farmers in three of four locations (Fig 2.14) while the modern germplasm was always the least frequently selected. In one location, the farmers more often selected the landraces and the crosses with landraces that in that location did not differ greatly from the crosses between *Hordeum spontaneum* 41 and landraces in the drought score.

This is a further indication that, if carefully selected, some *Hordeum spontaneum* lines can contribute significantly to enhance the tolerance to drought of cultivated barley.

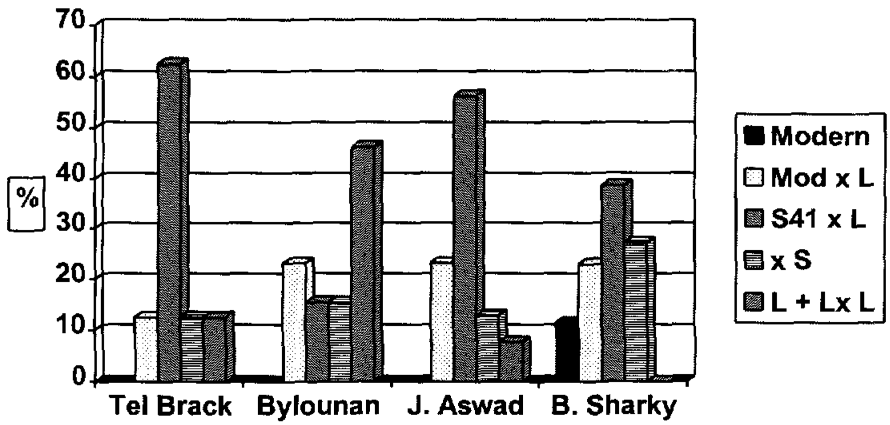

Fig. 2.14. Frequency of selection by farmers of five types of germplasm grown under severe stress in four locations in Syria Total rainfall was 87 mm in Tel Brack and Bylounan, 121 mm in J. Aswad and 130 mm in Bari Sharky.

1.8.2. Drought Stress Tolerance

Drought stress tolerance is the major focus of a collaborative barley breeding and germplasm exchange between the Waite Campus (Adelaide, South Australia) and ICARDA.

Replicated field trials were grown at two sites in S. Australia, during the 2000 season, comprising 83 ICARDA lines selected from 1999 trials, 37 selections made by Prof. A. Barr at ICARDA in 1998, and 20 parental lines of the ICARDA mapping populations (see 3.2.6.6). Whereas yields were around 0.5 t/ha in 1999, yields over 2 t/ha and 3 t/ha were recorded at Minnipa and Port Wakefield respectively, providing a marked contrast in test conditions. A significant number of ICARDA lines performed at least as well as the best Australian feed varieties in each season, but furthermore some ICARDA lines have performed as well as the best varieties over both contrasting seasons. Table 2.28 shows the performance of four of the top lines across the two seasons compared to three current varieties. Yields are expressed as a percentage of the mean yield of six control varieties. A common feature of wild- and landrace-derived barley is reduced grain size, but the best performing ICARDA lines have a grain size similar to current elite varieties. The ICARDA lines tested possibly represent the extremes of genetic variation within cultivated barley. The pedigrees include improved varieties from around the world, primitive landraces, and wild barley. Despite this variation, selections or derivatives from one particular cross dominate the lines that have performed well in Australian conditions. Table 2.28 show the yield of the best ICARDA and Australian lines (in % of the checks) in both seasons and both locations. This material therefore represents an important resource for understanding the genetic basis of adaptation, as well as key parental lines that will be used in further pragmatic selection.

Table 2.28. Grain yield (in % of the checks) of the best ICARDA and Australian lines in Minnipa (M) and Port Wakefield (PW) in 1999 and 2000.

Genotype	1999		2000		tot
	M	PW	M	PW	
ER/Apm/3/Arr/Esp//Alger/Ceres362-1-1/4/ER/Apm//WI2198	-	-	96	123	110
ER/Apm/3/Arr/Esp//Alger/Ceres362-1-1	103	109	100	123	108
Clipper/Volla/3/Arr/Esp//Alger/Ceres362-1-1/4/Harmal	-	-	104	107	106
ER/Apm/3/Arr/Esp//Alger/Ceres362-1-1	124	82	96	111	103
Keel	128	107	104	106	111
Barque	104	112	108	111	109
Schooner	93	107	104	90	99

1.8.3. Stress Physiology

During 2000 a study was conducted at Texas Tech University, Lubbock, Texas, USA, with the objective of determining the variation in root and shoot morphology in selected ICARDA barley genotypes. Earlier, genotypes were evaluated for osmotic adjustment (OA). The information will be used to select genotypes and develop mapping populations for tagging QTLs/genes associated with OA, root and shoot morphology for drought tolerance in barley.

Eleven genotypes were evaluated for osmotic adjustment (OA) in the spring and fall of 1999. Out of these, 4 were selected for a morphology study based on their high (Athenais and Alanda-01) and low (*H. spontaneum* 41-1 and Sara) OA capacity (Table 2.29).

Table 2.29. Osmotic adjustment (OA) capacity of 4 barley genotypes, spring and fall, 1999.

Genotypes	Spring 1999 OA (MPA)	Fall 1999 OA (MPA)	Average of two season OA (MPA)
Athenais	1.06	1.09	0.99
Alanda-01	0.99	0.91	0.90
H. spontaneum 41	0.28	0.46	0.46
Sara	0.27	0.46	0.37

The experiment was conducted in a temperature-controlled greenhouse in a randomized complete block design with three replications. Seeds of the four barley genotypes Athenais, Alanda-01, *H. spontaneum* 41-1 and Sara were sown in PVC tubes (15 cm diameter and 1 m long). The bottom end was sealed with fiberglass screen mesh so that soil could be held inside and excess water could be drained. The tubes were filled to the top with potting mixture (Ball Growing on Mix, Ball Seed Co, West Chicago, IL, USA). Seedlings were thinned to one in each tube 10 days after sowing (DAS). The plants were watered twice a week and supplied with Miracle-Gro nutrient solution (Stern's Miracle-Gro product Inc., New York, USA) once in every two weeks. No insect infestation was observed. The average air temperature in the greenhouse during the experimental period was 25 ± 3°C.

The sampling was made at 55 DAS. Plant height (ph) was measured from the soil surface to the tip of the longest leaf. Tiller number (tln) was recorded and the shoot was cut near the soil surface. Intact roots along with soil were pulled out from the tubes and washed carefully to remove the soil. Maximum root length (mrl) was measured from the base of the shoot to the tip of the longest root. Shoots and roots were dried at 65°C for three days for shoot dry weight (sdw) and root dry weight (rdw).

Variation in shoot and root morphology for the tested genotypes is presented in Table 2.30. Variation in PH ranged from 57 cm in Athenais to 61 cm in Sara, and no significant differences were found. Significant differences were found in tln, which ranged from 16 in Alanda-01 to 5 in Athenais. Significant differences were also found for mrl, which ranged from 60 cm in Sara to 27 cm in Athenais.

Table 2.30. Mean of root and shoot traits of four barley genotypes, Fall 2000.

Genotypes	*ph	tln	mrl	sdw	rdw
Athenais	57a	5c	27b	3.1c	0.5c
Alanda-01	59a	16a	51a	5.6b	1.2b
H. *spontaneum* 41-1	59a	7b	59a	5.8b	1.6a
Sara	61a	6c	60a	8.3a	1.6a
LSD	7.9	1.1	14.4	1.9	0.25

*ph=plant height; tln= tiller number; mrl= maximum root length; sdw= shoot dry weight; rdw= root dry weight. Means within a column followed by same letter are not significantly different ($p > 0.05$) using LSD.

The cultivar Athenais had the highest OA capacity (0.99 mpa, as average of two experiments, table 2.29) but the lowest mrl (27 cm). On the other hand, Sara had the lowest OA capacity (0.37 mpa, as average of two experiments, Table 2.29) but the highest mrl (60 cm). Similar findings were also reported in rice (Babu et al., 1999, Zhang et al., 2000) and in Tef (Ayele et al., 2001). Significant differences were found in sdw, ranging from 8.3 g in Sara to 3.1 g in Athenais. There were no significant differences in sdw in Alanda-01 and *H. spontaneum* 41-1. Significant differences were also observed for rdw, which ranged from 1.6 in Sara to 0.5 in Athenais. A significant correlation was observed between mrl and sdw (0.74), mrl and rdw (0.93) and sdw and rdw (0.81) (Table 2.31).

Shoot-based drought tolerance traits such as osmotic adjustment allow plants to survive short-term drought stress. Longer roots also allow plants to absorb water from the deeper soil layers during water stress and help to maintain normal physiological activities for a short time. The present study identified Sara and *H. spontaneum* 41-1 as having higher mrl. Genotypes having higher OA capacity have a shorter root system and genotypes having a longer root system have lower OA, but they can get water from lower soil during stress. Combining the two drought tolerance mechanisms; higher OA capacity and longer root system into the same genetic background would allow plants to survive longer during drought spells. Crosses between Athenais and Sara or between Athenais and *H. spontaneum* 41-1 would be a good choice to develop mapping populations for tagging QTLs/genes associated with OA, root, and shoot morphology for drought tolerance in barley.

Table 2.31. Simple correlation among root and shoot traits of four barley genotypes (abbreviations are given in Table 2.30).

	ph	tln	Mrl	sdw	Rdw
Ph	-	.04^{ns}	.05 ^{ns}	.09 ^{ns}	.10 ^{ns}
Tln		-	.04 ^{ns}	.05 ^{ns}	.01 ^{ns}
mrl			-	.74**	.93**
sdw				-	.81**

ns = non significant; ** = significant at $P<0.01$ level.

1.8.4. Development of Cold Tolerant Germplasm

All the screening for cold tolerance is decentralized, and is conducted by the Krasnodar Research Institute of Agriculture in Russia, and by the Central Research Institute for Field Crops (CRIFC) in Turkey.

Every year a large number of breeding materials from ICARDA (90% winter types and 10% spring types) are screened both in the field and in controlled conditions. Only the lines with a sufficient level of cold tolerance are selected for yield trials in representative locations in Turkey, Iran, Central Asia and the Caucasus. Once the material has gone through this screening mechanism, the best performing lines become available to NARS for utilization in the breeding programs either directly or in crosses.

The weather during winter was very mild all over the CAC countries, and it was difficult to evaluate the cold tolerance of the breeding material in natural environments. Only in some sites in Turkey it was possible to evaluate the barley germplasm under natural cold conditions. To obtain reliable data every season testing of all barley nurseries is also done under controlled conditions.

In 2000, 5080 entries were screened for frost tolerance in freezing chambers with methods developed at the Krasnodar Research Institute of Agriculture. The methods include freezing plants sown in boxes; planting on concrete beds in Krasnodar and in the Severo-Kuban Station, planting on the special ground installations from which the snow cover was taken away, as well as early and late planting in the field on the Station. The data obtained with the different methods were in close agreement with each other and with those obtained in Haymana experimental station in Turkey.

As a result of intense selection pressure applied in previous years in different ICARDA nurseries, there are now lines with increased cold tolerance. Some of them also have very high resistance to snow mold, which severely affected crop stands in Turkey this season (Table 2.32).

Table 2.32. Cold tolerance (CT as % of survival), cold damage (CD 1=no damage, 5=severe damage) of the most cold tolerant and resistant to snow mold lines of winter barley based on data from Krasnodar (Russia) and Haymana (Turkey).

Variety	Entry	Krasnodar		Turkey
		CT	CD	CD
Radical/Precoce	IWBYT00-23	78.3	5	5
Radical	IWBYT00-16	82.5	5	4.5
Bulbul	IWBYT00-1	58.6	3	3
Rihane-03	IWBYT00-8	5.6	1	1
YEA455…//Scio	IWEBON00-39	63.9	4	4
Batal-01	IWEBON00-40	79.6	4	4
BKF Maguel./Lignee	IWBON00-41	96.4	5	3
Alfa/Cum/3/Igri…	IWBON00-78	61.2	4	5
Antares/Ky63…	IWBON00-88	86.9	5	5
Alger/Ceres…/Zarjau	IWBON00-89	73.2	4	5
Radical/Precoce	IWBON00-106	84.2	4	3
Radical/TX850706	IWBON00-113	83.4	4	5
Mal/OWB…/Radical	IWBON00-134	88.6	4	5
Robur…/Radical	IWBON00-135	80.4	4	5
Ranniy/Cyclone	IWBON00-142	82.3	4	4
ICB-107766…//Luther	IWBCB00-8	74.8	4	4
Omega GK	IWBCB00-19	71.4	4	5
Pamir-168	IWBCB00-51	68.2	4	4
Batal-02	IWBCB00-53	78.7	4	4

Winter hardiness is a complex character conditioned by many factors, among which frost resistance is the most important one. The Uniform Barley Winter Hardiness Nursery (UBWHN00) is one of the best sources of cold tolerance. The evaluation of the UBWHN00 nursery under control environments confirmed the high frost resistance of lines such as NE95713, NE97891, Dictoo, and Kearney, which have an average survival rate close to the winter wheat variety Kenosha (Table 2.33).

Table 2.33. Frost tolerance (as % of plant survival) of the Uniform Barley Winter Hardiness Nursery after treatment in freezing chambers under temperature -12^{0}C 24 hours

Ent. No.	Entry name	% plant survival
1	Tenn. Winter(check)	22.9
2	Trebi (check)	0
3	Kearney (check)	64.3
4	Kenosha (wht check)	100
5	Dictoo (check)	73.5
6	Kentucky 1 (check)	64.7
7	NE95713	100
8	NE97891	97
9	PA9550-151	98.3
10	PA9550-157	64
11	VA96B-248	71.7
12	VA97B-178	57.5
13	VA96-44-321	52.2
14	VA97B-176	56
15	VA97B-275	80.5
16	VA96-44-307	59
17	VA97B-415	57.2
18	VA97B-388	81.9
19	TX95D013	67
20	TX97D420	45.3
21	H159-42	91.2
22	H159-45	82
23	H184-01	56.6
24	92Ab1841	71.2
25	88Ab536-B	69.2
26	95Ab2299	59.7
27	94Ab1274	69.2
28	Dobrinya-3	89.5
29	Pamir 168	61.2
	LSD 0.05	

The new entries, PA9550-151, VA97B-275, VA97B-388, H159-42, H159-45, and Dobrinya-3, also have an improved frost resistance. The work on the depth of crown nodes, carried out at ICARDA, showed that the winter barley varieties Nebraska 92 716, Nebraska 93 760, Dictoo, Rostov-55, and Dobrinya-3 form the crown node at a depth of 5-7 cm compared with 3-4 cm in standard checks. A deep crown node gives considerable advantage for successful field survival during severe winters without snow cover.

Some progress was made in improving the cold tolerance of two-row winter barley. This issue has a direct relevance for the improvement of malting barley. If we are able to develop two-row germplasm with a sufficient level of cold tolerance, the malting industry in many CAC countries will get a profitable and reliable basis for the production of the necessary breeding material. ICARDA has already contributed to partially solve this problem. Some new two-row lines combine cold tolerance with a number of desirable agronomic traits. The two-row variety Pamir 168 performed well in some areas. A total of 586 entries (among the 5080 tested this season at Krasnodar), have been selected for further evaluation in yield trials. The best ICARDA lines, identified as sources of valuable traits or good combination of agronomic characters in the previous years, were tested in preliminary trials. One of the most cold-tolerant two-row lines, Forma 72…/299-1-2, performed well in the northern zone of the Krasnodar region. Its yield, in rotation with legumes, reached 8860 kg/ha, in comparison with the 7830 kg/ha of the standard check Vavilon and the 9055 kg/ha of the newly released variety Michailo. The new promising breeding material has been identified after testing under different rotations and agronomic practices (Table 2.34).

It was noticed earlier that six-row barley usually had some yield advantage at yield levels of 4-5 t/ha and above, and that two-row genotypes are in general less cold tolerant than six-row ones. Therefore, these lines can be considered as a significant achievement in the improvement of malting barley germplasm. They have increased cold tolerance, good initial growth vigor, uniform seed shape, bigger grain size, and better grain quality than the six-row standard checks. The productivity of some of them was close to the best checks. Three advanced lines are multiplied for on-farm verification trials. This area of research will be strengthened in the future because it fits with one of the new directions of the project, which gives more emphasis to the improvement of malting barley for human food. This also represents one of the requests of NARS from Central Asia and the Caucasus, as emerged during the Fourth Regional ICARDA/CAC Coordination Meeting in Bishkek/Issyk-Kul (September, 2000).

Table 2.34. Day to heading (dh), resistance (score from 1=susceptible to 9=resistant) to powdery mildew (pm), net blotch (nb) and lodging (ldg), plant height (ph in cm), and grain yield (gy in kg/ha) of two-row winter barley lines in preliminary trials

Nursery/Name	Entry	Dh	Resistance to:			ph	gy
			pm	nb	Ldg		
IWBON-CH-CW 98							
Michailo check		4.V	5	7	9	95	6210
Antares/Kyb3-…//Lignee131	39	28.IV	5	7	9	81	6110
Antares/KYB3-1294//Piper	43	6.V	9	7	6	118	5810
Lignee 131/3/4679/105//…	46	2.V	5	8	8	87	5800
Dobrinya-3 check		3.V	6	8	9	94	5880
Alpha/Durra//Sonata	126	28.IV	8	7	9	87	6710
IWFBON-CH-CW 98							
Skorohod check		25.IV	6	6	9	98	5120
Michailo check		4.V	5	7	9	95	6110
Alpha/Durra//Sonata	5	1.V	7	5	9	92	5700
Foma 72…/Hexa//Sonata	129	28.IV	8	7	8	92	5640
CWB 22-6-13//Alpha/Durra	131	28.IV	6	6	8	95	5880
LSD 0.05							360

1.9. Biotic Stresses: Diseases, Nematodes, Insects and Viruses

1.9.1. Diseases

1.9.1.1. Screening for Disease Resistance in Latin America

Scald and Stripe Rust

As in the past, all experiments and segregating populations were inoculated with scald at Toluca in 2000. The levels of disease development allowed for the identification of the resistant genotypes. The level of disease resistance found in the segregating populations was relatively high, resulting in a higher number of plants selected in the field in comparison with previous years. This allowed a higher selection pressure in the post-harvest visual kernel selection.

Stripe rust was artificially inoculated in special nurseries. The disease was present in all nurseries, either naturally or due to artificial inoculation, allowing selection of resistant genotypes also for this important disease.

Fusarium Head Blight

The *Fusarium* Head Blight (FHB) screening was carried out at Toluca with the collaboration of Dr. Lucy Gilchrist. Forty advanced genotypes were tested for Type I and Type II resistance. Selected genotypes with improved levels of resistance compared to susceptible and resistant checks are shown in Table 2.35.

Table 2.35. Selected genotypes with enhanced levels of FHB resistance selected at MV00.

	Name	**RT**	**Damage % Type I**	**Damage % Type II**
1	Tocte//Gob/Humai10/3/Atah92/Aleli	2	5.6	7.07
2	Penco/Chevron-Bar	6	1.51	17.32
3	Zhedar#1/Shyri//Olmo	2	5.68	8.04
4	Atah92/Gob	2	5.79	9.13
5	Atah92/Gob	2	4.88	4.27
6	Canela/Zhedar#2	2	5.28	5.33
7	Mns1	6	3.43	17.12
8	Zhedar#1/4/Shyri//Gloria-	2	3.21	4.03
9	Svanhals-Bar/Msel//Azaf/Gob24dh	2	3.29	8.76
10	Svanhals-Bar/Msel//Azaf/Gob24dh	2	6.25	8.36
	Checks			
	Azafran (Mr-R)	2	8.5	8.3
	Gobdh83(R-R)	2	5.1	7.6
	Gobdh89(S-S)	2	13.4	27.7
	Penco/Chevron-Bar (R-Mr)	6	4.69	12.05

1.9.1.2. Disease Evaluation in Experimental Stations and in Farmer's Fields in Eritrea

Diseases represent an important limiting factor to barley production in Eritrea. The disease evaluations of the breeding material at Halahale and St.Georgeo research stations, show that a good progress has been made in the level of resistance among international breeding nurseries. The local cultivars (landrace collection) show very low levels of resistance to rusts. Only three landrace accessions showed immune reactions to rust, these lines should be exploited in the breeding program as sources of resistance to yellow, leaf, and stem rust, a set of 14 accessions showed adequate levels of resistance to the three rusts (yellow, leaf, and stem rust).

The survey covered 53 fields that included not only barley, but also wheat and hanfetse in 25 sites. In the GalaNefhi region, 13 fields were surveyed, and preliminary results show that smut diseases were common on barley. The survey at the highland region (itinerary Asmara-Adikeyh) showed the predominance of barley cultivation, and the prevalence of net blotch, smuts, and leaf rust diseases. The survey in the high rainfall area (itinerary Asmara-Waki), showed that the prevalent barley diseases were scald (particularly on late-planted six row barley), net blotch (net and spot forms), and sporadic incidences of septoria (*Septoria passerinii*).

Disease Evaluation of Breeding Material

Evaluation of diseases at the experimental stations and disease surveys in farmers' fields were conducted with the participation of Eritrean breeder (Mr. Bereket Bekele) and the fresh graduate Mr. Simon Tekele Kahsae, recently assigned to breeding. The screening of barley nurseries for disease resistance was conducted at Halhale and St.Geogeo experiment stations. Even though barley nurseries were already mature, the evaluation for scald, leaf rust, and in some instances net blotch was still possible. Cover and loose smuts were also observed on barley.

Two barley seed multiplication nurseries were evaluated at Halhale for resistance to scald and relative observations of their reactions to leaf rust and net blotch (when possible) were made.

The first includes 44 pure lines selected by farmers in 1999, and the following list shows sets of lines with similar reaction types to scald

- Moderate resistance: 16, 23, 24, 25, 29, 38, 40, 41, and 43
- Susceptible: 1, 2, 3, 4, 10, 12, 14, 17, 19, 20, 22, 27, 28, 30, 37, 39, 42,and 44
- Highly susceptible: 5, 6, 8, 9, 11, 15, 21, 26, 31, 32,and 36
- Susceptible to leaf rust: 6, 7, 16, 20, 21,and 23.

The second included the 25 bulks selected in 1999 by farmers (Table 2.36). The bulks showed better resistance to scald than the pure lines. The evaluation for scald and leaf rust shown below deals with the reaction levels. It was not possible to estimate the infection (%), particularly for leaf rust, since the plants were totally dry.

Table 2.36. Types of reaction to scald and leaf rust in 25 pure lines from landraces.

Entry.	Scald	Leaf Rust	Entry	Scald	Lrust
1	MR	VS	13	MR	S
2	MR	VS	14	MR	VS
3	MR	VS	15	MR	VS
4	MR	MS	16	MR	VS
5	MR	MS	17	MS	S
6	MR	MS	18	MR	S
7	S	S	19	MR	VS
8	MR	VS	20	MR	VS
9	MR	S	21	MR	VS
10	MR	VS	22	S	S
11	MR	VS	23	MS	S
12	MR	S	24	S	S
			25	MR	VS

Evaluation of Barley Nursery at St.Georgeo Station

The barley nursery (122 entries) was evaluated for resistance to net blotch. Figure 2.15 shows the frequency distribution of the resistance levels to net blotch in the barley nursery. Lines showing low susceptible levels (MS) could be exploited in the breeding program and could eventually be cultivated in areas where net blotch does not represent a problem. The resistant lines were lines 1, 2, 3, 4, 14, 18, 19, 24, 25, 26, 36, 38, 44, 45, 81, 84, and 85.

1.9.2. Nematodes

For the first time, sources of resistance to cereal cyst nematodes (CCN) were identified in our breeding material by the barley-breeding program at the Waite Campus.

The names, pedigree, and row type of the resistant lines and of three of the most susceptible lines are shown in Table 2.37.

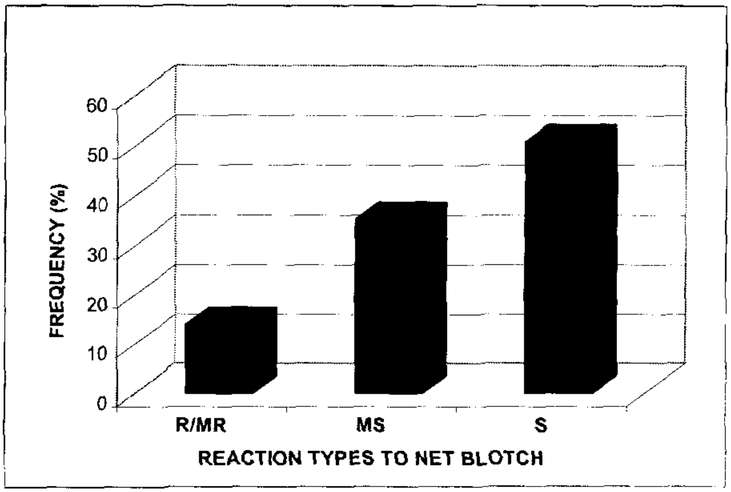

Fig. 2.15. Frequency distribution of reactions to Net Blotch.

1.9.3. Insects

1.9.3.1. Progress in Barley Breeding for Resistance to Russian Wheat Aphid (RWA)

Russian wheat aphid, *Diuraphis noxia* (Mordvilko), is a pest of barley important in several countries of North Africa and West Asia, e.g., Morocco, Algeria, Tunisia, Ethiopia, Yemen, and some parts of Turkey. Host plant resistance is the most economical and practical means of controlling this insect. Field and greenhouse screening of barley germplasm at ICARDA resulted in the identification of 41 sources of resistance. The first crosses to introgress resistance into North African barley were made in 1997 using five sources of resistance and six barley cultivars from that region. Segregating populations (F_2's, F_3's and F_4's) were advanced at Tel Hadya based on their resistance reactions and on phenology in comparison to North African checks. During the 1999/2000 growing season, 71 F_4 lines (Table 2.38) were selected as homozygous resistant and have been sent to Morocco, Algeria and Tunisia for evaluation under local conditions for RWA resistance and agronomic adaptation.

Table 2.37. Lines resistant to cereal cyst nematodes identified in South Australia compared with three highly susceptible lines.

Entry	Name	RT	Mean
144	Arimar/Aths	6	0.8
119	Clipper/Volla/3/Arr/Esp/Alger/Ceres..	2	0.8
111	ER/Apm//Lignee 131/4/Antares//...	2	0.8
114	ER/Apm/3/Arr/Esp//Alger/Ceres 362-1-1	2	2
82	ER/Apm/3/Arr/Esp//Alger/Ceres 362-1-1	2	0.6
92	ER/Apm/3/Arr/Esp//Alger/Ceres,362-1-1	2	1
95	ER/Apm/3/Arr/Esp//Alger/Ceres,362-1-1	2	0.2
39	ER/Apm/3/Arr/Esp//Alger/Ceres.362-1-1/4/Moroc 9-75/PmB	2	1
149	Esp/1808-4L//ER/Apm/3/Lignee131/..	2	0.6
67	Harmal-02/Arabi Abiad//ER/Apm	2	2
54	Harmal-02/Arabi Abiad/3/Api/CM67/..	2	0.2
160	JLB 70-63	6	0.5
110	LOCAL 2	2	1
155	Mari/Aths*2	6	0.3
148	Mari/Aths*2//M-Att-73	6	1.4
103	Moroc 9-75/Arabi Aswad	2	0.4
62	Orge 905/Cr.289-53-2	6	2
61	Rihane-03	6	1.4
141	Roho	2	1
40	Roho/Arabi Abiad//ND7014/Bowman	2	2
91	Salmas	2	0
131	Sara	2	0.8
35	SB73358-B-104-16-1-3//ER/Apm/5/Pitayo/	2	2
88	Weeah 11//WI2291/Bgs	2	2
109	WI2269//Alger/Ceres 362-1-1	2	2
63	WI2291*2/WI2269	2	0.2
112	WI2291//Apm/PI 000046/3/Hml-02	2	0.2
77	WI2291/4/7028/2759/3/69-82//Ds/Apro	2	0.8
79	WI2291/Bgs/4/Cq/Cm//Apm/3/12410/Giza 134-2L	2	0.6
102	WI2291/Tadmor	2	0.8
139	WI2291/Tadmor	2	1.2
Susceptible			
8	UC566/5/M64-76/Bon//Jo/York/3/M5....	6	21
20	Harmal	2	20.5
14	NK1272//Manker/Arig 8/3/DeirAlla205..	6	20

The new sources of resistance and the breeding lines were sent to Morocco to test against the Moroccan RWA population in both field and greenhouse at the Entomology Laboratory of the Centre for Aridoculture in Settat (Morocco).

Table 2.38. List of BF4 lines selected as resistant to RWA at Tel Hadya.

Cross/Pedigree	Number of lines
Bda/RWAM46	5
Lignee 527/Aths//RWAM47	6
Lignee 527/Aths//RWAM46	7
Rhn-08/Arar//RWAM46	10
Rhn-08/Arar//RWAM47	12
Apm/11012-2//Np CI 00593/3/IFB974/4/RWAM46	15
RWAM46/3/Alanda//Lignee 527/Arar	14
RWAM53/Ballan	2

The results showed that 39 lines of the BF4RWA00 nursery were resistant, and 11 other lines were moderately resistant (Table 2.39). This indicates that good progress has been made in introgressing the resistance into adapted material.

Table 2.39. Reaction of the ICARDA BF4RWA2000 nursery for resistance to RWA in Morocco.

Cross	Entry number	Reaction type
Badia/RWAM46	7,31,32	Resistant
Lignee527/Aths//RWAM46	171,179,187,189,190, 197	Resistant
Rhn-08/Arar//RWAM46	208,213,217,224,230, 237,241	Resistant
Apm/11012-2//NpCI00593/3/ IFB974/4/RWAM46	403,405,410,416,421, 428,452,454,458,459, 462,463,492	Resistant
RWAM46/3/Alanda//Lignee 527/Arar	603,605,606,607,610, 612,614,619,640	Resistant
Badia/RWAM46	27	Moderately resistant
Lignee527/Aths//RWAM47	154, 155, 161, 166	Moderately resistant
Lignee527/Aths//RWAM46	177	Moderately resistant
Rhn-08/Arar//RWAM46	205,223	Moderately resistant
Rhn-08/Arar//RWAM47	366	Moderately resistant
Amp/11012-2//NpCI00593/3/ IFB974/4/RWAM46	457	Moderately resistant

The screening of the International Barley Russian Wheat aphid Germplasm Pool (IBRWAGP2000) collection showed that a large number of entries from this collection carry good levels of resistance to the RWA. With the exception of number 14 that carries resistance from M55, all the remaining lines are plant introductions that have already been selected for resistance. The remaining lines were moderately susceptible to susceptible (Table 2.40).

Table 2.40. Reaction of the IBRWAGP2000 collection to the RWA in Morocco

Entry number	Resistance reaction
35	HR
41	R
39	R
37	R
14	R
38	R
34	HR
32	R
36	R
33	R
31	R

1.9.3.2. The Barley Stem Gall Midge

The 174 lines selected in 1999 from the 5274 entries of the BI99IN nursery were planted again in the field at both Sidi El Aidi and Jemaa Shaim research stations. They have been screened at both stations and showed good performance. However, because last season was completely dry, they are planted again to collect more data on yield performance and other agronomic traits.

The other nurseries screened for the BSGM were SEGMAG00, NURMAG00, and ISNBON00. The results showed that these nurseries did not carry any level of resistance; the plants were all susceptible.

1.9.3.3. Wheat Stem Saw Fly

Wheat stem sawfly (WSSF) is an important insect pest of barley in WANA, with an average infestation rate of about 20%. Larval feeding inside the stems causes the damage.

Additional damage result after the larvae cut the stem at the base of the plant before aestivation and hibernation, thus causing lodging.

A total of 910 barley lines (590 spring, 320 winter) were evaluated for resistance to this pest in the field at two locations (Tel Hadya and Hourane). An alpha design was used with two reps and systematically repeated checks every 10 entries. Each entry was planted in 1 m long row. The material was evaluated just before harvest. The evaluation was based on the number of stem cut/entry caused by wheat stem sawfly. 110 lines (60 spring, 50 winter) were selected with less than one stem cut per row. These promising lines will be retested in 2001 for confirmation. The confirmed sources of resistance will be studied for mechanisms of resistance.

1.9.3.4. Viruses

1.9.3.4.1. Selection for Resistance to Barley Yellow Dwarf Virus (BYDV) in F_2 and F_3 Populations

The F_2 populations of 26 barley crosses, with three of the parents being BYDV resistant (QB813-2, Sutter//Sutter*/Numar and Gustoe/NK1272) and 18 parents chosen because of their adaptation to different agro ecologies in WANA, were inoculated with BYDV and the presence of the virus was monitored using tissue blot immunoassay (TBIA) three weeks after inoculation (Table 2.41). There was a strong correlation between plants with no visual symptoms and no detectable virus by TBIA three weeks following virus inoculation ($r=0.657$, $P<0.01$). All plants with clear BYDV symptoms, and high virus concentration were discarded, and seeds were harvested only from resistant, good-looking plants. BYDV resistance in the F_3 populations will be monitored during the coming growing season.

132 F_3 single plants that were selected last year from 68 crosses were planted and re-evaluated for BYDV under field conditions in 2000. All plants with no symptoms were selected and the resistant F_4 families will be distributed as a BYDV nursery to different targeted environments.

1.9.3.4.2. Screening Breeding Lines for their Reaction to(BYDV)

Barley breeding lines are evaluated for their reaction to

BYDV over a three years period. In the first year, the breeding lines are evaluated in 30-cm short rows, which permits the evaluation of a large number of entries. In the second year, the entries tolerant to infection based on visual symptoms in the first year are planted in 1 m rows, and are evaluated on the basis of diseases index, biomass, grain weight, and height. In the third year, only the best performing lines from the second years are planted in plots of rows 1m long, which permit the evaluation of grain yield loss due to BYDV infection by comparing infected plots to the healthy ones. From previous experience in cereal crops, yield loss evaluation was found to be the most reliable factor in determining resistance to BYDV infection.

Evaluation in Short Rows

The preliminary evaluation of 55 barley genotypes, resistant to either powdery mildew (7 lines) or scald (48 lines), indicated that some lines also possess tolerance to BYDV. All plants were artificially inoculated with BYDV and evaluation was based on the severity of symptoms produced. The results showed that the following lines were tolerant to BYDV infection: IBPMGP (# 3 and 4); IBSCGP (# 4, 11, 13, 16, 17, 18, 19, 21, 41, 43 and 48). These lines will be evaluated further during the next growing season.

Table 2.41. Monitoring virus concentration in parents and F2 populations of different barley crosses planted in the field at 3 weeks after inoculation with barley yellow dwarf virus, using the tissue-blot immunoassay (TBIA), and visual symptom evaluation for segregating populations, during 1999-2000 growing season.

Cross		Distribution (%) of plants with different BYDV concentration levels				(%) of plants with different BYDV sym. Levels			
Female	**Male**	**F2 Segregating Population**				**F2 Segregating Population**			
Parent	**Parent**	**0**	**+**	**++**	**+++**	No	Mild	Mod	Severe
P4	P1	46	47	4	3	37.4	58.5	4.1	0
P4	P2	63	36	1	0	40.7	47.5	11.9	0
P5	P1	22	36	27	16	12.4	54.3	33.3	0
P5	P2	18	40	39	11	11.5	20.3	30.4	37.8
P6	P1	15	32	35	18	12.2	43.5	36.7	6.8
P6	P2	21	29	29	21	10.4	21.5	48.6	19.4
P7	P1	6	15	39	39	3.4	23.9	37.6	35
P7	P2	6	31	33	30	15.2	37.9	37.9	9.1
P8	P1	23	30	32	15	15.2	41.1	36.4	7.3
P8	P2	30	40	24	5	8.8	40.1	45.3	5.8
P9	P1	10	35	27	11	5.4	32.9	57.7	4
P9	P2	19	36	29	20	4.2	21.8	62.2	11.8
P10	P1	15	38	29	17	2.3	18.8	58.6	20.3
P10	P2	6	26	37	31	7.2	23.9	64.1	4.8
P11	P1	9	27	36	27	13.3	21.3	60	5.3
P11	P2	7	20	41	31	15.1	28.8	54.9	10.3
P12	P2	21	42	31	6	21.7	2.4	39.1	15.2

Cont'd. 2.41

P13	P3	5	10	30	55	8.3	16.5	61.3	14
P3	P14	21	51	23	5	17.6	54.9	27.5	0
P3	P15	3	17	19	61	7.8	28.7	50.4	13
P3	P16	10	19	18	53	17.4	39.6	39.6	3.5
P3	P17	12	11	16	61	20	26.4	46.4	7.2
P3	P18	8	13	33	46	25.8	31.2	37.1	5.3
P19	P3	6	15	14	65	23.8	21.3	46.7	8.2
P20	P3	7	8	29	43	5	15.7	55.4	24
P21	P3	3	2	20	75	7.4	20.2	30.3	42.2

P1: **Sutter//Sutter*2/Numar**, **P2:** **Gustoe/NK1272**, **P3:** **QB813.2**, **P4:** Rhn-03//**Lignee527/NK1272**/3/**Lignee527**/Chn, **P5:** Hamra/Arar, **P6:** Saida/N-Acc4000-172-80, **P7:** 80-5145/N-Acc4000-301-80, **P8:** Mtn-01, **P9:** Rhn-03, **P10:** Saida, **P11:** Bda, **P12:** Express, **P13:** Line9-26F27, **P14:** Hma-02//11012-2/**CM67/3/NK1272**//Manker/Arizona, **P15:** Aths/**Lignee 686**/4/Rhn-03/3/Bc/Rhn//Ky63-129, **P16:** Alanda-02/4/Arizona, 5908/Aths//Asse/3/F208-7, **P17:** Alanda/Hamra, **P18:** Alanda-01/Hamra, **P19:** Alanda//Ssn/Lignee640, **P20:** Saida/6/M66-69-1/M65-94//70-22109/3/Apm/IBP, **P21:** Algerian Selection Plot 202/3/Mari/Aths*2//Arizona

(2) All genotypes in bold have a BYDV resistance gene.

Evaluation in 1-m Rows

The barley lines included in the Wheat Stem Sawfly and Russian Wheat Aphid nurseries, identified in the previous season as highly tolerant to BYDV (based on the BYDV symptoms), were re-evaluated for their reaction to BYDV in 1-m row. Two lines resistant to the Russian wheat aphid (RWA-Ba-99-31 and 32) and another two lines resistant to the Sawfly (WSSF-Ba-99-11 and 13) were also tolerant to BYDV infection (Table 2.42). These lines will be further evaluated during the next growing season.

Evaluation in Small Plots

The re-evaluation of the best performing lines of different nurseries from previous seasons for BYDV tolerance/resistance in small plots, showed that some lines such as BIT-98-2, BIT-98-451, BPT-98-171 and SCR-98-204 from spring barley nursery, and WBCB-98-24 and HBON-98-40 from winter barley, were all highly resistant/tolerant to BYDV infection (Table 2.43). The grain yield of these lines when infected with BYDV was almost equal to that of the healthy control.

Table 2.42. Performance of barley lines from the Russian Wheat Aphid and Wheat Stem Sawfly nurseries, selected on the basis of previous seasons preliminary evaluation in short rows, planted during the 1999-2000 growing season in 1 m rows, and that showed tolerance to BYDV infection after artificial inoculation with the virus.

Entry	D.I. (0-9)	by (g/m)	gy (g/m)	ph (cm)
RWA-Ba-99-6	5.5	170	64.0	70
RWA-Ba-99-15	6.5	193	89.6	60
RWA-Ba-99-31	5	255	132.8	65
RWA-Ba-99-32	6	257	130.9	55
WSSF-Ba-99-11	5	242	120.0	65
WSSF-Ba-99-13	5	379	194.3	65
WSSF-Ba-99-15	8	61	21.4	50

RWA-Ba= Russian Wheat Aphid nursery barley lines, WSSF-Ba= Wheat Stem Sowfly nursery barley lines, D.I. =Disease Incidence, by = biomass yield, gy= grain yield, ph = plant height.

Table 2.43. Best performing barley lines from previous seasons planted in 4 ×1 m plots during the 1999-2000 growing season and evaluated for their reaction to BYDV infection after artificial inoculation with the virus, on the basis of symptoms disease index, biomass and grain weight, and grain yield loss (%).

Entry	D.I.	by	gy	ph	Yield loss %
Spring Barley					
BAT-97-17	6	226	105.4	57.5	25.9
BAT-97-75	5	331	154.4	62.5	20.7
BIT-98-2	5	405	195.1	62.5	0.0
BIT-98-367	5	320	137.6	75.0	16.7
BIT-98-403	5	284	152.4	67.5	1.8
BIT-98-445	6	323	162.1	67.5	0.0
BIT-98-451	5	338	170.9	77.5	4.2
BIT-98-458	5.5	296	147.5	70.0	5.6
BPT-98-104	6	348	136.5	62.5	4.0
BPT-98-171	5	332	156.5	70.0	0.0
SCR-98-188	6	351	162.7	52.5	11.3
SCR-98-204	6	385	159.8	55.0	0.0
BON-MRA-89-4	5	335	151.8	70.0	9.3
Corris	4	447	194.0	70.0	0.6
Susc-B(susc. check)	9	101	9.3	32.2	93.7
Winter Barley					
WBCB-98-24	2	349	166.9	72.5	0.1
WBCB-98-52	3	356	167.3	70.0	0.0
WBCB-98-183	5.5	302	124.2	62.5	19.0
HBON-98-16	5	275	108.1	65.0	0.7
HBON-98-40	4	372	185.7	77.5	13.8
IFBON-98-26	5.5	252	112.6	62.5	21.8
IFBYT-98-17	4	352	159.7	72.5	23.6
IWBON-97-142	5	274	131.9	60.0	15.5
IWBYT-97-6	4	267	128.8	67.5	29.9
VA82-42-63	4.5	281	134.6	62.5	0.0
Sutter	4	284	113.0	70.0	11.4
Wysor	3	378	156.7	62.5	28.2
QB813-2	5	361	163.3	77.5	0.2
Cyclon	9	29	6.6	17.5	96.2

BAT= Barley Advanced yield Trial, BIT= Barley Initial yield Trial, BPT= Barley Preliminary yield Trial, SCR= Syrian and Jordanian Landraces. WBCB= Winter Barley Crosse Block, HBON= Winter & Facultative Hulless Barley Observation Nursery, IFBON= International Facultative Barley Observation Nursery, IWBON= International Winter Barley Observation Nursery, IFBYT & IWBYT= International Winter & Facultative Barley Yield Trials.

1.9.4. Promising Lines

As a result of the activities listed above, a number of promising lines have been identified in a number of countries.

In Kazakstan, three outstanding lines of spring barley performed exceptionally well:

Mrq/M54-247//Mips/Be
WI 1298/ Emir/3/Arr/Esp//Alger/Ceres
RWA-M 53.

The new lines performed especially well in 1999, which was very favorable for spring barley and out-yielded a local standard check Tselinniy30 due to high resistance to diseases (*Helmintosporium* and stem rust) during heading stage. Even in the crop season of 2000, under severe drought and heat during the grain filling stage, these lines performed better than the check. They are considered as candidates for on-farm trials and demonstration plots. Their seed multiplication is now underway.

In Kyrgyzstan, three early ripening lines are under seed multiplication and have good perspective for inclusion into on-farm trials and demonstration plots and official state yield trials. The best one (MV-46/Mazurka/3/Roho// Alger/ Ceres) out-yielded by 31% the standard check variety during two year testing in the advanced yield trials. The new variety ripens 15 days earlier than the check. It is a two-row barley with plump good shaped grain and with 1000kw of 50.3 gr. After seed multiplication the new variety will be tested in wide range of environments for evaluation of its adaptation and yield potential. Also, its malting and brewing grain quality will be analyzed. Farmers need such a variety, because at this moment in time only varieties with high grain quality are economically profitable.

In Iran, Xemus and CWB-117-77-9-7/ICB 104073 out-yielded the best check by nearly 30% in the Kermanshah region; Yesevi-93 yielded well in the Maragheh region after a good performance in Shirvan, Ardebil, and Ghamloo during 1999; the line Wieselborger/Ahor1303-61//Steptoe/Antares showed an excellent performance at Ghamloo, where it out yielded Sahand by 37%.

In Jordan two lines, JLB 06-38 and Roho/Arabi Abiad//6250/1161 (Pedigree ICB82-0354-6AP-0AP-11AP-0TR) have been proposed for release. The first is a pure line selection from a Jordanian landrace collected in the Madaba area, while the second has been introduced into Jordan through the International Yield Trials for Low-rainfall areas with warm winters in 1996.

In Libya, two new barley varieties, Wadi Hay and Wadi Zart, were submitted for release. The two varieties were selected through the collaboration between the Libyan national program and the barley project at ICARDA.

Output 2: Methodology to Enhance Adoption Developed

2.1. Introduction

Breeding philosophies and methodologies developed for favorable conditions and high input agriculture have been ineffective in generating improved cultivars for marginal conditions and low input agriculture. The barley project has developed and implemented a novel breeding approach for barley improvement in low potential, marginal rainfall environments based on: (a) early selection and testing under real farmer conditions, (b) use of farmers' selection criteria, and (d) validation and quantification of grain and straw qualities used as selection criteria. The major expected output is an increased adoption of new varieties in low-input agriculture. The new breeding program, targeted at marginal conditions and low-input agriculture, moves selection and testing work outside experiment stations and puts breeding into the hands of farmers. We expect that, even in a relatively small geographical area, farmers will tend to exploit specific adaptation. Specific adaptation benefits biodiversity through selection and spreading of a number of different cultivars, instead of the few, often closely related, cultivars characteristic of conventional breeding for wide adaptation.

The barley project started experimenting with participatory plant breeding in 1996 with a project supported by BMZ in Syria. In 1998, the number of countries collaborating with the barley project in the use of participatory plant breeding methodologies increased to 3 countries (Syria, Tunisia and Morocco), and in 1999 to six countries (Syria, Tunisia, Morocco, Yemen, Eritrea and Egypt). In 2000, while the project in Tunisia and Morocco ended, and the project in Eritrea was interrupted by the war, a new project started in Jordan.

In this section, we will present the main results obtained in Syria, Egypt and Yemen, while the participatory activities in Jordan that started in November 1999 will be reported next year.

2.2. Participatory Barley Breeding in Syria

During 2000, we started the implementation of the second phase of the project on farmer participation in Syria. The major features of the second phase are 1) the transformation of the component of the barley improvement project addressing the environments where barley is grown in Syria (which also represent the northern part of Iraq and Jordan) into a decentralized-participatory program, 2) the increase in the number of farmers directly involved in the project, and 3) the initiation of village-based seed production. The details of the second phase, such as number of lines, plot size, type of germplasm, selection criteria, and seed production issues, were discussed in meetings with farmers (one meeting in each village except for two villages where we had just one meeting involving farmers from both villages). These meetings took place between August and September 1999. The host farmers and a number of neighbors that varied from 4 to 12 attended these meetings that were organized by the host farmers.

The main results of these meetings were (1) a general consensus that 200 lines was a manageable number of lines to start with, (2) that the type of germplasm for each of the eight locations had to be decided by the farmers, and (3) that in some locations there was a need to duplicate the trials to check whether differences in soil type, soil depth, or in rotation resulted in changes of the ranking of breeding material.

In the case of the type of germplasm, the farmers generally expressed strong preferences for the seed color and the row type. As shown in Table 2.44, the farmers in three villages, namely Tel Brack (03), Bylounan (05) and Melabya (07), wanted only two-row types with black seed. In contrast, the farmers in Mardabsi (02) and Suran (09) only wanted two-row types with white seed. The farmers in the other three villages wanted both seed colors within the two row-types (J. Aswad, (04), or a combination of two- and six-row types, such as in Bari Sharky (08), or all the three types as in Al Bab (06).

In three of the eight locations, namely Al Bab, Bari Sharky and Melabya, the farmers requested two sets of the same trial to expose the genetic material to different environments or practices within the same village. In Al Bab the two sets were planted in two different rotations (barley-barley and vetch-barley), in Bari Sharky in deep and shallow soil and in Melabya in two different types of soils.

Table 2.44. Type of germplasm (row type and seed color) chosen by farmers for the initial yield trials planted in eight villages in 1999-2000.

Group	Composition of the trials	Locations[a]
1	100% 2R Black	03-05-07A-07B
2	100% 2R White	02-09
3	90% 2R White 10% 6R	08A-08B
4	45% 2R White 45% 2R Black 10% 6R	06A-06B
5	50% 2R White 50% 2R Black	04

[a]locations' codes are given in the text

The trials were unreplicated with systematic checks every ten plots including the first and the last. Therefore, there were 179 breeding lines (entries), while 21 plots were allocated to the checks. In each location, we used two checks chosen together with the farmers among cultivars that they already know and/or grow. The checks were Tadmor and Zanbaka in Tel Brack, Bylounan and Melabya, Arta and WI2291 in Mardabsi, Bari Sharky and Suran, Arta and Tadmor in J. Aswad, and Arta and Sara in Al Bab.

In each location, we used a different randomization, even when two sets were planted in the same village.

Selection in seven of the eight villages was done by the host farmer, and in six of them also by a group of between 6 and 11 farmers who scored each plot. In total, 53 farmers participated in the selection.

The data were analyzed with the Residual Maximum Likelihood Method (REML) and with the software ASREML. Different models with entries as random factors were compared using the magnitude of the Log Likelihood to chose the best model. In most cases, a two-dimensional separable auto-regressive spatial model of first order was found to be the most efficient model. The data reported in the following Table are the BLUP's (Best Linear Unbiased Predictors of the entry effects obtained with the appropriate REML model.

As mentioned earlier, 2000 was a very dry year that in some locations such as Tel Brack, J. Aswad, Bylounan and B. Sharky, it was the second consecutive dry year (see Table 2.44, Annual Report for 1999). In Melabya the crop did not even germinate, and in Tel Brack, Bylounan and J. Aswad, there was a crop failure, with only few plots able to produce a small amount of grain. One of the two trials planted at Bari Sharky was grazed before harvesting and no yield data were collected.

The highest yielding location was Mardabsi (Table 2.45) with an average of 3.4 t/ha of grain, and 9.2 t/ha of biomass; the maximum yield of 4.4 t/ha obtained with a cross involving Arta, while the maximum biomass yield (more than 11 t/ha) was obtained with a cross between a landrace and a modern cultivar. Suran was the second highest yielding location, although it received the highest rainfall. The average yield was 1.7 t/ha and the top yielding line (a line selected from the same collection site of Arta), yielded nearly 2.5 t/ha.

The yield advantages of the highest yielding line over the better of the two widely grown landraces (Table 2.46) ranges from less than 10% (as in Al Bab) to more than 100% (as J. Aswad and Bylounan, two of the driest locations).

Table 2.45. Total rainfall (mm) and mean and range for grain yield (gy in kg/ha), 1000-kernel weight (g), plant height (ph in cm) and biomass (by in kg/ha) in seven of the eight villages where the initial yield trials were planted in 1999-2000. In Melabya rainfall was only 50 mm and there was no germination.

	Rainfall						
Location	2000	1999		gy	kw	ph	by
Mardabsi	221	-	Mean	3410	42	75	9200
			Max	4425	48	96	11861
			Min	2688	35	63	7092
Tel Brack	87	130.2	Mean	-	-	14	351
			Max	-	-	15	509
			Min	-	-	13	196
J. Aswad	121	189.5	Mean	164	28	16	742
			Max	342	35	22	1190
			Min	62	10	12	506
Bylounan	87	162.5	Mean	107	-	16	359
			Max	338	-	24	819
			Min	25	-	13	88
Al Bab (A)	221	203	Mean	914	36	32	2573
			Max	1045	44	48	3619
			Min	790	29	21	1448
Al Bab (B)	221	203	Mean	909	34	36	3068
			Max	1011	46	42	5431
			Min	826	23	21	1186
B. Sharky (B)	130	128	Mean	368	28	28	2103
			Max	545	36	41	3088
			Min	167	18	22	1450
Suran	252	212.8	Mean	1718	41	45	4509
			Max	2496	52	66	6038
			Min	943	32	32	3509

Table 2.46. Yield advantage of the best entry over the two widely grown landraces

Location	Best line	% advantage	A. Abiad	A. Aswad
Mardabsi	4425	35.8	3233	3258
Tel Brack	509	43.8	331	354
J. Aswad	342	100.1	148	163
Bylounan	338	218.8	-	106
Al Bab (A)	1045	9.0	848	959
Al Bab (B)	960	4.5	919	855
B. Sharky	545	42.0	341	384
Suran	2496	54.4	943	1616

- total biomass

Selection in seven of the eight villages was done by the host farmer, and in six of them also by a group of between 6 and 11 farmers who scored each plot. In total, 53 farmers participated in the selection. The breeders also scored the plots in all the locations. In the driest locations, the score was repeated twice.

The breeder's agronomic scores, the mean scores of the farmers at each site, and the quantitative data on grain yield, biomass, harvest index, plant height, spike length and kernel weight, were analyzed with a similarity analysis based on the Euclidean distances. The dendrograms of the various combinations of environments of selection and selectors were obtained by the unweighted pair group method with arithmetic average (UPGMA) cluster analysis. These analyses were done using the program NTSYS-PC version 2.0 (Numerical Taxonomy System, Applied Biostatistics, N.Y.). The results are shown in Figures 16-22.

In Mardabsi (Fig. 2.16) the breeder's score was associated more closely with plant height, while the farmers' average score was more closely associated with biomass. A similar association was observed in Jurn Al Aswad (Fig 2.17), with both the breeder's agronomic scores being more closely associated with plant height, while the average of the farmer scores was closely associated with biomass, grain yield, harvest index and kernel weight.

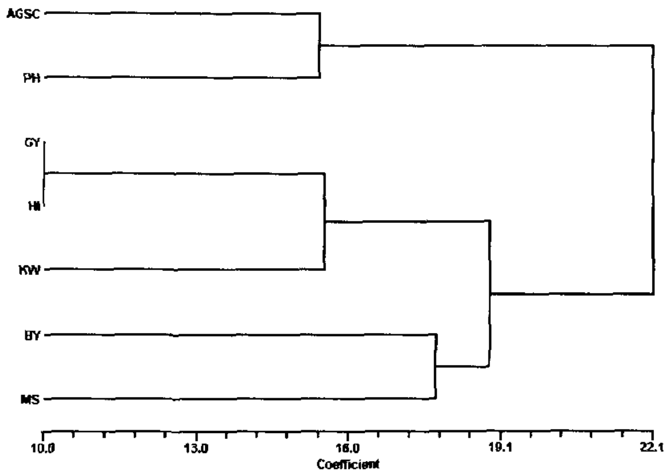

Fig. 2.16. Dendrograms of Euclidean distances between breeder's agronomic score (AGSC), farmers' mean score (MS) and grain yield (GY), biomass (BY), harvest index (HI), plant height (PH), and kernel weight (KW) in Mardabsi.

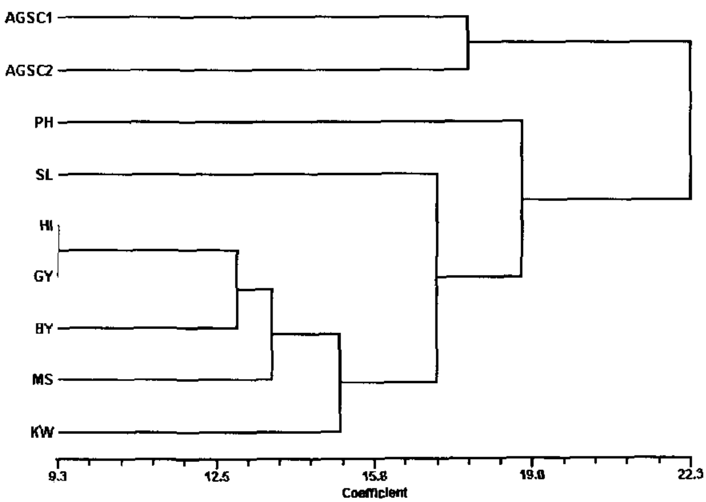

Fig. 2.17. Dendrograms of Euclidean distances between breeder's agronomic scores (AGSC1 and AGSC2), farmers' mean score (MS) and grain yield (GY), biomass (BY), harvest index (HI), plant height (PH), spike length (SL), and kernel weight (KW) in Jurn al Aswad.

In Al Bab, where the trial was planted in two different rotations, we analyzed the similarity between scores and quantitative traits in the two (Fig. 2.18) as well as the similarity between farmers' scores in the two rotations (Fig. 2.19). Breeder's scores were similar in the two rotations, and similar to the ranking for both grain yield and biomass in the barley-barley rotation, and to the ranking for biomass in the vetch-barley rotation. Farmers' average score was similar to the ranking for plant height in both rotations. Only kernel weight, and to a lesser extent plant height, were similar in the two rotations, while both biomass and grain yield were not associated.

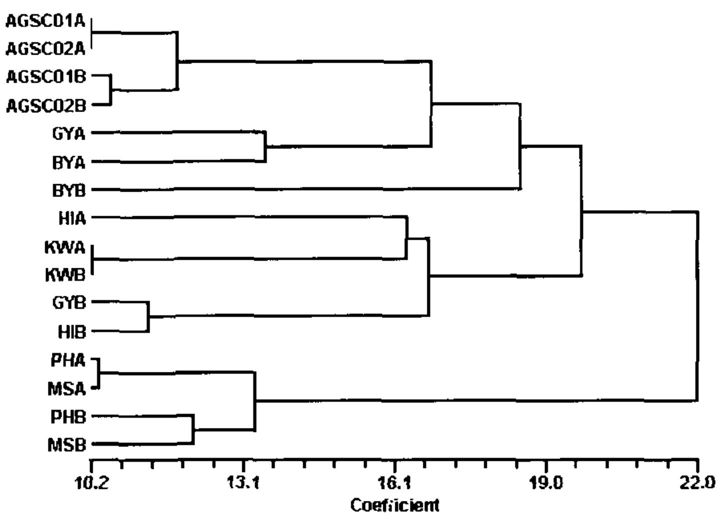

Fig. 2.18. Dendrograms of Euclidean distances between breeder's agronomic score (AGSC), farmers' mean score (MS) and grain yield (GY), biomass (BY), harvest index (HI), plant height (PH), and kernel weight (KW) in Al Bab (A = barley-barley, B = vetch-barley).

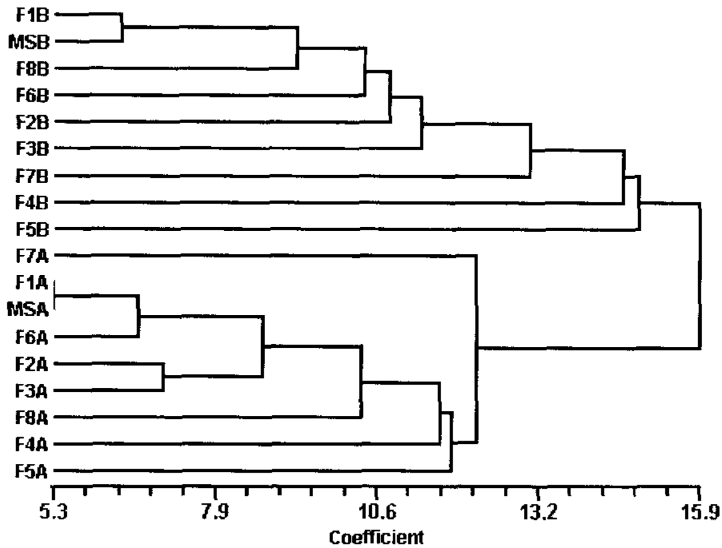

Fig. 2.19. Dendrograms of Euclidean distances between the farmers' scores and the average score (MS) in Al Bab (A = barley-barley, B = vetch-barley).

Farmers' scores tend to form two distinct clusters with more similarity within the same rotation than between rotations (Fig. 2.20).

In Suran (Fig. 2.21), similarly to what observed in Mardabsi and J. Al Aswad, breeder's score were more similar to the ranking for plant height, while farmers' average score was more similar to the ranking for grain yield, harvest index and kernel weight.

The opposite situation was observed in Bari Sharky (Fig. 2.22), where the breeder's score were more similar to the ranking for grain yield and harvest index, while farmers' average score was more similar to the ranking for plant height in both shallow and deep soil.

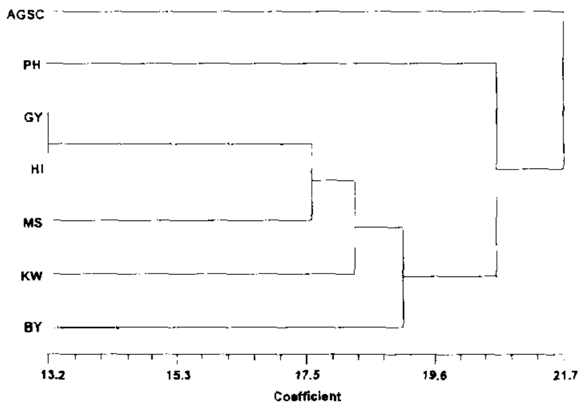

Fig. 2.20. Dendrograms of Euclidean distances between breeder's agronomic score (AGSC), farmers' mean score (MS) and grain yield (GY), biomass (BY), harvest index (HI), plant height (PH), and kernel weight (KW) in Suran.

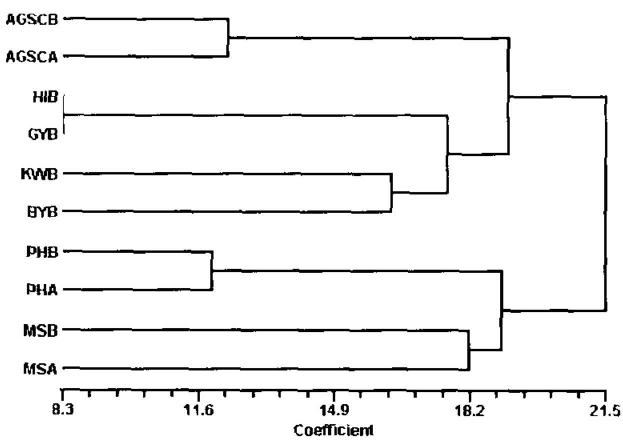

Fig. 2.21. Dendrograms of Euclidean distances between breeder's agronomic score (AGSC), farmers' mean score (MS) and grain yield (GY), biomass (BY), harvest index (HI), plant height (PH), and kernel weight (KW) in Bari Sharky (A= shallow soil, B = deep soil).

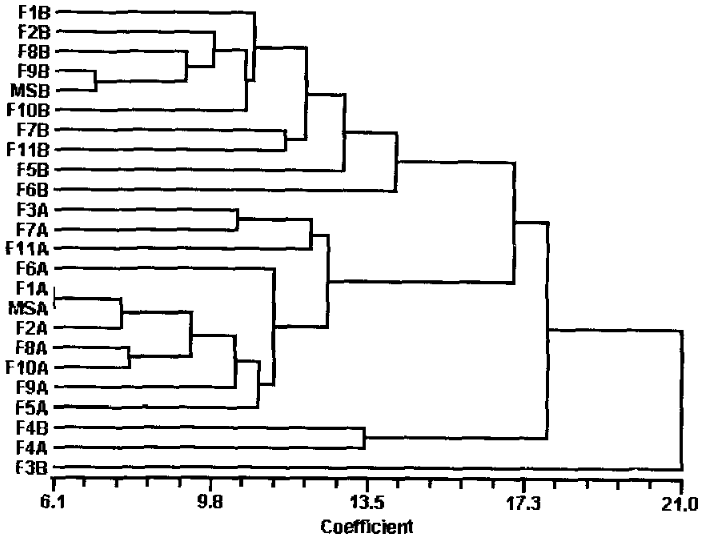

Fig. 2.22. Dendrograms of Euclidean distances between farmers' scores in Bari Sharky (A= shallow soil, B = deep soil).

Farmers' individual scores, as well as the average scores) formed two distinct clusters for deep and shallow soils, indicating that the preferences within the same soil depth were more similar than between soil types. The only exceptions were farmers 3 and 4 who in the trial planted in deep soil gave scores more similar to those given by other farmers in the trial planted in shallow soil.

After harvesting and data analysis, the quantitative results and the farmers' scores were discussed in each village. As a result of these meetings, the farmers decided that the lines selected during 2000 should be tested in 2000/2001 cropping season in two types of trials:

1. FAT (Farmer Advanced Trials) that includes all the lines visually selected by all the farmers as well as the highest yielding lines: these trials have a plot size that is double the plot size of the initial trials.
2. FET (Farmer Elite Trials) which includes only the lines which were visually selected by the majority of the farmers: these trials have a plot size which is five times larger the plot size of the initial trials.

Eventually each host farmer received a new initial yield trial (FIT = Farmer Initial Trials) of the same size (200 plots) and with the same layout as in the first year. In total, we established 35 FAT with a total of 168 lines, 32 FET with a total of 54 lines, and 11 FIT with a total of 389 lines (see Map 4).

2.3. Participatory Barley Breeding in Yemen

The PPB activities in Yemen are conducted in the framework of a special project, "Village Based Participatory Breeding in the Mountain Slopes of Yemen", supported by the SWPPRGA and conducted in collaborations with the Agricultural Research and Extension Authority (AREA).

In the three villages selected in the project area in the Northern Highlands (Hasn Azan, Bit Al-Wali and Al-Ashmor) and described in the 1999 reports, we planted the barley lines selected during 1999. The number of barley lines was 19, 16, and 21 in Hasn Azan, Bit Al-Wali and Al-Ashmor, respectively. The total number of different lines was 26 out of the initial fifty. All trials were planted in two replications and each entry was planted in plots of 10 rows at 25 cm distance and 5m long.

Both men and women conducted selection, individually, and in groups of various sizes. Individual selection was conducted by 23 individual farmers (8 men and 15 women), and by four groups of men and 5 groups of women. In total, 19 men and 17 women were involved in selection. In Hasn Azan, where the crop was late due to late planting, the time of selection coincided with the peak of women's activities in the household, thus they were not able to do selection. Similarly, there was no selection at the Al Erra research station because of severe drought, and the breeder did the selection only in the three villages.

The data were analyzed by REML. In the case of the new trials described below, the environmentally standardized data were used to analyze genotype x environment interactions using clustering and ordination procedures (using the software GEBEI). Eventually, farmers' and breeders' selections were compared using similarity analysis. This year we used the Euclidean distance as coefficient of similarity because this allows the use of the actual scores given by the participants. Both the farmers and the breeders scored all the entries in both replications, and therefore the average scores were used in the similarity analysis.

As anticipated in the previous report, the project was extended to the Central Highlands, a very different agro-ecological environment from the terraced-agriculture of the Khulan Affar area. The trials were planted in two villages (Yarim and Balasan) as well as in the research station at Dhamar, where most of the research for the Central Highlands is conducted, and where the headquarters of AREA are located.

The trials included a new set of 45 entries, and were conducted in two replications with plot size of 4 rows at 25 cm distance and 2m long.

Only the breeder conducted selection on station, while the breeder and the farmers, both men and women, conducted selection in the two villages. The total number of farmers involved was 20 (10 men and 10 women). A number of traits were measured in each plot and the data were analyzed using the methods described above.

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The days to heading, plant height, spike length, number of kernels/spike, biomass yield, grain yield, and harvest index of the 21 barley lines selected in 1999 and evaluated in Al Ashmor in 2000 are shown in Table 2.47. Eleven entries out-yielded the common check for both grain yield and biomass. The yield increases of the three top yielding lines ranged from 57 to 128% for grain yield, and from 91 to 148% in the case of biomass.

In Bit Al Wali (Table 2.48), where both the grain yield and the biomass of the common check was much higher than in Al Ashmor, only two entries (entries 10 and 13) out-yielded the common check for both grain and biomass yield. The yield increases were slightly more than 20% in the case of grain yield and 44-47% in the case of biomass.

In Hasn Azan (Table 2.49), yields were similar to Al Ashmor but the yield of the common check was very low. In fact, nearly all the entries yielded more grain than the check and twelve entries yielded more biomass. The three top yielding entries for grain yield (entries 8, 14, and 18) out-yielded the check by between 81 and 186%, while the three top yielding entries for biomass (entries 8, 12 and 18) out-yielded the check by between 42 and 124%.

Table 2.47. Days to heading (dh), plant height (ph in cm), spike length (sl in cm), number of kernels/spike (knr), biomass yield (by in g/plot), grain yield (gy in g/plot), and harvest index (hi) of 21 barley lines selected in 1999 and evaluated in Al Ashmor in 2000.

Entry	Name	dh	ph	sl	knr	by	gy	hi
1	BALADY	56.5	39.5	6.0	18.5	208	123	0.55
2	ACSAD 1420	65.5	68.0	8.0	41.5	360	166	0.46
3	ACSAD1486	67.5	62.0	7.0	35.0	425	185	0.44
4	ER20 (97-98)	62.0	47.5	7.5	33.0	330	185	0.59
5	ACSAD 1490	68.5	44.0	6.5	16.5	209	63	0.29
6	BAKKUR	66.0	51.0	6.0	14.5	219	79	0.36
7	Common Check	65.0	52.5	5.5	13.0	225	119	0.53
8	SAKHLA	63.5	52.0	5.5	12.5	221	82	0.38
9	ER60 (97-98)	67.5	78.5	7.5	28.0	318	115	0.37
10	ACSAD 1125	65.0	67.5	7.5	35.0	558	270	0.49
11	ER7 (97-98)	66.0	53.5	6.5	20.5	333	134	0.40
12	ER20 (97-98)	69.5	55.0	6.5	15.0	245	102	0.41
13	ACSAD 1464	67.0	63.5	5.5	31.5	430	186	0.43
14	ACSAD 1422	67.0	61.5	7.0	18.0	342	136	0.40
15	ER6 (97-98)	66.0	55.0	5.5	27.0	298	104	0.36
16	ER36 (97-98)	66.0	49.0	5.0	13.0	198	68	0.34
17	ACSAD 1468 (S)	66.0	55.0	5.0	36.5	343	119	0.34
18	ACSAD 1422	66.0	49.5	7.0	35.0	272	100	0.36
19	ACSAD 1420	68.0	55.0	5.5	49.0	352	162	0.46
20	ACSAD 1468 (S)	66.0	49.0	6.0	29.0	309	131	0.42
21	ER18 (97-98)	66.0	50.0	7.5	36.0	503	227	0.45
Mean		65.7	55.2	6.4	26.6	319	136	0.42
Max		69.5	78.5	8.0	49.0	558	270	0.59
Min		56.5	39.5	5.0	12.5	198	63	0.29
s.e.		3.8	3.3	0.7	7.1	59	28	0.09
Mean Impr.		66.4	56.7	6.5	29.4	342	144	0.41
Mean Land.		62.8	48.8	5.8	14.6	218	101	0.45

As a result of the yield evaluation and of the visual selection by the farmers, thirteen entries (Table 2.50) were selected for seed multiplication and for independent testing by the farmers in 2001. Of these, three entries (ACSAD 1125, ACSAD 1474 and ER 18) were added by the breeder because they combined high grain yield and high biomass, and ten were visually selected by farmers.

Table 2.48. Days to heading (dh), plant height (ph in cm), spike length (sl in cm), number of kernels/spike (knr), biomass yield (by in g/plot), grain yield (gy in g/plot), and harvest index (hi) of 16 barley lines selected in 1999 and evaluated in Bit Al Wali in 2000.

Entry	Name	dh	ph	sl	knr	by	Gy	hi
1	BALADY	46.0	64.5	8.0	31.0	587	288	0.49
2	ACSAD1486	65.0	59.0	7.5	29.0	485	112	0.23
3	ER60 (97-98)	46.0	75.0	8.0	45.0	733	188	0.27
4	ER58 (97-98)	46.0	83.0	10.5	75.0	824	376	0.46
5	ER20 (97-98)	46.0	58.0	7.0	18.5	785	219	0.32
6	SAKHLA (Kharen)	50.0	57.0	7.5	31.0	487	226	0.46
7	ACSAD 1474	46.0	70.5	8.5	41.0	840	369	0.44
8	ACSAD 1448	50.0	70.5	8.0	62.5	681	278	0.41
9	BAKKUR (Kharen)	46.0	65.0	8.0	35.5	570	213	0.41
10	ACSAD 1468 (S)	68.0	60.5	5.0	53.0	466	225	0.48
11	BALADY	71.0	80.0	12.0	29.0	633	182	0.29
12	Common Check	46.0	60.5	7.0	49.0	571	305	0.56
13	ACSAD 1420	63.0	51.5	7.0	21.0	346	133	0.39
14	ACSAD 1470	70.0	56.0	7.0	37.0	569	205	0.42
15	ER20 (97-98)	73.0	51.0	7.0	21.0	200	89	0.44
16	ACSAD 1468 (S)	63.0	60.0	6.0	56.0	405	201	0.51
Mean		55.9	63.9	7.8	39.7	574	225	0.41
Max		73.0	83.0	12.0	75.0	840	376	0.56
Min		46.0	51.0	5.0	18.5	200	89	0.23
s.e.		n.r.v	6.7	0.5	4.9	146	34	0.12
Mean Impr.		57.8	63.2	7.4	41.7	576	217	0.40
Mean Land.		51.8	65.4	8.5	35.1	569	242	0.44

Of the latter, the breeder selected five on station in 1999, while the other five would have been missed had the selection been conducted only on station, and assuming that all the five entries selected in 1999 would have been selected again in 2000.

