GERMPLASM PROGRAM CEREALS

Annual Report for 1997

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 West and Central 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 extending from residential courses for groups to advanced research opportunities for individuals. These efforts are supported by seminars, publications, and specialized information services.

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 a wide variety of 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.

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The World Bank, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), and the United Nations Environment Programme (UNEP) 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.

GERMPLASM PROGRAM
CEREALS

Annual Report for 1997

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 West Asia and North Africa, with whom ICARDA has close collaboration. Owing to the tight production deadlines, editing of the report was kept to a minimum.

TABLE OF CONTENTS

1.	**INTRODUCTION**	1
2.	**BARLEY IMPROVEMENT**	**12**
2.1.	Introduction	12
2.2.	Headquarters Activities	14
2.2.1.	The Crossing Program	14
2.2.2.	The Yield Trials	15
2.2.3.	Cold Tolerance	26
2.2.4.	Farmer Participation	28
2.2.5.	Biotechnology	42
2.2.6.	Stress Physiology	51
2.2.7.	Virology	54
2.2.8.	Grain and Straw Quality	58
2.3.	The Near East and West Asia	63
2.3.1	Decentralized Screening for Cold and Drought	64
2.3.2	Syria	65
2.3.3	Jordan	69
2.3.4	Lebanon	70
2.3.5	Turkey	71
2.3.6	Iraq	72
2.3.7	Iran	74
2.3.8	Pakistan	75
2.4.	North Africa	76
2.4.1.	Decentralized Barley Breeding Program	76
2.5.	East Africa and Yemen	100
2.5.1.	Ethiopia	100
2.5.2.	Eritrea	102
2.5.3.	Yemen	103
2.6.	Central Asia and Russia	104
2.7.	Far East	106
2.7.1.	India	106
2.7.2	China	107
2.8.	Central and Latin America	111

2.8.1.	Yield Potential	113
2.8.2.	BYDV Screening	120
2.9.	Acknowledgements	122
2.10.	Entomology	123
2.10.1.	Russian Wheat Aphid	123
2.10.2.	Barley Stem Gall Midge	123
3.	**DURUM WHEAT IMPROVEMENT**	**125**
3.1	Durum Breeding	125
3.1.1.	Widening the Genetic Base	125
3.1.2.	Biotic Stress Resistance	126
3.1.3.	Grain Quality	130
3.1.4.	Associations of RFLP-Markers with Grain Yield and Morpho-Physiological Traits under Dryland Conditions, Breda, 1996/97	132
3.1.5.	Performance of Crosses Derived from Abiotic Stress Tolerant Genotypes and Wild Relatives	136
3.1.6.	Conclusion	137
3.2.	Durum Biotechnology	139
3.2.1.	Interspecific Hybridization in Durum Wheat	139
3.3.	Durum Entomology	140
3.3.1.	Wheat	140
4.	**SPRING BREAD WHEAT IMPROVEMENT**	**153**
4.1.	Spring Bread Wheat Breeding	153
4.1.1.	Introduction	153
4.1.2.	Importance of Bread Wheat in WANA	153
4.1.3.	Wheat Production Environments in WANA	154
4.1.4.	Breeding Methodology	155
4.1.5.	Multilocation Testing and Selection	158
4.1.6.	Yield Stability and Adaptation in the Mediterranean Drylands	161
4.1.7.	Interaction with NARS	168
5.	**FACULTATIVE AND WINTER WHEAT**	**169**

5.1.	Growing Conditions	170
5.2.	Germplasm Development and Screening	171
5.3.	Genetic Stocks	178
5.4.	Germplasm Characterization and Targeting	179
5.5.	Regional Cooperation	183
5.5.1.	Iternational Nurseries	183
5.5.2.	Iran	184
5.5.3.	Morocco	185
5.5.4.	Turkey	185
6.	**PATHOLOGY**	**187**
6.1.	Introduction	187
6.2.	Survey	187
6.3.	Host Resistance	188
6.3.1.	Screening for Disease Resistance	188
6.3.2.	Screening Wild Triticum for Resistance to Wheat Diseases	196
6.3.3.	Germplasm Pools for Sources of Resistance (GPPLs)	197
6.3.4.	Identification and Localization of Resistant Genes Using Molecular Markers	199
6.4.	Race Identification and Virulence Analysis for Wheat Yellow and Leaf Rusts	199
6.5.	Crop Loss Assessment for Wheat Yellow Rust	200
6.6.	Etiological Studies on Septoriosis of Wheat in Syria	201
6.7.	Root Rot Diseases	201
6.7.1.	Evaluation of Farmers Fields	202
6.7.2.	Evaluation of Long-term Rotation Trials	204
6.7.3.	Biological Control	206
6.8.	Cereal Cyst Nematodes	208
6.8.1.	Evaluation of Long-term Rotation Trials	208
6.8.2.	Crop Loss Assessment	209
6.8.3.	Interaction between Cereal Cyst Nematodes and Root Rot	209
6.9.	Head Sterility in Barley and Seed-Gall	

	Nematodes of Wheat and Barley	210
6.10.	Organic Seed-Treatment as Substitute for Chemical Seed-Treatment to Control Common Bunt of Wheat	211
6.11.	Use of Cultivar Mixtures to Control Air-Borne Diseases	212
7.	**VIROLOGY**	**215**
7.1	Cereal Viruses	215
7.1.1.	Evaluation of Wheat Wild Relatives	215
7.1.2.	Evaluation of Wheat Interspecific Hybrids for their Reaction to BYDV	215
7.1.3.	Evaluation of Best Performing Cereal Genotypes from Previous Seasons	218
7.1.4.	Evaluation of ICARDA Cereal Nurseries for their Reaction to BYDV Infection	219
8.	**TRAINING AND VISITS**	**230**
8.1.	Long-term Training Course in Cereal Improvement	230
8.2.	Short Courses	231
8.2.1.	Integrated Management of Cereal and Food Legume Insect Pests	231
8.2.2.	DNA Molecular Marker Techniques for Crop Improvement	231
8.2.3.	Cereal Diseases and Insects	233
8.2.4.	Pedigree Management	233
8.3.	Individual Training	234
8.3.1.	Individual Non-degree Training	234
8.3.2.	Graduate Research Training	234
8.4.	Visits	234
8.5.	Facultative and Winter Wheat	235
8.5.1.	Training and Visits	235
9.	**PUBLICATIONS**	**236**
9.1.	Journal Articles	236

9.2.	Conference Papers	236
9.3.	Book Chapters	238
10.	**VARIETIES RELEASED BY NARSs**	**239**
11.	**STAFF LIST**	**250**

1. INTRODUCTION

The crop improvement research on cereals and legumes at the International Center for Agricultural Research in the Dry Areas (ICARDA) is done by the Germplasm Improvement Program. Among the cereals, it covers barley, durum wheat and bread wheat, while amongst the legumes it covers lentil, chickpea, faba bean, forage legumes and pea. 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 pea 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 mandate for this crop.

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 the headquarters. In the case of chickpea, ICRISAT posted a chickpea breeder at ICARDA to address the needs of the crop in WANA.

The overall objective of the Germplasm Improvement 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, Latakia 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, Russia, 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 1996/97 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 higher than the long term average in Bouider and Tel Hadya, and lower in Breda and Terbol. The deviation in precipitation from the long term average were considerable in descending order at Tel Hadya, Terbol, Bouider and Breda, in this order.

In Bouider, the total precipitation exceeded the long term average by approximately 50 % (348 mm versus 226 mm). The highest monthly precipitation deviations from the average were positive and occurred in December, March and April (more than 40 mm above average). The mean maximum temperature during the cropping season was 1°C below the long term average, whereas the mean minimum temperature was 2°C above the average.

In Breda, the total precipitation was 15 % lower than average (231 mm versus 266 mm). The highest monthly precipitation deviations from the average were negative and occurred in January and February (26 mm below the average), whereas in March the precipitation was 25 mm above average. Minimum and maximum temperatures were about 2.5°C below the average from January to April.

In Tel Hadya, the total precipitation exceeded the long term average by 25 % (434 mm versus 348 mm). The highest monthly precipitation deviations from the average were positive and occurred in December, March, and above all in April (80 mm above average). During November and February, the precipitation was less than half of the average. Though the minimum and maximum temperatures during the cropping season were average, they were 2°C below average from February to April.

In Terbol, the total precipitation was 12 % lower than average (496 mm versus 565 mm). The highest monthly precipitation deviations from the average were negative and occurred in November and January (54 mm and 67 mm below average). Precipitation in April was the double of average. The minimum and maximum temperatures followed the average, however between February and April the maximum was 3°C and the minimum 2°C below the average.

One of the major events in 1997 was the Center Commissioned External Review (CCER) of cereal projects and integrated pest management, held in Aleppo in early February 1997. Overall, the CCER produced an excellent, well-balanced report which showed a depth of understanding of our research on cereals and integrated pest management (IPM) and gave constructive ideas for change. The CCER made the following key recommendations regarding cereal and IPM research:

1. ICARDA should define clearly its long-term strategy to carry out its global mandate on barley
2. Durum program should receive strong support to maintain its lead as a world center of excellence for durum wheat
3. ICARDA should develop a systematic, multi-disciplinary, smooth flowing approach to germplasm evaluation, identification of traits; and pre-breeding centered on its cereal germplasm collections
4. Planning to enlarge the storage facilities should be initiated, including the possibility of storing duplicate samples for important crops of the area that have been collected by NARS
5. Increased level of staffing for the Integrated Pest Management Program should be made available
6. Biotechnological activities should be conducted within a well-defined, multidisciplinary experimental framework, and that ICARDA's biotechnology laboratories should focus on the application of molecular markers to tackle clearly defined problems in phenotypically and agronomically well-characterized material (germplasm)
7. The guiding scientific vision of the biotechnology/GRU/germplasm enhancement collaborative effort should be an emphasis on characterization of germplasm using appropriate molecular biology techniques, and this approach should be integral to the Center's research thrusts; further, molecular biology and biotechnology methods of partnerships between molecular biologists, breeders and supporting disciplines should permeate and underpin all germplasm enhancement programs at ICARDA
8. ICARDA should examine how best to serve the Central Asian Republics and Trans-Caucasus Republics through research partnerships, training and exchanges of germplasm

The program accepted these recommendations and has started to make the necessary changes during 1997 within available budgetary limitations.

During the year the following changes in senior staff occurred:

a. Dr Guillermo Ortiz-Ferrara (CIMMYT) Spring bread wheat breeder left and was replaced by Dr Osman Abdalla
b. Dr Mustafa El-Bouhssini joined as Entomologist in the program
c. Dr Habib Ketata was transferred to Ankara as Wheat breeder in the CIMMYT/ICARDA/Turkey program
d. Dr Abderrezak Belaid (Socio-economist) was transferred to ICARDA Tunis.
   Dr. Omar Mamluk (Cereal Pathologist) retired
c. Dr. Franz Weigand (Biotechnologist) resigned
d. Dr. S. K. Yau (Cereal International Trials Scientist) resigned
e. Mr Suren Jurgensen joined as a Junior Professional Officer from Denmark in barley breeding

More than 70 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 1997:

1. **Use of DNA-markers in selection for disease resistance genes in barley**, supported by BMZ and in collaboration with Technische Universität München, Lehrstuhl für Pflanzenbau und Pflanzenzüchtung, Munich, Germany (person in charge: M. Baum)
2. **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 (person in charge: F. Weigand)

3. **Improving Yield and Yield Stability of Barley in Stress Environments**, supported by the Government of Italy (person in charge: S. Grando)
4. **Farmer Participation and Use of Local Knowledge In Breeding Barley For Specific Adaptation** supported by BMZ and in collaboration with University of Hohenheim (person in charge: S. Ceccarelli)
5. **Increasing the Relevance of Breeding to Small Farmers: Farmer Participation and Local Knowledge in Breeding Barley for Specific Adaptation to Dry Areas of North Africa** supported by IDRC and in collaboration with IRESA (Tunisia) and INRA (Morocco) (person in charge: S. Ceccarelli)
6. **Resistance to nematodes in lentil and chickpea,** in collaboration with the Institute of Nematology of Bari, (persons in charge: R.S. Malhotra)
7. **Development of Chickpea Resistant to Biotic and Abiotic Stresses using Interspecific Hybridization and Genetic Transformation** supported by the Government of Italy and in collaboration with ENEA, University of Napoli and the University of Tuscia in Viterbo (person in charge: R.S. Malhotra)
8. **Fusarium Wilt in Chickpea**, supported by the Government of Spain and in collaboration with INIA (person in charge: R.S. Malhotra)
9. **Wheat Adaptation Studies for Wheat in WANA and Australia**, supported by Grains Research Development Council (GRDC) Australia, in collaboration with the University of Sydney (person in charge: G. Ortiz-Ferrara)
10. **International Durum Wheat Improvement**, supported by Grains Research Development Council (GRDC) Australia, in collaboration with the New South Wales Department of

Agriculture (person in charge: M. Nachit)

11. **Coordinated Improvement Program for Australian Lentils**, supported by Grains Research Development Council (GRDC) (person in charge: W. Erskine)
12. **Improvement of Drought and Disease Resistance in Lentils in Nepal, Pakistan and Australia**, supported by the Australian Centre for International Agricultural Research (ACIAR) (person in charge: W. Erskine)
13. **Central and West Asia Rusts Network-enhanced Regional Food Security Through the Development of Wheat Varieties with Durable Resistance to Yellow Rust** (person in charge: O. Mamluk)
14. **West Asia and North Africa Dryland Durum Improvement Network (WANADDIN)** supported by IFAD (person in charge: M. Machit)
15. **Faba Bean in China**, supported by the Australian Centre for International Agricultural Research (ACIAR) and in collaboration with the Genetic Resources Unit (person in charge: L. Robertson)
16. **Integrated Management of Pest and Diseases**, supported by BMZ (person in charge: K. Makkouk)
17. **Durum Wheat Improvement** supported by the Australian Centre for International Agricultural Research (ACIAR)(person in charge: M. Nachit)
18. **Kabuli Chickpea** supported by the Australian Centre for International Agricultural Research (ACIAR)(person in charge R.S. Malhotra)
19. **Development and use of Molecular Genetic Markers for Enhancing the Feeding Value of Cereal Crop Residues for Ruminants** (supported by the Australian Centre for International Agricultural Research-ACIAR) (person in charge: S. Ceccarelli).
20. **Application of Molecular Genetics for Development of Durum Wheat Varieties Possessing High Yield Potential, Rust Resistance, Stress Tolerance, and Improved Grain Quality** (supported by Agricultural Technology,

Utilization and Transfer Project-ATUT) (person in charge: M. Nachit).

21. **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) (person in charge: Dr O. Abdalla).
22. **Genetic transformation of barley for improved stress resistance** (supported by CGIAR) (person in charge: Dr M. Baum).
23. **Adaptation of barley to drought and temperature stress using molecular markers** (supported by USDA, Texas Tech University, U.S.A.) (person in charge: Dr S. Ceccarelli).
24. **Inheritance and linkage of winter hardiness in lentil** (supported by USDA, Washington State University, U.S.A.) (person in charge: Dr W. Erskine).
25. **Use of entomopathogenic fungi for the control of Sunn pest** (supported by USDA, University of Vermont, U.S.A.) (person in charge: Dr M. El Bouhssini).

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

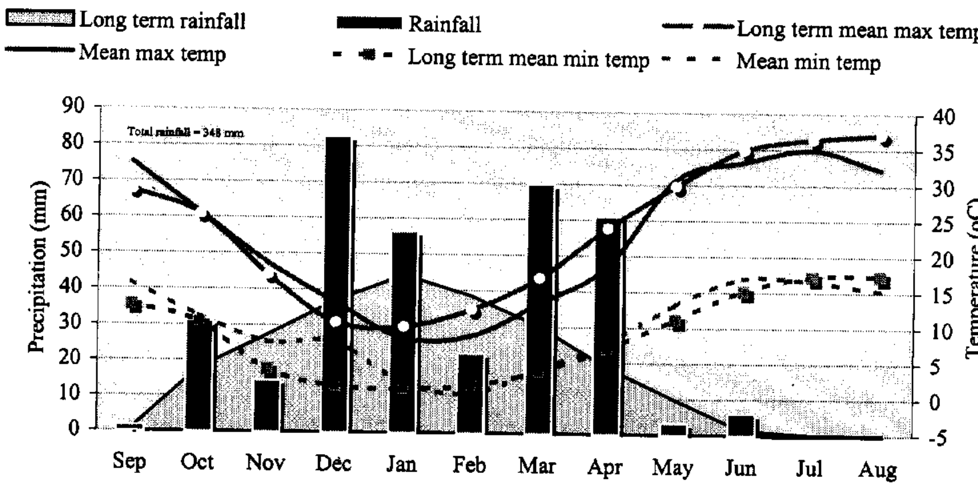
Mashreq and Maghreb (M&M) Project
Mediterranean Highland Project
Barley Improvement Project in Ethiopia
Problem-solving Regional Network Project in Egypt Ethiopia, Sudan and Yemen
Matrouh Resource Management Project in Egypt

This report is published in two sections, one with the results of cereal crops improvement work and one with results of the legume crops improvement work.

Most of the results reported in the two sections were obtained during the 1996-97 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. Space limitations prevent to mention all our collaborators individually, but 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.

Bouider



Breda

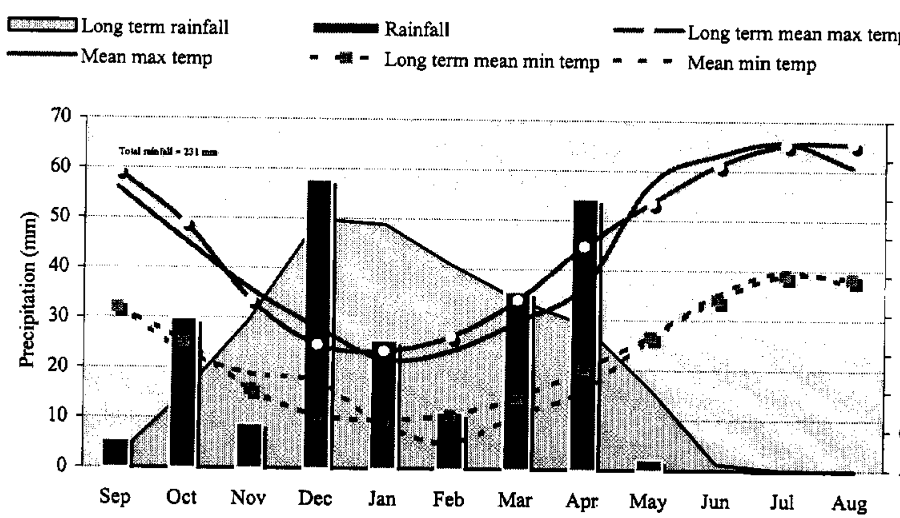
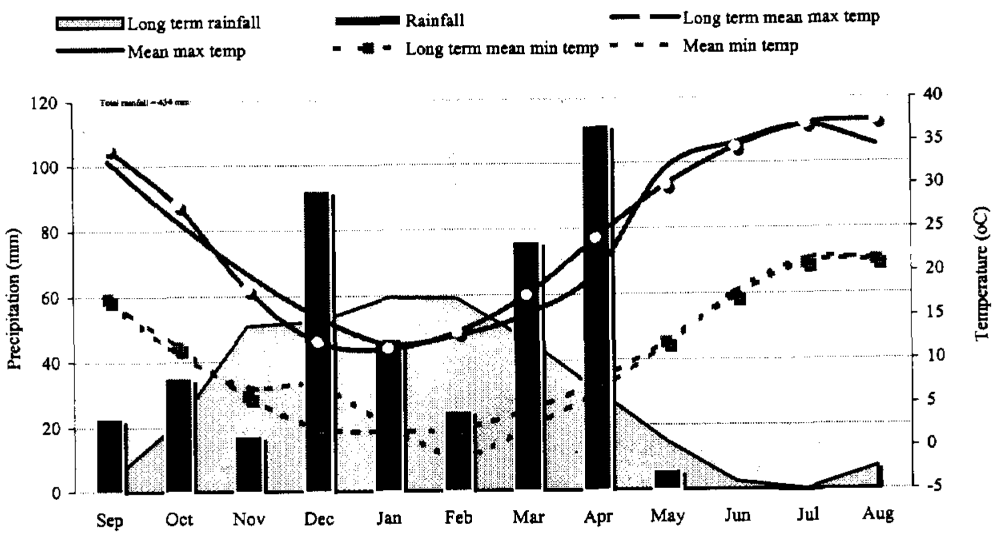


Fig. 1.1. Weather conditions at Bouider and Breda during 1996-97.