The similarity between farmers' and breeder's selections is presented using the mean of the scores given by the various participants. In Al Ashmor (Fig. 2.23), the highest similarity was between the scores given by the individual women and by the women's groups, and the highest dissimilarity was between the breeder and the farmers, regardless of the gender. There was more similarity between the men and the women than between the men and the breeder (also a man).

Table 2.49. Days to heading (dh), plant height (ph in cm), spike length (sl in cm), number of kernels/spike (knr), biomass yield (by in g/plot), grain yield (gy in g/plot), and harvest index (hi) of 19 barley lines selected in 1999 and evaluated in Hasn Azan in 2000.

Entry	Name	dh	ph	sl	knr	by	gy	hi
1	ACSAD1420	40.0	62.0	7.5	24.0	340	110	0.32
2	ER36 (97-98)	42.0	50.5	7.5	26.0	316	123	0.39
3	ER34 (97-98)	44.0	47.5	7.5	23.0	295	99	0.34
4	ER45 (97-98)	44.0	67.0	8.0	29.5	318	124	0.40
5	BALADY	44.0	51.0	8.0	31.0	404	166	0.41
6	SAKLA	38.0	50.0	6.5	25.0	353	138	0.40
7	ER60 (97-98)	38.0	66.0	6.5	22.5	253	122	0.48
8	ER66 (97-98)	44.0	68.0	7.5	46.5	716	266	0.37
9	ACSAD1448	64.0	44.0	5.0	32.0	382	128	0.34
10	BAKKUR	66.0	47.5	6.0	19.0	329	112	0.32
11	Common check	66.0	48.5	5.5	19.5	319	93	0.29
12	SAKLA	66.0	38.5	7.5	26.5	455	152	0.34
13	ER7 (97-98)	66.0	61.0	6.5	26.5	375	142	0.39
14	ACSAD1486	66.0	44.0	6.0	26.5	402	169	0.42
15	ACSAD1125	66.0	48.5	6.0	25.0	295	160	0.54
16	ER7 (97-98)	66.0	48.5	5.5	21.0	326	106	0.33
17	ER20 (97-98)	66.0	58.5	5.0	20.0	278	75	0.29
18	ER6 (97-98)	66.0	55.0	6.0	35.0	535	191	0.36
19	ER58 (97-98)	66.0	64.5	8.0	27.0	413	133	0.32
Mean		55.7	53.7	6.6	26.6	374	137	0.37
Max		66.0	68.0	8.0	46.5	716	266	0.54
Min		38.0	38.5	5.0	19.0	253	75	0.29
s.e.		n.r.v	4.8	1.1	5.8	97	37	0.05
Mean Impr.		55.6	56.1	6.6	27.5	374	139	0.38
Mean Land.		56.0	47.1	6.7	24.2	372	132	0.35

Table 2.50. Barley entries selected in 2000 by farmers based on visual selection (fs) and by the breeder using the actual data (gy = grain yield, by = biomass) in the three locations. The last column shows whether the breeder on station in 1999 selected the line.

Name	Location	Germ.	Sel. Crit.[a]	On station in 1999
ACSAD 1125	Alashmor	Modern	gy-by	-
ACSAD 1420	Alashmor	Modern	fs	YES
ACSAD 1468 (S)	Bit Al Wali	Modern	fs	YES
ACSAD 1474	Bit Al Wali	Modern	by-gy	-
ACSAD1486	Alashmor	Modern	fs	-
Bakkur(Kharen)	Bit Al Wali	Landrace	fs	-
Balady	Bit Al Wali	Landrace	fs	YES
ER18(97-98)	Alashmor	Modern	gy-by	-
ER20(97-98)	Alashmor-Bit Al Wali	Modern	fs/by	-
ER58(97-98)	Bit Al Wali-HasnAzan	Modern	by-gy-fs/fs	-
ER6(97-98)	HasnAzan	Modern	by-gy-fs	YES
ER60(97-98)	HasnAzan-Alashmor	Modern	fs/fs	YES
ER66(97-98)	HasnAzan	Modern	by-gy-fs	-

[a] Selection Criterion: in the case of two locations, the selection criteria follow the order of the location

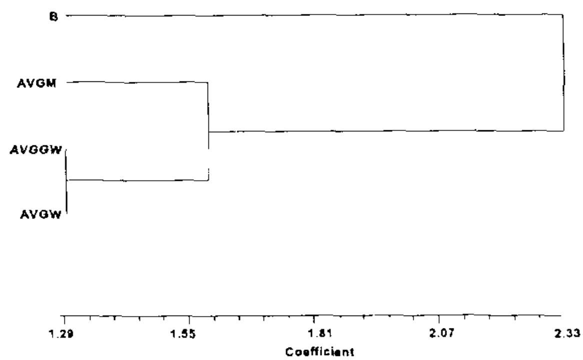

Fig. 2.23. Dendrogram of Euclidean distances based on selection made by breeder (B), individual male or female farmers (AVGM, AVGW), and groups of female farmers (AVGGW) in the barley trial at Al Ashmor.

A large dissimilarity between breeder and farmers' selections (as expressed by the scores) was also observed in Bit Al Wali (Fig. 2.24) and Hasn Azan (Fig. 2.25); the dendrogram of the latter location also shows dissimilarities among the farmers.

The correlation coefficients between the visual scores and the various traits (Table 2.51, 2.52 and 2.53) show large differences between locations as well as between participants within the same location. The breeder tended to give better scores to modern germplasm in Al Ashmor and Hasn Azan, while the scores given by the farmers, both men and women, were not significantly correlated with the type of germplasm. Only in Bit Al Wali, the highest yielding location, there was a preference for early types even though there were differences among participants. Tall entries received a higher score by farmers both in Al Ashmor and Bit Al Wali, and by one farmer in Hasn Azan.

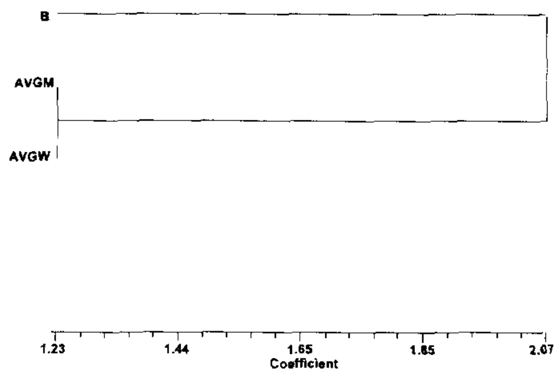

Fig. 2.24. Dendrogram of Euclidean distances based on selection made by breeder (B) and by the individual male or female farmers (AVGM, AVGW) in the barley trial at Bit Al Wali.

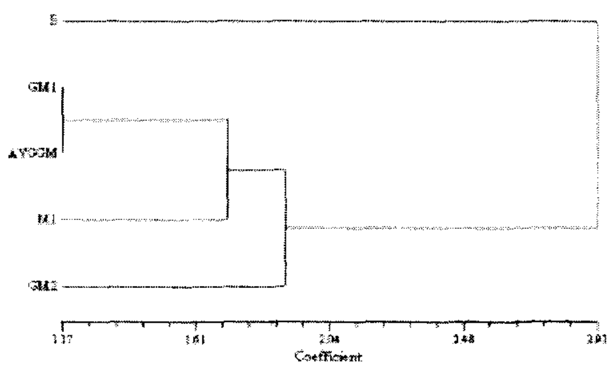

Fig. 2.25. Dendrogram of Euclidean distances based on selection made by breeder (B), individual male, or groups of male farmers (GM), and the average score of the two groups (AVGGM) in the barley trial at Hasn Azan.

Table 2.51. Correlation coefficients[a] between the visual score given by the breeder (B), by groups and individual men farmers (GM and M), by groups and individual women farmers (GW and W) and type of germplasm (germ: 1=modern; 2= landraces), days to heading (dh), plant height (ph), spike length (sl), number of kernels/spike (knr), biomass yield (by), grain yield (gy), and harvest index (hi), of 21 barley lines selected in 1999 and evaluated in Al Ashmor in 2000. AVGGM, AVGGW and AVGW indicate the mean score given by the groups of men, by the group of women and by individual women, respectively.

	Germ	dh	ph	sl	knr	By	gy	hi
Bs	-0.468	0.087	0.452	0.456	0.773	0.793	0.780	0.355
GM	-0.315	0.153	0.406	0.367	0.079	0.369	0.358	0.127
M1	0.226	0.138	0.607	0.320	0.015	0.350	0.379	0.259
M2	0.223	0.097	0.505	0.125	-0.120	0.187	0.158	0.031
M3	0.126	0.161	0.680	0.219	0.014	0.316	0.376	0.335
GW1	0.146	0.049	0.492	0.128	0.142	0.284	0.349	0.345
GW2	-0.016	0.235	0.524	0.457	0.004	0.108	0.160	0.214
GW3	-0.207	0.328	0.295	-0.082	-0.230	-0.16	-0.22	-0.16
GW4	-0.103	0.263	0.744	0.448	0.246	0.337	0.329	0.215
W1	0.220	-0.389	0.442	0.245	0.006	0.204	0.323	0.462
W2	-0.086	-0.045	0.286	0.543	0.110	0.350	0.398	0.265
W3	0.086	0.200	0.577	0.131	0.106	0.247	0.267	0.228
W4	-0.070	0.172	0.033	-0.222	-0.241	-0.20	-0.21	-0.10
W5	-0.070	0.079	0.137	-0.222	-0.205	-0.07	-0.08	0.042
W6	-0.048	0.142	0.611	0.577	0.131	0.196	0.239	0.238
AVGG	0.212	0.144	0.652	0.247	-0.031	0.314	0.336	0.229
AVGG	-0.056	0.288	0.694	0.374	0.073	0.204	0.224	0.219
AVGW	0.003	0.050	0.547	0.303	-0.009	0.185	0.236	0.287

[a] underlined (significant at $P< 0.05$), bold (significant at $P< 0.01$)

The breeder's scores were either independent from, or weakly correlated with plant height as in Al Ashmor. Some participants gave a better score to entries with long spikes, although this character does not seem to be frequently considered (one correlation coefficient was even negative). The breeder's scores were positively and significantly ($P<0.01$) correlated with kernel number, grain yield, and biomass in Al Ashmor where none of the correlation coefficients relative to farmers' scores was significant. By contrast, in Bit Al Wali, breeder's scores were significantly correlated only with grain yield, while several of the farmers' scores were positively and strongly correlated with kernel number, biomass (particularly men and only one woman), and grain yield (both men and women). In Hasn Azan, and for this last group of traits, only the correlation coefficient between the breeder's score and grain yield was significant (P<0.05). It seems as if the farmers did not identify systematically the highest yielding entries in the two low yielding locations, where presumably some other traits were of primary interest. It should be remembered however, that the farmers identified most of the top yielding entries in each of the three locations.

Table 2.52. Correlation coefficients[a] between the visual score given by the breeder (B), by groups and individual men farmers (GM and M), by groups and individual women farmers (GW and W) and type of germplasm (germ: 1=modern; 2 = landraces), days to heading (dh), plant height (ph), spike length (sl), number of kernels/spike (knr), biomass yield (by), grain yield (gy), and harvest index (hi) of 16 barley lines selected in 1999 and evaluated in Bit Al Wali in 2000. AVGM and AVGW indicate the mean score given by the individual men and women, respectively.

	Germ	dh	ph	sl	knr	by	gy	hi
Bs	0.051	-0.480	0.070	-0.020	0.357	0.431	0.693	0.522
GM	0.417	-0.465	0.728	0.674	0.253	0.549	0.429	-0.127
M1	0.244	-0.637	0.388	-0.082	0.684	0.322	0.672	0.544
M2	-0.05	-0.090	0.155	-0.179	0.667	-0.01	0.209	0.249
M3	0.347	-0.760	0.658	0.451	0.400	0.644	0.597	0.058
M4	0.035	-0.202	0.227	-0.163	0.772	0.056	0.398	0.517
GW	0.313	-0.214	0.563	0.408	0.428	0.222	0.182	0.043
W1	0.164	-0.258	0.451	0.192	0.535	0.192	0.364	0.229
W2	-0.03	-0.673	0.150	0.122	0.053	0.454	0.387	-0.121
W3	-0.18	0.025	-0.293	-0.470	0.053	-0.18	-0.01	0.411
W4	0.127	-0.415	0.104	-0.021	0.309	0.226	0.316	0.301
W5	0.284	-0.248	0.240	0.188	0.098	0.146	0.239	0.205
W6	0.221	-0.576	0.326	0.100	0.444	0.306	0.475	0.325
W7	0.255	-0.376	0.415	0.179	0.259	0.258	0.269	0.023
W8	0.244	-0.272	0.472	0.408	0.402	0.156	0.278	0.193
W9	0.323	-0.705	0.200	-0.020	0.320	0.477	0.744	0.464
AVGM	0.176	-0.524	0.443	-0.003	0.803	0.309	0.588	0.439
AVGW	0.307	-0.692	0.438	0.156	0.534	0.406	0.631	0.434

[a] underlined (significant at P< 0.05), bold (significant at P< 0.01)

Table 2.53. Correlation coefficients[a] between the visual score given by the breeder (B), by groups and individual men farmers (GM and M), type of germplasm (germ: 1=modern; 2 = landraces), days to heading (dh), plant height (ph), spike length (sl), number of kernels/spike (knr), biomass yield (by), grain yield (gy), and harvest index (hi) of 19 barley lines selected in 1999 and evaluated in Hasn Azan in 2000.

	germ	dh	ph	sl	knr	by	gy	hi
B	-0.467	-0.219	0.187	0.301	0.449	0.362	0.473	0.255
GM1	0.005	-0.067	0.354	0.095	0.182	0.373	0.282	-0.125
GM2	0.127	-0.145	0.224	0.129	-0.114	0.055	-0.064	-0.285
M1	-0.359	-0.165	0.526	0.111	0.219	0.312	0.222	-0.118

[a] underlined (significant at P< 0.05), bold (significant at P< 0.01)

Dhamar - Central Highlands

The days to heading, plant height, biomass yield, grain yield, and harvest index of the 46 barley lines are shown in Table 2.54 together with the values of the local check. As in the case of lentil, Yarim was the most favorable location with taller and later flowering plants and higher biomass and grain yield. Balasan was the most stressful site with an average grain yield 9 times lower than in Yarim and with half the average plant height. There was a wide range of variation among the new barley lines with several out-yielding the local check in total biomass (29 in Yarim, 13 in Balasan and 15 in Dhamar with yield increases between 3 and 89%). Fewer lines (1 in Balasan, and 18 in both Yarim and Dhamar) out-yielded the local check in grain yield with yield increases between 59 and 187%. Genotypes x Environment (GE) interactions explained about 51% and nearly 60% of the variance of environmentally standardized data for grain yield and biomass, respectively. Although the three environments were strongly correlated in the case of grain yield (Fig. 26), only few entries, such as entry 29, 15, 13, 42, and 46 (the local check), yielded above the average in all locations. By contrast, several yielded below the average in all the locations.

Table 2.54. Mean and range of days to heading (dh), plant height (ph), biomass yield (by in t/ha), grain yield (gy in t/ha) and harvest index (hi) of 46 barley lines tested in two farmers fields (Yarim and Balasan) and one research station (Dhamar) in 2000.

Location		dh	ph	by	gy	hi
Yarim	Mean	57.5	77.0	16.2	3.6	0.23
	Max	70.0	99.0	26.9	6.3	0.37
	Min	48.0	53.0	7.5	0.9	0.12
	Loc check	56.0	64.5	14.2	3.8	0.27
Balasan	Mean	55.1	32.1	3.4	0.4	0.12
	Max	64.0	45.5	4.4	1.1	0.49
	Min	46.5	24.5	2.2	0.2	0.08
	Loc check	49.5	31.5	3.9	0.7	0.18
Dhamar	Mean	52.9	61.0	6.2	1.3	0.22
	Max	70.0	77.0	8.4	4.6	1.04
	Min	44.5	40.5	2.8	0.3	0.08
	Loc check	46.5	46.5	6.7	1.6	0.24

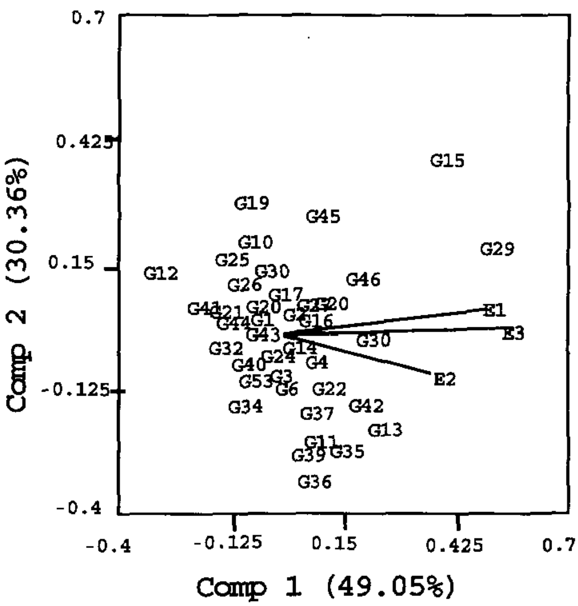

Fig. 2.26. Biplot of the first two components of grain yield of 46 barley entries grown in 3 locations in 2000 (E1= Balasan, E2 = Yarim, and E3 = Dhamar).

In the case of total biomass (Fig. 2.27), the correlation between locations was much weaker, and Dhamar was very poorly represented (very short vector). As a consequence, no lines performed well in all locations, but there were lines yielding much more than the mean in either Balasan (such as entries 45, 10, 29, and 19) or Yarim (such as entries 39, 40, 36, 8, and 34).

There was a clear location effect with all the selections in Balasan clustering together, and the usual higher similarity between men and women than between farmers and the breeder (Fig. 2.28). In Yarmin, the similarity between men and women was even stronger, while the breeder's selections in Dhamar and Yarmin were the most dissimilar among all the participants.

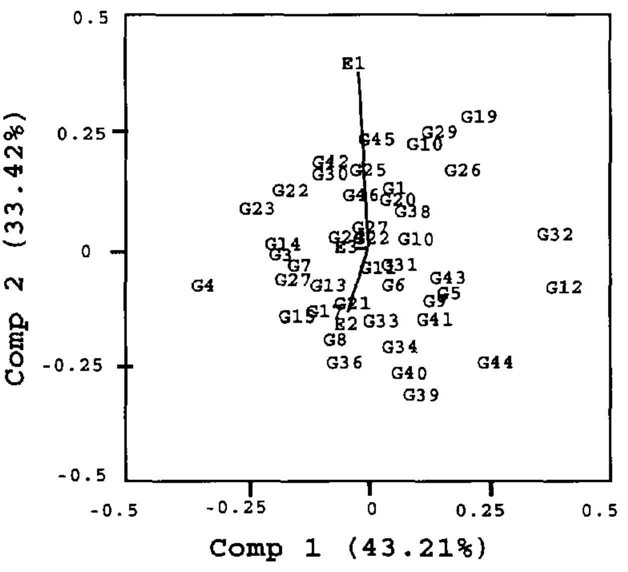

Fig. 2.27. Biplot of the first two components of biomass yield of 46 barley entries grown in 3 locations in 2000 (E1= Balasan, E2 = Yarim, and E3 = Dhamar).

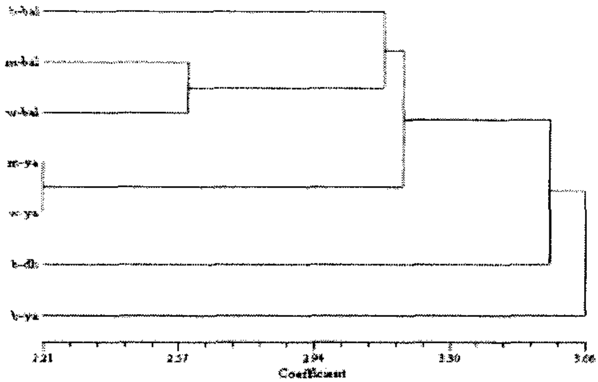

Fig. 2.28. Dendrogram of Euclidean distances based on selection made by breeder (b) and by male or female farmers (m, w) in the barley trials at Balasan (BA), Yarim (YA, and in Dhamar (DH).

Few correlation coefficients between the participants' scores were significant (Table 2.55). In general farmers (both men and women in Yarmin, and the women in Balasan), gave a higher score to tall plants and to earlier entries (only in Yarmin). With the exception of the women in Balasan, the farmers' scores were unrelated to yield, while with the exception of grain yield, the breeder's scores were positively and significantly correlated with biomass and grain yield. The comparison between the correlation coefficients in lentil and barley suggest that it could be misleading to draw conclusions on the selection ability of the farmers on single experiments, in a single location, and in a single crop.

The participants selected 33 entries in both Balasan and Yarmin, while the breeder selected 30 entries on station (Table 2.56). In both villages, all the participants missed only few entries with either high biomass or high grain yield. There were ten entries (four in Balasan and six in Yarmin) that the breeder selected and that were not selected by either the men or the women or both. The agreement between breeder and farmers was good at Yarmin, where fifteen entries were commonly selected, but poor in Balasan, where only two entries were commonly selected.

In both villages, there were some entries that were uniquely selected by women (nine in Balasan and three in Yarmin) or uniquely selected by men (seven in Balasan and four in Yarmin).

The entries selected by the participants will be planted in July 2001 in replicated trials in the same village (or in the station) where selection was done in 2000.

Table 2.55. Correlation coefficients[a] between the visual score given by the breeder (br), by farmers (w= women; m = men) and, days to flowering (df), plant height (ph), height of the first pod (bp), number of pods per plant (pp), seed weight (sw), days to maturity (dm), biomass yield (by), grain yield (gy) and harvest index (hi) of 46 barley entries grown in Balasan (bal), Yermin (ya) and the research station at Dhamar (dh) in 2000.

	dh	ph	Sl	dm	by	gy	hi
				Yarim			
br-ya	-0.342	0.257	0.435	0.268	0.540	0.793	0.479
m-ya	-0.412	0.307	0.192	0.092	-0.166	0.170	0.304
w-ya	-0.708	0.355	-0.098	-0.085	-0.108	0.205	0.383
br-dh	-0.063	0.139	-0.150	-0.130	0.327	0.217	-0.002
				Balasan			
br-	-0.262	-0.034	0.024	-0.234	0.251	0.439	0.369
m-bal	-0.131	0.208	0.068	-0.150	0.211	0.298	0.257
w-bal	0.021	0.371	0.262	-0.166	0.244	0.428	0.287
br-dh	-0.222	-0.021	-0.165	-0.098	0.198	0.075	-0.009
				Dhamar			
br-dh	-0.319	0.190	-0.149	-0.194	0.406	0.292	0.079

[a] underlined (significant at P< 0.05), bold (significant at P< 0.01)

2.4. Participatory Barley Breeding in Egypt

Barley is estimated to cover about 50,000 ha in the North-West Coast of Egypt. The area is divided in five regions; Ras El-Hekma, Marsa Matrouh, El-Negeila, East Barrani, and West Barrani; each region is served by a SubRegional Support Center (SRSC). Each region is divided in three zones or strips; the coastal or first zone, the second zone, and the third zone. The production systems include different combinations of barley, orchards, horticultural crops, and livestock. Only 6-row barley is grown in the area; some farmers were exposed in the past to a 2-row variety distributed by a development project, but the variety was very poorly adapted to the region.

Table 2.56. Barley entries selected in the two villages of the Central Highlands in 2000.

Village	Selected by or for:								
	Total	Breeder only	Men only	Women only	Men and women	Breeder and men	Breeder and women	Breeder and farmers	Yield
Balasan	33	4	7	9	7	1	0	1	4
Yarmin	33	6	4	3	3	5	3	7	2

The major use of barley is feed, mainly for small ruminants (barky sheep). The use of barley grain for food preparation is widespread, although in small amounts in each household. Barley flour is mixed with wheat flour for bread making or used for the preparation of sweets, (the most famous is called beggina, barley flour mixed with sugar and then cooked in milk). A barley soup (made of cracked grains), is also common, and some farmers mentioned a sort of couscous (kisk) made out of barley and cooked in milk.

Farmers do not grow different varieties for feed and food; they usually grow one or two varieties, one of them being the local and the other being Giza 126. The latter has been distributed by MRMP and has been quickly adopted and appreciated in the area.

Planting is always done by hand, with seed rate varying from 45 to 75 kg/ha. Continuous barley is common; some farmers have already adopted barley-lentil or barley-vetch rotations introduced by MRMP. The crop is grown without inputs such as fertilizers, herbicides, or pesticides. When asked about the reasons for not using fertilizers and any other inputs, the answer was always; 'they are not available', intending both the unavailability on the market and the unavailability of cash.

Some farmers keep the seed for planting the following season; some buy the seed from neighboring farmers or from the local market.

The most desirable attributes for a barley variety are drought tolerance, high tillering ability, long spikes, white seed, and resistance to smut and leaf rust. One farmer in El-Negeila is interested in early heading but (relatively) late maturing barley.

During 1999/2000, a new project was started with the long term objective of increasing barley production in the area, and with the short term objective of assessing the possibility of using a participatory approach in the development of new cultivars. After consultation with farmers, eight locations were identified; El-Karamis and El-Hebella in Ras El-Hekma SRSC, El-Shawaier and Ghout Rabbah in Marsa Matrouh SRSC, El-Magroun and El-Dawaia in El-Negeila SRSC, West Barrani, and East Barrani.

In each location, we planted 53 barley entries and one local check (from seed obtained from the farmer), repeated seven times, for a total of 60 plots. The trial was unreplicated and arranged in six blocks of 10 plots each. Selection was conducted in each farmer's field by the host farmer and by a group of five expert farmers.

At tillering stage and at maturity, a group of five expert farmers, including the host farmer, gave an agronomic score to each plot in each farmer's field. A score from 0 (worst) to 5 (best) was used in all locations. In each region, the same five farmers scored the two trials planted in that area. Selection was conducted in such a way as to reveal the criteria being used by the farmers in making their choices. At the end of the selection, we sat with farmers to discuss about the trial, to have their impression about the germplasm, and to decide which entries to select for the next year. In all locations, farmers decided to use only the score given at maturity for final selection and to keep the entries that received the top scores (5 or 4) by the majority of the group. One barley breeder scored the trials at maturity.

The following traits were measured: plant height (ph) in cm; spike length (sl) in cm; number of spikes per m^2 (ssm); biomass (by) in kg/ha; grain yield (gy) in kg/ha.
The data were analyzed by fitting different models of the residual maximum likelihood method (REML) using the ASREML software. The environmentally standardized data were used to analyze genotype x environment interactions using clustering and ordination procedures (using the software GEBEI). Eventually, a similarity analysis was used to compare the score given in different locations by the individual farmers and the breeder, and the final selection in the eight locations. These analyses were done using the program NTSYS-PC version 2.02 (Numerical Taxonomy System, Applied Biostatistics, N.Y.).

Plant height, spike length, number of spikes per m^2, grain yield, and biomass of the 53 entries are shown in Table 2.57 together with the values of the local check.

Yields varied widely both between and within locations. The average yield of grain varied from about 200 kg/ha in West Barrani (WB) to more than 1000 kg/ha at El Magroun (El-N). The highest yielding entries out-yielded the local check by two to three folds. Similarly, the average total biomass yield varied from about 700 kg/ha at El Hebella to nearly 4000 kg/ha at El Magroun. The highest yielding entries out-yielded the local check by between 30% to three times. In three locations (El Karamis, El Shaweir, and El Dawaia), farmers were able to identify the top yielding line.

Genotypes x Environment (GE) interactions explained about 76% and 82% of the variance of environmentally standardized data for grain yield and biomass, respectively. The biplot of grain yield (Fig. 2.29) shows that El Hebella (E1) and El Magroun (E6) are closely correlated, like El Shawaier (E3), El Dawaia(E5), El Karamis (E2), East barrani (E7), and West Barrani (E8). By contrast, Ghout Rabbah (E4) is dissimilar from all other locations.

Table 2.57. Mean and range of biomass yield (by in kg/ha), grain yield (gy in kg/ha), plant height (ph in cm), spike length (sl in cm), number of spikes per m^2 (ssm) of 53 barley entries and one local check tested in eight farmers fields in the northwest coast of Egypt.

Location		by	gy	ph	sl	ssm
El Hebella	Mean	734.5	335.2	39.5	14.4	49.4
	Max	1485.9	669.2	50.1	16.5	73.0
	Min	201.9	86.1	32.1	12.4	28.4
	Loc check	791.0	264.0	35.2	13.9	45.4
El Karamis	Mean	928.5	294.5	35.3	12.3	32.8
	Max	1605.9	734.1	46.1	14.8	65.0
	Min	485.8	45.7	26.5	9.6	18.1
	Loc check	778.4	289.0	34.0	11.6	23.7
El Shawaier	Mean	1412.5	436.4	22.4	9.6	52.7
	Max	2029.7	1079.3	40.0	15.1	69.7
	Min	891.2	0	10.1	6.3	35.0
	Loc check	1515.0	484.9	17.9	8.4	53.6
Ghout Rabbah	Mean	1574.2	370.0	29.2	12.4	43.5
	Max	3228.0	1124.9	45.7	15.8	57.4
	Min	707.8	12.3	17.6	9.1	28.2
	Loc check	1281.0	263.2	24.4	11.7	47.2
El Dawaia	Mean	1883.1	919.1	52.1	15.8	46.6
	Max	2851.0	1439.5	71.0	21.3	65.4
	Min	1043.5	484.4	38.9	11.4	27.9
	Loc check	1750.0	962.3	45.9	14.7	47.2
El Magroun	Mean	4068.4	1063.2	62.9	14.7	56.8
	Max	6933.0	1752.7	78.4	19.1	81.3
	Min	2193.0	566.0	44.5	10.3	27.9
	Loc check	3341.0	1146.0	53.4	13.2	69.6
East Barrani	Mean	1084.2	304.2	37.7	12.3	54.1
	Max	2011.9	659.2	52.0	14.7	74.4
	Min	306.0	20.4	18.2	9.9	31.2
	Loc check	859.9	232.3	33.4	12.6	49.6
West Barrani	Mean	1326.9	249.2	33.1	14.0	48.8
	Max	2343.0	632.3	48.4	20.6	72.3
	Min	716.5	0	22.7	10.6	32.7
	Loc check	1016.0	230.3	33.6	14.2	49.1

The correlation coefficients (Table 2.58) show that in general, farmers gave a higher score to tall plants. The farmers' scores were positively and significantly correlated with biomass and grain yield, with the exception of biomass in El Hebella and West Barrani and biomass and grain yield in El Magroun. There was occasionally a significant correlation between the farmer's score and spike length and number of spikes per m^2.

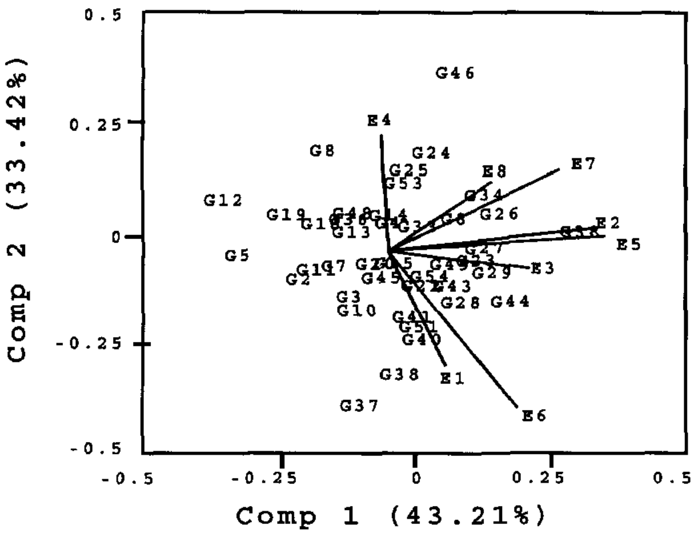

Fig. 2.29. Biplot of the first two components of grain yield of 54 barley entries grown in 8 farmers' fields in the northwest coast of Egypt (E1=El Hebella, E2=El Karamis, E3=El Shawaier, E4=Ghout Rabbah, E5=El Dawaia, E6=El Magroun, E7=East Barrani, E8=West Barrani).

The similarity analysis of the selections of the breeder and the farmers shows that each location tends to cluster separately, with each cluster including both the farmers' and the breeder's selections. In general, there was a clear effect of the location, with higher similarity between the score of farmers and the breeder in the same site, with the exception of Barrani (Figures 2.30 to 2.33).

Table 2.58. Correlation coefficients[a] between the visual score given by the group of farmers and biomass yield (by), grain yield (gy), plant height (ph), spike length (sl), and number of spikes per m^2 (ssm) of 53 barley entries and one local check grown in 8 farmers' fields in the northwest coast of Egypt.

Location	by	gy	ph	sl	ssm
El Hebella	-0.094	0.323	0.488	0.303	0.110
El Karamis	0.424	0.359	0.346	0.222	0.088
El Shawaier	0.512	0.485	-0.007	0.057	-0.233
Ghout Rabbah	0.349	0.327	0.293	0.520	-0.111
El Magroun	0.138	0.057	0.443	0.228	0.203
East Barrani	0.465	0.519	0.446	0.039	0.162
West Barrani	0.235	0.372	-0.208	-0.384	-0.053

[a] underlined (significant at P< 0.05), bold (significant at P< 0.01)

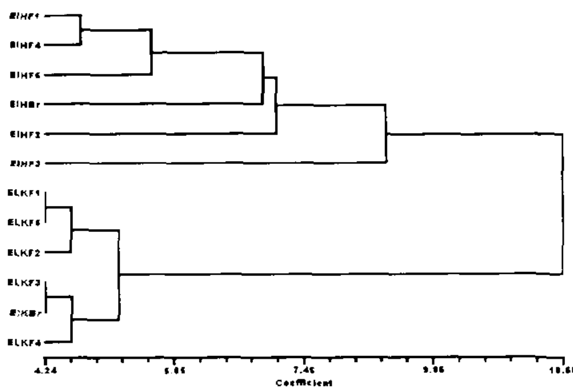

Fig. 2.30. Dendrogram based on cluster analysis of the selection score of five farmers (F1 to F5) and one breeder (Br) in 54 entries (53 new entries and 1 local check) at El Hebella (ElH) and El Karamis (ElK).

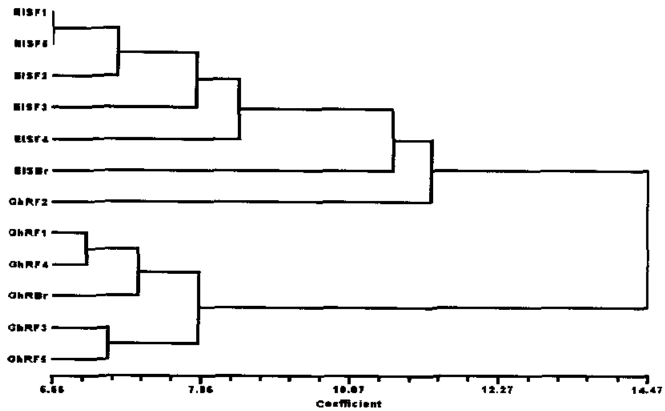

Fig. 2.31. Dendrogram based on cluster analysis of the selection score of five farmers (F1 to F5) and one breeder (Br) in 54 entries (53 new entries and 1 local check) at El Shawaier (ElS) and Ghout Rabbah (GhR).

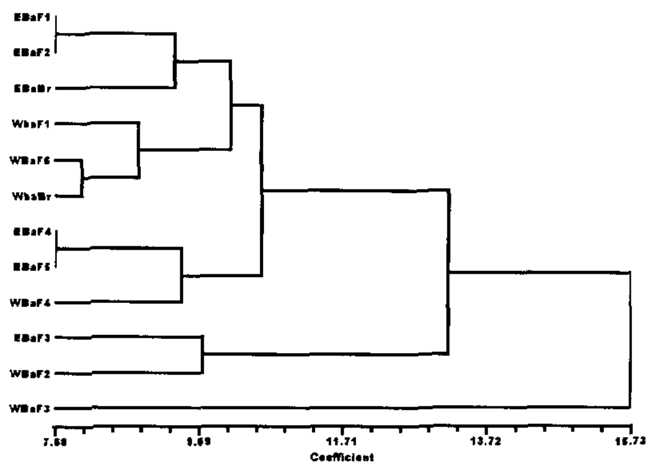

Fig. 2.32. Dendrogram based on cluster analysis of the selection score of five farmers (F1 to F5) and one breeder (Br) in 54 entries (53 new entries and 1 local check) at El Dawaia (ElD) and El Magroun (ElM).

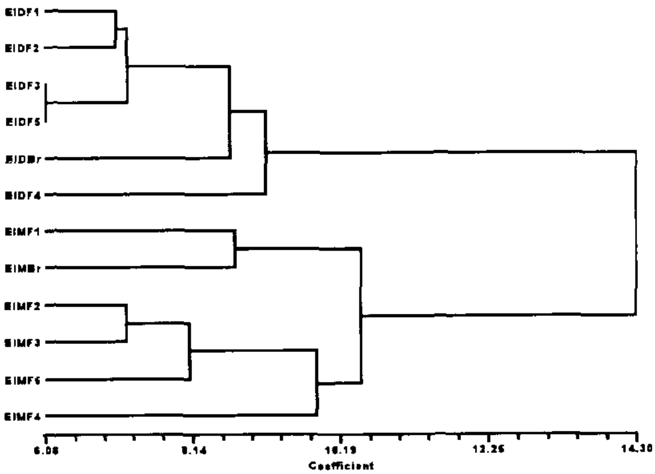

Fig. 2.33. Dendrogram based on cluster analysis of the selection score of five farmers (F1 to F5) and one breeder (Br) in 54 entries (53 new entries and 1 local check) at East Barrani (EBa) and West Barrani (WBa).

Farmers selected a total of 28 entries; of those, one was selected in five locations, two in four locations, one in three locations, and three in two locations. The list of entries selected in each location is reported in Table 2.59, while Table 2.60 shows the most frequently selected entries.

The entries selected by the participants have been planted in three fields in each of the sites where selection was done in 2000, for a total of 24 trials.

The participatory barley trials generated a large interest between farmers, researchers, and extensionists. All farmers except one did not find the number of entries too large, and they proposed to go up to one hundred plots in the next season. Some farmers (not hosting the trial this year), were interested in having a trial in their fields next season. Farmers were also interested in getting the seed of the selected entries to be increased in their farms.

Farmers were very enthusiastic about the trials and showed interest in continuing the work. They also gave suggestions on how to improve the layout of the trials.

Table 2.59. Entries selected in 1999-2000 season by farmers in eight locations in the North West Coast of Egypt.

SubRegional Support Cente	Location	Number of entries selected	Entry selected
Ras El-Hekma	El-Karamis	3	28-33-48
	El-Hebella	3	32-34-35
Marsa Matrouh	El-Shawaier	8	28-31-32-34-41-43-48-54
	Ghout Rabbah	3	28-29-32
El-Negeila	El-Magroun	11	9-33-37-42-45-52-55-56-57-58-59
	El-Dawaia	7	6-15-17-18-26-32-33
Sidi Barrani	East Barrani	3	18-28-33
	West Barrani	5	6-7-8-32-48

Table 2.60. Entries selected in more than one location.

Entry	Name	Number of locations
32	Aw Black/Aths//Arar/3/9Cr.279-07/Roho/4/Aths	5
33	Acc # 116131 - Coll # 89013-44/Giza 123	4
28	Aw Black/Aths//Arar/3/9Cr.279-07/Roho/4/DD-14/Rhn-03	4
48	Alanda/5/Aths/4/Pro/TolI//Cer*2/TolI/3/5106/6/Aths	3
34	IPA7/4/Aw Black/Aths//Arar/3/9Cr.279-07/Roho	2
18	JLB70-01/5/DeirAlla106//DL70/Pyo/3/RM1508/4/Arizona5908/Aths//Avt/Attiki/3/Ager	2
6	Aw Black/Aths//Arar/3/9Cr.279-07/Roho/6/Alanda-01/5/CI 01021/4/CM67/U.Sask.1800//Pro/CM67/3/DL70	2

The selection conducted by farmers has resulted in different lines selected in different sites, showing that farmer participation in selection is very powerful in maintaining genetic diversity. The positive and significant correlations between the farmers' scores and grain yield indicate the ability of farmers to identify the high-yielding entries under stress conditions.

The World Bank end-of-year review mission visited one of the sites while farmers were doing selection, and the review members were very positive about the participatory barley improvement activities.

Output 3: Breeding Methodology for Stress Environments Developed

3.1. Introduction

3.2. Molecular Breeding

3.2.1. Molecular Characterization of the Scald Disease Fungus *Rhynchosporium secalis* using RAPD and AFLP

R. secalis (Oud.) Davis, is the causal organism of the scald disease of barley. *R. secalis* occurs throughout the world and can cause economically significant yield loss. Part of the difficulty in the control of scald is that populations of *R. secalis* are extremely variable. For example, more than 350 pathogenic races (pathotypes) have been identified in California alone on the basis of their ability to infect 14 barley cultivars with different resistance genes.

In this study, the RAPD and AFLP genetic markers were used to assess genetic heterogeneity between and among *R. secalis* populations from nine different locations with the sample focus on Syria. The two DNA fingerprinting techniques are believed to provide a multilocus comparison by scanning the DNA of isolates at loci arbitrarily selected across the genome. Unique RAPD and AFLP bands can be considered to represent genetic markers that are generated (or lost) by mutations during the evolution of diverse genomes from a common ancestor. The aim of the study is to use these anonymous markers for the molecular characterization of different *R. secalis* pathotypes from a collection of *R. secalis* isolates from Syria, Lebanon, Tunisia, Turkey, Azerbaijan, and Kyrgystan.

Barley leaves infected with *R. secalis* were sampled from 10 different locations as indicated in Table 2.61. All leaf samples were collected near the end of the growing seasons 1999, 2000. In order to identify polymorphic primers, seventy different primers provided by Operon Technologies (Alameda, California) were screened with a small subset of isolates. A number of 9 primers revealed polymorphisms and a total of 67 isolates were subjected to the RAPD analysis with these primers.

Comparison of profiles for each primer was performed on the basis of the presence or absence of RAPD and AFLP fragments presumed to be of the same length. Fragments of the same molecular weight were scored as identical. The presence or absence of amplified DNA bands was determined for each isolate and scored as 1 or 0, respectively. A dissimilarity index was calculated between isolates across bands for all primers using the Nei 72 coefficient (Nei 1972). Using the RAPD and AFLP dataset a genetic distance matrix was generated, which was then used to construct a dendrogram with the UPGMA unweighted pair-group method for the arithmetic average.

A total of 70 random primers were evaluated for their ability to prime PCR amplification in a preliminary survey using genomic DNA from one individual of each of the 10 different locations. Of all the tested primers, nine polymorphic primers A10, A20, C13, G19, N2, N3, P5, R7, W5 which generated easily detectable, well resolved bands, were chosen for the analysis of the whole sample set. Of the 37 polymorphic bands generated by the nine primers, the number of scorable RAPD fragments generated per primer was very small and varied between 1 and 6. The number of polymorphic bands ranged from 1 to 3.

Variation within the populations was only detected in the case of Turkey (Bt 12), Tunisia (Bt 4), and Azerbajian (Bt 18). Genetic differences were only observed for isolates from different leaves while no variation was found for isolates from the same lesion. Most bands allowed differentiation between populations from different localities. Thus, the majority of bands were diagnostic markers, and these occurred in all representatives from one location.

To further test the extent of genetic variation in the genome of *R. secalis*, AFLP profiles were generated with 3 primer combinations; M62-P11, M42-P11 and M82-P20. These primer combinations generated fingerprints with 5 to 13 polymorphic fragments.

No variation was detected within the same location and polymorphisms were only found between populations. Thus, all polymorphic fragments were diagnostic for the respective population.

The genetic distances based on the polymorphic AFLP bands and calculated according to the Nei 72 coefficient are shown in Table 2.61.

Table 2.61. Nei 72 genetic distances between populations of the different locations based on the AFLP data.

	1	2	3	5	6	7	8	9	10
	Elbab Syria	ElBab (batajik) Syria	Tel Hadya	Eskesihir Turkey	Aktep-Turkey	Tunisia Rihane	Tunisia-Kef	Bishkek-Kyrgysta	Gobustan-Azerbajian
	Bt 13	Bt 15	Bt 11	Bt 12	Bt 17	Bt 4	Bt5	Bt9	Bt18
1	0								
2	0.052	0							
3	0.37	0.31	0						
4	0.97	0.73	0.72	0					
5	1.2	0.85	0.77	0.17	0	0			
6	0.81	0.86	0.66	0.97	1.2	0			
7	0.62	0.52	0.47	0.9	1.0	0.4	0		
8	0.81	0.86	0.66	2.07	2.07	1.1	1.03	0	
9	0.5	0.42	0.51	0.72	0.77	0.8	0.19	1.3	0

The UPGMA cluster analysis shows that populations from Syria, Elbab and Tel Hadya group together, as do the two populations from Turkey. The population from Gobustan (Azerbajian) is more similar to Kef (Tunisia) than the two populations from Tunisia to each other. The *R. secalis* population from Bishek, Kyrgystan forms the basal group in the phenogram.

The present molecular characterization of *R. secalis* populations revealed a low level of genetic differentiation, while virtually no variation was detected within sampling sites. This result is surprising, as former pathogenicity assays on *R. secalis* showed a high degree of phenotypic variation.

In the present study, *R. secalis* isolates exhibited low levels of genetic diversity as revealed by RAPD and AFLP analysis, although the fungus is one of the most variable with respect to race phenotype, with over 350 races identified worldwide. However, the extent of the overall genetic differences was assessed by comparing the background genotype of isolates at loci arbitrarily selected across the genome. The race phenotype of plant pathogenic fungi is controlled by relatively few loci. Consequently, phenotypic variation may give no indication of the extent of other genetic differences between different populations.

Past studies on the pathogenicity of *R. secalis* isolates revealed greater diversity for virulence than the genetic markers showed in the present study. However, future pathogenicity assays on the same sample set will show whether phenograms based on virulence differences will group the isolates similarly to phenograms based on RAPD and AFLP markers. Genetic analyses and pathogenicity assay data will show whether the phenotypic characteristics of *R. secalis* correlate with RAPD and AFLP cluster analysis, and hence imply a relationship between virulence and RAPD and AFLP groupings.

3.2.2. Localization of Molecular Markers for Scald (*Rynchosporium secalis*) Resistance in Barley.

The genetic mapping of the Tadmor/sel160 population revealed a major resistance locus for *Rynchosporium secalis* on chromosome 4H. The aim of this study was to develop a high-resolution linkage map of the resistance locus. AFLP analysis was carried out as described in the AFLP plant-mapping kit (PE Applied Biosystems). For selective amplification fluorescent-labeled EcoRI and MseI primers with three additional nucleotides were employed. Multifluorophore fragment analysis was carried out on an ABI prism ™ 377 DNA Sequencer. Semi-automated AFLP fragment analysis was performed with GeneScan™ analysis software version 2.0.2 and Genotyper™ analysis software version 2.0 (PE Applied Biosystems).

High-resolution mapping was based upon the segregating data of the F7 population using the bulk-segregant approach.

O9 and N20 RAPD markers on chromosome 4H flanked the *Rynchosporium secalis* resistance present in the population. Pools of 10 homozygous resistant and 10 homozygous susceptible plants were used in the bulked segregant analysis to discover and localize tightly linked molecular markers. AFLP analysis was performed on bulked DNA samples of resistant and susceptible plants using EcoRI and MseI adaptors and a set of primers corresponding to the EcoRI and MseI adaptors. 78 combinations were analyzed in total. Approximately 7800 loci were inspected for polymorphism. The genetic distances between the R gene and the flanking AFLP markers were calculated with JoinMap version 2.0 software using the Kosambi mapping function. Eight AFLP markers revealed polymorphism between the parents and bulked DNA, three of them were linked to the scald resistance gene. Two of the AFLP markers were clustered in the same locus with the interval distance 0.5 cM, and the third one was linked with the scald locus by 0.4 cM.

Two objectives are followed with the present study. First, closely linked markers are identified that will be tested for MAS in the breeding program. Second, the study could lead to the isolation of this gene via map-based cloning.

3.2.3. Genetic map of the Doubled haploid Lines of the Cross WI2291 x Tadmor

In order to verify linkages between molecular markers and agronomic traits established in a single seed descent (SSD) derived barley population (Tadmor/WI2291), a doubled haploid population of the cross Tadmor and WI2291 was subjected to molecular marker analysis. Seventy-one doubled haploid lines (DH) were developed from the cross Tadmor/WI2291 by anther-/microspore culture. Different types of molecular markers RFLP, RAPD, STMS, AFLP were used for the analysis as well as the traits seed color and powdery mildew resistance. The map derived from linkage data of DH progeny comprises 104 loci, which are identified by 149 markers. 11 linkage groups were assigned to the 7 chromosomes. The map of chromosomes 5(1H), 3(3H), 4(4H), 1(7H) consists of more than one linkage subgroups that have not yet shown linkage with one another. 13 markers were not linked to any one of the linkage groups, and 33 markers were unassigned. The total map covers 930.9 cM, with an average and a maximum distance between adjacent loci of 8.95 and 27.8 cM, respectively. The numbers of markers mapped differed greatly among the chromosomes. Most of the molecular loci were mapped to chromosomes 1H and 4H and the map size was 182 cM. Twenty-three loci (22.1% of the total numbers of loci) were mapped to chromosome 1H, 14 loci (13.5%) to 2H, 18 loci (17.3%) to 3H, 31 loci (29.8%) were mapped to 4H, 6 loci (5.8%) to 5H, 3 loci (2.9%) to 6H, and 9 loci (8.6%) to 7H.

3.2.4. Genetic Mapping of the Cross Arta/Harmal

247 molecular markers (73 SSR, 174 AFLP) were used to map the 94 RIL populations from the cross (Arta/Harmal). JoinMap 2.0 software was employed for map construction. Segregating ratio was tested using chi-square test at p=0.05, and p=0.01 respectively. Out of 247 molecular markers, 14 distorted markers were excluded from the linkage mapping. Markers were grouped using LOD thresholds at 6. Then the linkage groups were assigned to the 7 chromosomes. The provisional linkage map constructed for the cross (Arta/Harmal) included 173 molecular markers covering 610 cM on seven chromosomes (28, 1H; 44, 2H; 14, 3H; 9, 4H; 26, 5H; 25, 6H; 27, 7H, see Fig. 34). More detailed analysis need to be done to verify markers within linkage groups. More unlinked markers (mainly AFLPs) need to be assigned to linkage groups. For linkage group 3H, but particularly for linkage group 4H, more microsatellite markers need to be added.

The two parents and 88 RILs of 4 populations (360 entries) were evaluated for field performance during 1998/99 (season 1) and 1999/00 (season 2) at ICARDA's research stations located near Tel Hadya, (36 °01' N; 37°20'E, elevation 300 m asl) and near Breda (35 °56' N; 37°10'E, elevation 354 m asl), in Syria. In the second year the material has also been tested in four locations in Jordan. The experimental design was an alpha-lattice with two replications and independent randomizations in each location. QTL analysis will be performed using the Best Linear Unbiased Estimates of the entry means obtained with the most suitable REML model.

3.2.5. Genetic Map of the Cross Arta x *H. spontaneum* to Tag Plant Height under Drought Stress and Brittle Rachis (of *H. spontaneum*)

A population of 494 F_7 RILs derived by single seed descent from the cross Arta/*H. spontaneum* 41-1 was developed at ICARDA. Arta, a pure line selected from the Syrian white-seeded landrace Arabi Abiad, is well adapted to Syrian conditions, high-yielding, but becomes very short under dry conditions. *H. spontaneum* 41-1, a pure line selected for its adaptation to severe drought stress conditions, combines earliness with acceptable cold tolerance, and its ability to maintain plant height under drought.

The two parents and the 494 RILs were evaluated for field performance in 1997 and 1998 at ICARDA's research stations located near Tel Hadya, (36°01' N; 37°20' E, elevation 300 m asl) and near Breda (35°56' N; 37°10' E, elevation 354 m asl), in Syria. The F_1 was advanced to F_6 by single seed descent and then multiplied for field-testing.

Segregation analysis was performed according to Lander et al. (1987), and JoinMap 2.0 (Stam et al, 1995) was employed for map construction. Recombination fractions were converted to centiMorgans (cM) according to the Kosambi's mapping function. The QTL analysis was performed using PLABQTL v. 1.1. This program uses a interval mapping approach by multiple regression with flanking markers. Markers to be included as co-factors in the regression to increase the power of the detection and to reduce the bias in the estimated QTL positions and effects were selected through step-wise regression by the program.

The 887 cM genome map contained 187 markers and one morphological locus (btr = brittle rachis locus). SSR markers with known location were used to anchor the linkage groups to chromosomes. Chromosomes 1H contain 2 SSR and 17 AFLPs, 2H 6 SSRs and 26 AFLPs, 3H 4 SSRs and 19 AFLPs, 4H 4 SSRs and 17 AFLPs, 5H 3 SSRs and 22 AFLPs, 6H 6 SSRs and 23 AFLPs, and 7H 5 SSRs and 34 AFLPs. For QTL mapping, closely mapped markers were deleted to allow a better interval mapping. The QTL map consisted of 128 markers, 25 SSR and 103 AFLP markers.

The brittle rachis was located on the proximal end of 3H and used as a morphological marker in the linkage map. The closest marker, AFLP marker e38m49-07 is located at a distance of 6 cM.

Biological yield and grain yield were influenced by the brittle rachis. Although a major QTL for biological yield was identified to be located on the proximal end of 3H (position

1 and 2), if the whole population was analyzed, the trait is predominately influenced by the variation associated with the brittle rachis. Therefore, if only the non-brittle lines are used for the analysis, only QTLs on 3H (position 76) and 6H (position 25) were identified. Similarly, for grain yield the analysis of the non-brittle lines only revealed QTLs on 3H (position 78-80) and 4H (position 28) explaining about 10% of the phenotypic variation respectively.

QTLs for kernel weight (measured on the non-brittle lines, were located on chromosomes 2H, 3H, 4H, 5H 6H and 7H. The QTLs with the biggest effect were located on 2H (position 8-9), and expressed in both environments (Tel Hadya and Breda); on 4H, (position 43-46) again expressed in both environments and explaining 19.5% and 26.5% of the phenotypic variation, and 6H (position 21-25), also expressed in both environments, explaining 6.5 and 12.6% of the phenotypic variation.

The major QTL for plant height was located on 3H (position 76) and expressed in Breda 97, Breda 98, Tel Hadya 97 and explaining 11.5%, 25.2%, 5.5% of the phenotypic variation. The allele of the higher plant height originates from the *H. spontaneum* parent. Additionally, a QTL was identified on 2H (Br98, position 122) explaining 10.8% of the additive genetic variation and on 5H (TH97, position 77) explaining 6.7% of the phenotypic variation. In both cases, the allele for the higher plant height originates from the *H. spontaneum* parent

QTLs for days to heading were identified on 2H, 3H, 4H, 5H and 7H. The QTL on 7H (position 50) identified only in Breda in 1997 explained 33.7% of the phenotypic variation. A QTL on 2H (position 122) explained 6.6 and 10.7% of the phenotypic variation in Br97 and TH97 respectively.

QTLs for cold damage, which was only recorded in Tel Hadya in 1997 and 1998, were identified on 5H (position 46) and 2H (position 25).

Straw was analyzed by NIRS and correlations were previously established for acid detergent fiber (r= 0.989), neutral detergent fiber (r=0.83), lignin (r=0.988), dry organic matter digestibility (r=0.974), voluntary intake (r=0.971+-1.96), and nitrogen (r=0.99+-0.036).

QTLs for lignin content were identified on 2H, 3H, 6H, and 7H. The QTL on 3H (position 3) that was expressed in Br97, Th97, explained 8% and 10.3% of the phenotypic variation. Another QTL on 2H (position 123), but only expressed in Breda97 explained 14.4% of the phenotypic variation. The allele of the higher lignin content originates from the Arta parent.

QTLs for dry organic matter digestibility were identified on 2H, 3H, 4H, 5H and 6H. However, only the QTL on 3H (position 1) expressed in Br97 and Br98 and explaining 11.1% and 10.2% of the phenotypic variation, was expressed in more than one location/year. The allele of the higher dry matter digestibility originates from the *H. spontaneum* parent. On 2H (position 126) a QTL was identified that was expressed in Breda97, and explaining 15.8% of the phenotypic variation, and a QTL (position 119) expressed in TH98 explaining 3.7% of the phenotypic genetic variation.

For neutral detergent fiber a QTL was identified on 2H and 4H in a single environment (Br97) explaining 15.4% and 6.8% of the additive genetic variation.

The objective of the cross Arta/*H.spontaneum* was to combine the high yielding ability in Syrian dryland condition of Arta with the drought tolerance, earliness with acceptable cold tolerance, and the ability to maintain plant height under drought of *H. spontaneum.* QTL analysis of this cross might additionally identify markers for brittle rachis that could be used for selection against brittle rachis in other crosses.

In the cross Arta/*H.spontaneum,* three chromosomal regions were identified that are of major importance and that deserve closer attention; location 1-3, location 76-80 on 3H, and location 113-131 on 2H. The QTLs for brittle rachis, lignin content, and dry organic matter digestibility map on location 1-3 on 3H. The QTLs for grain yield, biological yield, and plant height map on location 76-80 on 3H. The QTLs for lignin content, dry organic matter digestibility, neutral detergent fiber, voluntary intake, and nitrogen map on location 113-131 on chromosome 2H. Fine mapping of these three regions might yield more closely linked markers for MAS. Bulks of the type high x low for some of the parameters mapped to the three regions will be used to screen more AFLP and microsatellite markers. A number of RFLP markers known to be located in these regions will also be mapped. This should allow using appropriate RFLP markers to screen BAC libraries for the corresponding genomic clones. Sequence analysis of some of these genomic clones might give an insight into some of the responsible genes.

Output 4: New Methodologies Disseminated

The dissemination of new methodologies takes place through the participation to Conferences, Workshops and Meetings, through publications of various types, through visits of ICARDA scientists to various countries, and through training.

In this section, we will report on the first three activities while the latter will be reported under Output 5.

4.1. Conferences, Workshops and Meetings

Dr S. Grando attended the National Barley Traveling workshop in Egypt (April 2-7).

Dr S. Ceccarelli and Dr S. Grando attended the Annual Review and Planning Workshop of the National Seed Development Programme supported by DANIDA held in Asmara (Eritrea) on 11-13 April 2000.

In May 2000, the ICARDA Office in Tunis, in collaboration with INRAT, organized a Barley traveling workshop in Tunisia that was attended by 3 scientists from Tunisia, 3 scientists from Algeria, 3 scientists from Egypt, 1 scientist from Morocco and 3 scientists from Libya.

Dr Ceccarelli attended the Lebanon - ICARDA Coordination Meeting on 19-20 June at Tal Amara (Lebanon).

In September 2000, ICARDA, in collaboration with AGERI, SNBC, and FAO organized a Bio-safety Workshop attended by 50 scientists from Syria, Jordan, Lebanon, Morocco, Tunisia, Libya, and Algeria.

Dr V. Shevtsov attended the Iran/ICARDA Coordination Meeting in Iran and the regional Coordination Meeting in Bishkek, 18-21 September, 2000. Drs A. Petrosyan (Armenia), G. Orujev (Azerbaijan, B. Sariev (Kazakstan, Almaty), N. Kravchenko (Kazakstan, Shortandy, T. Bessonova (Kyrgyzstan), S. Oripov (Uzbekistan), R. Babajanov (Turkmenistan), B. Urov and I. Eshonov (Tajikistan) also attended the Meeting.

On 8-14 October, Dr Capettini attended the International Symposium on 'Scientific Basis for Participatory Improvement and Conservation of Crop Genetic Resources', in Oaxtepec, Mexico.

In October 2000, a group of six ICARDA scientists (Drs S. Ceccarelli, F. Capettini, M. Baum, S. Grando, V. Shevtsov, and A. Yayhaoui) attended the 8th International Barley Genetic Symposium held in Adelaide (S. Australia). ICARDA sponsored the participation of 2 scientists from Tunisia, 1 scientist from Algeria, 1 scientist from Morocco, and 1 scientist from Eritrea.

In November 2000 Dr S. Ceccarelli attended the III International Seminar "Uniting Science and Participation in Research" (November 6-9) and the PPB Small Grant Workshop (November 10-11) in Nairobi (Kenia). Both events were organized by the CGIAR Program on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation and co-sponsored by ICRAF and ILRI.

Dr S. Grando attended the North Africa Regional Coordination Meeting in Algeria where she gave a presentation on 'Integrated Gene Management'.

Dr V. Shevtsov attended the International seminar "Advanced methods in breeding and seed production ", on May 4-6, 2000 in Dushanbe, Tadjikistan, and gave a lecture on Classical methods in plant breeding.

Dr V. Shevtsov took part in organizing the In-country traveling workshop "Conducting On-farm Trials and Demonstration Plots" on May 8-11, 2000, in Jizak, Uzbekistan, and made a presentation "On-farm Trials: methodology and analysis of results".

4.2. Publications

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Benbelkacem, A., Boulif, M., Amri, A. and Ceccarelli, S., 2000. Variation in the pathogenicity of 20 Algerian Isolates of Pyrenophora graminea Ito & Kur. on nine barley (*Hordeum vulgare* L.) varieties. Phytopatologia Mediterranea, 39: 389-395.

S. Ceccarelli, O. Kafawin, S., H. Saoub, and S. Grando, H. Halila, M. Ababneh, Y. Shakatreh, and E. Bailey, 2000. Increasing the Relevance of Breeding to Small Farmers: Farmer Participation and Local Knowledge in Breeding Barley for Specific Adaptation to Dry Areas of Jordan. Proceedings of the International Symposium on PPB, Pokhara, Nepal, 1-5May 2000.

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4.3. Visits to National Programs

Dr S. Ceccarelli and Dr S. Grando visited Amman (Jordan) on February 20, 2000 were they had a meeting with representatives from the Institution participating in the new project 'From Formal to Participatory Plant Breeding: Improving Barley Production in the Rainfed Areas of Jordan' supported by IDRC. At the conclusion of the meeting, we formulated a workplan for the first year's activities, and we decided the responsibilities of scientists involved in the project as well as the responsibilities and the mode of scientific reporting.

Dr S. Ceccarelli and Dr Capettini visited Bolivia (5 - 15 February, 2000), together with Dr A. Rodriguez, to meet scientists and institutions involved in the development of two projects on participatory barley improvement in the highlands and on small ruminant production systems.

Dr S. Grando visited Eritrea from January 26 to February 5, 2000 and a) discussed and finalized the 1999 report, b) based on the results of 1999 and on breeding material available, developed a detailed list of activities to be implemented in the year 2000, including technical visits, and c) explored the possibility of off-season seed increase to accelerate the breeding program.

Dr F. Capettini spent three weeks in Aleppo to familiarize with the project activities at the headquarters.

Dr S. Ceccarelli and Dr Capettini visited Ciudad Obregon, in Mexico (5 - 15 March, 2000): to introduce Dr Capettini to the barley project activities in Mexico, to participate in the Barley Symposium organized to celebrate the retirement of Dr H. Vivar, and to discuss ICIS and international nurseries.

Dr V. Shevtsov visited the Galla-Aral Branch of Uzbeck Research, the Khorezm Region of Uzbekistan (an area heavily affected by salinity), and the Krasnodar Research Institute of Agriculture. The objectives of the visits ranged from the evaluation of the performance of nurseries after winter, to discuss the issues related to training courses, to evaluate on-farm demonstration plots of winter wheat and winter barley varieties, and to collect data on barley nurseries (a total of 5430 entries) tested for cold tolerance.

Dr S. Grando visited Egypt (May 21-25) to organize the final selection in the barley participatory trials, participate in the final selection with farmers, help to organize the harvesting and data collection of the trials, discuss and plan with MRMP staff and farmers future activities.

Dr S. Ceccarelli visited Yemen (April 15-18) to present to AREA the final report on the activities conducted by the project "Village-based participatory breeding in the terraced mountain slopes of Yemen" supported by the SWP PRGA and to develop a work plan for the activities in the year 2000.
Dr V. Shevtsov presented the accomplishments of the GP

projects in CAC countries at a Program Steering Committee Meeting for the CGIAR program, May 30-June 1, 2000 at Ashgabat and visited Turkey, Uzbekistan, Krasniy Vodopad (Kazakstan) and the headquarters for selection in the winter barley nurseries.

Dr Flavio Capettini, visited Uruguay in May to discuss possible collaborations in barley breeding.

Dr V. Shevtsov visited the Andijan Research Institute of Grain and Legumes in Uzbekistan, the Uzbeck Research Institute of Plant Industry at Galla-Aral, and the Kazakh Research Institute of Grain Production at Shortandy.

Dr S. Ceccarelli and S. Grando attended the Coordination Meeting in Jordan, where they also discussed the progresses in implementing the new participatory barley-breeding project.

Dr S. Grando visited Morocco, September 25-29, following a request by Dr A. Arifi, Director General of INRA, to assist in the evaluation of the national barley program. This review has been conducted in the framework of an evaluation process INRA has launched for its cereal research program. After examining the achievements of the barley program in the last five years, mainly varieties registered in the official catalogue, the breeding objectives and strategy, and the resources presently allocated to barley, the review came up with recommendations to allow the barley program to achieve efficiently its mission. One major recommendation, unanimously accepted, is the decentralization of the barley program to the three major targeted zones (Highlands, Arid and Semiarid, and Favorable) with the participation of farmers from the early stages of selection. The Highlands and the Arid and Semiarid Zones will be given highest priority.

Dr V. Shevstov visited the Uzbeck Research Institute of Plant Industry and the Galla-Aral Branch of Andijan Research Institute of Grain, Armenian Scientific Center on Breeding and Plant Protection, Azerbaijan Research Institute of Agriculture to evaluate ICARDA nurseries and discuss the program of the future collaboration.

Dr S. Grando visited Egypt (October 8-13) to discuss with the participating farmers and the staff of the Matrouh Resource Management Project the results of the past season and the planning of the 2000-2001 trials.

Output 5: NARS Research Capabilities Improved

5.1. Training

The project maintains active collaboration with several National programs through the decentralized breeding programs and through special projects, most of which are on participatory plant breeding or on farmer participation. These collaborations have an ongoing effect in upgrading the research capabilities of all partners. In addition to the visits of the project's staff to the National programs, National program scientists visit ICARDA's headquarters. In the year 2000, 15 scientists visited the barley project to discuss various aspects of barley improvements. The details of these visits together with those of scientists from developed countries are reported in Table 2.62.

The activity more directly targeted at improving the research capabilities of National Program is training, which takes different forms, from individual to group training conducted at the headquarters, to degree training and eventually to in-country training.

More than 30 scientists from 15 countries (Syria, Bangladesh, Palestine, Uzbekistan, Azerbeijan, Kyrgistan, Tadjikistan, Tunisia, Iran, Libya, Algeria, Egypt, Iraq, Morocco and Sudan) attended individual non-degree courses in barley improvement (Table 2.63), while three students continued their degree training (Table 2.64). Four training courses were offered in the year 2000 (Table 2.65), of which three in-country and one at ICARDA's headquarters. These course were attended by a total of 46 trainees. In addition to the training activities shown in Tables 2.63-2.65, Dr F. Capettini participated in the CIMMYT annual Wheat Improvement Training course from February 21 through August 26, 2000 at Cd Obregon and El Batan, Mexico. Sixteen trainees from 10 countries participated in the course. During September 4-29, 2000, Dr F. Capettini participated in the Advanced Wheat Improvement Course at El Batan, Mexico. Six scientists from 5 countries attended the course.

Table 2.62. Visitors to the project in the Year 2000.

Visitor Name	Country	Activity	Duration	Date
Dr M. El-Faleh	Tunisian	Visit barley project	1 week	February 25 to March 02
Mr A. Abdulghani	Jordanian	To participate in the crossing work and to evaluate the floral behavior of cultivated and wild barley grown in Tel Hadya	10 days	March 20-30
Mr A. Abdulghani	Jordan	To evaluate the floral behavior of cultivated and wild barley grown in Tel Hadya and the gene bank	15 days	April 24 to May 08
Mr I. Naji	Syria	Data analyses of the barley mixture trials	4 days	April 25-28
Ms I. Abu Al-Rub	Palestine	To discuss and visit barley activities on landraces	1 week	April 25 to May 02
Dr J. Eglinton Dr A. Barr	Australia	To visit the activities at ICARDA for the collaborative project funded by GRDC	1 week	May 06-12
Mr H. Al-Rashi Mr Y. Al-Mousa Mr A. Omar Mr B. Al-Boun Mr A. Al-Shami Ms K. Wannous	Syria	To participate in the barley group selection in Syria	3 days	May 08-10
Dr D. Soleri	USA	To discuss possible collaboration with University of California and the Barley project	8 days	June 22-29
Mr A. Lutfi	Yemen	Analyze data of PPB in Yemen and prepare 2000 report	8 days	December 03-10
Ms F.Ahmadi	Iran	Visit Biotechnology laboratory	5	November 19- April 24
Dr A. Jahoor	Germany	To discuss on going and future collaboration on barley biotech, breeding and pathology	8 days	September 21-28
Dr H. Kayyal	Syria	To coordinate the doctoral study of Mr. Haitham Sayed	2 days	October 08-09
Dr J. L. Araus	Spain	To collect information for advancing the reduction of the spectro-radiometriacal work developed last	1 week	February 18-26
Mr J. B. Ferrio Diaz	Spain	Assist to evaluate and take notes on the collaborative research on stress physiology	15 days	April 27 to May 11
Dr J. L. Araus	Spain	To discuss on-going work and future action with ICARDA scientists	5 days	October 18-22
Ms M.V.K. Shmising	Germany	Molecular characterization of barley scald fungus Rhynchosporium secalis	4 months	August 8-Nov. 30 December 01-07

Table 2.63. Individual non-degree courses in barley improvement in the Year 2000.