Tel Hadya



Terbol

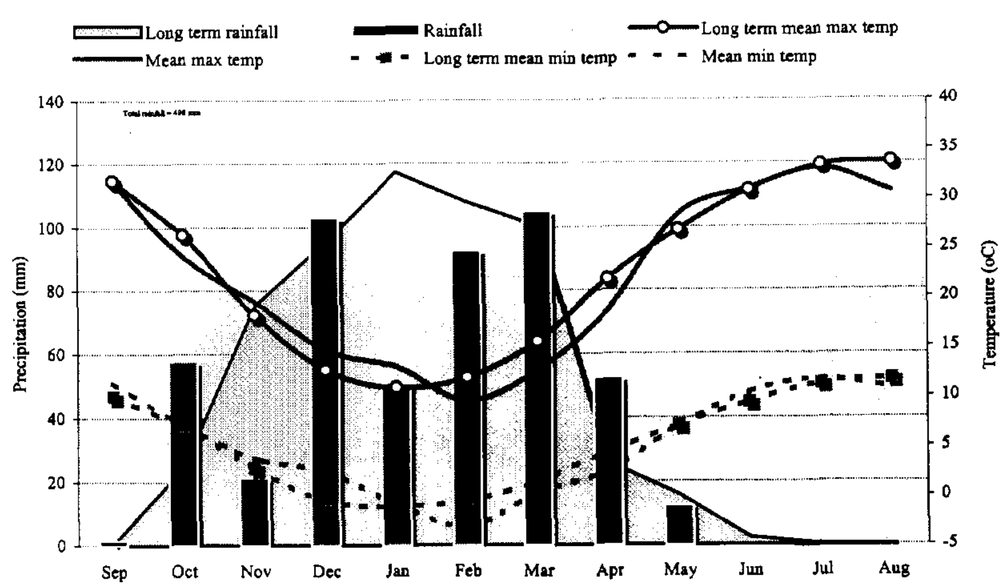


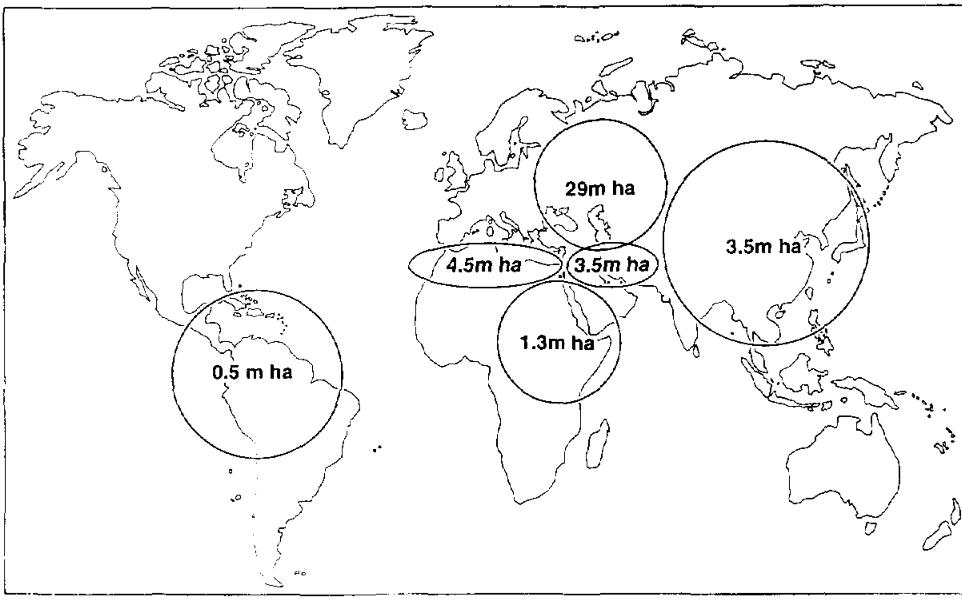
Fig. 1.2. Weather conditions at Tel Hadya and Terbol during 1996-97.

2. BARLEY IMPROVEMENT

2.1. Introduction

The *overall objective of the project is to increase barley* production in less developed countries thus contributing to alleviation of poverty. This objective is pursued with different strategies depending on the research capacity of the various cooperating national programs, and ranges from the development of finished varieties to the development of breeding methodologies. Such methodologies emphasize specific adaptation and include decentralized breeding and farmers' participation, the use of sustainable levels of inputs, and the maintenance and enhancement of the crop's biodiversity.

Barley improvement at ICARDA has a global perspective aiming to address the problems of the crop in all developing countries. The target areas of the project can be divided in six geographic regions (Fig. 2.1), Central Asia and Russia, Far East, North Africa, Near East and West Asia, East Africa and Yemen, and Central and Latin America with a total area exceeding 42 million hectares. These regions differ in the type of barley grown (for example, mostly 6 row in North Africa and mostly 2 row in Near East and West Africa) and in its use (for example, as animal feed in Near East and West Asia, as animal feed and human food in North Africa, and as animal feed, human food and malt in the other regions). In the East Africa and Yemen and in Central and Latin America, large part of barley is grown at high elevations, is photoperiod insensitive and it develops and matures at decreasing temperatures, the opposite of the lowland barley grown in North Africa and Near East and West Asia, where the crop develops and matures at increasing temperatures and water stress. Central Asia and Russia on one side and the Far East on the other, are very heterogenous since they grow both winter and spring barley in both high and low rainfall areas. These two geographical areas are grouped based more on tactical than biological reasons. In fact they would probably require specific sub-project conducted by staff acquainted not only with the crop but with the culture of these populations.



A global program to serve 42 million hectares of barley

Fig. 2.1. A global barley project to serve 42 million hectares in four continents.

In these regions barley is variously grown for animal feed, human food and malt, and in many different types of environment. However, most barley is grown in marginal environments, often on the fringes of deserts and steppes or at high elevations in the tropics, and receives modest or no inputs.

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.

(S. Ceccarelli, H. Vivar, S. Grando, V. Shevtsov)

2.2. Headquarters Activities

2.2.1. The Crossing Program

Despite its global nature, to maximize specific adaptation the barley project develops new germplasm starting with geographically targeted crosses. The crosses made by the project in 1997 are given in Table 2.1.

Table 2.1. Number and type of crosses done in 1997 in the barley project.

Country/Objective	Number	Type of crosses
Algeria	98	F_1
Egypt	88	F_1 and F_1xF_1
Iraq (irrigated areas)	41	F_1
Libya	62	F_1
Morocco	171	F_1, BC and F_1xF_1
Tunisia	211	F_1, BC and F_1xF_1
Syria, Jordan and north Iraq	306	F_1, BC, TC and F_1x F_1
Vietnam	24	F_1 x F_1
Far East	102	F_1
Cold tolerance	856	F_1
Disease and pest resistance	129	F_1 and F_1 x F_1
Eritrea/Tigray	9	F_1
Tunisia and Powdery Mildew	23	F_1
Recurrent selection	25	F_1 x F_1
Malting quality	45	F_1
Total	2198	

Crosses with landraces and with *H. spontaneum* are not listed separately as most of the crosses for Syria, Jordan and northern Iraq have a landrace and/or *H. spontaneum* as one parent. The crosses for Central and Latin America are made in Mexico.

In the past we made mostly single crosses. Recently we increased the use of backcrosses and topcrosses, particularly in the case of transferring sources of resistance to different diseases and/or pests. In 1995 we began using crosses between F_1's followed by intercrossing random F_2 plants to increase frequency of recombination.

(S. Ceccarelli, S. Grando)

2.2.2. The Yield Trials

The most commonly used breeding method at the headquarters is the bulk-pedigree. The method is implemented by visually selecting among F_2 bulks in two locations, and by yield testing the F_3, F_4, and F_5 bulks (in the initial, preliminary and advanced trials described below). As the bulks are yield tested, single plants progenies are derived from the superior bulks either by classical pedigree or, in the case of the best 1% of the bulks, by SSD.

The yield testing conducted at the headquarters supports the breeding activities addressing the areas with mediterranean climate with cool winters, i.e. Syria, Jordan, Iraq, part of Turkey and of Iran. Within these areas barley is grown in two major types of environments. The first type, which is nearly 75% of the 3 million hectares of barley grown in Syria and Iraq, receives usually 250 mm of annual rainfall or less between November and the end of April, has cold winters with as many as 60 days with minimum temperatures below 0°C and absolute minimum temperatures of -15°C, a probability of nearly 60% of grain yields of 1.5 t/ha or less, and a probability of only 14% of grain yields of 3 t/ha or more[1]. The second type receives more than 250 mm of annual rainfall between October and May, has cold winters with 35-40

1 Ceccarelli, S. et al., 1998. Decentralized breeding for marginal environments (in press)

days with temperatures below 0°C and absolute minimum temperatures of -10°C, a probability of 25% of grain yields of 1.5 t/ha or less, and a probability of nearly 45% of grain yields of 3 t/ha or more.

Three types of yield trials are conducted, namely initial, preliminary and advanced yield trials. Initial and preliminary trials are conducted in two locations and two replications, the advanced in five locations and two replications.

All yield trials are designed as α-lattices: randomization and analysis are performed using ALPHANAL (AFRC Statistics, Edinburgh).

2.2.2.1. Initial Yield Trials

The initial yield trials in 1997 were planted in two locations (Tel Hadya with 434 mm rainfall, about 100 mm more than the long term average) and Breda (with 231 mm rainfall, about 35 mm less than the long term average), had the same structure as in 1996, and included 858 new breeding lines and eleven checks.

There was a large variability for important traits such as plant height (which ranged from 27 to 82 cm in Breda, and from 64 to 124 cm in Tel Hadya) and grain yield (which ranged from 350 and 2700 kg/ha in Breda and from 1500 and 5900 kg/ha in Tel Hadya).

Average grain yield was 1181 kg/ha in Breda and 3980 kg/ha in Tel Hadya. The drought intensity index (Fischer and Maurer, 1978)[2], expressed on a scale from 0=absence of stress to 1=maximum stress, was 0.656 (much higher than in 1996 when it was only 0.283). In Tables 2.2 and 2.3 we show the ten

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2 Fischer, R.A. and Maurer, R., 1978. Drought Resistance in Spring Wheat Cultivars. I. Grain Yield Responses. Aust. J. Agric. Res., 29: 897-912.

best lines in Tel Hadya and in Breda, respectively.

Only 63 entries (7.3% of the total) out-yielded the best check in Tel Hadya (Arabi Abiad): these were all six-row, relatively early and very susceptible to drought as shown by their yields in Breda. The yield advantage of the best line in Tel Hadya over the best check was about 21% (Table 2.2).

In Breda only 4 lines out-yielded the best check (Arabi Abiad) and these were all landraces, three of which from the same collection site (nr. 39) of Arta. Other 26 entries did not differed significantly from the best check. All the highest yielding entries in Breda were two-row and different from the highest yielding entries in Tel Hadya. However, two of the highest lines in Breda, namely the landraces SLB 39-055 and SLB 39-037 out-yielded the best check both in Breda (by 8.6 and 5.9%) and in Tel Hadya (by 1.5 and 6.1%).

2.2.2.2. Preliminary Yield Trials

The preliminary yield trials comprised 249 breeding lines in the second year of testing and eleven checks. As observed in the initial yield trials, the average grain yield at Tel Hadya (4260 kg/ha) was much higher than in Breda (945 kg/ha) with a drought intensity index of 0.778, three times higher than in 1996 (0.278).

There was a large variability for important traits such as plant height (which ranged from 30 to 72 cm in Breda, and from 63 to 114 cm in Tel Hadya) and grain yield (which ranged from 317 and 2603 kg/ha in Breda, and from 2222 and 5789 kg/ha in Tel Hadya). The best check in 1997 both in Tel Hadya and in Breda was Arabi Abiad with 1830 kg/ha in Breda and nearly 4700 kg/ha in Tel Hadya.

The check with the highest average yield in 1996 and 1997 in Breda was Tadmor with 2030 kg/ha: 23 lines had a higher average grain yield, but of these only five lines out-yielded Tadmor both in 1996 and in 1997 (Table 2.4). Of

Table 2.2. The ten best lines in the Initial Yield Trials in Tel Hadya. Heading date was scored in Tel Hadya. Grain yield is in kg/ha.

Entry[a]	Row Type	Heading	Breda Plant height	Breda Grain Yield	Tel Hadya Plant height	Tel Hadya Grain Yield
1422	6	120	43	1051	101	5984
2372	6	121	39	932	105	5897
2273	6	120	39	802	87	5770
2304	6	122	51	994	112	5586
2303	6	124	48	1036	108	5519
2319	6	122	50	759	110	5490
2292	6	122	51	927	112	5487
1421	6	116	44	1012	88	5448
2227	6	122	33	810	84	5428
2179	6	125	38	666	88	5428
Checks						
Arabi Abiad	2	124	41	2387	81	4872
Arabi Aswad	2	127	64	2257	94	3492
Arta	2	125	41	1288	77	4418
Rihane-03	6	129	60	1580	98	4599
Tadmor	2	129	54	1997	89	3248
Zanbaka	2	127	57	1090	97	3243
SLB 5-96	2	123	44	1030	90	4435
Mean		124	47	1181	88	3980
s.e.		0.12	0.3	13	0.4	22
N		858	858	858	858	858
Max		139	81	2705	124	5984
Min		108	27	356	64	1551

[a]Entry Name

1422 Chaaran-01/3/Arizona5908/Aths//Bgs/4/WI2291/3/Api/CM67//L2966-69
2372 Arar/Rihane-03
2273 Chaaran-01/3/Arizona5908/Aths//Bgs/4/WI2291/3/Api/CM67//L2966-69
2304 Avt/Attiki//Aths/3/Giza 121/Pue
2303 Avt/Attiki//Aths/3/Giza 121/Pue
2319 Aths/Lignee 686//Orge 905/Cr.289-53-2
2292 As46/Aths*2//Aths/Lignee 686
1421 Th.Unk.23//M6/Robur-35-6-3
2227 Gloria'S'/Copal'S'
2179 Gustoe/Arar

Table 2.3. The ten best lines in the Initial Yield Trials in Breda. Heading date was scored in Tel Hadya. Grain yield is in kg/ha.

Entry[a]	Row Type	Heading	Breda		Tel Hadya	
			Plant height	Grain yield	Plant height	Grain yield
1214	2	133	59	2705	77	3441
1106	2	130	58	2671	94	3694
1229	2	122	47	2591	81	4944
1219	2	124	53	2529	91	5170
1391	2	129	53	2330	88	4363
2080	2	125	70	2282	100	3201
1206	2	123	43	2263	83	4189
1334	2	122	56	2259	100	4916
2389	2	126	64	2246	105	4824
1411	2	124	52	2211	86	3563
Checks						
Arabi Abiad		124	41	2387	81	4872
Arabi Aswad		127	64	2257	94	3492
Arta		125	41	1288	77	4418
Rihane-03		129	60	1580	98	4599
Tadmor		129	54	1997	89	3248
Zanbaka		127	57	1090	97	3243
SLB 5-96		123	44	1030	90	4435
Mean		124	47	1181	89	3980
s.e.		0.12	0.31	13.00	0.39	22.33
N		858	858	858	858	858
Max		139	81	2705	124	5984
Min		108	27	356	64	1551

[a]Entry Name
1214 SLB 39-029
1106 JLB 37-064
1229 SLB 39-055
1219 SLB 39-037
1391 Onslow/Tipper
2080 SLB 05-96/H.spontaneum 41-1
1206 SLB 39-005
1334 Arabi Abiad/WI2291//Tadmor/4/H.spont.93-4/3/Roho//Alger /Ceres362-1-1
2389 Arta/Lignee 527
1411 SLB 05-96/Arta

these, two were selections from landraces (SLB 32-039 and SLB

31-024) and one was a line derived from a cross between *H. spontaneum* and Tadmor: these three lines out-yielded Tadmor by 18 to 22%. The other two were unrelated to Syrian landraces, their superiority was between 4 and 7.5% and their seed size was very small.

The check with the highest average yield in 1996 and 1997 in Tel Hadya was Rihane-03 with about 4500 kg/ha of grain: 69 lines had an higher average grain yield over the two years, but only thirteen out-yielded Rihane-03 in both years (Table 2.5). These were all six-rows, they had a wide range of phenologies (heading date ranged from 113 to 134 days from emergence), and the yield advantage of the best six over Rihane-03 was between 13 and 19%.

Table 2.4. Lines in the Preliminary Yield Trials out-yielding Tadmor in Breda both in *1996* and in *1997*. Heading date and lodging (1=resistant, 5=susceptible) were scored in Tel Hadya, while plant height (PL) and 1000 kernel weight (KW) were scored in Breda.

Entry[a]	RT	Lodging	Heading	PH	KW	Grain yield(kg/ha)		
						1996	1997	Mean
2	2	1.0	130	33	48	2776	2166	2471
7	2	3.9	125	62	35	2663	2222	2443
1	2	0.8	124	40	46	2775	2011	2393
85	2	0.9	125	41	31	2549	1817	2183
182	6	1.0	128	43	32	2558	1676	2117
Checks								
Tadmor	2	4.0	130	49	39	2480	1580	2030
Arabi Abiad	2	1.5	129	42	43	2183	1830	2006
Arta	2	3.5	123	41	43	2822	870	1846
Arabi Aswad	2	2.8	130	53	39	2274	1412	1843
Zanbaka	2	2.6	129	49	34	2787	519	1653
Rihane-03	6	0.9	130	43	30	2520	785	1652
SLB 5-96	2	1.0	121	39	35	2107	617	1362

[a]Entry Name

182 Lignee 640/Lignee 527//Lignee 527/Rihane

85 Harmal//Kv/Mazurka/5/WI2198/Emir/4/7028/2759/3/69-82 //Ds/Apro

1 SLB 31-24

2 SLB 32-39

7 *H. spont*.41-3/Tadmor

Table 2.5. Lines in the Preliminary Yield Trials out-yielding Rihane-03 in Tel Hadya both in 1996 and in 1997. Heading date, lodging (1=resistant, 5=susceptible), plant height (PL) and 1000 kernel weight (KW) were scored in 1997.