Topic	Number of Participants	Period	Country
Micro Satellites techniques	Mr Samir El-Khoury	January 17-Feb. 17	Syria/AEC
Visit cereal and legume breeding	Dr Mohamed Abdul Hamid	January 23-Feb. 10	Bangladesh
Doubled Haploid production in cereals	Mr Aziz Salameh	Feb. 1-March 31	Palestine
Advanced technology for virus identification	1	February 6-17	Syria
Training in cereal pathology	1	March 5-30	Uzbekistan
Training in cereal pathology	1	March 5-30	Azerbeijan
Training in cereal pathology	1	March 5-30	Kyrgistan
Training in cereal pathology	1	March 5-30	Tadjikistan
Training in cereal pathology	1	March 5-May 4	Uzbekistan
Evaluation resistance to BYDV and BBMV	Mrs Asma Najar	March 5-16	Tunisia
Cereal entomology	1	March 5-June 1	Iran/SPII
Barley disease (Scaled & Barley Stripe)	1	March 5-June 1	Iran/SPII
Barley pathology	1	April 1-30	Tunisia/ESAK
Doubled Haploid production in wheat & barley	Ms Fatma El-Qabtan	April 1-May. 31	Libya
Grain quality	Mr Faisal Al-Hleish	April 16-27	Syria
Cereal insects	1	April 16-May 15	Kyrgistan/Bishkek
Barley improvement	1	April 24-May 18	Iran/DARI
Barley improvement	1	April 24-May 18	Iran/SPII
Barley breeding	1	April 30-May 11	Algeria
Screening techniques for drought & cold tolerance in barley	1	April 30-May 11	Algeria

Cont'd. Table 2.63

Barley breeding	1	April 30-May 11	Egypt
Barley breeding	1	April 30-May 11	Iraq
Barley breeding	1	April 30-May 11	Libya
Segregating population management & handling barley at harvest time	1	April 30-May 11	Libya
Barley breeding	1		Morocco
Barley breeding	Mr. Ahmed Sahli	April 30-May 11	Tunisia
Farmer participation in barley breeding	Khalfet Brahim	April 30-May 11	Tunisia
Cereal entomology	1	May 1-31	Algeria
Breeding and management of field crops research **(Cereals)**	1	May 1-June 30	Palestine
Barley improvement PPB	2	May 7-18	Egypt/MRMP
Cereal insects	1	May 14-25	Syria
Entomology, laboratory techniques and field screening	Mr Ghazi Krida	May 14-25	Tunisia
Doubled Haploid Production in Wheat & Barley	Ms Haala Mohamed Mustafa	June 1-Sept. 30	Sudan
Tissue culture	1	Oct. 1-Nov. 30	Palestine

Table 2.64. Graduate Research Training Year 2000

Topic	Student/ Nationality	Scheduled Date	Degree	University/Country
Resource use of contrasting barley mixture in response to harsh variable Mediterranean Environment	Mr Issam Naji/ Syria	1996-2000	Ph.D.	Damascus University
Barley Biotechnology	Mr Hamad A. Salman/ UAE	1998-2000	Ph.D.	Glasgow University
Use of DNA markers in selection for disease resistance genes in barley	Mr Haitham El Sayed/ Syria	1997-2000	Ph.D.	Damascus University

Table 2.65. Training Courses in the Year 2000.

Topic	Participant	Date	Location	Countries
Sub-regional course on "Integrated Approach to Breeding Cereals for Drought Resistance"	12	March 27-Apr 7	Morocco	North Africa
Regional course on "In-vitro Biology/Transformation Technology"	10	August 27-31	AGERI, Egypt	Sudan Morocco Iraq Egypt Tunisia AP countries
Short-course on "Integrated management of cereal & Legume Pests"	10	October 8-19	ICARDA HQ	(3) AP (7) Rest of WANA

5.2. Collaboration with NARS in Latin America

The NARS and private research companies of Latin America were contacted and informed about the changes that occurred in the program in the 2000. There is the intention to continue previous collaboration and carry out closer contact in certain research areas. Countries like Uruguay and Brazil already expressed their intention to enhance collaboration in areas of common interest. Elite barley germplasm from both countries was received, tested, and crossed at Toluca and is already planted again at Ciudad Obregon. Uruguay is especially interested in having support in BYDV research, and Brazil requested support for Stripe Rust and FHB testing and research. Their intention is to collaborate with additional testing of diseases that are important in the region (spot and net blotch), and give support and exchange experience on initial malting quality testing if this objective is formally incorporated in the program. The Southern Cone of South America plants approximately 350,000 ha of malting barley per year and can be an attractive impact objective to our program.

V. ACKNOWLEDGEMENTS

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- **The International Development Research Centre (IDRC, Canada)**
- **The United States Agency for International Development (USAID)**
- **The System Wide Program on Participatory Research and Gender Analysis (SWP PRGA)**

The European Union

2. Collaborators

Several research support staff and scientists have contributed to this report. Their assistance, help and contribution is gratefully acknowledged:

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TABLE OF CONTENTS

I. PROJECT TITLE: DURUM WHEAT GERMPLASM IMPROVEMENT FOR INCREASED PRODUCTIVITY, YIELD STABILITY AND GRAIN QUALITY IN WEST ASIA AND NORTH AFRICA

II. EXECUTIVE SUMMARY

In 1999/2000 emphasized the use of landraces specific to each agro-ecological zone and development of appropriate morph-phenology for the different 3 major agro-ecological zones. In addition, the specific constraints were more targeted for each zone. For the temperate dryland, resistance to drought/ heat, Hessian fly, leaf rust, septoria tritici, and root rot were upgraded; for the continental areas: increased dryland yield and resistance to drought, heat, and cold, and yellow rust and common bunt; and for continental areas: dryland yield and resistance to cold and yellow rust and stem rust.

Introduction

More than 10 million hectares are cultivated to durum wheat annually in WANA region. Five countries, Morocco, Algeria, Tunisia; Syria, and Turkey produce more than 85% of the total production in WANA. The average grain yield per hectare is for the three countries 1.5 ton/ha. However, during the last decade the durum grain yield has increased by 35.7% particularly in North Africa compared to 17.4% for West Asia and North Africa.

The durum annual consumption per capita in WANA is high and above 200 kg. This is almost twice than in Western Europe and Northern America. The durum grain is used mainly for pasta, burghul, couscous, and durum-bread. The grain quality is important in all countries.

Compared with South Europe, the durum wheat cultivation in the WANA region is more affected by abiotic stresses, particularly drought, cold, and terminal heat. Further also the durum crop is affected heavily by biotic stresses, and particularly by the diseases leaf rust and Septoria tritici; and by the insect Stem sawfly and Hessian fly. These abiotic and biotic stresses have in this region strong negative effect on durum grain yield and production.

The major traits considered to be essential by farmers are higher grain yield, drought tolerance, diseases and insects resistance, and grain quality.

In 1999/2000 season, severe drought has cut durum production in all WANA region, and higher import were made to satisfy local demand for durum grain consumption by most countries, except Syria.

III. PROJECT ACHIEVEMENTS

Output 1: Adapted Genotypes with High and Stable Yield, Resistant to Abiotic and Biotic Stresses, and with Improved Grain Quality Produced.

1.1. Breeding

In 2000 season, more than 15 international nurseries and genetic stocks targeted to three major agro-ecological environments: Continental, temperate, and high altitude areas. *Special durum germplasm for these 3 environments* requiring different morpho-phenology was developed, and lines/populations carrying tolerance to drought, heat and; high yield potential; resistance to diseases and insects; and good grain quality were distributed to cooperating breeders, pathologists, entomologists, virologists in the region. In 1999/2000 season around 800 advanced lines and 10 000 segregating populations were tested for appropriate morpho-phenology, yield, stability, and resistance to biotic and biotic stresses. The trials and nurseries were grown across in contrasting environments representing hot spots for the different constraints. Targeted nurseries and trials were also grown in different environments in the WANA region, in collaboration with NARS. Grain quality analysis was conducted for yield trials and candidate for yield test.

1.2. Breeding for Insects Resistance

Wheat stem saw fly (WSSF) is an important insect pest in WANA, with an average infestation rate of about 20%. Damage of this insect is caused by larval feeding in side the stems. Additional damage result after larvae cut the stem at the base of the plant before aestivation and hibernation, which cause lodging. A total of 192 lines were evaluated for resistance to this pest in the field at two locations (Tel Hadya and Hauran region). Forty-eight (48) lines were selected with a low number of stem cut of <1. These promising lines will be retested in 2001 for confirmation. The confirmed sources of resistance will be studied for mechanisms of resistance. The hope will be to identify resistant lines to WSSF with hollow or semi hollow stems.

The Sunn pest (*Eurygaster integriceps Put.*) is a very damaging insect pest of wheat in some 15 million ha in West and Central Asia. The present control strategy for this pest has been only on chemical control. ICARDA in collaboration with its partners NARS's and ARI's are developing IPM options to replace the present insecticide-based strategy. Host plant resistance is one of the IPM options we are investigating for possible use against Sunn pest.

Following some field observation in 1999, it was noticed that the spikes of the durum wheat variety Sebah was less damaged by Sunn pest feeding than other varieties grown in the same area. The variety Sebah and two others, Cham1 and Sebou were evaluated for resistance to Sunn pest under artificial infestation using big mesh cages (9m x 6m x 3m). The artificial infestation was done using six adults/m^2 when Sunn pest adults started migrating to wheat fields from the overwintering sites. Four criteria were used for evaluation, % spike damage, % shoot damage, and % reduction of kernel weight and gluten strength (SDS).

The results showed that Sebah did have the lowest spike damage (8.3%) than the other two varieties. But this variety had a highest percent of shoot damage (18%) and a comparable percent reduction of kernel weight (19%) to the other varieties. However, the most important finding is the quality analysis, the SDS. Even though the spike had only minor damage of 8%, the gluten strength was severely affected; the SDS was 10 and that of the uninfested one was 42. The gluten strength of the three varieties was similarly affected (Table 1). These results show that quality parameters are the most important criteria needed in evaluating durum wheat for resistance to Sunn pest. To look for resistance to Sunn pest, a durum wheat collection will be evaluated under artificial infestation in the field using the same technique next season.

Table 1. Evaluation of three durum wheat varieties for resistance to Sunn pest under artificial infestation, Tel Hadya, 2000.

Variety	% spike damage	% shoot damage	% reduction of kernel weight	SDS	
				infested	uninfested
Sebah	8.3	18	19	10	42
Sebou	12.3	9	21.4	9	44
Cham 1	15.7	13	17.5	10	51

1.3. Breeding for BYDV Resistance

1.3.1. Screening Durum Wheat Breeding Lines for their Reaction to Barley Yellow Dwarf Virus (BYDV)

Durum wheat breeding lines are evaluated for their reaction to BYDV at three stages. During the first year, the breeding lines are evaluated in 30-cm short rows, which permits the evaluation of large number of entries. During the second year, the entries that showed during the 1st year tolerance to infection based on symptoms produced, are planted in 1 m rows and the lines are evaluated on the basis of diseases index, biomass, grain weight and height. During the third year, only good performing lines form the second year are planted in 4x1m plots, which permit the evaluation of grain yield loss due to BYDV infection by comparing infected plots to the healthy ones. From previous experience in cereal crops, yield loss evaluation was found to be the most reliable factor in determining resistance to BYDV infection.

The preliminary evaluation of 516 durum wheat lines from different nurseries indicated that some of these lines (based on the severity of BYDV symptoms produced) can be defined as tolerant to infection. The best lines are summarized in Table 2. These lines will be evaluated further during the next growing season.

Table 2. Preliminary evaluation of durum genotypes in short 30 cm rows for their reaction to BYDV infection after artificial inoculation with the virus during the 1999/2000 growing season.

Nursery [a]	Number of Lines tested	Lines with tolerance to infection [b]
DKL-2000	180	3, 19, 22, 23, 25, 26, 37, 54, 56, 69, 79, 85, 89, 91, 95, 101, 107, 112, 116, 126, 129, 131, 132, 135, 143, 177
G1DW	144	2, 8, 14, 17, 24, 31, 33, 40, 48, 61, 63, 71, 72, 76, 78, 80, 88, 93, 104, 105, 107, 112, 113, 119
G2DW	168	2, 10, 16, 34, 40, 48, 76, 88, 90, 103,107, 118, 122, 123, 127, 136, 156, 160, 161
G4DW	24	19, 22

[a] DKL= Durum Wheat Key Location Disease Nursery. G1DW, G2DW, G4DW= Durum Mapping population. [b] Evaluation was based on the severity of symptoms produced.

The re-evaluation of selected durum wheat lines from the previous season indicated that some lines such as DKL-99-93, DKL-99-146 and WSSF-DW-3 were tolerant to BYDV infection on the basis of disease index, grain and biomass weight (Table 3). These lines will be further evaluated during the next growing season.

Table 3. Performance of durum lines selected on the basis of previous seasons preliminary evaluation in short rows, planted during the 1999-2000 growing season in 1 m rows, and showed tolerance to BYDV infection after artificial inoculation with the virus.

Entry	D.I. (0-9)	Biom. (g/m)	GWT (g/m)	Plant H. (cm)
DKL-99-2	7	158	58.9	55
DKL-99-53	6	163	56.7	60
DKL-99-62	5	172	58	60
DKL-99-63	5	209	68.2	56
DKL-99-76	6	180	70.3	55
DKL-99-96	5	184	61.8	65
DKL-99-101	5	190	64.4	60
DKL-99-103	5	148	51.4	55
DKL-99-114	7	176	61.3	60
DKL-99-118	6	191	74.1	60
DKL-99-119	5	172	65	65
DKL-99-121	6	155	63.1	60
DKL-99-125	6	214	81.5	60
DKL-99-130	7	169	67.2	65
DKL-99-135	6	159	58	75
DKL-99-137	6	208	80.7	65
DKL-99-146	5	189	71.6	70
DKL-99-147	5	179	68.3	70
DKL-99-163	6	237	89.8	65
DKL-99-166	6	170	68.9	65
DKL-99-175	7	149	63.2	70
DKL-99-179	6.5	154	59.2	55
WSSF-DW99-2	6	147	64.4	55
WSSF-DW99-3	6	173	69.4	50
WSSF-DW99-4	6	131	58	50
WSSF-DW99-5	7	147	66.8	65
WSSF-DW99-7	6.5	145	66.2	60
WSSF-DW99-10	6	154	63.6	70
WSSF-DW996 (susc. check)	8	43	19.9	55

DKL= Durum Key Location Disease Nursery, WSSF-DW= Wheat Stem Sawfly nursery durum lines.

The evaluation of best performing lines of different nurseries from previous season in small plots of 4x1 m, which permits yield loss determination in response to BYDV infection, showed that many lines were tolerant to infection and summarized in Table 4.

Table 4. Best performing durum lines from previous seasons during the 1999-2000 season, evaluated for reaction to BYDV infection after artificial inoculation, on the basis of symptoms disease index, biomass and grain weight, and grain yield loss (%).

Entry	DI	Biom. (g)	GWT (g)	PH (cm)	Yield loss %
DCC-97-16	6	304	123.3	62.5	32.3
DCC-97-68	6	259	108.8	70.0	27.1
DCC-97-77	6.5	234	92.6	70.0	5.3
DKL-97-142	5	276	102.4	67.5	42.9
DKL-98-2	5	326	127.6	67.5	27.1
DKL-98-6	5.5	271	101.4	67.5	26.3
DKL-98-161	6	250	97.8	62.5	26.1
DKL-98-186	6	205	65.9	57.5	22.7
DKL-99-179	6	229	92.6	60.0	13.5
WSSF-DW-7	6	248	102.4	67.5	29.5
WANA-DW-21	6	302	112.7	70.0	10.8
WANA-DW-27	6	261	106.0	67.5	27.8
DKL-93-156	5	259	91.2	77.5	34.2
12th-IDS-227 (Res. check)	5	269	96.8	67.5	9.3
12th-IDS-74 (Susc. check)	7	162	52.7	55.0	57.7

DCC= Durum Core Collection, DKL= Durum Key Location Disease Nursery, Wanaddin Durum Observation Nursery.

1.4. Breeding for Disease Resistance

Disease resistance continues to play a major in the improvement of durum wheat production in WANA region. Improvement of resistance to root rot complex (*Fusarium culmorum, Helminthosporium sativum*, and other *Fusarium spp.*) cereal cyst nematodes (*Heterodera avenae, Heterodera latipons*), and septoria leaf blotch (Mycosphaerella *graminicola*) would contribute effectively to enhance productivity of durum wheat under dry land conditions. Resistance to leaf rust (*Puccinia recondita*), yellow rust (*Puccinia striiformis fsp. tritici*), and in some cases stem rust (*Puccinia graminis fsp. tritici*) would give the yield advantage to durum wheat cultivated in sub-humid regions and under irrigated conditions. It is therefore essential to continuously pursue strict screening for disease resistance of the breeding material. At ICARDA headquarters, the screening ids conducted under artificial inoculation to ensure proper identification of resistance levels in the breeding nurseries and advanced germplasm, and eventually to identify new sources of resistance to be incorporated in NARS breeding programs.

Resistance to individual disease is very important in area where single diseases prevail. Such as the case of septoria tritici in Tunisia, leaf rust in Morocco, and yellow rust in Turkey. Nonetheless in most regions of WANA where durum wheat prevails, diseases occur simultaneously during the growing season. In North Africa we seek to develop multiple disease resistance to cover resistance to septoria, leaf rust, root rots, and eventually cereal cyst nematodes. In West Asia, emphasis is on developing combined resistance to yellow rust septoria, and root rots. For the Nile Valley Region combined resistance to rusts will effectively enhance durum wheat productivity under irrigated conditions.

1.4.1. Screening for Resistance to Rusts, Septoria, and Common Bunt

A set of breeding nurseries comprising around 1300 accessions (Table 5 are screened for resistance to rusts, septoria and to common bunt diseases under artificial inoculation at Tel Hadya and Lattakia (Syria), and Terbol (Lebanon). The overall evaluation (Table 6 Fig.1) shows that has been made for yellow rust resistance where over 70% of the evaluated material showed high level of resistance, whereas the level of resistance to leaf rust and stem rust exceeded 40%. An improvement could be made for resistance to leaf rust where only 30% of the material screened showed good resistance levels. Even though only 7% of the breeding material was evaluated for resistance to common bunt, the level of resistance is very low (10%), hence major effort would be made to test more material and eventually identify more resistance sources.

Disease nurseries DST, DSR, DLR, and DYR are made up of selected breeding lines and were tested for specific disease i.e. lines in DST would have good level of resistance to septoria and would be tested by NAPS at septoria hot spots or it could be used in crossing program. The lines within each nursery were also tested for resistance to other diseases (Table 6).

Table 5 Durum wheat nurseries screened in 1999/2000 for disease resistance under artificial inoculation in Syria and Lebanon

Durum Wheat Nurseries	No of Entries	Diseases[1]	Testing sites[2]
Durum wheat Aleppo Crossing block (DACB)	140	ST CB,YR, LR, SR	Th, Lt Th
Durum wheat Key Location Disease Nursery (DKLDN)	180	ST CB,YR, LR, SR	Th, Lt Th
Durum Preliminary Disease Nursery (DPD)	270	ST CB,YR, LR, SR	Th, Lt Th
Durum Stem Rust Nursery (DSR)	30	YR, SR, LR	Th Th, Te
Durum Septoria Nursery (DST)	25	ST, CB, YR	Th, Lt
Durum Leaf Rust Nursery (DLR)	25	YR, SR LR	Th Th, Te
Durum Yellow Rust Nursery (DYR)	35	YR LR	Th Te
DOUMA	72	ST CB, YR	Th, Lt Th
Farmer Verification Trials (FFVT)	57	ST CB, YR,LR, SR	Th, Lt Th
Durum Wheat Collection (DWC)	456	ST, CB, YRSR	Th

[1] ST: septoria tritici; CB: common bunt; YR: yellow rust; LR: leaf rust; SR: stem rust.
[2] Th: Tel Hadya (Syria); Te: Terbol (Lebanon).

1.4.2. Multiple Disease Resistance in Durum Wheat Germplasm

Multiple disease resistance could be attained by step wise screening of large numbers of lines from the breeding program, testing them against different diseases and selecting those that show acceptable levels of resistance. Figure 2 shows the overall resistance levels in over 1900

Table 6. Levels of combined resistance to rusts and septoria diseases in eleven durum wheat nurseries tested in 1999/2000.

Nursery[1]	No. of Entries	DISEASES[2]				
		YR	LR	SR	ST	CB
DACB	140	111 (79)	13 (9)	71 (51)	65 (46) 23 (16)Lt	5 (3.5)
DKLDN	180	147 (82)	46 (25)	63 (35)	45 (25) 19 (10.5)Lt	6 (3.3)
DPD	270	201 (74)	78 (29)	158 (58)	100 (37) 15 (5.5)Lt	NT
DOUMA	72	65 (90)	NT	NT	20 (28) 13 (18)Lt	6 (8)
FFVT	57	39 (68)	17 (30)	17 (30)	30 (53) 2 (3.5)Lt	4 (7)
DWC	456	265 (58)	NT	147 (32)	317 (70)	69 (15)
DYR	35	33 (94) 33 (94)Lt	33 (94)Te	NT	NT	NT
DLR	25	21 (84)	15 (60) 20 (80)Te	14 (56)	NT	NT
DSR	30	27 (90)	24 (80)Te	17 (57) 21 (70)Te	NT	NT
DST	25	22 (88)	NT	NT	14 (56) 6 (24)Lt	HT
TOTAL	1290	931 (72)	226 (31)	485 (42)	591 (49)	90 (10)

[1] DACB; Durum wheat crossing block, DKNLDN: Durum wheat key location disease nursery, DPD: Durum preliminary disease nursery, FFVT: Farmer Verification Trials, DWC: Durum wheat collection, DYR: Durum yellow rust nursery, DLR: Durum leaf rust nursery. DRS: Durum stem rust nursery, DST: Durum septoria nursery

[2] YR: yellow rust, *LR: Leaf rust, SR: Stem rust, ST: Septoria, CB: common bunt; NT: Not tested, Te: Terbol, Lt:* Lactakia

durum wheat lines. The emphasis was to detect combined resistance to rust and septoria tritici. Over 25% of the accessions showed good resistance to both yellow rust and septoria. Different levels were obtained for the other combinations.

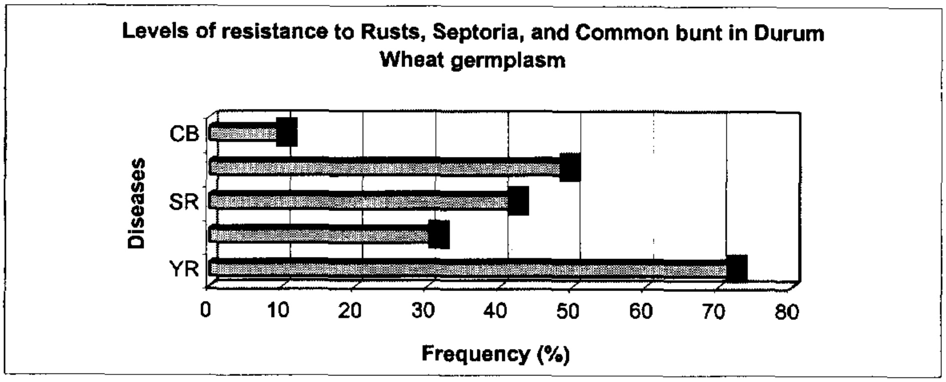

Fig. 1. Overall resistance levels in durum wheat germplasm evaluated in 1999/2000.

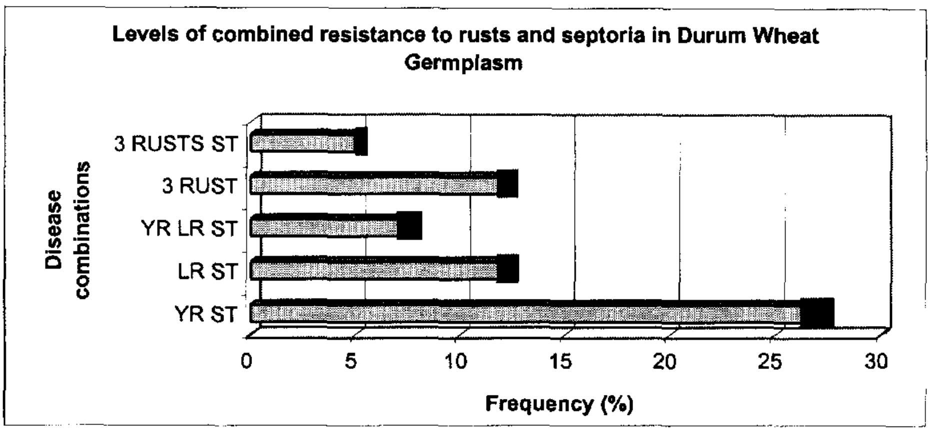

Fig. 2. Overall resistance levels to combination of rust and septoria diseases in the durum wheat germplasm

A collection of durum wheat comprising 456 lines, advanced breeding lines and new varieties that are tested "on-Farm Trials" (FFVT) were evaluated for resistance to combination of three diseases: combination of rust diseases, rusts and septoria, and rusts and common bunt. Table 7 shows the relative levels of resistance to the disease combinations in DWG and FFVT. Levels of resistance were higher for combinations of two disease compared to that for three diseases in FFVT and DWG nurseries. Figures 3 and 4 show the relative frequency distribution of the level of resistance to disease combinations tested. Durum wheat genotypes resistant to leaf, yellow, and stem rust are listed in Table 8. Durum wheat lines that combined resistance to rusts and septoria are listed in Table 9.

Table 7 Disease combinations and resistance levels in DWG and FFVT nurseries.

Disease Combination	Resistance levels (%)	
	Durum wheat collection (456 lines)	Farmer Verification Trials (57 lines)
Septoria, Yellow and Stem rust	15.0	17.5
Common bunt, Yellow and Stem rust	4.5	-
Septoria, Stem rust, Common bunt	6.0	-
Common bunt, Septoria, Yellow and stem rust	4.0	-
Septoria leaf and stem rust	-	19
Septoria, yellow and Leaf rust	-	10.5
Septoria, yellow, Leaf, and stem rust	-	10.0

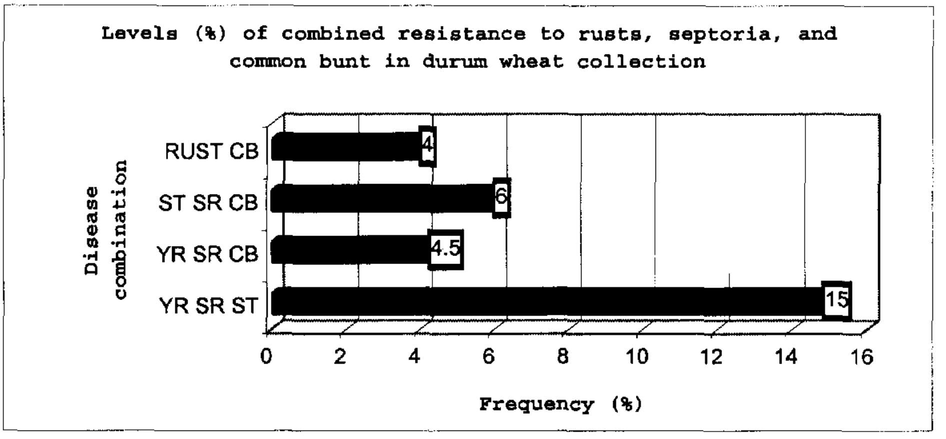

Fig. 3. Frequency distribution of combined resistance in DWC

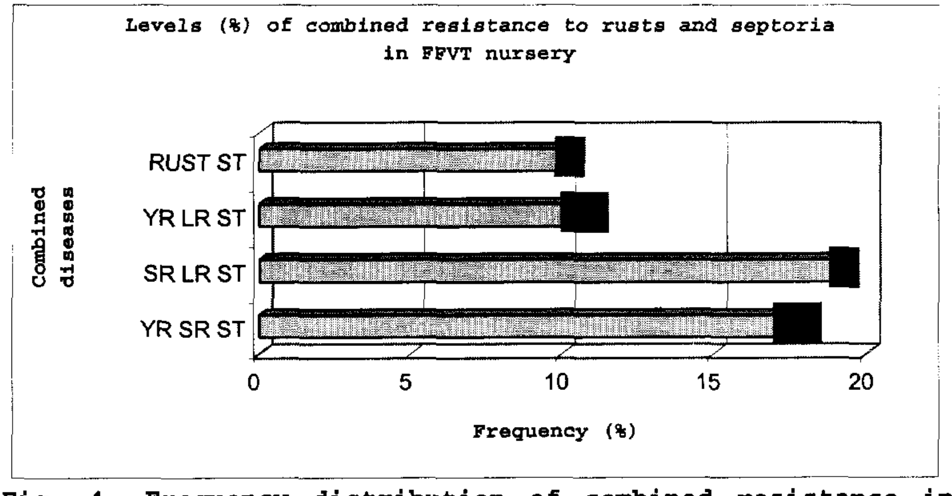

Fig. 4. Frequency distribution of combined resistance in FFVT

Table 8. Durum wheat genotypes resistant to combination of rust diseases

Selected in DACB	Pedigree	Source
Ossl-1/Gdfl	ICD92-0940-CABL-0AP-5AP-0TR	DAB00N
Msbl-1/4/Quadalete//Erp/Mal/3/Unk	ICD95-1127-T-0AP-9AP-0AP	DAB00N
Ossl1/Stj5	ICD92-0976-C-0AP-6AP-0TR-2AP-0AP	DAB00N
Mrf2//Bcr/Grol	ICD94-0875-CABL-3AP-0AP-1AP-0AP	DAB00N
1346/Lahn//Bcr/Lks 4	ICD94-0404-T-7AP-0AP-6AP-0AP	DAB00N
Msbl-1/4/Quadalete//Erp/Mal/3/Unk	ICD95-1127-T-0AP-1AP-0AP	DAB00N
TH-CB00-74	ICD94-0307-WABL-4AP-0AP-9AP-0AP	DAB00N
D68-1-93A-1A//Ruff/Fg/3/Mtl-5/4/Lahn	ICD95-0169-C-0AP-3AP-0AP	DAB00N
Lines Selected in DKLDN		
1346/Lahn//Bcr/Lks 4	ICD94-0404-T-7AP-0AP-1AP-0AP	DAT 2000
Aghrass-1	ICD92-MABL-0237-5AP-0AP-5AP-0TR	DAT 2000
Bicrederaa-1	ICD92-0175-CABL-0AP-5AP-0TR-2AP-0AP	DAT 2000
Terbol97-4	ICD92-0150-CABL-8AP-0AP-1AP-0TR-5AP-0AP	DAT 2000
Terbol97-1	ICD92-0150-CABL-7AP-0AP-5AP-0TR	DAT 2000
Mrf1/Stj2	ICD93-0746-C-TR-3AP-4AP-0AP	DAT 2000
Bcrch-1	ICD87-0459-0TR-ABL-9AP-0TR-4AP-0AP	DAT 2000
1346/Lahn//Bcr/Lks 4	ICD94-0404-T-7AP-0AP-6AP-0AP	DAT 2000
Bcr/3/Chl//Gta/Stk/4/Bcr/Lks4	ICD92-0150-CABL-11AP-0AP-8AP-0TR-4AP-0AP	DAT 2000
1346/Lahn//Bcr/Lks 4	ICD94-0404-T-7AP-0AP-4AP-0AP	DAT 2000
Villemur/3/Lahn//Gs/Stk/4/Dra2/Bcr	ICD94-0450-T-0AP-6AP-0AP	DAT 2000
Aristan/3/Lahn//Gs/Stk/4/Brch	ICD94-0422-T-4AP-0AP-2AP-0AP	DAT 2000
Aristan/3/Lahn//Gs/Stk/4/Brch	ICD94-0422-T-3AP-0AP-2AP-0AP	DAT 2000
D68-1-93A-1A//Ruff/Fg/3/Mtl-5/4/Lahn	ICD95-0169-C-0AP-2AP-0AP	DAT 2000

Table 8/cont'd…

Table 8 (continued)

Selected in DLR Name	Pedigree	Source
Ossl-1/Stj-5	ICD92-0976-CABL-0AP-6AP-0TR-2AP-0AP	DKL99
Villemur/3/Lahn//Gs/Stk/4/Dra2/Bcr	ICD94-0450-T-0AP-7AP-0AP	DKL99
Mrf2//Bcr/Gro1	ICD94-0875-CABL-3AP-0AP-1AP-0AP	DPD99
Mrf2//Bcr/Gro1	ICD94-0875-CABL-3AP-0AP-2AP-0AP	DPD99
Mrf2//Bcr/Gro1	ICD94-0875-CABL-3AP-0AP-5AP-0AP	DPD99
Heca-1/3/Gdfl/T.dic20013//Bcr	ICD95-1200-W-3AP-0AP-9AP-0AP	DPD99
D68-1-93A-1A//Ruff/Fg/3/Mtl-5/4/Lahn	ICD95-0169-C-0AP-3AP-0AP	DPD99
Gnt/4/D68-1-93A-1A//Ruff/Fg/3/Mtl-5	ICD95-1368-C-0AP-5AP-0AP	DPD99
Ossl1/Stj5	ICD92-0976-C-0AP-6AP-0TR-2AP-0AP	DACB99

Table 9. Durum wheat genotypes resistant to combination of rusts and septoria diseases.

NAME (DACB)	PEDIGREE	SOURCE
Ossl-1/Gdfl	ICD92-0940-CABL-0AP-5AP-0TR	DABOON
Msbl-1/4/Quadalete//Erp/Mal/3/Unk	ICD95-1127-T-0AP-9AP-0AP	DABOON
Ossl1/Stj5	ICD92-0976-C-0AP-6AP-0TR-2AP-0AP	DABOON
Mrf2//Bcr/Gro1	ICD94-0875-CABL-3AP-0AP-1AP-0AP	DABOON
1346/Lahn//Bcr/Lks 4	ICD94-0404-T-7AP-0AP-6AP-0AP	DABOON
1346/Lahn//Bcr/Lks 4	ICD94-0404-T-7AP-0AP-1AP-0AP	DAT 2000
Aghrass-1	ICD92-MABL-0237-5AP-0AP-5AP-0TR	DAT 2000
Bicrederaa-1	ICD92-0175-CABL-0AP-5AP-0TR-2AP-0AP	DAT 2000
Terbol97-4	ICD92-0150-CABL-8AP-0AP-1AP-0TR-5AP-0AP	DAT 2000
Terbol97-1	ICD92-0150-CABL-7AP-0AP-5AP-0TR	DAT 2000
Mrf1/Stj2	ICD93-0746-C-TR-3AP-4AP-0AP	DAT 2000
Bcrch-1	ICD87-0459-0TR-ABL-9AP-0TR-4AP-0AP	DAT 2000
1346/Lahn//Bcr/Lks 4	ICD94-0404-T-7AP-0AP-6AP-0AP	DAT 2000
Bcr/3/Ch1//Gta/Stk/4/Bcr/Lks4	ICD92-0150-CABL-11AP-0AP-8AP-0TR-4AP-0AP	DAT 2000
Lines Selected in DPD		
Gcn/4/D68-1-93A-1A//Ruff/Fg/3/Mtl-5	ICD95-1302-C-2AP-0AP-3AP-0AP	DPTOON
Quadalete//Erp/Mal/3/Unk/4/Gbch-2	ICD96-0779-C-5AP-0AP-2AP-0AP	DPTOON
Quadalete//Erp/Mal/3/Unk/4/Gbch-2	ICD96-0779-C-5AP-0AP-4AP-0AP	DPTOON
Quadalete//Erp/Mal/3/Unk/4/Gbch-2	ICD96-0779-C-5AP-0AP-6AP-0AP	DPTOON
Lgt3/4/Bcr/3/Ch1//Gta/Stk	ICD94-0918-C-12AP-0AP-4AP-0AP-1AP-0AP	DPTOON
Quadalete//Erp/Mal/3/Unk/4/Gbch-2	ICD96-0779-C-5AP-0AP-11AP-0AP	DPTOON
Msbl-1/4/Quadalete//Erp/Mal/3/Unk	ICD95-1127-T-0AP-9AP-0AP-6AP-0TR	DPTOON
Bcrch1/Kund1149	ICD97-1158-H-0TR	DPTOON
Gcn/4/D68-1-93A-1A//Ruff/Fg/3/Mtl-5	ICD95-1302-C-2AP-0AP-3AP-0AP	DPTOON
Lgt3/4/Bcr/3/Ch1//Gta/Stk	ICD94-0918-C-12AP-0AP-4AP-0AP-1AP-0AP	DPTOON
Bcrch1/Kund1149	ICD97-1158-H-0TR	DPTOON
Quadalete//Erp/Mal/3/Unk/4/Gbch-2	ICD96-0779-C-5AP-0AP-2AP-0AP	DPTOON
Quadalete//Erp/Mal/3/Unk/4/Gbch-2	ICD96-0779-C-5AP-0AP-6AP-0AP	DPTOON
Quadalete//Erp/Mal/3/Unk/4/Gbch-2	ICD96-0779-C-5AP-0AP-4AP-0AP	DPTOON
Quadalete//Erp/Mal/3/Unk/4/Gbch-2	ICD96-0779-C-5AP-0AP-11AP-0AP	DPTOON
Msbl-1/4/Quadalete//Erp/Mal/3/Unk	ICD95-1127-T-0AP-9AP-0AP-6AP-0TR	DPTOON

1.5. Breeding for Yield Stability

Durum genotypes were developed with better yield and stability; improved resistance to drought, cold, and heat than available material. These genotypes are included for further testing at representative sites with national programs. Earlier selected lines identified at NARS durum breeding programs are advanced for large scale testing or proposed for release; e.g., in Syria, Lebanon, Turkey, Tunisia, Algeria, Jordan, Egypt, and Morocco. From the research on multiple abiotic stress resistance, the drought and heat resistant genotype Massara was released in Lebanon. Table 10 shows the stability performance of the newly developed genotypes with multiple abiotic stress resistance and productivity in WANA region

Table 10. Durum genotypes that were identified with high productivity and stability.

Entry	Cross/ genotype	Relative Yield stability
104	Syrian-3	165.1
113	Mrb3/Albit-1	163.1
518	Mna-1/Rfm-7	138.2
112	Bcr/3/Ch1//Gta/Stk/4/Bcr/Lks4	137.3
504	Mrb3/Albit3	125.6
810	Zna-3	124.3
415	Mrb3/Mna-1	120.7
221	Azul-5	120.0
101	Mrb5/Mgr-4	118.1
605	Altar84/Stn//Wdz-2	117.3
110	Bcr/3/Ch1//Gta/Stk/4/Bcr/Lks4	114.1
503	Syrian-1	113.7
410	Lahn/Hcn	113.2
619	Lgt1//Khb1/Amarelo De Barba Branco	113.0
320	Ruff/Fg//Turk1/3/Gil3	112.2
413	Ainzen-1	111.2
218	Mrf1//Mrb16/Ru	110.0
102	Om rabi 5 (Check)	108.5
116	Waha (Check)	100.0

Output 2: New Breeding Methodology for Mediterranean Dry Lands further Made Efficient and Developed to Generate Better Adapted Material.

The season 1999/2000 was very dry in the whole region. Figure 5 shows that the last season was the driest during the last 15 years in Syria, as indicated by the results obtained at Breda station.

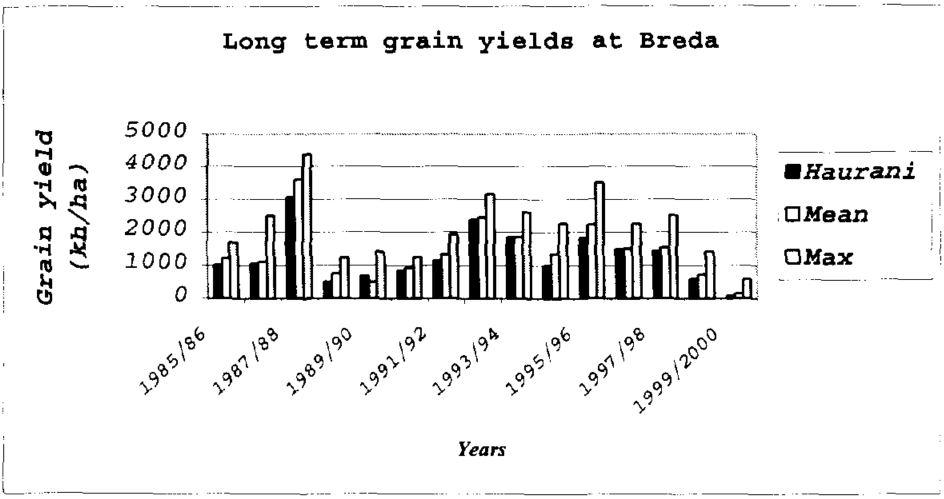

Fig. 5. Long term grain yield at Breda station: 1985/86-1999/2000.

The work on stress physiology and grain quality in durum has focused in 1999/2000 on studying the following: introgression of novel genes from wild relatives; and traits of fluorescence, relative water content, and spectral radiometry; and for grain quality the processing grain quality: gluten strength. These tests were carried out on the mapping population Jennah Khetifa/Cham1.

Major Achievements in 2000

The progress achieved for tolerance to drought and development of agricultural system is shown in Table 11. Using the introgression of genes from wild relatives and the rotation system with vetch, new durum genotypes were developed with high yields under dryland yield.

Table 11. Newly developed durum genotypes originated from crosses with wild relatives and tested under dry conditions (230 mm) and rotation with hay vetch, Tel Hadya, 1999/2000.

Entry	Cross/ genotype	Kg/ha	%
66	Bcr/Sbl5//*Ae. peregrinacylindros* 401047	5243	207
79	RSP *Aegilops*	5146	204
49	Lgt3/3/Gdfl/*T. dicoccoides*-SY 20013//Bcr	4854	192
80	Gidara-2	4854	192
90	Korifla (band 6-8)	2524	100

Examples of stress physiology traits are shown below in figure 6 for relative water content, chlorophyll inhibition (Quenching) and leaf temperature for the mapping population Jennah Khetifa/ Cham1. The two parents differ largely for several parameters of stress physiology, such as RWC and chlorophyll inhibition. These results indicate the importance of the transgressive inheritance for these parameters. However, there are cases where the two parents do not differ significantly from each other, as for leaf temperature.

In 1999/2000 studies on relationship of some traits of abiotic stress resistance with dryland grain yield were identified and mapped on two populations. The most salient results were on strong relationship between carbon isotope discrimination and grain yield. Further several other traits are also under study. However for the QTL-Mapping of Genomic Regions Controlling Carbon Isotope Discrimination and Gluten Strength in Durum are discussed below:

2.1. Drought Tolerance

Drought tolerance research usually requires a large number of testing sites and seasons to determine the genotypic resistance to a given stress. Research on drought tolerance, use of molecular markers and exploitation of the genetic variation of the triticum wild relatives to enhance resistance/ tolerance to abiotic stresses are of major interest in CIMMYT/ICARDA dryland durum breeding program. In this study grain yield, yield components, stress physiological traits were associated with some molecular markers. Several markers showed strong relationships with

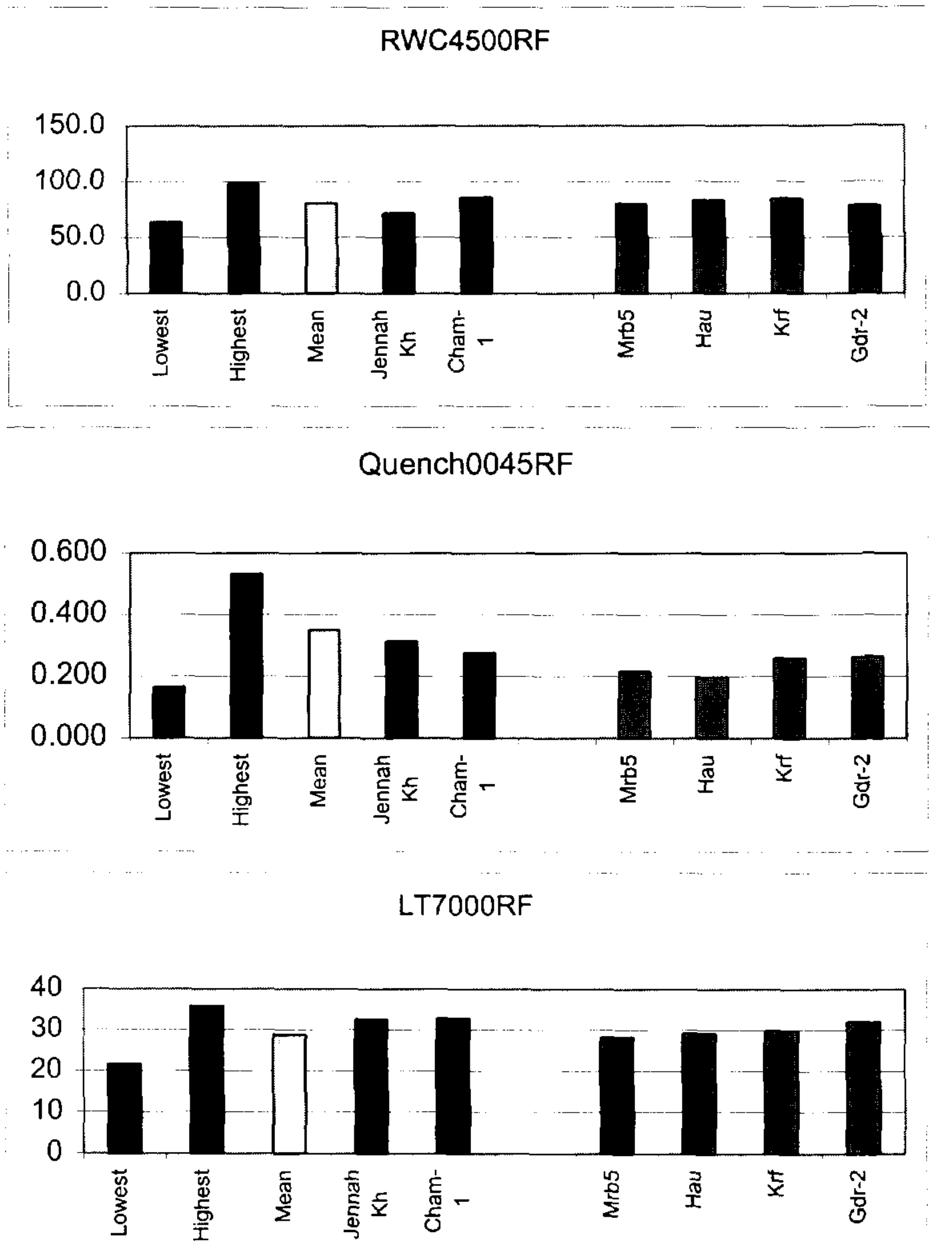

Fig. 6 Variation of Relative Water Content (RWC), Chlorophyll inhibition (Quenching), and Leaf Temperature (LT) in the mapping population Jennah Khetifa/Cham1, compared to main checks.

grain, yield components, and stress physiological traits, and are proposed as potential markers to be used in marker assisted selection, in order to improve drought tolerance of durum in the Mediterranean region.

The employed trait for dryland selection needs to be simple and rapid to use and less expensive than the field and design techniques used in the empirical selection approach.

Understanding drought tolerance basis of the morpho-physiological traits in durum, will offer the potential to select germplasm based on key-traits linked with grain yield in dryland. Morpho-physiological traits can be used as indirect selection criteria for grain yield in dryland; however, their effectiveness depends on their correlations with grain yield under drought and the degree to which each trait is genetically controlled. Usually, a dryland crop deploys a complex set of interacting to grow and survive under moisture-stress. Therefore it is of interest to know the efficiency with which water is used by a crop in the dry area (mol CO2 fixed per mol H2O transpired). The Carbon Isotopic Discrimination (CID) was found as a useful tool to screen for variation in water use efficiency (WUE). Molecular markers could serve to identify traits that are difficult to identify phenotypically. Durum drought tolerance had shown that some markers could be associated with grain yield in dryland and with stress physiological traits for drought tolerance. The markers CDO395 and BCD1661 associated with high grain yields, osmotic adjustment, canopy temperature, and chlorophyll inhibition (quenching). Further, relationships between grain yield, yield components, and carbon isotope discrimination (CID) were positively correlated (Table 12) among each other. The association of CID with grain yield was similar to that of number of fertile tillers and number of spike kernels with grain yield. Molecular markers that associated with grain yield had also shown association with CID.

Table 12. Correlation between Carbon Isotope Discrimination, Grain Yield and Yield Components

Trait	Grain yield	Fertile tillers	No. Grains per spike	100 Kernel weight
CID	0.54***	0.30***	0.42***	0.22**

, * significant at 1, and 0.1% level, respectively.

These results are promising and suggest the usefulness of molecular markers to enhance drought tolerance in durum. The progress in molecular markers analysis will allow the use of molecular markers to be integrated in studying drought tolerance; however, more fundamental studies need to be conducted and results generated, to devise sound approach for the use of molecular markers in marker assisted selection and breeding. The analysis for carbon isotope QTL shows the main genes controlling region in the Jennah Khetifa/Cham1 mapping population is located on the short arm of 4B (Fig.7). Further SSR markers are going to be added to saturate this region.

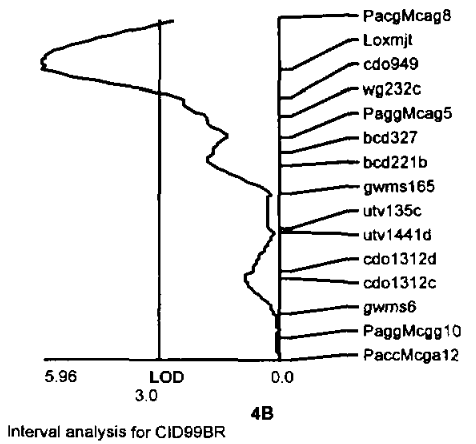

Fig. 7 Carbon isotope discrimination QTL localization in durum.

Gluten strength is the main determinant of the end-use quality in durum. The gluten strength is affected by genetic variation at genes coding for gliadins and glutenins, and by environmental factors. Hundred-and-ten recombinant inbred lines of the cross Jennah Khetifa / Cham1 were grown in 13 environments (sites and years), and analyzed for gluten strength. We used Simple Interval Mapping (SIM) and simplified form of Composite Interval Mapping (sCIM) to estimate the positions of QTL and QTL x environment interactions on a 319-marker linkage map. Five QTL were detected. Two of these are on chromosome 6B, one with a main effect across environments and one with a QTL-by-environment interaction but no significant main effect. Two QTL exhibited both main effects and QTL-by-environment interactions: one near on chromosome 1A and one on chromosome 1B. A QTL on chromosome 4B exhibited a QTL-by-environment interaction but no significant main effect. Together, these five QTL explained 35% of the total phenotypic variation for gluten strength. Our results show a clear combined effect of genes, rainfall, nitrogen fertilization, drought, and heat on gluten strength.

There have been no previous reports of genes on chromosome 4B affecting gluten strength. This chromosome is known to be very important for abiotic stress and carries the alpha-lipoxigenase gene. In our analysis, this QTL seems to interact positively with high nitrogen fertilization and highland conditions. The two QTL detected on chromosome 6B did not correspond with the Gli-B2 gene.
Preliminary studies conducted on durum core collection with 144 accessions, showed the high level polymorphism encountered in this nursery. This nursery was earlier studied with RFLP markers. Already 240 polymorphic bands were detected using 45 SSR, ranging from 1 to 11 bands per marker.

Output 3: Improvement of Breeding Methodology for Temperate, Continental, and High Elevation Areas

The segregating populations and advanced material for the temperate dryland were grown for root rot and Hessian fly screening in Marchouch and Settat stations. Selection was made for field resistance. The best material will be also re-tested in 2001. For heat tolerance screening was made for terminal stress and early heat at Tel Hadya, whereas for leaf rust and BYDV selection at Terbol.

In Marchouch the selection (%) for the segregating populations was at 20% the material targeted to continental areas, 32% to temperate areas, and 13% to highland. The selection was made mainly for Hessian fly and root rot.

As for leaf rust, it was conducted at Tel Hadya, Terbol, and Lattakia. The resistance in the segregating populations was 88% in the material targeted to continental areas, 91% in the material targeted to temperate areas, and 40% in the material targeted to highland. The resistance in the segregating population with crosses of wild relatives was 98%. Whereas the resistance percentage selection for *septoria tritici*, although it has improved compared with available germplasm in WANA and worldwide, it is still below the resistance level achieved for other diseases in CIMMYT/ICARDA durum program. The results for septoria tritici resistance screening at Lattakia was 34% for germplasm targeted to continental areas material, 43% for germplasm targeted to temperate areas, and 18% for germplasm with crosses made with wild relatives. When multiple resistances were considered, the material targeted to temperate dryland showed the highest selection (8.2%), followed by continental dryland (5.2%), and by highland (1.4%).

As for Russian wheat aphid, very few sources of resistance have been previously identified in durum. For the past 15 years, thousands of durum wheat lines and wild species were screened for resistance to Russian wheat aphid, both in the field and in the greenhouse under artificial infestation at Tel Hadya, Syria. Six durum landraces from North Africa (Aouej, Jennah Khetifa, Mahmoudi Pubescent, Medea, Frigui, and Sinlikat), two improved CIMMYT/ICARS durum cultivars (Terbol 97-1 and Altar 84/Stn/Wdz-2), and 19 accessions of wild species were resistant to Russian wheat aphid. These sources of resistance are being used in the durum wheat breeding program to develop varieties resistant to Russian wheat aphid. The 19 accessions of wild relatives including *Aegilops ovata* and *biuncialis* were identified to widen the genetic base of resistance to RWA and provide new resistance genes to use against new biotypes. Crosses with resistant *Aegilops* have showed resistance to RWA. The highest levels of resistance were found in *Aegilops biuncialis*, *Aegilops ovata* and in the durum lines originated from crosses with wild relatives: Haucan/*Aegilops Columnaris*, Haucan/*Aegilops*400020// Omtel-1/3/Omlahn-3; and RSP Carthlicum.

Further, the data also show that antibiosis and antixenosis were the two most important mechanisms in the resistant accessions. It is also interesting to note that lines like Haucan/Aeg.400020//Omtel-1/3/Omlahn-3 has high level of antibiosis, but at the same time has a moderate level of antixenosis. Combining different mechanisms should be sought in breeding for resistance to insects, as this should slow down biotype development. The inheritance study is underway to determine the number of genes and their mode of action. Below are shown the genotypes with the resistances to the different diseases:

<u>Yellow Rust</u> : Azul-3; Syrian-1; Terbol97-1; Aghrass-1; Lagonil-3

Leaf Rust: 1346/Lahn//Bcr/Lks 4; Ossl-1/Stj-5; Terbol97-3; Bicrederaa-1; Stj3//Dra2/Bcr
Stem Rust: Gidara-1; Azul-4; Ruff/Fg//Turk1/3/Stj6; Azul-3
Septoria tritici: Arthur71/Bcr//Ch5; Ruff/Fg//Turk1/3/Stj6; Bicrederaa-1; Aghrass-1; Mrf1/Stj2
Common Bunt: Mrf1//Mrb16/Ru; Altar 84; Altar84/Stn//Wdz-2; Gy/4/Quadalete//Erp/Mal/3/Unk, Quadalete//Erp/Mal/3/Unk.
Barley Yellow dawarf virus: Mrf2//Bcr/Sbl5, Aghrass-2, Msbl-1//Awl2/Bit, Aristan//Mergu/Altar84/3/Bcr/Sbl5, HFN94N 40/Blrn.

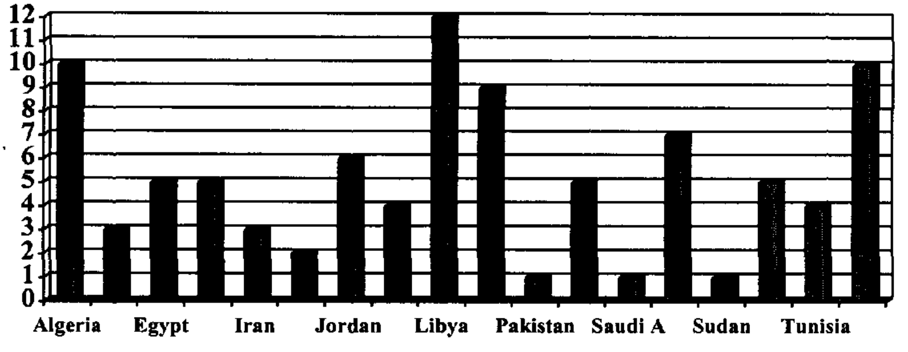

Fig. 8. Durum varieties released in WANA region

Output 4: Identified Improved Varieties for Commercial Production.

International nurseries and trials comprising promising genotypes were sent and grown by national programs for testing and selection. Several lines were selected and are tested and the ones that their performance are confirmed, are tested in on-farm trials or used in national breeding programs as parental material for own crosses, for sources of resistance to drought, cold, and heat, and different biotic stresses.

On-farm trials were conducted in Syria, Morocco, Turkey, Lebanon, Tunisia, and Algeria. Genotypes with high performance in farmers fields were identified (Fig.8). In Syria 2 cultivars of durum were released, in Lebanon one cultivar. In Morocco cultivars with Hessian fly resistance and heat tolerance are registered in the national catalogue

Output 5: Enhancement of NARS Research Capabilities

Eight trainees from Syria, Morocco, Lebanon, Ethiopia, Iran, and Algeria; and 6 MSC and PhD students.

Trainees have joined the breeding program and learned about screening and testing of durum germplasm for drought and cold tolerance. Trainees were also trained in stress physiology, grain quality, entomology, pathology, and virology.

PhD students in stress physiology (Algeria), grain quality and marker assisted selection (Morocco, Algeria, Syria, Turkey, and Lebanon), pathology, entomology, and virology have been working in the breeding program.

IV. COLLABORATORS

- The Durum Improvement Program at ICARDA is conducted in collaboration with CIMMYT.
- Resistance breeding for drought, cold, terminal stress, diseases, insects, viruses: ITGC, Algeria; ARC, Egypt; NCARTT, Jordan; INRA, Morocco; IAV-Hassan II, Morocco; ARC, Syria; University of Aleppo, Syria; University of Tichreen, Syria; INRAT, Tunisia; FCRI, Turkey; Plant Breeding Institute, Cobbity, Australia; University of Sydney, Australia; Agriculture Canada; Laval University, Canada.
- Molecular markers, genome mapping, double haploids: CIMMYT; Cornell University, USA; Paris-Sud University, France.
- Grain quality: Hassan II University, Morocco; Tuscia University, Italy; Cordoba University, Spain.
- Moisture stress: ENSA/INRA Montpelier, France; Barcelona University, Spain; IRTA-Llerida, Spain; Grenada University, Spain.
- Adoption studies: ARC, Libya; NCARTT, Jordan; ARC, Syria; LARI, Lebanon; ARC, Iraq.
- Crop modelling/GIS: Wageningen University, Netherlands.
- Morocco- INRA- Dr Abderrahman Lyamani
- Tunisia -CTC (Centre Technique des Cereales) Mr M'Hedhbi Khelifa,

- Turkey- CRFCI. Mr Lutfi cetin
- Azerbaijan- Dr M. Saidov
- INRA-Rennes, France - Dr R.Rivoal
- North Dakota State University, USA . Dr E. Elias
- University of Manitoba, Canada , Dr L. Lamari
- Oregon State University, USA. Dr D. Smiley

V. DONORS

- Ministry of Foreign Affairs, *IFAD* - *Italy*
- Ministry of Agriculture, INIA - Spain
- USAID, ATUT - USA
- CIMMYT - Mexico

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TABLE OF CONTENTS

I. PROJECT TITLE: SPRING BREAD WHEAT GERMPLASM IMPROVEMENT FOR INCREASED YIELD AND YIELD STABILITY IN WEST ASIA AND NORTH AFRICA (WANA) (PROJECT 1.3).

II. EXECUTIVE SUMMARY

The Spring Bread Wheat Improvement Program for West Asia and North Africa (WANA) Region is a joint program between the International Maize and Wheat Improvement Center (CIMMYT) and the International Center for Agricultural Research in the Dry Areas (ICARDA). The project aims at increasing productivity of spring bread wheat in WANA through the development of improved bread wheat varieties with NARS in the WANA region.

The breeding activities carried out during 2000 included hybridization, selection and multilocation evaluation of germplasm at ICARDA main stations as well as at key test sites in WANA in collaboration with NARS. High priority in program has been given to broadening the genetic base for resistance/tolerance to the main abiotic (drought, cold and heat stress) and biotic (rusts, Septoria leaf blotch, Hessian fly, Wheat Stem Sawfly, and viruses) constrains to wheat production in WANA. Improving bread-making quality has received increased attention lately.

The program has been successful in providing NARS in WANA with germplasm adapted to their conditions. During 2000, a total of 11 International Nurseries comprising 5 breeding nurseries, 2 entomology gene pool nurseries, and 4 pathology gene pools were distributed to NARS. Three varieties were released in 2000 including, Cham-8 in Syria and Tanour in Lebanon and Imam in Sudan.

In addition to germplasm the program has been successful in enhancing the research capabilities of NARS through consultation, traveling workshops, information exchange, and hands-on training on breeding and selection techniques.

III. PROJECT ACHIEVEMENTS

Output 1: Spring Bread Wheat Genotypes with High and Stable Yield, Resistant/Tolerant to Abiotic and Biotic Stresses, and Better Grain Quality.

1.1. Breeding for Biotic and Abiotic Stress Resistance

The breeding activities carried out during 2000 included hybridization, selection and multilocation evaluation of spring bread wheat (SBW) germplasm at ICARDA main stations (Tel Hadya, Breda and Terbol) as well as at key test sites in WANA in collaboration with NARS.

High priority in 2000 crossing program was given to the main abiotic and biotic constrains to wheat production in WANA. The main abiotic stresses in WANA include drought, cold and heat stress, whereas, yellow rust, leaf rust, Septoria leaf blotch, Hessian fly (HF) and Wheat Stem Sawfly (WSSF) constitute the main biotic stresses. Emphasis was made to broaden the genetic base and enhance the adaptation of spring bread wheat through the utilization of locally adapted cultivars, landraces, wheat relatives and non-conventional material including the use of synthetic bread wheat. Tables 1, 2, and 3 list locally adapted cultivars from North Africa (Morocco, Algeria and Tunisia, respectively) that were used in 2000 crossing program. In North Africa, particularly in Morocco, Hessian fly is a serious pest on wheat. Collaborative research efforts with INRA, Morocco, have resulted in identification of resistant cultivars. Table 4 lists lines representing Hessian fly resistant families identified in Morocco from CIMMYT/ICARDA Germplasm in 1999/2000 season. However, recent introgression of HF resistance from bread wheat into durum wheat has potentially enhanced the vulnerability of both bread and durum wheat. Hence in 2000 crossing program, special attention has been given to broadening the genetic base of HF resistance through the utilization of D-genome resistance sources for spring bread wheat (Table 5). On so doing resistance in A and B genome could be used in durum wheat. This approach will greatly reduce the vulnerability of both bread and durum to this devastating pest.

Table 1 Moroccan Varieties used in 1999/2000 Crossing Program

Name / Cross	Characters
ACHTAR	Adapt.
MARCHOUCH 8	Adapt. + Sept.
AMAL	Adapt. + Sept.
RAJAE	Adapt. + Sept.
SAADA = SD8036	Adapt. + HF
MASSIRA	Adapt. + HF
AGUILAL	Adapt. + HF
ARREHANE	Adapt. + HF

Adapt = Adaptation; HF= Hessian fly Resistance; Sept= Septoria Resistance

Table 2. Tunisian Varieties used in 1999/2000 Crossing Program.

Name / Cross	Characters
BT109=BOW'S'/DOUGGA74	Adapt. + Sept.
BT114=JUP/BJY//URES=KAUZ'S'	Adapt. + Sept.
BYRSA 87	Adapt. + Sept.
UTIQUE 96 = BT2715= ATTILA	Adapt. + Sept.
VAGA 92 = CHILLERO"S"	Adapt. + Sept.

Adapt = Adaptation; HF= Hessian fly Resistance; Sept= Septoria Resistance

Table 3. Algerian Varieties used in 1999/2000 Crossing Program

Name / Cross	Characters
F134.71/CROW"S"	Adaptation
TR380-16-3A-614/CHAT"S"	Adaptation
HIDHAB	Adaptation
ZIDANE 89	Adaptation
AIN ABID	Adaptation

Table 4. Lines Representing Hessian Fly Resistant Families Identified in Morocco from CIMMYT/ICARDA Germplasm in 1999/2000 season.

Nursery* Source	Entry No.	Name / Pedigree	Selection History
WON-D99/00	3	PRL/SARA//TSI/VEE#5	CM103448-39M-030M-020Y-010M-4Y-010Y-0M-0AP
RWYT-LR/SC99/00	215	NS732/HER//SUDAN #11	ICW91-0292-0TS-3AP-0TS-0AP
HFON 2000	10	TEVEE'S'//BOL'S'/PVN'S'	ICW91-0233-0TS-6AP-1AP-1AP-1AP-0AP
HFON 2000	74	TEVEE-1/SHUHA-6	ICW94-0103-0AP-6AP-6AP-0AP
HFON 2000	76	TEVEE-1/KARAWAN-2	ICW94-0104-0AP-2AP-1AP-0AP
HFON 2000	78	SHUHA-2//NS732/HER	ICW94-0233-0AP-1AP-1AP-0AP
HFON 2000	89	PREW//NS732/HER	ICW94-0239-0AP-4AP-2AP-0AP
HFON 2000	100	TRACHA-2//NS732/HER	ICW94-0262-0AP-4AP-5AP-0AP
HFON 2000	108	BOCRO-4/TEVEE-2	ICW94-0321-0AP-4AP-4AP-0AP
HFON 2000	119	TEVEE-1/SD 8036	ICW96-0119-1AP-0AP
HFON 2000	123	SD 8036/DORRAGE	ICW96-0220-1AP-0AP
HFON 2000	125	NS732/HER//KAUZ	ICW96-0228-1AP-0AP
7th SAWYT 99-00	32	ALTAR 84/Aeg Sqa (TAUS)//OPATA	CMBW98Y3514-4Y-010M-010Y-10M-1Y-0M-0SY
7th SAWYT 99-00	33	ALTAR 84/Aeg Sqa (TAUS)//OPATA	CMBW98Y3514-4Y-010M-010Y-62M-5Y-0M-0SY

WON-D= Wheat Observation Nursery Dryland; RWYT-LR/SC = Regional Wheat Yield Trial Low Rainfall/Subcontinental; HFON = Hessian Fly Observation Nursery; SAWYT = Semi-Arid Wheat Yield Trial

Table 5. Hessian Fly (HF) Resistance Sources and Chromosome Location of Resistance Genes

Resistance Source	Origin	HF Gene	Chromosome Location
JOUDA/SAADA	INRA-MOROCCO	H5	1A
JOUDA/KS811261-5	INRA-MOROCCO	H13	6D
NASMA*2/261-9	INRA-MOROCCO	H13	6D
POTAM*2/KS811261-8	INRA-MOROCCO	H13	6D
NASMA*2/14-2	INRA-MOROCCO	H22	1D
SAIS*2/14-2	INRA-MOROCCO	H22	1D
ALTAR 84/Aeg. Squarrosa (TAUS)//OPATA	CIMMYT	?	?D

A total of 260 Elite Advance spring bread wheat lines were evaluated in 13 yield trials under various abiotic (drought, cold, and heat) and biotic (common bunt, yellow, leaf and stem rusts) stresses to identify superior lines. Under low rainfall (250-350 mm) superior lines exhibited 6-20% yield increase over the best check (Table 6) and under moderate rainfall (350-450 mm) conditions yields superiority of 8-18% were observed (Table 7). Identified superior lines were assembled based on their adaptation into regional observation nurseries or regional wheat yield trials and made available to NARS. Similarly, lines that confer resistance to the major prevailing diseases and pests in the region were assembled in gene pools that constitute resistance sources to the biotic stresses in question. In 1999/2000 season a total of 11 International Nurseries comprising 6 breeding nurseries (WON-D, HTON, RWYT-LR-SC, RWYT-MR-SC, RWYT-LR-CA and RWYT-MR-CA), 2 entomology gene pool nurseries for Russian wheat aphid and Hessian fly (RWA and HF), and 4 pathology gene pools for Septoria resistance, stem, leaf and yellow rusts (WGPST, WGPSR, WGPLR, and WGPYR) were distributed to NARS (Table 8).

For NARS such nurseries constitute a good source of germplasm adapted to the prevailing stresses in the region. For example, Table 9 list lines selected from CIMMYT/ICARDA nurseries that were found to be adapted to the cold and dry environment at El-Kef, Tunisia and Table 10 list lines identified at Beja, Tunisia, adapted to the moderate rainfall conditions where Septoria leaf blotch is endemic disease. Table 11 lists the most frequently selected cultivars from the Regional Wheat Observation Nursery - Dryland (WON-D) for 1999/2000.

Table 6. Yield and Rust Reaction of Promising Dryland Lines Identified in 1999-2000

PWYT/LR	Genotype	Yield Performance		Pathology		
Entry No.	Name / Pedigree	YLD (Kg/ha)	YLD % of CHAM-6	YR	LR	SR
1707	GH'S'/ANZA//NS732/HER	3271	106	5R	1R	1R
1517	KEA'S'/3/MN72252//HD2169/BOW'S'	3593	107	10R	1R	5MR
1702	NAI 60/HN7//SX/3/SHUHA-4	3344	108	5R	70MS	5MR
1705	GH'S'/ANZA//NS732/HER	3347	108	10R	1R	20MR
1605	KEA'S'/MN72252//SHUHA-15	3817	119	10R	1R	5R
1914	SHA5//CARC/AUK/3/VEE#5//DOBUC'S'	4175	120	5MS	80S	5MR

PWYT/LR = Preliminary Wheat Yield Trial Low Rainfall, YR = Yellow Rust, LR = Leaf Rust, SR = Stem Rust

Table 7. Yield and Rust Reaction of Promising Moderate Rainfall lines, 1999-2000.

PWYT/MR -VAR	Line	Yield Performance		Rust Reaction		
No.	Name / Pedigree	YLD (Kg/ha)	YLD % of CHAM-4	YR	LR	SR
2305	SUDAN#3/KAUZ'S'	3813	117	5MS	1R	5MR
2306	SUDAN#3/KAUZ'S'	3710	114	1R	5R	1R
2318	FLORKWA-2/KAUZ'S'	3682	113	5R	1R	10R
2319	FLORKWA-2/KAUZ'S'	3786	116	1R	1R	5R
2419	CHAM-4/TEVEE-2	4005	111	5R	1R	1MR
2504	CHAM-4/TEVEE-2	4377	112	1R	5R	1MR
2513	KAUZ/ATTILA	4186	108	10R	1R	10MR
2620	NEMURA/CETTIA	5039	118	1R	30MR	1R
2709	TRACHA-2//NS732/HER	3831	113	15MS	1R	20MR

PWYT = Preliminary Wheat Yield Trial; YR=Yellow Rust; LR=Leaf Rust ; SR=Stem Rust

Table 8. List of Spring Bread Wheat Nurseries distributed to NARS in 1999/2000.

Nursery	Entries No.
Regional Wheat Observation Nursery -Dryland	120
Heat Tolerance Observation Nursery	100
Hessian Fly Observation Nursery	123
Regional Wheat Yield Trial - MR / SC	24
Regional Wheat Yield Trial - LR / SC	24
Regional Wheat Yield Trial - LR / CA	24
Yellow Rust Gene Pool	151
Leaf Rust Gene Pool	34
Stem Rust Gene Pool	28
Septoria Leaf Blotch Gene Pool	42
Russian Wheat Aphid Nursery	15

Table 9. Promising Lines selected in Kef-Tunisia in 1999/2000 Season.

Nursery	Var No.	Name/Cross
RWYT-CA99	10	Salwa'S'/Vee'S'/Myna'S'
RWYT-CA99	23	Tevee'S'/KAUZ'S'
RWYT-CA99	11	Vee'S'//Koel'S'/Vee'S'
RWYT-SA 98	5	DOVIN-1
RWYT-SA 98	11	KAYSON/GLEN 81
RWYT-SA 98	16	SERI 82/SHUHA'S'
RWYT-SA 98	18	TEVEE'S'/SHUHA'S'

RWYT = Regional Wheat Yield Trial; CA = Continental Areas; SA = Semarid Areas

Table 10. Promising Lines Selected in Beja-Tunisia in 1999/2000 Season

Nursery	Var No.	Name/Cross
RWYT-MR00	19	TUI//CMH76-252/PVN'S'
RWYT-MR00	21	SHUHA-6//TJB368.251/BUC'S'
RWYT-MR00	11	MAYON'S'//CROW'S'/VEE'S'
RWYT-MR00	4	ATTILA-3
RWCB-2000	33	MAYON'S'//BOW'S'*2/PRL'S'
RWCB-2000	35	MAYON'S'//CROW'S'/VEE'S'
RWCB-2000	36	W3918A/JUP//GHURAB'S'
RWCB-2000	69	CHIL/BUC
RWCB-2000	106	TUI//CMH76-252/PVN'S'

RWYT= Regional Wheat Yield trial; MR= Moderate Rainfall; 00=2000; RWCB = Regional Wheat Crossing Block

Table 11. Bread Wheat Observation Nursery - Dryland Areas - 1999/2000 : Selection Frequency across 11 Sites in WANA.