						Grain yield (kg/ha)		
Entry[a]	RT	Lodging	Heading	PL	KW	1996	1997	Mean
116	6	1.0	113	89	37	5335	5398	5366
207	6	1.0	126	90	43	5759	4884	5321
190	6	1.0	125	88	37	5415	5112	5263
193	6	1.0	132	95	46	5903	4580	5242
202	6	1.0	133	87	34	5383	4864	5123
246	6	1.0	129	93	39	5330	4841	5086
111	6	1.0	129	86	37	5628	4498	5063
203	6	1.0	129	87	39	5338	4545	4942
211	6	1.0	134	80	25	5396	4486	4941
170	6	1.0	132	79	33	5586	4131	4858
248	6	1.0	130	88	30	5311	3927	4619
232	6	1.0	134	93	37	5452	3750	4601
Checks								
Rihane-03	6	0.9	130	82	40	5304	3700	4502
Arabi Abiad	2	1.5	129	75	41	2871	4698	3785
SLB 5-96	2	1.0	121	80	43	3246	4124	3685
Arta	2	3.5	123	72	43	2716	4614	3665
Tadmor	2	4.0	130	74	33	2435	3688	3061
Arabi Aswad	2	2.8	130	92	33	2060	3676	2868
Zanbaka	2	2.6	129	94	27	2340	3143	2742

[a]Entry	Name
111	NK1207/3/Api/CM67//Mona/4/Aths/Lignee 686
232	CI 01021/4/CM67/U.Sask.1800//Pro/CM67/3/DL70/5/Gizeh 134/Apm//Aths
202	Deir Alla 106//DL71/Strain 205/3/F4 Bulk//Sutter*2 /Numar
246	Lignee 527/Rihane//Rihane-03
248	CM67/Apro//Sv.02109/Mari/3/EB921
170	Lignee 640/Lignee 527//Arar
203	Deir Alla 106//DL71/Strain 205/3/F4 Bulk//Sutter*2 /Numar
211	Lignee 527/NK1272/4/Lignee 527//Bahtim/DL71/3/Api/ CM67//Mzq
190	Hyb 85-6//As46/Aths*2
116	Aths/Lignee 686//N-ACC4000-301-80/IFB974
193	Saida//H 85-6 (Rihane'S'/LM4448-1)
207	Arar/Rihane-03

2.2.2.3. Advanced Yield Trials

The advanced yield trials comprised 89 breeding lines in the third year of testing and eleven checks. They were evaluated at Tel Hadya, Breda and Bouider in Syria, and Terbol and Kfardan in Lebanon, with average grain yields of 4633, 948, 2767, 3473 and 1533 kg/ha, respectively. The best entries in the two most contrasting locations, Tel Hadya and Breda are shown in Tables 2.6 and 2.7.

In Tel Hadya, most of the highest yielding lines were six-row, and only few out-yielded marginally the best check (Rihane-03). In general they did not perform well in the other locations: in fact only one line out-yielded the best check in Bouider, while another line out-yielded the best check in Kfardan. None of these lines out-yielded the best check in the yielding location in 1997 (Breda). The yield advantage of the best line over Rihane-03 was only 5%.

In Breda, the highest yielding lines were selections from landraces and three lines derived by single seed descent (SSD) from crosses involving landraces and/or *H. spontaneum*. One of the Moroc 9-75/Arabi Aswad SSD lines (entry nr. 88) out-yielded the best check in four of the five locations. Other lines performed well in some of the other locations. The yield advantage of the best line in Breda was nearly 22%.

The lines in the advanced yield trials were tested in 1995 and 1996 in Breda and Tel Hadya; when their performance was assessed across the three years we found large differences in ranking, depending on whether the actual or the standardized yields were used. However some of the lines shown in Tables 2.6 and 2.7, namely entries 23, 51, 14, 17, 77 and 88, were amongst the ten top yielding lines across years and locations irrespective of whether the original or the standardized data were used.

Yield under stress (YS) was estimated as the average grain yield of all the lines in the lowest yielding year-location combinations (Breda 1995, Breda 1996, Breda 1997 and

Table 2.6. Grain yield (kg/ha) in five locations of the best lines in the Advanced Yield Trials in Tel Hadya.

Entry[a]	RT	Breda	Bouider	Tel Hadya	Terbol	Kfardan
23	6	1050	3712	6444	2489	1807
10	6	772	2912	6205	2575	759
51	2	1012	2970	6116	3179	2823
20	6	612	2521	6073	2315	659
42	2	613	2484	6007	3282	1793
14	6	878	3234	5890	4069	1340
22	6	920	2413	5771	3247	1296
17	6	891	3092	5736	3743	1343
8	6	743	2314	5691	3645	811
Checks						
Arabi Abiad	2	1249	2624	4084	4322	1995
Arabi Aswad	2	961	3188	3328	3357	1499
Arta	2	1130	2602	4966	2746	2219
Rihane-03	6	969	2207	6112	3459	930
Tadmor	2	1226	3132	3475	4601	1837
Zanbaka	2	1043	3332	3482	3835	1169
Mean		948	2767	4633	3473	1533
s.e.		24	56	91	87	59
N		89	89	89	89	89
Max		1520	3979	6444	5286	3233
Min		505	855	2857	1332	380

Entry	Name
23	Aths/Lignee 686/3/Deir Alla 106/Lignee 527//Assala
10	M-Att-73-337-1/3/Mari/Aths*2//Avt/Attiki
51	Harmal-02/ArabiAbiad*2/4/Soufara-02/3/RM1508/Por//WI2269
20	80-5145/Rihane-05
42	Soufara-02/3/RM1508/Por//WI2269/4/Roho/Arabi Abiad//6250/1161
14	Hyb 85-6//As46/Aths*2
22	Alanda-01
17	Hyb 85-6//As46/Aths*2
8	Arar/3/Mari/Aths*2//M-Att-73-337-1

Table 2.7. Grain yield (kg/ha) in five locations of the ten best lines in the Advanced Yield Trials in Breda.

Entry[a]	RT	Breda	Bouider	Tel Hadya	Terbol	Kfardan
67	2	1520	3282	3368	3121	1633
66	2	1509	2906	3279	4693	2772
85	2	1423	2981	4636	3736	1440
68	2	1417	3889	3803	3392	1696
65	2	1413	3504	3280	4773	2138
71	2	1301	2462	3041	4009	1729
77	2	1283	2563	4518	4733	1978
70	2	1270	3025	3137	4645	2107
88	2	1260	3529	4911	5286	2275
89	2	1251	2521	3121	3444	1588
Checks						
Arabi Abiad	2	1249	2624	4084	4322	1995
Arabi Aswad	2	961	3188	3328	3357	1499
Arta	2	1130	2602	4966	2746	2219
Rihane-03	6	969	2207	6112	3459	930
Tadmor	2	1226	3132	3475	4601	1837
Zanbaka	2	1043	3332	3482	3835	1169
Mean		948	2767	4633	3473	1533
s.e.		24	56	91	87	59
N		89	89	89	89	89
Max		1520	3979	6444	5286	3233
Min		505	855	2857	1332	380

[a]Entry	Name
67	SLB 28-03
66	SLB 27-99
85	Moroc 9-75/Arabi Aswad
68	SLB 28-14
65	SLB 26-91
71	SLB 28-53
77	SLB 39-01
70	SLB 28-48
88	Moroc 9-75/Arabi Aswad
89	*H.spont*.41-1/Tadmor

Kfardan 1997), and yield potential was estimated as the average grain yield of all the lines in the highest yielding year-location combinations (Tel Hadya 1995, Tel Hadya 1996, Tel Hadya 1997 and Terbol 1997). The entries with the highest yield under stress are shown in Table 2.8 together with the yield potential, the average grain yield across all locations, the plant height and kernel weight under stress and the lodging resistance.

The check with the highest yield under stress was Arta which yielded nearly half a tonne more than the best check for yield potential (Rihane-03). Arta was very short under stress but had very large kernels (see also under grain quality).

The ten lines with the highest yield under stress were either selections from landraces (entries 66, 65, 76, 69 and 77), or crosses with landraces (entries 50, 51, 81 and 88) with only one exception (entry 24) which was also the only six row entry.

The maximum yield advantage under stress was 21% and was associated with a 30% reduction in yield potential compared with Rihane-03. The two lines derived from crosses between modern germplasm and landraces (entries 50 and 51) had the best combination of YS and YP, with an advantage in YS of 14 and 10% (compared with Arta), and a reduction in YP of 16 and 6% (compared with Rihane-03).

Most of the lines in Table 2.8 are taller than Arta but are more lodging susceptible and have smaller kernels. The six row line is by far the worst being very short and with very small kernels.

Only two lines had a slightly higher (+3.5%) yield potential than Rihane-03 (Table 2.9); they were two sister lines with a yield under stress higher than Rihane and similar to the black-seeded landrace Arabi Aswad.

(S. Ceccarelli, S. Grando)

Table 2.8. Barley lines with the highest grain yield under stress (YS = mean yield in Breda 1995, 1996 and 1997 and Kfardan 1997) in kg/ha, their yield potential (YP = mean of Tel Hadya 1995, Tel Hadya 1996, Tel Hadya 1997 and Terbol 1997), their average grain yield (AVGY) across all locations and years, plant height (PH) and 1000 kernel weight (KW) in Breda (1997) and lodging (1=resistant, 5=susceptible) in Tel Hadya.

Entry[a]	RT	YS	YP	AVGY	PH	Lodging	KW
66	2	2084	3482	2797	45	8.3	37
50	2	1963	4118	3001	38	0.9	39
51	2	1891	4605	3217	37	0.9	36
65	2	1837	3566	2791	42	5.3	34
76	2	1812	3636	2824	38	8.7	39
81	2	1806	3968	3006	40	1.8	40
24	6	1765	4344	2987	25	1.2	28
69	2	1743	3626	2759	42	8.0	38
88	2	1736	4360	3102	44	0.9	41
77	2	1735	4387	3006	34	8.5	40
Checks							
Arabi Abiad	2	1668	4007	2814	31	7.6	37
Arabi Aswad	2	1378	3111	2349	42	8.2	33
Arta	2	1723	3802	2745	33	1.7	46
Rihane-03	6	1292	4851	2976	43	0.7	36
Zanbaka	2	1297	3097	2323	49	7.3	36
Tadmor	2	1442	2675	2178	43	8.9	35

[a]Entry	Name
66	SLB 27-99
50	INRA55-86-2/Rabat 1703//Harmal-02/Arabi Abiad*2
51	Harmal-02/Arabi Abiad*2/4/Soufara-02/3/RM1508/Por// WI2269
65	SLB 26-91
76	SLB 29-90
81	Tadmor//ER/Apm
24	Chaaran-01/3/Arizona 5908/Aths//Bgs/4/Ager//Api/CM67/3/Cel/WI2269//Ore
69	SLB 28-22
88	Moroc 9-75/Arabi Aswad
77	SLB 39-01

2.2.3. Cold Tolerance

The percentage of selected material sharply decreased this season in some testing sites due to very severe frosts. This determined a high selection pressure, that resulted in the identification of more tolerant lines and populations. In

Table 2.9. Barley lines with the highest grain yield potential (YP = mean yield in Tel Hadya 1995, 1996 and 1997, and Terbol 1997) in kg/ha, their yield under stress (YS = mean of Breda 1995, Breda 1996, Breda 1997, and Kfardan 1997), their average grain yield (AVGY) across all locations and years, plant height (PH) and 1000 kernel weight (KW) in Breda (1997) and lodging (1=resistant, 5=susceptible) in Tel Hadya.

Entry[a]	RT	YS	YP	AVGY	PH	Lodging	KW
14	6	1398	5022	3212	39	0.9	32
17	6	1392	5016	3191	39	0.9	35
Checks							
Arabi Abiad	2	1668	4007	2814	31	7.6	37
Arabi Aswad	2	1378	3111	2349	42	8.2	33
Arta	2	1723	3802	2745	33	1.7	46
Rihane-03	6	1292	4851	2976	43	0.7	36
Zanbaka	2	1297	3097	2323	49	7.3	36
Tadmor	2	1442	2675	2178	43	8.9	35

[a]Entry Name

14 Hyb 85-6//As46/Aths*2

17 Hyb 85-6//As46/Aths*2

Turkey, Iran and Lebanon the season was very favorable for precise evaluation of the germplasm tested for cold tolerance. In the Central Anatolian Plateau temperature dropped to -26°C without snow cover. Some lines from the advanced yield trials, observation nurseries and preliminary yield trials displayed better cold tolerance than national checks (Table 2.10).

The low temperature caused severe negative effect in the form of poor crop stand development, leaf and underground node damage, low tillering and seed set. In addition to the frost, the crop was affected by a long drought in combination with heat in Syria, Turkey and some locations in Iran. The high temperature at grain filling stage caused very shrunken endosperm development, low one thousand kernel weight and decreased grain quality parameters. Even on the North Caucasus, where between mid-May to mid-June, just after heading, air temperature raised to 35-37°C, the combined

Table 2.10. Percentage of barley lines in different classes of cold damage.

Nursery	Cold damage[a]				
	1	2	3	4	5
WFBYT (48 Entries)	20.8	14.6	12.5	30.5	19.6
WFBON (300 Entries)	17.6	13.0	20.0	31.2	17.9
PWFBYT (1045 Entries)	9.9	11.2	14.6	34.3	20.0
Rihane-03 score 4.5					
Tokak score 3.0					
Radical score 1.0					

[a]Cold damage, score:1-very low, 2-low, 3-middle, 4-high, 5-very high

effect of heat and drought caused considerable yield decrease in all cereals and especially in spring barley.

(V. Shevtsov)

2.2.4. Farmer Participation

The barley project started in 1997 two experiments on participatory plant breeding through two special projects. The first project "Increasing the Relevance of Breeding to Small Farmers: Farmer Participation and Local Knowledge in Breeding Barley for Specific Adaptation to Dry Areas of North Africa" is supported by IDRC, is conducted in Tunisia and Morocco, and will be reported in section 2.4 on North Africa. The second, "Farmer Participation and Use of Local Knowledge in Breeding Barley for Specific Adaptation", is supported by BMZ, started in 1996 and is conducted in Syria.

This project is a collaboration between the "Institut für Agrar- und Sozialökonomie in den Tropen und Subtropen", University of Hohenheim, Germany, the Agricultural Research Center, the Ministry of Agriculture and Agrarian Reform, Syria, the Germplasm Program and the Natural Resources Management Program at ICARDA.

The objectives of the project are (1) to produce improved barley varieties that fulfill the needs and objectives of poor farmers in marginal rainfed environments; (2) to enhance the rate of adoption of new varieties through farmers' participation in selection and testing, and (3) to develop a participatory approach to barley breeding for stress conditions.

The project has five components:

1. Orientation and Targeting
2. Indigenous Knowledge
3. Market Study
4. Participation of Farmers and Barley Breeders in Selection On-Farm and On-Station
5. Measurement of Farmers' Selection Criteria of Grain and Straw Qualities

and in this report we will refer the major achievements in components 3, 4 and 5.

2.2.4.1. Market Study

The price paid by farmers and dealers for grain is expected to vary with observable grain quality, as well as with location and date. Over 435 samples of barley seed collected from Aleppo, Hama and Hassakeh markets, were analyzed non-destructively for various characteristics: NIRS spectrum on whole grain, 400-kernel weight, contamination (dirt, other seeds, loose awns), damaged barley (empty hulls, broken or moldy barley), inadequate threshing (attached awns, their length and smoothness), and color (white, off-white, grey, and dark grey/black). Except for 400-kernel weight and color score, which were measured on all samples, the remaining characters were estimated on a subsample of 108 and used to develop NIRS calibrations.

The results of a first attempt of a hedonic price analysis done in 1996 confirmed the hypothesis that under general equilibrium conditions, price can be explained as a function of evident and cryptic quality traits. This implies the following conclusions:

1) The price of barley grain can be used as an indicator of consumers' preferences for the quality characteristics inherent in the corresponding sample.

b) The variables explaining price can be used as objectively measurable indicators of what is commonly called a "good quality".

3) The variables included in the final model represents objectively measurable indicators which could be relevant to breeders for selection. The coefficients of these variables describe the importance (relevance) for consumers preferences.

In the model developed in 1996, percentage of awns, protein content, crude ash, dry matter, thousand kernel weight and grinding resistance explained about 60% of the variability in the price of barley grain.

Table 2.11 shows the coefficients of determination as well as the expected signs for the coefficients of the explanatory variables obtained in 1997. The results are not consistent with the preliminary hedonic price model which had been formulated in 1996. Especially the lack of influence of kernel weight and crude protein (not shown in the Table) on market price of barley does not correspond to the initial hypotheses based on empirical observations as well as on economic theory.

The sample were re-analyzed and a new data set was generated which has been analyzed only for the Aleppo market. The final model explains 86% of the variability in price by the variables kernel weight, protein, dry matter, loose awns in the sample, white samples and season (Table 2.12).

All coefficients in the model have the expected sign and moreover the model corresponds to the result of previous hedonic price analysis conducted in 1996 with samples from

1995. The decrease in the coefficient of determination from .60 in the 1996 model to .50 in the present model, is probably due to the fact that the variable "grinding resistance" was not determined for the data used in the 1997 model.

Table 2.11. Results of multiple regression estimates between various traits and market price of barley grain. Only the signs of the coefficients and the level of significance of t-values are shown.

	Aleppo		Hama		Hassakeh	
Traits[a]	sign coef..	sig.	sign coef..	sig.	sign coef..	sig.
ADF	-	0.06	-	0.12		
ADFashf					-	0.09
AwnL	-	0.00			-	0.01
AwnRG			+	0.30		
AwnS						
SclW	-	0.02				
Sbrkn	-	0.09			-	0.03
Shull			-	0.06		
adj. R2		0.59		0.36		0.35
		17		21		25

[a] ADF = acid detergent fibre; ADFashf = acid detergent fibre ash free; AwnL = loose awns; AwnRG = awns' roughness; AwnS = seeds with attached awns; SclW = % of white seeds; Sbrkn = % of broken seeds; Shull = % of empty seeds.

Table 2.12. Results of formulated Hedonic Price Model.

DF	F-value	sig.F	R2	variables	coeff.	t-value	sign of t
32	29	0.0000	0.86	constant	19.20	3.5	0.0018
				dtmrkt	0.28	8.3	0.0000
				DAwnL	0.09	3.18	0.0039
				Dwhite	-0.13	-3.63	0.0013
				CP	0.03	3.1	0.0047
				KW	0.63	3.4	0.0023
				KW2	-0.02	-3.3	0.0027
				TS	-0.19	-2.9	0.0068

Especially interesting is the fact that kernel weight appears as a quadratic term in the model. This means that if kernel weight increases beyond an optimal level, the influence on price will be negative. This finding is consistent with empirical results. During the 1996 survey of market days in Aleppo it was often observed that samples with very high kernel weight yielded lower prices than samples with medium kernel weight. A reason for these findings is the negative correlation between kernel weight and protein, which is due to physiological mechanisms in cereal crops. The question is however why in the 1996 model the relationship between price and kernel weight was linear while it was quadratic in the actual model. A possible reason is that the average kernel weight of the barley samples for the 1997 model was about 10% higher compared to the barley samples which were collected for the 1996 model.

The results demonstrate that the hedonic price analysis can be used as a helpful tool for selection. This was especially shown by the fact that variables included in models of different cropping years were consistent, although rainfall conditions were considerably different. The parameter coefficients show the marginal willingness to pay for one more unit of the respective characteristic. As the model has been formulated based on prices reflecting market demand and based on barley samples reflecting supply, we can conclude that the coefficients are representative indicators of farmers' preferences as well as of the economic utility for each barley quality characteristic. Provided that the model turns out to be consistent for a larger number of samples, it establishes a valuable and easy-to-handle tool for variety selection for quality which is based on farmers' demand.

(S.Pecher, M. von Oppen)

2.2.4.2. Participatory Breeding

One cycle of decentralized participatory plant breeding was conducted in nine locations in Syria, with 208 barley entries (fixed lines and segregating populations) planted unreplicated in farmers fields, where it was entirely managed (except planting) by the host farmers, and in two research stations (Table 2.13).

The 208 entries were deliberately chosen to test hypothesis about the importance of different attributes and/or characteristics. In fact they could be classified based on four qualitative attributes in:

4) "modern germplasm" (100 entries) and "landraces" (108 entries)
5) "fixed lines" (108 entries) and "segregating populations" (100 entries)
6) "two rowed" (158 entries) and "six-rowed" (50 entries)
7) "white seed" (161 entries), "black seed" (28 entries), and "segregating for seed color" (19 entries).

The following types of selection were performed:

9) Individual selection by each participating (host) farmer on his own field **(decentralized-participatory selection)**: this was repeated a variable number of times during the season and on different traits, and was done without the presence of researchers. Each farmer did his final selection by visually inspecting the seed characteristics of those entries which received the best score during the last selection before harvesting;
10) Individual selection by each participating farmer in Breda and Tel Hadya **(centralized-participatory selection)**. This was done only once, in two consecutive

Table 2.13. Rainfall (recorded by farmers through rain-gauges), average grain yield (kg/ha), total biological yield (kg/ha), harvest index and plant height (cm) of 208 barley entries in nine farmers' fields and two research stations (Breda and Tel Hadya).