ENTRY	Name	Yield (kg/ha)	% Selection
10	ATTILA-7	3343	64
19	KASYON/GENARO.81//TEVEE-1	2826	64
52	BOOMA-2	2600	55
1	PRL/SARA//TEVEE'S'	2743	45
4	KAUZ*2//K134(60)/VEE	2288	45
9	PASTOR	2974	45
21	ANGI-3	3521	45
44	BANA-4	2700	45
51	BOOMA-1	2687	45
64	CHORIZO/3/NAC//F76/ALD'S'	2734	45
40	NATIONAL CHECK	2816	27
100	CHAM-4 (CHECK)	2476	18
60	CHAM-6 (CHECK)	2312	9

1.1.1. Breeding for Bread-Making Quality

In WANA, bread wheat is the principal food source for the majority of the population, which on average consumes more than 185 kg/capita/year, the highest per capita consumption in the world. The major end-use of wheat in WANA is in the form of Flat and Leavened breads. Recently, there has been increased demand for improving wheat quality in WANA. Identification of parental lines combining good quality and adaptation to the region is prerequisite to future advance in this area. Thus during 1999/2000 season selected WANA varieties as well as Preliminary and Advance Yield Trials were evaluated for grain quality characteristics, with emphasis on gluten strength, utilizing Farinograph test. Farinograph results revealed that only 10 % of the lines were of strong gluten, i.e. suitable for making leavened (French) bread and additional 20 % were of medium-strong gluten, adequate for making the traditional flat (Arabic) bread. These results highlighted the need to strengthen the efforts for improving bread-making quality. Table 12 lists some of the identified strong gluten lines of potential good bread-making quality.

It is generally known that Gluten strength is associated with certain High Molecular Weight (HMW) Glutenin subunits. Thus, in 2000, the High Molecular Weight (HMW) Glutenin composition of the Regional Wheat Crossing Block was determined utilizing Sodium Dodecyle Sulphate Polyacrylamid Gel Electrophoresis (SDS-PAGE). Figure 1 shows HMW-GS pattern of some of the entries of the crossing block. The obtained results will be of great utility in designing future crosses to improve bread-making quality.

Table 12. Quality Attributes of Good Bread-making Lines in CIMMYT/ICARDA SBW Program

NAME/PEDIGREE	GRAIN COLOR	GRAIN HARDNESS	TKW g	PROTEIN %	FAB %	FDT Min	FST Min	FMT BU
OPATA/BOW//BAU/3/OPATA/BOW	W	M	39.6	11.9	62.5	4.6	6.8	90.0
NAI60/HN7//SX/3/F134-71/CROW'S'	R	M	33.0	12.5	61.5	5.5	7.4	60.0
W3918A/JUP/3/NAI60/HN7//SX	W	S	30.9	13.4	61.0	5.0	6.5	60.0
RSK/5/…/6/BOW'S'*2/PRL'S'	W	M	34.2	12.5	61.0	4.8	6.6	50.0
SHUHA'S'//VEE'S'/SNB'S'	W	M	37.4	13.8	63.5	5.7	6.0	60.0
KAUZ'S'//BOW'S'/CM64798.7H.3H	W	M/H	36.5	12.3	63.0	5.0	7.2	50.0
SHUHA'S'//TSI/VEE'S'	W	M	34.5	14.8	64.0	5.0	7.0	55.0
RSK/5/…/6/BOW'S'*2/PRL'S'	W	M	33.4	13.1	62.0	5.6	7.3	40.0
VEE#7//MT773/EMU'S'	W	M	33.7	13.6	62.5	5.0	5.5	95.0
ACCEPTABLE QUALITY	W	M/H	>30.0	>11.0	<63.0	>3.0	>3.0	<100

W= White; R= Red. S= Soft; M= Medium; H= Hard; TKW= Thousand Kernel Weight; FAB= Flour Absorption; FDT= Farinograph Development Time; FST= Farinograph Stability Time; FMT= Farinograph Mixing Tolerance.

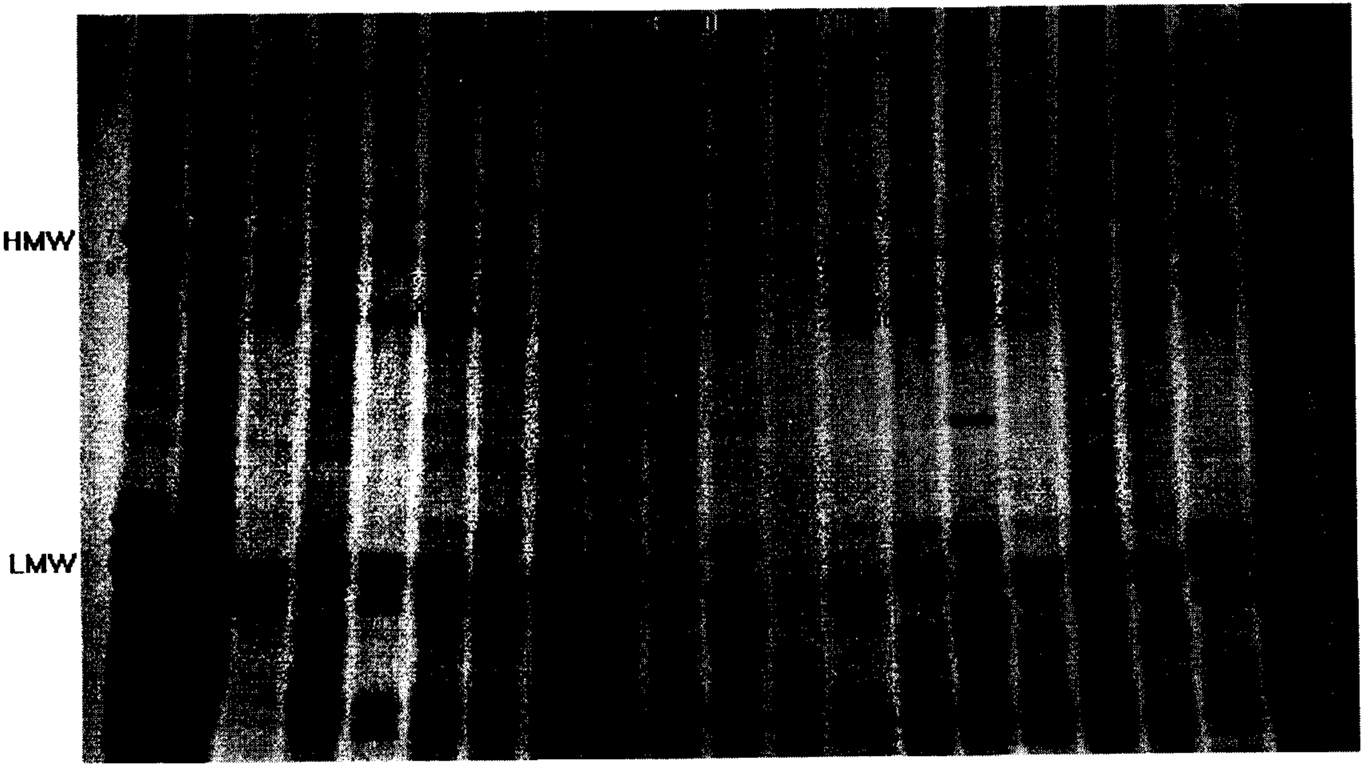

Fig. 1. Regional Wheat Crossing Block: HMW-GS

1.1.2. Cereal Screening for Disease Resistance

Resistance to rusts, common bunt, septoria leaf blotch, and common root rot diseases is of major importance in the bread wheat project. Bread wheat nurseries (Table 13) were screened for disease resistance under artificial inoculation at Tel Hadya and Lattakia (Syria), Haymana (Turkey), and at Terbol (Lebanon). The wheat Key Location Disease Nursery (WKLD) nursery was also tested by NARS in CWANA. Sources for resistance to single and multiple diseases were identified in the bread wheat germplasm.

Wheat accessions in the crossing block (WAPCB), key location disease nursery (KLDN), and the preliminary disease nurseries were tested against the three rusts, septoria leaf blotch, and common bunt diseases. Disease nurseries (WST, WSR, WLR, and WYR) were tested against the respective disease and for combined resistance to rusts and to rust and septoria. Resistance to leaf rust (*Puccinia recondita*) and septoria (*Mycosphaerella graminicola*) diseases, is of major importance in North Africa, where as yellow rust (*Puccinia striiformis fsp. tritici*) is more important in Western Asia and some locations in the Nile valley region. Resistance to stem rust (*Puccinia graminis fsp. tritici*) is till important in the Nile valley region.

Table 13. Bread wheat nurseries screened in 1999/2000 for disease resistance under artificial inoculation.

Bread Wheat Nurseries	No of Entries	Diseases[1]	Testing sites[2]
Wheat Aleppo Crossing block	242	ST. CB	Th
(WAPCB)		YR, LR, SR	Th
Wheat Key Location Disease	200	YR	Th, Hy, Te
Nursery (KLDN)		LR	Th, Te
		ST, CB	Th
Wheat Preliminary Disease	300	YR, LR, SR	Th, Te
Nursery (WPD)		ST	Th
Wheat Stem Rust Nursery (WSR)	80	SR, LR	Th, Te
Wheat Septoria Nursery (WST)	70	ST, YR	Th
Wheat Leaf Rust Nursery (WLR)	75	LR	Th
Wheat Yellow Rust Nursery	70	YR	Th, Te
(WYR)		LR	Te

[1] ST: septoria tritici; CB: common bunt; YR: yellow rust; LR: leaf rust; SR: stem rust.[2] Th: Tel hadya (Syria); Te: Terbol (Lebanon); Hy: Hymana (Turkey)

1.1.2.1. Screening for Resistance to Individual and Combination of Diseases

Levels of resistance to individual and combined diseases in WAPCB were evaluated at Tel Hadya under artificial inoculation. Resistance to common bunt was very low (0.8%) in the WAPCB. The entries that showed resistance to combinations of *Telletia foetida* and *Telletia carries* were:

- NS732/NER//PRL'S'/CHOVA'S' ICW92-0850-0AP-1AP-0L-0BR-2AP-2AP-0AP
- SHUHA-15//NAC/VEE'S' ICW92-0850-0AP-1AP-0L-0BR-2AP-2AP-0AP

These two lines also showed resistance to septoria leaf blotch, leaf and stem rust. Over 30% of the WACCB accessions showed good resistance to individual diseases (Table 14). The levels of resistance in KLDN nursery to individual diseases were relatively higher at Tel Hadya than at Terbol where leaf and stem rust were evaluated in the summer nursery.

Figure 2 shows the resistance levels to combination of two rust or rust and septoria diseases. Lines that carry resistance to leaf rust and septoria leaf blotch would be appropriate for exploitation in North Africa, particularly in Morocco where septoria is very important on bread wheat. Lines that showed resistance to leaf and yellow rust and yellow rust and septoria would be adapted to Western Asia and Nile valley region. Resistance to stem and leaf rust will be targeted to Nile Valley region. The lines with resistance to septoria and ruts could be used by NARS in CWANA.

Selected line from the KLDN will be tested for yield in WANA region. Combined resistance to leaf rust and septoria and yellow rust and septoria would of great importance to NARS in WANA. Accessions that showed good resistance levels to three rusts and to septoria are listed in Table 15.

To further build the resistance to rusts and septoria in wheat, special disease nurseries (WLR, WYR, WSR, WST) were selected from advanced breeding material. The nurseries were then tested for specific disease i.e. Wheat accessions in WLR nursery are targeted for leaf rust resistance, to be eventually used at leaf rust hot spots. The best lines from each nursery were also evaluated for

Table 14. Levels of resistance to individual disease in different wheat breeding nurseries

Nursery	Number Of Entries	Septoria	Leaf rust	Yellow rust	Stem rust	Common bunt
		Number of resistant lines, (percent resistant), site[1]				
WAPCB	242	103 (42.5)	88 (36)	103 (42.5)	76 (31)	2 (0.8)
KLDN	200	149 (74.5)	152 (76)	173 (86.5)	73 (36.5)	6 (0.3)
		44 (22)-Lt	46 (23)-Te	109 (54.5)-Hy	80 (40)-Te	
				177 (88.5)-Te		
WPD	300	226 (75.3)	220 (73.3)	208 (69.3)	222 (74)	NT
		28 (9.3)-Lt		247 (82.3)-Te		
WST	70	68 (97)	NT	63 (90)	NT	NT
		13 (18.5)-Lt				
WSR	80	18 Te		73	57	NT
WLR	75	NT	57 (76)	73 (97)	60 (80)	NT
			29 (38)-Te			
WYR	70	NT	NT	64 (91)	NT	NT
				62 (88)-Te		

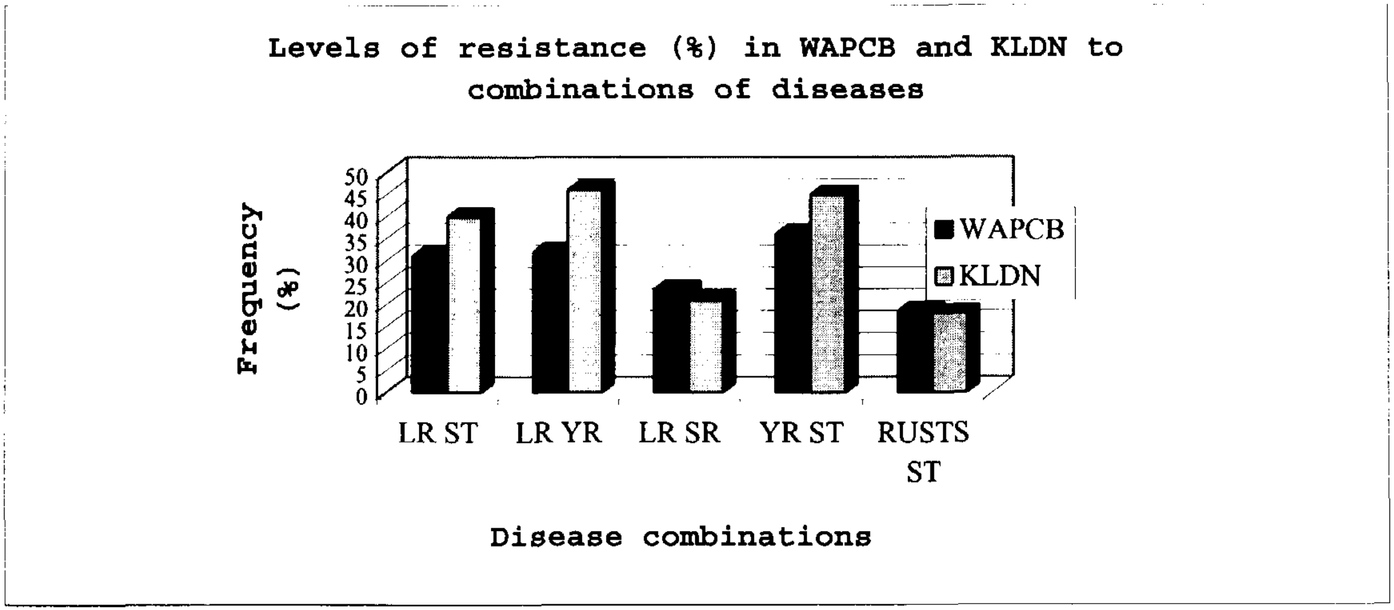

Fig. 2. Levels of resistance in WAPCB and KLDN to combination of rust and septoria diseases

Table 15. Genotypes in KLDN that showed combined resistance to septoria leaf blotch, leaf, stem, and yellow rust diseases at Tel Hadya in 1999/2000 crop season

NAME	PEDIGREE	SOURCE	SN
Dove'S'/Buc'S'//STAR'S'	ICW93-0168-4AP-0L-2AP-0L-0AP	WLR99	3
Zidane 89/3/Peg'S'//HD2206/Hork'S'	ICW93-0020-3AP-0L-4AP-0AP	WLR99	12
Tsi/Vee'S'//Bol'S'/Pvn'S'	ICW91-0233-0TS-6AP-1AP-3AP-3AP-0AP	WKL99	7
4777(2)//Fkn/Gb/3/Vee'S'/4/Buc'S'/Pvn 'S'/5/Tsi/Snb'S'	ICW92-0600-1AP-3AP-3AP-0AP	WKL99	29
Shi#4414/Crow'S'/4/Nif/3/Soty//Nad63/ Chris	ICW92-0671-4AP-0L-2AP-0L-1AP-0AP	WKL99	35
Shi#4414/Crow'S'/4/Nif/3/Soty//Nad63/ Chris	ICW92-0671-4AP-0L-3AP-0L-2AP-0AP	WKL99	37
STAR'S'/LIZ	ICW92-0751-0AP-1AP-0L-3AP-0L-1AP-0AP	WKL99	48
Dove'S'/Buc'S'//Carp	ICW93-0170-2AP-0L-2AP-0L-1AP-0AP	WKL99	75
CHORIZO/3/NAC//F76/ALD'S'	ICW93-0570-1AP-OL-7AP-0L-2AP-0AP	WKL99	91
Vee#7//Kasyon/Bow'S'	ICW93-0060-1AP-OL-1AP-0L-1AP-0AP	WKL99	133
Zidane 89/3/Peg'S'//HD2206/Hork'S'	ICW93-0020-3AP-0L-1AP-4AP-0AP	WPD99	2
Zidane 89/3/Peg'S'//HD2206/Hork'S'	ICW93-0020-3AP-0L-2AP-1AP-0AP	WPD99	3
Shuha'S'/4/Nif/3/Soty//Nad63/Chris	ICW92-0671-4AP-0L-1AP-0L-1AP-1AP-0AP	WPD99	204
Chilero//Tsi/Snb'S'	ICW92-0600-1AP-3AP-6AP-2AP-0AP	WPD99	302
Shuha'S'/4/Nif/3/Soty//Nad63/Chris	ICW92-0671-4AP-0L-3AP-0L-2AP-2AP-0AP	WPD99	359
Tevee'S'//Bol'S'/Pvn'S'	ICW91-0233-0TS-1AP-1AP-2AP-2AP-1AP-0AP	WPD99	386
GOV/AZ//MUS/3/DODO/4/BOW	CM79515-0	WACB99	17
PRINIA	CM90722-2	WACB99	21
CATBIRD	CM91045-9	WACB99	25
PGO/SERI//BAU	CM91927-O	WACB99	27
CBRD/KAUZ	CMBW90M24	WACB99	42
Chil'S'	CM66634-B	WACB99	180

resistance to rust and to septoria diseases as much as possible. Adequate levels of resistance were found in the different nurseries to single diseases (Table 14) and to disease combinations (Figure 2). Over 90% of the lines showed resistance to septoria and to yellow in the respective nurseries, where as resistance level to leaf rust is over 75% and that to stem rust exceeded 55% in the respective nurseries. The levels of combined resistance to rusts and/or rust and septoria in the disease nurseries are shown in Figure 3.

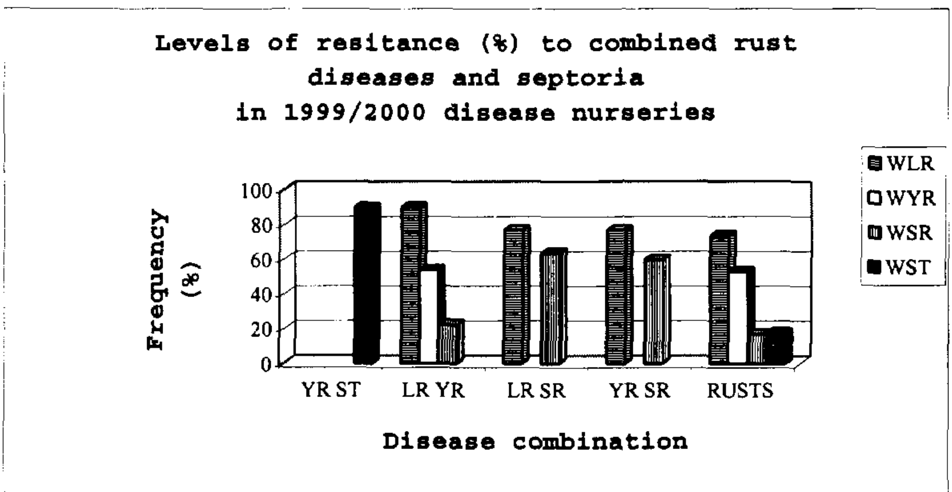

Fig. 3. Levels of resistance (%) to combined rust diseases and septoria.

1.1.3. Screening Spring Bread Wheat Breeding Lines for their Reaction to Barley Yellow Dwarf Virus (BYDV)

Spring Bread Wheat breeding lines are evaluated for their reaction to BYDV at three stages. During the first year, the breeding lines are evaluated in 30-cm short rows, which permits the evaluation of large number of entries. During the second year, the entries that showed during the 1st year tolerance to infection based on symptoms produced, are planted in 1 m rows and the lines are evaluated on the basis of diseases index, biomass, grain weight and height. During the third year, only good performing lines form the second year are planted in 4x1m plots, which permit the evaluation of grain yield loss due to BYDV infection by comparing infected plots to the healthy ones. From previous experience in cereal crops, yield loss evaluation was found to be the most reliable factor in determining resistance to BYDV infection.

1.1.3.1. Evaluation in Short Rows

The preliminary evaluation of 200 spring bread wheat lines from bread wheat key location (WKL) nurseries, and based on the severity of BYDV symptoms, the results indicated that a total of 32 lines were tolerant to infection. These lines are the following: WKL-2000 #1, 12, 14, 21, 22, 37, 39, 42, 43, 52, 57, 58, 59, 64, 65, 66, 71, 83, 85, 87, 93, 108, 109, 113, 117, 119, 121, 136, 152, 159, 182 and 185.

1.1.3.2. Evaluation in 1-m Rows

The re-evaluation of selected spring bread wheat lines, from the previous season evaluation, indicted that a total of 14 lines were tolerant to BYDV infection on the basis of disease index, biomass and grain weight. The performance of the best lines is summarized in Table 16. These lines will be further evaluated during the next growing season.

1.1.3.3. Evaluation in Small Plots

The re-evaluation of best performing lines, from the different spring bread wheat nurseries, in small plots of 4x1 m rows, showed that a total of 7 lines were tolerant to BYDV infection and exhibited lesser yield losses in comparison to "Pollet", a worldwide BYDV-resistant/tolerant variety (Table 17).

Table 16. Performance of bread wheat lines, selected on the basis of previous seasons preliminary evaluation in short rows, planted during the 1999-2000 growing season in 1 m rows, and showed tolerance to BYDV infection after artificial inoculation with the virus.

Entry	D.I. (0-9)	Biom. (g/m)	Gr.wt. (g/m)	Plant H (cm)
WKL-99-1	5	276	109.1	65
WKL-99-9	6	229	78.3	65
WKL-99-27	6	182	66.4	60
WKL-99-29	6	189	74.5	70
WKL-99-33	6	159	68.4	55
WKL-99-65	6	160	60.0	60
WKL-99-70	6	197	83.2	60
WKL-99-73	5	175	68.2	65
WKL-99-78	6	148	55.2	60
WKL-99-81	6	140	66.2	50
WKL-99-85	6	149	56.2	55
WKL-99-87	6	177	73.7	55
WKL-99-96	6	149	58.3	50
WKL-99-119	5	249	94.0	60
WKL-99-133 (susc. check)	7	65	23.4	50
RWA-BW-99-16	6	145	56.2	70
WSSF-BW-99-2	7	127	56.8	55
WSSF-BW-99-16	6	157	65.0	65

WKL= Bread Wheat Key Location Disease Nursery, RWA-Bw = Russian Wheat Aphid nursery bread wheat lines, WSSF-Bw= Wheat Stem Sawfly nursery bread wheat lines.

Table 17. Best performing bread wheat lines from previous seasons planted in 4 ×1 m plots during the 1999-2000 growing season and evaluated for their reaction to BYDV infection after artificial inoculation with the virus, on the basis of symptoms disease index, biomass and grain weight, and grain yield loss (%).

Entry	D.I.	Biom.	G.WT.	P.H.	Yield loss %
WON-FA-98-106	5	267	106.0	62.5	38.4
WON-FA-98-144	5	222	94.0	60.0	32.7
WON-SA-98-8	5	213	84.7	57.5	15.1
WON-SA-98-10	5	227	87.8	67.5	6.0
WON-SA-98-47	6	262	107.5	60.0	0.8
WON-SA-98-165	6	227	91.3	57.5	8.7
WKL-96-30	5	234	95.3	62.5	11.6
WKL-97-151	6	227	84.0	57.5	0.5
WKL-98-13	5	227	92.1	60.0	5.1
WKL-98-21	5	233	85.0	57.5	0.0
WKL-98-63	5	271	101.0	67.5	0.1
WKL-98-228	4	256	106.6	65.0	2.2
WKL-98-234	5	248	99.7	65.0	12.8
WKL-99-15	5	261	106.5	62.5	1.2
WKL-99-29	6	284	111.7	62.5	0.7
WCB-96-9	5	205	66.0	62.5	0.0
RWA-BW-99-16	5	336	138.5	85.0	13.2
Pollet (Res. check)	4	300	89.0	82.5	1.4
Katepwa (Susc. check)	7	162	54.8	57.5	40.6
12th-IBW-459 (Susc. check)	7	258	76.3	62.5	39.9

WON-FA= Wheat Observation Nursery Favorable Areas, WON-SA= Wheat Observation Nursery Semi-arid Areas, WKL= Bread Wheat Key Location Disease Nursery.

1.1.4. Cereal Entomology

1.1.4.1. Wheat Stem Sawfly

Wheat stem sawfly (WSSF) is an important insect pest of wheat in WANA, with an average infestation rate of about 20%. Damage of this insect is caused by larval feeding in side the stems. Additional damage result after larvae cut the stem at the base of the plant before aestivation and hibernation, which cause lodging.

A total of 240 spring bread lines were evaluated for resistance to this pest in the field at two locations (Tel Hadya and Hourane). An Alpha design was used with two replications and systematically repeated checks every 10 entries. Each entry was planted in 1 m long row. The material was evaluated just before harvest. The evaluation was based on the number of stem cut/entry caused by wheat stem sawfly.

35 lines were selected with a low number of stem cut of <1. Table 18 lists some of the identified promising Wheat Stem Sawfly resistant lines. These promising lines will be retested in 2001 for confirmation. The confirmed sources of resistance will be studied for mechanisms of resistance. The hope will be to identify resistant lines to WSSF with hollow or semi hollow stems.

Table 18. Promising Wheat Stem Sawfly Resistant Lines

Source Nursery	Entry No.	Name/Pedigree	% Stem Cut
AWYT2000-MR	801	MEXIPAK	0.00
AWYT2000-MR	1304	DOBUC'S'/CARP	0.00
AWYT2000-LR	509	ZIDANE 89/3/PEG'S'//HD2206/HORK'S'	0.25
AWYT2000-MR	1113	SHUHA-17/SHUHA-18	0.25
AWYT2000-LR	522	FOW-2/PORTUGAL OLD VARIETY-80	0.25
AWYT2000-MR	1303	TEVEE'S'/SHUHA'S'	0.50
AWYT2000-MR	1310	CHORIZO//GH'S'/ANZA	0.50
AWYT2000-MR	1319	CHORIZO/BOCRO-4	0.50
AWYT2000-MR	1011	KARAWAN-1/4/NIF/3/SOTY//NAD63/CHRIS	0.75
AWYT2000-MR	1020	SHUHA-7/4/NIF/3/SOTY//NAD63/CHRIS	0.75
		Susceptible Check	20.00

AWYT = Advance Wheat Yield Trial; MR = Moderate Rainfall; LR = Low Rainfall

1.1.4.2. Russian Wheat Aphid

Russian wheat aphid (RWA) is an important insect pest of wheat in many parts of North Africa and West Asia, particularly in dry areas. The aphid injects a toxin into the plant that destroys the chloroplast membrane, causing longitudinal chlorotic streaks to develop. Host plant resistance has been the most practical and economical means of controlling this pest.

A total of 240 spring bread wheat lines were screened in the field at Tel Hadya for resistance to RWA. The entries were planted in hill plots, 10 seeds/ hill using an alpha design with 2 reps. One susceptible check was used every 10 entries. When plants were at tillering stage, they were infested with about 10 aphids per plant. The evaluation was done when symptoms were clearly seen on susceptible checks using a 1-3 scale for leaf rolling and a 1-6 scale for leaf chlorosis. Promising lines, selected from the field were evaluated in the greenhouse for confirmation. The method of infestation and evaluation in the greenhouse was similar to that of the field, except that seeds were planted in regular greenhouse flats and individual plants were infested at one leaf stage with 10 aphids.

None of the lines tested showed an acceptable level of resistance for Russian wheat aphid.

Output 2: Breeding Methodology for Stress Environments Improved.

2.1. Use of Improved Experimental Designs and Field Plot Techniques

To deal with the highly variable experimental and environmental conditions in WANA, efforts were made to identify and utilize efficient experimental designs. In 1999/2000 season, incomplete design, Alpha-Lattice design, was used instead of the usually used Randomized Complete Block design (RCBD) in all yield trials conducted at Tel Hadya, Breda, and Terbol stations. Results obtained from yield trials conducted at ICARDA main research stations revealed that the use of Alpha-Lattice design exhibited relative efficiency of 120 - 206% over the usually used Randomized Complete Block Design (RCBD). Thus in all international yield trials distributed in 2000, the usually used Randomized Complete Block design (RCBD) was replaced by Alpha-Lattice design to improve the efficiency of identifying superior cultivars.

2.2. Use of Synthetic Bread Wheat to Broaden the Genetic Base of Spring Bread Wheat

Synthetic bread wheat, derived from crosses of durum wheat with *T. tauschii* (*Aegilops squoarossa*) constitute a bridge for the introgression of useful genes from *T. tauschii*, D-genome donor, into bread wheat. Resulting synthetic bread wheat has been found to be a good source of resistance to a number of abiotic (drought, cold, and heat) and biotic (Septoria leaf blotch and Hessian Fly) stresses prevalent in WANA region. Thus to broaden the genetic base of stress tolerance in spring bread wheat there has been an increase of about 20% in the number of crosses made with synthetics during 2000.

2.3. Use Biotechnological Tools: Development of Doubled Haploid in Spring Bread Wheat

Doubled haploid (DH) technique is an efficient method for fast generation advance particularly in locations where only one growing season can be made per year. In addition, the technique is useful in developing recombinant inbred lines (RIL), for gene mapping and marker assisted selection. During 2000, there has been an increase of 15% in the use of DH technique to speed up generation advance mainly for the development of mapping populations for yellow rust and Hessian fly resistance.

2.3.1 Development of Doubled Haploid Lines from Sudanese Crosses

F_1 hybrids obtained from crosses between leading Sudanese cultivars and elite breeding lines were subjected to the doubled haploid technique for the production of homozygous lines and for the testing of Sudanese wheat lines with the ICARDA anther-culture system. All of the tested hybrids responded to calli induction with a frequency ranging between 3.3 to 248% (Table 19). The obtained number of green plants ranged between 0 to 83 per cross, while albinos were 0 to 89. Hybrid No. 7 was the best hybrid resulting in 313 green plantlets. These results are encouraging and indicate that the Sudan material are responsive to the anther/microspore culture system used at ICARDA.

2.3.2. Double Haploid Production of the Cross Sids 6-10 x WYR 96-2-11

Sids lines have long spike and heat stress tolerance. However, they lack yellow rust resistance. The objective of this cross was to combine heat tolerance with yellow rust resistance of the ICARDA resistance pools.
Quantitative trait analysis with the help of molecular markers requires populations of the size of >150 recombinant inbred lines. The second objective of this cross was to test individual F1 response to the anther culture technique to obtain a sufficient number of DH lines for QTL analysis. On average 75 DH lines per F1 were produced; in total 12 F1 plants yielded 885 green plantlets. Expectations are that (after colchicine treatment and growing to maturity) 500 DH lines will be recovered from this interesting cross (Table 20).

Table 19. Response of 15 inter-varietal and breeding line F1 hybrids to anther culture under ICARDA's conditions.

Hybrid No.	No of plants	No of anthers	No of calli	Calli %	No of green plants	Green plants %	Albinos
1	11	540	142	26.3	115	21.3	5
2	18	2790	1167	41.8	132	4.7	79
3	11	1080	334	30.9	191	17.7	10
4	1	90	3	3.3	0	0	5
5	17	1800	317	17.6	108	6.0	28
6	12	1215	114	9.9	38	3.1	7
7	5	225	559	248.4	313	139.1	4
8	1	45	26	57.7	27	60	1
9	9	810	692	85.4	94	11.6	93
10	6	495	281	56.8	41	8.3	43
11	7	630	749	119	135	21.4	88
12	7	945	442	46.8	190	20.1	57
13	8	855	576	67.4	79	9.2	62
14	8	1575	723	45.9	73	4.6	64
15	8	540	891	165	378	70	182
Subtotal	128	13635	7016	51.4	1914	14.03	728

Table 20. Anther-culture response of the cross Sids 6-10 X WYR 96-2-11.

No of plants	No of anthers	No of calli	Calli %	No of green plants	Green plants %	Albinos
1	270	305	112.9	93	34.4	2
2	225	181	80.4	80	35.5	5
3	135	247	182.9	86	63.7	3
4	270	181	67	85	31.4	0
6	225	215	95.5	83	36.8	1
7	180	182	101.1	95	52.7	10
8	270	176	65.1	71	26.2	10
11	270	221	81.8	46	17	5
12	180	134	74.7	84	46.6	2
13	180	127	70.5	20	11.1	1
14	45	37	82.2	21	46.6	0
15	270	451	167	121	44.8	10
Total	2520	2457	17.5	885	35.1	1.9

2.4. Identification of Physiological and Morpho-Physiological Adaptive Traits Associated with Wheat Adaptation under Drought

Limited physiological studies were carried out in 2000 in collaboration with the Univ. of Barcelona. The studies were conducted utilizing radio-Spectrometry and Carbon Isotope Discrimination to identify physiological and morpho-physiological adaptive traits associated with wheat adaptation under drought.

Output 3:New Breeding Methodologies Disseminated.

The activities carried out to disseminate breeding methodologies include participation in workshops, conferences, research planning and coordination meetings with NARS. Thus, in 2000, the senior bread wheat breeder participated in 3 research planning and coordination meetings with the NARS of Egypt, Sudan and Syria. In addition 5 consultation and traveling workshops in the Nile Valley and Red Sea Regional Program (Egypt and Sudan), Morocco, Tunisia, and Syria were attended where breeding methodologies were discussed.

Output 4: Identified Improved Varieties for Commercial Production.

During 2000, the senior spring bread wheat breeder of the joint CIMMYT/ICARDA wheat improvement program for WANA, actively participated in planning, establishment and evaluation of on-farm validation trials in Syria and Lebanon to identify promising cultivars for commercial production. In addition, the senior spring bread wheat breeder participated in the evaluation of On-farm trials in Tunisia and Egypt.

In Lebanon on-farm trials were conducted at four zones (Southern, Central and Northern Bekaa and the Costal Zone). In Syria, on-farm trials were carried out at three agro-ecological zones: (a) Irrigated Zone. (b) Zone A (>400mm) and (c) Zone B (300-400 mm).

During 1999/2000 crop season, on-farm evaluation has resulted in the identification of a number of promising cultivars for commercial production. List of varieties released in WANA during 1999/2000 is presented in Table 21.

Table 21. New Varieties Released in WANA during 1999/2000.

Country	Variety Name	Name or Cross	Selection History
Afghanistan	AMU-99	BLOYKA	ICW84-0008-013AP-300L-0AP
Afghanistan	HEART-99	MYNA/VUL//PRL	CM97958-0M-7Y-030M-8Y-0M
Afghanistan	MAZAR-99	PASTOR	CM85295-0101TOPY-2M-0Y-0M-3Y-0M
Sudan	IMAM	ATTILA	CM85836-50Y-0M-0Y-3M-0Y
Syria	CHAM-8	MEMOF-22= KAUZ'S'	CM67458
Lebanon	TENOUR	MEMOF-22= KAUZ'S'	CM67458

Output 5: Enhanced NARS Research Capabilities.

To enhance NARS research capabilities a number of formal and informal training activities were carried out in 2000 including:

Hands-on training on breeding and selection techniques for drought, cold, and heat tolerance was conducted at Tel Hadya, ICARDA, for trainees from WANA region for duration of 1-2 months. Beneficiaries from such training were a trainee each from Eritrea, Morocco, Palestine, and Syria.

The Biotechnology Unit conducted training on Doubled Haploid production in cereals for a period of 1-4 months. Beneficiaries from such training were a trainee each from Libya, Sudan and Syria.

Two M.Sc. students, from Somalia and Sudan, carried out their thesis research in collaboration with the spring bread wheat program. The titles of their thesis's were: "Evaluation of Selected Bread Wheat Lines under Different Moisture Stress Environments" and "Genetic Improvement in Grain Yield and Accompanied Changes in Associated Traits of Bread Wheat Cultivars in the Sudan"

In addition to the above, a number of visitors to ICARDA were attended to, interacted with and assisted in selecting SBW germplasm adapted to their areas.

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VI. PUBLICATIONS

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TABLE OF CONTENTS

I. PROJECT TITLE: WINTER AND FACULTATIVE WHEAT GERMPLASM IMPROVEMENT FOR INCREASED YIELD AND YIELD STABILITY IN HIGHLANDS AND COLD WINTER AREAS OF CENTRAL AND WEST ASIA AND NORTH AFRICA (CWANA). ICARDA MTP PROJECT 1.4.

II. EXECUTIVE SUMMARY

A severe drought hit most of CWANA wheat growing areas during the 1999-2000 season, bringing about substantial reduction of wheat production and a consequent raise in wheat imports into the region. This also affected the irrigated areas of Central Asia that witnessed a reduction of available water, and where 3 irrigations, instead of five or six, were given. Scientists involved in this Project, however, did carry out their activities as planned. Although these activities link to the joint Turkey-CIMMYT-ICARDA (TCI) partnership for international winter wheat improvement, this report will focus on the specific work by ICARDA scientists, both at ICARDA Headquarters, and in Turkey, Iran and the CAC region.

About 700 crosses have been made using ICARDA greenhouse and field facilities, with the objective of widening the germplasm base necessary for development and selection of adapted materials. Segregating and more advanced populations were subjected to biotic (yellow rust, leaf rust, common bunt, BYDV, Russian wheat aphid and wheat stem sawfly) and abiotic (drought, cold) for an effective germplasm screening. Field testing and selection in all project nurseries was carried out both at research sites in Turkey (Konya, Eskisehir, and Ankara) and at Tel Hadya, Syria. About 3500 test entries were evaluated for grain quality parameters, as part of the increased emphasis to improve the bread-making characteristics of the new germplasm. Five international nurseries were assembled, jointly with TCI partners in Turkey and 40 sets were sent out to cooperators in CWANA. Additional genetic stocks for specific traits (Yellow rust trap nursery, RWA nursery) were also dispatched from ICARDA to researchers upon request. NARS selected germplasm for direct or indirect use, and returned data that are assembled and shared with

cooperators.

Available research facilities at ICARDA were used to assess the tolerance to drought and cold of 400 advanced breeding lines and cultivars. The testing techniques for these stresses have been fine-tuned for more effective screening and sharing with NARS. Drought being the major stress in the region, drought tolerance testing now forms the backbone of this project breeding activities, using Tel Hadya as a typical environment of CWANA areas prone to terminal drought (cum heat) stress.

Over 3000 test lines have been screened for diseases under controlled conditions, with an emphasis on yellow rust, common bunt and leaf rust. Results on slow-rusting has been shared with other scientists in an International Wheat Conference. ICARDA scientists also found 20 winter wheat lines with good tolerance to BYDV, and two with a high degree of tolerance, which will be intensively used in crossing. A heavy natural field-infestation by cereal cyst nematode (CCN) was exploited to screen the germplasm for this pest and to quantify the yield loss (up to 100%) that it may cause on susceptible cultivars. Over 1000 entries were subjected to Russian wheat aphid (RWA), leading to the identification of 143 tolerant F3 lines that will be advanced for further testing and study of the inheritance of RWA resistance in winter wheat. ICARDA scientists found some indication of wheat tolerance to sunnpest, and identified 6 breeding lines as highly tolerant to wheat stem sawfly. A disease survey was conducted in collaboration with TCI partners in Turkey, that pointed to the potential importance of RWA and other pests (nematodes, root rot, BYDV) in the Central Anatolian Plateau of Turkey.

ICARDA scientists worked with NARS to promote the adoption of improved cultivars. On-farm testing and demonstration, with farmer participation have been conducted, using the newly-identified, promising cultivars in Uzbekistan, Turkmenistan, Azerbaijan, and Tajikistan. But inadequate seed production still remains a bottleneck to farmer adoption in most countries.

ICARDA scientists provided on-job training to NARS researchers during visits to Iran, Turkmenistan, Azerbaijan, and Uzbekistan. A workshop was organized in Uzbekistan to train 42 researchers and production specialists on techniques of on-farm testing and demonstration. Two researchers, one each from Pakistan and

Turkey visited ICARDA, Aleppo for one-month training on winter wheat improvement, with an emphasis on diseases and drought tolerance. Three wheat scientists from CAC were supported to participate in the 6th International Wheat Conference at Budapest, Hungary, in June 2000.

III. PROJECT ACHIEVEMENTS

Output 1: Wheat Germplasm with Improved Yield Potential, Enhanced Adaptation to Local Environments, and Better Grain Quality Developed for NARS Use.

1.1. Germplasm Generation and Evaluation

A total of 704 crosses were made during March-April 2000, using greenhouse and field facilities at ICARDA, Tel Hadya, Syria. These included 480 single crosses, and 224 three-way crosses involving this season's F1 hybrids and a few F2's. Other parents used in the various crosses included: (a) improved breeding lines from the TCI program, (b) winter wheat cultivars widely grown in the CWANA region, with an emphasis on CAC (c) genetic stocks identified by ICARDA or other scientists for their desirable attributes such as resistance to a particular stress, (d) landraces from CWANA, (e) outstanding spring wheat cultivars, and (f) exotic germplasm from winter wheat growing areas of the world, chosen particularly for their cold tolerance (USA), bread-making quality (USA, Russia, Eastern Europe) and earliness (China).

F1 hybrids (749) were grown in single row-plots at Tel Hadya for seed increase and use in crossing. As in previous seasons, other crosses and hybrid populations are made and grown in Turkey (Table 1). Segregating populations and advanced breeding lines were subjected to heavy artificial inoculation with yellow rust at Tel Hadya; the consistently successful inoculation along with the wide-race spectrum of the Syrian inoculum make of the yellow rust screening at Tel Hadya the backbone of the effective early screening of TCI germplasm to this disease, and to a large extent accounts for the rapid improvement of early generations for resistance to yellow rust. Preliminary yield trials (PYT), in addition, are inoculated with common bunt, enabling breeders to discard a large number of susceptible entries at this early stage of testing.

Table 1. Type and size of TCI facultative and winter wheat nurseries, 2000.

Nursery	No.entries	Test sites in
Crossing block	172	Syria, Turkey
F1:	1565	
Syria (ICARDA-Tel Hadya)	704	Syria
Turkey (Eskişehir Research Institute)	861	Turkey
Segregating Populations		
F2 (Syria: 721, and Turkey: 900)	1621	Syria, Turkey
F3 (Syria: 500, Turkey: 440, other: 296)	1236	Syria, Turkey
F4, F5, F6,...Head rows (HR)	44,000	Turkey
Preliminary Yield Trials (1 rep):		
For irrigated or high rainfall conditions (PYTIR00, A and B)	1706	Syria, Turkey
For rainfed, moisture-limited conditions (PYTRF00, A and B)	1457	Syria, Turkey
Intermediate Yield Trials (2 reps):		
For irrigated or high rainfall conditions (YTIR00)	350	Syria, Turkey
For rainfed, moisture-limited conditions (YTRF00)	225	Syria, Turkey
Advanced Yield Trials (3 reps):		
For irrigated or high rainfall conditions (AYTIR00)	125	Syria, Turkey
For rainfed, moisture-limited conditions (AYTRF00)	100	Syria, Turkey
International Nurseries/Trials:		
Third Winter Wheat Observation Nursery-Irrigated Cond. (3rdWWONIR)	107	CWANA
Third Winter Wheat Observation Nursery-Rainfed Cond. (3rdWWONSA)	88	CWANA
Ninth Facultative - Winter Wheat Observation Nursery (9thFAWWON)	163	CWANA
Fourth Elite Yield Trial for Irrig. Conditions (4thEYTIR); 3 reps	25	CWANA
Fourth Elite Yield Trial for Rainfed Conditions (4thEYTRF); 3 reps	25	CWANA
Special Nurseries (introductions, special germplasm, special studies)	variable	Syria, Turkey

All nurseries and trials are grown under both rainfed and irrigated conditions, for an effective selection of drought tolerant materials (see section 2. 3. below). Selected entries, based on their performance at both Syria and Turkey, are advanced to the next stage of evaluation. Because of persistent segregation observed in a large number of PYT's (typically F5 families), a second round of individual head selection within those PYT's (conveniently designated as PYT-A) led to the introduction of another more homogenous type of PYT, dubbed PYT-B (typically F7, but also more advanced-generation families). Intermediate yield trials, or in short, "yield trials" (YT) are generally homogenous, with occasional exceptions. Table 2 shows some of the most promising lines of the advanced yield trials (AYT's) for irrigated (AYTIR00) and rainfed (AYRF00) conditions.

Selected entries in AYTIR00 are superior or equal in yield to the check, whereas in AYTRF00, they are equal or inferior to the check. This is partly due to systematic allocation, by collaborating breeders, of the "best" entries in previous year selection to the "irrigated" nurseries, while tall, low tillering, "second-best" entries are generally allocated to "rainfed" nurseries.

1.2. Grain Quality

Over 3400 entries of the PYT's are evaluated for the following grain quality traits: grain color, grain size, hardness, and protein percent, using the NIRS technique, at ICARDA Quality Laboratory in Tel Hadya. This provides a further tool to effectively cut down the number of entries to retain for future testing. More elaborate quality testing is applied to the elite materials(EYT), including the following farinograph-related traits: water absorption, development time, stability time, and mixing tolerance. These, along with grain volume weight and flour yield give a more precise determination of the industrial or bread-making quality. More resources should be sought to routinely evaluate all advanced, fixed materials more precisely for bread making quality, including the use of electrophoresis for HMWG subunits determination. Early generation materials will continue to be evaluated through the rapid and efficient NIRS technique.

1.3. Production of Double Haploids (DH's)

Thirty-two F2 populations derived from crosses of contrasting parents for yellow rust, leaf rust, growth habit, and cold tolerance, were grown in growth chamber towards mid-1998 to provide donor plants for anther-derived

Table 2. Selected entries of the advanced yield trials for irrigated (AYTIR00) and rainfed (AYTRF00) areas, 1999-2000.

Entry	Name	YLD		GH	HT	HD	YR	LR	CLD
		Trait*							
		t/ha	CHK %						
	AYTIR00:								
9012	DORADE-5	4.2	109	WF	T	M	R	MR	MS
9016	RSK/CA8055//CHAM6	4.3	111	FS	M	E	R	R	S
9052	ATAY/GALVEZ87	4.1	105	W	M	E	MR	MR	R
9089	TAM200/KAUZ	4.2	105	FS	M	E	R	R	S
9005	ZANDER-13	4.0	104	F	T	M	R	MS	MR
9074	CHAM4/TAM200//RSK/FKG15	3.9	100	FS	M	E	MS	MS	S
9103	ID800994.W/FALKE	4.4	111	FS	S	E	MR	MS	MR
	AYTRF00:								
9408	ZANDER-18	2.9	83	S	T	M	R	MS	MS
9412	NE COMP1/5/BEZ//TOB/815	3.5	102	W	M	M	MR	MR	MS
9422	885K1.1//1D13.1/MLT/3/Y	3.1	91	W	M	M	MR	R	MR
9442	093.44/NO57/3/258.2.2/N	3.0	86	W	M	M	R	MS	MR
9473	CHAM4/TAM200//RSK/FKG15	2.8	97	FS	T	M	R	MS	S

* YLD: grain yield, in t/ha, based on the average over 4 sites in Turkey-Edirne, Samsun, Baysehir and Cumra-, and 3 environments (rainfed, 1 irrigation at planting, and 2 irrigations: at planting and stem elongation) at Tel Hadya, Syria for AYTIR00, and on the average of 2 sites in Turkey-Ankara and Eskisehir- and the same 3 environments at Tel Hadya for AYTRF00; CHK %: percent of check; GH: growth habit (W: winter, F: facultative, S: spring); HD: heading (E: early, M: intermediate, L: late); HT: plant height (T: tall, S: short, M: medium, MT: mid-tall); YR: reaction to yellow rust, and LR: reaction to leaf rust (R: resistant, MR: moderately resistant, MS: moderately susceptible, and S: susceptible); CLD: plant reaction to cold stress, under controlled, growth chamber conditions (R: resistant, S: susceptible, MS: moderately susceptible, and MR: moderately resistant).

double haploids. By November 2000, a total of 1260 seeds were obtained, and thereafter planted at Tel Hadya for evaluation during the 2000-2001 season. These seeds were harvested on a total of 174 DH plants belonging to 26 of the initial 32 F2 populations. The number of DH/cross varied from 1 to 16, and the number of seeds/DH ranged from 1 to 291, with an average of 48. These low numbers are primarily due to inadequate facilities during the years 1998-1999, which now have been improved and can be used to produce acceptable numbers of DH's. Another batch of 30 F1's involving parents with resistance to yellow rust or to Russian wheat aphid will be used for the same purpose.

1.4. International Nurseries

Results for 2nd WWONIR, 2nd WWONSA, 3rd EYTIR, 3EYTRF, and 8th FAWWON were returned too late for their inclusion in the GP report for 1999. Some of the promising entries from the observation nurseries are shown in Tables 3 and 4.

Table 3. Selected promising entries of the 8th FAWWON, 1998-1999.

Entry	Name	Trait*			
		CT	HD	YR	LR
25	TAM200/KAUZ	S	E	MR	S
26	VORONA/HD2402	MS	M	R	MS
36	NWT/3/TAST/SPRW//TAW12399.75	MS	E	MR	S
82	91167G1.3	MS	M	MS	MS
128	LUTESCENS28148	MR	L	R	MS
132	ERYT1828.87	MS	E	MS	MR
135	ERYT2999.91	MR	M	MS	MR
137	MIROVSKAYA OSTISTAYA	MR	E	R	MS
1	BEZOSTAYA1	R	M	MS	S
2	SERI82	S	E	S	MS

* CT: reaction to cold (R: resistant, MR: moderately resistant, MS: moderately susceptible, S: susceptible); HD: heading (E: early, M: intermediate, L: late); YR: reaction to yellow rust, and LR: reaction to leaf rust (R: resistant, MR: moderately resistant, MS: moderately susceptible, and S: susceptible).

Table 4. Selected entries of the observation nurseries 2WWONIR and 2WWONSA, 1998-1999.

Entry	Name	Trait*				
		SL	GH	HD	YR	LR
	2WWONIR:					
217	AGRI/NAC//ATTILA	5	F	E	R-MR	S
231	VORONA/HD2402	5	FS	M	R-S	S
244	GAV/ALD//1D13.1/MLT/3/TX62A4793.7 /CB809/V	5	FS	M	R-MS	MR-S
265	ZCL/3/PGFN//CNO67/SON64(ES86-8)/4/SERI/5/	5	F	L	R	S
221	AGRI/NAC//KAUZ	4	WF	L	MR-S	S
233	VORONA/TR810200	4	S	E	R-MR	MS-S
278	LS607.4728	4	W	L	R-S	S
201	BEZOSTAYA1 (winter wheat check)	1	W	M	MS	MS-S
202	SERI82 (spring wheat check)	0	S	E	S	R
	2WWONSA:					
314	AGRI/NAC//KAUZ	5	F	L	R-MS	R
324	130L1.11/GUN91//KINACI97	5	F	L	R-MR	R
377	ZANDAR	5	WF	L	R-MS	R-MR
361	TAST/PCH//BEZ2B/CGN/3/ZAR	4	F	M	R-MS	R-S
367	TSI/VEE//1D13.1/MLT/4/HYS/NO//LV11 /3/KVZ/	4	WF	L	R-MR	R-S
301	BEZOSTAYA1 (winter-wheat check)	0	WF	M	MS-S	R-S
302	SERI82(spring-wheat check)	0	S	E	S	R-S

* SL: frequency of selection in 19 sites for 2WWONIR and 15 sites for 2WWONSA; GH: growth habit (W: winter, F: facultative, S: spring); HD: heading (E: early, M: intermediate, L: late); YR: reaction to yellow rust, and LR: reaction to leaf rust (R: resistant, MR:moderately resistant, MS: moderately susceptible, and S: susceptible).

In 2000, the winter and facultative international nurseries, were dispatched to and data returned from cooperators as shown in Table 5.

Table 5. International winter-facultative wheat nurseries (TCI) for 1999-2000.

Nursery	th FAWWON	3WWONIR	3WWONSA	4EYTIR	4EYTRF
Total number of entries/nursery	163	107	88	25	25
Sets distributed (total)	124	45	42	42	45
Returned data sets (total)	59	25	21	28	20
Returned data sets (CWANA)	28	22	19	26	18

Results of selected promising entries from the 5 nurseries are summarized in Tables 6, 7, and 8.

Table 6. Most-frequently-selected entries of the 9th FAWWON, 1999-2000.

Entry	Name	Trait*					
		SEL	GH	CT	HD	YR	LR
35	ID#840335//PIN39/PEW	10	W	M	M	S	S
156	YMH/HYS//HYS/TUR3055/3/DGA/4/VPM/MOS/	10	S	S	M	S	R
38	RPB868/CHRC//UT1567.121/	10	W	R	M	S	S
2	SERI	9	S	S	E	S	M
26	VORONA/BAU	9	W	M	M	S	M
95	ZHETYSU	9	W	R	M	S	S
162	MOMCHIL/KATYA1	9	S	S	E	M	S
163	F6038W12.1	9	W	R	E	M	M
15	VORONA/CUPE	8	FW	M	M	R	M
7	TX71A1039.V1*3/AMI//BUC/CHRC	8	W	R	L	R	R
27	VORONA/BAU	8	W	M	L	S	R
55	NWT/3/TAST/SPRW//TAW12399.75	8	W	R	E	S	S
155	BOEMA	8	W	M	M	M	R
1	BEZOSTAYA1 (Check)	6	W	R	M	M	S

* SEL: frequency of selection in 27 sites; GH: growth habit (W: winter, F: facultative, S: spring); CT: reaction to cold (R: resistant, M: intermediate, S: susceptible); HD: heading (E: early, M: intermediate, L: late); YR: reaction to yellow rust, and LR: reaction to leaf rust (R: resistant, M: moderately susceptible, and S: susceptible).

The results show a relatively high frequency of selected yellow-rust susceptible entries in the 9thFAWWON; they are selected in some CWANA countries, because of low or absent infection due to unfavorable disease conditions (refer to section 2.3). The TCI germplasm still lacks an adequate resistance to leaf rust, and a good bread making quality.

Table 7. Selected entries of the observation nurseries 3WWONIR and 3WWONSA, 1999-2000.

Entry	Name	Trait*					
		SL	GH	HD	YR	LR	CB
	3WWONIR:						
205	KATIA	5	FW	E	S	S	R
292	ID800994.W/FALKE	5	W	M	MS	S	-
298	BATERA//BUC/TOL73	5	FW	M	MR	MS	S
250	VORONA/HD2402	5	W	L	R	R	-
291	ID800994.W/FALKE	4	FS	E	MS	S	-
240	FRTL//AGRI/NAC	4	S	E	MS	S	MS-S
247	ATAY/GALVEZ87	4	W	M	MR	S	MS-S
252	VORONA/HD2402	4	W	M	S	S	S
260	NAI60/HEINEVII//BUC/3/F59.71/GHK	4	W	L	MS	S	S
276	VORONA/TR810200	4	W	M	MR	S	MS
239	FRTL//AGRI/NAC	4	FW	L	MS	S	MR
201	BEZOSTAYA1 (winter-wheat check)	2	W	M	MS	S	R
	3WWONSA:						
450	RPB868/CHRC//UT1567.121/3/TJB368.251/BUC	7	W	M	R	MS	S
443	RSK/CA8055//CHAM6	6	S	E	MR	MR	S
406	BUC/5/NAPHAL/CI13449/4/SEL14.53/3/LANCER/	6	W	L	MR	MS	MS
422	885K1.1//1D13.1/MLT/3/YE2453	6	W	E	MR	MS	MS
414	PMF/MAYA//YACO/3/CO693591/CTK	5	W	E	MR	S	-
423	885K1.1//1D13.1/MLT/3/YE2453	5	W	M	MR	MS	MS
424	NS55-58/VEE//SULTAN95	5	W	L	MR	S	S
466	1D13.1/MLT//KAUZ	5	FW	M	MR	MS	-
482	KATIA	5	FW	E	MS	MS	-
401	GEREK79 (winter-wheat check)	4	W	M	S	R	S

* SL: frequency of selection in 8 sites for 3WWONIR, and 14 sites for 3 WWONSA; GH: growth habit (W: winter, F: facultative, S: spring); HD: heading (E: early, M: intermediate, L: late); YR: reaction to yellow rust, LR: reaction to leaf rust, and CB: common bunt (R: resistant, MR: moderately resistant, MS: moderately susceptible, and S: susceptible).

Table 8. Selected entries of the yield trials 4EYTIR and 4EYTRF, 1999-2000.

Entry	Name	Trait*						
		YLD	GH	HD	HT	YR	LR	QL
	4EYTIR:							
9814	BURBOT-4	4.9	W	M	M	MR	S	Poor
9809	OK82282//BOW/NKT/3/F4105	4.8	W	E	M	MR	S	Fair
9819	AGRI/NAC//ATTILA	4.7	FW	M	M	MS	S	Poor
9825	TAM200/JI5418	4.7	W	E	S	R	S	Fair
9824	OK82282//BOW/NKT/3/F4105	4.6	W	E	M	MS	S	Fair
9801	BEZOSTAYA1(check)	3.8	W	M	MT	MS	S	Good
	4EYTRF:							
9925	WA476/3/391//NUM/5/W22/5/ANA/	2.9	W	M	MT	R	-	Fair
9915	LFN/VOGAF//LIRA/5/K134(60)/4/	2.9	FS	E	M	MS	-	Fair
9913	VEE/TSI//GRK/3/NS55.03/5/C126	2.9	W	E	MT	R	-	Fair
9912	KVZ/TI71/3/MAYA//BB/INIA/4/KA	2.8	F	M	M	S	-	Poor
9901	GEREK79 (check)	2.4	FW	M	M	S	-	Poor

* YLD: grain yield, in t/ha, selected entries are significantly different from the respective check; GH: growth habit (W: winter, F: facultative, S: spring); HD: heading (E: early, M: intermediate, L: late); HT: plant height (T: tall, S: short, M: medium, MT: mid-tall); YR: reaction to yellow rust, and LR: reaction to leaf rust (R: resistant, MR: moderately resistant, MS: moderately susceptible, and S: susceptible); QL: grain quality for bread making.

Output 2: Improved Understanding of Cultivar Response to Abiotic Stresses Achieved, Used in Breeding, and Made Accessible to NARS

2.1. Response to Cold

Over 400 advanced lines and cultivars from the TCI Program, and from CAC and Iran were tested for their response to cold, under controlled temperature conditions. A procedure, developed and improved by the Project was employed, whereby seedlings at early tillering are subjected to -14°C after hardening, then brought to normal growing temperature and scored for recovery (1: total recovery, 5: complete death). The technique discriminates well between known susceptible and resistant genotypes. It is therefore much more precise than field testing, which suffers from cold heterogeneity across the test area, and uneven blowing winds. Results showed a preponderance of cold resistant types among entries from USA (e.g KS 82W409/STP, TX91V2112, KS89108B, Bayles,…), Russia (YUNA, BEZOSTAYA, SKIPHYANKA), and Eastern Europe (BUL5626.5.2, BUL4.BC1.2.3, MV OPTIMA, ODESSKAYA132, ODESSKAYA162, KATIA). In CAC, tolerant materials are found in Kyrgyzstan (ADYR, KYIAL, TILEK) and Kazakstan (SAMALY, NAZ, KARLYGASH, KRASNOVODOPADSKAYA25), and cold susceptible ones in Turkmenistan (TURKMANBASHI, GYOURS 1, TURSIKUM 57) and Azerbaijan (MIRBASHIR 128, PIRSHAHIN, GUIMATLI 2/17). Germplasm from Iran (27) was surprisingly susceptible, except for the commercial cultivars (SABALAN, SARDARI). TCI germplasm also lacks cold tolerance, with a cold tolerance frequency of 25% in the Crossing Block (2000), 39% in AYTRF00, and 46% in AYTIR00. Growth habit, scored in the field at Tel Hadya (an excellent discriminating site for this trait) is an acceptable but not good indicator of cold tolerance, with a low, albeit significant correlation (0.3** to 0.5**). Grain yield measured in the field at Tel Hadya did not correlate with cold tolerance. In fact, fast growing, facultative types, generally cold susceptible, outyielded the cold tolerant ones. This is not surprising, given the mild winter of the season. In Turkey, during the past 6 seasons, only one was relatively cold, perhaps reflecting the trend of global warming in the region. If the trend continues, as it seems it would, most of the wheat areas will be grown to spring or facultative types.

2.2. Vernalization and Photoperiod Response

Studies of specific winter and spring wheat genotypes under controlled light and temperature showed that vernalization hastens heading of winter types by >20 days under long days and by >30 days under short days; these 2 figures become respectively 2-10 days and 8-20 days for spring types. When seedlings have been vernalized, short photoperiod can delay heading by >30 days in winter types, and by 6-10 days in different spring types. The genes Ppd1 and Ppd2 in Miranovskaya 808 background have such a strong effect that heading is prevented in short days irrespective of vernalization. In contrast, Ppd3, in the same background, does not prevent heading in short days, although it delays it, by 6 days or 12 days, depending on whether vernalization has taken place or not. The gene Vrn2, alone or in combination with Vrn3, requires both vernalization and long photoperiod to allow heading, although in combination with Vrn1, it does not prevent heading.

These summarized results show the complexity of the interaction between different Vrn and Ppd genes and point to the need to take into consideration the specific genotypic requirements for photoperiod and vernalization in any breeding program targeting different agroecologies and management practices.

2.3. Drought Tolerance

During the past several years (refer to GP Annual report for 1995 onwards), drought, often combined with terminal heat, has been the major stress across CWANA, accounting for the wheat production shortages in the region. The season 1999-2000 was extremely dry in most of the CWANA countries. In Turkmenistan and Uzbekistan, the number of irrigations was cut down by half, as a result of the large reduction of available water for irrigation.

It was pointed out in GP Annual report for 1999 that the Central Anatolian Plateau (CAP), where most of segregating and fixed TCI germplasm is tested, differs with respect to terminal drought-heat stress from the majority of CWANA wheat areas. Indeed, the grain-filling period in CAP is cooler and wetter than other rainfed wheat areas of the region, such as Iran, Turkmenistan, Uzbekistan, Tajikistan, northern Syria, etc. (look up Table 9 for

Table 9. Meteorological characteristics* for selected testing sites in Central and West Asia and North Africa, 1999-2000.

	Konya, Turkey				Eskisehir, Turkey				Ankara, Turkey				Maragheh, Iran			
Month	Max	Min	Rnf	<0	Max	Min	Rnf	<0	Max	Min	Rnf	<0	Max	Min	Rnf	<0
Sep	31.4	6.6	18.8	0	32.5	3.8	19.6	0	31.8	8.0	20.8	0				
Oct	31.4	0.6	19.8	0	32.5	-2.9	9.6	4	32.2	1.8	43.3	0	27.5	-1.5	18.2	2
Nov	22.2	-11.8	0.5	17	22.4	-9.2	25.7	16	20.0	-7.0	31.1	11	15.5	-13.5	30.7	23
Dec	20.0	-10.3	5.3	24	16.2	-8.0	21.1	18	16.4	-5.8	38.9	16	14.0	-10.5	14.5	26
Jan	16.2	-17.0	30.1	31	10	-22.4	28.6	30	14.0	-15.2	47.3	29	16.0	-17.0	44.0	29
Feb	12.2	-11.2	15.2	29	8.4	-9.2	18.7	28	7.7	-11.2	42.6	27	10.5	-18.0	35.3	28
Mar	25.2	-11.8	11.2	23	22.3	-11.6	42.1	26	21.8	-8.8	41.4	19	15.8	-11.0	55.4	28
Apr	26.0	-2.0	38.7	2	28	-5.4	122.	2	25.2	-1.9	75.7	2	23.6	-2.5	46.7	2
May	26.0	4.4	56.2	0	27	-0.6	33.1	1	27.4	2.8	17.3	0	27	2.5	15.5	0
Jun	33.4	3.7	17.6	0	31.8	2.2	8.7	0	33.0	5.4	34.6	0	34	4.5	0.0	0
Jul	40.6	13.2	0	0	40.6	7.6	15.3	0	40.8	14.1	0.0	0	35.6	13.5	0.4	0
Total			213.4	126			345	125			393	104			261	138

	Kermanshah, Iran				Tel Hadya, Syria				Gallaral, Uzbekistan			Andijan, Uzbekistan		
Month	Max	Min	Rnf	<0	Max	Min	Rnf	<0	Max	Min	Rnf	Max	Min	Rnf
Sep					38.0	10.0	0.7	0	28.5	10.5	4.9	28.8	13.2	10.0
Oct	33.2	2.6	16.1	0	38.0	3.5	10.1	0	22.2	4.0	18.0	23.0	7.2	11.0
Nov	21.8	-9.6	28.3	9	26.0	-6.8	7.6	5	11.1	-1.1	74.0	11.2	0.8	61.0
Dec	18.4	-7.8	40.7	19	19.8	-5.5	22.4	12	9.3	-4.7	4.0	6.1	-2.7	18.0
Jan	16.5	-9.8	98.4	24	18.5	-8.7	110.	14	7.7	-4.9	46.8	5.8	-3.8	23.9
Feb	16.4	-9.0	37.2	25	17.0	-5.5	38.1	13	7.7	-6.5	19.2	8.1	-3.5	11.2
Mar	21.8	-7.8	46.1	17	26.6	-4.0	41.3	5	14.7	-1.7	41.3	15.9	1.5	21.1
Apr	27.6	1.4	24.1	0	31.5	1.0	29.9	0	24.8	6.8	37.8	25.4	11.0	32.0
May	33.6	3.2	12.5	0	35.0	5.5	0.3	0	28.7	12.3	0	30.4	16.2	3.7
Jun	40.2	7.4	0	0	41.7	11.4	0	0	38	9.2	10	37.0	15.0	3.0
Jul	40.5	14.2	0	0	45.5	12.8	0	0	37	15.8	0.7	39.0	12.8	19.0
Total			304	94			261	49			256.7			213.9

* Max and Min: absolute maximum and minimum temperature. Rnf: precipitation in mm. "<0": days with subzero temperature.

examples). Despite this lack of "representativeness", and despite its inherent soil problems (such as mineral deficiency or toxicity), the CAP may still be useful for international testing, provided it is complemented by early-generation testing at least at one site with more acute drought-heat stress, conducive to shorter grain filling period. In view of the relative importance of drought and cold in CWANA (drought is more important), it should be more efficient to test and select within the early segregating populations (F2 and F3) at such a site. This site may be Tel Hadya, Syria, a site in rainfed wheat areas of Iran such as Sararood, or in the Dyarbakir region of Turkey, although Diyarbakir itself may not be an ideal site because of its "high" annual rainfall (495 mm). Alternatively two sites (one in CAP, and one as suggested above) may be used to grow duplicate large plots of F2 and F3, to select for two types of environments with contrasting conditions for the grain filling period. This is the best alternative, but requires some additional resources.

In drought experiments conducted at ICARDA during 1999-2000, winter wheat entries (225) grown at Tel Hadya yielded 1943 kg/ha under rainfed conditions (261mm) and 3322 kg/ha under 2 supplementary irrigations, of 25 mm each at planting and stem elongation. The study of their relative performance under those conditions revealed 5 major groups (Table 10). Group1 comprises the most drought tolerant entries (highest yield under rainfed conditions). These are early genotypes that escape terminal drought-heat stress, but tend to lodge under moisture-favorable conditions, due to weak or tall stem. They are best fit to dry areas. In contrast, G2 entries yield extremely well under added water, and also possess a good - but not the best - level of drought tolerance. They are fit to dry areas with supplementary irrigation and to high rainfall areas. The remaining groups yielded similar to G1 under supplementary irrigation, and differed under drought conditions, with group5 being the most susceptible to drought. Another study of 50 winter wheat cultivars, grown under rainfed conditions versus 3 supplementary irrigations, confirmed the same trend.

These studies show that: (1) using a *differential* water-supply regime in a dry environment is an effective technique to discriminate between drought-tolerant and

Table 10. Response to drought of 225 winter-wheat entries subjected to water stress in ICARDA research fields at Tel Hadya, Syria, 1999-2000.

Group (examples of entries)*	Yield (kg/ha)**		Response to***	
	Rainfed	Irrigated	Drought	Irrigation
G1(9003, 9016, 9018, 9039)	3230 a	3540 a	++	+
G2(Katia,9061, 9066, 9103, 9117)	2580 b	4552 b	+	++
G3(Cham6, Kinaci, 9089)	2720 b	3660 a	+	+
G4(Bezostaya, Dagdas,Sultan, 9010)	1820 c	3420 a	0	+
G5 (Atay, 9023, 9055, 9081, 9109)	920 d	3400 a	-	+

* Entry numbers for yield trials of 1999-2000. ** Rainfed: 261 mm; Irrigated: 25 mm at planting plus 25 mm at stem elongation; yield figures within a column not followed by the same letter are significantly (0.05) different. *** ++: excellent drought tolerance (fourth column), or highly responsive to added water (fifth column); +: good drought tolerance (fourth column) or well responsive to irrigation (fifth column); 0: slightly tolerant to drought, -: drought intolerant (susceptible).

drought susceptible cultivars, (2) although some cultivars perform well under both severe drought and supplementary irrigation (G1 and G2), there appears to exist a certain tradeoff between drought tolerance and high responsiveness to well-watered conditions (such as full irrigation), conducive to potential yield levels beyond 4 t/ha. Therefore, combining drought tolerance with high yield is possible up to a limit of about 4 t/ha in the environmental conditions of northern Syria, and the many similar areas within CWANA. This is confirmed by the observed on-farm performance of drought tolerant cultivars, recently released in Iran.

Output 3: Genetic Diversity for Enhanced Tolerance to Biotic Stresses Improved

3.1. Tolerance to Rusts and Bunt

Breeder's materials, including segregating populations, preliminary and other yield trials in observation 2-row plots, crossing block and miscellaneous introduced germplasm (e.g. from CAC and Iran), totaling more than 3500 entries, excluding segregating germplasm, were subjected to yellow rust (YR) *Puccinia striiformis*, common bunt (CB), *Tilletia caries*, *T. foetida*, and leaf rust, LR, *Puccinia recondita* (3WWONIR, 3WWONS, and Crossing Block only). The frequency of YR resistant germplasm continues to improve (60% in 3WWONIR, 55% in 3WWONSA, 70-76 % in the PYT00's, and 52% in 9thFAWWON). Resistance to leaf rust was less frequent (e.g. 47% in 3WWONIR and 30% in 3WWONSA, and common bunt resistance was even less common (10% in each of the 3WWON's, 15-25% in the PYT's, and 19% in the 9thFAWWON). Combined resistance to 2 or more diseases is still very low (e. g. YR cum CB), and needs to be further pursued to build up genetic stocks for use by NARS breeders.

The yellow rust study initiated in 1998 was completed in 2000, where results consolidated previous findings on slow rusting as an effective and sustainable mechanism for YR control. Results were presented at the 6^{th} International Wheat Conference, 5-9 June, 2000, at Budapest, Hungary. Crosses were initiated using slow-rusters versus others to study the mode of inheritance of slow-rusting.

A YR trap nursery was distributed to interested researchers for planting and evaluation against the local YR races in Turkey, Iran, Azerbaijan, Kyrgyzstan and Kazakstan. The nursery includes lines and cultivars with specific genes for resistance, allowing pathologists to monitor the distribution and shifts of pathotype composition of the indigenous inocula. Results are shared among all cooperating scientists.