Location (code)		Rainfall	Grain Yield	Biol. Yield	Harvest Index	Plant Height[a]
Ibbin (01)	Mean	436.2	3248	8600	0.37	102.1
	s.e.		81	147	0.005	0.57
Ebla (02)	Mean	459.5	2857	8000	0.36	98.0
	s.e.		58	113	0.005	0.65
Tel Brak (03)	Mean	278.4	3685	7661	0.48	87.6
	s.e.		69	101	0.006	0.85
Jurn El-Aswad	Mean	284.0	1415	7259	0.20	45.1
(04)	s.e.		51	228	0.005	0.69
Baylonan (05)	Mean	192.9	280	2599	0.11	46.0
	s.e.		13	60	0.004	0.68
Al Bab (06)	Mean	350.0	376	1514	0.24	33.0
	s.e.		15	39	0.009	0.53
Melabya (07)	Mean	241.1	713	2733	0.26	-
	s.e.		29	103	0.005	-
Bari Sharki (08)	Mean	247.5	1017	4534	0.22	52.1
	s.e.		36	163	0.006	0.70
Sauran (09)	Mean	303.2	2515	7117	0.36	69.3
	s.e.		46	101	0.006	0.88
Breda (10)	Mean	233.2	811	2689	0.31	43.7
	s.e.		18	51	0.005	0.59
Tel Hadya (11)	Mean	433.7	4495	12336	0.36	95.6
	s.e.		63	110	0.003	0.72

[a] Melabya was not sampled

days, when the crop was at full heading in Tel Hadya and at dough stage in Breda. Each farmer was assisted by a researcher to record both quantitative and qualitative data;

11) Individual selection in each of the nine farmers' fields by the senior barley breeder of DASR (Directorate of Agricultural and Scientific Research) of the Ministry of

Agriculture and Agrarian Reform in Syria **(decentralized-non participatory selection)** as well as in Breda and Tel Hadya **(centralized-non-participatory selection)**. This was done in a period of about ten days when the crop was close to maturity and without knowing the selections made by the farmers. The final selection was based on visual inspection of seed characteristics of those entries which received the best score during the last visual selection before harvesting. Eventually he prepared a list of selected entries for each site as well as for the two research stations. This took into account not only the evaluation of a line at that site (or station) but also the performance of that line at all sites within the same rainfall area;

12) Group selection by neighbors farmers in five of the nine locations, namely Jurn El-Aswad, Baylonan, Al Bab, Bari Sharki and Sauran (as a different type of decentralized-participatory selection). In each of the five locations a group of eight farmers (nine in two locations) did a one-time visual selection with a score from 0 (discarded) to 4 (best) with the assistance of a researcher who helped in recording both quantitative and qualitative data. At the end of the selection process, each farmer was asked to identify the best 15 entries and to rank them from best to worse. Only one farmer refused to do so. The group selection was done when the crop was close to full maturity.

In their fields, farmers selected less entries than the breeder (about 1/10) while on station they selected, on average, half of the number of lines selected by the breeder.

For some broad attributes, such as modern germplasm versus landraces, selection was mostly environmentally driven, for others it was partly environmentally driven and partly due to individual preferences. In particular there were no preferences for fixed or segregating populations.

One of the hypothesis tested with this experiment on participatory plant breeding is that farmers' selection contributes more to maintain and/or enhance diversity than breeder's selection. The similarity of selection done in different environments by the breeder and by the individual farmers was evaluated with the similarity analysis based on the dice coefficient.

Fig. 2.2 shows the dendogram of the nine farmers and of the breeder based on cluster analysis of their selections in the nine farmers fields. There was a high degree of similarity among the selections done by the breeder in the various farmer fields, with dice coefficients always higher than 0.57, and a much lower degree of similarity among the selections done by the farmers in their fields, with dice coefficient always lower than 0.33. Also there was little similarity between the selections done by the breeder and the farmer in the same field. The large dissimilarity between the lines selected by the farmers in different locations should result in a higher diversity left in the breeding material after one cycle of selection done by the farmers than after one cycle of selection done by the breeder. These data show that decentralized breeding can give different results depending on whether is participatory or not.

Actual selection criteria (as opposed to declared selection criteria) were considered to be those traits for which the mean of the selected lines differed significantly from the mean of the population of 208 lines.

The traits which were actually selected for by at least four out of nine farmers were:

in farmers' fields	plant height (taller plants), kernel size (larger kernels), grain yield and total biological yield;
in Tel Hadya	lodging resistance, kernel size (larger kernels), grain yield and total biological yield;
in Breda	good growth vigor, tillering

	(higher), plant height (taller plants), kernel size (larger kernels) and grain yield.

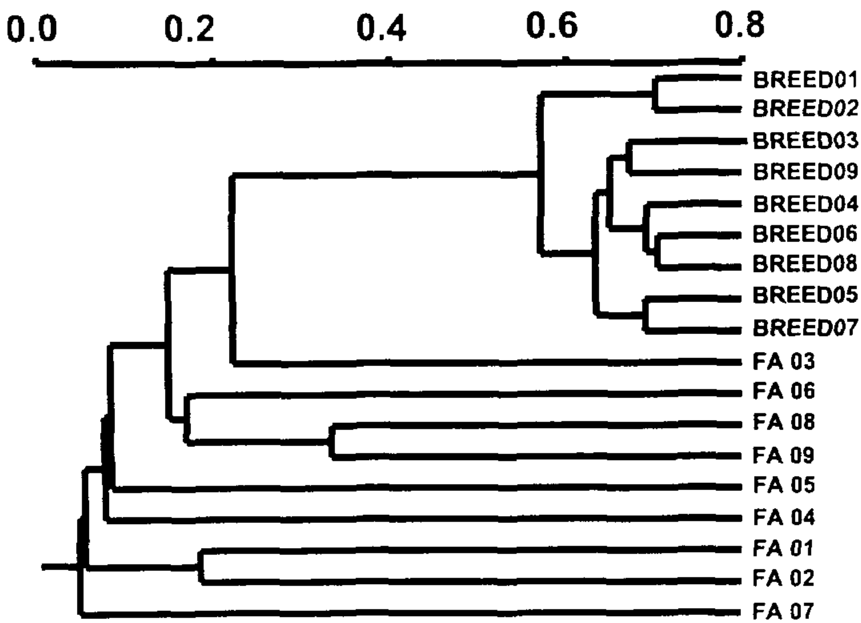

Fig. 2.2. Dendogram of the nine host farmers and of the breeder based on cluster analysis of their selections in farmers' fields (FA=farmer, BREED=breeder). Individual locations are indicated with the location code used in Table 2.13.

In the case of the breeder, the traits which were actually selected for were:

in farmers' fields	increased lodging susceptibility in Tel Hadya, spike length (longer spikes), plant height (taller plants), kernel size (larger kernels), grain yield and total biological yield;
in Tel Hadya	dark leaf color, lodging resistance, kernel size (larger kernels), grain

	yield and total biological yield;
in Breda	kernel size (larger kernels) and grain yield.

Both grain yield and total biological yield, were the selection criteria actually used most commonly by both the breeder and the farmer together with kernel size. The most remarkable result was that farmers were effective in identifying high yielding entries both in their fields (the lines selected in 6 out of the 9 locations had a significantly higher average grain yield than the population mean) and even more so in the experiment stations (the lines selected by all the nine farmers in Tel Hadya and by eight of the nine farmers in Breda had a significantly higher average grain yield than the population mean). The higher effectiveness on station could be explained by the higher precision of the trials, but one should also remember that modalities of selection were not the same. The breeder's selections were also significantly higher yielding than the population mean in 6 out of the 9 farmers fields and in the two experiment stations. The lines selected by the farmers and by the breeder in the 9 locations never differed significantly in grain yield (Table 2.14) with the exception of Al Bab, where farmers' selections yielded significantly more grain and more biomass than breeder's selections.

In the case of plant height (Table 2.15), the farmers' and breeder's selections were taller than the population mean in the locations where the crop was very short (Jurn El-Aswad, Al Bab and Bari Sharki); breeder's selection were also taller in Baylonan. The farmer also selected significantly taller entries in Ebla were one would expect than short and lodging resistant varieties would be more attractive.

These data confirm that plant height is actually used as selection criterion by both the farmer and the breeder particularly, but not exclusively in the driest locations, and could be considered as one of the trait for which decentralized selection is more important than participation.

Table 2.14. Grain yield (kg ha^{-1}) and total biological yield (kg/ha) of the lines selected by the farmers and by the breeder in each of the nine farmers' fields.

	Grain yield			Biological yield		
Location (code)	Farmer	Breeder	Δ[a]	Farmer	Breeder	Δ[a]
Ibbin (01)	4615***	3971***	n.s.	10687**	9686***	n.s
Ebla (02)	3498*	3199**	n.s.	8743	8233	n.s
Tel Brak (03)	4235	4020*	n.s.	8729*	8036	n.s
J. El-Aswad (04)	2049*	1724**	n.s.	10535**	8429*	n.s
Baylonan (05)	454*	324	n.s.	3198	2816	n.s
Al Bab (06)	649***	488***	***	2272***	1787***	***
Melabya (07)	915	920***	n.s.	4127**	3246*	n.s
Bari Sharki (08)	1366*	1129	n.s.	5276	4708	n.s
Sauran (09)	2561	2654	n.s.	6796	7257	n.s

* P<0.05; **P<0.01; ***P<0.001 relative to the comparisons with the population mean
[a] comparison between breeder's and farmers' selections based on t-test for samples of unequal size.

Table 2.15. Plant height (cm) of the lines selected by the farmers and by the breeder in each of the nine farmers' fields.

Location (code)	Population	Farmer	Breeder	Δ[a]
Ibbin (01)	102.1	105.3	102.1	n.s.
Ebla (02)	97.5	107.0**	96.5	***
Tel Brak (03)	87.6	85.2	86.0	n.s.
J. El-Aswad (04)	45.1	56.6***	48.3*	*
Baylonan (05)	46.0	47.5	49.9**	n.s.
Al Bab (06)	33.0	43.3***	36.4***	**
Bari Sharki (08)	52.1	62.4***	55.2*	**
Sauran (09)	69.3	67.4	68.8	n.s.

* P<0.05; **P<0.01; ***P<0.001 relative to the comparisons with the population mean
[a] difference between breeder's and farmers' selections based on t-test for samples of unequal size.

Eventually the farmers' selections were significantly taller

Given that grain yield was used as selection criteria by both the breeder and the farmer, we addressed the question of whether, and how effectively, the breeder and the farmers than the breeder's selections in three of the driest locations were able to identify the highest yielding entries in each location. As a measure of effectiveness we considered the frequency with which the top yielding 20 entries (approximately 10% of the total) were included among the farmers' and the breeder's selections in each farmers' field and in the two research stations.

With the exception of the farmer from Sauran, all the other farmers were remarkably successful in identifying the highest yielding lines in their fields (Table 2.16). The breeder was able to identify a higher number of high yielding lines by selecting a total number of entries which was much higher than the farmer, hence the lower percentage as compared with farmers.

Table 2.16. Frequency[a] of the top yielding 20 lines in each of the 9 farmers' fields among the selections made by the breeder and the farmers in farmers' fields and research stations.

	Selection done by:					
Location	Farmer in his field	Breeder in farmer field	Farmer in Tel Hadya	Farmer in Breda	Breeder in Tel Hadya	Breeder in Breda
01	36.4	20.6	17.6	3.1	15.7	10.5
02	18.2	17.2	11.5	14.3	17.1	9.0
03	30.8	18.9	1.6	9.3	7.1	10.5
04	33.3	22.5	4.6	39.1	11.4	19.4
05	33.3	14.6	0.0	13.0	12.9	9.0
06	81.8	18.3	9.3	18.2	7.1	14.9
07	30.0	15.2	10.2	7.0	8.6	9.0
08	35.7	16.5	7.4	10.7	8.6	10.5
09	0.0	11.4	19.4	20.0	12.9	7.5

[a] calculated on the number of selected entries.

In general, direct selection (selection in the farmer fields) was more efficient then indirect selection (selection in Tel Hadya or Breda for grain yield measured in farmers fields) both in the case of the breeder and of the farmers. However, the difference between the efficiency of direct and indirect selection was in general smaller when comparing Tel Hadya with some of the high yielding sites (such as 01, 02 and 09), and Breda with some of the low yielding sites (such as 04, 05, 06, 07 and 08).

In Tel Hadya and Breda the frequency with which the 20 highest yielding entries were included among the breeder's selections was 14.3% and 16.4%, respectively (Table 2.17). In the case of farmers' selections in Tel Hadya, only in one case the frequency was higher than the breeder, while in the case of farmers' selections in Breda, where the differences between entries were much more obvious at the time the selection was made, in seven out of nine cases the frequency was higher than the breeder.

Table 2.17. Frequency of the top yielding 20 lines in the two research stations among the selections made by the breeder and the farmers in the research stations.

	Selection done by[a]:									
Location	01	02	03	04	05	06	07	08	09	Breeder
Tel Hadya	5.9	11.5	8.2	13.6	8.3	11.3	13.6	14.8	9.7	14.3
Breda	21.9	38.1	20.9	21.7	13.0	20.5	21.1	32.1	15.0	16.4

[a] farmers are indicated with the location code.

In the five locations where we conducted group selection there were various levels of ability in identifying the top yielding lines (Table 2.18).

The frequency with which the 20 highest yielding entries were included among the farmers' selections tended to be higher in the four lowest yielding locations (04, 05, 06 and 08) than in Sauran, which was the highest yielding among the five locations where group selection was conducted. The host

Table 2.18. Frequency of the top yielding 20 lines among the selections made by the farmers during group selection in five farmers' fields.

	Selection done in:				
Farmer	04	05	06	08	09
1 (Host)	24.1	20.0	19.8	14.3	12.5
2	26.2	12.4	38.5	20.0	7.9
3	15.8	15.5	22.4	22.2	17.3
4	15.5	15.5	50.0	12.9	5.0
5	20.0	24.2	40.0	22.5	11.0
6	24.6	15.6	27.1	18.4	15.6
7	19.4	16.7	36.4	20.0	10.3
8	13.5	17.5	50.0	30.8	6.3
9	-	-	-	21.4	-

farmer in Sauran, who in the final selection did not include any of the 20 top yielding entries (Table 2.18), during the group selection, included 12.5% of them in his visual selection done at the time of the group selection. The data of Tables 2.17 and 2.18 seem to indicate that, in general, farmers' ability to identify the highest yielding lines is higher in stressful environments than in relatively favorable environments. It would have been useful to verify this hypothesis by conducting group selection in other favorable environments such as Ibbin and Ebla.

(S. Ceccarelli, S. Grando, R. Tutwiler, J. Baha, A. M. Martini, H. Salahieh, A. Goodchild, M. Michael, A. Shikho, M. Al Issa, A. Al Saleh, G. Kaleonjy, S. M. Al Ghanem, A. L. Al Hasan, H. Dalla, S. Basha, T. Basha)

2.2.5. Biotechnology

2.2.5.1. QTL Analysis in the Barley Cross Tadmor/WI2291

A genetic linkage map in barley was developed using the cross

Tadmor x WI2291 in collaboration between the University of Munich and molecular markers for the two diseases powdery mildew and scald have been identified. The conversion of these markers into easy-to-use PCR markers will allow marker-assisted selection for these two traits in the barley program.

Table 2.19 shows the result of the linkage map with molecular markers. Of 91 loci scored in the population, 70 have been assigned to linkage groups with more than two markers. It was possible to establish linkage maps for all chromosomes, even if there was more then one linkage group for all chromosomes except chromosome 7H. Where there is an up and down arrow near the name of the linkage group, the orientation of the linkage group is not sufficiently clear. The whole map has an extension of 1173.6 cM with an average marker distance of 16 cM. QTL detection.

The data of the QTL detection are shown in table 2.20, table 2.21 and table 2.22. Table 2.20 shows the trait observed, the units for the respective traits, the environments where the traits were scored and a summarising of the number of QTLs found for the respective traits. The name of the different environments is composed of two letters for the locations (TH = Tel Hadya, Br = Breda) and a figure for the year. In these columns, a black square shows that the trait has been observed in the respective environment. As can be seen from this table QTLs have been found for 19 of the 40 traits observed.

Table 2.21 shows the results related to individual QTLs. In table 2.21 the first three columns show the name of the QTL, the linkage group, where the QTL is localised and the position of the QTL in the linkage group as is shown in table 1. The next two columns indicate the support interval for the respective QTLs, which is the interval where the LOD curve declines for one unit from the suspected position of the QTL. The following columns record the LOD value at the suspected

Table 2.19. Distances to next marker ('dist.') and cumulative map positions ('pos.') in Haldane-cM. ↑↓ = unknown orientation of the map, marker in () parenthesis are excluded from QTL-analysis.

Chrom.1H			**chrom.4Ha**			**chrom. 6Ha**		
Marker	dist.	pos.	marker	dist.	pos.	marker	dist.	pos.
MWG-2197	3.1	0.0	WG622a	12.3	0.0	MWG-951	35.5	0.0
MWG-920a	6.8	3.1	MWG-77	8.0	12.3	Op-O9b	13.7	35.5
MWG-837		9.9	HV-M40a	0.0	20.3	Op-O9c	15.5	49.2
MWG-912			(HV-M40b)	10.0	20.3	Op-O9d	33.2	64.8
chrom 1Hb	↑↓		MWG-2033		30.3			
Marker	dist.	Pos.				**chrom. 6Hb**		
Seed-color	29.6	0.0	**chrom. 4Hb**	↑↓		marker	dist.	Pos.
MWG-912		29.6	marker	dist.	pos.	MWG-880	31.3	0.0
chrom. 2Ha			HVM3a	2.7	0.0	MWG-934	41.2	31.3
	dist.	Pos	HVM3c	20.2	2.7	MWG-897	5.6	72.5
MWG-682	9.6	0.0	MWG-58		22.9	(MWG-514)	0.2	78.1
MWG-878	28.2	9.6				MWG-2053	2.6	78.3
MWG-858		37.8	**chrom. 4Hc**	↑↓		MWG-10		80.9
			marker	Dist.	Pos.			
chrom. 2Hb			Op-R3b	9.5	0.0			
Marker	Dist.	Pos.	HV-M68	36.5	9.5			
Op-S5b	24.5	0.0	Op-10a	31.6	46.0	**chrom. 7H**		
MWG-503	9.9	24.5	OP-O9a	11.1	77.6	marker	dist.	Pos.
Op-U7	28.2	34.4	Op-N20		88.7	MWG-2080	30.4	0.0
MWG-82	8.6	62.6				MWG-832	6.9	30.4
MWG-46	6.7	71.2	**chrom. 4Hd**	↑↓		MWG-18	5.1	37.3
MWG-649c	13.3	77.9	marker	Dist.	Pos.	MWG-836	6.4	42.4
MWG-920b	7.2	91.2	Op-V6	24.5	0.0	MWG-539		48.8
MWG-532	5.2	98.4	MWG-2247	8.0	24.5			
MWG-920c	33.0	103.6	Op-T17		32.5			
MWG-950	8.6	136.6						
MWG-949		145.2	**chrom. 5Ha**	↑↓				
			marker	dist.	Pos.			
chrom. 3Ha	↑↓		Op-M14a	15.8	0.0			
Marker	Dist.	Pos.	MWG-54	6.7	15.8			
Op-S9	31.8	0.0	MWG-522		22.5			
MWG-584		31.8						
			chrom. 5Hb					
chrom. 3Hb	↑↓		marker	Dist.	pos.			
Marker	Dist.	Pos.	HVDHN7	2.7	0.0			
Op-R17	5.5	0.0	HVDHN9	8.6	2.7			
Op-O18	41.0	5.5	Op-A1	9.8	11.3			
MWG-975	29.0	46.5	MWG-533	27.9	21.1			
Op-G6b	8.7	75.5	MWG-569	11.0	49.0			
Op-S5c	2.9	84.2	MWG-850	38.4	60.0			
Op-S5a	17.3	87.1	WG-622	32.6	98.4			
Op-M14c		104.4	MWG-571		131.0			

QTL position the part of the variance explained by the QTL and finally the additive effect of the QTL, which indicates the change in the trait expression by exchanging a Tadmor allele for a WI2991 allele.