3.2. Cereal Cyst Nematode (*Heterodera avanae*)

A natural infestation by cereal cyst nematode (CCN) was observed during March and later months of 2000 over an area of about 1 ha in Field A33, at ICARDA, Tel Hadya. A 2-course wheat-vetch rotation has been applied in this field for the past 3 seasons. The CCN infestation was evenly spread over the affected area, as judged by the homogenous symptoms over large (7m-by-1.5m) plots. Varietal differences were very clear. Luckily, some of the nurseries were replicated in affected and less- or unaffected plots, which gave more confidence in the germplasm screening of those nurseries and made it possible to estimate unambiguously and precisely, perhaps for the first time in the *region*, the wheat yield loss due to CCN (Table 11). In severely-infected plots, all plants were stunted and yellow, and no spike could develop, leading to zero grain yield. These results show that CCN can cause disastrous damage to wheat crops. This may be effectively avoided through the choice and use of proper cultivar and rotation.

The affected area in Field A33 was marked for future use as "sick" site for CCN screening.

Table 11. Grain yield reduction of wheat entries due to cereal *cyst nematode* (CCN), Tel Hadya, 1999-2000.

Wheat entry name or designation	Yield reduction(%) of up to:
Check cultivars	
Dagdas94	30
Bezostaya1	33
Kinaci97	60
Sultan95	70
YTIR00 entries	
7050	84
7047	100

3.3. Russian Wheat Aphid

A total of 845 F3 families derived from 5 winter wheat crosses were grown in the field at Tel Hadya during 1999-2000. Plants were subjected to Russian wheat aphid (*Diuraphis noxia*) following the method described in GP Annual report for 1999. Plant reaction to Russian wheat aphid (RWA) was scored when symptoms became clear on susceptible checks, using a 1-3 scale for leaf rolling and a 1-6 scale for leaf chlorosis. A total of 145 F3 lines were found to carry resistance. Individual plant selection was made within the selected lines to further confirm the RWA resistance and to combine it with desirable agronomic traits in F4 families.

About 220 wheat breeding lines were field screened for RWA resistance at Tel Hadya, and the promising selections re-tested in the greenhouse. None of the lines showed an acceptable level of resistance.

Three crosses of resistant-by-susceptible parents were made to study the inheritance of RWA resistance in winter wheat. The hybrid populations and the parents will be grown for evaluation at ICARDA station in Tel Hadya during 2000-2001.

A RWA wheat nursery, comprised of 32 bread wheat lines and 2 checks, was assembled at ICARDA and made available to NARS scientists for evaluation and selection, and for monitoring the occurrence and development of RWA in their area.

RWA infestation was observed on research and farmer fields in the Central Anatolia Plateau, during a diseases-and-pests survey in the Central Anatolia Plateau of Turkey during 29 May-1 June, 2000.

3.4. Wheat Stem Sawfly

Wheat stem sawfly (*Cephus* spp.) is an important insect pest of wheat in WANA, with an average infestation rate of about 20%. Damage of this insect is caused by larval feeding inside the stems. Additional damage results after larvae cut the stem at the base of the plant before aestivation and hibernation, which causes lodging.

A total of 220 lines were evaluated for resistance to this pest in the field at two locations (Tel Hadya and Hourane) in Syria. An alpha design was used with two reps and systematically repeated checks every 10 entries. Each entry was planted in 1m row. The material was evaluated just before harvest. The evaluation was based on the number of stem cut/entry caused by wheat stem sawfly.

Fifty lines were selected with a number of stem cut of <1, six of which were free of any stem cut. These promising lines will be retested in 2001 for validation. The confirmed sources of resistance will be studied for mechanisms of resistance. The hope will be to identify resistant lines to the pest with hollow or semi hollow stems.

3.5. Sunn Pest

Sunn pest (*Eurygaster integriceps* Put.) is a very damaging insect pest of wheat in some 15 million ha in West and Central Asia. The present control method of this pest has been based only on chemical insecticides. ICARDA and its NARS and ARI partners are jointly developing IPM options to replace the present control strategy. Host plant resistance is one of the IPM options that is being investigated at ICARDA for possible use against this pest.

Ten wheat test entries were evaluated for resistance to sunn pest under artificial infestation using large (9m x 6m x 3m) mesh cages. A RCB design with 3 replications was used. A separate cage, kept uninfested was used as control. Seeds of each entry were planted in rows,1 m long and 0.3 m apart. The artificial infestation was done using 6 adults/m2 when sunn pest adults started migrating to wheat fields from their over-wintering sites. Three criteria were used for evaluation, namely spike damage, shoot damage, and kernel weight reduction weight (all expressed in %)

The results showed significant differences among the tested entries for the three criteria (Table 12). The promising entries will be retested in 2000-2001 to confirm these results and to check for any differences in the degree of damage that may be inflicted to grain quality.

Table 12. Response of wheat breeding lines and cultivars to sunn pest under artificial infestation, Tel Hadya, 2000.

Cultivar or line	Damage (%)		
	Shoot	Spike	Kernel weight
Winter wheat lines (7)	11-19	11-26	15-24
Tabasi	22	45	21
Kavkaz	25	50	34
Falat	6	19	15
LSD (0.05)	10	11	11

3.6. Barley Yellow Dwarf Virus (BYDV)

Testing for BYDV was conducted in 3 stages as in previous seasons (GP Annual Report for 1999).

In preliminary testing, 42 of 225 (AYTIR00 and AYTRF00) entries were selected, among which are the cultivars Katia, Bezostaya1, Kinaci97 and Cham6, and Cham2 advanced breeding lines with high yield performance

(AYTIR00-9007 and AYTRF00-9422). In intermediate testing, 20 of the 36 entries retained last season, were again selected in 2000. In advanced, 3rd-year testing, the entries AYTIR99-9044 and Kinaci97 scored no yield loss (Table 13), confirming their previous tolerance to BYDV. The ICARDA breeding line TAST/SPRW//ZAR maintained its good response for several years and therefore will be included in the Germplasm Pool for BYDV.

Table 13. Performance* of BYDV most tolerant wheat germplasm in 3rd year testing under artificial inoculation at ICARDA, Tel Hadya, 1999-2000.

Entry	DI	BM	GWT	PH	YL
TAST/SPRW//ZAR	6	206	81	58	11
BOW/PRL//F12.71/BEZ/3/OK82282	5	197	79	70	19
ERYT3374/88PURDUE	6	244	80	55	11
ID800994.W/FALKE	5	220	83	73	0
KINACI97	5	237	91	63	0
WSSF-WW-99-6	5	258	97	58	12
CAN-93-21	5	256	84	93	23
KATEPWA (CHECK)	7	162	55	58	41

* DI: symptom disease index, based on degree of disease appearance on wheat plants, and expressed on a 0-9 scale, with lower values indicating lower-degree symptoms. BM: biomass, determined on a per-plot basis, and expressed in g/plot of 4mx1m.GWT: grain weight (g) per plot. PH: plant height(cm) of infected plants. YL: percent grain weight loss, due to BYDV infection.

Output 4: Strategies to Improve Technology Adoption Developed and Implemented

4.1. Multilocation Testing of Promising Breeding Lines and Cultivars

An active program was launched in most of the CAC countries for multilocation, state variety testing of advanced winter wheat breeding lines, identified from TCI germplasm and other sources. Table 14 shows some of the most promising breeding lines tested across several sites in CAC countries. Some of the sites were visited by Officials and production managers.

Table 14. Promising wheat breeding lines in state variety, multilocation testing in CAC countries, 1999-2000.

Country	Breeding line
Armenia	Ani326
Azerbaijan	Gobustan, Azematli95
Georgia	Koper, Mtskhetskaya-1
Kyrgyzstan	Kiyal
Tajikistan	Tacica, Norman
Turkmenistan	Garagum, Bitarap, Guncha
Uzbekistan	Dostlik, GallaAral-1, Chillaki

In Iran, the severe drought and heat stress that prevailed throughout the rainfed areas of the country enabled the breeders to identify drought tolerant germplasm, including two outstanding lines: 'Ogosta/Sefid' and 'Fenkang15/Sefid'. They are candidates for release to farmers in those areas. In Turkey, several cultivars were released or submitted for release.

4.2. On-farm Verification and Demonstration of Elite Lines and Cultivars

ICARDA encouraged and collaborated with CAC NARS's in on-farm verification and demonstration of the superiority of newly identified lines in state variety trials over the local cultivars. Farmers were associated in this work, particularly in Uzbekistan and Azerbaijan, where the new cultivars showed a 10-30% yield advantage over the local checks.

In Turkey, on-farm trials conducted (in collaboration with I. & F. Ozberk) over 2 years in the Elazig-Malatya region confirmed the superiority of improved cultivars over the landrace check (Table 15).

However, in all countries of the region, and particularly in CAC, seed production remains inadequate and will continue to be the major barrier to farmer adoption of the newly released cultivars, until proper action is taken by the concerned national institutions to produce seed of the new cultivars in sufficient quantity as soon as a cultivar is released.

Table 15. Grain yield*(kg/ha) of an elite breeding line (SHARK), an improved cultivar (PEHLIVAN), and a winter wheat landrace (ASHURE), at Elazig-Malatya, Turkey, 1998-1999 and 1999-2000.

Cultivar or line	Season	
	1998-1999	1999-2000
SHARK	4608 a	4580 a
PEHLIVAN	3492 b	4354 a
ASHURE	2600 c	3205 b

* means within a column not followed by the same letter are significantly (0.05) different.

Output 5: NARS Capacity for Wheat Research in the Highlands Strengthened.

5.1. Training and Visits

ICARDA scientists worked with and provided on-job training in wheat breeding and related disciplines, to NARS researchers during their visits to Azerbaijan, Iran, Turkmenistan, and Uzbekistan. Twelve researchers from 6 CAC countries were provided technical English language training to help them in their research work. A workshop was organized in Uzbekistan to train 42 researchers and production specialists on techniques of on-farm testing and demonstration. Two researchers, one each from Pakistan and Turkey visited ICARDA, Aleppo for one-month training on winter wheat improvement, with an emphasis on diseases and drought tolerance. An ICARDA breeder lectured at a seminar on "revival of plant breeding and seed production in CAC" held at Dushanbe, Tajikistan on 3-6 May, 2000. An ICARDA pathologist, accompanied by an Iranian pathologist visited Azerbaijan, Uzbekistan and Kyrgyzstan to observe disease trap nurseries in those countries and to initiate the Yellow Rust Network for Central and West Asia.

5.2. Workshops, Conferences, and Meetings

Two ICARDA breeders participated in a cereal traveling workshop, organized in Azerbaijan during 16-19 May 2000. Participants from Azerbaijan, ICARDA, and other institutions from the region visited Gobustan, Ter-Ter and Jalalabad regions to evaluate wheat and barley germplasm and to observe on-farm demonstrations organized with farmers of the region.

ICARDA wheat breeder participated in a workshop on "sustainable seed production systems for winter cereals and grain legumes in the GAP region", organized by GAP-RDA on 13-15 November 2000, at Sanliurfa, Turkey. The workshop participants identified the actions needed to enhance the production and use of certified seed, which related mainly to policy issues.

A disease survey in the Central Anatolia Plateau was co-organized by the three partners in the TCI IWWIP, during 29 May through 1 June 2000. Participants from Turkey (2), ICARDA (3) and CIMMYT (2) visited farmers fields and research stations and observed and discussed the occurrence and incidence of such diseases as root rot, nematodes, RWA, BYDV and rusts.

ICARDA breeders and pathologist participated in a meeting of the WWINET-CAC (winter wheat improvement network for CAC) on 22 September 2000, at Bishkek, Kyrgyzstan. Participants from ICARDA, CIMMYT and the CAC countries reviewed the regional research and training activities for 2000, and discussed further strengthening of those activities through more germplasm exchange, visits and inclusion of regional cooperation in yellow rust (YR) research and exchange of expertise and information among CAC countries and with CG Centers in this area. A YR trap nursery will be distributed from ICARDA, Aleppo, within the region and in neighboring West Asia to monitor virulence and resistance shifts and effectiveness in these regions.

ICARDA winter wheat breeder participated in the 6th International Wheat Conference, at Budapest Hungary, on 5-9 June 2000. Three scientists, one each from Azerbaijan, Kyrgyzstan and Uzbekistan were supported by ICARDA to participate in the same Conference.

IV. COLLABORATORS

Contributing scientists from ICARDA

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Contributing scientists from CIMMYT/Turkey

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V. DONORS (SUPPORTERS)

- ICARDA Core
- CGIAR Special Fund for CAC
- Iran/ICARDA Project

VI. PUBLICATIONS

Ketata, H., A. Yahyaoui, M. Jarrah, H.-J. Braun, M. Mergoum, A. Morgounov, L. Cetin, and F. Dusunceli. 2001. Slow rusting in winter and facultative wheat infected with yellow rust. *In* Z. Bedo and L. Lang (Eds.), Wheat in a Global Environment, p. 391-395. Kluwer Academic Publishers. Dordrecht, The Netherlands.

Rizvi, S. J. H., V. Rizvi, M. Tahir, H. Rahimian, P. Shimi, and A. Atri. 2000. Genetic variation in allelopathic activity of wheat (*Triticum aestivum L.)* genotypes. The International Journal for Wheat Genetics and Breeding, WIS: 91: 25-29.

TABLE OF CONTENTS

I. PROJECT TITLE: FOOD LEGUME GERMPLASM IMPROVEMENT (LENTIL, KABULI CHICKPEA AND FABA BEAN) FOR INCREASED SYSTEMS PRODUCTIVITY

II. EXECUTIVE SUMMARY

The overall of objective the food legume germplasm improvement program (Lentil, Kabuli chickpea and Faba bean) is to increase the productivity and sustainability of the farming system in partnership with NARS, NGOs and farmers. This objective is pursued through improving the methodologies for food legume breeding, training of NARS, improvement of production practices and genetic stocks with resistance to various biotic and abiotic stresses, sharing of the improved germplasm with NARS and its evaluation under targeted environments for identification of improved lines for future use.

During the year under report, 300 crosses in lentil, 200 in chickpea and 96 in faba bean were made to combine resistance to various biotic and abiotic stresses in varying agronomic backgrounds. The improved genetic materials were shared in the form of 669 different sets of trials for 27 different nurseries with the NARS in 52 countries through Food Legume International Nurseries.

Decentralization of breeding activities with NARS in South Asia, Ethiopia, Iran, Morocco, and Turkey resulted in identification of promising lines in lentil and chickpea. Scientists from Iran, Bangladesh, Syria, Pakistan, Libya, Turkey, Bulgaria, Jordan participated in training activities at ICARDA. A training course in Legume Improvement was organized in Tashkent and a DNA-marker technology course in Morocco.

The inheritance studies for chickpea Fusarium wilt to race 0 indicated the presence of both additive and dominance genes with genic interactions. Recessive genes controlled the resistance in the line studied.

New sources of resistance to various biotic and abiotic stresses in lentil (Vascular wilt, Sitona weevil, viruses, salinity and winter hardiness), chickpea (Ascochyta blight, Fusarium wilt, drought and cold) and Faba bean (Ascochyta blight, Chocolate spot, rust, Orobanche, and cold) have been identified and used in breeding program.

Lentil transformation for controlling broomrape and Sitona is in process and markers for Sitona resistance have been identified in wild lentil.

Four varieties in lentil. Rachayya in Lebanon, Idleb 2 in Syria, and Meyveci-2000 and Ali Dayi in Turkey have been identified from ICARDA supplied materials and released for general cultivation. Similarly, in chickpea cultivar Giza 3 (FLIP 80-120C), in Egypt and FLIP 93-93C was identified for release in Syria. In case of faba bean, however, mainly pre-breeding is done at ICARDA and improved populations are developed and shared with NARS. In Egypt one faba bean line Sakha-1 (X-957) was submitted for release. The screening techniques for various stresses were miniaturized. The improved production packages and technology transfer were developed and shared with NARS.

III. PROJECT ACHIEVEMENTS

Output 1: Improved Methodologies for Food Legume Breeding i.e. Decentralized Breeding, Marker-Assisted Selection, Durable Disease Resistance Breeding and Automation.

1.1. Crossing

300 crosses in lentil, 200 in chickpea and 96 in faba bean were made to combine resistance to various biotic and abiotic stresses in varying agronomic backgrounds needed for different agro-climatic regions. In case of chickpea and lentils, these crosses were advanced to F2 generation using off-season nursery in Terbol in the Beqaa valley in Lebanon.

1.2. Distribution of Segregating Populations and Improved Resistant Sources

Elite lines and segregating populations with appropriate combinations were developed and shared with NARS for their evaluation and adaptation under local conditions. A total of 669 sets comprising 27 different nurseries were developed: 277 sets of 12 nurseries in lentil, 296 sets of 11 nurseries in chickpea, and 96 sets of 4 nurseries in Faba bean were shared with NARSs in 52 countries for yield testing and evaluation against various stress traits and adaptation under their local conditions. The results for the nurseries distributed for evaluation during 1998/99 were received from some cooperators and salient features are given under outputs 3, 5, and 7.

1.3. Inheritance of Fusarium Wilt Resistance in Chickpea

The results of inheritance studies based on four crosses (*using generation mean analysis*) for Fusarium wilt race 0 indicated the presence of both additive and dominance genes with genic interactions. Further, the recessive genes controlled the resistance in the existing lines.

1.4. Inoculation of the Ascochyta Blight Disease Nurseries

Inoculation of the Ascochyta blight disease nurseries with debris and spore suspension early into the season was tested for building appropriate population pressure of the pathogen for improving the efficiency of disease infestation. Early inoculation with debris dissemination and spore suspension helped in building a reasonable population pressure of the *Ascochyta rabiei* pathogen and found useful in improving the field screening technique for Ascochyta blight evaluation. Screening techniques to identify durable resistance to Ascochyta blight miniaturized and for leaf miner under field conditions standardized and in use. Sources of resistance in wild lentils have been identified.

1.5. Decentralized Breeding (DB)

Decentralized breeding (DB) activities with NARS in South Asia, Ethiopia, Iran, Morocco, Turkey resulted in identification of promising lentil lines. However, in kabuli chickpea for DB. The special crosses have been made during the season will be advanced to F2 and sent to the countries with high capacity (India, Morocco, Tunisia and Turkey).

Output 2: 20 Researchers/Year Trained on Breeding Philosophies, Selection Methods and Techniques Related to Food Legume Germplasm Enhancement in the Target Areas of the Project.

2.1. Training

Ten scientists and technicians from Iran, Bangladesh, Syria, Palestine, Libya, Turkey and Jordan participated in the training activities in hybridization techniques, experimental design and layout, data recording and analysis, and evaluation techniques for biotic (root and foliar diseases) and abiotic (cold and drought) stress tolerance. A course on legume harvest mechanization was organized at the headquarters in Aleppo, and six trainees from Syria, Jordan and Lebanon participated in the course. A regional legume improvement course for participants from eight countries covering Central Asia and the Caucasus (CAC) was organized in Tashkent, Uzbekistan. All the Legume Coordinators from these CAC countries participated in the course. An in-country/ course on "DNA-marker technology and Crop improvement" was organized in Morocco that was attended by 21 Moroccans. A regional training course on "Double Haploid production, cytology and genetic transformation" was organized at AGERI, Cairo, Egypt and attended by 10 trainees from Egypt, Sudan, Morocco, Syria, and Libya.

2.2. Visiting Scientists

National grain legume research administrators from Bangladesh, Bulgaria, India, Turkey, Tunisia, and Morocco visited food legume improvement program and exchanged views on future research strategies and plan of action.

Output 3: Lentil: Improved Lentil Production Practices and Genetic Stocks with Increased Biomass for Food and Feed and Resistance to Key Stresses (Winter Cold, Drought, Vascular Wilt, Rust and Ascochyta Blight).

3.1. Introduction

The lentil is an under-exploited and under-researched annual legume and often treated as an orphan crop even in lentil producing countries. Average lentil yields are low because of cultivation of traditional landraces having low yield potential, poor crop management and grown in less favorable marginal environments. Moreover, diseases, particularly vascular wilt, rust and Ascochyta blight are major constraints, causing substantial yield loss and instability in yield. To achieve this, a multi-disciplinary approach is being perused for the development of improved genetic stock and production practices. ICARDA has the world mandate for lentil improvement. The lentil improvement program at ICARDA is closely linked with the NARSs of developing countries of WANA, Southerly latitude, CAC and Latin America. In addition, the developed countries like Australia, Canada receives spin-off benefits from ICARDA's lentil breeding program. Besides, we have collaboration with the advanced research institutes in basic research.

From the onset of lentil improvement at ICARDA, we studied the variation in the world germplasm collection to understand factors affecting lentil adaptation to direct the breeding program. Additional information on the specificity of adaptation within the crop has come from collaborative yield trials of common entries selected in different locations. Armed with this understanding of the specific adaptation of the lentil crop and the various consumer/end-use quality requirements of different geographic areas, we have designed the base-breeding program as a series of separate, but finely targeted streams linked closely to national breeding programs.

The three major target agro-ecological regions of production of lentil are: 1. S. Asia, E. Africa and Yemen 2. Mediterranean low to medium elevation and 3. High elevation area of West Asia and North Africa. These correspond to the maturity groups of early, medium and late maturity. Within each of these major regions there are specific target areas. Recently, the lentil improvement activities has been extended to Central Asia and Caucasus (CAC) region, where initial thrust has been given to study the adaptation and screening of diverse material suitable in agro-climatic conditions in CAC countries. In the CAC region, Uzbekistan, Kazakhstan, Azerbaijan, Georgia and Armenia have been given priority for lentil improvement. For Latin America (Argentina, Peru, Chile, Columbia) large-seed, yellow cotyledon with resistance to rust and Ascochyta blight are important traits. To achieve the objectives of lentil improvement program, the following research activities were undertaken in 1999/2000.

3.2. Hybridization

The hybridization program at ICARDA uses parents of diverse origin with known traits with the aim to combine gene(s) to contribute to yield and resistance to major biotic and abiotic stresses. Generally, the landraces/cultivars of a specific region or country are used in crosses commissioned for that target environment. In some cases crosses are agreed with the NARS scientists according to their demand. Wide crosses among cultigens are also done by manipulating planting date and providing extended light period to the parents to attain synchrony in flowering. In addition, crosses are made to study inheritance pattern of specific trait(s) and to develop recombinant populations for biotechnological research. In this endeavor, a total of 306 cross combinations were made for the following reasons.

- South Asia - 80 (red cotyledon, early to medium maturity, rust, wilt and Ascochyta blight resistance
- Targeted for Nepal - 25 (early, wilt resistance)
- Specific for Bangladesh - 30 (extra-early, rust and stemphylium blight resistance
- Yemen - 4 (red and yellow cotyledon, early, Ascochyta blight resistance)
- Ethiopia - 11 (early, rust and wilt resistance)
- Morocco - 12 (red and yellow cotyledon, rust and Ascochyta blight resistance)
- Large-seeded yellow cotyledon - 25 (large seed, wilt resistance)
- Highlands - 28 (winter-hardy)
- Low land Mediterranean - 74 (red, small seed, wilt resistance)
- Inheritance and biotechnological studies - 17 (Ascochyta blight, boron toxicity, Sitona resistance).

3.3. Yield Trials

Selections from the breeding program for the Mediterranean low and medium elevation region are tested at three locations varying in their annual average rainfall, namely Breda (267 mm) and Tel Hadya (323 mm) in Syria and Terbol (548 mm) in Lebanon.

Preliminary trial (F7): Preliminary yield trials for early type were conducted in Breda and Tel Hadya and for large and small seeded materials the trials were planted in Breda and Tel Hadya in Syria and Terbol in Lebanon. All test entries were simultaneously evaluated in fusarium WSP for second cycle. Experiments were conducted following lattice and RCB designs in 5-rows plot of 4 m length with 30 cm spacing between the rows. Three checks (one improved variety + two locals) were included in each trial for comparison. On the basis of wilt resistance (<20% plants affected in WSP), seed yield across locations and field performance, 24 early maturing lines were selected to include in International Nursery for southerly latitude countries and drought tolerant nursery (high biomass + early). Following the same strategy, 17 large seeded and 79 small-seeded lines were selected to evaluate in advanced yield trial.

Advanced yield trial (F8): Materials in advanced yield trials were tested in above three sites for yield performance and screened in wilt-sick plot. The experiments were designed in lattice with 25 entries and in RCB with 13 entries along with three checks. Each plot measured 4m x 10 rows with 30 cm row spacing. A total of 29 small-seeded red lentil and 8 large-seeded yellow lentil new breeding lines were selected and has been entered in International nursery for 2001.

3.4. Advancing Segregating Populations

In summer nursery in Lebanon, the F_1s were conformed and 157 F_2 populations were developed. A total of 107 F_3 populations have been advanced to F_4 generation. In Tel Hadya, following bulk-pedigree method, and 9,658 single plants were selected from F4 populations, 729 F5 progenies have been advanced to F6 to evaluate in preliminary screening nursery. On the basis of wilt reaction in wilt-sick plot, field performance and plot yield, 182 lines (large- and small-seeded, and early maturing type) have been selected to test in replicated preliminary yield trial.

3.5. Seed Increase of Elite Lines for International Dispatch

525 germplasm and breeding lines were increased at Tel Hadya. In addition, 1.8 t seeds of newly released variety in Syria "Idleb-2" was produced to provide seeds to the Syrian organizations, and to conduct research demonstrations in farmer's fields as a part of technology transfer.

3.6. Evaluation of Germplasm and Breeding Lines for Wilt Resistance

A total of 965 breeding lines and 633 germplasm accessions, were evaluated or re-screened, in the wilt sick plot at Tel Hadya, for their reaction to fusarium wilt. The lines tested were grouped into 3 categories: Cycle I - new untested lines (New germplasm accessions), Cycle II - lines tested previously for one seasons (preliminary screening nurseries and germplasm accessions selected from previous season(s)), and Cycle 3- lines tested previously for at least three seasons (preliminary screening nursery and yield trials, advanced yield trials). Percent resistance to lentil vascular wilt (highest score 20%) ranged between 22% for newly tested germplasm accessions (cycle I), 73% for germplasm accessions selected in the previous season and 79% for preliminary screening nurseries (cycle II), 85% for preliminary yield trials and 97% for advanced yield trials (cycle III). This indicates the reliability of the screening method and the efficiency of selection. Within same nursery, the resistance level was higher in the small-seeded and early accessions, as compared to that of large-seeded and late accessions. The new sources of resistance from the core collection are of particular importance, because of their diverse geographical origin

This screening is a key and integral part of the lentil-breeding program. Resistant material is made available to NARS for re-evaluation under their own conditions and selections are made for release or inclusion in the breeding programs.

3.7. Response of Lentil Genotypes to Salinity Tolerance

Salinity is one of the major impediments to crop production in many regions including Mediterranean basin. Under intensive crop management, it has been economically possible to desalinize the soil, however, the cost of desalinization is prohibitive. Selection and breeding for salt tolerance in crop species thus seems to be the only efficient and economic way to overcome soil salinity problems. Lentil is more sensitive to salinity compared to other food legume crops. It has been reported that critical level of soil salinity for lentil is 4 dS/m. A total of 200 lentil germplasm originated from India, Ethiopia, Iran, Jordan, Syria, and ICARDA breeding lines were screened for salinity effect on germination and seedling height in laboratory condition. Three concentrations (Ec) of saline water, viz., 4, 7, 10 dS/m collected from natural sources in Syria were used. Fresh Tel Hadya water was used as control, which exhibited a concentration of 0.5 dS/m. A progressive germination failure and retarded seedling growth was observed with increase in salinity level. At 4 dS/m concentration, 87% of the test lines showed 100% germination, while at 7 dS/m and 10 dS/m exhibited 42% and 20% germination, respectively. Effect on seedling height was negligible at 4dS/m, where as, 12-35% reduction was observed at 7 dS/m and 15-85% with 10 dS/m concentrations. 20 lines, which showed high germination and less effect on seedling height at 7 &10 dS/m were selected for further study on flowering, pod formation, maturity and yield (seed + biomass).

3.8. Screening of Wild Lentils Against Sitona Resistance

Sitona crinitus Herbst is the major insect pest of lentil in West Asia and North Africa. The adults feed on leaflets and larvae in the nodules. The only available option for control of this pest is the use of insecticides. However, farmers have been unable to use them, as they are expensive. Environmental concerns are also a factors that limit their use. Because genetic resistance has not been found in the cultivated lentils, we have been screening wild relatives for resistance to this pest. In 1999, one accession was identified as resistant under artificial infestation in the greenhouse.

The accession (ILWL 359) identified in the greenhouse in 1999 and another collection of wild relatives was evaluated under natural infestation in the field during the 2000 season. Twenty seeds of each accession were sown in hill plots. The material was evaluated for visual damage the first week of March using a 1-9 scale. 1, (no damage), 2 (1-10% leaflets damage), 3 (11-20% leaflets damage), 4 (21-30% leaflets damage), 5 (31-40% leaflets damage), 6 (41-50% leaflets damage) 7 (51-70% leaflets damage), 8 (71-90% leaflets damage), 9 (more than 90% leaflets damage). By the middle of April, a random sample of five plants/accession was taken to the lab for nodule damage evaluation.

The results showed that the accession ILWl 359 had a very low leaflet damage score (2), but a high nodule damage

(70%). Out of the 100 accessions tested, ten were selected with a low percent nodule damage (<25%). These accessions are retested this season under filed conditions for confirmation. We are also studying the mechanisms of resistance (antixenosis and/or antibiosis) that make the ILWL 359 less preferred (low visual damage score) by Sitona. Some of the parameters we are studying include the fecundity of Sitona and the percent egg hatch when females are reared on this wild accession leaflets vs on those of a cultivated lentil.

3.9. Screening for Faba Bean Necrotic Yellows Virus (FBNYV) and Bean Leaf Roll Virus (BLRV) Resistance in Lentil

During the 1999/2000 growing season, 59 lentil genotypes (including 9 genotypes selected from the previous season proved as good yielders and highly tolerant to virus infection) were evaluated for their reaction to local isolates of BLRV (SV64-95) and FBNYV (SV66-95) using artificial inoculation with the aphid vector *Acyrthosiphon pisum* (10-15 viruliferous aphids per plant). Genotypes tested were planted in the field in two replicates, each represented by two one-meter rows, with 35 plants per meter in a randomized complete block design (RCB) for both the inoculated and non-inoculated treatments. Yield loss (%) and symptoms severity (SS) (0-3 scale) based on symptoms produced were determined for all the genotypes tested and are summarized (Table 1 and 2). Based on these results it was possible to group the genotypes tested into four categories: (1) Highly resistant: genotypes which did not produce symptoms (SS=0) and grain yield loss (%) was less than 10%; (2) Resistant: genotypes where SS=1 and grain yield loss was less than 25%; (3) Moderately resistant: genotypes where SS=2 and grain yield loss was less than 50%; (4) Susceptible genotypes: which had a yield loss of above 50% and SS=3. Results obtained from this growing season and the last three growing seasons suggested that many genotypes were resistant to BLRV. Moreover, four genotypes were found resistant to BLRV for two years (ILL 2684, 7203, 7513, 7659), three genotypes (ILL 85, 213, 6816) were found to be resistant to BLRV and FBNYV for three years and two genotypes (ILL 74 and ILL 75) were resistant for four years to BLRV and FBNYV. Work conducted on some of the highly resistant genotypes showed that virus multiplication and movement in such genotypes was greatly reduced.

Table 1. Variability in yield loss (%) and symptom severity* among lentil genotypes in response to infection with *Bean leaf roll virus* (BLRV) (SV 64-95) evaluated during 1999/2000 growing season.

Lentil Genotypes	Yield loss (%)
ILL 74, 75, 2684, 5604, 6258, 6818, 7115, 7203, 7204, 7219, 7285, 7502, 7513, 7543, 7657, 7659, 7661, 7701, 7986, 7988, 7990, 8123, 8613, 8615	1-10
ILL 5490, 6264, 7163, 7200, 7207, 7547, 7657, 7706, 7716, 7981, 7981, 8104, 8105, 8106, 8118, 8120, 8121, 8125, 8126, 8616	11-25
ILL 2439, 5782, 6002, 6207, 6258, 6467, 7701, 7177, 7719, 8119, 8128, 8140, 8142, 8186,	26-50
ILL 8127	51-100
	Symptoms severity (0-3)
ILL 74, 75, 2684, 5604, 6258, 6818, 7115, 7204, 7219, 7502, 7513, 7543, 7657, 7659, 7661, 7701 7988, 7990, 8123, 8613, 8615	0
ILL 5490, 6264, 7163, 7200, 7207, 7547, 7657, 7706, 7716, 7981, 7981, 8104, 8105, 8118, 8120, 8121, 8125, 8126, 8616, 7203, 7285, 7986	1
ILL 2439, 5782, 6002, 6207, 6258, 6467, 7177, 7701, 7719, 8106, 8119, 8128, 8140	2
ILL 8127, 8142, 8186	3

* Symptoms of infected plants was measured based on BLRV symptoms (yellowing + stunting) severity, using a 0-3 scale (0, no symptoms and 3, severe symptoms).

3.10. International Testing Program

The international testing program on lentil is an instrument for the distribution of genetic materials and improved production practices, in the form of international nurseries, to the national programs all over the world. The genetic materials comprise segregating populations, and elite lines with wide or specific adaptation, special phenotypes, and resistance to common biotic and abiotic stresses. A list of nurseries supplied in the 2000/2001 season is given in Table 3.

Table 2. Variability in yield loss (%) and symptom severity* among lentil genotypes in response to infection with *Faba bean necrotic yellows virus* (FBNYV) (SV 66-95) evaluated during 1999/2000 cropping season.

Lentil Genotypes	Yield loss (%)
ILL 74, 75, 2439, 2684, 6258, 6264, 6818, 7204, 7207, 7219, 7285, 7657, 7657, 7659, 7661, 7701, 7701, 7716, 7719, 7988, 7990, 8105, 8119, 8120, 8123, 8128, 8140, 8142, 8613, 8615	0
ILL 5490, 5604, 6002, 6467, 7200, 7203, 7547, 7981, 7986, 8106, 8127, 8616	1-10
ILL 6207, 6258, 7163, 7177, 7513, 7543, 7981, 8104, 8118, 8121, 8125, 8126	11-25
ILL 5782, 7115, 7502, 7706, 8186	26-50
	Symptoms severity (0-3)
ILL 74, 75, 2439, 2684, 6264, 6818, 7204, 7285, 7657, 7659, 7661, 7701, 7701, 7716, 7719, 7990, 8105, 8119, 8120, 8123, 8140, 8613	0
ILL 5490, 6002, 6258, 7203, 7207, 7219, 7547, 7657, 7981, 7986, 8106, 8127, 8142, 8615, 8616	1
ILL 6207, 6467, 7163, 7177, 7200, 7513, 7543, 7988, 8104, 8118, 8121, 8125, 8128,	2
ILL 5604, 5782, 6258, 7115, 7502, 7706, 7981, 8126, 8186	3

* Symptoms of infected plants was measured based on FBNYV symptoms (yellowing + stunting) severity, using a 0-3 scale (0, no symptoms and 3, severe symptoms).

The international testing program helps in identification of genotypes with specific and wide adaptation. The performance data permit assessment of genotype x environment interaction and help in targeting breeding efforts for specific agro-ecological conditions.

The salient features of the 1998/99 international nursery results received from cooperators are presented here. The stability analyses of some of the trials were done using Eberhart and Russell (1966) model.

Table 3. *Distribution of Lentil International Nurseries to Cooperators in 2000/01.*

International nursery	No. of sets
Elite Nursery, Large-Seed (LIEN-L-01)	47
Elite Nursery, Small-Seed (LIEN-S-01)	36
Elite Nursery, Early (LIEN-E-01)	32
F_5 Nursery, Large Seed (LIF_5N-L-01)	26
F_5 Nursery, Small Seed (LIF_5N-S-01)	17
F_5 Nursery, Early (LIF_5N-E-01)	14
F_5 Nursery, Cold Tolerance (LIF_5N-CT-01)	19
Cold Tolerance Nursery (LICTN-01)	13
Drought Tolerance Nursery (LIDTN-01)	35
Ascochyta Blight Nursery (LIABN-01)	17
Fusarium Wilt Nursery (LIFWN-01)	29
Rust Nursery (LIRN-01)	14
Total	289

The international testing program for lentil screening nurseries contemplates four kinds of nurseries: one for large seed (LISN-L), one for small seed (LISN-S), one for southerly latitudes genotypes (LISN-SL), and another for drought tolerance (LISN-DT).

The Lentil International Screening Nursery-Large (LISN-L-99) was distributed to 43 locations (25 countries) but field data were reported from 20 locations (11 countries). The five entries with the best ranks across locations were: FLIP 97-1L, FLIP 97-8L, Local check, Siluima Inta, and FLIP 97-4L. Few test entries exceeded the local check by a significant margin ($P \leq 0.05$) only at Gelline and Hama (Syria). The results of the stability analysis for seed yield showed that the entry FLIP 97-5L was generally adapted across environments, and the entry FLIP 97-1L exhibited adaptation across favorable environments.

The Lentil International Screening Nursery-Small (LISN-S-99) was distributed to 40 locations (24 countries) but field data were reported from 21 locations (12 countries). The five entries with the best ranks across locations were: FLIP 98-15L, FLIP 98-29L, FLIP 98-2L, FLIP 97-15L, and FLIP 95-29L. A number of test entries exceeded the local check by a significant margin ($P \leq 0.05$) at Ardabil (Iran), Quetta (Pakistan), and at Gelline, Hama and Harran (Syria). The entries FLIP 95-27L, FLIP 98-18L and FLIP 98-11L were generally adapted across environments, the entry FLIP 98-15L showed adaptation to the favorable environments, while the entry FLIP 95-29L exhibited adaptation to less favorable environments.

The Lentil International Screening Nursery-Southern Latitudes (LISN-SL-99) was distributed to 27 locations (16 countries) but field data were reported from seven locations (four countries). The entries with the best ranks across locations were: 88527, 91516, FLIP 97-33L, and FLIP 97-31L. The results of the stability analysis for seed yield showed that the entries 88527 and 91516, had general adaptation across environments. The entry Bari-Masur-4 was the earliest to flower (96 days) followed by FLIP 86-50L, FLIP 97-29L and DPL-44 (97 days).

The Lentil International Screening Nursery-Drought Tolerance (LISN-DT-99) was distributed to 36 locations (14 countries) but field data were reported from 11 locations (nine countries). The best entries across all the locations were: FLIP 95-63L, FLIP 99-11L, FLIP 96-53L, and FLIP 95-61L. The entry FLIP 99-11L, was generally adapted across environments. The entry FLIP 96-53L was the earliest to flower (99 days), followed by FLIP 86-51L (100 days).

The results of Lentil International F_5-Nursery Small (LIF_5N-S-99), Lentil International F_5-Nursery Large (LIF_5N-L-99), Lentil International F_5-Nursery Southerly Latitudes (LIF_5N-SL-99), and Lentil International F_5-Nursery Cold Tolerance (LIF_5N-CT-98) revealed that at most of the locations individual plant selections were made at most of the places for progeny row evaluation in the next year. The results of Lentil International Ascochyta Blight Nursery (LIABN-99), were received from two locations but uniform and high disease incidence was present only at General Toshevo (Bulgaria). The results of Lentil International Fusarium Wilt Nursery (LIFWN-99), and Lentil International Rust Nursery (LIRN-99) were received from six and one location respectively, but uniform and high disease incidence was not present at any of the location.

Major Varietal releases in 2000: The following four varieties were released for general cultivation:

Syria: Idleb-2 (ILL 5883)
Lebanon: Rachayya,
Lesotho: FLIP 84-99L; FLIP 86-51L; FLIP 92-48 L
Afghanistan: ILL 5582 and ILL 7180.

3.11. Distribution of Targeted Segregating Populations to NARS

As a part of decentralized breeding strategy, specific crosses were commissioned on NARS demand using improved landraces and released varieties in respective countries. The following F_5 populations were supplied as special dispatch.

- Turkey-7 (cold tolerance)
- Bangladesh-9 (extra-early, rust resistance)
- Yemen-5 (bold-seeded, ascochyta blight resistance)
- Nepal-9 (wilt resistance, early)

3.12. Farmer-Participatory Varietal Selection

Fifty advanced lines adapted to the Mediterranean environments were grown in farmers' fields in three villages in intensive lentil-growing regions in Syria. The farmer who offered the land was responsible for agronomic management of the crop and is termed as "lead farmer". At maturity, the lead farmer and other farmers took part in selection. The farmers emphasized the traits like plant height, standing ability, disease reaction, seed size, color, seed-coat color, seed shape and maturity. Considering these traits, the farmers were advised to rate the lines on a 1 to 5 scale (1=excellent, 5=very bad). Twenty farmers took part in selection in Ebtin and eight lines received 1 score from all the farmers. At Soran, 18 farmers were involved in selection and they selected 10 best lines with 1 rating. At Tel Rafat, 17 farmers participated in selection and 10 lines were scored at 1 rating. The farmers of Ebtin and Soran selected all red lentils and 80% was common among the best lines. On the contrary, the farmers of Tel Rafat chose 70% (7 lines out of 10 best lines) yellow lentils. This is explained by the fact that Tel Rafat being high rainfall area (350-400 mm), the farmers traditionally grow large-seeded yellow lentils. The best selected lines by the farmers will be included in on-farm testing over years and across locations by the Syrian national breeding program.

3.13. Demonstration of Lentil Harvest Mechanization

Lentil area in some countries has been declining in the recent years due to high hand-harvest cost. About 47% of total cost of lentil production is required for manual hand harvest. As lentil straw is a valued animal feed, the farmers in the region are willing to use cutter bar harvest system. In collaboration with General Organization for Agricultural Mechanization (GOAM), lentil harvest by side-mounted double knife cutter bar was demonstrated in Syria. This was combined with the varietal suitability for machine harvest. The newly released variety in Syria, "Idleb-2" having good standing ability was compared with the local variety. Efficiency of the machine was demonstrated compared to hand harvest. About 75 farmers from adjacent villages, Extension Directorate and GOAM personnel, and ICARDA scientists participated in demonstration.

3.14. Inheritance and Mapping of Winter-Hardiness Genes in Lentil

Lentil is traditionally a spring-sown crop grown on approximately 400,000 hectares in the highlands of West Asia, where yields are generally poor. Late-autumn sowing of winter-hardy cultivars can lead to major yield increases estimate at >50% by making better use of available water from winter rain. Therefore, development of winter-hardy variety is a major focus of lentil improvement programs for that region. The major objectives of this study are to determine genetic control of winterhardiness and their genetic map position, use of identified markers to predict winterdhardiness in the other populations and to establish a rapid and accurate artificial freezing test for evaluation of lentil breeding material for cold tolerance. Research is underway in collaboration with Washington State University, Pullman, USA and Central Research Institute for Field Crops, Ankara, Turkey.

From 1997/98, 1998/99 and 1999/00 field and laboratory studies, a genetic linkage map on population 6 (WA864909 x Precoz) was constructed, using AFLP, RAPD and ISSR markers. A total of 250 molecular markers were scored to use in QTL analyses. The QTL analyses revealed one major and one minor QTL, and a total of nine linkage groups were detected for winterhardiness.

Phenotypic associations were weak between winterhardiness, seed weight and flowering time. However, strong genotypic association was observed between winter-injury and seed size (0.254**), leaf size (0.333**) and flowering (0.210*) Leaf size and seed size are also significantly correlated (0.611**). Development of large-seeded and early-flowering genotypes can be achieved at the expense of diluted winterhardiness and mutual relationship found to exist between winterhardiness, late flowering and small seed. Significantly positive correlation between freezing tolerance and winter survival has been observed from data obtained from Pullman, Ankara in all the three seasons. Major genes for these traits are located on different chromosomes.

3.15. Development of DNA Markers for Sitona Resistance

In West Asia, the major insect pest of lentil is pea leaf weevil (*Sitona crinitus*). This insect causes considerable yield loss in lentil, through damage of nodules. No source of resistance against this insect has been found in cultivated lentil while different levels of tolerance and resistance has been detected in the wild relatives. *Lens culinaris* subsp. *orientalis,* which is considered the progenitor of cultivated lentil and is fully crossable with the cultigen *Lens culinaris* supsp. *Culinaris*.

The long term objective of the work is to transfer the resistance to *Sitona crinitus* H. from *Lens culinaris* subsp. *orientalis* to cultivated lentil through interspecific cross with the support of the molecular markers. Germplasm of the cultigen and its progenitors, *Lens culinaris* subsp. *orientalis* were screened for the resistance against *Sitona crinitus*, 18 accessions displayed different levels of tolerance and one of them (ILWL359) showed a complete resistant to *Sitona crinitus*.

3.15.1. Identification of Molecular Markers

Fourteen susceptible, seventeen tolerant and one resistant accessions from the wild species *Lens culinaris* subsp. *orientalis* were used in this study and compared with the susceptible cultivar, ILL5883. DNA was extracted from individual plants. The molecular techniques used in this study were Random Amplified Polymorphic DNA (RAPD), oligonucleotide fingerprinting using microsatellitte sequences as labeled probes, and Amplified fragment length polymorphism (AFLP)

3.15.2. RAPD Analysis

Three different DNA samples, representing the three different situations in the genotypes (Susceptible, tolerant and resistant against *Sitona critinus*), were used to detect polymorphism. 410 Operon primers were tested, 31.9% of primers gave smear or didn't amplify any sequences, 40.2% of primers amplified monomorphic fragments and 27.8% of primers were able to detect polymorphism between the analyzed accessions. The 114 polymorphic primers were considered promising because they were able to detect polymorphism between the three analyzed genotypes. Therefore, these primers were applied to all other accessions. Out of 82 primers used only three primers (OPJ-01, OPP-01 and OPC-13) were able to distinguish between the resistant and susceptible accessions. With primer OPJ-01, only the plants of the resistant accession possessed a fragment (about 450 bp). The experiments were repeated several times and with different reaction conditions and the results were reproducible.

3.15.3. Fingerprinting with Microsatellite DNA

DNA fingerprinting using the DNA microsatellites as labeled probes for hybridization were also used to detect polymorphisms between resistant and susceptible accessions. Four accessions with different level of resistance against *Sitona* were tested. The restriction enzymes used in the preliminary analysis were: EcoRI, EcoRV, BamHI, DraI, TaqI, BamHI+HindIII, EcoRI+HinfI. Hybridizations were carried out with the deoxygenated labeled oligonucleotide probes $(GATA)_4$, $(GACA)_4$, $(AATT)_4$, $(GGAT)_4$, $(AAC)_5$, $(GT)_8$, $(ACG)_5$, $(AAAT)_4$, $(AG)_8$.

All tested combinations detected polymorphism between the different plants and the genetic variability detected between the analyzed accessions varied from one probe to another. The probes $\{(GATA)_4, (GACA)_4\}$ gave very clear results and high level of variability. The results with the restriction enzymes HinhIII+BamHI, EcoRI+HinfI, TaqI, are informative and will be applied to all other accessions.

3.15.4 Amplified Fragment Length Polymorphic (AFLP) Analysis

DNA of different accessions, were tested for AFLP polymorphisms. DNA was digested with restriction enzymes

PstI/MseI and the selective amplifications were carried out with the combinations P81/M182, P100/M62 and P16/M62. The presence of some specific fragments, which are present only in the resistant accession were revealed by the amplification and were tested for their specificity.

A number of markers have been identified that provide polymorphism between resistant and susceptible accessions. The RAPD markers OPJ-01, OPP-01 and OPC-13 will be tested in a higher number of plants to assure the presence of the specific fragment in all resistant plants and its absence in all susceptible and tolerant plants. For the oligonucleotide fingerprinting, the promising combinations (enzyme/probe) will be applied to all the accessions used in this study to determine the best and the more specific combination. For the AFLP technique, other selective primers will be tested.

Output 4: Lentil: Transgenic Lentils with the Appropriate Bt Toxin Gene to Control Sitona Weevil and Herbicide Resistance for Orobanche Control Produced.

4.1. Development of Transformation- and Regeneration Systems for Lentils

The objective of this study is to develop a regeneration and transformation system for lentil. Due to the lack of biosafety regulations in Syria, the current work is being carried out at the Agricultural Genetic Engineering Research Institute (AGERI) as a collaborative project between CLIMA, Australia and ICARDA. At AGERI, 22 transformation experiments have been conducted so far. For these experiments the three lentil lines ILL 5588 (Northfield), ILL 5582 (Idleb-1) and ILL 5883 (Idleb-2) were used to set up the transformation system and to test its efficacy. Initial transformation experiments were carried out using the pCGP1258/Ag10 construct on ILL 5588 and compared with the results obtained for the other two lentil lines used (Table 4).

Of this first set of experiments only ILL5582 yielded explants that survived 12 rounds of selection on Basta containing-medium (Table 4). These explants could be transferred to routing medium and provide the stocks for potential transgenic plants. Other experiments have been set up using the pROK2/GST construct, harboring a drought resistance gene from wheat, obtained from Dr A. Markis of

MAICh (Mediterranean Agronomic Institute of China), Crete, Greece (Table 5).

Table 4. Results of 19 lentil transformation experiments with 1258/Aglo.

ILL	No. of Expts.	GUS-assay	SC[1]	SM1[2]	SM3	SM5	SM7	SM9	SM12	RM[3]
5588	8	0.77	1368	987	423	119	34	3	ND[4]	ND[4]
5883	5	0.73	871	573	231	37	33	2	0	0
5582	6	0.76	967	768	319	125	25	5	2	2(12)
Total	19	0.75	3206	2328	973	281	92	10	2	2(12)

SC[1] Number of explants placed on co-cultivation medium
SM[2] Number of explants placed on selection medium 1, 2 etc.
RM[3] Number of explants placed on rooting medium
ND[4] No data available yet

Table 5. Preliminary Results of 2 lentil transformation experiments with pROK2/GST sense conducted at AGERI.

Lentil Line (ILL)	# Experiments	SC[1]	SM1[2]	SM2	SM3	SM4
5588	3	500	441	222	47	ND[3]

SC1 Number of explants placed on co-cultivation medium
SM[2] Number of explants placed on selection medium 1, 2 etc.
ND[3] No data available yet

Major Achievements (milestones) in 2000:
Progress has been made in the development of transgenic lentils.

Output 5: Kabuli Chickpea: Germplasm with Large Seed, Durable Sources of Resistance to Ascochyta Blight, Fusarium wilt, Insect Pests, Cold and Drought in those Combinations Required by the Target Environment Produced.

5.1. Introduction

ICARDA has a mandate for the improvement of Kabuli chickpea and works jointly with ICRISAT, India. The main objective of the program is to increase and stabilize kabuli chickpea production in the developing world. The Mediterranean region and Latin America produce mostly kabuli-type and in addition 5 to 10% of the area in the Indian subcontinent, East Africa, and Australia is also devoted to production of the kabuli type. The kabuli chickpea is also grown at high elevation areas (>1000 m elevation) in West Asia, especially in Afghanistan, Iran, Iraq, and Turkey; and in the Atlas Mountains of North Africa.

Ascochyta blight and fusarium wilt, are the two important diseases of chickpea. Leaf miner in the Mediterranean region and pod borer in other regions, are the major insect pests. In some areas the nematodes and viruses also effect the chickpea production. Among abiotic stresses, drought is the major abiotic stress throughout the chickpea growing areas and cold assumes importance in Mediterranean environments and the temperate region especially for winter-sown crop. The kabuli chickpea is mainly grown as a rainfed crop in the wheat-based farming system in areas receiving between 350 mm and 600 mm annual rainfall in the West Asia and North Africa (WANA) region. In Egypt and Sudan, the crop is only grown with supplemental irrigation and in South Asia, West Asia and Central America; a small part of area is grown with supplemental irrigation.

In WANA, where the crop is currently spring-sown, yield can be increased substantially by advancing sowing date from spring to early winter. Early spring or winter sowing results in increased productivity, and increased plant height which also allows the crop to be mechanically harvested.

To stabilize chickpea productivity the efforts are underway at ICARDA to breed cultivars resistant to various diseases (Ascochyta blight and fusarium wilt), insect pest (leaf miner), parasite (cyst nematode), and cold and drought. The exploitation of wild Cicer species for widening the genetic base of chickpea and transfer of genes for resistance to different stresses are receiving high research priority at the Center. DNA fingerprinting in *Ascochyta rabiei*, development of genetic markers for MAS, and chickpea transformation, are being pursued for mapping the pathogen variability, improving the selection efficiency, and combating Ascochyta blight.

During 2000, several collaborative projects continued to operate. Studies on characterization of chickpea genotypes and *Ascochyta rabiei* isolates using restriction fragment length polymorphism (RFLP) are carried out in collaboration with the University of Frankfurt, Germany. Research on the development of irrigation-responsive

cultivars is being conducted with the Agriculture Research Center, Giza, Egypt. Fusarium wilt resistance screening was done in association with the Department of Plant Pathology, University of Cordoba, Spain. The screening for cyst nematode resistance is carried out in association with the Institute of Agricultural Nematology, C.N.R. Italy. The project on development of kabuli chickpea for the Mediterranean Environments similar to West Australia and Izmir is carried out in collaboration with Aegean Agricultural Research Institute (AARI) Izmir, and Australian Council of International Agricultural Research (ACIAR).
Specific objectives in the development of improved germplasm for different regions are:

1. Mediterranean region: (a) Winter-sowing: resistance to Ascochyta blight, tolerance to cold, suitability for machine harvesting, medium to large seed size; (b) Spring sowing: cold tolerance at seedling stage, resistance to Ascochyta blight and fusarium wilt, tolerance to drought, early maturity, medium to large seed size.
2. High elevation areas: Spring-sowing: cold tolerance at seedling stage, resistance to Ascochyta blight, terminal drought tolerance, early maturity, and medium to large seed size.
3. Indian subcontinent *and east Africa*: Resistance to Ascochyta blight and/or Fusarium wilt, drought tolerance, early maturity, small to medium seed size, response to supplemental irrigation.
4. Latin America: Resistance to Fusarium wilt and root rots, and large seed size.

Major strategic research projects are:

1. Exploitation of wild Cicer species for transfer of resistance genes for cold and cyst nematode, and for widening the genetic base of chickpea.
2. Pyramiding of genes for resistance to Ascochyta blight.
3. Identification of races of Fusarium wilt in the WANA region.
4. Development of molecular markers and tagging these for economically important traits and using these for improving the efficiency of selection for these traits.

5. Development of transgenic chickpea with resistance to Ascochyta blight and other stresses.

5.2. Tagging DNA Markers for Ascochyta blight Pathogen

5.2.1 Identification of Markers Linked to *Ascochyta rabiei*

Recombinant inbred lines (RILs) derived from the cross ILC 1272 x ILC 3279 were used to identify markers linked to Ascochyta blight. ILC 3279 is highly resistant and ILC 1272 susceptible to pathotype II of *Ascochyta rabiei* pathogen. This population has been mapped with 67 polymorphic microsatellite markers. LG1 contains 7 markers, (42.5 cM), LG2 7 markers, (89.9cM), LG3 5 markers (27.8 cM), LG4 6 markers (117.8cM), LG5 8 markers (47.3 cM), LG6 5 markers (12.8 cM), LG7 7 markers (52 cM), LG8 5 markers (19.6 cM). The evaluation of resistance to the isolate could classify the RILs to two classes, susceptible and resistant. The observed segregation for the resistance indicated that two recessive genes control the resistance. One of the loci could be mapped in linkage group3. Further markers are required to map additional loci. Unfortunately, only microsatellite markers seem to reveal polymorphism between two closely related breeding lines.

5.2.2 Development of Microsatellite Markers

It has been demonstrated that expressed-sequence tags (ESTs) are a good source of microsatellites and these microsatellites are polymorphic across cultivars, (Vitis spp) and even between the related genera. Therefore, the dbEST section of GeneBank provides not only the opportunity for discovery of novel genes but also a novel source of microsatellites that are physically associated with coding regions of the genome. Extensive EST collections already exist for soybean (147,859), *Arabidopsis* (112,500), rice (70,969), *Medicago* (101,752), maize (76,069) etc. These tags are available in the public domain. To develop sequence tagged microsatellites several (TAA)n containing EST were identified from the soybean dbEST section of GeneBank. From the ESTs with more than 12 repeat size were picked and primers were designed for 17 of them. Further work in this direction will be continued for several other microsatellites and other sources of ESTs. Simultaneously, a pilot experiment was conducted to develop microsatellites from genomic chickpea clones. Small insert genomic library of chickpea was screened for (TAA)n microsatellites. Fifty positive clones were fished out from the library. About 20 of these clones were sequenced. With the sequence information of 9 clones, primers were designed for the flaking unique sequences. Further work in this direction is in progress. Developed STMS markers will be applied to chickpea as well as lentil lines for identification of polymorphic markers.

5.3. Development of Protocol on Transformation and Regeneration for Ascochyta blight Resistance at AGERI

5.3.1 Development of a Transformation System for Chickpea

A robust and reliable *Agrobacterium*-mediated transformation system for chickpea was developed in recent years at the University of Hannover, in the group of Prof. H.J. Jacobsen. The protocol has been successfully adapted by different scientists and also on different varieties including desi-types. The established protocol combines a simple and efficient regeneration process by thiadiuruzon (TDZ)-induced multiple shoot formation (minimizing the need for sophisticated tissue culture procedures), an easy-to-prepare and always available ex-plant (minimizing the risk of contamination and allowing easy experimental planning) and the reliability and efficiency of *Agrobacterium*-mediated gene-transfer.

5.3.2. Development of afp- and vstl Harbouring Binary and Relaxed Plasmids

All the available anti-fungal protein (*afp)* constructs are provided with a *npt* II gene for kanamycin selection of putative transgenic plants. Because of the patent rights on the *pat/bar* genes and because it was also possible to recover transgenic plants by kanamycin selection we used only nptII-furnished vectors in combination with the *afp*-genes. The pHK vst construct, harbouring a *stilbene synthase* gene (*vst*1) from *Vitis vinifera* in combination with a *bar* gene was transferred to AGERI (Egypt) for transformation.

5.3.3. Transgenic Chickpea Prototypes: Expression and Hereditary Analysis

For the varieties FLIP 82-150C, FLIP 82-105C, FLIP 88-85C as well as ILC 482 and ILC 3279, no significant differences were detectable by transient *gus* expression assays, the explants behaved similar also in tissue culture.

In the first 11 transformation experiments with 5128 explants we followed exactly the presented protocol (Annual report 1999). Here we used the new variety FLIP 88-85C besides our internal standard ILC 482 (on which the protocol was established) for the transfer of the *Stilbene synthase* gene (*vst1*). Only two of 11 experiments gave rise to the presumption that transgenic plants could be emerged. One failed and the other one is still on shoot induction medium containing 5 mg/l ppt. Till today, we could not recover intact shoots from the completely vitrified meristematic explants although a propagation is possible. Vitrification was not identified as the major problem but the stunted growth of the explants due to TDZ. So we were forced to modify the protocol. In the modified protocol only during the co-culture phase 10μM TDZ is supplemented to the medium. In all the subcultures 1 mg/l BAP and 0,01 mg/l IBA is used. This phytohormone regime promotes a multiple shoot development without shoot elongation inhibitory side effects.

Following the modified protocol the variety FLIP 88-85C was inoculated with the Agrobacterium strain EHA 105 provided with the afp constructs pFAJ 3068 , pFAJ 3033 and pFAJ 3034 (total 1610 expl. in 5 experiments) and subjected them to a kanamycin selection at concentrations between 50-100 mg/l. In another 5 transformation experiments with 1300 explants in total, FLIP 88-85 and ILC 482 varieties were subjected to the modified regeneration protocol. For the transformation the pHK *vst* construct was used.

5.3.4. Chickpea Transformation

FLIP 82-150C and FLIP 88-85C have been used to test the available chickpea transformation system at AGERI. A total number of 34 experiments have so far been conducted with two constructs. The first construct is pCGP1258/Ag10 harboring the gene encoding beta-glucoronidase and the *bar* gene, the second is the pROK2/GST construct harboring a drought resistance gene from wheat, obtained from Dr A. Markis of MAICH (Mediterranean Agronomic Institute of Chaina), Crete, Greece. Preliminary results are shown in Table 6.

Five putative transformants harboring the pROK2/GST construct are ready for rooting and 11 experiments with pCGP1258/Ag1O and pROK2/GST are still ongoing.

5.4. Crossing Chickpeas for Combining Resistance to Different Stresses with Good Agronomic Background

Two hundred crosses were made to combine stress resistance and other agronomic traits. The hybrid seeds from these crosses were advanced to F_2 seed in the off season in the Beqaa valley in Terbol in Lebanon.

5.5. Evaluation of Breeding Materials for Various Biotic and Abiotic Stresses

5.5.1 Biotic Stresses

Among the biotic stresses diseases are major limiting factors for the production of chickpea in the WANA region. Chickpea Ascochyta blight caused by *Didymella rabiei* (Kovach) v. Arx (=anamorph *Ascochyta rabiei* (Pass.) Labr. is a major problem in most chickpea growing region in the world. If advantage of the winter rains is to be taken to almost double chickpea yield in the region as compared to that of later planting, particularly in dry seasons, it is absolutely necessary to control the disease.

Chickpea vascular wilt caused by *Fusarium oxysporum* f.sp. *ciceris* (Padwick) Snyd. & Hans is the most prevalent soil-borne disease of chickpea in the region. It is particularly prevalent on the spring-sown crop when dry and hot conditions favor its development.

In addition chickpea are also effected by nematodes, viruses, and leaf miner but these are localized and don't create heavy yield losses like Ascochyta blight and Fusarium wilt.

Table 6. Preliminary results of chickpea transformation experiments with FLIP 82-150C (Line 1) and FLIP 88-85C (Line 2) at AGERI.

Line	Construct	# Exp.	No. inoculated	No. on Sub 2	No. on Sub 4	No. on Sub 5	No. on Sub 6	No. on Sub 7	Still in culture
Line 1	pCGP1258/Ag1O	11	4057	2475	1521	1192	376	169	0
	pCGP1258/Ag1O	3	1054	699	535	ND*	ND*	ND*	ND*
	pROK2/GST	5	1627	1216	632	517	261	60	0
	pROK2/GST	1	196	146	109	ND*	ND*	ND*	ND*
Line 2	pCGP1258/Ag1O	9	3335	2348	1699	1495	708	471	0
	pCGP1258/Ag1O	2	575	261	197	ND*	ND*	ND*	ND*
	pROK2/GST	3	882	798	383	199	40	27	5
Total		34	11726	7942	4693	3403	1385	727	5

- ND: no data yet available

(a) Screening for Ascochyta Blight Resistance

The use of host plant resistance continues to be the backbone of Ascochyta blight disease management at ICARDA. For disease development in the Ascochyta blight nursery field the infected chickpea debris collected from previous season is spread in the field early in the growing season to initiate the disease and spore suspensions (350.000 spore/ml) of the most prevalent pathotypes (Pathotype I & II) are sprayed later at a rate of 50 l/ha. The field is equipped with mist irrigation system to create conditions conducive for disease development. Lines showing field resistance are re-screened under controlled conditions in the plastic house using Pathotype III, the more virulent pathotype of the pathogen.

Evaluation of breeding materials: The reactions of the F_2-F_7 segregating populations to Ascochyta blight during the 1999/2000 cropping season are presented in Table 7. Out of the 12301 breeding material evaluated in these generations, 5.5% were highly resistant with a rating of 3 on a 1-9 rating scale, 20.5% were resistant with a rating of 4 and 24.6% showed intermediate reactions with a rating of 5. All the others were susceptible. Within the resistant by resistant (RxR) cross populations in the gene pyramiding trials, many of the F_6 (82%) and F_7 (63%) material were rated as highly resistant indicating the efficiency of gene pyramiding method.

Table 7. Reaction of different breeding materials and elite lines to Ascochyta blight resistance under field conditions at Tel Hadya, 1999/2000

Breeding lines	Reaction on (1-9) scale)										
	1	2	3	4	5	6	7	8	9	Total	
F2	0	0	2	25	43	31	5	2	0	108	Crosses
F3 BULK	0	0	0	3	21	33	30	10	0	97	Crosses
F3 PROGL	0	0	0	141	362	891	755	484	457	3090	
F4 PROG.	0	0	23	532	1014	798	328	80	81	2856	
F4 PROGL.	0	0	0	15	62	88	59	13	2	239	
F4 TER AB.	0	0	51	351	558	791	471	140	47	2409	
F5 LARGE	0	0	3	86	66	37	5	3	1	201	
F5 PROG.	0	0	6	1276	846	336	39	7	7	2517	
F6RXR BIO.	0	96	221	42	24	20	4	0	0	507	
F7 RXR	0	57	119	59	26	16	0	0	0	277	
Total	0	53	425	2530	3022	3041	1696	739	595	2301	

Evaluation of elite lines: Among the 40 lines screened in the Chickpea International Ascochyta Blight Nursery (CIABN), 23 lines (FLIP 96-48C, FLIP 96-75C, FLIP 96-76C, FLIP 97-110C, FLIP 97-127C, FLIP 97-227C, FLIP 97-229C, FLIP 97-89C, FLIP 94-90C, FLIP 94-92C, FLIP 94-99C, FLIP 95-51C, FLIP 95-58C, FLIP 95-60C, FLIP 95-67C, FLIP 95-68C, FLIP 95-69C, FLIP 96-47C, FLIP 96-68C, FLIP 96-69C, FLIP 96-78C, FLIP 97-125C, FLIP 97-84C) with a rating of 3 or 4 rating were resistant. In total, out of the 1347 lines included in international, preliminary, and Ascochyta blight differential trials and evaluated for Ascochyta blight resistance, 192 lines were rated 3 and 296 were rated 4 and were resistant (Table 8).

Table 8. Reaction of elite lines in different trials and nurseries to Ascochyta blight during the 1999/2000 cropping season

	Reaction on (1-9) scale									
Nursery	1	2	3	4	5	6	7	8	9	Total
CIABN	0	0	8	15	15	2	0	0	0	40
DIFF.	0	0	7	3	5	8	0	0	0	23
INT AB.	0	0	74	51	27	50	21	26	16	265
PYT AB.	0	0	100	200	153	189	54	25	46	767
PYT INT AB	0	0	0	3	0	5	39	53	88	188
PYT RXR	0	0	3	24	18	17	1	0	1	64
Total	0	0	192	296	218	271	115	104	151	1347

Screening for Ascochyta blight resistance to pathotype-3 of *Ascochyta rabiei* under controlled conditions: The reaction of 64 advanced breeding lines earlier identified as resistant under field conditions was studied against pathotype-3 (a highly aggressive and less prevalent Pathotype in WANA region) under controlled conditions in the plastic house. In addition, a set of 249 lines of 8 wild annual wild relatives of chickpea were also included in this study. The test entries were rated for reactions to the isolate at 15, 30 and 60 days after inoculation using 1-9 rating scale, where 1=free, 9=killed. Out of the 64 advanced breeding lines, one line, Sel 99TH15042 was highly resistant, 3 lines (Sel 99TH15039, Sel 99TH15063, Sel 99TH15243) were resistant (rating 4), and 16 lines (Sel 99TH15026, Sel 99TH15041, Sel 99TH15045, Sel TH15048, Sel 99TH15050, Sel 99TH15254, Sel TH15278, Sel 99TH15285, Sel 99TH15293, SelTH15294, Sel 99TH15303, Sel 99TH15308, Sel99TH15314, Sel 99TH15317, Sel 99TH15005, Sel 99TH15072) were moderately resistant (rating 5) and others were moderately or highly susceptible. Out of the 249 accessions belonging to eight wild annual *Cicer* species none was rated 4 or less after 60 days after inoculation of Ascochyta blight pathogen. This study indicated that the wild relatives don't possess higher level of resistance to Pathotype 3 as compared to the cultigen.

(b) Chickpea Fusarium Wilt

Trials evaluated for resistance to chickpea wilt in the Fusarium wilt "sick plot" during the 1999/2000 cropping season included, F_2 - F_5 breeding materials, elite lines in preliminary yield trials and international elite nurseries, Chickpea International Fusarium Wilt Nursery, and reconfirmation of resistance in lines selected in the previous season. Percent terminal wilt (% of dead plants) was taken as a criterion to select resistant material (20% killed plants). There was generally good and uniform germination of all the material planted in these trials. Percent terminal wilt (% of dead plants) was taken as a criterion to select resistant material (20% killed plants). There was generally good and uniform germination of all the material planted in these trials. The uniform kill of the susceptible check confirmed uniform distribution of the Fusarium wilt inoculum in the plots. The evaluation of the entries in Chickpea International Fusarium Wilt Nursery revealed that the entries including, FLIP 85-29C, FLIP 85-30C, FLIP 89-14C, FLIP 90-144C, FLIP 90-2C, FLIP 90-74C, FLIP 92-171C, FLIP 93-52C, FLIP 96-153C, FLIP 96-154C, UC 15, FLIP 90-155C, FLIP 91-217C, FLIP 93-28C, FLIP 96-158C, FLIP 91-20C, FLIP 96-157C, ICCV-95506, FLIP 89-73C, FLIP 92-113C, FLIP 92-148C, and FLIP 92-49C, were tolerant. The results for other trials and nurseries revealed that 431 lines possessed rating as highly resistant and in addition 382 lines were resistant (Table 9).

(c) Breeding for Cyst Nematode Resistance *(Heterodera ciceri)* in Chickpea

The chickpea cyst nematode (*Heterodera ciceri*) is an important pest and it effects the chickpea crop in several Middle East countries. Although nematicides can

Table 9. Reaction of elite lines in different trials and nurseries to chickpea Fusarium wilt in Fusarium wilt sick plot at Tel Hadya in 2000.

Trial/Nursery	Disease reaction				
	HR	R	MR	S	HS
Derived inbred lines	53	32	5	3	9
Resistant sources	80	39	0	0	1
Int. Fusarium wilt nursery	14	23	5	2	0
Differential set	5	3	1	0	1
Reconfirmation of experiment	37	62	11	2	3
Resistant Pure Lines	90	16	53	1	0
Elite lines in PYTs	121	147	139	67	231
Elite Lines in International Nurseries	45	83	40	58	171
Elite lines in cold tolerance Nursery	0	0	16	18	154
TOTAL	445	405	270	151	570

satisfactory control the nematode, the use of resistant cultivars is considered to be the most appropriate way of control as it is economical and environmentally safe. Our evaluation of the chickpea germplasm for the chickpea nematode resistance has indicated the lack of resistance in the cultigen. However, the evaluation of wild Cicer species, however, has revealed the resistance is available in some accessions of *Cicer reticulatum*, *C. bijugum* and *C. pinnatifidum*. Among these species, only *C. reticulatum* is easily crossable with *C. arietinum*. We have succeeded in transfer of the Cyst nematode resistance from wild to the cultivated but the first phase introgressed materials are agronomically poor. We are now improving the agronomy of the Cyst nematode resistant selections and the newly developed materials are being evaluated. During the year 2000 we evaluated 2234 F_3, 1851 F_7, and 768 F_8 plants and the results are presented in this report. The nematode infestation was recorded on a 0-5 scale (0=no female on the roots, 1=1-2, 2=3-5, 3=6-20, 4=21-50 and 5=>50 females per root). Plants with rating between 0-2 were considered resistant to *H. ciceri*, those rated 3 moderately resistant and those rated >3 susceptible. Among F_3, only one plant was rated 0, six were rated 1 and 144 rated 2. Among F_7, only two plants were rated as 0, 79 as 1, and 495 were rated 2. Among plants in F_8 generation, 12, 99, and 165 were rated 0, 1, and 2, respectively. Only plants with 0-2 rating were selected to further increase of seeds. The seed obtained from these resistant plants will be grown under field conditions and the plants with possessing good agronomic traits (seed shape, seed size, seed color etc.) will be selected and re-evaluated next season. The nematode sick plot is also being developed for evaluation of derived lines under field conditions so that agronomic traits can also be evaluated simultaneously.

(d) Screening for Bean Leaf Roll Virus (BLRV) and Soybean Dwarf Virus (SbDV) Resistance in Chickpea Genotypes

During the 1999/2000 growing season, 100 chickpea genotypes (including 40 genotypes selected from the previous season proved to be good yielders and highly tolerant to virus infection) were evaluated for their reaction to local isolates of BLRV (SV64-95) and SbDV (SL1-94). All the above plants were artificially inoculated with the virus, using the aphid vector *Acyrthosiphon pisum* (10-15 viruliferous aphids per plant). Reaction of the different genotypes to virus infection was monitored by evaluating per cent of infection (based on the symptoms) and the seed yield. In addition, all these chickpea genotypes were evaluated for their reaction to SbDV under plastic house condition. Reaction of the different genotypes to virus infection was monitored by evaluating % of infection (using TBIA test).