Finally, table 2.22 exhibits the results from linear models (multiple linear regression) built from the QTLs found and the QTL ´ QTL interrelations if significant in a stepwise regression. The phenotypic and genotypic variation explained by the model is shown in the first row. Genotypic variation was calculated only in cases, where data from more than one environment were present. In the first columns the name of the factors (QTL or QTL ´ QTL interrelations), the regression coefficient in the multiple linear regression, which is comparable to the effect of the single QTLs in table 2.20, and the squared partial regression coefficient of the factors are indicated. The effect of the single QTL calculated as the regression coefficient can vary from the effect calculated from the regression e.g. because of QTL ´ QTL interrelations. In the case of the partial regression the influence of the other factor is excluded from the effect of the single QTL. So this could be seen as the "true" effect of the QTL. This could also be said about the partial regression coefficient compared to the coefficient of determination of single QTLs. Finally, a further column in this table shows the significance of QTL ´ environment interrelations, which indicates the effect of the environment on the presence of the QTL.

Some striking features should be mentioned. The QTL with the highest effect was found for Rhynchosporium in both experiments, i.e. in the field trials as well as in the disease nursery. The amount of phenotypic variation explained by the QTL (50.5% as squared partial correlation coefficient in the field trials and 40% in the disease nursery) shows, that a real major QTL for this trait had been found. For powdery mildew, a major QTL has also been found on chromosome 1H, explaining 18.0 to 22.6% of the phenotypic variation in

Table 2.20. Overview over traits examined.

Trait	Units	TH94	TH95	TH96	Br96	TH97	Br97	QTLs
a) agronomic traits								
Ground coverage	Scaling points (1-9)	■	■	■	□	□	□	1
Growth habit	Scaling points (1-9)	■	■	■	□	■	□	1
Growth vigor	Scaling points (1-9)	□	■	■	■	■	□	3
Days to heading	Days	■	■	■	□	■	■	1
Plant height	Cm	■	■	■	■	■	■	1
Tiller number	no. per m	□	□	■	■	■	■	0
Thousand kernel weight	G	□	□	■	■	□	□	0
Protein content kernel	%	□	□	■	■	□	□	1
Grain yield	Kg/ha	□	□	■	■	■	■	3
Cold damage	Scaling points (0-4)	□	□	■	□	■	□	2
Lodging, 1.scaling	Scaling points (1-9)	□	□	■	■	□	□	1
Lodging, 2. Scaling	Scaling points (1-9)	□	□	■	■	□	□	0
b) disease resistances								
Powdery mildew (1)	Percent	□	■	□	□	□	□	1
Powdery mildew (2)	Percent	□	■	□	□	□	□	2
Rynchosporium field	Scaling points	□	■	□	□	□	□	1
Rynchosp. Dis. Nursery	Scaling points	□	■	□	□	□	□	2

c) physiological traits								
Leaf colour (estimated)	Scaling points	□	■	□	□	□	□	2
Leaf dry weight	g/cm^2	□	■	□	□	■	□	0
Leaf area	Cm^2	□	■	■	■	■	□	0
Dry weight per area	g/cm^2	□	■	□	□	□	□	0
N per dry weight	Percent	□	■	□	□	□	□	0
SPAD	Relative	□	■	■	■	□	□	0
SPAD per dry weight	Relative	□	■	□	□	□	□	0
C13/C14 rel. to limestone	Relative	□	■	■	■	□	□	1
C13-discrimination	Relative	□	■	□	□	□	□	0
Percent carbon	%	□		■	■	□	□	0
N per area	g/cm^2	□	■	□	□	□	□	0
d) straw characteristics								3
Awn roughness	Scaling points (1-5)	□	■	□	□	□	□	
Tem proportion	Percent	□	■	■	■	■	□	0
Leaf blade proportion	Percent	□	■	■	■	□	□	0
Leaf sheath proportion	Percent	□	■	■	■	□	□	0
Mass of bottom internodes	g/30 stems	□	□	■	■	□	□	1
Mass of middle internodes	g/30 stems	□	□	■	■	□	□	0
Mass of top internodes	g/30 stems	□	□	■	■	□	□	2
Ratio top/bottom internodes	-	□	□	■	■	□	□	1

Table 2.21. Results of the CIM - Analysis (individual QTLs).

QTL	Chrom.	pos.	support Interval	LOD	r^2	effect
		- ground coverage -				
GC-1	2Hb	144	140 - 144	5.92	15.3 %	- 0.367
		- growth habit -				
GH-1	5Hb	24	12 - 40	3.41	6.4 %	- 0.175
		- growth vigour -				
GV-1	2Hb	144	138 - 144	3.75	9.9 %	- 0.139
GV-2	3Hb	22	0 - 40	3.58	6.7 %	- 0.161
GV-3	5Hb	0	0 - 4	3.80	7.3 %	+ 0.110
		- plant height -				
PH-1	3Hb	72	54 - 83	3.71	7.0 %	- 1.077
		- days to heading -				
DH-1	5Ha	2	0 - 12	4.80	9.3 %	- o.678
- protein content kernel -						
PC-1	7H	0	0 - 12	3.14	6.1 %	- 0.140
		- grain yield -				
GY-1	5Ha	14	10 - 16	4.32	8.5 %	- 46.91
GY-2	5Hb	0	0 - 2	7.39	13.7 %	- 60.44
GY-3	5Hb	130	118 - 130	3.96	7.6 %	+ 44.73
		- cold damage -				
CD-1	5Ha	22	18 - 22	10.15	19.2 %	+ 0.365
CD-2	5Hb	0	0 - 4	4.67	8.9 %	+ 0.236

chrom. = chromosome, pos. = putative QTL position, support intervall = interval with a LOD fall off
of 1.0 from the maximum, r^2 = coefficient of determination of the phynotypic variance, effect
=
estimated additive effect = estimated additive effect of one allel of Tadmor (units as *described in table 2.19)*

Table 2.21. (continued): Results of the CIM-Analysis (individual QTLs).

QTL	Chrom	pos.	support interval	LOD	r^2	Effect
- lodging (1) -						
L1-1	4Hd	10	0 - 22	3.62	6.9%	- 0.238
- powdery mildew (1) -						
P1-1	1Ha	4	2 - 8	13.03	22.8%	-12.85
- powdery mildew (2) -						
P2-1	1Ha	6	0 - 8	9.81	17.6%	- 5.811
P2-2	3Hb	4	0 - 26	3.46	6.5%	+ 3.064
- rhynchosporium (field)						
RF-1	4Hc	78	76 - 80	34.1	50.5%	- 1.147
- rhynchosporium (lab) -						
RL-1	4Hc	78	76 - 80	25.21	39.6%	- 0.706
RL-2	4Hd	30	24 - 32	3.08	6.5%	+ 0.221
- mass of bottom internodes -						
IB-1	4Hc	88	84 - 88	4.17	12.9%	- 0.083
- mass of top internodes -						
IT-1	1Hb	4	0 - 18	3.12	11.8%	+ 0.120
IT-2	4Hc	88	82 - 88	8.56	23.8%	- 0.16
- top/bottom internodes -						
IR-1	4Hc	86	8- - 88	6.42	19.0%	- 0.051
- leaf colour (est.) -						
LE-1	3Hb	78	60 - 82	5.35	9.6%	+ 0.270
LE-2	4Hd	18	10 - 26	6.39	11.6%	+ 0.331
- C13/C14 -						
CR-1	2Hb	144	138 - 144	5.18	13.5%	- 0.131
- awn roughness -						
AR-1	1Hb	20	10 - 28	4.87	11.5 %	- 0.476
AR-2	5Hb	0	0 - 2	19.81	33.7 %	+ 0.775
AR-3	7H	42	36 - 44	3.95	7.7 %	+ 0.302

chrom. = chromosome, pos. = putative QTL position, support intervall = interval with a LOD fall off
of 1.0 from the maximum, r^2 = *coefficient of determination* of the phynotypic variance, effect = estimated
additive effect = estimated additive effect of one allel of Tadmor (units as described in table 2.19

Table 2.22. Results of the CIM-Analysis (multiple regression including most significant effects).

Groun cov.	r^2 phenot. = 4.3 %		
Factor	regr. coeff.	partial r^2	factor x env.
Gc-1	- 0.239	4.3 %	**
Growth vigour	r^2 phenot. = 4.0 % r^2 genet. = 9.7 %		
Factor	regr. coeff.	partial r^2	factor x env.
GV-1	- 0.115	4.0 %	**
tiller number		r^2 =4.4%	
Factor	regr. coeff.	partial r^2	factor x env.
TN-1	- 3.925	4.4 %	*
lodging (1)		r^2 =4.3%	
Factor	regr. coeff.	partial r^2	factor x env.
TN-1	- 0.192	4.3 %	**
p. mildew (1)	r^2 phenot. = 22.6 % r^2 genet. = 28.3 %		
Factor	regr. coeff.	partial r^2	factor x env.
P1-1	- 13.25	22.6 %	-
p. mildew (2)	r^2 phenot. = 19.7 %		
Factor	regr. coeff.	partial r^2	
P2-1	-6.322	18.0 %	
P2-2	+2.667	4.3%	
rhynchosp. fld.	r^2 phenot. = 50.5 %		
Factor	regr. coeff.	partial r^2	
RF-1	-1.165	50.5 %	
rhynchosp. dn .	r^2 phenot. = 43.8 %		
Factor	regr. coeff.	partial r^2	
Rdn-1	-0.702	40.2%	
Rdn-2	+0.170	3.4%	
Rdn-1 x Rdn-2	-0.077	0.7%	

r^2 phenot. = phenotypical variance explained by the model
r^2 genet. = genetical variance explained by the model
regr. coeff. = regression coefficient as estimated additive effect of one allele of Tadmor (for units see table 1)
part. r^2 = squared partial correlation coefficient
factor x env. = significance of the factor x environment-effects (** = < 0.001, *= < 0.01, + = <0.05)

the multiple regression. On linkage group 5Hb, QTLs with large effect were found for awn roughness grain yield (13.6% partial r^2) and for cold damage (16.5% partial r^2) on the same mapping position. A further QTL with strong influence on cold damage was found on linkage group 5Ha (19.2% partial r^2). A QTL strongly influencing the mass of internodes and the relation of top/bottom internodes was detected on 4Hc with 20.1% partial r^2 for "mass of top internodes" and 24.5% partial r^2 for "top/bottom internodes". Significant QTL ´ QTL effects could only be detected in the case of Rhynchosporium as revealed in the lab.

(M. Baum, A. Sabbagh, S. Grando, S. Ceccarelli, V. Mohler, G. Backes, A. Jahoor)

2.2.5.2 Analysis of Genetic Diversity in Barley Using Microsatellite Markers

A core set of mapped barley microsatellite markers (170) have been generated through collaboration with scientists from Scottish Crop Research Institute (SCRI).

Twenty-four mapped microsatellites are being used to study the extent and distribution of genetic diversity in 125 barley landraces from Syria and Jordan (5 lines from 5 collection sites from 5 regions ranging from Southern Jordan to North-East Syria). Preliminary results indicate high levels of diversity both within each collection site and significant differentiation between each site (Fig 2.3). Furthermore, the total number of alleles (n=26) revealed in these landraces is greater than in European cultivated and landrace material (n=10).

(W. Powell, M. Baum, S. Grando, S. Ceccarelli)

2.2.6. Stress Physiology

2.2.6.1. Carbon Discrimination

For C3 plants, discrimination against 13C (Δ) is an integrated indicator of the ratio of intercellular to atmospheric partial pressure of CO_2 (pi/pa) and therefore of the water use efficiency (WUE). Changes in pi/pa, and thus in Δ, can arise from changes in the balance between leaf stomatal conductance and photosynthetic capacity. Any decrease in

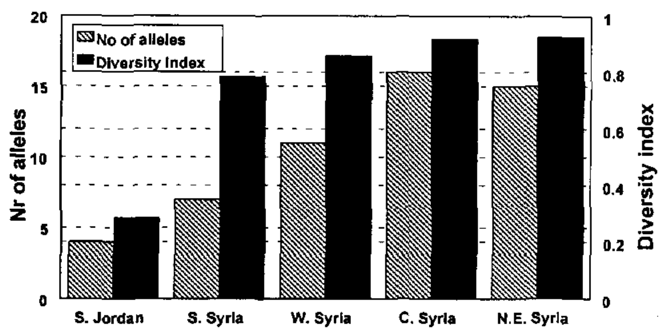

Fig. 2.3. Number of alleles and diversity index for 5 regions evaluated with a single microsatellite (ac213).

stomatal conductance will in turn decrease pi/pa and Δ therefore increasing WUE. However, yield can be negatively affected by increasing the stomatal limitation on photosynthesis rates. Alternatively, if the intrinsic photosynthetic capacity of leaves is increased, pi/pa and Δ could decrease and WUE could be improved, without compromising potential yield.

We examined the relationship between Δ and different leaf structural indicators of photosynthetic capacity in a set of F_6-lines of two-row barley derived through Single Seed Descent from the cross between Tadmor and WI 2291, with contrasting leaf chlorophyll content, grown under rainfed conditions with 313 mm rainfall. Total chlorophyll content (SPAD) was measured in penultimate leaves with a portable meter in the field. Further, the specific leaf dry weight (SLDW) and the nitrogen content and carbon isotope discrimination (Δ) was measured in the same leaves.

The SLDW was positively correlated with both nitrogen (SLNW) and chlorophyll (SPAD) content per unit leaf area, which in turn were negatively correlated with Δ of leaf dry matter (Δ-DW). The Δ of the water soluble fraction (Δ-SF) from the same leaves was further analyzed to provide information on the discrimination of the current photo assimilates, therefore ignoring the photo assimilates coming from other parts of the plant during leaf development. Correlation between Δ-SF and either SLDW or SLNW was consistently higher than correlations with Δ-DW. The leaf parameter best correlated with Δ, of either total dry matter of the soluble fraction, was SLDW, indicating that genotypes with thicker and/or more compact leaves have lower Δ. The results[3] suggest that SLDW and SPAD measurements can be used as a single, rapid surrogate for Δ in barley.

(J. Araus, S. Ceccarelli, S. Grando)

2.2.6.2 Osmotic Adjustment

The objective of this project is to determine the genetic variation in drought resistance mechanisms, namely osmotic adjustment capacity and root morphology, in barley. The work has been conducted in controlled greenhouse conditions at

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3 Araus, J.L., Bort, J. Ceccarelli, and S.Grando, S., 1997. Relationship between leaf structure and carbon isotope discrimination in field grown barley. Plant Physiology and Biochemistry 35: (7), 533-541.

Texas Tech University in Lubbock, Texas since September 1997. Germplasm materials are provided by the barley breeders at ICARDA. Our aim is to identify parental lines and populations for the genetic mapping of drought resistance traits in barley and develop marker-assisted selection strategy for improving productivity and stress adaptation under semi-arid and arid environments.

Initial results obtained with *H. spontaneum* (line 41-1), Tadmor and Arta indicate that *H. spontaneum* consistently has high osmotic adjustment (8-9 bars), Arta is intermediate (4 bars), and Tadmor has low (2 bars) osmotic adjustment. The mapping population *H. spontaneum* 41-1/Arta, already developed to find markers useful for the introgression of genes from *H. spontaneum* to *H. vulgare* should be useful also to map osmotic adjustment.

(H. Nguyen, S. Grando, S. Ceccarelli)

2.2.7. Virology

2.2.7.1. Evaluation of Best Barley Genotypes from Previous Seasons

One of the most serious virus problems in barley world-wide is Barley Yellow Dwarf Virus (BYDV). Re-evaluation of 52 barley lines from previous seasons identified some entries which are good yielders and highly tolerant to BYDV as their yield was not affected by virus infection, e.g. entries 2BIT-96-307 and 2BIT-96-385 (Table 2.23) and 1BIT-96-40 and HBON-96-53 (Table 2.24).

Table 2.23. Best spring barley lines after re-evaluation of their reaction to BYDV infection after artificial inoculation with the virus, on the basis of symptoms disease index (D.I.), grain yield and yield loss (%).

Entry	D.I. (0-9)	Gr. wt. (g/m)	Yield loss (%)
1BIT-96-30	4	132	20
2BIT-96-206	4	160	15
2BIT-96-296	4	177	4
2BIT-96-307	3	282	3
2BIT-96-313	3	140	11
2BIT-96-385	3	300	20
BKL-85-237	5	114	12
Corris	5	162	10
Atlas-68	5	152	26
Abee	7	122	27

Table 2.24. Best winter barley lines after re-evaluation of their reaction to BYDV infection after artificial inoculation with the virus, on the basis of symptoms disease index (D.I.), grain yield and yield loss (%).

Entry	D.I. (0-9)	Gr. wt. (g/m)	Yield loss (%)
IFBON-96-40	3	192	1
IFBON-96-111	4	223	23
IWBON-96-116	4	171	7
IWBON-96-118	5	143	14
IWBON-96-123	4	205	0
HBON-96-64	4	172	12
HBON-96-53	4	254	2
Sutter	3	158	19
Wysor	3	206	0

2.2.7.2. Evaluation of Barley Nurseries for their Reaction to BYDV Infection

Evaluation of 1378 lines of barley nurseries in 30 cm rows, on the basis of symptoms produced indicated that 121 lines (8.8%) were tolerant to infection (Table 2.25). The best performing lines will be evaluated next season on the basis of yield loss due to infection in addition to symptoms severity.

When 76 spring barley and 35 winter barley which were tested in the previous season in 30 cm rows, were evaluated for their reaction to BYDV in 1 m rows during the 1996/97 growing season, some lines showed high tolerance to BYDV infection. Results of the best performing lines are presented in Tables 2.26 and 2.27, respectively.

(K.M. Makkouk, W. Ghulam)

Table 2.25. Evaluation of barley germplasm for tolerance to BYDV infection after artificial inoculation with the virus.

Nursery	Number of lines tested	Lines with tolerance to infection
Spring barley		
1 BIT-1997	440	5, 13, 18, 53, 74, 126, 185, 206, 303, 321, 371, 375, 381, 390, 396, 397, 398, 405, 407, 410, 420, 423, 425, 428, 429
2 BIT- 1997	440	1, 12, 91, 92, 103, 129, 145, 154, 176, 179, 180, 210, 221, 222, 225, 256, 267, 284, 309, 326, 336, 347, 359, 360, 361, 371, 379, 388, 389, 393, 397, 399, 400, 413, 422
BAT-1997	100	12, 27, 34, 71, 80, 86, 100
Winter barley		
IFBON- 1997	150	7, 15, 19, 20, 26, 27, 29, 30, 31, 33, 68, 82, 86, 97, 109, 112, 115, 119, 122, 124, 139
IWBON- 1997	150	11, 16, 19, 37, 39, 44, 54, 66, 94, 96, 97, 113, 114, 122, 142
HBON- 1997	50	1, 3, 13, 26, 45
IFBYT- 1997	24	2, 8, 17
IWBYT- 1997	24	1, 2, 6, 9, 12, 13, 15, 17, 18, 20

Table 2.26. Performance of selected spring barley lines planted in 1 m rows showing tolerance to infection after re-evaluation, during the 1996-97 growing season.

Entry	D.I. (0-9)	Gr.wt. (g/m)
1BIT-96-18	3	154
1BIT-96-30	5	105
1BIT-96-34	5	104
1BIT-96-35	5	112
1BIT-96-45	5	170
1BIT-96-49	5	246
1BIT-96-55	5	197
1BIT-96-80	4	150
1BIT-96-153	5	140
2BIT-96-96	5	171
2BIT-96-120	5	119
2BIT-96-135	5	121
2BIT-96-190	4	145
2BIT-96-195	5	131
2BIT-96-203	3	199
2BIT-96-206	5	161
2BIT-96-267	5	141
2BIT-96-282	5	190
2BIT-96-284	5	111
2BIT-96-285	5	132
2BIT-96-289	5	215
2BIT-96-291	5	122
2BIT-96-295	5	210
2BIT-96-296	5	191
2BIT-96-307	4	286
2BIT-96-313	5	207
2BIT-96-315	5	191
2BIT-96-316	5	239
2BIT-96-334	5	200
2BIT-96-340	5	156
2BIT-96-361	5	121
2BIT-96-385	4	232
2BIT-96-393	5	209
2BIT-96-419	5	134
2BIT-96-374 (Susc.)	6	33

Table 2.27. Performance of selected winter barley lines provided by barley breeders at ICARDA and planted in 1 m rows showing tolerance to infection after re-evaluation.

Entry	D.I. (0-9)	Gr.wt. (g/m)
IFBYT-96-7	5	203
IWBYT-96-5	4	125
IWBON-96-88	2	122
IWBON-96-116	4	161
IWBON-96-118	5	155
IWBON-96-120	4	188
IWBON-96-123	3	174
HBON-96-68	5	43
IFBON-96-40	4	154
IFBON-96-111	5	137
WBCB-96-85	3	199
WBCB-96-37(Susc. Check)	7	14

2.2.8. Grain and Straw Quality

Grain quality

Barley germplasm under yield testing is also evaluated for grain quality characteristics, mainly thousand kernel weight, protein content and, starting from this year, β-glucan content.

Grain protein content is an important parameter both for feed and food barley. Recently barley has been reported to lower the cholesterol level in the blood if consumed regularly. This has been attributed to its high content of β-glucan, and therefore the grain content of β-glucan is an important character for food barley.

The content of β-glucan in different types of barley varies between 2 and 9%. Barley with higher β-glucan level can be used in special diet for particular cases and considered as healthy food, while barley with a lower β-glucan content is desirable for malting.

In recent years chemical methods have been developed to estimate β-glucan content, but there is no generally accepted, quick and simple screening procedure which can be used in a breeding program. ICARDA developed several calibrations to predict β-glucan content using an advanced near-infrared analyzer "NIRSystems 5000".

In the Barley Advanced Yield Trials, 1000 kernel weight ranged from 27 to 45 g at Tel Hadya and from 24 to 46 g in Breda. The largest seeded check was Arta in both locations (46 g in Breda and 44 in Tel Hadya). Eight lines, all two-row, had 1000 kernel weight equal or higher than 40 g in Tel Hadya and Breda. Five six-row lines had 1000 kernel weight higher than 40 g in Tel Hadya, but their values dropped in Breda.

The protein content ranged from 7.5 to 13.0 % and from 6.8 to 11.0 %, the β-glucans content from 2.7 to 5.5 % and from 3.4 to 5.5 %, at Tel Hadya and Breda respectively.

The lines with the best quality characteristics are shown in Table 2.28.

(F. El-Haramein, S. Grando, S. Ceccarelli)

Straw quality

One of the methods farmers use to estimate the feeding value of barley straw is tactile; they feel the texture of straws between their fingers. To quantify farmers' knowledge, we have been using an SMS Texture Analyser[14] (TA) to develop objective measurements of texture. The TA, which electronically records characters of straws, was used to quantify shearing and bending resistance of the straw of the 208 barley entries used in the Farmer Participation Experiment in Syria.

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4 Stable Microsystems Ltd, Godalming, Surrey, U.K., Model TX-TA2 (5 kg).

Table 2.28. Grain quality characteristics of barley lines in the advanced yield trials, compared to three checks. Values are average of Tel Hadya and Breda.

Entry[a]	Row type	1000 KW (g)	Protein (%)	β-glucans (%)
79	2	43.7	11.1	4.9
35	2	43.4	11.3	4.4
31	2	42.3	11.8	4.4
47	2	41.2	10.9	4.5
39	2	41.3	10.4	4.2
52	2	40.3	10.6	4.2
60	2	42.5	10.5	5.2
88	2	42.1	9.2	5.0
Checks				
A.Abiad	2	36.8	10.0	4.3
A.Aswad	2	31.5	10.4	4.0
Arta	2	45.1	10.2	4.5

[a]Entry	Name
79	OP/Zy//Gem/3/Harma-01
35	SLB 03-18//Roho/Arabi Abiad
31	Roho/Arabi Abiad//JLB 06-36
47	Pld10342//Cr.115/Pro/3/Bahtim/4/Ds/Apro/5/......
39	INRA55-86-2/Rabat 1703//Harmal
52	SLB 05-96/Harmal
60	Aths/Lignee 686/3/CI 08887/CI 05761//Harmal-02
88	Moroc 9-75/Arabi Aswad

From bundles of whole plants sampled before grain harvest, ten plants were taken at random. The heads of these plants were removed, kernel number and spike length measured, then a bend test was performed. The bend test was simplified, so that ten of the lowest whole internodes (LWI) or ten peduncles (PED) could be tested simultaneously. To bend internodes supported at points 50 mm apart by a distance of 4 mm would have caused irreversible weakening; instead, they were bent by only 1 mm, and were bent three times to ensure that measurements were consistent. Since the peduncles or LWI were not absolutely straight and therefore the *finger* could not contact all of them simultaneously, measurement of *inelasticity* was made from the point when the finger had descended 0.6 mm from its first contact, and was continued until the lowest point of travel of the finger, usually 1.0 mm.

Shearing tests were performed on LWI only, on ten separate internodes (five LWI in each of two runs). The stem diameter was measured as the distance between the start of the curve (actually, where the force encountered was 1 Newton) and 8 mm, divided by 1.5 to allow for the 60° shape of the V-notch. The shearing energy was the area (force x distance) under the curve.

The shape of different shear test graphs (Fig. 2.4) suggests that some internodes are brittle, absorbing energy as a series of fracture peaks, and that others are malleable, not absorbing energy until the tissues of the internode were fully compressed by the V-shaped notch. A simple way to distinguish between these two types of graph was use a Texture Expert macro to count the number of force peaks in the graph that were taller than 1 N, a measurement called *brittleness*.

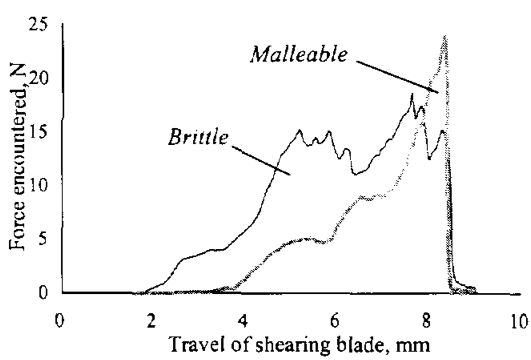

Fig. 2.4. Genotypes with brittle and malleable shearing curves are distinguishable by the number of force peaks. (Ibbin site).

In general, genotypic coefficients of variation (CV) of traits were larger in the wetter sites than in the drier sites (Table 2.29). In wet sites, genotype CVs ranged from 0.28 for shearing energy down to 0.08 for diameter; in dry sites, they ranged from 0.18 to nil. CVs between sites were up to four times greater than CVs between genotypes; classification of sites into "wet" and "dry" reduced the between-site CV for diameter and shearing energy, but not for inelasticity or brittleness.

Table 2.29. Sources of variation of mechanical characteristics in 208 barley genotypes grown in village fields in eight locations.

Test	Mean	$SD_{genotype}$‡	Sd_{site}	SD_{error}
Inelasticity of lowest whole internode, N/mm bend	**1.06**	**0.20*** **	**0.80*** **	**0.783**
Within four drier sites	1.07	0.092ns	1.09***	0.991
Within three wetter sites	1.04	0.108†	0.34***	0.451
Inelasticity of peduncle, N/mm bend	**0.51**	**0.11*** **	**0.41*** **	**0.403**
Within four drier sites	0.49	0.00 ns	0.52***	0.504
within three wetter sites	0.53	0.12***	0.32***	0.227
Diameter of LWI, mm	**2.54**	**0.19*** **	**0.32*** **	**0.203**
within four drier sites	2.27	0.14***	0.16***	0.184
within four wetter sites	2.81	0.24***	0.11***	0.213
Shearing energy of LWI, mJ	**48.5**	**11.6*** **	**16.6*** **	**20.32**
within four drier sites	41.1	7.22***	4.98***	18.61
within four wetter sites	56.2	15.9***	11.5***	19.42
Brittleness of LWI, number of peaks§	**2.04**	**0.21*** **	**0.36*** **	**0.493**
Within four drier sites	1.85	0.10†	0.33***	0.461
Within four wetter sites	2.24	0.30***	0.28***	0.511
Shearing energy / LWI diameter², mJ/mm²	**15.6**	**1.23** **	**5.05*** **	**5.84**
within four drier sites	16.6	1.56†	7.28***	7.42
within four wetter sites	14.4	1.15***	1.97***	3.38

†, *, **, ***, denote statistical significance at *P*<0.1, 0.05, 0.01, 0.001, estimated using sas proc glm.
‡SD denotes the square root of variance components estimated using sas proc varcomp.
§Brittleness is indicated by the number of force peaks taller than 1 Newton.

Some relationships between LWI shear energy or peduncle bending force and LWI diameter are shown in one dry site (Al Bab) and one wet site (Ibbin) (Fig. 2.5). Shear energy tended to increase with the square of stem (LWI) diameter. In the study of Arta and *H. spontaneum* reported elsewhere, shear energy was highly correlated with the ratio of stem mass to length, itself proportional to the square of diameter.

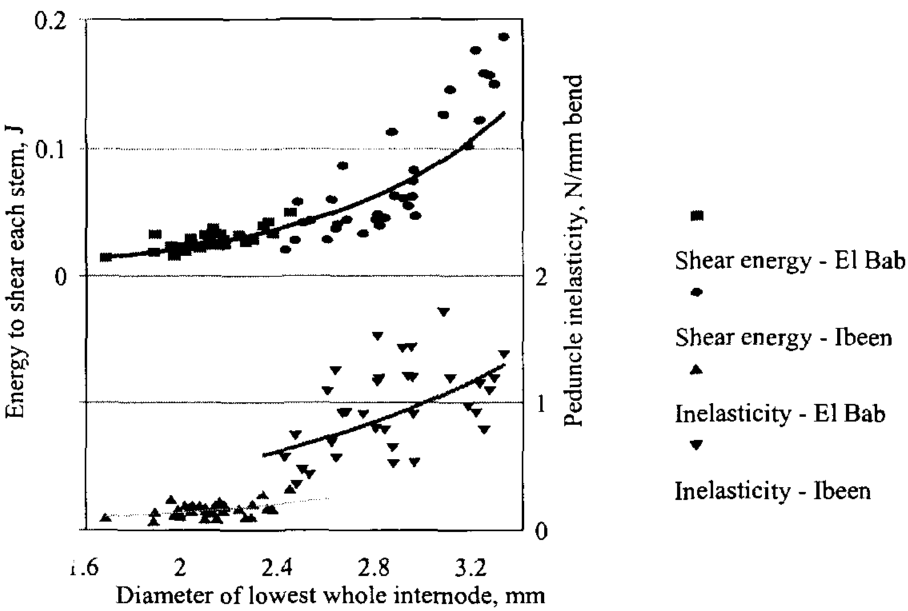

Fig. 2.5. Relationship between shear energy, or inelasticity, and stem diameter at two contrasting sites.

(A. Goodchild, F. El-Haramein)

2.3. The Near East and West Asia

The germplasm development for the Near East is largely a product of the headquarters activities. Therefore in this section we will mainly report progress in breeding for continental areas with very cold winters, as well as specific collaborative activities with the National Programs of the countries of the Near East. Many of these activities are also part of the Mashreq and Maghreb project, and more details can be found in the reports of that project.

2.3.1 Decentralized Screening for Cold and Drought

Two sets of nurseries, with winter and facultative types, including four checks and 20 best lines for testing, were evaluated in many locations of the Highland Region. In this section we will report the results of six sites from Syria, Lebanon and Turkey as the more typical for the season. Each of these locations represents various agroecological environments, which differed greatly in soil-climate conditions. But the main commonality of the season was a very high importance of cold and drought tolerance in determining yield. In general, facultative lines performed better than winter types, because in addition to cold tolerance, good growth vigor and earliness are needed for successful agronomic performance. The best three lines from the facultative barley yield trials were CWB 117-77-9-7/3/Roho//Alger/Ceres, 362-1-1, Tipper/ICB-102 854, Roho//Alger/Ceres,362-1-1/3/Tipper, which ranked first, second and third in average yield across 6 locations in three countries, out-yielded significantly the checks (Table 2.30).

The fact that checks turned out to be at the end of the list, showed once more the importance of germplasm improvement for cold and drought resistance.

The program has developed several very cold tolerant lines. However, these lines have not performed very successfully, because their strong vernal genes determined the late maturity and very poor growth parameters, that resulted in yield decreased under heat and drought during grain filling stage. A two-rowed line 85M1 is worth

Table 2.30. Performance of top yielding facultative barley lines in six locations of three countries.

Entries	Lebanon	Turkey	Syria	Mean kg/ha	Mean rank
CWB 117-77-9-7/3/Roho/ /Alger/Ceres,362-1-1	2306	1207	2304	1939	1
Tipper/ICB 102854	2237	1035	2347	1873	2
Roho//Alger/Ceres, 362-1-1	2343	520	2642	1873	3
Checks					
Rihane-03	1531	0	1807	1112	24
Tokak	2243	702	1751	1565	14
National check	1456	942	2065	1487	20
L.S.D.	260	114	220		

mentioning because of its very good agronomic characteristics and successful combination of cold tolerance with disease resistance and productivity. On average, it considerably out-yielded the checks at Kazan and Altinova in Turkey. This mutant line can be used as a complex of very valuable traits in barley breeding for high and stable productivity.

(V. Shevtsov)

2.3.2. Syria

One specific type of collaboration with the Syrian National Program is represented by the jointly conducted On Farm Verification Trials (OFVT). This is a very important collaboration because from the results of these trials recommendations are made to release varieties in Syria.

The OFVT with barley are conducted in several locations of 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.

Promising lines to be tested in the OFVT are nominated by ICARDA, DASR (Directorate for Agricultural and Scientific Research) and ACSAD (Arab Center for Studies of the Arid Zones and Dry Lands) Damascus, Syria 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 1996/97 (Table 2.31) included nine promising lines and five checks. They were conducted in 10 locations with mean yields ranging from 515 kg/ha in Sijwa to 3743 kg/ha in Horan.

Table 2.31. Performance of lines in the on farm verification trials in zone B in Syria (the data are means of 10 locations).

Lines	Grain Yield		Rank	
	Mean	Range	Mean	Range
Mo.B1337//WI2291/Emir..	2227	635-3796	4	4-9
A.Abiad/WI2291//Tadmor	1910	354-4017	10	3-14
Alanda	2513	812-4427	1	1-4
Zanbaka/3/ER/Apm//.....	2089	458-3312	10	4-10
Roho//Alger/Ceres......	2285	468-4009	2	1-12
SLB44-56/Lignee 131	2162	500-3701	5	2-11
ACSAD 1028	1723	312-3783	13	3-14
ACSAD 410	1657	375-3552	14	7-14
Furat 4482	2245	572-4239	3	1-8
Checks				
A. Abiad	2091	562-3810	7	4-13
Furat 1	1812	250-3498	12	1-14
Furat 2	1864	291-3985	11	5-14
A. Aswad	2067	687-3010	9	1-14
Arta	2124	698-4046	6	2-11

Arta had the highest mean yield across locations, as well as the best rank, among the checks; while two of the newly promoted lines from ICARDA ranked first and second, with yield advantages over Arta of 18 and 8%, respectively. Alanda is a six-row high yielding cultivar with a high yield stability as indicated by the consistency of the rankings across locations.

The OVFT for zone C (Table 2.32) included eleven promising lines and two checks (the two local landraces since no new varieties have been officially released for the dry areas of Syria). They were conducted in 9 locations with mean yields ranging from 653 kg/ha in Shwileh to 2615 kg/ha in Majarja. Six location means were below 1 t/ha, while two were about 2.5 t/ha.

Table 2.32. Performance of lines in the on farm verification trials in zone C in Syria (the data are means of 9 locations).

Lines	Grain Yield		Rank	
	Mean	Range	Mean	Range
Harmal/Kv/Mazurka/3/A.Aswad	1247	299-2761	10	4-12
PI386540/A.Abiad//SLB 60-97	1439	644-2496	1	1-12
H.spont 41-1/Tadmor	1375	660-2937	5	1-13
WI 2197/CI13520//SLB 39-60	1258	671-2468	8	4-10
ACSAD 410	1143	542-2531	13	5-13
ACSAD 1028	1222	367-3000	11	3-13
Furat 4506	1416	406-3394	3	1-13
Furat 3082	2245	492-3015	2	2-10
Furat 5312	1209	324-2687	12	2-13
Furat 5319	1257	355-2773	9	2-10
Furat 5169	1319	464-2917	7	2-13
Checks				
A. Abiad	1339	542-2816	6	2-12
A. Aswad	1392	636-2707	4	1-11

Three of the four new ICARDA lines in the trial performed well, particularly in the very dry locations. This is not always reflected in the mean which is affected more by the performance in the highest yielding locations.

In the trials in zone C the stability of performance was much lower than in those conducted in zone B, an indication than even in the dry areas of Syria some levels of specific adaptation are needed.

Arta, the variety released as A. Abiad Mohasan, was tested for the second year in farmers fields by the Directorate for Agricultural and Scientific Research (DASR). Table 2.33 summarizes the results of the comparison between Arta and the local (A. Abiad or A. Aswad, depending on the location) in six provinces. Overall, Arta has a yield advantage of 18% (or nearly 300 kg/ha) over the local landrace. There is only a modest yield gain (and sometimes a yield loss) in the three provinces with the highest average yields (Aleppo, Idlib, and Hama), while the advantage of Arta over the local is higher and consistent (in the two years) in the provinces of Hassake, Raqqa (the two provinces with the largest barley growing area) and Homs. In these three provinces the yield advantage of Arta is about 36% or nearly 400 kg/ha.

Table 2.33. Grain yield (kg/ha) of Arta and of the local landrace (A. Abiad or A. Aswad, depending on the location) in six provinces in Syria.

Year	Province	Fields	Local	Arta	Increase (%)
1996	Hassakeh	17	964	1416	0.32
	Raqqa	18	1763	2009	0.12
	Aleppo	17	2311	2564	0.10
	Idleb	4	3041	2794	-0.09
	Hama	6	2160	2466	0.12
	Homs	7	1310	1879	0.30
1997	Hassakeh	13	598	1151	0.48
	Raqqa	26	956	1362	0.30
	Aleppo	16	1746	1724	-0.01
	Idleb	7	3353	3265	-0.03
	Hama	1	1450	1560	0.07
	Homs	7	1233	1417	0.13
Means			**1553**	**1836**	**0.18**

(S. Ceccarelli, S. Grando, M. Michel)

2.3.3. Jordan

During 1997 we increased considerably our collaboration with Jordan both through the University of Jordan (UOJ) in Amman and the National Center for Agricultural Research and Technology Transfer (NCARTT). We tested an adaptation nursery with 84 entries in five locations (Mowaggar, Khanasri, Ramtha, Rabba and Ghweer) and an adaptation trial with 10 lines in three locations (Mowaggar, Khanasri and Ghweer). The performance of the lines was affected by an exceptionally late frost which occurred during the first week of April. The best lines (based on agronomic score) were Moroc 9-75//H.Spont.41-1/Tadmor, Sara, Arta and Sara-01 in this order. This trial will be repeated during 1998 with the addition of the best lines selected from the adaptation nursery.