Four genotypes, ILC 71, ILC 102, ILC 359 and ILC 3210 were not free from SbDV infection, one genotype (ILC 303) exhibited 11% infection, 6 genotypes (ILC 300, ILC 328, ILC 1313, ILC 1261, ILC 7192 and ILC 7963) had 12-20% infection, and 22 genotypes had 20-30% infection. All others had 100% infection.

The field results, however, were not very conclusive as there was no consistency of the evaluation of the lines across the two replicates of the experiment. Nevertheless, as a preliminary observation, the chickpea genotypes, namely ILC 296, ILC 348, ILC 385, ILC 519, ILC 9196, ILC 8948 and ILC 9636, were found, more or less, resistant to BLRV infection. None of the chickpea genotypes used in the present study showed resistance to SbDV infection. More work is needed to improve the methodology of screening chickpea for resistance to virus diseases.

(e) Screening Chickpea for Resistance to Leaf Miner

Chickpea leafminer (*Liriomyza cicerina* Rond). is an important insect pest of chickpea in WANA. Yield losses caused by this pest could go as high as 30%. Six hundred chickpea breeding lines (PYT) were evaluated in the field at Tel Hadya for resistance to leaf miner. The lines were planted late in April to allow good natural infestation by the leaf miner. Plants were evaluated on 23 May and on 17 June, on a visual damage score from 1-9, where 1= no mining and 9= many mines in almost all the leaflets (90%) and defoliation of greater than 31%. Fifty-four lines with a visual damage score of 5 or less were selected for further testing and confirmation in 2001.

5.6. Breeding for Abiotic Stresses

Cold and drought are the most important abiotic stresses effecting chickpea crop. Drought is predominant in spring plantings and cold in winter plantings at all stages of growth and drought mainly at the late stage of crop growth. The evaluations of different breeding materials under these stresses are discussed here.

Cold Tolerance: Cold tolerance at seedling, vegetative and pre-flowering stages, is a pre-requisite for winter planting of chickpea and at seedling stage for spring planting. The field screening for cold tolerance is done by planting the chickpea materials early into the autumn in the end of September or beginning of October. The evaluations are done on 1-9 scale, where 1=no visible damage by cold and 9=plant killed by cold. In Chickpea International Cold Tolerance Nursery, six entries namely FLIP 97-115C, FLIP 97-126C, FLIP 97-173C, FLIP 97-230C, FLIP 93-261C, and ILWC 235 exhibited tolerant reaction to cold. During the season 27 F3 bulk populations and 257 F4 progenies were evaluated and individual plants with cold tolerance were selected for further evaluations. The evaluations for cold tolerance of elite entries in different nurseries and trials revealed that 76 and 112 entries had cold tolerant ratings of 4 and 5, respectively. The evaluations under highlands in Maragheh in Iran, showed ILC 8262, was the most cold tolerant line and also possessed high yield under autumn sown conditions. The seed of this cultivar is being multiplied for its general release under Maragheh conditions.

Drought tolerance: A reliable drought screening technique involving delayed sowing by three weeks during spring at a relatively drier site, and preliminary evaluation of the germplasm and breeding materials on 1 (=resistant) to 9

(=susceptible) scale, was used for evaluation of germplasm and breeding materials. In the Chickpea International Drought Tolerance Nursery 40 entries were evaluated at Tel Hadya, one of the entries was rated as 3, 25 as 4 and 15 as 5, showing thereby that all were resistant/tolerant. The lines showing 4 or less rating included ILC 3843, FLIP 87-8C, FLIP 87-58C, FLIP 87-59C, FLIP 87-85C, FLIP 88-42C, ICCV-2, ILC 1792, ILC 1799, ILC 19, ILC 2651, ILC 3101, ILC 3105, ILC 3166, ILC 3182, ILC 3210, ILC 3321, ILC 3458, ILC 3832, ILC 4134, ILC 4236, ILC 4737, ILC 477, ILC 588, ILC 6023, ILC 6119, and were resistant. 360 entries exhibiting up to 5 rating in a non-replicated drought nursery during 1998/99 were re-screened in two replications during 1999/2000. Out of these 7, 77, and 69 entries exhibited 3, 4, and 5 ratings. Four hundred entries included in different international nurseries during 1999/2000 were evaluated in drought tolerance nursery and 47 exhibited tolerance to drought. Among the 680 newly developed lines, 99 were resistant (with 4 rating). Single plant selections were made in F3, and 159 uniform lines with resistance to drought were bulked in F5 for further evaluations.

5.7. Performance of Elite Entries in Different Yield Trials

The performance of newly developed lines were evaluated in 8 trials (576 entries) under winter sowing and 10 trials (678 entries) under spring planting at Tel Hadya; and 7 trials (504 entries) under winter sowing and 8 trials (576 entries) under spring sowing at Terbol (Table 10). At Tel Hadya 144 entries during winter and 129 entries during spring excelled the check in seed yield by a significant margin with average seed yield of 602 Kg/ha for winter and 337 Kg/ha for spring. For Terbol, however, only 15 entries exceeded the check by a significant margin only in winter trials, the mean seed yield across trials during winter was 2289 Kg/ha as compared to spring which gave 2000 kg/ha under Terbol conditions.

5.8. International Testing Program

For the year 2000/2001, 342 sets of 11 different nurseries were supplied to the cooperators in 52 countries (Table 11). The five best entries across locations in different nurseries evaluated during 1998/ 1999 included FLIP 97-

Table 10. Performance of Newly Development lines During Winter and Spring Plantings at Tel Hadya and Terbol 1999/2000

		No. of Entries				Yield		
Location	No. of Trials	Tested	Exceeding Check	Sig. Exceeding Check	Mean of Location	Mean of Highest Entry	C.V %	Range for LSD ($P \leq 0.05$)
				Tel Hadya				
Winter	8	576	284	144	602	999	13.5-24.2	57-249
Spring	10	678	303	129	337	778	19.9-33.3	106-297
				Terbol				
Winter	7	504	131	15	2289	3005	9.9-16.5	367-444
Spring	8	576	20	0	1177	2000	13.3-19.3	362-529

Table 11. Distribution of 2000/2001 Chickpea Nurseries to Cooperators.

International Trial/Nursery	No. of sets
Elite Nursery Winter (CIEN-W-01)	51
Elite Nursery Spring (CIEN-S-01)	47
Elite Nursery, Southerly Latitudes-1 (CIEN-SL1-01)	17
Elite Nursery, Southerly Latitudes-2 (CIEN-SL2-01)	12
Elite Nursery, Latin American (CIEN-LA-01)	17
F_4 Nursery, Mediterranean Region (CIF_4N-MR-01)	26
F_4 Nursery, Southerly Latitudes (CIF_4N-SL-01)	15
Ascochyta Blight Nursery (CIABN-01)	49
Fusarium Wilt Nursery (CIFWN-01)	31
Cold Tolerance Nursery (CICTN-01)	28
Drought Tolerance Nursery (CIDTN-01)	49
Total	342

132C, ILC 482, FLIP 97-158C, FLIP 97-101C, and FLIP 97-62C (Chickpea International Screening Nursery-Winter-Mediterranean Region); FLIP 95-152C, FLIP 95-154C, FLIP 97-232C, FLIP 97-157C, and FLIP 97-167C (Chickpea International Screening Nursery Southerly Latitudes-1). From the Chickpea International F_4 Nursery for Mediterranean Region (CIF_4N-MR) a large number of cooperators selected individual plants, and the most frequently selected populations were X96 TH63, X96 TH45, X96 TH 50, X96 TH 59, X96 TH 60, X96 TH 61, X96 TH 62 and X96 TH 64. Various stress nurseries including Chickpea Ascochyta Blight Nursery, Chickpea Fusarium Wilt Nursery, Chickpea Cold Tolerance Nursery and Chickpea Drought Tolerance Nursery with resistant sources identified at Tel Hadya, were shared with the NARSs. The NARSs tested these materials and identified the resistance materials under their local conditions for their use.

Large quantity of seed of some of the lines, were supplied to NARSs as per their request for multi-location testing and release.

5.9. Farmer's Participatory Selection in Syria and Turkey

Farmers Participatory Varietal Selection was initiated at 2 sites in Syria and 3 in Turkey. This created a big interest in the farmers, and the farmers selected some of the lines for further evaluation in the coming season. In Tavas province in Turkey the Directors of Agricultural Extension and personal from Leb Lebe industry also participated and showed a great interest in the activity.

5.10. On-Farm Trials

On-farm trials were conducted in many countries including Algeria, Egypt, Iran, Iraq, Lebanon, Morocco, Syria, and Tunisia, and Turkey. Some of the high yielding lines were identified for seed increases and registrations. On the basis of On-farm Trials in Syria, FLIP 93-93C which gave high seed yield, possesses tolerance to Ascochyta blight and good seed size was selected for submission to the Ministry of Agriculture for its release for general cultivation in Syria. Similarly another cultivar, ILC 8262 with tolerance to cold and high yield under high altitude site in Maragheh in Iran was identified for registration and seed increase.

5.11. Varietal Identification and Release

To date NARS in 22 countries have released 80 lines as cultivars, from the elite materials, genetic stocks, and segregating populations furnished by ICARDA. Some of the lines namely ILC 8262, Sel 95 TH 1716, and Sel 96 TH 11439, were identified as high yielding under drought and cold conditions in Iran. The cooperators in Eritrea and CAC countries also identified promising lines for their use in multi-location and on-farm evaluation. The seed of these lines will be increased for large scale testing next season. Two cultivars, namely Maddad -99 (FLIP 93-93C) and Sehat-99 (FLIP 93-58C) were released for general cultivation in Afghanistan, and one with the name of Areti (FLIP 89-84C) for general cultivation in Ethiopia. Another cultivar Giza 3 (FLIP 80-120C) was released for general cultivation under irrigated conditions in Egypt.

Output 6: Widening the Genetic Base of Kabuli Chickpea and Introgression of Desirable Genes for Biotic and Abiotic Stresses, High Biomass, and other Important Traits from Wild Annual Wild Cicer Species to the Cultivated Kabuli Type.

6.1. Introgression of Traits from Wild to the Cultigen

The advanced generation materials from the crosses between *C. reticulatum* and cultigen were evaluated for cyst nematode resistance and good resistant plants with kabuli types were identified for increase and evaluation next season.

6.2. Wide Hybridization among Non-Crossable Species

A few seeds were obtained from crosses between *C. arietinum* and *C. bijugum,* and *C. pinnatifidum* which will be tested for their hybridity.

6.3. Mutation for Widening the Genetic Base

The mutated materials were advanced to M2 generation for study of variability during 2001.

Output 7: Faba Bean Gene Pools for West Asia, North Africa, the Nile Valley, and China for Recurrent Selection for Adaptation and High Yield and Biotic Stress Resistance Produced.

7.1. Introduction

Faba bean is an important pulse crops grown for dry seeds and green pods for human nutrition in developing countries, and for animal feed in developed countries. Yield stability and low production are mainly constrained by fungal and virus diseases, parasitic weeds, drought and cold damage. Accordingly, priorities are given to establish a targeted pre-breeding program covering development of improved populations, resistant to various biotic and abiotic stresses in close cooperation with NARS.

7.2. Development of Improved Populations with Multiple Stress Resistance

Ninety-six crosses were made to combine early maturity with resistance to chocolate spot; early maturity with resistance to Ascochyta *blight;* and early maturity with chocolate spot, Ascochyta blight resistance and tannin free seed. Thirty five F1s with combined resistance to chocolate spot with early maturity, and 54 crosses with resistance to Ascochyta blight and early maturity were raised.

7.3. Development of Germplasm Accessions with Resistance to Various Stresses

a) Three F_2 improved populations, 126 F_3 families, and 7 back crosses were grown under the screen houses at Lattakia, under natural and artificial infection in chocolate spot and Ascochyta blight disease nurseries. From these materials 162 single plants with resistance to chocolate spot, 118 plants with combined resistance to chocolate spot and Ascochyta blight, and 152 plants with combined resistance to chocolate spot, Ascochyta blight and Orobanche were selected. The evaluation of International Chocolate Spot Nursery 2000 at Lattakia in Syria and two sites from Egypt (Giza and Sakha) revealed that 16 accessions at Lattakia, 13 at Sakha, and 11 at Giza, were highly resistant to chocolate spot. Across three sites, 8 accessions along with the local checks, were highly resistant.

b) Across three locations, four germplasm accessions, ILB4708, ILB4709, ILB4726 and ILB5323 exhibited combined resistance to chocolate spot and rust and were found promising.

c) The evaluation entries in the International Ascochyta Blight Nursery 2000 at Lattakia, exhibited that four accessions, ILB 3743-D, S96009, S96010 and Ascot, were highly resistant to Ascochyta blight.

d) A nursery with two improved populations, 4 double and 2 back crosses was grown under heavy natural infestation with *Orobanche* at Tel Hadya. The individual plants with resistance to Orobanche were selected for increase and further use. The evaluation of the entries in International *Orobanche* Nursery 2000 grown at Lattakia and Tel Hadya in heavy infected soil revealed that all the twelve test entries included in the nursery exhibited lower number of Orobanche shoots and low dry weight of *Orobanche* spikes/m^2, and were tolerant to Orobanche. At Sids (Egypt), however, differences were not significant among entries for these traits.

7.4. Development of Genetic Stocks

Five lines, 438/440, 1340/1341, 2199/2202, 2693/2696, and 2697/2701, with resistance to Ascochyta blight and cold, and high seed yield developed for sharing with the NARSs.

7.5. Seed Multiplication

A total of 118 accessions (67 resistant to chocolate spot, 33 to Ascochyta blight, and 18 to Orobanche) were increased under the screen houses to maintain their genetic purity.

7.6. Advancing Population

a) S_0 population: The F_2 seed of 18 early crosses made for incorporation of early maturity (A), 17 crosses for resistance to chocolate spot (B); 19 crosses for resistance to chocolate spot and Ascochyta blight(C); 23 crosses with resistance to chocolate spot, Ascochyta blight, and Orobanche; and 7 crosses with resistance to various stresses were planted in isolated field plots, under screen houses at Lattakia. At flowering honey beehive was introduced in each population plot to induce a intercrossing and at maturity, each of these plots was harvested and threshed separately. Plant population for early maturity (A), was grown under the screen house at Lattakia and subjected to random inter-cross pollination by honey bees, however, the three populations (B, C, and D) were subjected to individual plant selections under artificial and natural infection with chocolate spot and Ascochyta blight to select combined resistance.

b) S_1 seed: Seeds of the isolated population plots (B,C, and D) at Tel Hadya along with that produced under the screen house (A) at Lattakia are used, as S_1 population, and shared with NARS for recurrent selection through Faba bean international S_1 population nursery. The results of Faba bean international S_1 population nursery 2000, grown at Lattakia (Syria) and Sids research Station (Egypt) revealed that one S_1 population (HBP/A/EM) at Sids yielded 67.6% more than the local check cultivar (Giza 2), and was followed by two S_1 populations-

HBP/D/B.F+A.F+Orobanche and BP/E/Orobanche, with 20.5% more yield than the local check.

7.7. Faba Bean International Nurseries

A total of 103 sets of chocolate spot, Orobanche, and Ascochyta blight nurseries were supplied to different cooperators for evaluate during 2000/2001. The salient features of the 1998/99 international nursery results received from cooperators are summarized as follows:

- In the Faba Bean Chocolate Spot Nursery (FBICSN-99) the entries, ILB 368-A, ILB 4709, ILB 5284 and ILB 5286 showed resistant reaction (rating $\leq$ 5 on 1-9 scale where 1= free, and 9= plant killed)
- In the Faba bean International Orobanche Nursery (FBION-99) reported from 2 locations, Oued Smar (Algeria) and Beja (Tunisia) most of the test entries showed a lower level of incidence of Orobanche as compared to the local check.

7.8. Screening Faba Bean for Resistance to Aphids

Aphids are the most devastating insects of faba bean in WANA, two most important species are *Aphis craccivora* Koch. and *Aphis fabae* Scpoli. The aphids cause about 50% damage and also transmit the viruses to faba bean crop. Two faba bean populations, NA 112 X R. Blanca, and NA 112 X Giza 2, and 114 F6 lines were evaluated for resistance to aphids under filed conditions at Tel Hadya. The evaluation was based on visual damage score from 1-4, where 1= no damage and 4= severe damage. The results showed that none of the lines tested was resistant to the aphids. A wider germplasm collection of faba bean is being tested in 2001 to try to locate resistance to these pests.

7.9. Screening Faba Bean Genotypes for Bean Leaf Roll Virus (BLRV) and Faba Bean Necrotic Yellows Virus (FBNYV) Resistance

a) **Evaluation of Best Performing Faba bean Genotypes from Previous Seasons:** Screening faba bean for BLRV resistance was conducted in collaboration with Tamworth Crop Improvement Center, NSW Agriculture and with partial support from GRDC, Australia. A total of 180 single faba bean plants selections obtained from 99 genotypes identified in the previous season as highly tolerant to BLRV were re-evaluated for their reaction to a local isolate of BLRV (SV64-95). Similarly, a total of 120 faba bean genotypes (selected from plants of 120 genotypes from the previous season as highly tolerant to FBNYV infection) were also re-evaluated for their reaction to a local isolate of FBNYV (SV66-95) under in a screen house for each virus under artificial inoculation with the virus, using the aphid vector Acyrthosiphon pisum (10-15 viruliferous aphids per plant). Reaction of the different genotypes to virus infection was monitored by evaluating (i) incidence and severity of infection, (ii) virus distribution and concentration (using TBIA test), and (iii) seed yield.

Lines characterized by mild or no symptoms, no or little virus content and good yield were identified. Variability among plants within each genotype existed and seed from selected best performing individual plants were harvested and will be evaluated under screen house conditions during the next season. The lines with 0% infection included, ILB 86//99-In9-S-LR//, ILB 388//99-In1-S-LR//, ILB 426//99-In3-S-LR//, ILB 485//99-In1-S-LR//, ILB 485//99-In6-S-LR//, and ILB 4130//99-In1-O-LR// for BLRV; and for Faba bean necrotic yellows virus (FBNYV) resistance included ILB 603-A//99-B-O-NY//.

b) **Evaluation of New Faba bean Genotypes:** During 1999/2000 growing season, new faba bean genotypes obtained from ICARDA Gene Bank and originated from 23 countries (Afghanistan, Algeria, Australia, Canada, China, Colombia, Czech Republic, Ecuador, Egypt, Ethiopia, Greece, India, Iraq, Lebanon, Morocco, Pakistan, Russia, Spain, Sudan, Syria, Turkey, Yemen and Yugoslavia) were evaluated for their reaction to BLRV (206 genotypes) and FBNYV (270 genotypes) using artificial inoculation of the virus with its aphid vector under field conditions. A number of faba bean genotypes were found to be highly resistant to BLRV and FBNYV infection were identified, and single plant selections of high yielding and immune to infection were made. During the next growing season, all these plants/genotypes will be re-evaluated under screen house conditions.

Output 8: Alternative Plant Types (Independent Vascular System, Determinate and Auto-Fertile Populations) of Faba Bean for NARS and their Recombination with Biotic Stress Resistance.

Due to lack of funds the activities were not initiated for this output.

IV. COLLABORATORS

a. Collaborating Scientists within ICARDA

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TABLE OF CONTENTS

I. PROJECT TITLE: FORAGE LEGUME GERMPLASM IMPROVEMENT FOR INCREASED FEED AND FOOD PRODUCTION AND SYSTEM PRODUCTIVITY IN DRY AREAS. (PROJECT 1.6).

II. EXECUTIVE SUMMARY

The 2000 growing season was constrained by low rainfall and a prolonged period drought with intermittent and inadequate rainfall. The total precipitation was 260, 230, 339, and 335 at the testing sites of Tel Hadya, Breda (Syria), Terbol and Kfardan (Lebanon), which represent 78, 86, 66 and 85% of the long-term average respectively.

New germplasm of *Vicia sativa* was evaluated and the new genotypes showed good adaptation where identified. Selected genotypes of *Vicia sativa* and *Lathyrus sativus* were evaluated in micro plot yield trials at Tel Hadya and promising genotypes were selected for further evaluation in advanced yield trials and for international nursery programs.

Promising elite lines of *Vicia sativa*, *Vicia narbonensis*, *Vicia ervilia*, *Lathyrus sativus* and *Lathyrus cicera* were tested in multi location advanced yield trials. Narbon vetch grain yields measured have averaged 1.2 t/ha and one variety "VELOX" was released in Sicily, Italy for dry areas. Improved lines of *Lathyrus sativus* and *Lathyrus cicera* which combined both high herbage and grain yields were identified. One line of *Vicia ervilia* # 2552 was recommended for release by the Syrian National Program. Successful incorporation of the shuttering resistance character to locally adapted lines of common vetch, through a breeding program enhanced the popularity of the crop.

Selection for early flowering in *Vicia spp.* and *Lathryus spp.* was important for high yielding crops in short-dry season environments. Early flowering and maturity selections from narbon vetch and grasspea showed improved adaptation to low rainfall sites compared with latter flowering and maturity selections. Further improvement in vetches could be achieved by selecting for more rapid development.

A hybridization program was initiated for incorporating the character of low neurotoxin *B*-ODAP content from ICARDA's low neurotoxin into locally adapted land races from Ethiopia, Bangladesh and Nepal. Selection in F_3 onwards resulted in low neurotoxin (<0.15%) and high yielding lines. Also, exploitation of somaclonal variation

has helped in isolating various somaclones. Somaclones with low *B*-ODAP combined with a high yield have been developed. Added zinc to the soil reduced the level of neurotoxin, and the reduction was higher in the high-level neurotoxin lines than those of low levels.

Improved lines of underground vetch can be developed having 50% more herbage yield than the wild types.

III. PROJECT ACHIEVEMENTS

Output 1: Improved Cultivars and Populations of Forage Vetches (*Vicia spp.*) and Chicklings (*Lathyrus spp.*) Adapted to Low Rainfall Areas, Resistant to Biotic and Abiotic Stresses and Suitable for Different End-Uses (Direct Grazing, Hay Making and Grain & Straw).

1.1. Common Vetch Germplasm Evaluation

In 1999-2000, one experiment was conducted at Tel Hadya to assess 100 accession originated from different origins of common-vetch (*Vicia sativa*) in nursery rows in a cubic lattice design with three replicates (6 rows each). The experiment was fertilized with 40kg/ha P_2O_5/ha.

In this trial the accessions were visually scored at 1-9 scale (1=poor: and 9=very good) for cold tolerance, winter growth, spring growth, leafiness, pod shuttering and at full maturity the grain and straw yields were measured. Time to start flowering and full maturity was recorded.
A broad variation was observed for the character studies. The results showed that there was a wide range of adaptation, which was fully documented for reference and future exploitation. Thirty accessions showing good adaptation, drought tolerance and high yield potential were identified as good sources of desirable traits for future breeding program.

We believe that Germplasm is the forage breeder's most valuable natural resources. Therefore, we systematically evaluate large numbers of forage germplasm to identify desirable traits of the species we wish to improve.

1.2. Preliminary Evaluation in Microplot Yield Trials (MYT) for Common-Vetch (*Vicia sativa*) and Grasspea (*Lathrus sativus*)

Objective selection for desirable traits begins in microplot yield traits following nursery rows evaluation for selected genotypes form the individual plant selections and segregated population of the target crosses. Selection continues through advanced yield trials, before regional testing of the selected promising lines by national programs.

In 1999-2000, season two microplot yield trials one of common vetch and one for grasspea were grown at Tel Hadya. The number of entries was 64 for common vetch and 49 for grasspea. These microplot yield trials were divided in two sets each, one was harvested at 50% flowering to determine the herbage yield (DM) and its quality parameters, while the others were harvested at maturity to measure seed and straw yields and other agronomic traits.

Out of the sixty-four selections of common vetch, the top 25 selections which combined both high seed and herbage (DM) production were identified for more critical evaluation. Herbage yield (DM) at 50% flowering varied from 3.5 to 5.0 t/ha, (mean of 4.4 t/ha), total biological yield from 3.6 to 5.9 t/ha (mean of 4.9 t/ha), grain yield from 0.5 to 1.5 t/ha (mean of 0.95 t/ha) and harvest index from 14 to 25% (mean 19%).

Out of the forty-nine selections of grasspea which were tested, the top 16 selections which were combined both high grain and herbage yield (DM) production were identified for more critical evaluation as forage types. Herbage yield from 2.5 to 5.0 t/ha, with a mean of 3.5 t/ha. Seed yield ranged from 0.7 to 1.7 t/ha, with a mean of 0.98 t/ha, whereas the total biological yield ranged from 4.0 to 6.0 t/ha, with the mean of 5.2 t/ha. Harvest index (HI) ranged from 17.5 to 28%. The low values of HI were due to attack by broomrape (*Orobanche Crenata*) damage. Seed yield was negatively correlated with days to flowering ($r = -0.73$, $p<0.01$). Therefore, early maturity entries escaped from broomrape attack and produced high grain yield.

1.3. Advanced Yield Trials (AYT) of Forage Vetches (*Vicia spp.*) and Chicklings (*Lathyrus spp.*)

Elite lines from our breeding program are tested over multiple environments (location & year) for yield performance and consistency. These lines are either progenies of single plants (selections or pure lines), selected from the wild types or selected F_3, F_4, and F_5 families of intra-specific crosses. These lines are selected on the basis of their performance in microplot yield trials for two successive years. Yield of these lines and their relative ranking or consistency in performance in multi-location advanced yield trials form the basis for recommendations to growers.

The growing season of 1999-2000 was constrained by low rainfall and a prolonged period of drought with intermittent and inadequate rainfall. The total precipitation was 260, 230, 339 and 335mm at the testing sites, Tel Hadya, Breda (Syria) Terbol and Kfardan (Lebanon), which represent 78, 86, 66, and 85% of the long-term average, respectively.

1.3.1. Common Vetch Advanced Yield Trials

Forty-nine elite lines of common vetch were tested at Tel Hadya, Kfardan and Terbol. There were large variations between lines within the same location and between locations for winter growth, herbage, biological and grain yields.

In 1999-2000, dry-matter yield at 50% of flowering varied from 2.5t/ha at Kfardan to 4.0 t/ha at Tel Hadya. The total biological yield was greater at Terbol than Tel Hadya and Kfardan. Grain yield varied from 1.1 t/ha at Tel Hadya to 2.2 t/ha at Terbol. Three lines of IFLVS# 2556, 2714 and 2003 showed high adaptation and were the most promising and high yielding across the three locations.

Early flowering and maturity are important characteristics for high yielding common vetch in short-low rainfall environment. Early flowering and maturity selections of common vetch showed improved adaptation and seed yield at low rainfall site of Tel Hadya, compared with late flowering selections. Further improvement of common-vetch could be achieved by selecting for more rapid development and early maturity.

1.3.2. Improving Seed Retention (Pod-Shattering) in Common Vetch)

Little variation in resistance to pod shattering has been observed among existing genetic resources of common-vetch.

Pod shattering in common vetch reduces its popularity as forage legume crop in rotation with cereals. Its seed germinating during the cereal phase of the rotation represent serious "weed problem". Therefore a breeding program to develop non-shattering cultivars suitable for mechanical harvesting was initiated using two natural non-shattering mutants IFLVS# 1416 and #1361, with undesirable agronomic traits. The genetic of pod shattering was studied using parental (P_1, P_2), foliar generations (F_1, F_2) and backcrosses. The results revealed that non-shattering trait is conditioned by a single recessive gene. Incorporation of this gene into agronomically its promising lines was achieved by backcrossing, selfing and selection for non-shattering trait in erect, large and soft seeded and early-matured genotypes. Selection was efficient in obtaining 16 superior lines having 97-99% non-shattering pods compared to 40-60% shattering in the original breeding lines. The non-shattering released cultivar (*Baraka*), IFLVS# 2556 is widely used in Syria, Iraq, Jordan, Lebanon and CAC Countries.

Developing non-shattering cultivars is continuing with the aim to incorporate the erect growth habit to facilitate mechanical harvest. IFLVS#2558 was identified as erect and non-shattering and is also characterized by white flower color, which facilitates maintenance purity of the line.

1.3.3. Narbon Vetch Multi Location Advanced Yield Trials

In 1999-2000 narbon vetch advanced yield trials were sown at three sited (Tel Hadya, Breda in Syria and Kfardan in Lebanon). The total number of the tested lines was 49. Winter growth, biological and grain yields were measured at each site. There were differences in the performance of the tested lines for all the measured traits. Grain yield at maturity ranged from 0.9 t/ha with sel# 2390 at Breda to 2.1 t/ha with sel# 2475 at Kfardan. In general yield were greater at Kfardan than Tel Hadya and Breda. On average across the three sites, five improved lines, IFLVN # 2744, 2387, 2383, 2377, 2380 produced the highest grain yield. IFLVN 2380, was released in Italy under the name of velox and IFLVN # 2383, in Cyprus.

The growing seasons of 1998/1999 and 1999/2000 were constrained by severe drought in the spring. Narbon vetch, proved to have a great potential as forage legume in dry areas. At Breda and Tel Hadya, where rainfall was 230 and

260mm, respectively in 1999/2000 improved lines of narbon vetch produced grain yield up to 1.2 and 1.5 t/ha, respectively. Under these conditions its yield is more than other legumes.

1.3.4. Bitter Vetch Multi Location Advanced Yield Trials

Twenty-five elite lines were tested at Tel Hadya and Kfardan. Herbage yield (DM) ranged from 0.9 to 2.6 t/ha, and from 1.7 to 3.5 t/ha, at Tel Hadya and Kfardan, respectively. Biological and grain yields at Kfardan were greater than Tel Hadya. IFLVE 2522 and 2514 had the greatest ($P<0.05$) seed yield at the two sites. On average across the two sites, selections # 2522, 2514, 2510, 2646 and 2518 produced the greatest seed yield. IFLVE # 2522 is recommended for release by the Syrian national program based on its performance in on-farm trials for four successive growing seasons.

1.3.5. Wooly-pod Vetch Multi Location Advanced Yield Trials

Twenty-five elite lines were tested at Tel Hadya and Kfardan. There were great differences in winter and spring growth, herbage (DM), biological and grain yields within location and between lines. Herbage (DM), biological and grain yields were higher at Kfardan than in Breda. Dry matter at 50% flowering varied from 1.6 to 2.1 t/ha at Tel Hadya and from 3.1 to 3.9 t/ha at Kfardan. IFLVD sel# 2455 had the greatest seed yield at the two locations with a maximum seed yield of 0.98 t/ha at Kfardan. Low grain yield at Tel Hadya was mainly due to delays in the appearance of floral buds, and the drought and heat stress that occurred at bud development, which caused a large proportion of flower and young pools drops and the buds development were inhibited by high temperature in the spring. On average across the two sites sel# 2455, 2436 and 2446 produced the highest herbage and grain yields, followed by sel# 2562 (the released variety at Quetta, Pakistan under the name of Kuhale 96).

1.3.6. Multi Location Advanced Yield Trial of *Lathyrus sativus* and *Lathyrus cicera* as Forage Types

Twenty-five elite lines each of grasspea (*Lathyrus sativus*) and dwarf chickling (*Lathyrus cicera*) were tested at three sites, Tel Hadya, Breda and Kfardan. Table 1 shows herbage, biological and grain yields at the three locations. *Lathyrus sativus* produced the highest herbage yield at Tel Hadya followed by *Lathyrus cicera* at Tel Hadya, whereas, *lathyrus cicera* produced the highest grain yield at Tel Hadya and Breda.

Great variability was observed between species and lines within the same species. The early maturity lines of *Lathyrus sativus* and *Lativus cicera* had high grain yields and the high herbage yield was due to the rapid winter growth during the mild winter of 2000. On average across the three locations four lines of *Lathyrus sativus* (IFLS# 504, 531, 556 and 526), were combined both high herbage and grain yields.

Overall, 1999/2000 was one of the driest years with most areas receiving about 66 to 86 of their long-term mean annual rainfall. The results of the multi location advanced yield trials of *Vicia spp.* and *Lathyrus spp.* showed great differences between the tested locations and among entries within the same location for the tested traits. Considerable genetic variation exists within each species for attributes indicative of yield and its components. The variations could be exploited by appropriate breeding procedures in rain-fed agriculture. Vetch and chickling species showed considerable potential as forage legume crops in the medium and low rainfall areas. The vetches evaluated showed their adaptation to a range of rainfall varying from 230mm at Breda to 339mm at Kfardan. Among the vetch species tested, elite lines of *Vicia sativa* and *Vicia ervilia* showed the most potential in terms of dry-matter and seed yield when rainfall is >300mm (Kfardan and Terbol). All narbon vetch lines had rapid rate of winter and spring growth than other vetches, and proved to have great potential as feed legume crops in dry areas.

At Breda and Tel Hadya, where rainfall was 230 and 260mm, respectively, advanced breeding lines produced grain yield of 1.2 and 1.5 t/ha, respectively. All narbon vetch lines retained the majority of their leaves at maturity at all locations, which increases its nutritive value, when its grain and straw are used for winter flattening.

The utilization of different species varies between regions and growers. Consequently, characters for selection vary according to response to local needs. As forage legumes can be used for direct grazing, haymaking, straw and grain, we can begin to see how the various species will

Table 1. Means and ranges of herbage, biological and grain yields (t/ha) of two *Lathyrus spp.* in advanced yield trials at Tel Hadya (TH), Breda (Br) and Kfradan (Kfr).

Species	Herbage yield (t/ha)			Biological yield (t/ha)			Grain yield	
	TH	Br	Kfr	TH	Br	Kfr	TH	Br
L. sativus								
Mean	4.4	1.9	2.2	4.0	3.0	3.6	0.95	0.8
SE±	0.17	0.17	0.1	0.28	0.16	0.2	0.1	0.09
Range	3.8-5.5)	(0.72-2.5	(1.6-2.2)	(3.4-4.5)	(2.6-3.4)	(2.6-3.9)	(0.76-1.3	(0.4-1.2)
L. cicera								
Mean	4.2	1.7	2.8	4.6	3.7	3.5	1.2	0.9
SE±	0.3	0.16	0.2	0.2	0.19	0.15	0.12	0.6
Range	4.2-5.2)	(1.0-2.4)	(2.3-3.6)	(3.7-5.5)	(2.8-3.8)	(2.6-4.2)	(0.8-1.5)	(0.6-1.2)

(+) Mean for all 25 entries, each species.

meet the farmer's needs in the prevailing farming systems. The high grain and straw yields, cold tolerance and early maturity of narbon-vetch make it ideal feed legume for producing winter stocks of grain and straw for feeding sheep during the peak of feed demand in winter. The long flowering period prostrate to semi-erect growth habit, rapid winter and spring growth, cold tolerance and high herbage production are the most important attributes to make the wooly-pod vetch the most suitable for grazing in the cold areas. It is proved to be well adapted to highland areas and a released cultivar Kuhak 96 is in hand. Common vetch and bitter vetch are versatile feed legume crops. The rapid winter growth types can be used for early grazing, the non-shattering erect types can be used to produce grain and straw, and the leafy and rapid spring growth types can be used for haymaking. For farmers who require hay or grazing dwarf chickling could be another option in dry areas. The grasspea is susceptible to broomrape (*Orobanche Crenata*), but in dry areas it can still be used for grain and straw.

1.4. Assessment of Nutritional Quality

Improved forage quality is an important objective in our breeding program. Also, achieving high yield potential and adaptation to different niches, agro-ecological zones and utilization needs to be complemented by ensuring that the end products are acceptable by livestock. Therefore, quality of hay, straw and grain are given great consideration.

1.4.1. Hay and Straw Quality of Vetches and Chicklings

The quality parameters utilized in forage breeding program are crude protein (CP%), neutral detergent fibers (NDF%), acid detergent fibers (ADF%), dry matter organic matter digestibility (DMOM%) and tanins content, the latter is especially in the grain of narbon-vetch.
Great variations in all forage quality characters tested were observed both between and within species (Tables 2 and 3). Hays and straw of narbon-vetch having higher protein content than those of other vetches. Also, hays and straw of *Lathyrus sativus* are higher in protein content and digestibility than those of *Lathyrus cicera*. High protein content in hay and straw is mainly due to high leaf: stem ratio and high proportion of leaf retention.

Table 2. Mean and range of protein content (%), NDF (%), ADF (%) and DOMD (%) for hays and straws of four vicia spp. promising lines in advanced yield trials at Tel Hadya 1999/2000.

	Hay				Straw			
Species	Protein%	NDF%	ADF%	DOMD%	Protein%	NDF%	ADF%	DOMD%
V. sativa								
Mean	17.0	41.0	26.0	78.0	9.0	47.0	32.0	55.0
SE±	0.13	0.28	0.10	0.17	0.16	0.41	0.15	0.56
Range	14-20	36-45	24-28	75-81	7-12	39-55	30-35	39-61
V. dasycarpa								
Mean	15	35	22.0	74.0	7.0	44.0	30.0	48.0
SE±	0.08	0.22	0.14	0.18	0.11	0.32	0.13	0.54
Range	20-22	33-37	21-24	72-76	8-11	41-47	29-32	47-58
V. narbonensis								
Mean	20.0	28.0	18.0	83.0	12.0	43.0	31.0	51.0
SE±	0.13	0.21	0.1	0.19	0.10	0.30	0.15	0.42
Range	18-21	25-31	16-20	81-86	8-10	39-47	29-32	47-58
V. ervilla								
Mean	17.0	22.0	15.0	82.0	9.0	59.0	30.0	60.0
SE±	0.32	0.75	0.27	0.32	0.35	0.97	0.38	0.79
Range	15-20	15-31	13-20	77-84	7-15	52-69	22-32	55-73

1.4.2. Variation in Tanins and Protein Contents in Narbon-Vetch

In small ruminant, tannins in narbon-vetch seed have a negative effect as anti-palatability factor and a positive effect as a protein out-flow from rumen.

Tanin and protein contents in the grains of the thirty-six improved lines grown at Tel Hadya and Breda were estimated. None of the thirty-six lines were Tanin-free (Table 4). Tannin and protein contents were higher at Breda than Tel Hadya. Elite lines IFLVN# 2390, 2389, 2380, 2475 and 2378 having tannin content <0.2% and average yield of 1.2 t/ha.

1.5. International Testing Program

The international testing program on feed legumes is an instrument for the diffusion of genetic materials and breeding populations with adequate diversity to the national programs in an out-side WANA region. These materials comprise elite lines with wide or specific adaptation, special morphological or quality traits and resistance to common biotic and abiotic stresses. In 1999/2000, three international *Lathyrus* adaptation trials (ILAT), namely *Lathyrus sativus* (ILAT-LS), *Lathyrus cicera* (ILAT-LC) and *Lathyrus orchus* (ILAT-LO), and three International Vetch Adaptation Trials (IVAT) namely, *Vicia sativa* (IVAT-VS), *Vicia naronensis* (IVAT-VN) and *Vicia ervilia* (IVAT-VE), were supplied to cooperators at 27 countries. In each of these trials, there were 15 test entries and one local check.

1.6. Use of Forage Legumes by NARS

a. The Mashreq countries, Iraq, Jordan, Lebanon and Syria have an extensive work on farmers field to demonstrate the potential of vetches and chicklings, as the best option in rotation with barely and durum wheat. The released variety, common-vetch (Baraka) is widely used as a versatile crop for direct grazing, haymaking or grain and straw. In Lebanon, the released variety *Lathyrus cicera* cv. Jaboula is widely grown in El-Kasr

Table 3. Mean and range of protein content (%), NDF%, ADF (%), and DOMD (%) for hays and straws of two *Lathyrus* spp. elite lines in advanced yield trials at Tel Hadya 1999/2000.

Species	Hay				Straw			
	Protein%	NDF%	ADF%	DOMD%	Protein%	NDF%	ADF%	DOMD%
Lathyrus sativus								
Mean	21.0	32.0	18.0	75.0	14.0	45.0	25.0	60.0
SE±	0.09	0.13	0.09	0.12	0.07	0.78	0.37	0.57
Range	20-29	29-37	16-20	73-79	12-15	39-52	22-29	54-66
Lathyrus cicera								
Mean	18.0	24.0	13.0	79.0	12.0	46.0	26.0	55
SE±	0.30	0.39	0.24	0.29	0.11	0.5	0.27	0.29
Range	16-23	20-28	11-17	77-82	10-15	39-51	24-29	53-63

Table 4. Mean and range of protein content, Tannins content and 100 seed weight for elite lines of narbon vetch grain, at Tel Hadya and Breda in 1999/2000.

Location	Analysis					
	Protein %		Tannins content (%)		100 seeds weight (g)	
	Mean (±SE)	Range	Mean (±SE)	Range	Mean (±SE)	Range
Tel Hadya	32.0 (0.10)	30-34	0.35 (0.01)	0.15-0.48	19.0 (0.54)	11-24
Breda	33.0 (0.10)	31-34	0.39 (0.01)	0.13-0.45	18.0 (0.50)	11-23

area. Where rainfalls below 200mm. Using common-vetch and narbon vetch in cereal-vetch rotation continues to be better than monoculture cereals and enhanced the integration between crop and livestock production. Narbon-vetch produced 1.5 t/ha, in on-farm trials: area of 8 hectares in Syria. The Syrian national program has identified *Vicia sativa* sel # 1887, 2960, 2961 and *Vicia ervilia* sel# 2790 and 2849 for on-farm trials as pre-released cultivars.

b. In Griz Alta, Brazil improved lines of *Vicia sativa*, *Vicia dasycarpa*, and *Vicia ervilia* were tested and highly adapted lines were selected from materials supplied by ICARDA during the last three years. Due to its high grain yield and ability to cover the soil surface, *Vicia ervilia* improved lines were identified for use as dual-purpose crop for grain production and as a manure to recycle nutrients in the crop rotation. Common vetch sel# 3652, due to its earliness (68 days for emergence to flowering as compared to 93 of local entries and 117 days from emergence to maturity compared to 145 days of local entries) was also selected for on farm trials. Forty-nine elite lines of *Vicia dasycarpa* were tested and 13 lines were selected for further evaluation. The results also showed the possibility to grow *Lathyrus cicera* because of its acceptable grain production, herbage yield and earliness in flowering and maturity.

c. The Mexican, ICAMEX (Investigaciony Capacitacion Acuicolay Forestal del Estado de Mexico) has identified three lines of *Vicia sativa* (sel# 2650, #2496, and #2489) for release. These lines were supplied by ICARDA. These lines have been selected for adoption to Tolaca valley (dry high plateau lands of Mexico).

d. Stazio Sperimentale Granieoltura, Sicily, Italy, released a variety of narbon vetch given a name of VELOX. This variety was selected from IFLVN sel# 2380. it is adapted to dry areas with high yield potential, low tannin and high seed protein contents and suitable for mechanical harvesting.

e. In turkey, an extensive program for developing feed legumes for highlands of Turkey is conducted with ICARDA. Improved germplasm of *Vicia sativa*, *Vicia* *panonica, Vicia dasycarpa* and *Lathyrus cicera* were tested. Selection has been made for improved cold tolerance common vetch and Hungarian vetch at Haymana and Ulas locations. Underground vetch improved lines are used in rejuvenating marginal non-arable lands at Polatli. One hundred kilograms of narbon vetch seed was supplied to GAP, Project for seed multiplication.

f. The growing season of 1999/2000 was the second season for testing forage vetches and chicklings in Central Asia and Caucasus countries (CAC). A large number of improved lines have been introduced to CAC republics for evaluation and selection, under rain fed conditions, and eventually for seed multiplication and distribution to farmers. Selected lines of common vetch, narbon vetch, Hungarian vetch, grasspea and dwarf chickling, were tested. In Uzbekistan selected lines were tested at four locations with yield varying from 0.6 to 1.4 t/ha for vetches and from 0.7 to 1.9 t/ha for chicklings. Lines of *Vicia narbonensis, Vicia panonica* and *Vicia sativa* showed high resistance to cold. Four lines of *Vicia sativa*, viz# 2628, 2035, 2694 and 2003 have been selected as promising compared to the check Bistole-84. Of them 2628 is a candidate for release. In Kazakhstan, common vetch lines produced up to 1.1 t/ha and grasspea up to 2.0 t/ha. Both common vetch and grasspea showed high levels of adaptation, and higher yields than the local land races. In Armenia and Azerbaijan, as well as in Georgia, selected lines of vetches and chicklings showed high drought tolerance.

g. Evaluation of vetches (*Vicia spp.*) and chicklings (*Lathyrus sativus*) introduced from ICARDA under Alpine grassland conditions in China: Promising lines of vetches and chicklings were tested for 3rd growing season under alpine grasslands where about one third of the total grassland areas in China. The limiting factors of grassland livestock production in the region is the shortage of forage legumes for improving grassland and for supplementary feeding due to harsh environment. Evaluation and selection of *Vicia spp.*, and *Lathyrus spp.* for alpine grasslands was commenced in 1997 with support of Gansu provincial government. Improved lines of *Vicia sativa, Vicia villosa spp. dasycarpa, Vicia narbonensis, Lathyrus sativus* and *Lathyrus cicera* were supplied to DR. Zhi Biao for testing at Xiahe County, Gansu province, which is typical alpine grassland. The elevation at the testing site is 3000m, a.s.l, the annual rainfall is 350mm, and the mean annual temperature is 40°C.

Ten elite lines of each species were tested and the results revealed that *Vicia villosa spp. dasycarpa* produced the highest herbage yield (DM) followed by *Lathyrus cicera*, whereas, *Vicia narbonensis* had the lowest herbage yield. The mean herbage (DM) yield was 9.0, 7.4, 6.4, 5.6, and 3.6 t/ha, respectively. The results also revealed that *Vicia sativa*, and *Vicia narbonensis* showed high adaptation with average grain yields of 1.04 and 1.07 t/ha, respectively. Average seed yield of *Lathyrus cicera* was 0.8 t/ha.

Based on the two years results elite lines of *Vicia narbonensis*, *Vicia sativa*, and *Lathyrus cicera* that showed high adaptation and the yield potential under the Alpine grassland conditions in China were identified for further tests on a large scale on-farm trials.

Output 2: Improved Lines of Grasspea (*Lathyrus Sativus*) with High Yield Potential under Low Inputs with Low or Zero Neurotoxin 3-(*N-Oxalyle*)-*L*-2, 3-Diaminopropanioc Acid (*B*-ODAP).

ICARDA is placing special emphasis on improving grasspea, with objective aiming at improving its yield potential and nutritional quality through the reduction of the neurotoxin 3-N-(*Oxalyl*)-*L*-2, 3-diaminopropanoic acid (*B*-ODAP) content in its grain. Four approaches are being adopted to achieve this objective: 1.) evaluation of germplasm, 2.) genetic detoxification (hybridization program), 3.) exploitation of somaclonal variation (plant biotechnology), and 4.) effect of micronutrients, Zn^{++} and F_2^{++}.

2.1. Germplasm Evaluation

The appraisal was carried out of 225 land race originated from Bangladesh, and 100 land race originated from Ethiopia. The land races were visually scored at 1-9 scale (1=poor; 9=very good) for seedling vigor, cold tolerance, winter growth, spring growth, leafiness and pod-shattering. Days to flowering and to physiological maturity were recorded. At maturity, grain yield was estimated and the neurotoxin in the grain was determined.

A broad variation was observed for the characters studied for each group (Table 5 and 6). Land races from Bangladesh have relatively low *B*-ODAP in the seeds compared with those of Ethiopia. The results indicate that none of the tested land races was <0.2% *B*-ODAP content in the grains. Land races showed high yields and early flowering and maturity were identified as a good source for desirable traits for future breeding programs.

2.1.1. Evaluation of Exotic Grasspea Germplasm in Ethiopia

Twenty-one grasspea accessions introduced from ICARDA and one local check were evaluated at Debre Zeit for their adaptability and desirable agronomic traits. Genotypes IFLLS 175 and IFLLS 967 had high grain production, above 1.2 t/ha, which is higher than the yield obtained from the local check (0.68 t/ha). The neurotoxin content of IFLLS 175 and IFLLS 967 was 0.1% and 0.13%, respectively, whereas the content of the Ethiopian local check was 0.85%.

2.2. Genetic Improvement (hybridization)

Genetic improvement work on *Lathyrus sativus* (grasspea) was initiated at ICARDA with emphasis being placed on reducing the neurotoxin 3-(*N-Oxalyl*)-L-2, 3-diaminopropanoic acid (*B*-ODAP) content in the grain. In the beginning, intensive screening program was initiated with the possibility of isolating low neurotoxin lines from germplasm collected from different origins. Germplasm having 0.07% to as much as 1.9% was found indicating large variation in B-ODAP with less than 0.09% (0.9mg/g). Along with these five genotypes, one wild type, of *Lathyrus ciliolatus* (underground chickling) was found to contain 0.02% from the neurotoxin B-ODAP.

A hybridization program was initiated for incorporating the character of low neurotoxin into locally adapted land races.

Four grasspea lines and one underground chickling line with low *B*-ODAP were inter-crossed in all possible combinations (including reciprocals) to 12 land races from Ethiopia, 12 land races from Bangladesh, and 12 land races from Nepal. These lines represent the variability for the neurotoxin *B*-ODAP (more than 0.4%) and diversity in agro-

Table 5. Range, mean, standard error and coefficient of variation (CV%) for 10 characters of 225 grasspea (*Lathyrus sativus*) landraces originated from Bangladesh.

Character	Range	Mean (±SE)	CV%
Seedling vigor	0.5-0.9	6.3 (0.8)	114.0
Cold tolerance	0.5-0.8	5.7 (0.9)	20.0
Winter growth	0.5-0.9	6.9 (1.0)	16.0
Spring growth	0.6-0.9	7.5 (0.8)	15.0
Days of flowering	75-92	86.0 (1.2)	3.0
Days of maturity	120-140	147 (1.8)	4.0
Total Biological yield (t/ha)	2.5-5.6	4.2 (0.35)	15.0
Grain yield (t/ha)	0.7-1.9	1.3 (0.2)	17.0
Harvest index (%)	28-38	32.7 (2.2)	12.0
B-ODAP in grains	0.40-0.85	0.63 (0.05)	-

Table 6. Range, mean, standard error and coefficient of variation (CV%) for 10 characters of 100 grasspea (*Lathyrus sativus*) landraces originated from Ethiopia.

Character	Range	Mean (±SE)	CV%
Seedling vigor	0.4-0.8	6.8 (0.8)	14.0
Cold tolerance	0.4-0.8	7.0 (0.7)	20.0
Winter growth	0.3-0.8	6.6 (0.7)	15.0
Spring growth	0.5-0.9	7.7 (0.9)	17.0
Days of flowering	79-100	97.0 (1.2)	2.0
Days of maturity	135-155	146.0 (2.0)	2.5
Total Biological yield (t/ha)	4.0-7.0	5.0 (0.4)	16.0
Grain yield (t/ha)	0.5-2.1	1.3 (0.3)	20.0
Harvest index (%)	12-30	21 (3.0)	12.0
B-ODAP in grains	0.49-1.2	1.09 (0.06)	-

climatic conditions among places of origin. Gene markers such as seed and flower colors were used to eliminate pods, which might have developed from selfing. The 180 hybrid combinations were obtained. Selections were made from F_2 to F_6 *and were directed for early maturity,* small and large seeded sizes and less than 0.9-0.1% *B*-ODAP content in the grain. F_2 segregated populations were sent to Ethiopia for selection under Ethiopian conditions (*in-situ* selection). In 1999/2000, F_4, F_5 and F_6, families were grown under rain-fed conditions at Tel Hadya (260mm) and Breda (230mm), and at Debre-Zeit, Ethiopia. To assess their yield potential, resistance to insects and diseases *B*-ODAP content.

2.2.1. Variability in F_2 Segregating Population in Ethiopia

A total of 122 F_2 segregating populations of crosses among Ethiopian land races and ICARDA low neurotoxin lines were evaluated at Denre-Zeit for their adaptability and desirable agronomic traits. Single plant selections were made under field conditions and a total of 1364 individually plants were selected. Seed samples of these single plant selections were analyzed for *B*-ODAP content and those of low content with <0-2% will be planted to advance generation and further screening for low *B*-ODAP. Yield adaptation, and reaction against insects and diseases.

2.2.2. Selection in F_4 Families under Ethiopian Conditions

Thirty-eight F_4 populations previously received from ICARDA were shown at Debre-Zeit, research center and evaluated for their performance compared to an Ethiopian local check. These populations were high yielding with an overall mean yield of 2.2 t/ha. The highest yield of 4.29 t/ha was recorded. The neurotoxin content varied from 0.08% to 0.20%. The populations with low neurotoxin content and high yield will be selected for seed multiplication.

2.2.3. Selection of Promising F_5 Families in Crosses of Ethiopian Landraces x ICARDA Low *B*- ODAP Lines, under Ethiopian Conditions

Forty-eight segregated populations and one local check were grown at Debre-Zeit. The mean yield was 2.88 t/ha, with a maximum yield of 4.2 t/ha and neurotoxin content varied from 0.086% to 0.197%. These populations were found to be more adaptable to Ethiopian conditions compared with those of F_4 families.

2.2.4. Evaluation of Advanced Materials (F_6), under Ethiopian Conditions

Twelve lines of grasspea including local check were evaluated at Debre-Zeit for their yield potential and neurotoxin content. These lines were F_6 progeny lines supplied to EARO from ICARDA. Seed yield varied from 1.46 t/ha to 3.0 t/ha. All these lines performed much better than the local Ethiopian check. They were resistant to insects and foliar diseases and the neurotoxin content was below 0.1%.

2.2.5. Adaptation of Low Neurotoxin Lines of Grasspea to Ethiopian Condition

Four lines, LSB11, LSB22, LSBio-482 and LS 736, developed at ICARDA for low neurotoxin content < 0.09%, were evaluated at Debre-Zeit Research Center, Ethiopia. LS Bio 482 and LS B22 gave the highest yields of 2.2 and 2.3 t/ha with neurotoxin content of 0.09% and 0.07% respectively, and were highly resistant to insects and diseases. These two lines will be evaluated in multi-location yield trials for further evaluation and seed increase for distribution to farmers.

2.2.6. Evaluation of Advanced Materials, F_5, Families at Tel Hadya and Breda

Sixty-four F_5 families (improved lines) were evaluated at Tel Hadya and Breda, *rainfall* was 260 and 230mm respectively. To assess their yield potential and *B*-ODAP content in the grains. The ten families with lower *B*-ODAP and higher yield at each site are shown in (Table 7). Yield was relatively higher at Tel Hadya than Breda despite the low rainfall in the growing season of 22% and 14% at Tel Hadya and Breda, respectively. The ten selected lines produced grain yields around 1.0 t/ha. Three families, IFLLS # 685, 711 and 652, showed high grain yield and low *B*-ODAP at the two tested sites.

Table 7. Grain yield (t/ha), crude protein (CP%) and *B*-ODAP content (%) of the best 10 promising F_5 families of grasspea at Tel Hadya and Breda 1999/2000.

	Tel Hadya (rainfall 260mm)			Breda (rainfall 230mm)			
IFLLS#	Grain yield (t/ha)	CP (%)	*B*-ODAP (%)	IFLLS#	Grain yield (t/ha)	CP 9%)	*B*-ODAP (%)
716	0.93	31	0.09	654	0.84	31	0.092
704	0.79	30	0.07	681	0.78	31	0.080
685*	0.85	31	0.09	695	0.70	30	0.090
711*	0.89	31	0.09	679	0.73	31	0.100
652*	1.1	31	0.09	685*	0.96	31	0.100
735	0.9	31	0.07	672	0.79	31	0.090
689	1.2	30	0.07	696	0.87	30	0.070
699	1.0	31	0.09	711*	0.75	31	0.100
717	0.90	30	0.09	653	0.71	31	0.090
703	0.85	31	0.07	652*	0.71	31	0.050
Mean+	0.90	31	0.16	Mean	0.78	31	0.170
SE±	0.04	0.153	0.007	SE±	0.02	0.133	0.005

(+) Mean of all 64 tested families.
(*) Families with high yield and low *B*-ODAP at the two sites.

2.2.7. Evaluation of Advanced Materials F_6 Families at Tel Hadya and Breda

Nine F_6 families were evaluated at Tel Hadya and Breda. These lines were selected for their high yield potential and low *B*-ODAP content from F_5 families of 1998/1999, growing season. Grain yields were slightly higher at Tel Hadya than Breda, whereas, the neurotoxin *B*-ODAP content in the grain was slightly higher at Breda than Tel Hadya (Table 8).

2.3. Use of Somaclonal Variation in *Lathyrus sativus* to Select Variants with Low *B*-ODAP Concentration

Lathyrus sativus plants were regenerated from internodes and shoot explants from four Ethiopian land races. A total of 800 plants developed by tissue culture were grown in the plastic house of which 690 survived and set viable seeds for *B*-ODAP determination. The somaclones generated showed great variability in morphological characters like, seed

Table 8. Grain yield (t/ha), crude protein (CP%) and *b*-ODAP content (%) of 8 promising F_6 families of grasspea at Tel Hadya and Breda 1999/2000.

IFLLS	Tel Hadya			Breda		
	Grain yield (t/ha)	Protein (%)	*B*-ODAP (%)	Grain yield (t/ha)	Protein (%)	*B*-ODAP (%)
190	0.9	32	0.08	0.8	32	0.09
288	0.9	32	0.09	0.8	31	0.08
289	0.6	31	0.06	0.6	32	0.09
290	0.8	31	0.09	0.7	32	0.11
299	0.8	30	0.11	0.6	31	0.12
387	0.6	32	0.10	0.7	32	0.10
390	0.7	32	0.08	0.7	31	0.13
499	1.0	32	0.10	0.8	32	0.13
Mean	0.78	32	0.08	0.71	32	0.11
SE±	0.04	0.25	0.005	0.028	0.17	0.006

color, flower color, pod shape and number of seeds per pod. These characters are used as gene markers. Individual plants were analyzed for *B*-ODAP content and seeds of low *B*-ODAP content were grown individually in the field for subsequent generations. We have somaclones from $SC_1(R_1)$ up to $SC_4(R_4)$ generation. Continuous selection for low *B*-ODAP content resulted in obtaining and maintaining low *B*-ODAP lines. LSBio482 (R_4) was tested at Debre-Zeit, Ethiopia and gave grain yield of 2.2 t/ha with *B*-ODAP content of 0.09%.

2.4. Effect of Neurotoxin Content of *Lathyrus sativus* to Cyst Nematode, Broomrape and Insects

A preliminary experiment was conducted to evaluate the reaction of a set of 27 lines of *Lathyrus sativus*, representing three groups for their neurotoxin content (low<0.2%, medium, 0.21-0.4% and high >0.4%) to broomrape (*Orobanche crenata*), and cyst nematodes (*Heterodera spp.*). Levels of infestation of both Orobanche and cyst nematodes was good and evenly distributed. Reaction to cyst nematode was measured on 20 April 2000 as percent incidence (%) and severity on a 1 to 9 scale. Reaction to Orobanche was measured on 3 May 2000 as a number of Orobanche shoots per square meter. Total biological yield and grain yield were estimated at maturity.

Significant differences in cyst nematode incidence and severity were observed between the three categories of different levels of neurotoxin. Values for mean incidence were 32.6, 16.3 and 16.0% and for mean severity were 4.2, 3.1, and 3.0 for the low, medium and high neurotoxin content groups, indicating inverse correlation between neurotoxin content and incident and severity of cyst nematodes.

Although the differences in Orobanche shoot number between the three groups were not significant, the shoot number was high (9.4 shoot/m^2) in the high neurotoxin group as compared to 4.9 shoot/m^2 in the low neurotoxin group.

Biological yield was higher in the high neurotoxin group. Mean values were 132, 205, and 208 g/m^2 for the low, medium and high neurotoxin content, respectively. The grain yield followed the same pattern with 31.5, 35.0 and 38 g/m^2 for the above-mentioned group, respectively.

The same lines were evaluated under field conditions at Tel Hadya for resistance to pea aphid and Sitona. Plants were artificially infested with about 10 aphids/plant when they were 10cm high. The entries were evaluated after one month using a visual damage scale from 1 to 3, where 1=resistant; 2=moderately resistant and 3=susceptible. Susceptible plants were stunted and had honey dew. Five plants were randomly sample and examined under a binocular for nodule damage caused by Sitona. The evaluation for resistance to Sitona was based on natural infestation.

The level of infestation of resistance to pea aphid seems to be correlated with the level of neurotoxin content, as all the lines with the lowest neurotoxin content (0.2%) are susceptible with a scare of 3 in the 1-3 scale. The lines with levels of neurotoxin of 0.21-0.4% and >0.4% were either moderately resistant or resistant.

The level of resistance to Sitona does not seem to be correlated with the level of neurotoxin content. IFLLS723 with a neurotoxin content of >0.4% had the highest percent of module damage (29%). The best lines with the lowest percent of nodule damage (2%) were IFLLS453 with a neurotoxin content of 0.2%. This line also showed a moderate level of resistance (1.75) to pea aphid. All the 27 lines are being evaluated under field condition at Tel Hadya, in 2001 to confirm their resistance to the two insect pests, Sitonia and pea aphid.

2.5. Zinc Effect on Neurotoxin in *B*-ODAP Content in *Lathyrus sativus*

There is some evidence that toxicity of grasspea may be related to certain soil micronutrients notably iron (Fe^{++}) and Zinc (Zn^{++}). The micronutrients status of the vertisols of Ethiopia is low in zinc and high in iron, maybe particularly conducive to the development of high content of neurotoxin.

A preliminary field experiment was conducted at Tel Hadya in Field B_3 where the zinc level in the soil is low (0.38ppm). Zinc was added to the soil in a shape of zinc phosphate at 0, 5, 10, 20 Kg/ha. Three lines of grasspea, LS#190, LS#716 and LS#502, which representing low, medium and high levels of neurotoxin in the grain. The resulting data from the trial are presented in (Table 9). The results showed that added zinc consistently reduced the level of neurotoxin in the seeds, i.e., decreases from 0.11 to 0.09%for LS#190, from 0.47 to 0.35% for LS#716 and from 0.67 to 0.43% for LS#502. The level of neurotoxin reduction was higher in the high neurotoxin line than in the low neurotoxin line. The results also showed added zinc consistently increased grain yield. The rate of grain yield increase was 13, 20 and 6% for the low, medium and high neurotoxin line respectively.

Output 3: Improvement of Amphicarpic Type Legumes Such as Underground Vetch (*Vicia amphicarpa*) for Marginal Non-arable Lands Rejuvenation

3.1. Breeding for Abiotic Stress Resistance

Drought is the major environmental constraint to forage production in marginal low rainfall areas, where shortage of available water during the growing season is the main cause of year-to-year variability in yield of herbage production to feed livestock.

Vicia sativa subspecies *sativa* (common vetch) is a temperate annual forage legume which is widely sown because of its high yield and quality, unfortunately, it is not adapted to rainfall areas <350mm, and moderately resistant to cold conditions. Our studies on other *Vicia spp.* like *Vicia sativa* subsp. *Amphicarpa* (underground vetch), which is grown as wild type in the Central Anatolia region and marginal non-arable lands of Syria revealed that its ability to produce both aerial and underground pods increases its winter hardiness, drought tolerance and persistence under heavy grazing, but it is less desirable than common vetch because of its very low herbage production, with less quality. To enhance the herbage production of underground vetch and improve the drought and cold tolerance of common vetch, crosses between the two subspecies were made to develop more agriculturally, valuable feed legume crops for both of them by transferring the desirable genes from the wild cultivated subspecies and vice-versa.

The materials were derived from crosses of improved lines of common vetch (IFLVS#715, 2558, 713 and 1448) with two wild accessions of underground vetch ((#2660 and #2614). High vegetative vigor was observed in the F_1 plants carrying few underground pods near the soil surface. The F_2 population released enormous variability transcending even the limits of the parents in some traits as the number of underground pods, cold and drought tolerance, leaf : stem ratio and herbage yield. F_3 descended from F_2 single plant selection of the eight crosses were selected for high herbage yield and 10-15 underground pods/plant for *Vicia sativa* subspecies *amphicarpa* and high cold and drought

Table 9. Effect of zinc application on 100 seed weight (g), grain yield (t/ha) and *B*-ODAP (%) on three lines of *Lathyrus sativus*

Added Zn^{++} (kg/ha)	Parameter	LS 100	LS 190	LS502
0	100 seed Weight (g)	8.7	11.6	10.7
5		8.8	12.5	10.3
10		8.8	12.8	11.1
20		8.8	12.3	11.7
Mean		8.76	12.29	10.92
SE±		0.032	0.258	0.308
0	Yield t/ha	0.80	1.03	1.28
5		0.85	1.10	1.30
10		0.90	1.20	1.35
20		0.93	1.30	1.36
Mean		0.87	1.16	1.32
SE±		0.029	0.059	0.018
0	*B*-ODAP (%)	0.11	0.47	0.67
5		0.09	0.42	0.57
10		0.09	0.37	0.50
20		0.09	0.35	0.43
Mean		0.10	0.40	0.54
SE±		0.005	0.026	0.050

tolerance for *Vicia sativa* subspecies *sativa*. Through selection in advanced generations, families with average 10 underground pods/plant and more than 50% increase over the underground vetch parents in herbage production will be selected as improved lines of underground vetch. Also families with increased cold and drought tolerance and maintained vigorous growth of common vetch will be selected as improved lines of common vetch.

Output 4: Strengthened Capacity of NARS in Forage Legumes Germplasm Evaluation, Enhancement and Quality Assessments

4.1. Sub-Regional in-Country Training Course

In collaboration with project 1.5, a sub regional in-country training course was held from March 27 to April 7, 2000 in Tashkent, Uzbekistan. Eleven senior scientists, three from Uzbekistan, two from Kazakhstan, and one from Kyrgistan, Tajikistan, Turkmenistan, Armenia, Georgia, and Azerbaijan participated in this course. The aim of the course was to get senior scientists from the CWANA region acquainted with ICARDA's methodologies and research activities in the area of forage and food legume crops. Each participant presented a country report about the status and research activities on forage and food legumes in his Country.

At the end of the course participants requested the germplasm which they feel is suitable for their own countries. Continued contact with scientists participated in the course is maintained through visits and correspondence.

4.2. Individual Short-Term Training

This kind of training comprises field and laboratory work on a specific discipline, as requested by national programs, over a certain period of time. In February 2000, one candidate from Hino Research Center, Syria was trained for one week, on assessment of quality parameters of forages. Another candidate from Iraq was trained in March, for one week on assessments of grain quality of feed and food legumes. In April 2000, one candidate from Hama Research Center, Syria was trained on breeding methodologies of forage legumes for one month. Another candidate from Aleppo Research Center was trained on selection criteria of forage legumes for one week. One trainee from the Ethiopian Agricultural Research Organization (EARO) was trained for a period of three months (April 24-July 4) on breeding methods of *Lathyrus sativus* (grasspea), as a part of DFID project in collaboration with EARO.

The project also offered opportunities to experienced scientists from national programs to conduct research on topics of mutual interest. In 2000, Dr Legussa Dadi, from EARO, visited ICARDA for three weeks and developed a structure of socio-economic survey of grasspea and prepared a proposal and work plan for its implementation on collaboration with Dr Aden Aw-Hassan, MRMP, socio-economist, and Dr Ali M. Abd El-Moneim, GP, forage legumes breeder. He developed a questionnaire for the survey. This work is a part of the DFID project on grasspea improvement in Ethiopia.

IV. COLLABORATORS

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V. DONORS

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2. Grant from DFID CRF for the improving of nutritional quality of grasspea in Ethiopia.

VI. PUBLICATIONS

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I. PROJECT TITLE: INTEGRATED PEST MANAGEMENT IN CEREAL AND LEGUME-BASED CROPPING SYSTEMS IN DRY AREAS

II. EXECUTIVE SUMMARY

A series of surveys for fungal, viral diseases and insect pests of cereal and legume crops were conducted in collaboration with NARS colleagues in Central Asia, Eritrea, Iraq, Peru, Syria and Tunisia.

Surveys covered incidence, severity of attack and pest variability. Studies to evaluate IPM components for the different agroecological zones covered host resistance, natural enemies, and natural pesticides. In host resistance evaluation, work included resistance in barley to scald and powdery mildew, resistance in food legumes to major diseases affecting chickpea (Fusarium wilt and Ascochyta blight), faba bean (Chocolate spot and Ascochyta blight) and lentil (Fusarium wilt), resistance in faba bean and lentil to bean leaf roll and faba bean necrotic yellow viruses. Work also conducted on resistance in lentil to Sitona beetle. The work on the use of natural enemies to control pests focused on (i) entomopathogenic fungi and egg parasitoids to control Sunn pest, (ii) the use of coccinellids to control bird cherry oat aphid and black bean aphid. Work on the use of natural products to control pests focused on the use of *Melia azedarach* extract to control the Sitona beetle. Integrated pest management options were evaluated in Syria to manage chickpea Ascochyta blight, lentil root rot and lentil broomrape. In addition two IPM pilot sites to manage cereal and legume pests were established in Egypt and Morocco.

III. PROJECT ACHIEVEMENTS

Output 1: Improved Understanding of Occurrence, Spread, Variability and Losses Caused by Pests in WANA.

1.1. Conduct Pest Surveys in Partnership with NARS of CWANA

1.1.1. Cereal Disease Surveys in Central Asia, Eritrea and Tunisia

Surveys of pest populations and the genetic characterization of resistance continue to provide valuable information to design breeding strategies and prioritize targeting disease species and or races.

1.1.1.1. Central Asia

In Central Asia, yellow rust was encountered in all the countries visited at different incidence levels. Severe rust development was observed in Azerbaijan and Kyrgystan. In Uzbekistan high infection occurred early in the season and disease development stopped with increased temperatures during the months of April and May. In Turkey high infection was observed on Gerek, that covered about one million hectares and losses would be expected to be at least 30%. Common bunt was a problem in most of the experimental station in Azerbaijan, and a high *Fusarium* infection was observed in Zaqatala region. Only few breeding lines showed low level of infection by *Fusarium*, powdery mildew and tan spot were severe in most farmers' fields in Kyrgystan.

1.1.1.2. Eritrea

In Eritrea, the survey covered major wheat and barley growing areas. 25 sites were visited and 53 fields were surveyed. The general disease incidence in the regions surveyed showed that yellow rust is widely spread followed by leaf rust in wheat. In the case of barley, net blotch was the most spread disease, followed by scald then smut diseases.

1.1.1.3. Tunisia

In Tunisia cereal production areas in the Governorate of Beja, Bizerte, Jendouba, Kef, Siliana, and Zaghouan were surveyed for disease incidence. The survey was conducted with the participation of NARS scientists. On wheat, severe incidence of common root rot on wheat was observed at all sites, but with high incidence at "le Kef". Moderate infection of septoria was recorded at Bizerte, Jendouba, and Beja. Incidence of cereal cyst nematodes was recorded at Seliana and Kef. On barley, net blotch was observed at all sites but severe infection was recorded only at Zaghouan. Moderate infection of powdery mildew and scald were also observed at all sites.

1.1.2. Survey of Cereal Cyst Nematodes in Syria

Data on cereal cyst nematode in cereal growing fields in Syria, showed a different numbers of lemon shape cysts, with different sizes. In addition, very small global cysts were observed in approximately all soil samples. In Southern Syria, two barley and 10 wheat fields were inspected and 11 were found infested with cereal cyst nematode. Number of CCN cysts ranged between 8 and 66/200g soil. The highest infestation rate was recorded in barley fields in Tanbeh (Khoubab). In Central region of Syria, four out of five fields inspected were infested with CCN. Number of CCN cysts ranged between 2 and 251/200 g soil. In this region, some cysts were discolored and apparently parasitized at different levels. In Northern region of Syria, twelve fields were inspected and 11 were found infested with CCN. Number of CCN cysts ranged between 1 and 388/200 g soil. In general, level of infestation was lower in bread wheat fields as compared to durum wheat and barley fields.