In the adaptation nursery, planted as two rows plots, reliable data were obtained from four locations (at Mowaggar the germination and establishment were too poor). Grain yields varied from 60 g/plot in Ramtha to 155 g/plot in Rabba The 10 entries with the largest average grain yield (in standardized units) are shown in Table 2.34.

This year the results suggest that Jordan could be considered with the same region as Syria and northern Iraq since the best adapted materials are very similar. While we continue the evaluation of this breeding material during 1998, we will start exploring the possibility of sharing with Jordanian scientists the same segregating populations which are generated for Syria and north Iraq and to initiate a program of decentralized selection.

(O. Kafaween, Y. Shakatreeh, S. Ceccarelli, S. Grando)

Table 2.34. Ten barley lines with the highest average grain yield (as standardized units) in four locations in Jordan. Data are g/plot.

	Locations			
Entry[a]	Rabba	Khanasri	Gweer	Ramtha
6	537	82	321	173
61	350	108	212	216
4	365	118	207	199
84	366	146	222	149
8	323	116	213	177
63	325	118	233	154
22	418	144	225	98
24	362	58	257	162
17	309	116	180	171
47	357	130	164	145
Location mean	155	69	115	60

[a]Entry Names

6 = WI 2291/Tadmor
61= Salmas/Arabi Aswad
4 = WI 2291/Tadmor
84= Arta
8 = WI2291/Tadmor
63= Arta/3/Chi Cm/An57//Albert
22= SLB 45-95/3/ChiCm/An57//Albert
24= Tadmor/SLB 39-10
17= WI 2291/Tadmor
47= Harmal//Kv/Mazurka/3/Arabi Aswad/WI2269

2.3.4 Lebanon

Two new varieties, Assy (Mari/Aths*2) and Er/Apm (already released in a number of North African countries with the name of Faiz), both adapted to the northern Beka'a valley, were released in 1997.

Until recently Lebanon has provided additional testing sites to test the germplasm developed at the headquarters, and facilities for the summer nurseries. In 1995 we have started developing specific germplasm for Lebanon by gradually replacing the International Nurseries with segregating populations. In 1995 we sent 1562 F_3 bulks which were visually selected both at Kfardan and Terbol by the ICARDA staff at Terbol station. In 1996 we supplied a new set of 1248 F_3 bulks, which were again visually selected in Terbol and Kfardan, while 181 selections from the 1562 F_3 bulks sent in 1995 were evaluated for the second year both in Terbol and Kfardan. Eventually in 1997, the first cycle was concluded with a yield trial of the best 27 lines resulting from two cycles of selection, a nursery of 293 selections from the 1248 F_3 bulks supplied in 1996, and a new set of 556 F_3 bulks.

The results of the yield trials (Table 2.35) indicated that the best check, both in Terbol and Kfardan was Arta. The differences among the checks were small in Terbol, but considerable higher in Kfardan. The yield advantage of the best three selections (16, 9 and 4) in Terbol was between 23 and 39% over Arta and 37 to 55% over Rihane-03, which is one of the barley varieties most popular in Lebanon. The yield advantage were even higher in Kfardan (43 to 55% over Arta). It may be noticed that selection nr. 4 (Clipper/Arabi Abiad//Tipper) out-yielded the best check both in Terbol (by 23%) and in Kfardan (by 43%).

(N. Rubeiz, S. Ceccarelli, S. Grando)

2.3.5 Turkey

In Turkey, where the main constraints in order of importance are frost, drought, boron toxicity and diseases (scald), the newly released varieties, Orsa and Yesevi 93, showed an excellent yield performance in station and on-farm verification trials. The average yield of winter barley varieties was: Tokak - 2.9 t/ha, Tarm 92 - 3.3 t/ha, Bulbul 89 - 3.5 t/ha, Yesevi 93 - 3.6 t/ha, Orsa - 4.9 t/ha.

Table 2.35. New barleys specifically selected for Lebanon compared with the three checks Arta, Rihane-03 and Litani in two locations.

	Terbol		Kfardan	
Entry[a]	Yield	Rank	Yield	Rank
13	2998	6	1744	1
24	2911	10	1656	2
16	3735	1	1478	5
9	3401	2	1256	11
4	3306	3	1633	3
8	3134	4	1589	4
17	3003	5	989	21
Arta	2682	15	1144	15
Litani	2537	17	667	26
Rihane-03	2413	20	622	27

[a]Entry Names

24	Deir Alla 106//DL71/Strain 205/3/Aths/Lignee 686
13	Harmal-02/Arabi Abiad//ER/Apm/3/WI2269/Espe
16	Viringa'S'//Harmal-02/Arabi Abiad*2
9	Soufara-02/3/RM1508/Por//WI2269/4/Harmal-02/Arabi Abiad//ER/Apm
4	Clipper/Arabi Abiad//Tipper
8	Soufara-02/3/RM1508/Por//WI2269/4/WI2197/Mazurka
17	Bonita/Weeah/5/WI2198/Emir/4/7028/2759/3/69-82//Ds/Apro

The multiplication of the new promising winter and facultative lines identified during this cropping season, is in progress for the wide scale evaluation all over the country in the nearest future.

(V. Shevtsov, S. Ceccarelli)

2.3.6 Iraq

In Iraq the decentralized selection among and within segregating populations produced at ICARDA is entirely conducted by Iraqi barley breeders.

In 1995 we began supplying Iraq with two types of segregating populations. The first is based on six-row types for the warm and irrigated environments of the Baghdad area where barley is used mainly as forage crop and as dual purpose. The second is based on two-row types predominantly with black seed for the Gezira area (northern Iraq).

Usually the data on the performance of the nurseries are not returned, and the segregating populations are fully and autonomously exploited within the country. We do receive however the seed of promising lines and of released varieties to be included in the crossing program. As of today the crossing program for the Baghdad type of environment is entirely based on promising lines and on released varieties (such as IPA 9, IPA 77 and IPA 265) from Iraq.

In 1997 a joint study on the impact of Rihane-03, recently released in Iraq, was undertaken with IPA Agricultural Research Center. The average annual rainfed barley area in Iraq is 440,000 hectares, with a yield of 600 kg/ha. Before 1994, virtually all rainfed barley was unimproved landraces. In the 1994/95 season, some 5,000 ha were planted with Rihane 03, as seed increase for the following year. Two years later (in 1997), Rihane 03 was being grown on almost 200,000 hectares by more than 4,000 farmers in moderate (350-450 mm) and low (200-350 mm) rainfall zones. A survey of 495 farmers revealed that Rihane-03 out-yielded the landrace by 67% in moderate rainfall areas and by 28% in low rainfall areas. When all costs are included, the average net revenue per hectare increased by 79%, for a total increase in farmers' incomes of about USD 4 million or USD 1,000 per farm, at international exchange rates.

Tadmor and Arta have been also performing well (Table 2.36) and large amount of seed (20 tonnes and 12 tonnes, respectively) have been produced for distribution to farmers in the next cropping season and further seed multiplication.

Table 2.36. Grain yield (kg/ha) of Arta, Tadmor and Rihane-03 in five locations of Al-Jazeera[a] in Iraq.

Location	Arta	Tadmor	Rihane-03	Local
Blaige	2160	2400	1200	2040
Shuwarate	264	332	188	284
Mukhazaka	440	400	120	240
Ain Jahash	205	449	175	327
Tel Abta	240	280	240	280

[a] most of the area has been officially declared as drought affected.

(E. Al-Shamma, B. Al-Rawi, A. Adary, S. Ceccarelli, S. Grando)

2.3.7 Iran

Several nurseries have been evaluated and selected at various locations in Iran (Table 2.37) and the results show that there is be a flow of new promising germplasm that will become available for different environments in Iran.

Table 2.37. Number of entries selected from different ICARDA nurseries in different locations in Iran.

Nursery	Nr of entries	Qamloo	Sararood	Maragheh	Zanjan
IWFBCB	95	25	n.p.	all	9
IWFBON	150	37	55	102	5
IWFBSP	150	34	n.p.	n.p.	n.p.
F_3 WBSP	138	n.p.	n.p.	105	n.p.
F_4 WBSP	126	n.p.	n.p.	88	n.p.
F_5 WBSP	44	n.p.	n.p.	26	n.p.
HBON	50	2	17	n.p.	n.p.
IWFBYT	24	4	n.p.	8	6
IFBYT	24	n.p.	4	n.p.	n.p.
IFBON	46	n.p.	12	n.p.	n.p.
PBYT	286	n.p.	n.p.	127	n.p.
IWFBPYT	625	n.p.	n.p.	265	n.p.

n.p. not planted

In the future there will be an increase in the number of locations where early segregating populations are tested as bulks.

Two spring (Ganub and Izeh) and one winter barley variety (Sahand) were released during the year and a new promising line, ChiCm/An57//Albert, is considered for release.

(M. Tahir, S. Ceccarelli)

2.3.8 Pakistan

Special nurseries for Pakistan have been used in parallel with the traditional international nurseries since 1989, although not in a systematic and continuous manner. These early efforts to produce germplasm with specific adaptation, particularly to the province of Baluchistan, were useful to recognize the adaptation of the white-seeded Syrian landrace, Arabi Abiad, to the conditions of Baluchistan. Arabi Abiad was eventually released in 1997 as Sanober-96.

Specific germplasm has been also developed for the favorable environments of Pakistan. Table 2.38 show some of the highest yielding lines evaluated at Peshawar in an unreplicated nursery grown in 1997.

The nursery included the variety Frontier 87 (released in 1987 for high yielding environments) as systematic check (repeated ten times). In the table the yield of the individual lines are compared both with the mean of the ten plots of the check cultivar and with the highest yielding plot of the check. The results show that high yielding lines, both two-row, such as 101 and 37, and six-row are now available for the more favorable areas of Pakistan.

It will be now possible to provide more precisely targeted germplasm for the different agroclimatic environments of Pakistan.

(A. Majid, S. Ceccarelli)

Table 2.38. Highest yielding lines at Peshawar

Entry[a]	Grain yield (kg/ha)	% increase over the best check
101	6667	66.7
116	6667	66.7
29	6333	58.3
95	6333	58.3
126	5667	41.7
81	5000	25.0
37	5000	25.0
61	4667	16.7
82	4333	8.3
best check	4000	0.0
mean of checks	2852	

[a]Entry	Name
101	Gloria'S'/Cita'S'//Arrow/3/Teran 78
116	Ager/3/Robust//Gloria'S'/Copal'S'
29	Tichedrette
95	Robust//Gloria'S'/Copal'S'
126	80-5112/3/Robust//Gloria'S'/Copal'S'
81	Ase/3CM//Ro/3/Smal/4/CM67/Centeno//Cam/5/Gloria'S'/Come'S'
37	Senat/4/RM1508/Pro//WI2269/3/Soufara-02
61	Gustoe/6/M64-76/Bon//Jo/York/3/M5/Galt//As46/4/Hj34-80/Astrix/5/NK1272
82	Violeta

2.4. North Africa

2.4.1. Decentralized Barley Breeding Program

Barley breeding for North Africa (Maghreb), a region which includes five countries (Morocco, Algeria, Tunisia, Libya and Egypt) and nearly 4.5 million hectares of barley, is almost entirely conducted in a decentralized mode. The details have been given in previous Annual Reports.

During 1996/97 the following special nurseries for Maghreb were grown in a total of 22 locations in five countries (Table 2.39).

Table 2.39. Number of entries evaluated in special nurseries for Maghreb during 1996/97 (frequency of selected entries in parenthesis).

Country	No. of locations	Segregating Populations(*)	Nursery	Yield trials
Egypt	5	271	287 (18%)	88
Libya	3	271	287 (20%)	80
Tunisia	6	271	287 (26%)	54
Algeria	4	271	287 (33%)	54
Morocco	4	271	287 (26%)	112

* selections were only available from Tunisia, Egypt and Morocco, and therefore this nursery will be evaluated again in 1998 as NURMAG98

The season was very dry, particularly in Tunisia, Libya and Algeria, and it was not possible to harvest and/or select from all locations where the nurseries and the yield trials were planted.

2.4.1.1. New Varieties and Promising Lines

Four new barley varieties were released in Libya, namely Borjouj (CI 08887/CI 5761) Maknosa (Deir Alla 106/DL71//Strain 205) Ariel (WI 2291/WI 2296) and Irawen (ER/Apm). Borjouj and Maknosa are six-row while Ariel and Irawen are two-row.

Two new barley varieties were released by INRA, Morocco, with the names of Aguilal (which means beautiful stallion in Berber) and Safia.

In Morocco about 20% (or 500,000 hectares) of the 2.5 million hectares planted with barley annually, are occupied by improved varieties such as Tamellalt, Asni, Tissa, Arig 8, ACSAD 60, Aguilall and Annaceur.

The variety Annaceur (Rihane-03), released in 1991, has occupied for the last two years about 120,000 hectares and there is an increasing demand. The expectations are that in the next two years it will reach about 300,000 hectares, or 12% of the barley area in Morocco. However

Tunisia released Manel, derived from a single plant selection within an F_2 provided by ICARDA.

The barley line Mari/Aths*2//Arizona 5908/Aths, has been recommended for dissemination to farmers in rainfed areas of Egypt.

Out of 502 entries tested for leaf rust, 112 were classified as resistant. Fifteen entries of the 108 tested at seedling stage were resistant to powdery mildew, one was classified as resistant under field conditions.

Three barley genotypes were identified as resistant to leaf rust, net blotch, and powdery mildew. Fifty barley genotypes were screened for aphid resistance and four genotypes were classified as resistant (R.I.=1 and percentage of infested plants between 0 and 5%).

The severe drought in Algeria caused extensive crop failures. We report here only the result of a comparison between 18 barley varieties which were planted in the ITGC experiment station of Khroub (Table 2.40) and used to assess farmers' selection criteria.

The data confirm the ability of farmers to identify high yielding lines. Interestingly, two of the lines selected by farmers were two-row, suggesting that also the preference of north African farmers for six-row barleys admits some exceptions.

Table 2.41 shows the performance of some promising lines identified in Egypt during 1996/97, a very dry cropping season. Line 25 out-yielded both checks in both locations for grain yield. Lines 73, 70, 5, 34, and 19 were the top yielder in Sakha, while lines 24, 23, 26, and 78 performed better than the checks in Rafah. Some lines identified in Egypt

Table 2.40. Grain yield (kg/ha) of 18 barley cultivars grown in the experiment station at Khroub and farmers' preferences.

Cultivar	Origin	Grain yield	Farmer selection
IPA 265	Iraq	2400	
Numar (local)	Iraq	2600	Selected
ACSAD 1176	Jordan	2720	Selected
ACSAD 176	Jordan	2400	
ACSAD 1164	Jordan	2850	Selected
Rum	Jordan	2900	Selected
Deir Alla	Jordan	2460	
	Jordan		
Saida (check)	Algeria	2560	Selected
Furat 1	Syria	1440	
Furat 2	Syria	2410	
Furat 4484	Syria	2250	
Furat 5069	Syria	2400	
Arta	Syria	2730	Selected
Litani	Lebanon	2420	
Faiz	Lebanon	1920	
HDS	Lebanon	1820	
Local	Lebanon	2120	

in the framework of the OPEC project were distributed to Yemen. Three were selected for further testing.

In Tunisia four barley yield trials, each with twenty five entries, were evaluated at five sites in different agroclimatic zones. Krib, which receives more than 500 mm annual rainfall, is used to test for high yield under heavy disease pressure particularly leaf rust, powdery mildew, and net blotch. Le Kef, located in the moderate rainfall area, is characterized by irregular rainfall (total annual rainfall varies from 350 to 550 mm) and cold winters.

Major foliar diseases are scald and powdery mildew. Tejerouine is characterized by cold winters and a wide diurnal temperature range. Annual rainfall does not exceed 300 mm and crop failure occurs once every five years.

Table 2.41. Grain yield (kg/ha) in two locations and biological yield in one location of promising barley lines identified in Egypt in 1996/97.

	Sakha		Rafah
Line[a]	Straw yield	Grain yield	Grain yield
73	**4179**	**2063**	1102
70	**3619**	**2013**	1819
5	**2913**	**1996**	1506
34	**3825**	**1985**	1637
19	**3456**	**1970**	1878
25	**3730**	**1827**	**2471**
24	3425	1439	**2552**
23	3790	1570	**2429**
26	3360	1525	**2428**
78	2839	1640	**2427**
Checks			
Giza 125	3448	1663	1502
Giza 126	3844	1354	1673

[a] Entry Names

73 Lignee 527/NK1272/3/Arimar/Aths//Orge 905/Lignee 686
70 Hyb 85-6//As46/Aths*2
5 CN100/DC23//Fun*3/3/Tra/4/10925-1/5/BcoMr/As/6/Seed Source 72-Sal/7/Cita'S'/4/Apm/Rl//Manker/3/Maswi/Bon /5/Copal'S'
34 Man/4/Bal.16/Pro//Apm/DwII-1Y/3/Api/CM67/5/Arimar/Aths
19 M-A tt-73-337-1/3/Mari/Aths*2//M-Att-73-337-1
25 Avt/Attiki//M-Att-73-337-1/3/Aths/Lignee 686
24 Deir Alla 106/Cel/3/Bco.Mr/Mzq//Apm/5106/4/Deir Alla 106//7028/2759
23 Deir Alla 106/Cel/3/Bco.Mr/Mzq//Apm/5106/4/Deir Alla 106//7028/2759
26 Avt/Attiki//M-Att-73-337-1/3/Aths/Lignee 686
78 Rihane-03//Lignee 527/NK1272/4/Lignee 527/Chaaran-01/ 3/Arizona 5908/Aths//Lignee 640

Foussana, in central Tunisia, is characterized by low rainfall and high temperature during spring. In Mograne, annual rainfall varies between 300 and 500 mm, most of which occurs in winter and early spring. Temperature and relative humidity are high, net blotch, powdery mildew, and often leaf rust are very severe. Lines susceptible to net blotch cannot be grown at this site.

Each trial had 25 entries, including two checks (Rihane and Martin) and three replications, plot size was 15 m^2. Trials at Foussana and Tejerouine were conducted under low input conditions (no application of fertilizers and no weed control). Trials at Krib, Le Kef, and Mograne were conducted under optimum growing condition.

Table 2.42 shows the grain yield of the two checks, and number and average yield of entries out-yielding the checks. In low rainfall areas (Tejerouine, Foussana, and Mograne) a higher number of lines out-yielded the checks. At Foussana, 17 lines yielded more than Rihane in the Elite 3. In the intermediate trial (Orge 2) about 20 and 28% of the lines yielded more than Rihane and Martin, respectively.

In Morocco one yield trial of 112 entries, including 4 checks and two replications, was planted at Merchouch, Annaceur and Jemaa Shaim. Table 2.43 shows the best performing lines identified in the three locations. ER/Apm was the best improved check in Merchouch and Jemaa Shaim, Rihane-03 was the best check in Annaceur. Line 49 out-yielded the best improved check both in Merchouch and Annaceur. Line 60 ranked first in Jemaa Shaim and performed better than Rihane-03 in Annaceur. Interestingly, three of the five lines that out-yielded the best improved check (lines 49, 50, and 101), have Deir Alla 106//D171/Strain 205, a line which has been considered for release, as common parent.

(S. Grando, S. Ceccarelli)

Table 2.42. Number and average grain yield (kg/ha) of barley lines out-yielding Rihane (R) and/or Martin (M) in four trials grown at five locations.