1.1.3. Survey of Common Root Rot Disease in Northern Syria

A survey of common root-rot disease was conducted in 1999/2000 growing season. Sixty-five fields in two major cereal-growing areas in northern Syria were surveyed. The survey covered Aleppo and Idleb governorates, which represent two different agroecological zones. Random plant samples of wheat and barley were collected from 53 fields in Aleppo and 12 fields in Idleb. Visual assessment, based on the discoloration of the sub-crown internodes, was made on sampled plants. Random samples were taken from all the plants collected and analyzed in the laboratory. Small pieces of plant samples were planted on PDA medium (Potato-Dextrose-Agar). Different pathogens were isolated, purified, and identified. Visual assessment and laboratory isolation showed that average incidence was relatively higher in barley fields than in wheat fields in both areas. The cereal-root pathogen, *Cochliobolus sativus* (Ito & Kurib.) Drechsl. ex Dastur (Anamorph *Bipolaris sorokiniana* (Sacc. in Sorok.) Shoem. and several *Fusarium* species were the most prevalent. Incidence of *Cochliobolus sativus* was estimated at 50% of the fields assessed in Idleb and 60% in Aleppo. The level of infestation with C. *sativus* was higher on wheat (75%) than on barley (48%) in Aleppo, but at Idleb the rate was identical on both crops (50%). The prevalence of *Fusarium* spp. was higher than *C. sativus,* and was about 83% in Idleb and 64% in Aleppo. The incidence of *Fusarium* spp. at Aleppo was about 83% on barley and over 41% on wheat. *Fusarium* spp. was more prevalent in Idleb where barley was more affected than wheat. The incidence level was 100% on barley and 67% on wheat.

1.1.4. Survey of Faba Bean Diseases in the Andean Highland of Peru

A Field survey was conducted in farmers' fields in the Andean highland of Peru in April 2000 to identify main biotic stresses affecting faba bean production. The survey covered randomly selected fields in Cusco, Maras, Huatata, San Paulo, Ayacucho and Acobamba. Main biotic stresses identified, based on visual symptoms, were Chocolate spot (*Botrytis fabae*), leaf spot (mainly due to *Cercospora zonata* but also *Alternaria alternata)*, rust *(Uromyces viciae fabae*), viruses including a non-identified viral disease complex; and root diseases particularly wilt. Attacks of a mycoplasma-like organism that causes phyllody especially in April sowing were observed.

1.1.5. Survey of Cereal Insects in Tunisia

An insect survey was conducted in April 2000. The regions covered were Mograne, Kairouan, Sousse, Kef and Beja. The two predominant pests found were Hessian fly and Barley stem gall midge. This latter was found in all the regions surveyed, and the mean percent of infested plants was 40%. Hessian fly was found mostly in Morgane, Sousse and kef, with a mean percent of infested plants of 25-30%. The results of this survey confirm those of previous years in showing that in Tunisia both Barley stem gall midge and Hessian fly are economical pests of barley and wheat, respectively.

1.1.6. Collection of Entomopathogenic Fungi of Sunn Pest

Sunn Pest (*Eurygaster integriceps*) affects grain quality and yield of wheat and barley on approximately 15 million ha throughout the CWANA region. Few alternatives, other than the use of pesticides, are available for management of this serious pest. ICARDA is cooperating with national scientists in Syria, Turkey, Iran, Uzbekistan, Kazakhstan, Kyrgyz Republic and experts at the University of Vermont to develop insect-killing fungi as the foundation of an appropriate IPM strategy. One of the first steps in the developmental process is the collection of a bank of entomopathogenic fungi directly from sunn pest. These collections began in 1996 in Syria and Turkey. This year exploratory activities were done in overwintering sites of Sunn Pest in Kazakhstan and the Kyrgyz Republic. Over 500 symptomatic Sunn Pest insects were found and from these 49 insect-killing fungal isolates were recovered. Each was established in pure culture, identified and all identifications verified by an expert mycological taxonomist. They have been placed in long-term storage. The majority was *Beauveria bassiana* but isolates of *Paecilomyces, Hirsutella,* and *Verticillium* sp. were also discovered.

1.1.7. Survey for Legume and Cereal Viruses in Tunisia

A survey to identify virus diseases affecting legume (chickpea, faba bean and lentil) and cereal (bread and durum wheat and barley) crops at different locations in Tunisia was conducted during April, 2000. The survey covered randomly selected 38 legume (34 faba bean, 3 chickpea and one lentil) and 44 cereal (21 durum wheat, 7 bread wheat, 15 barley and one oat) fields. Virus disease incidence was determined on the basis of laboratory testing of 100-200 randomly collected samples from each field against antisera of 12 legume and 6 cereal viruses. All samples were tested for the presence of viruses by tissue-blot immunoassay (TBIA) at the Virology Laboratory of INRAT, Tunisia. In faba bean fields, *Broad bean mottle virus* (BBMV) and *Beet western yellows virus* (BWYV) were the most common followed by *Faba bean necrotic yellows virus* (FBNYV). In cereal fields, *Barley stripe mosaic virus* (BSMV) was the most common followed by *Barley yellow dwarf virus* (BYDV) and *Barley yellow striate mosaic virus* (BYSMV). Two cereal fields had a virus disease incidence of 6% or higher. The highest virus disease incidence was in two faba bean fields, 24.5% (BWYV and/or FBNYV) in one field in Siliana region and 23% (BBMV and/or BWYV) in another field in Jendouba region and 10.5% (BSMV) in a barley field in Cap-Bon region. Other viruses were detected rarely, such as *Broad bean stain virus* (BBSV), *Bean leaf roll virus* (BLRV) and *Cucumber mosaic virus* (CMV) in legumes, and *Wheat dwarf virus* (WDV) in cereals. This is the first report of FBNYV and BWYV affecting faba bean; and BYSMV, BSMV and WDV affecting cereals in Tunisia.

1.1.8. Survey for Legume and Cereal Viruses in Iraq

A survey to identify virus diseases affecting legume (chickpea, faba bean and lentil) and cereal (wheat and barley) crops at different locations in Iraq (Baghdad, Al-Anbar, Diyala, At-Tamim and Ninawa governorates) was conducted during April 18-27, 2000. The survey covered randomly selected 54 legume (36 faba bean, 8 chickpea and 10 lentil) and 23 cereal (18 wheat and 5 barley) fields. The identity of the viruses present and virus incidence were determined on the basis of laboratory testing of 100-200 randomly collected samples in addition to 20-25 symptomatic samples from each field. A total of 7663 legume (6819 randomly collected and 844 symptomatic) and 3455 cereal (3093 randomly collected and 362 symptomatic) samples were collected and tested for the presence of 12 legume and 5 cereal viruses by the tissue blot immunoassay procedure at the Virology Laboratory of IPA Agriculture Research Center in Baghdad and Mosul. In faba bean fields, *Bean yellow mosaic virus* (BYMV) was the most common followed by luteoviruses [such as *Bean leaf roll virus* (BLRV) and *Beet western yellows virus* (BWYV)]. Four faba bean fields had, at the time of the survey a virus disease incidence of 21% or higher based on field observations. Whereas, the highest virus disease incidence based on laboratory testing of randomly collected samples was 80-100% in 18 fields; 16 fields (9 in Baghdad, 5 in Al-Anbar, one in Diyala and one in At-Tamim) were infected mostly with BYMV and in two fields in Ninawa Governorate were equally infected with BYMV and BWYV. In cereal fields, only *Barley yellow dwarf virus* (BYDV) was detected on average in 1% of random samples and 9% of symptomatic samples. Virus disease incidence in all cereal fields was less than 5% based on field observations. Other viruses were rarely detected in legume crops, such as *Alfalfa mosaic virus* (AMV), *Faba bean necrotic yellows virus* (FBNYV), *Cucumber mosaic virus* (CMV), *Broad bean wilt virus* (BBWV) and *Chickpea chlorotic dwarf virus* (CCDV). This is the first report of FBNYV, BWYV and CCDV affecting legumes in Iraq.

1.2. Studies of Pest Variability

1.2.1. Emergence of New Races of Yellow Rust of Wheat in West and Central Asia

A wide range of virulent yellow rust pathotypes is evolving in Central and Western Asia (CWA) region, causing the breakdown of widely utilized sources of resistance in wheat. Diverse yellow rust physiologic races have been identified in Syria and Lebanon, which include compatibility with Yr_{SU}, Yr_{10}, and Yr_{SD} resistance genes that have not been deployed in the region. In the field population, virulence to lines with Yr_6, Yr_7, Yr_A and Yr_9 resistance genes were above 70% and virulence to lines with Yr_{3V} and Yr_{SD} were less than 5% Virulence frequencies to all other lines were between 15 and 70%. New virulence on Yr $_{3V}$, Yr_{4+}, Yr_{Sd}, Yr_{Su}, Yr_{Sk}, Yr_{17}, and Yr_{18} were observed in Kyrgystan, and virulence on Yr_{10}, Yr_{15}, and Yr_{18} were observed in Azerbaijan. The breakdown of the Yr. resistance genes will facilitate the rapid spread of the yellow rust pathogen and the occurrence of widespread epidemics, and eventually losses in crop production. Monitoring of the new races allows to better target resistance sources and ensure appropriate deployment of resistance genes in association with adapted wheat cultivars.

1.2.2. Status of Yellow Rust in CWANA; Pathotypes and Resistance Genes

Relevant and effective pathogenicity surveys are of fundamental importance to breeding programs aimed at incorporating resistance to obligate plant pathogens. Surveys to monitor the distribution of current pathotypes, are directed at the early detection of new avirulence/virulence combinations of importance to agriculture, and if results can be related genetically to cultivated genotypes, contribute to decisions on cultivar recommendation. Surveys also allow the selection of pathogen isolates of known pathogenic profile for use in germplasm screening, and the accumulated historical data provides valuable insights into pathogen epidemiology and disease management. Thus an efficient and relevant means of monitoring pathogenicity facilitates cultivar development and deployment. The NILs are based on the Australian cultivar Avocet that should, given an appropriate planting date, be sufficiently adapted to grow in most areas where stripe rust is of concern. In addition to assisting in the development of the lines, the aim was to foster the seed distribution, initial increases at receival laboratories and the growing and assessment of the materials with CIMMYT, ICARDA and PBI Cobbitty staff visits to the testing locations. The Avocet isogenic lines have been extensively tested at ICARDA headquarters under field and controlled environmental conditions. These lines have been also included to the trap nursery that comprises all the previously used differential lines, most cultivated varieties, and promising lines. The trap nursery amounts to 100 entries and is aimed at monitoring yellow rust in Central and Western Asia (CWAYRTN), hence it includes varieties recommended or cultivated in this region. The trap nursery of 1999 (CWAYRTN 1999), has been updated (CWYRTN 2000) to include promising breeding lines and to eliminate the cultivars that are not used in Central Asia. The trap nursery for 2001 will allow including national checks. The nursery has been distributed to sixteen countries (Turkey, Iran, Pakistan, Iraq, Syria, Lebanon, Ethiopia, Egypt, Yemen, Azerbaijan, Uzbekistan, Kyrgystan, Turkmenistan, Georgia, and Kazakstan) during the past two cropping season (1999 & 2000). The nursery has been tested at three to five sites in each country. The data assembled so far shows tremendous variability among and between countries, and the NARS collaborators are appreciative of the information provided by the trap nursery.

1.2.2.1. Syria

The results shown in Table 1 demonstrate the wide range of yellow rust pathotypes in Syria. The number of effective resistance genes is getting smaller every year as new yellow virulence types (races) appear. In Syria, the YR-genes can be classified as follows:

1. Highly effective genes that show good level of resistance at all sites in Syria: Yr_1, Yr_5, Yr_{10}, Yr_{15}, and Yr_{Sp}
2. Effective resistance genes that show an intermediate reaction type (MR) at most sites in Syria: Yr_{17}, Yr_{24}, and Yr_{26}
3. Less effective resistance genes that show moderate susceptible reaction at most of the sites and susceptible reaction at some sites in Syria:Yr_8, Yr_{12}, and Yr_{Sk}.

4. Ineffective resistance genes that show susceptible reaction at most: Yr_6, Yr_7, Yr_9, Yr_{11}, Yr_{18}, and Yr_A.

Table 1. Reaction of "Avocet" Isogenic to three races (TH1-3) and to bulk isolates of yellow rust at seedling and adult growth stages (1999-2000).

Known Resistance Gene For Yellow Rust		Reaction of YR-genes at seedling stage[1]					Adult stage
Cultivar	Yr Gene	TH1	TH2	TH3	TH-B	TH-F	TH-F
Yr1/ 6* Avocet S	Yr1	R	R	R	R	R	R
Yr 5/ 6* Avocet S	Yr5	R	R	R	R	R	R
Yr 7/ 6* Avocet S	Yr7	S	S	S	-	-	S
Yr 8/ 6* Avocet S	Yr8	S	R	R	S	S	S
Yr 9/ 6* Avocet S	Yr9	S	S	S	S	S	S
Yr 10/ 6* Avocet S	Yr10	R	R	R	S	S	R
Yr 15/ 6* Avocet S	Yr15	R	R	R	R	R	R
Yr 17/ 4* Avocet S	Yr17	R	R	R	S	S	S
Avocet S		-	-	-	S	S	S
Avocet R	YrA	S	R	S	R	R	S
Jupateco R	Yr18	-	-	-	S	S	S
Jupateco S	-	-	-	-	S	S	S

[1]TH1, TH2, TH3: Specific races (reaction on same YR. Genes in the differential set due to lack of seed); TH-B, TH-F= bulk isolates tested at seedling and adult growth stages (TH-B tested in growth chamber, TH-F tested in the field)

The isogenic lines were also tested at seedling and adult growth stages against three individual yellow rust races, and a bulk isolate that is used for field evaluation (Table 1). The resistance genes "Yr_1, Yr_5, and Yr_{15}" showed resistance at both growth stages, Yr_{10} gene conferred resistance only at adult growth stage, Yr_{18} and Yr_{17} were susceptible to the bulk isolate both at seedling and adult growth stages. The resistance gene "Yr_A" showed a resistant reaction to some isolate and a susceptible reaction to others at seedling stage, but a susceptible reaction to all isolates at adult stage, whereas "Yr_7 and Yr_9" were susceptible to all isolates at seedling and adult growth stages.

1.2.2.2. Western Asia (Lebanon, Iraq, Turkey), Ethiopia and Yemen

The "Avocet" isogenic lines were tested under field condition and natural infection in Lebanon, Iraq, Ethiopian and Yemen, and under artificial inoculation and field conditions in Turkey (Table 2). None of the resistance genes gave complete resistance at all sites, however four genes (Yr: 1, 5, 15 and 10) showed good level of resistance that varied among and between countries from highly resistant (R) to intermediate resistant (MR). The other resistance genes behaved in different ways:

1. Yr_{17} showed susceptible reaction in Syria (Tel Hadya), Lebanon (Terbol), and Turkey (Eskesihir).
2. Yr_{18} showed a susceptible to moderate susceptible reaction types at all sites.
3. Yr_{8} showed a susceptible reaction type in Turkey and Lebanon, and a resistant reaction type in Ethiopia, Yemen, and Iraq.
4. Yr_{A} and Yr_{9} showed susceptible reaction type at all sites.

1.2.2.3. Central Asia

Yellow rust in Central Asia is widely spread and most of the varieties grown in this region are highly susceptible. Selection for resistance among breeding nurseries is lacking in all the countries. Susceptible variety such as the bread wheat cultivar "Yuna" occupies over 60% of the area in Uzbekistan, likewise for the cultivar "intensivenya" in Kygystan, and "Mirbashir" in Azerbaijan.

The results from this region are incomplete and feed back will be improved as collaborators are being identified and proper seed dispatch, nursery establishment, and data recording being put in place. The "avocet' lines were included in the trap nursery (CWAYRTN2000) but not in the previous one due to lack of seed. The reaction of the specific genes was recorded on the previous differential set. The avocet lines will be tested in all the sites in Central Asia this coming season. Virulence types in Central Asia differ slightly from those in western Asia (Table 3). Virulence on Yr1 and Yr17 is common. Yr5 and YrSP were the only resistance genes effective at all sites in Azerbaijan, Kyrgystan, and Tajikistan. Virulence on Yr1 was recorded in Tajikistan and in Kyrgystan. Yr1 was effective in

Table 2. Field reaction of "Avocet" Isogenic lines to yellow rust at adult plant in Syria, Lebanon, Turkey, Ethiopia, Yemen, and Iraq (1999-2000).

Cultivar	Yr.	Syria	Lebanon		Turkey			Ethiopia		Yemen	Iraq
	Gene	Thed[1]	Terb	Esk	Hay	Kul	Arob	Mer	Asa	Dha	Bag
Yr1/ 6* Avocet	Yr1	R	5MR	5MR	R	-	-	-	-	-	-
Yr5/ 6* Avocet	Yr5	R	5MR	5MR	10R	0	0	0	0	10R	-
Yr7/ 6* Avocet	Yr7	85S	90S	60S	80S	(S)	-	-	-	-	-
Yr8/ 6* Avocet	Yr8	25MS	30S	30S	30MS	0	0	0	0	R	R
Yr9/ 6* Avocet	Yr9	90S	95S	50S	70S	(S)	-	-	-	(S)	-
Yr10/ 6* Avocet	Yr10	R	5MR	R	R	-	-	-	-	-	-
Yr15/ 6* Avocet	Yr15	R	5MR	5MR	R	0	0	0	0	R	-
Yr17/ 4* Avocet	Yr17	60S	90S	90S	R	-	-	-	-	-	-
Avocet R	YrA	95S	95S	95S	90S	(S)	-	-	-	90S	S
Avocet S	-	95S	95S	95S	90S	30S	60S	80S	60S	90S	S
Jupateco R	Yr18	75S	80S	80S	60S	25MS	25MS	50S	25MS	80S	S
Jupateco S	-	80S	90S	90S	80S	50S	40MS	70S	30MS	80S	-

[1] Thed: Tel hedya; Terb: Terbol; Esk: Eskesihir; Hay: Haymana: Kul:Kulumsa; Arob: A.Robe; Mer; Meraro; Asa: Asasa; Dha:Dhamar; Bag:Baghdad Reaction in parenthesis taken on same resistance gene in differential set.

Table 3. Field reaction of "Avocet" Isogenic lines at four sites in Azerbaijan, one site in Kyrgystan (June 2000), and at one site in Tajikistan (1999)

Cultivar	Yr Gene	Tajikistan	Kyrgystan	Azerbaijan			
			Bishkek	Absheron	Tartar	Gobustan	Jalilabad
Yr1/ 6* Avocet S	Yr1	(S)	30S	0	0	(0)	0
Yr5/ 6* Avocet S	Yr5	(-)	R	0	0	0	-
Yr6/ 6* Avocet S	Yr6	(S)	40S	80S	20S	(80S)	60MS
Yr7/ 6* Avocet S	Yr7	(S)	60S	90S	20S	(50S)	100S
Yr8/ 6* Avocet S	Yr8	(R)	70S	10MR	0	40S	10R
Yr9/ 6* Avocet S	Yr9	(S)	1OMS	60S	40S	(80S)	5R
Yr10/ 6* Avocet S	Yr10	(S)	R	10MR	0	(30S)	5R
Yr11/ 3* Avocet S	Yr11	-	50S	30S	20S	-	-
Yr12/ 3* Avocet S	Yr12	-	40S	50S	20S	-	-
Yr15/ 6* Avocet S	Yr15	-	R	0	20S	0	-
Yr17/ 4* Avocet S	Yr17	-	30S	20MS	0	(0)	20R
Yr18/ 3* Avocet S	Yr18	(S)	20S	20MS	40S	-	-
YrSp/ 6* Avocet S	YrSp	(R)	R	0	0	(0)	10R
YrSk/ 3* Avocet S	YrSk	-	20S	10MS	0	-	10R
Avocet R (YrA)	YrA	(R)	70S	80S	60S	0	100S
Avocet S	-	-	80S	70S	70S	80S	20MR
Jupateco R (Yr 18)S	Yr18	(S)	10MS	20MS	60S	30MR	90S
Jupateco S	-	-	30S	50S	70S	80S	100S

Reaction in parenthesis taken on same resistance gene in differential set

Azerbaijan. Virulence on the resistance genes Yr6, Yr7, Yr8, Yr9, Yr11, Yr12, and Yr18 was recorded in Azerbaijan, Tajikistan, and Kyrgystan. Differential reactions on the other genes were recorded at different sites among and between countries:

1. Yr15 showed resistant reaction type except at tartar in Azerbaijan.
2. Yr10 showed resistance at all sites except at Gobustan site in Azerbaijan.
3. YrSk showed resistant reaction in at three sites in Azerbaijan, a moderate susceptible reaction at the fourth sites (Absheron) in Azerbaijan, and a susceptible reaction at Bishkek in Kyrgystan.
4. YrA was susceptible at all testing sites but showed resistant reaction at one site (Gobustan) in Azerbaijan.

As information becomes available from the other sites in Central Asia, the scope of virulence types of yellow will be better understood; hence closer monitoring of yellow rust in this region is needed for eventual development and deployment of resistant sources.

1.2.2.4. Iran

The avocet lies were tested at 10 sites in Iran. Virulence on the Yr-genes was recorded at most sites. Virulence on Yr_1 was recorded at three sites in Iran, and virulence on Yr_{17} was wider spread and was recorded at seven sites. Virulence on Yr6, Yr7, Yr8, and Yr12 was recorded at all sites. The resistance genes Yr5, Yr15, and YrSp were highly effective against yellow rust populations in Iran.

1.2.3. Variability in Barley Scald

Scald is commonly observed in major barley growing areas in North Africa (Algeria, Morocco, and Tunisia), Western Asia (Syria, Jordan, Turkey, Cyprus, Iran, and Iraq) and in Nile Valley (Egypt, Ethiopia, Eritrea, and Yemen) regions. Heavy scald infection was recorded during last crop season in Eritrea, Ethiopia, Morocco, Syria, Tunisia, and Turkey. A trap nursery comprising 100 accessions, tested in Syria for the past 4 years was evaluated in 2000 at several sites in the region (Turkey, Tunisia, Morocco, Syria, and Lebanon) to determine the variability in scald population at different sites and the durability of resistance among the selected genotypes. The reaction of "differential genotypes" against the following eight different scald isolates, evaluated at adult growth stage (Table 4):

1. TH.97 (1) Scald population prevalent under field conditions at Tel Hadya (ICARDA's major experimental station) in 1997.
2. TH.98 (2) Scald population prevalent under field conditions at Tel Hadya (ICARDA's major experimental station) in 1998.
3. TH.99 (3) Scald population prevalent under field conditions at Tel Hadya (ICARDA's major experimental station) in 1999.
4. TH.00 (4) Scald population prevalent under field conditions at Tel Hadya (ICARDA's major experimental station) in 2000.
5. Bb. 00 (5) Scald population prevalent under field conditions at Al Bab in Northern Syria in 2000.
6. Ter.00 (6) Scald population prevalent under field conditions at Terbol (ICARDA's major experimental station in Lebanon) in 2000.
7. Th.SS1 (7) Single spore isolate evaluated at seedling growth stage.
8. Th.SS2 (8) Single spore isolate evaluated at seedling growth stage.

The highest virulence levels were associated with the isolates tested at Tel Hadya under field conditions. Different virulence patterns were observed between years

Table 4. Reaction of differential cultivars to eight scald isolates under field and controlled[1] conditions at ICARDA (Syria).

Differential Cultivars	Scald Isolates tested[2] TH.97 (1)	TH.98 (2)	TH.99 (3)	TH.00 (4)	Bb.00 (5)	Ter.00 (6)	Th.SS1 (7)	Th.SS2 (8)
Armelle	R	R	R	R	R	R	R	R
Astrix	R	R	R	R	R	R	R	R
Atlas 46 (CI 07323)	R	R	R	R	R	R	R	R
Steudelli (CI 02226)	R	S	S	R	R	R	R	R
Bey (CI 05581)	R	S	S	R	R	R	R	R
Osiris (CI 01622)	S	R	S	R	R	S	R	S
Trebi (CI 00936)	S	S	S	R	R	R	R	R
Jet (CI 00967)	S	S	S	R	R	R	R	I
Modoc (CI 07566)	S	S	S	R	R	S	R	R
Athene	S	S	S	R	R	S	R	S
Kitchin (CI 01296)	S	S	S	R	R	I	R	S
La Mesita (CI 07565)	R	R	S	R	S	S	S	S
Abyssinia	S	S	S	R	R	S	R	S
Pirate	S	S	S	R	R	S	S	S
Igri	S	S	S	R	R	S	S	S
Digger	S	S	S	S	R	S	S	S
Forrajera (CI 08158)	S	S	S	S	R	S	S	S
Rihane-03	S	S	S	I	R	S	S	S

[1] Six isolates were tested under field conditions, and single spore isolates (iso.7&8) were tested in green house. [2]Isolate reference (.) reference number of the isolate. , R=Resistant, I=Intermediate, =Susceptible

(1997-2000) at Tel Hadya and between sites in 2000. The infection level recorded at Tel Hadya was very low in 2000 due to rapid drying out of plants that stop scald evolution. The virulence level observed at Terbol station (Lebanon) is relatively high. Large difference in virulence was observed between the two single spore isolates originated from the same scald population. The differential cultivars Armelle, Astrix, and Atlas showed complete resistance against the isolates tested. The cultivars "Athen and Osiris" reacted in the same manner against the scald isolates tested; likewise for the following pairs of cultivars: Irate and Igri", and "Digger and Forrajera". Rihane is common commercially grown six-row barley in North Africa and is used as standard check.

1.2.4. Occurrence of Sexual Stage of *Ascochyta fabae* Speg. In Syria and its Role in Pathogenic Variability

Differential interactions of faba bean genotypes to *Ascochyta fabae*, the causal agent of faba bean Ascochyta blight have been reported from Australia, Canada and Poland. In Syria, disease severity at Tel Hadya (*dry and cold winter*) was always higher than that at Lattakia (*wet and mild winter*), which is caused by either GxE interactions or pathogen variability or both. The occurrence of the sexual or perfect stage of the pathogen (*Didymella* fabae Jellis & Punithalingam), leading to a large variability in the pathogen populations, was detected, for the first time this year, on faba bean debris at Tel Hadya and its pathogenicity confirmed. All attempts to locate this perfect stage at Lattakia site were not successful, although the inoculum used to artificially inoculate the plants at both sites was the same. Around 350 germplasm accessions and breeding populations are being evaluated every year since 1997. Resistant sources have been identified and shared with NARSs. The natural occurrence of the sexual stage of the fungus in northern Syria makes this region ideal for screening faba bean germplasm for resistance to Ascochyta blight. This will increase the chances of having resistance identified at ICARDA will also be resistant when tested by NARS collaborators in the region.

1.2.5. Pathogenicity of Different Isolates of *Botrytis fabae* and *Ascochyta fabae*

Pathogenicity tests were carried out using twenty-five isolates of each of *Ascochyta fabae* & *Botrytis fabae*, collected in previous seasons from faba bean screening nurseries at Jableh, Syria. The aim was to identify virulent isolates to be used for artificial inoculation of faba bean nurseries used for screening for resistance to faba bean Ascochyta blight and chocolate spot. A susceptible check, Giza 4 was used for *A. fabae* and Rebaya 40 for *B. fabae* isolates. The trial, which was carried out under plastic house conditions permitted to select 10 isolates of *A. fabae* (9901D, 9901E, 9902A, 9902D, 9902E, 9902H, 9903A, 9903F, S99, M99) and 5 isolates of *B. fabae* (9903B, 9904B, 9906B, 9907B, 9908B). These isolates are used to artificially inoculate the nurseries at both Tel Hadya and Jableh.

1.2.6. Race Situation of *Fusarium oxysporum* f. sp. *Ciceris* from Syria

A plant differential set composed of 14 chickpea lines, with known reaction to different races, was used to determine the race situation of *Fusarium oxysporum* f. sp. *ciceris* causing chickpea wilt. Single spore isolates were made out of diseased chickpea plant samples, collected from the chickpea sick plot at Tel Hadya as well as from farmers fields in Azaz and Ifrin (Aleppo governorate) and Jisr Al-Shoghour (Idlib governorate) and used to prepare spore suspensions for artificial inoculation. Plastic pots containing sterilized soil/sand mixture (2/1) were used. Five seeds/line were sown at 5 cm depth in each pot. The experimental design was a split plot design in three replications with the different isolates as main plots and the differential lines as the sub plot. After germination, each pot was artificially inoculated with 100 ml of a spore suspension containing 25 x 10^5 microconidia ml^{-1}. Plants were observed for wilting symptoms and scored for disease reaction at a 1-5 scale after 21 and 40 days from germination. Results revealed that isolates tested belong to either race 2 or race 3. and that Tel Hadya chickpea sick plot harbours both races. These results will be confirmed next season using additional differentials.

1.2.7. Effect of Temperature on Development of Chickpea Leaf Miner

This study was conducted in incubators set at three temperatures (15, 20, 25±2°C), 16:8h photoperiod and 55% RH. The experiment was a completely randomized design with 10 replications (pots). Few seed of the local susceptible cultivar ILC 3397 were planted in each pot. After germination, the number of plants was reduced to two/pot and covered with a well-aerated plastic cage. Eight pairs of leaf miner adults were released in each cage for infestation. Leaflets were sampled daily to record the time of egg hatching, pupation and adult emergence. The results showed that there was a significant effect of temperature on developmental time of all the three insect stages, egg, larva and pupa. The generation time was the shortest at 25°C with about 20 days and the lowest at 5°C with 66 days (Table 5). These data are useful for rearing leafminer under controlled condition for different purposes.

Table 5. Effect of temperature on developmental time of chickpea leaf miner, Tel Hadya, 2000.

Temperature (°C)	Developmental time			
	Egg	Larva	Pupa	Full generation
15	8.7	8.8	48.5	66.0
20	4.2	5.2	14.0	23.4
25	3.4	3.9	12.4	19.7
LSD	0.3	0.5	2.0	2.2

Output 2: IPM Components for the Different Cropping Systems and Agroecological Zones

2.1. Evaluation for Pest Resistance

2.1.1 Resistance to Powdery Mildew: Effective Resistance Genes

Seventeen powdery mildew virulence types were identified in 1999-2000 crop season. The isolates originated from four regions in Syria. Table 6 shows the origin of the isolate, virulence types within a population (bulk isolate), and the corresponding effective resistance genes. Genes and gene combinations effective against all Syrian isolates tested during this season are summarized in Table 7.

Table 6. Effective resistance genes/gene combinations to barley powdery mildew in Syria.

Isolate Origin	Resistance genes
Tel Hadya-bulk	Mla+, Mla3, Mla7-Ml(lg), Mla9-Mlk, Mla12,Mla13-Ml(ru), Mla9
Messiaf-Bulk	Mla+, Mla9-Mlk, Mla9, Mla13-Ml(ru)
Messiaf-1	Mla+, Mla9-Mlk, Mla9, Mla13-Ml(ru), mlo
Messiaf-2	Mla+, Mla3, Mla7-Ml(lg), Mla9-Mlk, Mla9, Mla12, Mla13-Ml(ru).
Messiaf-3	Mla+, Mla7-Ml(lg), Mla9-Mlk, Mla9, Mla12, Mla13-Ml(ru), mlo
Messiaf-4	Mla+, Mla3, Mla7-Ml(lg), Mla9-Mlk, Mla9.
Messiaf 5	Mla+, Mla7-Mlk, Mla7, Mla7-Ml(lg), Mla9-Mlk, Mla9, Mla12, Mla13-Ml(ru), Ml(ru)
El-Ghab (Bulk)	Mla+, Mla7-Ml(lg), Mla9-Mlk,Mla9,
Ghab-1	Mla+, Mla6-Mla14, Mla7-Ml(lg), Mla9-Mlk, Mla9, Mla13-Ml(ru), Ml(ru), mlo
Ghab-2	Mla+, Mla7-Ml(lg), Mla9-Mlk, Mla9, Mla12,
Ghab-3	Mla+, Mla7-Ml(lg, Mla9-Mlk,), Mla9, Mla12, Mla13-Ml(ru), Ml(ru), mlo
Ghab-4	Mla+, Mla9-Mlk, Mla9, Mla13-Ml(ru),mlo
Ghab-5	Mla+, Mla3, Mla7, Mla7-Ml(lg), Mla9-Mlk, Mla9, Mla12, Ml(ru),mlo
Al Bab (Bulk)	Mla+, Mla3, Mla7-Mlk, Mla7-Ml(lg), Mla9-Mlk, Mla9, Mla12, Mla13-Ml(ru), Ml(ru), Ml41/145, mlo
Bab-1 Bab-2 Bab-3	Mla+, Mla3, Mla6-Mla14, Mla7-Mlk, Mla7, Mla7-Ml(lg), Mla9-Mlk, Mla12, Mla13-Ml(ru), Mlc, Ml1402, Ml41/145, Ml(ru), Mlg-Mlcp, mlo

2.1.2. Evaluation of Food Legumes for Resistance to Diseases

Germplasm accessions and breeding material of chickpea, faba bean and lentil have been screened under controlled and field conditions to identify sources of resistance to major diseases affecting chickpea (Fusarium wilt and Ascochyta blight), faba bean (Chocolate spot and Ascochyta blight), and lentil (Fusarium wilt). Twenty seven new sources of resistance to faba bean chocolate spot originated from Tunisia (1), Morocco (3), Germany (1),Ecuador (1), Spain (5), Italy (1), Mexico (1), Portugal (5) and Syria (9). Also new sources of resistance to diseases affecting chickpea (Figure 1, Table 8) and lentil (Table 9) were identified. For more details, the reader is referred to the section on breeding faba bean, lentil and chickpea for resistance to diseases (Project 1.5). It is worth mentioning that excellent sources of resistance to faba bean Ascochyta blight (Rating 2 and less) were identified. Among those, 34 lines maintained their high resistance level to faba bean Ascochyta blight for the third consecutive year. These lines included 2 new BPL (4070 & 4071) from Spain, 5 accessions from Australia selected earlier from ICARDA material (Acc 611, 668, 683, 970 and 1003). The rest were all ICARDA selections from previous years. All faba bean selections will be screened next season for combined resistance to both Ascochyta blight and chocolate spot.

Table 7. Sources of genes effective against Syrian isolates of barley powdery mildew.

Resistance genes	Genotype	Origin
Effective Genes		
Mla+	P-01	Iso 1R CI 161137 (*Algerian*)
Mla9-Mlk	P-07	Mona Svalof- (*Monte Cristo)*
	P-08A	Senat Svalof-(*Triple awm lemma)*
Mla9	P-08B	Senat Svalof-(*Triple awned lemma*)
Ineffective genes against Syrian isolates		
Mla10-Ml(du)	P-09	Iso 12R CI 16149 (*Durani*)
Mlk	P-17	MC gene2 Svalof (*Monte Cristo)*
Ml(la)	P-23	Lofa Abed (H.*laevigatum*)
Mlh	P-24	Iso 3R CI 16141 (*Hanna*)

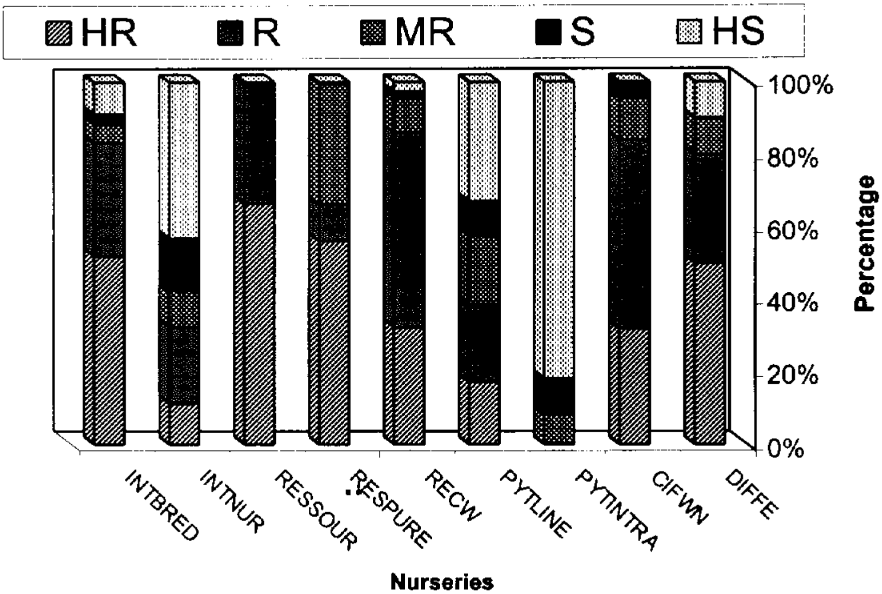

Fig. 1. Performance of different chickpea nurseries to chickpea vascular wilt during the cropping season 1999/ 2000 at Tel Hadya, Syria

2.1.3. Screening Faba Bean Genotypes for *Bean Leaf Roll Virus* (BLRV) and *Faba Bean Necrotic Yellow Virus* (FBNYV) Resistance

2.1.3.1. Evaluation of Best Performing Faba Bean Genotypes from Previous Seasons

Screening faba bean for BLRV resistance was conducted in collaboration with Tamworth Crop Improvement Center, NSW Agriculture and with partial support from GRDC, Australia. A total of 180 single faba bean plants selections obtained from 99 genotypes identified in the previous season as highly tolerant to BLRV (based on their yield and reaction to virus infection) were re-evaluated for their reaction to a local isolate of BLRV (SV64-95). Similarly, a total of 120 faba bean genotypes (selected from plants of 120 genotypes from the previous season as highly tolerant to FBNYV infection) were also re-evaluated for their reaction

Table 8. Ratings of different chickpea nurseries and breeding material to chickpea Ascochyta blight during the cropping season 1999/ 2000 at Tel Hadya, Syria

	Reaction on (1-9) scale)									
Trial	1	2	3	4	5	6	7	8	9	Total
Chickpea Nurseries										
CIABN	0	0	8	15	15	2	0	0	0	40
DIFF.	0	0	7	3	5	8	0	0	0	23
INT AB.	0	0	74	51	27	50	21	26	16	265
PYT AB.	0	0	100	200	153	189	54	25	46	767
PYT INT AB.	0	0	0	3	0	5	39	53	88	188
PYT RXR	0	0	3	24	18	17	1	0	1	64
WILD SP.	0	0	0	45	48	80	19	9	41	242
Total	0	0	192	341	266	351	134	113	192	1589
Breeding Material										
F2	0	0	2	25	43	31	5	2	0	108
F3 BULK	0	0	0	3	21	33	30	10	0	94
F3 PROGL	0	0	0	141	362	891	755	484	457	3090
F4 PROG.	0	0	23	532	1014	798	328	80	81	2856
F4 PROGL.	0	0	0	15	62	88	59	13	2	239
F4 TER AB.	0	0	51	351	558	791	471	140	47	2409
F5 LARGE	0	0	3	86	66	37	5	3	1	201
F5 PROG.	0	0	6	1276	846	336	39	7	7	2517
F6RXR BIO.	0	196	221	42	24	20	4	0	0	507
F7 RXR	0	57	119	59	26	16	0	0	0	277
Total	0	253	425	2530	3022	3041	1696	739	595	12298

to a local isolate of FBNYV (SV66-95). Genotypes evaluated were grown in a screen house for each virus. Each genotype was represented by 10 plants (1.5m row), replicated twice. All the above plants were artificially inoculated with the virus, using the aphid vector *Acyrthosiphon pisum* (10-15 viruliferous aphids per plant). Reaction of the different genotypes to virus infection was monitored by evaluating (i) incidence and severity of infection, (ii) virus distribution and concentration (using TBIA test), and (iii) yield. Lines characterized by mild or no symptoms, no or little virus content and good yield were identified.

Table 9. Summary reaction of a core collection of lentil germplasm to lentil vascular wilt during 1999/2000 cropping season at Tel Hadya, Syria

Origin	No. of genotypes tested	No. of genotypes were resistant	% resistant
AFG	5	2	40.0
AZE	3	3	100.0
BGD	9	7	77.8
BGR	2	2	100.0
CAN	2	2	100.0
CHL	16	3	18.8
CSK	1	1	100.0
DEU	3	2	66.7
DZA	1	1	100.0
EGY	50	2	4.0
ESP-	5	4	80.0
ETH	11	9	81.8
FRA	3	3	100.0
GRC	1	0	0.0
HUNG	7	6	85.7
IND	11	10	90.9
IRN	356	98	27.5
IRQ	1	1	100.0
ITA	1	1	100.0
JOR	16	0	0.0
LBN	20	2	10.0
MAR	4	4	100.0
MEX	1	1	100.0
NLD	1	1	100.0
NPL	11	9	81.8
PAK	11	8	72.7
POL	2	2	100.0
PRT	4	4	100.0
RUS	1	0	0.0
SYR	17	4	23.5
TUN	1	0	0.0
TUR	42	11	26.2
UKR	2	2	100.0
USA	1	1	100.0
YEM	6	6	100.0
YUG	5	2	40.0
	633	214	33.8

Variability among plants within each genotype existed and seed from selected best performing individual plants were harvested and will be evaluated under screen house conditions during the next season. The performance of the best faba bean genotypes are summarized in Tables 10 and 11.

2.1.3.2. Evaluation of New Faba bean Genotypes for BLRV Resistance

During 1999/2000 growing season, new faba bean genotypes obtained from ICARDA Gene Bank and originated from 23 countries (Afghanistan, Algeria, Australia, Canada, China, Colombia, Czeck Republic, Ecuador, Egypt, Ethiopia, Greece, India, Iraq, Lebanon, Morocco, Pakistan, Russia, Spain, Sudan, Syria, Turkey, Yemen and Yugoslavia) were evaluated for their reaction to BLRV (206 genotypes) and FBNYV (270 genotypes) using artificial inoculation of the virus with its aphid vector. Ten plants of each genotype tested were planted in the open field in one row (1.5 m long). A number of faba bean genotypes were found to be highly resistant to BLRV and FBNYV infection were identified, and single plant selections of high yielding and immune to infection were made. During the next growing season, all these plants/genotypes will be re-evaluated under screen house conditions.

2.1.4 Screening for Faba Bean Necrotic Yellows Virus (FBNYV) and Bean Leaf Roll Virus (BLRV) Resistance in Lentil

During the 1999/2000 growing season, 59 lentil genotypes (including 9 genotypes selected from the previous season proved as good yielders and highly tolerant to virus infection) were evaluated for their reaction to local isolates of BLRV (SV64-95) and FBNYV (SV66-95) using artificial inoculation with the aphid vector Acyrthosiphon pisum (10-15 viruliferous aphids per plant). Genotypes tested were planted in the field in two replicates, each represented by two one-meter rows, with 35 plants per meter in a randomized complete block design (RCB) for both the inoculated and non-inoculated treatments. Yield loss (%) and symptoms severity (SS) (0-3 scale) based on symptoms produced were determined for all the genotypes tested and are summarized in Tables 12 and 13. Based on these results

Table 10. The performance of the best 10 faba bean lines evaluated for *Bean leaf roll virus* (BLRV) on the basis of average TBIA score, % infection and yield (g/ plant) obtained during 1999/2000 when planting seeds from individual plants selected in the previous season (1998/1999) with TBIA score of 0 and yield (g/plant) was more than 10 grams (at least 20 seeds/ plant).

Faba bean line	Origin	Average TBIA score	% Infection	Mean Yield (g/ plant)
ILB 86//99-In9-S-LR//	Afghanistan	0.0	0	24.2
ILB 388//99-In1-S-LR//	Tunisia	0.0	0	27.8
ILB 426//99-In3-S-LR//	Sudan	0.0	0	28.5
ILB 485//99-In1-S-LR//	Afghanistan	0.0	0	32.0
ILB 485//99-In6-S-LR//	Afghanistan	0.0	0	29.7
ILB 4130//99-In1-O-LR//	China	0.0	0	37.4
ILB 485//99-In4-S-LR//	Afghanistan	0.2	5	32.8
ILB 894//99-In3-O-LR//	China	0.1	6	28.2
ILB 491//99-In5-S-LR//	Afghanistan	0.2	10	29.7
ILB 603-A//99-In1-S-LR//	Russian	0.2	10	22.1
ILB 14//99-In4-S-LR//	Syria	2.4	95	4.0
ILB 3870-C//99-In7-S-LR//	Canada	2.9	100	5.5

Table 11. The performance of the best faba bean genotypes evaluated for *Faba bean Necrotic Yellow Virus* (FBNYV) resistance under artificial inoculation conditions in the field at Tel-Hadya, Aleppo, Syria during the 1998/1999 and 1999/2000 growing seasons.

Virology Pedigree	Origin	% of infection		% of infection	
		1998/1999	1999/2000	1998/1999	1999/2000
ILB 603-A//99-B-O-NY//	Russian	0	0	23	21
ILB 397//99-B-O-NY//	Tunisia	26	11	19	17
ILB 3056//99-B-O-NY//	Ecuador	50	15	8	18
ILB 4258//99-B-O-NY//	China	70	15	5	17
ILB 3355//99-B-O-NY//	China	89	21	2	15
ILB 1814//99-B-O-NY//	Syria	37	25	14	13
ILB 1911//99-B-O-NY//	Greece	43	25	12	9
ILB 430//99-B-O-NY//	Sudan	60	25	7	16
ILB 4257//99-B-O-NY//	China	67	25	8	9
ILB 3357//99-B-O-NY//	China	90	26	3	9
ILB 296//99-B-O-NY//	Spain	55	30	7	7
ILB 14//99-B-O-NY//	Syria	50	32	10	16
ILB 3352//99-B-O-NY//	China	56	32	8	14
ILB 3362//99-B-O-NY//	China	91	33	3	13
ILB 4275//99-B-O-NY//	China	50	35	7	7
ILB 3347//99-B-O-NY//	China	60	35	12	10
ILB 3353//99-B-O-NY//	China	80	35	7	10
BPL3011//99-B-O-NY//	Unknown	60	60	7	4
BPL 4280	China	79	-	1.8	-

Table 12. Variability in yield loss (%) and symptom severity* among lentil genotypes in response to infection with *Bean Leaf Roll Virus* (BLRV) (SV 64-95) evaluated during the 1999/2000 growing seasons.

Lentil Genotypes	Yield loss (%)
ILL 74, 75, 2684, 5604, 6258, 6818, 7115, 7203, 7204, 7219, 7285, 7502, 7513, 7543, 7657, 7659, 7661, 7701, 7986, 7988, 7990, 8123, 8613, 8615	1-10
ILL 5490, 6264, 7163, 7200, 7207, 7547, 7657, 7706, 7716, 7981, 7981, 8104, 8105, 8106, 8118, 8120, 8121, 8125, 8126, 8616	11-25
ILL 2439, 5782, 6002, 6207, 6258, 6467, 7701, 7177, 7719, 8119, 8128, 8140, 8142, 8186,	26-50
ILL 8127	51-100
	Symptoms severity (0-3)
ILL 74, 75, 2684, 5604, 6258, 6818, 7115, 7204, 7219, 7502, 7513, 7543, 7657, 7659, 7661, 7701 7988, 7990, 8123, 8613, 8615	0
ILL 5490, 6264, 7163, 7200, 7207, 7547, 7657, 7706, 7716, 7981, 7981, 8104, 8105, 8118, 8120, 8121, 8125, 8126, 8616, 7203, 7285, 7986	1
ILL 2439, 5782, 6002, 6207, 6258, 6467, 7177, 7701, 7719, 8106, 8119, 8128, 8140	2
ILL 8127, 8142, 8186	3

* Symptoms of infected plants was measured based on BLRV symptoms (yellowing + stunting) severity, using a 0-3 scale (0, no symptoms and 3, severe symptoms).

Table 13. Variability in yield loss (%) and symptom severity* among lentil genotypes in response to infection with *Faba Bean Necrotic Yellow Virus* (FBNYV) (SV 66-95) evaluated during the 1999/2000 growing seasons.

Lentil Genotypes	Yield loss (%)
ILL 74, 75, 2439, 2684, 6258, 6264, 6818, 7204, 7207, 7219, 7285, 7657, 7657, 7659, 7661, 7701, 7701, 7716, 7719, 7988, 7990, 8105, 8119, 8120, 8123, 8128, 8140, 8142, 8613, 8615	0
ILL 5490, 5604, 6002, 6467, 7200, 7203, 7547, 7981, 7986, 8106, 8127, 8616	0.1-10
ILL 6207, 6258, 7163, 7177, 7513, 7543, 7981, 8104, 8118, 8121, 8125, 8126	10.1-25
ILL 5782, 7115, 7502, 7706, 8186	25.1-50
	Symptoms severity (0-3)
ILL 74, 75, 2439, 2684, 6264, 6818, 7204, 7285, 7657, 7659, 7661, 7701, 7701, 7716, 7719, 7990, 8105, 8119, 8120, 8123, 8140, 8613	0
ILL 5490, 6002, 6258, 7203, 7207, 7219, 7547, 7657, 7981, 7986, 8106, 8127, 8142, 8615, 8616	1
ILL 6207, 6467, 7163, 7177, 7200, 7513, 7543, 7988, 8104, 8118, 8121, 8125, 8128,	2
ILL 5604, 5782, 6258, 7115, 7502, 7706, 7981, 8126, 8186	3

* Symptoms of infected plants was measured based on FBNYV symptoms (yellowing + stunting) severity, using a 0-3 scale (0, no symptoms and 3, severe symptoms).

it was possible to group the genotypes tested into four categories: (1) Highly resistant: genotypes which did not produce symptoms (SS=0) and grain yield loss (%) was less than 10%; (2) Resistant: genotypes where SS=1 and grain yield loss was less than 25%; (3) Moderately resistant: genotypes where SS=2 and grain yield loss was less than 50%; (4) Susceptible genotypes: which had a yield loss of above 50% and SS=3. Results obtained from this growing season and the last three growing seasons suggested that many genotypes were resistant to BLRV. Moreover, four genotypes were found resistant to BLRV for two years (IL 2684, 7203, 7513, 7659), three genotypes (ILL 85, 213, 6816) were found to be resistant to BLRV and FBNYV for three years and two genotypes (ILL 74 and ILL 75) were resistant for four years to BLRV and FBNYV. Work conducted on some of the highly resistant genotypes showed that virus multiplication and movement in such genotypes was greatly reduced.

2.1.5. Screening for *Bean Leaf Roll Virus* (BLRV) and *Soybean Dwarf Virus* (SbDV) Resistance in Chickpea Genotypes.

During the 1999/2000 growing season, 100 chickpea genotypes (including 40 genotypes selected from the previous season proved to be good yielders and highly tolerant to virus infection) were evaluated for their reaction to local isolates of BLRV (SV64-95) and SbDV (SL1-94). Forty-seven of these genotypes were obtained from ICARDA Gene Bank and originated from 17 countries (Afghanistan, Australia, Chile, China, Cyprus, Egypt, Ethiopia, India, Iran, Mexico, Pakistan, Portugal, Spain, Syria, Tunisia, Turkey and USA) and 53 genotypes originated *from* ICARDA breeding material. Genotypes evaluated were grown in the field and each genotype was represented by 10 plants (1.5 m row), replicated twice. All the above plants were artificially inoculated with the virus, using the aphid vector *Acyrthosiphon pisum* (10-15 viruliferous aphids per plant). Reaction of the different genotypes to virus infection was monitored by evaluating (i) % of infection (based on the symptoms) and (ii) yield. In addition, all the above chickpea genotypes were evaluated for their reaction to SbDV under glasshouse condition. Each genotype was represented by 10 plants, planted in 2 pots (20 x 30 cm). Reaction of the different genotypes to virus infection was monitored by evaluating % of infection (using TBIA test).

Results obtained from the glasshouse experiment suggested that four genotypes were not infected with SbDV (ILC 71, ILC 102, ILC 359 and ILC 3210), one genotype had an infection level of 11% (ILC 303), 6 genotypes had an infection level of 12-20% (ILC 300, ILC 328, ILC 1313, ILC 1261, ILC 7192 and ILC 7963) and 22 genotypes had an infection level of 20-30%. Whereas, nine genotypes had 100% infection (ILC 66, ILC 252, ILC 266, ILC 9485, ILC 9587, ILC 15065, ILC 1760, ICC 15566 and ICC 11322). The results in the open field were not very conclusive as there was no consistency among the two replicates of the experiment. Nevertheless, as a preliminary observation, the following chickpea genotypes were found, more or less, resistant to BLRV infection: ILC 296, ILC 348, ILC 385, ILC 519, ILC 9196, ILC 8948 and ILC 9636. No chickpea genotypes showed resistance to SbDV infection. More work is needed to improve the methodology of screening chickpea for resistance to virus diseases.

2.1.6. Evaluation for Resistance Mechanism

2.1.6.1. Monitoring Virus Movement and Concentration in F2 Barley Populations in the Plastic House

The use of laboratory methods to identify plants resistant to BYDV, at the seedling stage and eliminate susceptible segregates early in the season, could make the selection of resistant plants in the F2 population simple and fast. The BYDV concentration was monitored in the F2 populations of 21 barley crosses and their parents. Plants were planted in Giffy 7 in plastic house and inoculated with BYDV at seedling stage. All plants were tested 3, 5, 9 and 14 days after inoculation by TBIA. Resistant plants were identified on the basis of no virus present in the phloem tissues 5 days after inoculation. Such differentiation was weaker when the test was conducted 9 days after virus inoculation, and was not possible 14 days after virus inoculation (Table 14). Using this technique, it was possible to eliminate susceptible plants 5 days after inoculation and transplant the resistant ones to the field for further observation until harvest.

Table 14. Proportion (%) of plants of selected F2 barley crosses with no virus detected in the phloem vessels at 3, 5, 9 and 14 days following artificial inoculation with barley yellow dwarf virus under plastic house condition.

Cross**		% of plants with no virus detected											
		3 days after inoculation			5 days after inoculation			9 days after inoculation			14 days after inoculation		
Female parent	Male parent	F*	M*	S.P*	F	M	S.P	F	M	S.P	F	M	S.P
P1	P2	-	-	-	70.6	27.8	45.7	5.9	5.3	14.3	15.4	0.0	0.0
P1	P3	-	-	-	70.6	0.0	28.0	5.9	5.3	5.7	15.4	0.0	0.0
P1	P4	-	-	-	70.6	36.8	50.0	5.9	0.0	13.3	15.4	0.0	0.0
P5	P1	-	-	-	11.1	70.6	45.8	0.0	5.9	12.5	0.0	15.4	4.2
P6	P1	-	-	-	5.9	70.6	37.7	0.0	5.9	0.0	0.0	15.4	3.6
P1	P7	-	-	-	70.6	10.5	34.0	5.9	0.0	2.2	15.4	0.0	7.7
P1	P8	-	-	-	70.6	40.0	28.6	5.9	0.0	0.0	15.4	0.0	00
P9	P1	63.2	70.0	29.1	30.0	65.0	27.8	10.5	0.0	5.8	-	-	-
P1	P10	70.0	31.6	24.0	65.0	10.0	2.2	10.5	0.0	4.2	-	-	-
P1	P11	70.0	60.0	80.0	65.0	20.0	38.2	10.5	0.0	1.9	-	-	-
P1	P12	70.0	40.0	34.0	65.0	0.0	29.8	10.5	0.0	2.1	-	-	-
P1	P13	70.0	35.0	21.1	65.0	20.0	27.1	10.5	0.0	8.8	-	-	-
P14	P1	40.0	70.0	29.1	35.0	65.0	29.1	0.0	10.5	7.4	-	-	-
P15	P1	20.0	70.0	29.1	0.0	65.0	30.8	0.0	10.5	13.2	-	-	-
P16	P1	52.6	70.0	41.8	5.0	65.0	15.1	0.0	10.5	21.6	-	-	-
P7	P1	25.0	70.0	45.5	20.0	65.0	38.2	0.0	10.5	5.4	-	-	-
P1	P17	70.0	26.3	41.8	65.0	15.0	5.3	10.5	0.0	8.5	-	-	-
P18	P1	45.0	70.0	66.7	25.0	65.0	35.7	10.0	10.5	21.8	-	-	-
P1	P19	70.0	55.0	64.4	65.0	50.0	41.4	10.5	20.0	35.6	-	-	-
P1	P20	70.0	45.0	69.4	65.0	20.0	63.5	10.5	10.0	24.5	-	-	-
P1	P21	70.0	25.0	66.7	65.0	15.0	32.4	10.5	0.0	25.0	-	-	-

*F: Female parent, M: Male parent, S.P: Segregating population

Cont'd table 14.

** All genotypes with the bold have BYDV resistance gene:
P1= QB813.2, P2= Arig 8, P3= Hamra/Arar, P4= Egypt, P5= Mari/Aths*2//Avt/Attiki/3/Aths/Lignee 686, P6= 80-5145/N-Acc4000-301-80, P7= Algerian Selection DZ 21-3/3/CM67/Apro//Sv.02109/Mari, P8= Alanda-//Ssn/Lignee 640, P9= Ager/3/Robust//Gloria'S'/Copal'S'', P10= Lignee 527/NK1272//UL76252/Jaidor, P11= Hma-02//11012-2/CM67/3/Arar, P12= Avt/Attiki//Aths/3/Giza 121/Pue, P13= Aw Black/Aths//Rhn-08, P14= Lignee 527/NK1272//Alanda, P15= Alanda-01, P16= Rhn-03//Lignee 527/NK1272/3/Lignee 527/Chn-01//Alanda, P17= Martin/Alanda, P18= ScottiaII/3/Robust//Gloria'S'/Copal'S', P19= CI-1021/4/CM67/U.Sask.1800//Pro/CM67/3/DL70/5/Gizeh 134/Apm//Aths, P20= M64-76/Bon//Jo/York/3/M5/Galt//As46/4/Hj34-80/Astrix/5/NK1272/6/Giza 121/Pue, P21= Lignee 527/Chn-01//Alanda

2.1.6.2. Quantitative Plastic House Assay for BYDV Resistance in Cereals Crops

In an effort to develop a simple plastic house test which could be used as a reliable guide for field performance, 15 barley lines, 15 bread wheat and 15 durum wheat were planted in pots in the plastic house, 4 plants/pot, 1 tiller/plant and 4 pots per genotype. The same genotypes were planted in the field in 4x1 m rows. All plants in the plastic house and in the open field were artificially inoculated with BYDV at the seedling stage and before tillering. In barley, there was a correlation (r=0.525) between the losses in average main head weight/plant in the plastic house and the yield losses % in the open field. Similar results were not obtained for bread and durum wheat. Consequently, at least in barley, it is possible to conduct a preliminary screening for BYDV resistance/ tolerance in the plastic house, based on three single heads (one head/plant), and extend testing to the field during the next season, only for those barely genotypes which demonstrate low yield loss in the plastic house test (Figure 2).

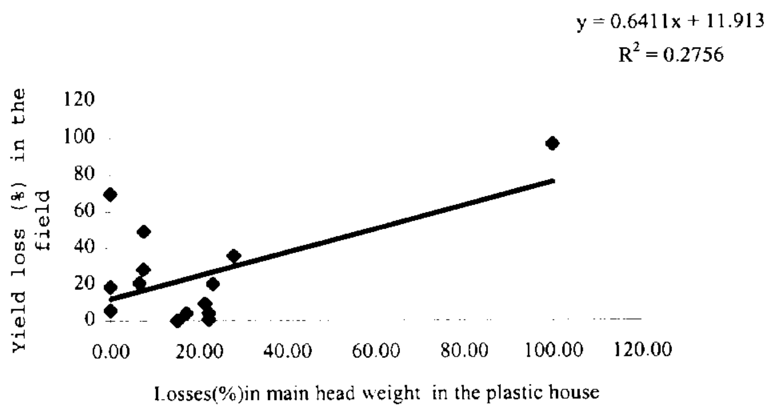

Fig. 2. Correlation between yield loss (%) in average main head weight/plant in the plastic house and yield loss in field plots for barley genotypes, when all plants were artificially inoculated with BYDV during the 1999-2000 growing season.

2.1.7. Effect of Neurotoxin Content on Reaction of *Lathyrus sativus* to Cyst Nematode and *Orobanche* spp.

An experiment was carried out to evaluate the reaction of a set of 27 accessions of *Lathyrus sativus*, belonging to three categories as for their neurotoxin content, (Low 0.2, medium 0.21-0.4 and high >0.4), to broomrapes (particularly *Orobanche crenata*), a redoubtable parasitic plants affecting feed and food legumes in the Mediterranean basin, and the cyst nematodes (*Heterodera* spp.). The experiment was planted on December 1^{st} 1999, under rain fed conditions, in field B5, Tel Hadya-ICARDA, Syria. Each experimental plot was 5.4 m^2 and consisted of 4 rows, each of 3 meters length, distanced by 45 cm. The experiment was a split plot design with 3 replications. The neurotoxin groups were the main plots and accessions tested as sub plots. No artificial inoculation with either Orobanche seeds or nematode cysts was performed. However, the field is known to harbour both pathogens. Level of infestation of both Orobanche and cyst nematode was good and evenly distributed. Reaction to cyst nematode was measured on 20 April 2000 as percent incidence (%) and severity on a 1-9 scale. Reaction to *Orobanche* was measured on 3 May 2000 as number of Orobanche shoots per square meter. Plants in the two median rows were harvested on 25 May 2000, and their biological and seed yield (g/m^2) as well as their harvest index determined. Data was subjected to ANOVA, using Genstat 5. Significant differences in cyst nematode incidence and severity were observed on lines belonging to different neurotoxin content groups. Values for mean incidence were 32.6, 16.3 and 16.3% and for mean severity were 4.2, 3,1 and 3.0 for the low, medium and high neurotoxin content groups, indicating negative correlations between neurotoxin content and incidence and severity of cyst nematode. Although the differences in Orobanche shoots number amongst various group were not significant, the shoot number was clearly superior (9.4) in the high neurotoxin group as compared to 4.9 shoot/m^2 in the low neurotoxin group LSD 5%=5.1. Biological yield was higher in the group comprising entries with higher neurotoxin content. Mean values were 132, 205, and 208 g/m^2 for the low, medium and high neurotoxin content groups, respectively. Seed yields followed similar trends, with 31.5, 35 and 38 g/m^2 for the above-mentioned groups, respectively. Interestingly, harvest index was significantly higher in the low neurotoxin content group

(23.3) compared with 16 for the medium and 17 for the high neurotoxin content groups (LSD5%=6.2). The above-mentioned results need confirmation and will have implications on the management of biotic stresses affecting forage legumes.

2.2. Effect of Cultural Practices, Biological Control Agents, Use of Chemicals Including Botanical Pesticides on Pest Population

2.2.1. Screening of a Wild Collection of Lentil for Resistance to Sitona

Sitona crinitus Herbst is the major insect pest of lentil in West Asia and North Africa. The adults feed on leaflets and larvae in the nodules. The only available option for the control of this pest is the use of insecticides. However, farmers have not been able to use them as they are expensive. Also, environmental concerns are another factor that limit their use. Because genetic resistance has not been found in the cultivated lentils, we have been screening wild relatives for resistance to this pest. In 1999, one accession was identified as resistant under artificial infestation in the greenhouse. The accession (ILWL 359) identified in the greenhouse in 1999 and another collection of wild relatives was evaluated under natural infestation in the field during the 2000 season. Twenty seeds of each accession were sown in hill plots. The material was evaluated for visual damage the first week of March using a 1-9 scale. (1, no damage; 2, 1-10%leaflets damage; 3, 20-11% leaflets damage; 4, 21-30% leaflets damage; 5, 31-40% leaflets damage; 6, 41-50% leaflets damage; 7, 51-70% leaflets damage; 8, 71-90% leaflets damage; 9, more than 90% leaflets damage. By the middle of April, a random sample of five plants/accession was taken to the lab for nodule damage evaluation. The results showed that the accession ILWl 359 had a very low leaflet damage score (2), but a high nodule damage (70%). Out of the 100 accessions tested, ten were selected with a low percent nodule damage (<25%). These accessions will be retested next season under field conditions for confirmation. The mechanisms of resistance (antixenosis and/or antibiosis) that make the ILWL 359 less preferred (low visual damage score) by Sitona are also envisaged. Some of the parameters studied include the fecundity of Sitona and the percent egg hatch when females are reared on this wild accession leaflets vs on those of a cultivated lentil cultivar.

2.2.2. Bioassays of Entomopathogenic Fungi on Sunn Pest Adults

Following consultation with NARS, two target areas were proposed for management of Sunn Pest with entomopathogenic fungi. One was at the borders of cereal fields and the other directly in the overwintering sites where Sunn Pest rest under litter. Initial steps were taken to develop data to substantiate these targets. On-plant and in-litter trials with adult Sunn Pests produced positive results. Select isolates were sprayed in the laboratory on wheat and on litter that had been seeded with adults. Mortalities >80% were noted 15 day post application. These results show that insect-killing fungi hold promise for use and further development is warranted. ICARDA will couple this viable alternative strategy for management with the use of other options to have a sustainable technique for control of this significant pest of wheat and barley.

2.2.3. Role of Egg Parasitoids as Natural Enemies for the Management of Sunn Pest

Hymenopteran egg parasitoids are among the natural enemies that contribute to the reduction of the Sunn pest population. Our surveys conducted in Syria from 1997-2000 showed that six parasitoid species belonging to two families in the order Hymenoptera were found to attack Sunn pest eggs. Four species of the family Scelionidae are *Trissolcus grandis* (Thomson), *T. simoni* (Mayr), *T. vassilievi* (Mayr), and *Gryon fasciatus* (Priener). *Ooencyrtus fecundus* (Ferrière & Voegelé) and *O. telenomicida* (Vassiliev) were the only species, which belonged to the family Encyrtidae. *Ooencyrtus fecundus* and *Gryon fasciatus* are reported for the first time in Syria as Sunn pest egg parasitoids. The evolution of egg parasitoids during the season was followed in a wheat field at Azaz. This field was sampled weekly using a metal frame (0.25 m^{2}), which was randomly thrown in the field 20 times at each sampling. The number of egg masses, healthy or parasitized, found in the framed area was recorded. In the 2000 season, Sunn pest oviposition started earlier than in 1999, as the first egg masses were found in the wheat experimental field at Azaz on 5 April. The early Sunn pest oviposition was most likely due to higher temperature during the end of March beginning of April with an average of 16.4 °C. The first parasitized egg masses were found on

27 April. In this season, the level of parasitism was also high by the end of the season and reached 100% on 18 May (Figure 3). It seems that these parasitoids could play an important role in reducing Sunn pest populations, provided they are not disturbed by the use of broad-spectrum insecticides for Sunn pest control, usually by aerial spraying covering large and continuous areas. Other practices such as over grazing in rangelands, thereby limiting natural vegetation that support pentatomids with common natural enemies (negative impact on biodiversity) and elimination of refuges for egg parasites (coarse-barked trees) will have to be avoided to enhance the role of these parasitoids. The level of egg parasitism should be taken into consideration when determining the economic threshold of the Sunn pest.

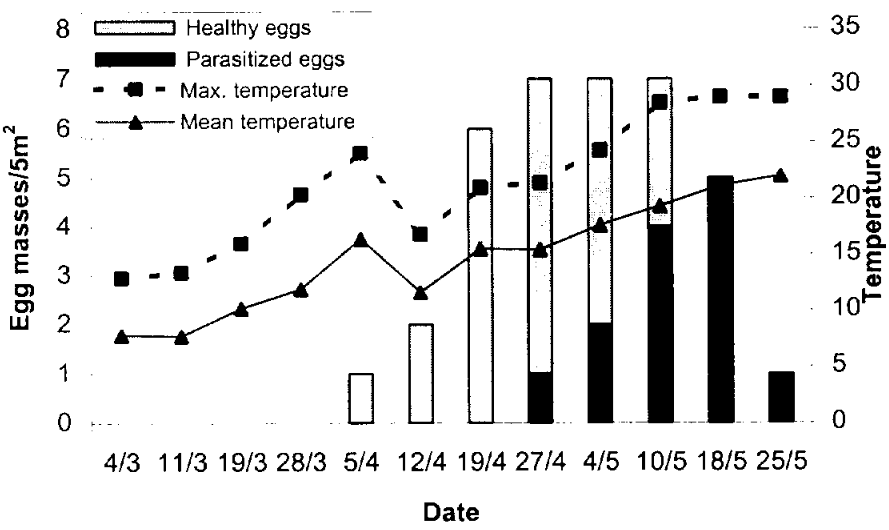

Fig. 3. Sunn pest oviposition and egg parasitism at Azaz, Syria in 2000.

2.2.4. Biocontrol of Aphids

2.2.4.1. Efficiency of Two Coccinellids for the Control of Bird Cherry Oat Aphid and Black Bean Aphid in Both Greenhouse and Field.

2.2.4.1.1. Greenhouse Studies

The two predators, *Coccinella septempunctata* L. and *Harmonia axyridis* Pallas, were reared on pea aphid, *Acyrthosiphon pisum*. Faba bean and wheat were planted (one plant/ pot) in the greenhouse at 22±2°C, 70-80% RH, 16:8 h photoperiod. Plants were infested with two aphid densities (20, 40 aphids/ plant for *Aphis fabae* and 5, 10 aphids for *Rhopalosiphum padi*). Then, the second instar larvae of the two predators were released in cages using 5 densities for each predator (1, 2, 3 and 4 larvae / plant). The results showed there is no significant difference between the two predators in term of efficiency against aphids. Both were able to consume all the aphids of *R. padi* within 3-5 days after release at densities of 2, 3 and 4 larvae/ plant (Figure 4). For *A. fabae*, the aphids were all consumed within 5-8 days at density of 20 nymphs/ plant and 6-11 days at density of 40 nymphs/ plant when the two predators densities were 2, 3 and 4 larvae/ plant (Figure 5).

2.2.4.1.2. Field Studies

2.2.4.1.2.1. Black Bean Aphid

The experimental field was divided to 18 plots of 1m^2 each. In each plot faba bean seeds were planted in 3 rows, approximately 7-9 seeds/row. When plants became 10 cm tall, they were thinned to a density of 30 shoots per plot. The plots were covered with muslin cages before aphid infestation (20 adults/shoot) and predator release. Two densities of the predators were used, 2 and 3 second instar larvae/shoot), in addition to the control (no predator release). The design used was a split plot with three replications. The results showed that there was no significant difference between the two predator larvae. Both species at the two larval densities significantly reduced the number of aphids (Figure 6A).

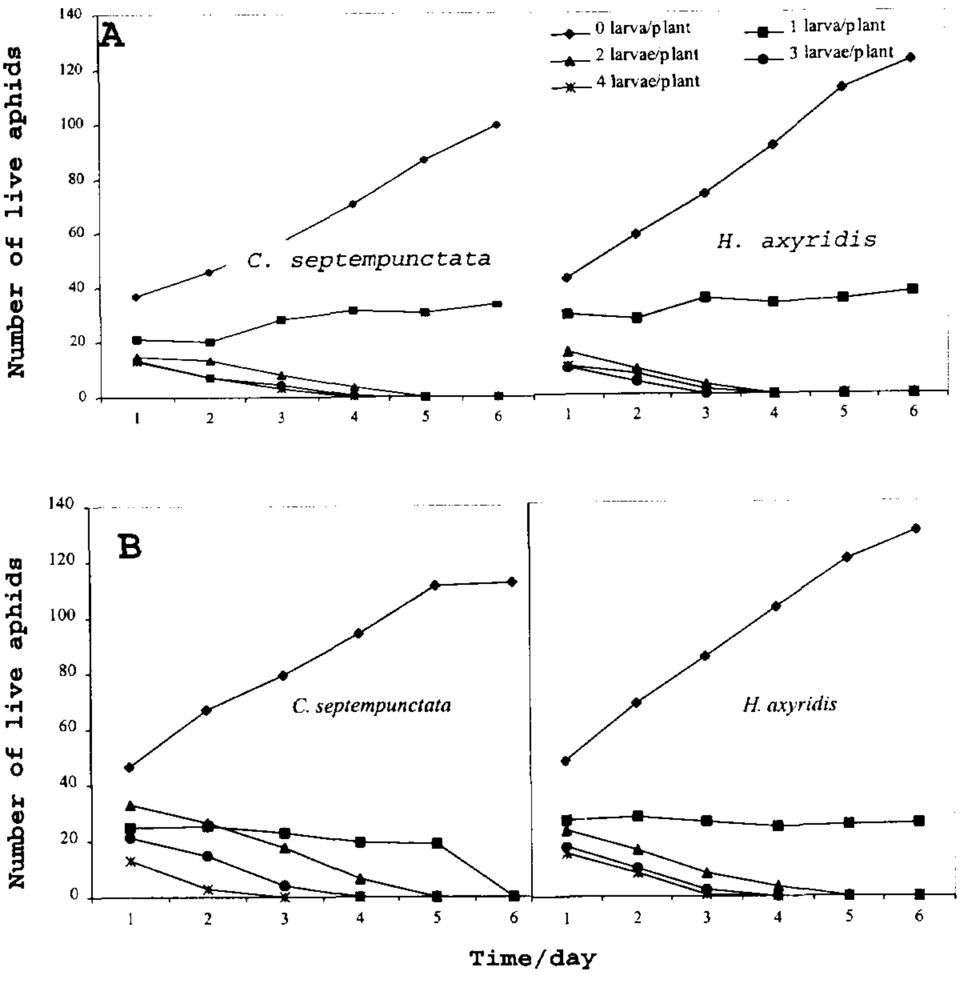

Fig. 4. The effect of different densities of *C. septempunctata* and *H. axyridis* larvae for the control of *R. padi* in the greenhouse at density 5 aphids/plant (A) and 10 aphids/plant (B).

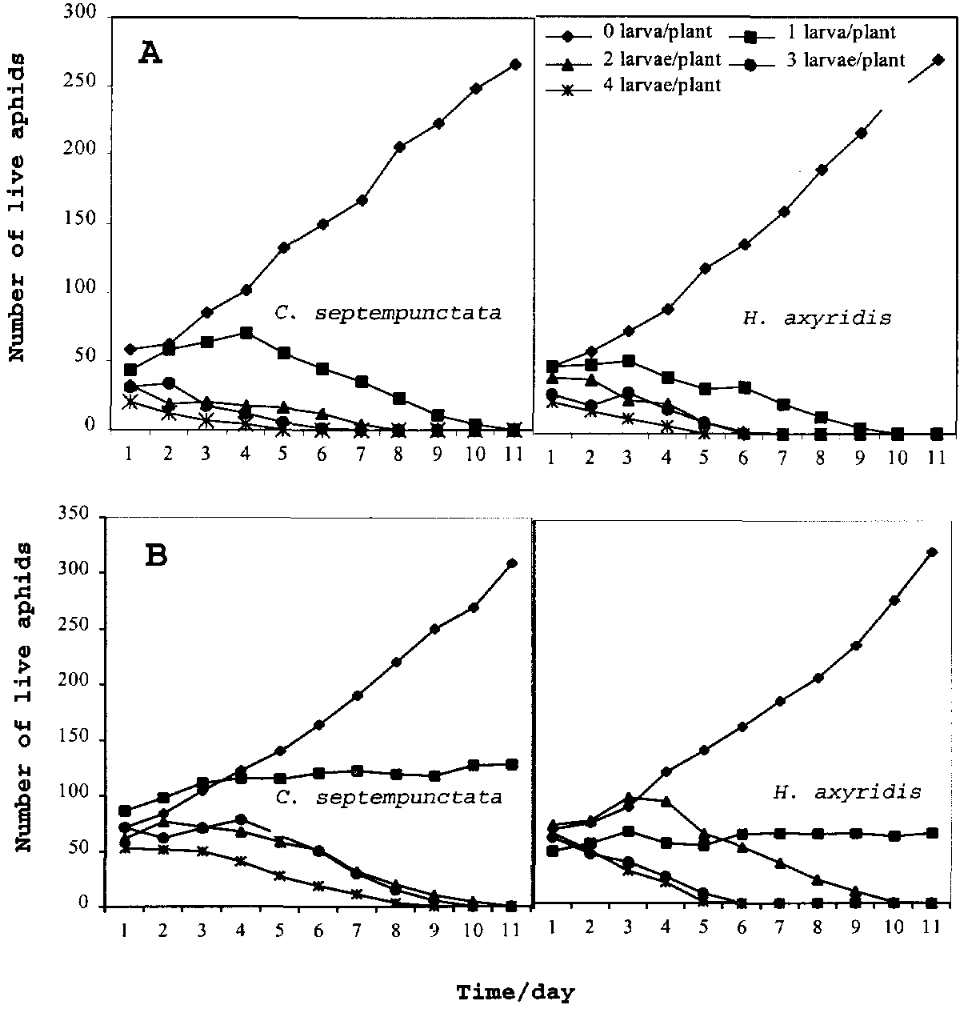

Fig. 5. The Effect of different densities of *C. septempunctata* and *H. axyridis* larvae for the control of *A. fabae* in the greenhouse at density of 20 aphids/ plant (A) and 40 aphids/plant (B).

2.2.4.1.2.2. Oat-Bird Cherry Aphid

This experiment was conducted similarly to the previous one, except that wheat plants were thinned to 50-tillers/plot. Each tiller was infested with 5 adults of *R. padi*. Two larval densities of the predators were released in the cages (2 and 3 larvae per tiller). As in the case of faba bean, there was no significant difference between the two predator larvae. Both species at the two larval densities reduced significantly the number of aphids (Figure 6B).

2.2.4.2. First Record of Parasitoids on the Predator Seven-Spotted Coccinellid in Syria

Two Hymenopteran parasitoids on the seven-spotted coccinellid, *Coccinella septempunctata* L. were recorded for the first time in Syria. The study was conducted at Tel Hadya research station during the 1999-2000 season. The first parasitoid, which was found on *C. septempunctata* adults, is *Dinocampus coccinellae* Schrank (Braconidae). The level of parasitism was 32.8 % in December 1999. The second parasitoid is *Oomyzus scaposus* Thomson (Eulophidae) and was found on *C. septempunctata* pupae. The level of parasitism was 46.21 % in May 2000.

2.2.5. Hessian Fly Parasitoids in Syria

Hessian fly is a major pest of wheat in North Africa. It also occurs in Syria, but is not an economical pest. The objective of this study was to determine the role of parasitoids in regulating the insect population in the country. Hessian fly flaxseeds were collected from susceptible wheat plants in coastal areas of Syria in early March to June. In the laboratory, plants were dissected to record flaxseed number. Flaxseeds were placed in moist carton containers in a rearing room set at 20 ± 2°C, 16:8h photoperiod. Water was added periodically to maintain high humidity. The emergence of parasitoids was recorded daily and placed in 70% alcohol. The samples were sent to the Systematic Entomology Laboratory Communications &Taxonomic Services Unit, US, for identification. The results showed a high level of parasitism, approaching 95% by the end of the season. Four Hymenopteran parasitoids species belonging to

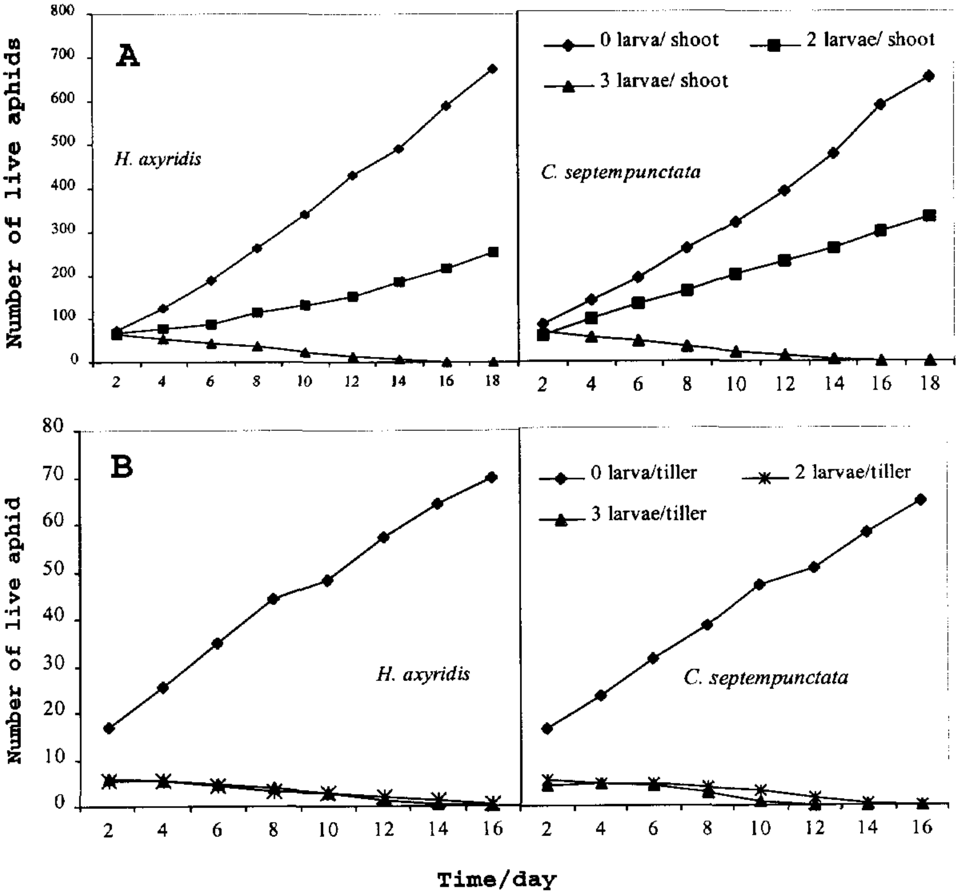

Fig. 6. The effect of two densities of *C. septempunctata* and *H. axyridis* larvae for the control of *A. fabae* at density 20 aphids/shoot in the field (A) and *R. padi* at density of 5 aphids/tiller in the field (B).

three families were identified: *Homoporus destructor* (Say) (Pteromalidae) was the most abundant species followed by *Eupelmus vesicularis* Retzius (Eupelmidae) with a rate of parasitism of 93.2 and 6.77%, respectively. Whereas the remaining two parasitoids, *Mesopolobus* sp. (Pteromalidae) and *Tetramesa* sp. (Eurytomidae) were the least frequent during the season. This study will be continued next season hoping to identify most of the Hessian parasitoids species in Syria and determine their role in regulating the pest population.

2.2.6. Effect of Melia Azederach Fruit Water Extract on Sitona Damage

Sitona crinitus H. is an important pest of lentil in West Asia and North Africa. *Sitona* adults feed on leaflets, but it is the larvae that feed on nodules that cause most damage. Insecticides effective against this pest have been identified, but their use in farmer fields is very limited because of the high cost while the environmental hazards associated with them is another consideration. ICARDA and its partner organizations in the region have been evaluating alternatives to the use of conventional insecticides. Powder from *M. azedarach* dry fruits was soaked in tap water for 24 hours; four concentrations were prepared, 5, 15, 25 and 50 g/l. Promet 400 (25mg/kg) and the untreated plot were used as checks. The experiment was carried out at Tel Hadya using a randomized complete block design with 4 replications, with a plot size of 12 rows x 5 m long x 0.3 m (spacing between rows). A random sample of five plants was taken at the end of flowering stage to assess nodule damage. The Melia concentration of 50 g/l gave a comparable level of control to the Promet, with 25.9 and 26% nodule damage, respectively. The three other Melia concentrations were not effective in reducing nodule damage caused by Sitona larvae, and the percent nodule damage was similar to that of the untreated check. The experiment will be repeated in 2001 for confirmation. Since *M. azedarach* tree is widely distributed in WANA, the use of water extracts from *Melia* fruits could provide a cheap and environment-friendly means for controlling this lentil pest.

2.2.7. Efficacy of Different Seed Dressing Chemicals Against soil-borne fungi Affecting Lentil and Chickpea

The efficacy of six different seed dressing chemicals (Diniconazole (*amco-eight*), Carboxin (*vitavax*), Tolcolophos methyl (*rhizolex*), Difenoconazole (*dividend*), Fenpiclonil (*beret*), and Captan to control soil-borne diseases, especially those caused by *Rhizoctonia solani, R. bataticola, Sclerotinia sclerotiorum, Fusarium oxysporum* f. sp. *ciceris* and *Fusarium oxysporum* f. sp. *lentis*) was determined under laboratory and plastic house conditions. The aim of the experiment was to find a replacement to Thiabendazole (tecto), which is no more available on the market. Three concentrations of each fungicide were tested (3, 6, and 9 g or ml/l) either to poison the culture medium or to dress lentil and chickpea seeds. The experiment was a split plot design with five replications. Results obtained enabled us to draw the following conclusions:

1. Vitavax and Tecto were the best as they affected all the fungal isolates tested. They can be recommended to disinfect seeds against wide spectrum of soil-borne fungi affecting lentil and chickpea. Both chemicals had no phytotoxic effects on both crops as determined in a conviron experiments.
2. Rizolex was effective against *Rhizoctonia solani* isolates and moderately effctive against *R. bataticola*. However, It had no effects on isolates of *Sclerotinia sclerotiorum, Fusarium oxysporum* f. sp. *ciceris* and *Fusarium oxysporum* f. sp. *lentis*. It can be recommended to treat seeds against *Rhizoctonia* spp. only. A possible application is to use this fungicide in sick plots destined to screen for resistance to *Fusarium oxysporum* f. sp. *ciceris* and *lentis* once infected with the former pathogen.
3. Captan was ineffective against *Rhizoctonia solani* isolates and moderately effective against all other pathogens tested. It can be used as replacement to vitavax when the inoculum level in the soil is low.
4. Dividend was effective against *Fusarium oxysporum* f. sp. *lentis*, moderately effective against *Fusarium oxysporum* f. sp. *ciceris*, *Sclerotinia sclerotiorum*, and *R. bataticola* isolates. However, it was ineffective against *Rhizoctonia solani*. The

fungicide can be used to prepare a selective medium to isolate *R. bataticola*.

5. Beret was effective against *Rhizoctonia* spp. And ineffective against *Fusarium oxysporum* f. sp. *ciceris* and *lentis* and *Sclerotinia sclerotiorum*. Its efficacy is similar to Rhizolex.
6. Amco-eight had an efficacy similar to that of captan and may be used as replacement for the later.
7. None of the fungicides used affected seed germination in both lentil and chickpea. However, significant differences were noted in their effects on plant height. Beret, at all concentrations tested, caused a 45% reduction in chickpea seedlings height. Rhizolex and vitavax caused a reduction of 27% and 21%, respectively. All others fungicides tested had no significant effects on this parameter. The same phenomenon was also observed with lentil seedlings where amco-eight, Beret, rhisolex, and vitavax caused a reduction of plant height of 38, 25, 31, and 28%, respectively. The reduction in plant height with other fungicides was not significant.

2.2.8. Viability of *Barley stripe mosaic virus* as Influenced by Cold Storage and Heat Treatment

Barley Stripe Mosaic Virus (BSMV) spread is efficiently controlled by using virus-free seeds. In this study, we evaluated the effect of cold storage and heat treatment on the viability of the virus in barley seeds. Infected seeds were stored for five years at 4°C and rate of seed infection was monitored at 6-month intervals (200 seeds/test) using tissue-blot immunoassay. The virus was not affected by storage since the infection level remained the same (around 50%) for the duration of the experiment. Similarly, germination of stored seeds was not affected and remained around 96% for the 5-year period (Table 15). When virus-infected seeds were exposed to 80°C for different durations (3, 5, 10, 12, 15 and 17 days), seed infection was reduced from 59% in untreated seeds to 33-57% for treated seeds, depending on duration of seed treatment. Such a reduction in the seed infection rate was accompanied by reduced seed germination, which ranged from 55 to 94%, based on the duration of the heat treatment. When virus-infected seeds were exposed to 85°C for 10 days, the infection rate was reduced from 59 to 25%, with a reduction in seed germination from 94 to 53%. It seems that cold storage up to 5 years has no effect on BSMV seed infection rate and, even though heat treatment reduced seed infection rate, it was not effective enough to rid seeds of the virus infection (Table 16).

Table 15. Germination of healthy and infected barley seeds and BSMV seed infection rate as affected by storage (1996-2000).

Date	% of infection	% of germination for infected seeds	% of germination for healthy seeds
January, 1996	48.5	94.0	95.0
July, 1996	45.0	88.0	97.0
January, 1997	45.0	88.3	93.3
July, 1997	46.0	84.0	98.0
January, 1998	49.2	63.0	78.0
July, 1998	63.0	73.0	68.5
January, 1999	59.9	93.5	87.5
July, 1999	62.0	79.0	88.5
January, 2000	52.0	96.0	99.0

Table 16. Effect of heat treatment on seeds infected with barley stripe mosaic virus (BSMV) and on seed germination.

Treatment (period and temperature)	% Germination of infected seeds	% infection
Positive control without treatment	94	59
3 days and 80°C	88	52
5 days and 80°C	85	57
10 days and 80°C	79	48
12 days and 80°C	75	45
15 days and 80°C	68	38
17 days and 80°C	55	33
10 days and 85°C	53	25

Output 3: IPM Options for the Different Cropping Systems and Agroecological Zones Developed.

3.1. Evaluation of Research-Managed On-farm Trials of Assembled IPM Options in Different Agro-Ecological Zones of WANA.

3.1.1. IDM Package to Control Lentil Broomrape

An IDM package comprising minimum use of herbicides as foliar spray, different sowing dates and cultivars to control lentil broomrape, was tested for the third year on research station. Results were similar to those reported in the previous seasons. The package is now ready for validation in farmers' fields with farmers' participation

3.1.2. IDM Package to Control Chickpea Ascochyta Blight

An IDM package comprising tolerant cultivar (Ghab 3), chemical seed treatment (Vitavax or Tecto) and one foliar spray with chlorothalonil (Bravo) at vegetative stage coupled with delayed sowing (10-15 January) was tested to control winter chickpea Ascochyta blight in researcher-managed and on-farmers' fields. The aim of the experiments was to demonstrate the benefit of the package to farmers. Spring chickpea (without any treatments) was planted in February as control. The package proved to be very effective in controlling the disease in winter chickpea. The yield of winter chickpea where the package was applied out yielded the local spring chickpea by almost double. The package will be validated next season in farmers' fields with farmers' participation

3.1.3. IDM Package to Control Lentil Root Rot

An IDM package comprising host resistance, chemical seed treatment, sowing dates and sowing depth to control lentil root rot was tested for the first year on researcher-managed trial with NARS collaboration, at Hama Research Station. The trial was conducted in a field with a history of *Sclerotinia sclerotiorum*. The dry conditions that prevailed during the growing season hampered the development of the disease. The experiment will be repeated next season using the same package in the same field.

3.2. Host Range Study of Cereal Root Rots and Cereal Cyst Nematodes

In crop rotations, legumes are often used as catch crops to reduce the spreading of certain soil-borne cereal pests and diseases. However, recently, observations were made of fungi (e.g., *Fusarium culmorum*.) attacking legumes, such as peas. If this holds true, the role of peas as a rotation crop with cereals needs to be re-studied and assessed. A host range experiment was designed to explore the possibilities of fungi infection on peas. The following Ten different plant species were tested: Bread wheat (Seri 82), Pea, Chickpea (F 85.17), Lentil (ILC 2130 Hu Romi-1), Lentil (ILC 5582 Edlib-1), Faba bean (Aquadolce), Faba bean (F 84.59 FB), Vetch (*Vicia sativa*), Grass pea (*Lathyrus sativus*), Medic (*Medicago rigidula*). Each crop species was inoculated with both *Fusarium culmorum* and *Cochliobolus sativus* isolates. Results indicated that the legume species were infected with *Cochliobolus sativus*, but without visible symptoms. There were some discoloration on the root of vicia and lathyrus. The fungus was re-isolated from root of the legume species infected, thus confirming that legumes could be host to *Cochliobolus sativus*. However, the fungus has no effect on plant growth, but could develop as saprophyte. *Fusarium culmorum* was recovered only from the two lentil varieties tested and from medic. Infection was also visible on the bread wheat, "*Seri 82* " which is used as the susceptible check variety.

Output 4: IPM Pilot Sites, with Farmers' Participation Developed at Selected Sites in WANA

4.1. Initiate IPM Pilot Sites at Different Locations in WANA, with Farmers and other Stake Holders (Extension, NGO ….etc) Participation

During 2000, two IPM pilot sites were initiated, one in Morocco and one in Egypt.

4.1.1. Morocco IPM Pilot Site

Collaborators: INRA (research), Ministry of Agriculture (extension), IAV Hassan II (research), ICARDA (research and coordination), CIMMYT (research), Farmers, Farmers Cooperative, SONACOS (seed company).

Selection of locations and farmers: Three clusters of farmers were selected at Sidi El-Aidi, Nzagh and Jemaa Shaim. In each cluster lead farmers were selected, three in the first two locations and two in the third location. That is a total of eight lead farmers. In each location there will be around 300-400 follower farmers that will be visiting the experimentation conducted at the farms of the lead farmers at different times during the growing season.

Crops managed: In the first two locations, wheat and chickpea crops were selected, whereas in the third location only wheat was selected.

Entry points and IPM options tested, as agreed upon by farmers:

1. Wheat- The major production constraints as agreed upon by farmers were Hessian fly, weeds, drought, fertilizers. Six IPM options were evaluated with the eight lead farmers. The experimental plot was 40X40 meters. The six IPM options tested were centered around the following components: (1) Hessian fly resistant wheat variety (seeds were treated with fungicides), (2) early seeding date with a recommended seed density, (3) optimum fertilizers based on soil analysis of each site, (4) optimum nitrogen top dressing, (5) weed chemical control at post emergence and at tillering, (6) chemical control of other insects and diseases, only if necessary.

2. Chickpea- The major production constraints as agreed upon by farmers were Ascochyta blight, drought, weeds, leaf miners and fertilization. Six IPM options were evaluated with six lead farmers. The experimental plot was 40X40 meters. The six IPM option centered around the following components: (1) planting the Ascochyta blight moderately resistant variety Rizki in late November as compared to planting the local variety in late February, (2) plant density of 35 per square meter for the November planting and 25 per square meter for the February planting, (3) Fertilization based on the soil analysis of each site, (4) Weed control, where two chemical treatments at pre-emergence and post emergence were adopted for the November planting and cultivation between rows was adopted for the February planting, (5) leah miner control (Nuvacron, neem oil), and (6) disease control depending on occurrence and severity.

4.1.2. Egypt IPM Pilot Site

Collaborators: Agricultural Research Center (research), Ministry of Agriculture (extension), ICARDA (research and coordination), CIMMYT (research), GTZ (extension), Farmers.

Selection of locations and farmers: Two clusters of farmers were selected at El-Fant and El-Mahmadya, both are in Beni Suef governorate. Twelve farmers in the first location and 10 farmers in the second location were selected.

Crops managed: The crops selected were faba bean and wheat. Five faba bean farmers in each of the two locations and seven and five wheat farmers in the first and second locations, respectively, were selected and agreed to experiment with IPM options.

Entry points and IPM options tested as agreed upon by farmers:

1. Faba bean- The major constraints as agreed upon by farmers were (i) Orobanche parasitic weed, (ii) virus diseases, and (iii) aphids. The IPM options evaluated were based on the following components: (1) Improved varieties, Giza 429 and Giza 843, moderately resistant to Orobanche, (2) seed rate of 150 kg/ha, (3) sowing during the last week of October, (4) fertilizers (37 kg N+ 71 kg P_2O_5 per ha), (5) hand weeding of Orobanche, (6) early chemical control of aphids with an aphicide, and (7) roguing of virus-infected plants early in the growing season. Each experimental plot was one acre.

2. Wheat- The major constraints as agreed upon by farmers were: (i) rust, (ii) salinity, (iii) aphids, and (iv) weeds. The IPM options evaluated were based on the following components: (1) Improved varieties, Sids 1 (salinity tolerant), Sids 4 (early maturing) and Beni Suef 1 (rust resistant), (2) Seed rate of 180 kg/ha for Sids 1 and 4 and 215 kg/ha for Beni Suef 1, (3) Optimum fertilization (175 kg N, 37 kg P_2O_5 and 60 kg K_2O per ha), (4) chemical control of aphids, and (5) chemical control of weeds. Each experimental plot was one acre.

Output 5: Expertise of National Scientists and Farmers in IPM Research and Implementation Improved

5.1. Train Relevant NARS Researchers, Extension Workers and Farmers in IPM Methodology and Implementation

5.1.1. Individual Non-Degree Training

Sixteen trainees from six countries received a 2-8 weeks training in the area of IPM; Algeria (1), Iran (3), Iraq (2), Morocco (1), Syria (5) and Tunisia (4). The trainees received specific training in the areas of Cereal Pathology (6), Legume Pathology (4), Virology (3) and Entomology (3).

5.1.2. Individual Degree Training

Thirteen graduate students were hosted by the IPM project to conduct their thesis research, 12 from Syria and one from Jordan. Twelve students worked on their M.Sc. thesis and one towards a Ph.D. thesis. These graduate students were distributed into the different disciplines; Cereal Pathology (4), Legume Pathology (2), Virology (4) and Entomology (3). Among these students only two completed their thesis research.

5.1.3. Visiting Scientists

The IPM project received 22 visiting scientists for a period of 4-60 days from the following countries: Australia (1), Denmark (4), France (1), Germany (1), Iran (6), Libya (1), Mexico (1), Sudan (1), Syria (3) and USA (1).

IV. COLLABORATORS

The following ICARDA staff has contributed to the IPM project for 2000:

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From NARS in developing and developed countries the following scientists have contributed to the IPM project for 2000:

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V. DONORS (SUPPORTERS)

1. GRDC-Project entitled "Selection of faba bean, chickpea and lentils for resistance to luteoviruses"
2. USAID and Conservation, Food & Health Foundation.
3. The United States Agency for International Development (USAID)
4. The System-Wide Program on IPM (SP-IPM)

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Crop	Region	Country	Year of Release	Variety_Name	Other Name
Barley	WA	Afghanistan	1998	Hewad-98	
Barley	WA	Afghanistan	1998	Watan-98	
Barley	NA	Algeria	1986	Dahbia	
Barley	NA	Algeria	1986	Nailia	
Barley	NA	Algeria	1987	Harmal	
Barley	NA	Algeria	1987	Soufara	
Barley	NA	Algeria	1990	Rahma	
Barley	NA	Algeria	1991	Express	
Barley	NA	Algeria	1992	Badia	
Barley	NA	Algeria	1992	Rebelle	
Barley	NA	Algeria	1993	Rihane-03	
Barley	CA	Armenia	1999	Mamluk	
Barley	DEV	Australia	1989	Yagan	
Barley	DEV	Australia	1993	Kaputar	
Barley	DEV	Australia	1993	Namoi	
Barley	FE	Bangladesh	1991	BARI barley1	
Barley	FE	Bangladesh	1991	BARI barley2	
Barley	LA	Bolivia	1991	Kantuta	
Barley	LA	Bolivia	1993	Kolla	
Barley	LA	Bolivia	1994	San Lorenzo	
Barley	LA	Brazil	1989	Acumai	
Barley	DEV	Canada	1992	Seebe	
Barley	DEV	Canada	1993	Falcon	
Barley	DEV	Canada	1994	Tukwa	
Barley	DEV	Canada	1995	Kasota	
Barley	LA	Chile	1989	Centauro	
Barley	LA	Chile	1989	Leo/Inia/Ccu	
Barley	FE	China	1988	Zhenmai 1	
Barley	FE	China	1989	Api/CM67//B1	
Barley	FE	China	1989	CT-16	
Barley	FE	China	1989	V-24	
Barley	FE	China	1998	S500	
Barley	FE	China	1998	V06	
Barley	WA	Cyprus	1980	Kantara	
Barley	WA	Cyprus	1989	Mari/Aths*2	
Barley	WA	Cyprus	1994	Achera	
Barley	WA	Cyprus	1994	Mia Milia	

Crop	Region	Country	Year of Release	Variety Name	Other Name
Barley	WA	Cyprus	1995	Lefkonoiko	
Barley	WA	Cyprus	1995	Lysi	
Barley	WA	Cyprus	1995	Sanokrithi-79	
Barley	LA	Ecuador	1989	Shyri89	
Barley	LA	Ecuador	1992	Atahualpa	
Barley	LA	Ecuador	2001	Shyri 2000	
Barley	LA	Ecuador	1992	Calicuchima	
Barley	NA	Egypt	1993	Giza 125	
Barley	NA	Egypt	1993	Giza 127	
Barley	NA	Egypt	1994	Giza128	
Barley	NA	Egypt	1995	Giza126	
Barley	NA	Egypt	2000	Giza129	
Barley	NA	Egypt	2000	Giza130	
Barley	NA	Egypt	2000	Giza131	
Barley	HAY	Ethiopia	1973	Beka	
Barley	HAY	Ethiopia	1975	IAR/H/485	
Barley	HAY	Ethiopia	1979	Holkr	
Barley	HAY	Ethiopia	1985	Ardu 12-60B	
Barley	HAY	Ethiopia	1986	HB-42	
Barley	HAY	Ethiopia	1994	HB-120	
Barley	HAY	Ethiopia	1996	Shege	
Barley	HAY	Ethiopia	1998	Abay	
Barley	HAY	Ethiopia	1998	Misratch	
Barley	CA	Georgia	2001	Tetnuldy	
Barley	WA	Iran	1979	Karoon	
Barley	WA	Iran	1983	Valfajr	
Barley	WA	Iran	1990	Kavir	
Barley	WA	Iran	1990	Star (Makoui)	
Barley	WA	Iran	1993	Dasht	
Barley	WA	Iran	1994	Rihane03	
Barley	WA	Iran	1994	Torkaman	
Barley	WA	Iran	1996	Afzal	
Barley	WA	Iran	1996	Ezeh	
Barley	WA	Iran	1996	Sahand	
Barley	WA	Iran	1997	Jonoob	
Barley	WA	Iran	1999	Sararood 1	
Barley	WA	Iraq	1993	Rihane03	
Barley	WA	Iraq	1994	IPA 265	
Barley	WA	Iraq	1994	IPA 7	
Barley	WA	Iraq	1994	IPA 9	
Barley	DEV	Italy	1992	Digersano	

Crop	Region	Country	Year of Release	Variety_Name	Other_Name
Barley	DEV	Italy	1992	Salus	
Barley	WA	Jordan	1980	Rum	
Barley	WA	Jordan	1982	Acsad176	
Barley	WA	Jordan	1986	Deir Alla106	
Barley	HAY	Kenya	1984	Bima	
Barley	HAY	Kenya	1993	Ngao	
Barley	WA	Lebanon	1989	Rihane-03	
Barley	WA	Lebanon	1997	Assy	
Barley	WA	Lebanon	1997	ER/Apm	
Barley	NA	Libya	1992	Wadi Gattara	
Barley	NA	Libya	1992	Wadi Kuf	
Barley	NA	Libya	1997	Ariel	
Barley	NA	Libya	1997	Borjouj	
Barley	NA	Libya	1997	Irawen	
Barley	NA	Libya	1997	Maknsa	
Barley	NA	Mexico	1986	Mona/Mzq/DL71	
Barley	NA	Mexico	1998	Capuchona	
Barley	NA	Morocco	1984	Asni	
Barley	NA	Morocco	1984	Tamelalt	
Barley	NA	Morocco	1984	Tissa	
Barley	NA	Morocco	1985	Acsad176	
Barley	NA	Morocco	1987	Aglou	
Barley	NA	Morocco	1987	Tiddas	
Barley	NA	Morocco	1988	Armal	
Barley	NA	Morocco	1988	Tessaout	
Barley	NA	Morocco	1991	Laannoceur	
Barley	NA	Morocco	1994	Massine	
Barley	NA	Morocco	1997	Aguilal	
Barley	NA	Morocco	1997	Amira(Safia)	
Barley	NA	Morocco	1997	Igrane	
Barley	FE	Nepal	1987	Bonus	
Barley	WA	Pakistan	1985	Jau-83	
Barley	WA	Pakistan	1987	Frontier 87	
Barley	WA	Pakistan	1987	Jau-87	
Barley	WA	Pakistan	1993	Jau-93	
Barley	WA	Pakistan	1995	AZRI-95	
Barley	WA	Pakistan	1996	Chiltan	
Barley	WA	Pakistan	1996	Sanober-96	
Barley	WA	Pakistan	1996	Soorab-96	
Barley	LA	Peru	1987	Nana 87	
Barley	LA	Peru	1987	Una-87	

Crop	Region	Country	Year of Release	Variety Name	Other Name
Barley	LA	Peru	1989	Buenavista	
Barley	LA	Peru	1994	UNA-94	
Barley	LA	Peru	1996	UNA-96	
Barley	DEV	Portugal	1982	Campones	
Barley	DEV	Portugal	1982	Enxara	
Barley	DEV	Portugal	1982	Sereia	
Barley	DEV	Portugal	1983	CE 8302	
Barley	DEV	Portugal	1990	Ancora	
Barley	WA	Qatar	1982	Gulf	
Barley	WA	Qatar	1983	Harma	
Barley	WA	Qatar	1988	Harma 88	
Barley	CA	Russia	2000	Dobrynia-03	
Barley	CA	Russia	2000	Rubicon	
Barley	WA	Saudi Arabia	1985	Gustoe	
Barley	DEV	Spain	1988	Deir Ala 106	
Barley	DEV	Spain	1990	Resana	
Barley	WA	Syria	1987	Furat 1	
Barley	WA	Syria	1990	Furat 2	
Barley	WA	Syria	1994	Arta	
Barley	WA	Syria	2000	Furat 3	
Barley	WA	Syria	2000	Furat 4	
Barley	WA	Syria	2001	Furat 7	
Barley	HAY	Tanzania	1991	Kibo	
Barley	FE	Thailand	1987	BRB-8	
Barley	FE	Thailand	1987	Semang 1	
Barley	FE	Thailand	1987	Semang 2	
Barley	NA	Tunisia	1985	Faiz	
Barley	NA	Tunisia	1985	Roho	
Barley	NA	Tunisia	1985	Taj	
Barley	NA	Tunisia	1987	Rihane-03	
Barley	NA	Tunisia	1992	Manel 92	
Barley	NA	Tunisia	1996	Tibica	
Barley	NA	Tunisia	1999	Momtaz	
Barley	WA	Turkey	1993	Tarm 92	
Barley	WA	Turkey	1993	Yesevi	
Barley	WA	Turkey	1995	Orza	
Barley	DEV	USA	n.a.	Micah	
Barley	DEV	USA	n.a.	Poco	
Barley	FE	Vietnam	1989	Api/CM67//B1	
Barley	HAY	Yemen	1986	Arafat	
Barley	HAY	Yemen	1986	Beecher	

Crop	Region	Country	Year of Release	Variety_Name	Other_Name
Bread	Wheat	Afghanistan	1996	Roshan-96	
Bread	Wheat	Afghanistan	1996	Gheri-96	
Bread	Wheat	Algeria	1982	HD 1220	
Bread	Wheat	Algeria	1982	Setif 82	
Bread	Wheat	Algeria	1989	Zidane 89	
Bread	Wheat	Algeria	1992	ACSAD 59 = 40DNA	
Bread	Wheat	Algeria	1992	Alondra = 21AD	
Bread	Wheat	Algeria	1992	Nesser = Cham 6	
Bread	Wheat	Algeria	1992	Rhumel = Siete Cerros	
Bread	Wheat	Algeria	1992	Sidi Okba=Cham 4	
Bread	Wheat	Algeria	1992	Soummam = DouggaXBJ	
Bread	Wheat	Algeria	1994	Ain Abid	
Bread	Wheat	Algeria	1994	Mimouni	
Bread	Wheat	Egypt	1982	Giza 160	
Bread	Wheat	Egypt	1988	Giza 162	
Bread	Wheat	Egypt	1988	Giza 163	
Bread	Wheat	Egypt	1988	Giza 164	
Bread	Wheat	Egypt	1988	Sakha 92	
Bread	Wheat	Egypt	1991	Gammeiza 1	
Bread	Wheat	Egypt	1991	Giza 165	
Bread	Wheat	Egypt	1993	Sahel 1	
Bread	Wheat	Egypt	1994	Giza 166	
Bread	Wheat	Egypt	1994	Giza 167	
Bread	Wheat	Egypt	1994	Sids 1	
Bread	Wheat	Egypt	1994	Sids 2	
Bread	Wheat	Egypt	1994	Sids 3	
Bread	Wheat	Egypt	1995	Sids 4	
Bread	Wheat	Egypt	1995	Sids 5	
Bread	Wheat	Egypt	1995	Sids 6	
Bread	Wheat	Egypt	1995	Sids 7	
Bread	Wheat	Egypt	1995	Sids 8	
Bread	Wheat	Ethiopia	2000	HAR 2501 (Hawii)	
Bread	Wheat	Greece	1983	Arachthos	
Bread	Wheat	Greece	1983	Louros	
Bread	Wheat	Greece	1983	Pinios	
Bread	Wheat	Iran	1986	Azadi	
Bread	Wheat	Iran	1986	Golestan	
Bread	Wheat	Iran	1988	Darab	

Crop	Country	Year of Release	Variety_Name	Other Name
Bread Wheat	Iran	1988	Quds	
Bread Wheat	Iran	1988	Sabalan	
Bread Wheat	Iran	1990	Falat	
Bread Wheat	Iran	1995	Darab 2	
Bread Wheat	Iran	1995	Mahdabi	
Bread Wheat	Iran	1995	Tajan	
Bread Wheat	Iran	1996	Gahar	
Bread Wheat	Iran	1996	Nicknejad	
Bread Wheat	Iran	1996	Zagroos	
Bread Wheat	Iran	1997	Alement	
Bread Wheat	Iran	1997	Alrand	
Bread Wheat	Iran	1997	Atrak	
Bread Wheat	Iran	1997	Chamran	
Bread Wheat	Iran	1997	Zareen	
Bread Wheat	Iran	1998	Azar 2	
Bread Wheat	Iraq	1989	Es14	
Bread Wheat	Iraq	1994	Abu Ghraib	
Bread Wheat	Iraq	1994	Adnanya	
Bread Wheat	Iraq	1994	Hamra	
Bread Wheat	Iraq	1997	IPA 99	
Bread Wheat	Iraq	1998	Vee 'S'	
Bread Wheat	Italy	1996	Sibilla	
Bread Wheat	Jordan	1988	L88 = Rabba	
Bread Wheat	Jordan	1988	Nasma	Jubeiha
Bread Wheat	Jordan	1990	Nesser	
Bread Wheat	Lebanon	1990	Seri	
Bread Wheat	Lebanon	1991	Nesser = Cham 6	
Bread Wheat	Lebanon	1998	Towpe	
Bread Wheat	Lebanon	2000	Tannour	Memouf-22
Bread Wheat	Libya	1985	Germa	
Bread Wheat	Libya	1985	Sheba	
Bread Wheat	Libya	1985	Zellaf	
Bread Wheat	Morocco	1984	Jouda	
Bread Wheat	Morocco	1984	Merchouch	
Bread Wheat	Morocco	1989	Kanz	
Bread Wheat	Morocco	1989	Saba	
Bread Wheat	Morocco	1996	Massira	
Bread Wheat	Morocco	1998	Aguilal	
Bread Wheat	Morocco	1998	Arrihane	
Bread Wheat	Oman	1987	Wadi Quriyat 151	
Bread Wheat	Oman	1987	Wadi Quriyat 160	

Crop	Country	Year of Release	Variety Name	Other Name
Bread Wheat	Pakistan	1986	Sutlej 86	
Bread Wheat	Pakistan	1987	Rawal-87	MAYA-MON'S'XKYZ-TRM
Bread Wheat	Pakistan	1993	Pothwar-93	URES/BOW'S'
Bread Wheat	Pakistan	1995	Kohsar-95	PSN'S'/BOW'S'
Bread Wheat	Pakistan	1996	AZRI-96	
Bread Wheat	Pakistan	1996	Suleman	F6-74/BUN'S'//SIS/3/ VEE#7 CM.86141-62M-0Y-0M-4Y-0M
Bread Wheat	Pakistan	1996	Tatara	JUP/ALD'S'//KLT'S '/3/VEE's'
Bread Wheat	Pakistan	1998	Ghajnavi	JUP//BJY'S'//URES CM67458-4Y1M3Y1M-4Y-0B=KAUZ'S'
Bread Wheat	Portugal	1986	LIZ 1	
Bread Wheat	Portugal	1986	LIZ 2	
Bread Wheat	Qatar	1988	Doha 88	NAC
Bread Wheat	Russia	2000	Gobustan	
Bread Wheat	Russia	2000	Azametli 95	
Bread Wheat	Sudan	1982	Debeira	HD 2172
Bread Wheat	Sudan	1987	Wadi El Neel	
Bread Wheat	Sudan	1990	Elnielain	
Bread Wheat	Sudan	1992	Sasaraib	
Bread Wheat	Sudan	1996	Nessr	
Bread Wheat	Syria	1984	Bohouth 2	
Bread Wheat	Syria	1984	Cham 2	
Bread Wheat	Syria	1986	Cham 4	
Bread Wheat	Syria	1987	Bohouth 4	
Bread Wheat	Syria	1991	Bohouth 6	
Bread Wheat	Syria	1991	Cham 6	
Bread Wheat	Syria	2000	Cham 8	Memof-22
Bread Wheat	Tunisia	1987	Byrsa	
Bread Wheat	Tunisia	1987	Salambo	
Bread Wheat	Tunisia	1992	Vaga 92	
Bread Wheat	Tunisia	1996	Tebica 96	
Bread Wheat	Tunisia	1996	Utique	
Bread Wheat	Turkey	1979	Gerek 79	
Bread Wheat	Turkey	1985	Atay 85	
Bread Wheat	Turkey	1986	Dogankent-1 (Cham 4)	

Crop	Country	Year of Release	Variety Name	Other Name
Bread Wheat	Turkey	1988	Dogu 88	
Bread Wheat	Turkey	1988	Genç-88	
Bread Wheat	Turkey	1988	Kaklic 88	
Bread Wheat	Turkey	1988	Kop	
Bread Wheat	Turkey	1989	Es14	
Bread Wheat	Turkey	1990	Karasu 90	
Bread Wheat	Turkey	1990	Katia 1	
Bread Wheat	Turkey	1990	Yuregir	
Bread Wheat	Turkey	1991	Gun 91	
Bread Wheat	Turkey	1994	Dagdas 94	
Bread Wheat	Turkey	1994	Kutluk 94	
Bread Wheat	Turkey	1995	Basribey 95	
Bread Wheat	Turkey	1995	F//68.44NZT/3/ CUC'5'	
Bread Wheat	Turkey	1995	Kasifbey 95	
Bread Wheat	Turkey	1995	Kirgiz 95	
Bread Wheat	Turkey	1995	Sultan 95	
Bread Wheat	Turkey	1996	Ikizce 96	
Bread Wheat	Turkey	1996	Pehlivan 96	
Bread Wheat	Turkey	1997	Kinaci 97	
Bread Wheat	Turkey	1997	Palandoken 97	
Bread Wheat	Turkey	1997	Suzen 97	
Bread Wheat	Turkey	1998	Aytin 98	
Bread Wheat	Turkey	1998	Mizrak 98	
Bread Wheat	Turkey	1998	Turkmen 98	
Bread Wheat	Turkey	1998	Uzunyayla 98	
Bread Wheat	Turkey	1998	Yildiz 98	
Bread Wheat	Turkey	1999	Genç-99	
Bread Wheat	Turkmenistan	1999	Garagum	
Bread Wheat	Turkmenistan	1999	Bitarap	
Bread Wheat	Turkmenistan	1999	Guncha	
Bread Wheat	UAE	1995	Cham 2	
Bread Wheat	UAE	1995	Kirgiz 95	
Bread Wheat	UAE	1995	Seyhan 95	
Bread Wheat	Uzbekistan	1999	Dostlik	
Bread Wheat	Yemen	1981	Ahgaf	
Bread Wheat	Yemen	1983	Marib 1	
Bread Wheat	Yemen	1988	Aziz	
Bread Wheat	Yemen	1988	Dhumran	
Bread Wheat	Yemen	1988	Mukhtar	
Bread Wheat	Yemen	1992	Alswiri	
Bread Wheat	Yemen	1995	Radfan	

Crop	Country	Year of Release	Variety Name	Other Name
Bread Wheat	Yemen	1998	Seiyun	
Durum	Algeria	1982	ZB//Fg/Loukos	
Durum	Algeria	1984	Timgad	D27617-21M-300Y-0BK
Durum	Algeria	1986	Sahl	CM199-29M-1Y-1M-0Y-0ALG-0AP
Durum	Algeria	1986	Waha	CM17904-B-3M-1Y-1Y-0SK-0AP
Durum	Algeria	1991	Korifla	CD523-3Y-1Y-2M-0Y-0AP
Durum	Algeria	1992	Om Rabi 6	L0589-1L-1AP-2AP-0AP
Durum	Algeria	1993	Belikh 2	L92-6AP-1AP-1AP-0AP
Durum	Algeria	1993	Heider	CD10535-D-1M-1Y-1M-2Y-0M-0AP
Durum	Algeria	1993	Kabir-1	L038-4AP-2AP-2AP-0AP
Durum	Algeria	1993	Om Rabi 9	L0400-1L-1AP-3AP-6AP-0AP
Durum	Cyprus	1977	Aronas	
Durum	Cyprus	1982	Mesaoria	1D31728-3L-0L-1A-0A
Durum	Cyprus	1984	Karpasia	CM17904-B-3M-1Y-1Y-0A
Durum	Cyprus	1994	Macedonia	
Durum	Egypt	1979	Sohag 1	Gdo VZ 469/3/Jo//61.130 /Lds
Durum	Egypt	1988	Beni suef	CM9799
Durum	Egypt	1988	Sohag 2	SH19...
Durum	Egypt	1990	Sohag 3	
Durum	Egypt	1994	Benesuef-3	
Durum	Greece	1982	Selas	
Durum	Greece	1983	Sapfo	
Durum	Greece	1984	Skiti	
Durum	Greece	1985	Samos	
Durum	Greece	1985	Syros	
Durum	Iran	1996	Seimareh = Om Rabi 5	

Crop	Country	Year of Release	Variety Name	Other Name
Durum	Iran	1997	Heider	
Durum	Iran	1997	Korifla	
Durum	Iraq	1994	Waha Iraq	CM17904-B-3M-1Y-1Y-0SK-0AP
Durum	Iraq	1997	Korifla	
Durum	Jordan	1988	ACSAD 65 = STK	Gdo VZ469/3/Jo//61.1 30/Lds
Durum	Jordan	1988	Amra	N-432
Durum	Jordan	1988	Cham 1	Waha
Durum	Jordan	1988	Maru = Cham 1	CM17904-B-3M-1Y-1Y-0SK-0AP
Durum	Jordan	1988	Petra	HN-NX Jori, Karifla
Durum	Jordan	1988	Petra = KRF	D523-3Y-1Y-2M-0Y-0AP
Durum	Lebanon	1987	Belikh 2	92-6AP-1AP-1AP-0AP
Durum	Lebanon	1989	Sebou	-
Durum	Lebanon	1993	Waha = Cham 1	
Durum	Lebanon	2000	Masarra	Massara-1
Durum	Libya	1985	Baraka	
Durum	Libya	1985	Fazan	D-25
Durum	Libya	1985	Ghuodwa	Cimarron-Sari Bursa 7113
Durum	Libya	1985	Marjawi	CD10535-D-1M-1Y-1M-2Y-0M-0AP
Durum	Libya	1985	Qara	CM17147-7M-0Y
Durum	Libya	1985	Zorda	
Durum	Libya	1991	Zahra 1	
Durum	Libya	1992	Khiar 92	
Durum	Libya	1993	Zahra 3	
Durum	Libya	1993	Zahra 5 = Korifla	
Durum	Libya	1995	Zahra 7	
Durum	Libya	1995	Zahra 9	
Durum	Morocco	1984	Marzak	BD 113
Durum	Morocco	1989	Om Rabi 1	Jori/Hau
Durum	Morocco	1989	Sebou	Cr/T.Polonicum
Durum	Morocco	1991	Tensift	CD26109-0AP-2TR-1AP-1AP-1AP-0SH

Crop	Country	Year of Release	Variety Name	Other Name
Durum	Morocco	1992	Brachoua	CD26701-0AP-1AP-0AP
Durum	Morocco	1992	Om Rabi 5	L0589-4L-2AP-2AP-0AP
Durum	Morocco	1994	Anouar	
Durum	Morocco	1994	Jawhar	
Durum	Morocco	1997	Telset	
Durum	Pakistan	1985	Wadhanak	CD19711
Durum	Portugal	1983	Celta	CM17904
Durum	Portugal	1983	Timpanas	CM362
Durum	Portugal	1984	Castico	CM14403
Durum	Portugal	1985	Helvio	CM9799
Durum	Portugal	n.a.	Te 9204	ICD-85-1340-ABL-6AP-OTR
Durum	Saudi Arabia	1987	Cham 1	CM17904-B-3M-1Y-1Y-0SK-0AP
Durum	Spain	1983	Mexa	CM470
Durum	Spain	1985	Nuna	CM9799
Durum	Spain	1989	Jabato	
Durum	Spain	1991	Anton	
Durum	Spain	1991	Roqueno	
Durum	Spain	1997	Polux	Syrian-2
Durum	Spain	1998	Altair	Syrian-3
Durum	Sudan	1996	Cham 1	CM17904-P-3M-14-OSK-OAP
Durum	Sudan	1997	Waha	
Durum	Syria	1984	Cham 1	CM17904-B-3M-1Y-1Y-0SK-0AP
Durum	Syria	1987	Bohouth 5	
Durum	Syria	1987	Cham 3	CD523-3Y-1Y-2M-0Y-0AP
Durum	Syria	1993	Om Rabi 3	
Durum	Syria	1994	Cham 5 = MRB-3	L0589-4L-2AP-3AP-0AP
Durum	Syria	2000	Furat5	30603
Durum	Tunisia	1983	T-DUMA-D6811-INRAT	
Durum	Tunisia	1987	Razzak	
Durum	Tunisia	1993	Khiar	
Durum	Tunisia	1996	Om Rabi 3	L0589-4L-2AP-3AP-0AP
Durum	Tunisia	1999	Nasr 99	
Durum	Turkey	1984	Susf bird	
Durum	Turkey	1985	Balcali	CM9799
Durum	Turkey	1988	EGE 88	

Crop	Country	Year of Release	Variety Name	Other Name
Durum	Turkey	1990	Cham 1	CM17904-B-3M-1Y-1Y-0SK-0AP
Durum	Turkey	1991	Kiziltan	
Durum	Turkey	1994	Aydin 93	
Durum	Turkey	1994	Firat 93	
Durum	Turkey	1997	Haran = Om Rabi 5	
Durum	Turkey	1998	Altin 98	
Durum	Turkey	1998	Ankara 98	
Faba Bean	Australia	1992	ICARUS	BPL 710
Faba Bean	Australia	1997	Rossa	ILB 3025
Faba Bean	Egypt	1994	Gizablanca	selected from Reina Blanca
Faba Bean	Egypt	1995	Giza 429	Selected from Giza 402
Faba Bean	Egypt	1995	Giza 461	
Faba Bean	Egypt	1995	Giza 643	
Faba Bean	Egypt	1995	Giza 674	
Faba Bean	Egypt	1995	Giza 714	
Faba Bean	Egypt	1995	Giza 716	
Faba Bean	Egypt	1995	Giza 717	
Faba Bean	Egypt	1997	Giza 2	
Faba Bean	Egypt	1997	Giza 3	
Faba Bean	Egypt	1998	Giza 40	Landrace, selected from local variety
Faba Bean	Egypt	1998	Giza 843	
Faba Bean	Ethiopia	1994	Bulga-70	Land race
Faba Bean	Ethiopia	1995	Mesay	Land race
Faba Bean	Ethiopia	1995	Tesfa	Land race
Faba Bean	Ethiopia	2000	EH011-22-1	Land race
Faba Bean	Iran	1986	Barkat	ILB 1269
Faba Bean	Portugal	1992	Favel	80S 43977
Faba Bean	Sudan	1990	Sellaim-ML	
Faba Bean	Sudan	1991	Shambat 104	
Faba Bean	Sudan	1991	Shambat 75	
Faba Bean	Sudan	1993	Basabeer	BB7
Faba Bean	Sudan	1993	Hudeiba 93	Bulk1/3
Faba Bean	Sudan	1993	Shambat 616	00616
Faba Bean	Syria	1991	Hama 1	Selection from Aquadulce
Faba Bean	Turkey	1998	Yilmaz 98	

Crop	Country	Year of Release	Variety Name	Other Name
Faba Bean	Yemen	1998	Shebam 1	FLIP 84-14FB
Faba Bean	Yemen	1998	Shebam 2	Giza 3 ex-Egypt via Nile Valley Project
Forage Legumes	Australia	1998	(*Lathyrus cicera*) Chalus	IFLLC-1279
Forage Legumes	Cyprus	1998	(*V. narbonensis*) acc. 568	Cyprus
Forage Legumes	Italy	1999	(*V. narbonensis*) Velox	Se 12380
Forage Legumes	Jordan	1994	(*L. ochrus*) IFLLO-185	IFLLO-185
Forage Legumes	Jordan	1994	(*V. sativa*) IFLVS - 715	IFLVS - 715
Forage Legumes	Jordan	1994	(*V. villosa ssp. dasycarpa*) IFLVD 683	IFLVD 683
Forage Legumes	Kazakstan	2001	Lathyrus Ali Bar	IFLS225Sel554
Forage Legumes	Lebanon	1997	(*L. cicera*) Jaboulah	IFLLC-492
Forage Legumes	Lebanon	1997	(*V. sativa*) Baraka	IFLVS - 715
Forage Legumes	Morocco	1990	(*V. sativa*) ILFVS-1812	ILFVS-1812
Forage Legumes	Morocco	1992	(*V. villosa ssp. dasycarpa*) IVLVD-2053	IVLVD-2053
Forage Legumes	Morocco	1994	(*V. narbonensis*) IFLVN-2387	IFLVN-2387
Forage Legumes	Morocco	1994	(*V. narbonensis*) IFLVN-2391	IFLVN-2391
Forage Legumes	Morocco	1994	(*V. sativa*) IFLVS-709	IFLVS-709
Forage Legumes	Pakistan	1997	(*V. villosa ssp. dasycarpa*) Kuhak-96	IFLVD-683
Kabuli Chickpea	Afghanistan	1999	Madad-99	FLIP 93-53C
Kabuli Chickpea	Afghanistan	1999	Sehat 99	FLIP93-58C

Crop	Country	Year of Release	Variety Name	Other Name
Kabuli Chickpea	Algeria	1988	ILC 3279	ILC 3279
Kabuli Chickpea	Algeria	1988	ILC 482	ILC 482
Kabuli Chickpea	Algeria	1991	FLIP 84-79C	FLIP 84-79C
Kabuli Chickpea	Algeria	1991	FLIP 84-92C	FLIP 84-92C
Kabuli Chickpea	China	1988	ILC 202	ILC 202
Kabuli Chickpea	China	1988	ILC 411	ILC 411
Kabuli Chickpea	China	1993	FLIP 81-40WC	FLIP 81-40WC
Kabuli Chickpea	China	1993	FLIP 81-71C	FLIP 81-71C
Kabuli Chickpea	China	1996	ILC 3279	ILC 3279
Kabuli Chickpea	Cyprus	1984	Yialousa	ILC 3279
Kabuli Chickpea	Cyprus	1987	Kyrenia	ILC 464
Kabuli Chickpea	Georgia	2000	Elixir	ILC533
Kabuli Chickpea	Egypt	1994	Giza 88	
Kabuli Chickpea	Egypt	1995	Giza 195	ILC 195
Kabuli Chickpea	Egypt	1999	Giza 3	FLIP 80-120
Kabuli Chickpea	Ethiopia	2000	Arerti	FLIP 89-84C
Kabuli Chickpea	France	1988	TS1009	ILC 482
Kabuli Chickpea	France	1988	TS1502	FLIP 81-293C
Kabuli Chickpea	France	1992	Roye Rene	F 84-188C
Kabuli Chickpea	India	1996	Pant G88-6	
Kabuli Chickpea	Iran	1995	Hachem	FLIP 84-48C
Kabuli Chickpea	Iran	1995	ILC 3279	ILC 3279
Kabuli Chickpea	Iran	1995	ILC 482	ILC 482
Kabuli Chickpea	Iraq	1992	Dijla	ILC 3279
Kabuli Chickpea	Iraq	1992	Rafidain	ILC 482
Kabuli Chickpea	Iraq	2000	IPA 510	FLIP 86-5C
Kabuli Chickpea	Iraq	2001		
Kabuli Chickpea	Italy	1990	Califfo	ILC 72
Kabuli Chickpea	Italy	1990	Sultano	ILC 3279
Kabuli Chickpea	Italy	1998	Ali	ILC 6188
Kabuli Chickpea	Italy	1998	Visir	FLIP 83-7C
Kabuli Chickpea	Italy	2000	Otello	
Kabuli Chickpea	Italy	2000	Pascia	FLIP 86-5C
Kabuli Chickpea	Italy	2000	Emiro	
Kabuli Chickpea	Jordan	1990	Jubeiha 2	ILC 482
Kabuli Chickpea	Jordan	1990	Jubeiha 3	ILC 3279
Kabuli Chickpea	Lebanon	1989	Janta 2	ILC 482
Kabuli Chickpea	Lebanon	1993	Baleela	FLIP 85-5C
Kabuli Chickpea	Lebanon	1998	Al-Wady	FLIP 86-6
Kabuli Chickpea	Libya	1993	ILC 484	ILC 484
Kabuli Chickpea	Morocco	1986	ILC 195	ILC 195

Crop	Country	Year of Release	Variety_Name	Other_Name
Kabuli Chickpea	Morocco	1986	ILC 482	ILC 482
Kabuli Chickpea	Morocco	1992	Douyet	FLIP 84-92C
Kabuli Chickpea	Morocco	1992	Rizki	FLIP 83-48C
Kabuli Chickpea	Morocco	1995	Farihane	FLIP 84-79C
Kabuli Chickpea	Morocco	1995	Moubarak	FLIP 84-145C
Kabuli Chickpea	Morocco	1995	Zahor	FLIP 84-182C
Kabuli Chickpea	Oman	1988	ILC 237	ILC 237
Kabuli Chickpea	Oman	1995	FLIP 87-45C	FLIP 87-45C
Kabuli Chickpea	Oman	1995	FLIP 89-130C	FLIP 89-130C
Kabuli Chickpea	Pakistan	1992	Noor 91	FLIP 81-293C
Kabuli Chickpea	Portugal	1992	Elmo	ICC 6304
Kabuli Chickpea	Portugal	1992	Elvar	FLIP 85-17C
Kabuli Chickpea	Portugal	1998	Elite	ICC 5035
Kabuli Chickpea	Spain	1985	Alcazaba	ILC 2555
Kabuli Chickpea	Spain	1985	Almena	ILC 2548
Kabuli Chickpea	Spain	1985	Atalaya	ILC 200
Kabuli Chickpea	Spain	1985	Fardan	ILC 72
Kabuli Chickpea	Spain	1985	Zegri	ILC 200
Kabuli Chickpea	Spain	1995	Athenas	
Kabuli Chickpea	Spain	1995	Bagda	
Kabuli Chickpea	Spain	1995	Kairo	
Kabuli Chickpea	Sudan	1987	Shendi	ILC 1335
Kabuli Chickpea	Sudan	1994	Jebel Marra-1	ILC 915
Kabuli Chickpea	Sudan	1996	Atmor	ICCV 89509
Kabuli Chickpea	Sudan	1998	Matama-1	FLIP 91-770
Kabuli Chickpea	Sudan	1998	Salawa	ICCV-2
Kabuli Chickpea	Sudan	1998	Wad Hamid	FLIP 89-826
Kabuli Chickpea	Syria	1986	Ghab 1	ILC 482
Kabuli Chickpea	Syria	1986	Ghab 2	ILC 3279
Kabuli Chickpea	Syria	1991	Ghab 3	FLIP 82-150C
Kabuli Chickpea	Tunisia	1986	Amdoun 1	Be-sel-81-48
Kabuli Chickpea	Tunisia	1986	Kassab	FLIP 83-46C
Kabuli Chickpea	Tunisia	1987	Chetoui	ILC 3279
Kabuli Chickpea	Tunisia	1991	FLIP 84-79C	FLIP 84-79C
Kabuli Chickpea	Tunisia	1991	FLIP 84-92C	FLIP 84-92C
Kabuli Chickpea	Turkey	1986	Guney Sarisi 482	ILC 482
Kabuli Chickpea	Turkey	1986	ILC 195	ILC 195
Kabuli Chickpea	Turkey	1991	Akcin	87AK81115
Kabuli Chickpea	Turkey	1992	Aydin 92	FLIP 82-259C
Kabuli Chickpea	Turkey	1992	Izmir 92	FLIP 85-60C

Crop	Country	Year of Release	Variety Name	Other Name
Kabuli Chickpea	Turkey	1992	Menemen 92	FLIP 85-14C
Kabuli Chickpea	Turkey	1994	Aziziye	FLIP 84-15C
Kabuli Chickpea	Turkey	1994	Damla-89	FLIP 85-7C
Kabuli Chickpea	Turkey	1997	Gokce	FLIP 87-8C
Kabuli Chickpea	USA	1994	Dwelley	Surutato x FLIP 85-58C
Kabuli Chickpea	USA	1994	Sanford	Surutato x FLIP 85-58C
Kabuli Chickpea	USA	1999	Sehat-99	FLIP 93-58C
Kabuli Chickpea	USA	2000	HB-14	US Line X FLIP83-13C
Kabuli Chickpea	USA	2000	Stan (HB-19)	US Line X FLIP90-1C
Lentil	Afghanistan	2000	Hirat	ILL 5582
Lentil	Afghanistan	2000	Takher	ILL 7180
Lentil	Algeria	1987	Syrie 229	n.a.
Lentil	Algeria	1988	Balkan 755	n.a.
Lentil	Algeria	1988	ILL 4400	ILL 4400
Lentil	Argentina	1991	Arbolito	ILL 4605 x ILL 4349
Lentil	Australia	1989	Aldinga	FLIP 84-80L
Lentil	Australia	1993	Cobber	FLIP 84-58L
Lentil	Australia	1993	Digger	FLIP 84-51L
Lentil	Australia	1993	Matilda	FLIP 84-154L
Lentil	Australia	1995	Northfield	78S 26013
Lentil	Australia	1998	Cassab	ILL 7200
Lentil	Australia	1998	Cumra	ILL 590
Lentil	Australia	1999	Nugget	ILL 7180
Lentil	Bangladesh	1993	Barimasur-2	ILL 8007
Lentil	Bangladesh	1996	Barimasur-4	ILL 8006
Lentil	Canada	1989	Indian head	ILL 481
Lentil	Canada	1994	CDC Matador	ILL 481 x Eston x PI 179310)
Lentil	Canada	1994	CDC Redwing	Eston x ILL 5588
Lentil	Chile	1989	Centinela	74TA 470
Lentil	China	1988	FLIP 87-53L	FLIP 87-53L
Lentil	China	1998	C 87	ILL 6980
Lentil	Ecuador	1987	INIAP-406	FLIP 87-53 L

Crop	Country	Year of Release	Variety Name	Other Name
Lentil	Egypt	1990	Precoz	ILL 4605
Lentil	Egypt	1998	Giza 51	FLIP 84-51L
Lentil	Egypt	1998	Sinai 1	ILL 4605
Lentil	Ethiopia	1980	R 186	R 186
Lentil	Ethiopia	1984	Chalew	LL 358
Lentil	Ethiopia	1984	Chikol	NEL 2704
Lentil	Ethiopia	1995	Ada'a	FLIP 86-41L
Lentil	Ethiopia	1995	Gudo	FLIP 84-78L
Lentil	Ethiopia	1998	Alemaya	FLIP 89-63L
Lentil	Georgia	2001	Pablo	ILL 759
Lentil	Iran	1999	Gachsaran	ILL 6212
Lentil	Iraq	1992	Baraka	ILL 5582
Lentil	Iraq	2000	IPA 98	ILL 5883
Lentil	Jordan	1989	Jordan 1	ILL 4400 * UJ 94 (ILL 5208)
Lentil	Jordan	1990	Jordan 2	ILL 5582
Lentil	Jordan	1990	Jordan 3	78S 26002
Lentil	Lebanon	1988	Talya 2	ILL 5582
Lentil	Lebanon	1995	Toula	FLIP 86-2L
Lentil	Lebanon	2000	Rachayya	FLIP 87-56L
Lentil	Lesotho	2000	FLIP 84-99L	FLIP 84-99L
Lentil	Lesotho	2000	FLIP 86-51L	FLIP 86-51L
Lentil	Lesotho	2000	FLIP 92-48L	FLIP 92-48L
Lentil	Libya	1993	El Safsaf 3	ILL 5582
Lentil	Morocco	1989	Bakria	ILL 4605
Lentil	Morocco	1999	Bichette	ILL 5562
Lentil	Morocco	1999	Hamira	ILL6238
Lentil	Nepal	1989	Sikhar	ILL 4404
Lentil	Nepal	1999	Khajura-2	ILL 2573
Lentil	New Zealand	1992	Rajah	FLIP 87-53L
Lentil	Pakistan	1989	Manserha 89	ILL 4605
Lentil	Pakistan	1993	Masoor-93	ILL 4400 x 18-12
Lentil	Pakistan	1996	Shiraz-96	ILL 5865
Lentil	Portugal	1999	Beleza	ILL 7711
Lentil	Portugal	1999	Cinderela	ILL 5770
Lentil	Sudan	1993	Aribo 1	ILL 818
Lentil	Sudan	1993	RUBATAB	ILL 813
Lentil	Sudan	1998	Nedi	ILL 6467
Lentil	Syria	1987	Idleb 1	ILL 5582
Lentil	Syria	2000	Idleb 2	ILL 5883
Lentil	Tunisia	1987	Nefza	ILL 4606
Lentil	Tunisia	1987	Nsir	ILL 4400

Crop	Country	Year of Release	Variety Name	Other Name
Lentil	Turkey	1987	Firat 87	75Kf 36062
Lentil	Turkey	1990	Erzurum 89	ILL 942
Lentil	Turkey	1990	Malazgirt 89	ILL1384
Lentil	Turkey	1991	Sazak 91	ILL 854
Lentil	Turkey	1996	Sayran 96	ILL 784
Lentil	USA	1991	Crimson	ILL 784
Lentil	Yemen	1998	Dhamar 1	ILL 4605
Dry Pea	Cyprus	1994	Kontemenos	PS 210713
Dry Pea	Ethiopia	1994	061K-2P-2192	Acc 446
Dry Pea	Oman	1995	A 0149 Dry Pea	Acc296
Dry Pea	Oman	1995	*Collegian Dry Pea*	*Collegian*
Dry Pea	Oman	1995	MG 102703 Dry Pea	Acc 173
Dry Pea	Oman	1995	Syrian Local Dry Pea	Syrian Local
Dry Pea	Sudan	1989	Krema-1	n.a.
Dry Pea	Sudan	1994	Ballet	Ballet
Dry Pea	Yemen	1998	Amran 1	n.a.

GERMPLASM PROGRAM
Staff List 2000

1.	*Dr Khaled Makkouk*	*Acting Leader Germplasm* Program & Plant Virologist
2.	Dr Salvatore Ceccarelli	Barley Breeder
3.	Dr Miloudi Nachit	Durum Breeder (CIMMYT) & Regional Representative WANA
4.	Dr Osman Abdallah	Bread Wheat Breeder (CIMMYT)
5.	Dr Habib Ketata	Acting Regional Coordinator-HRP & Winter Wheat Breeder
6.	Dr Ali Abd El-Moneim	Forage Legume Breeder
7.	Dr Michael Baum	Biotechnologist
8.	Dr Rajinder S. Malhotra	Senior Chickpea Breeder
9.	Dr Amor Yahyaoui	Senior Cereal Pathologist
10.	Dr Mustapha El-Bouhssini	Entomologist
11.	Dr Stefania Grando	Barley Breeder
12.	Dr Ashutosh Sarker	Lentil Breeder
13.	Dr Sripada Udupa	Associate Scientist (Biotechnology)
14.	Dr Bruno Ocampo	Acting International Trials Scientist & Research Associate
15.	Mr Fadel Afandi	Research Associate (Training Coordinator)
16.	Dr Flavio Capettini	Post-Doctoral Fellow (Barley Breeder) (based in CIMMYT/Mexico)
17.	Dr Imad Eujayl	Post-Doctoral Fellow (Biotechnology)
18.	Mr Bruno Schill	Post-Doctoral Fellow (Faba Bean Breeder)
19.	Ms Ismahane Elouafi	Research Fellow (Durum Breeding)
20.	Ms Elena Iacono	Research Fellow (Durum Breeding) (based in Italy)
21.	Mrs Bianca van Dorrestein	Research Fellow (Biotechnology) (based in Egypt)
22.	Mr Gaby Khalaf	Research Associate (Chickpea Breeding)
23.	Mr Michael Michael	Research Associate (On-Farm Trials)
24.	Mr Antoine P. Asbati	Research Associate (Durum Breeding)
25.	Mr Munzer Naimi	Research Associate (Cereal Pathology)
26.	Mr Fouad Jaby El-Haramein	Research Associate (Cereal Quality)
27.	Mr Samir Hajjar	Research Associate (International Trials)

28. Ms Safaa Kumari	Research Associate (Virology)
29. Mr Adonis Kourieh	Research Assistant (Barley Breeding)
30. Mr Henry Pashayani	Research Assistant (Barley Breeding)
31. Mr Mazen Jarrah	Research Assistant (Winter Wheat Breeding)
32. Mr Abdallah Joubi	Research Assistant (Entomology)
33. Mr Nicolas Rbeiz	Research Assistant (based in Terbol)
34. Mr Pierre Kiwan	Research Assistant (based in Terbol)
35. Mrs Siham Kabbabeh	Research Assistant (Legume Pathology)
36. Mr Hani Nakkoul	Research Assistant (Food & Forage Legume Quality)
37. Mr George Zakko	Research Assistant (Forage Legume Breeding)
38. Ms Suheila Arslan	Research Assistant (Chickpea Breeding)
39. Mr Hasan El-Hasan	Research Assistant (Lentil Breeding)
40. Mr George Kashour	Research Assistant (Barley Breeding)
41. Mr Munzer Kabakebji*	Research Assistant (Faba Bean Breeding)
42. Mr Alaa Yaljarouka	Research Assistant (Bread Wheat Breeding)
43. Mr Mahmoud Hamzeh	Research Assistant (Barley Breeding)
44. Mr Ziad Alamdar	Senior Research Technician (Cereal Pathology)
45. Mr Mohamed Azrak	Senior Research Technician (Durum Breeding)
46. Mr Riad Ammaneh	Senior Research Technician (Forage Legume Breeding)
47. Mr Adnan Ayyan	Senior Research Technician (Barley Breeding)
48. Mrs Widad Ghoulam	Senior Research Technician (Virology)
49. Mr Omar Labban	Senior Research Technician (Faba Bean Breeding)
50. Mr Nidal Kadah	Senior Research Technician (Lentil Breeding)
51. Mr Raafat Azzo	Research Technician (Barley Breeding)
52. Mr Aleddin Hamwieh*	Research Technician (Molecular Biology)
53. Mr Ahmad El-Saleh	Research Technician (Durum Breeding)

54. Mr Mohamed K.Issa	Research Technician (Chickpea Breeding)
55. Mr Mohamed El-Jasem	Research Technician (Chickpea Breeding)
56. Mr Noaman Ajanji	Driver/Store Keeper
57. Mr Bounian Abdel Karim	Research Technician (Lentil Breeding)
58. Ms Setta Ungi	Research Technician (Molecular Biology)
59. Ms Nadia Fadel	Research Technician (International Trials)
60. Ms Sawsan Tawkaz	Research Technician (Tissue Culture Application)
61. Mr Hani Hazzam	Research Technician (Durum Breeding)
62. Ms Aman Sabbagh	Research Technician (Molecular Biology)
63. Ms Iman Maaz	Research Technician (Cereal Pathology)
64. Mrs Mouna Baalbaki	Research Technician (Tissue Culture Application)
65. Mr Mohamed M. El-Karim	Research Technician (Bread Wheat Breeding)
66. Ms Nouran Attar	Research Technician (Virology)
67. Ms Nahed Al-Sokhny*	Research Technician (Tissue Culture Application)
68. Mr Obeid El-Jasem	Farm Labourer (Durum Breeding)
69. Mr Fawaz El-Abdallah	Labourer (Lentil Breeding)
70. Mr Joseph Karaki	Assistant Research Technician (based in Terbol)
71. Mr Ghazi Khatib	Assistant Research Technician (based in Terbol)
72. Ms Rita Nalbandian	Executive Secretary
73. Mrs Sossi Toutounji	Secretary
74. Ms Hazar Sabbagh	Secretary
75. Mrs Tamar Varvarian	Secretary

Consultants

76. Dr Victor Shevtsov	Barley Breeder (based in Uzbekistan)
77. Dr Shaaban Khalil	Faba Bean Breeder
78. Dr Bassam Bayaa	Lentil Pathologist
79. Dr Wafa Choumane	Biotechnologist
80. Dr Mohamed Shafik Hakim	Cereal Pathologist
81. Mr Haitham Sayed	Biotechnolgy

* Joined the Program in 2000

المركز الدولي للبحوث الزراعية في المناطق الجافة
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