Trial	Lines[a]	Locations: Kef	Krib	Tajerouine	Foussana	Mograne
Elite 1	Rihane				562	
	Martin				689	
	#>R	1757	3051	574	10	698
	#>M	1626	3159	533	(684)	1110
		2 (1778)[b]	7 (3429)	5 (674)	3	16 (990)
		4 (1738)	6 (3479)	6 (653)	(823)	5 (1206)
Elite 2	Rihane			532	397	
	Martin			700	440	
	#>R	1592	2232	13	12	814
	#>M	1556	3167	(746)	(505)	1191
		1 (1666)	15 (578)		10	5 (1315)
		1 (1666)	6 (916)		(499)	15 (1097)
Elite 3	Rihane			720	244	
	Martin			718	482	
	#>R	1454	2909	6	17	1091
	#>M	1421	3136	(865)	(462)	1777
		1 (1765)	13 (3363)	6	4	10 (1295)
		2 (1601)	10 (3473)	(965)	(530)	-
Orge 2	Rihane			708	708	669
	Martin			706	483	745
	#>R	1704	3222	6	-	1
	#>M	1285	3280	(773)		(889)
		-	6 (3288)	7	7	1
		9 (1418)	5 (3298)	(764)	(544)	(889)

[a] Rihane and Martin are an improved cultivar and a landrace, respectively; #>R and #>M are the number of lines out-yielding Rihane and Martin, respectively.

[b] Mean grain yield of selected lines.

Table 2.43. Grain yield (kg/ha) in three locations of promising barley lines identified in Morocco in 1996/97.

Line[a]	Grain yield		
	Merchouch	Annaceur	Jemaa
33	**3368**	1667	2667
65	**3299**	1353	1768
49	**3062**	**1896**	1500
74	1285	**2085**	2584
101	2376	**1958**	2716
50	2729	**1954**	2532
60	2466	**1788**	**3084**
55	1958	1269	**2917**
Checks			
ER/Apm	2938	1095	2900
Rihane-03	1376	1612	2667

[a] Entry Names

33 2762/Bc//11012-2/Tery/3/10L-2621-2Y/Bante 025/4/Mari/Aths*2//Avt/Attiki
65 Lignee 527/Chaaran-01//Lignee 640/Badia/4/Lignee 527//Bahtim/DL71/3/Api/CM67//Mzq
49 Deir Alla 106//DL71/Strain 205/3/Aths/Lignee 686
74 USask1766/Api//Cel/3/Weeah/7/Api/CM67//Harma-03/4/Cq/Cm//Apm/3/RM1508/5/Attiki/6/Mari/Aths*2
101 Deir Alla 106//DL71/Strain 205/3/F4 Bulk//Sutter*2/Numar
50 Deir Alla 106//DL71/Strain 205/3/Aths/Lignee 686
60 Lignee 527/Chaaran-01/6/80-5013/5/Cr.115/Pro//Bc/3/Api/CM67/4/Giza 120
55 Lignee 527//Bahtim/DL71/3/Api/CM67//Mzq/4/CI 08887/CI 05761//Lignee 640

2.4.1.2. Barley Stem Gall Midge (*Myeticola hordei* Keiffer) and Russian Wheat Aphid

***Barley Stem Gall Midge* (BSGM)**

Screening conducted at Settat, Morocco by Dr. S. Lhaloui on the barley germplasm developed for Maghreb led to the identification, for the first time of lines tolerant to BSGM and of one line possessing antibiosis (Table 2.44).

The 3270 entries were seeded in rows in wooden greenhouse flats, containing a mixture of soil and vermiculite, at a rate of 25 seeds per entry. The susceptible cultivars Tamelalt and Kanby were included as checks. When plants were at the one- or two-leaf stage, the plants were covered with a cheesecloth tent and infested. About 200 females of BSGM were confined in each flat and allowed to oviposit for 48 h. Three weeks after infestation, plants were removed from the flats and examined for their resistance reaction. Plants that were stunted and dark green in color were considered as susceptible. Those that were not stunted and retained their normal light green color were considered as resistant. Both susceptibility and tolerance were confirmed by the presence of live second instars or flaxseeds. Antibiosis was confirmed by the presence of dead first instars at the base of the stem. Plants that did not have any larvae were considered as escapes. The numbers of live larvae on each plant were recorded. Infested plants were also examined for the presence or absence of galls at the larval feeding sites.

The screening showed that almost all the barley lines were susceptible to BSGM. Plants were stunted, dark green in color, and hosted large numbers of live larvae and flaxseeds. However, some lines expressed various degrees of tolerance, and one line (BI97IN-1974) was heterogeneous for antibiosis (Table 2.44).

Tolerant plants were not stunted, and had live second instars or flaxseeds. Tolerance levels ranged from 7.2 to 64% tolerant plants per line that showed tolerance (Table 2.44). In general, the number of larvae per tolerant plant was lower than that on the susceptible checks. Both susceptible and tolerant plants had distinct galls at the feeding sites of larvae.

Plants that had antibiosis had dead first instars, normal growth, and no gall formations. However, the percent of resistant plants in the selected lines was low. These plants were saved, and seed was collected from them to repeat the test. Lines that showed tolerance will also be tested again.

(S. Lhaloui, M. El-Bouhssini, S. Grando, S. Ceccarelli)

Table 2.44. Barley lines tolerant to barley stem gall midge. RT = row type; LDG = lodging (1=min, 5=max); DH = days to heading in Tel Hadya (Syria), TOL = % of tolerant plant; LAR = Mean nr. of larvae per tolerant plant.

Nr.[a]	Source	SN	RT	LDG	DH	TOL	LAR
1	BI97IN	435	6	4	116	40.0	1.8
2	BI97IN	437	6	4	116	42.0	4.6
3	BI97IN	439	6	1	118	33.3	3.0
5	BI97IN	442	6	4	115	41.2	3.4
5	BI97IN	443	2	3	113	59.0	3.8
6	BI97IN	561	2	4	97	33.3	4.5
7	BI97IN	565	2	4	100	53.3	4.8
8	BI97IN	569	2	1	107	42.9	6.0
9	BI97IN	577	2	4	112	36.4	7.5
10	BI97IN	579	2	4	111	42.9	2.8
11	BI97IN	580	2	4	111	28.6	3.4
12	BI97IN	582	2	5	112	35.7	3.8
13	BI97IN	589	2	4	116	33.3	3.7
14	BI97IN	601	2	2	112	30.8	3.7
15	BI97IN	648	2	3	110	64.4	4.8
16	BI97IN	649	2	2	112	28.6	4.5
17	BI97IN	651	2	3	115	41.7	5.4
18	BI97IN	1974	2	2	95	20.0	3.0
19	Check	-	-	-	-	0.0	9.0
20	Check	-	-	-	-	0.0	8.0

[a]Nr. Name
1 to 5 Afghanistan
6 to 8 Yemen
9 to 16 Ethiopia
17 Eritrea
18 EB921/6/Pld10342//Cr.115/Por/3/Bahtim 9/4/Ds/Apro/5/WI2291

Russian Wheat Aphid

A number of sources of resistance to Russian Wheat Aphid

(RWA) introduced from Gene Banks and other Institutions have been recently confirmed at ICARDA, and a number of new sources of resistance has been identified. For the first time we have been able to distribute to all the north African countries except Egypt a nursery containing the sources of RWA resistance listed in Table 2.45.

(M. El-Bouhssini, S. Lhaloui, S. Grando, S. Ceccarelli)

2.4.1.3. Farmer Participation in Tunisia and Morocco

This is a new activity supported by the International Development Research Center (IDRC) Canada and which represents a further development of the concept of decentralized selection.

In Tunisia various types of germplasm (Table 2.46) were planted in farmers fields and used to assess farmers' selection criteria.

The performance of the barley yield trials is shown in Tables 2.47 and 2.48. Grain yield varied from 1779 kg/ha (Var.# 3 Elite I) to 323 kg/ha (Var.# 18 Orge XI) at Le Kef. The yield range at Mograne was 1283 kg/ha (Var. # 4 Elite I) to 458 kg/ha (Var.#2 Elite I); at Tejerouine the grain yield varied from 811 kg/ha (Var. #8 Elite I) to 105 kg/ha (Var.# 2 Elite I), and at Foussana the range within Elite I was 874 kg/ha to 295 kg/ha.

The barley lines within each yield trial are listed in a descending order based on grain yield within each site.

The number of lines that showed an average grain yield higher than that of the check Rihane (Var.#23) was higher at Mograne (17 lines) than at Foussana (11 lines), Tejerouine (5 lines), and lowest at Le Kef (2 lines).

Table 2.45. Barley lines resistant to Russian Wheat Aphid distributed for the first time to some North African NARS. RT = row type; GH = growth habit (S=spring; W=winter; I=intermediate).

Name	CI	PI	Coll. Site	RT	GH
R001	141	47541	Iran	6	W
STARS-9577B=R006	416	-	Afghanistan	6	S
R034	632	125	Afghanistan	6	S
R011	106	243	Iran	6	I
R013	107	243	Iran	6	W
R015	107	243	Iran	6	W
R016	107	243	Iran	6	W
R017	107	243	Iran	6	W
R018	122	289	UK	6	S
R022	-	328	Germany	6	S
R023	-	366	Afghanistan	6	S
R024	-	366	Afghanistan	6	S
STARS-9301B=R027	-	366	Afghanistan	6	S
R028	-	366	Afghanistan	6	S
R029	-	366	Afghanistan	6	S
R031	-	370	Afghanistan	6	S
RWA.M46	-	-	-	6	W
RWA.M53	-	-	-	6	W
RWA.M54	-	-	-	6	W
RWA.M55	-	-	-	6	W
RWA.M56	-	-	-	6	W
Mo.B1337/WI2291//Bonita/Weeah	-	-	-	2	-
Mo.B1337/WI2291//Stirling/FNC	-	-	-	2	-
NE417/Arta	-	-	-	2	-
H.spont.41-1//ER/Apm	-	-	-	2	-
H.spont.41-1//ER/Apm	-	-	-	2	-
ER/Apm//Lignee	-	-	-	2	-
Arar/H.spont.19-15//Arta	-	-	-	2	-
H.spont.38-	-	-	-	2	-
SLB 45-40/H.spont.41-5	-	-	-	2	-
WI2269/Lignee	-	-	-	2	-

Table 2.48 shows the grain yield of the other trials at Le Kef station. The yield range (kg/ha) was very large within these yield trials: Orge 1 (1518-554), Orge X (1122-376), and Orge XI (1133-323).

Table 2.46. Barley Germplasm used for farmer participatory selection at four sites in 1996-1997 crop season.

Yield Trials	No Line	
Elite I (AYT)	25	Fixed lines. Landrace accessions. Checks
Orge 1 (IYT)	25	Fixed lines. Checks
Orge X (PYT)	25	Newly introduced lines. Checks
Orge XI (PYT)	25	Fixed lines. Selected lines from NURMAG 95. Checks
NURSERIES		
SEGMAG 97		Special segregation population (F3) provided by ICARDA targeted for North Africa, six row barleys
NURMAG 97		Barley lines selected from SEGMAG 96, with emphasis on selection made in Tunisia and Morocco, and showing adequate disease resistance

[a] AYT = Advanced yield trial; IYT = Intermediate yield trial; PYT = Preliminary yield trial.

The number of lines that out-yielded the check was higher in the intermediate yield trial than in the preliminary yield trials at Le Kef. Entries in trials Orge X and Orge XI were selected for specific regions and therefore should be tested at the targeted sites next crop season.

The selection criteria varied among the group of farmers. Table 2.49 shows the selection criteria set by the group and ranked by each one of the participant farmers. Grain yield was ranked first by most of the farmers followed by straw yield. Drought resistance was considered as an important criteria for four farmers. Ranking of yield stability, grain quality and resistance to insects and diseases varied among the participating group.

Table 2.47. Average grain yield (kg/ha) in a descending order of the Elite Yield trial at four sites in Tunisia.

Le Kef		Mograne		Foussana		Tejerouine	
Var #	Yield	Var	Yield	Var #	Yield	Var #	Yield
10	1779.3	04	1283.0	06	874.9	08	811.9
03	1776.3	14	1261.3	05	861.3	22	736.1
23	**1756.7**	25	1226.3	10	728.9	07	652.1
05	1728.3	05	1131.3	24	6888.7	16	590.0
21	1668.3	08	1128.0	18	683.9	04	580.0
24	1626.3	24	1110.3	09	677.0	**23**	**574.2**
19	1544.3	10	1101.3	03	661.6	21	547.8
22	1543.0	03	1060.7	04	595.0	24	532.8
07	1517.7	13	1028.0	08	587.8	03	529.0
12	1467.0	20	971.7	13	586.0	01	528.7
08	1402.0	09	930.7	16	562.0	15	511.6
14	1353.3	01	869.7	**23**	**584.0**	05	495.4
04	1353.0	06	828.0	21	558.0	19	476.2
15	1339.7	12	803.7	12	553.0	25	446.2
01	1322.1	19	770.0	17	544.0	09	430.0
09	1253.0	17	739.0	19	541.6	17	426.2
17	1241.7	22	722.0	15	535.6	12	420.4
13	1166.3	**23**	**697.7**	01	522.6	13	415.6
16	1124.7	21	650.3	14	516.8	10	381.4
18	1116.7	15	608.7	22	495.4	11	359.8
25	1113.7	11	605.3	11	471.8	18	292.1
20	899.7	16	600.7	25	379.6	14	291.5
06	877.0	18	589.3	20	352.5	20	284.9
02	848.7	07	510.0	07	337.5	06	252.3
11	747.3	07	510.0	02	295.3	02	105.0

Check Rihane = Var # 23 emboldened

Based on the above criteria the farmers selected the best lines within three yield trials. Fourteen farmers participated in the selection (including the seven listed in Table 2.49), and the lines selected are shown in Table 2.50: each star represents selection done by one farmer. The selection was conducted at Le Kef. Most of the high yielding lines were selected by at least one farmer. Some of the selected lines have low grain yield but might have high biomass yield. Other criteria beside grain yield will be evaluated in future experiments.

Table 2.48. Average grain yield (kg/ha) in a descending order of three yield trials at Le Kef (Tunisia).

Orge 1		Orge X		Orge XI	
Var. #	Yield	Var. #	Yield	Var. #	Yield
17	1790.0	09	1172.3	**23**	**1133.3**
14	1528.3	**23**	**1152.3**	22	982.0
01	1518.5	18	1149.7	16	885.0
16	1459.3	10	1126.3	07	833.7
18	1454.0	14	1122.3	04	778.7
24	1320.0	17	954.3	14	739.3
23	**1314.3**	21	937.7	25	717.3
05	1261.7	15	867.0	02	679.3
06	1169.0	20	784.3	15	663.7
09	1162.0	02	747.0	09	653.7
03	1139.0	05	740.3	06	631.7
13	1088.7	07	702.3	01	608.0
02	1086.2	11	699.0	03	605.0
08	1074.0	01	666.3	08	601.3
20	1068.3	19	637.3	20	592.0
10	1055.0	08	626.0	24	582.7
15	1010.3	25	556.0	10	572.0
04	990.3	13	540.7	05	569.7
19	952.3	04	523.0	12	528.7
12	942.3	06	503.7	21	501.7
21	846.0	22	456.3	11	501.0
07	801.0	16	435.3	13	489.7
11	799.3	24	431.0	17	433.0
22	638.7	03	390.7	19	421.3
25	554.0	12	376.0	18	323.7

Check Rihane = Var # 23 emboldened

Table 2.49. Selection criteria as ranked by seven farmers from Le Kef region (Tunisia).

Farmer	Selection Criteria						
	Yield of:		Resistance			Grain	Yield
	Grain	Straw	Disease	Insect	Drought	quality	stability
1	3	4	5	7	6	2	1
2	1	3	2	4	5	7	6
3	1	2	3	5	7	6	4
4	1	2	4	5	3	6	7
5	2	3	6	5	4	1	7
6	1	4	6	7	2	5	3
7	1	2	6	7	3	5	4

Table 2.50. Lines within each yield trials selected by individual farmers and variety rank based on grain yield at Le Kef (Tunisia).

Variety #	Elite I	Orge 1	Orge X	Orge XI
1				* (12)
2				* (8)
3	** (2)			
4	* (13)	* (18)		
5				* (18)
6				
7				
8				
9				* (10)
10	** (1)		* (4)	* (17)
11				* (21)
12		* (20)		** (19)
13	** (18)	** (12)	** (18)	* (22)
14	* (12)	* (2)		* (6)
15		*** (17)		* (9)
16		** (4)	* (22)	
17	* (17)	* (1)		
18	** (20)		* (3)	* (25)
19	** (7)			
20				** (15)
21	* (5)	** (21)	* (7)	
22	** (8)	** (24)		*** (2)
23				
24			* (23)	
25	* (21)	* (25)		
Nb.	4	4	3	3

*. Selected by one farmer ; **. Selected by two farmers ; ***. Selected by three farmers
() Variety rank from tables 2.47 and 2.48.

In Morocco three farmers, each from Jemaa Shaim (arid zone), Merchouch (semi-arid zone) and Tanant (mountain zone) participated in this project. At Merchouch and Jemaa Shaim, both NURMAG 97 and MORYT 97 were planted while only MORYT 97 was planted at Tanant. NURMAG 97 is an observation nursery composed of 297 F4 bulks each planted in two rows of 2.5 meters long with 0.3 row spacing with an empty row between adjacent lines. MORYT 97 is a yield trial composed of 112 experimental lines and five checks: Aglou (2R), Tiddas (2R), Rabat 071 (6R landrace), Arig 8 (6R) and Laannoceur (6R).

These checks are replicated in four blocks in an augmented design while the experimental lines are not replicated. Each variety is sown in a plot of six rows of 3 meters long with 0.3 m as row spacing. The trial at Tanant was discarded due to insect damage at planting.

The NURMAG 97 and MORYT 97 (with two replications) were also planted at the experiment stations of Merchouch and Jemaa Shaim situated within 4-6 km from participating farmers' fields. Selections were made at late tillering and at maturity by the participating farmers and their neighbors. In total, three farmers participated in the selection process at Jemaa Shaim and eight at Merchouch. During the selection, farmers indicated the reasons for selecting given lines. Breeders (1 and 2) also made their selection both in farmer fields and at the experiment stations.

Plant height and grain yield in the four central rows were measured in the yield trials. Number of selected lines, the frequency of the occurrence of selection criteria, the selection intensity and the correlation between the selections made by the participating farmers with those made by the breeders were calculated using 0 (for line not selected) and 1 (for line selected).

A survey was conducted to determine the uses of barley by the participating farmers, their selection criteria and ideotypes characteristics.

For the NURMAG 97 nursery grown at farmer sites, the selections rates varied among farmers and with the breeder at both sites. At Merchouch and Jemaa Shaim, 113 and 63 lines were discarded by all the farmers and the breeders. At Merchouch, the participating farmer selected 36% of the lines while the neighboring two farmers selected 41 and 11% (Table 2.51). The barley breeders selected 20%. Among the lines selected by the breeder, 77% were also selected by at least two farmers.

At Jemaa Shaim, two farmers selected more than 60% of the lines, the participating farmer selected 46% of the lines, while the breeder selected only 25%. Among the lines selected by the breeder, 98% were also selected by at least two farmers.

Table 2.51. Selections by farmers and breeder in the NURMAG97 nursery at Merchouch and Jemaa Shaim (Morocco).

	Merchouch	Jemaa Shaim
Farmer 1 alone	25	0
Farmer 2 alone	55	26
Farmer 3 alone	2	3
Farmers 1 and 2	24	5
Farmers 1 and 3	2	1
Farmers 2 and 3	1	35
All three farmers	2	72
Breeder alone	4	0
Breeder + 1 farmer	9	1
Breeder + 2 farmers	16	25
Breeder + 3 farmers	29	46
Not selected	113	63
Selected by farmer 1	105 (36%)	131 (46%)
Selected by farmer 2	118 (41%)	212 (74%)
Selected by farmer 3	32 (11%)	187 (65%)
Selected by breeder	58 (20%)	72 (25%)

These results show that, with the exception of one farmer at Merchouch, most of the farmers tend to select more lines than the breeders who selected with a selection pressures of around 20 to 25%, which is usual for observation nurseries. None of the farmers at both sites selected the winter types and the two row check replicated three times within the nursery. Plant density, medium cycle and height (tall plants) guided the selection by most of the farmers, and none of them mentioned the reaction to major diseases as an important criterion. Some farmers judged that the number of lines tested was too large and they can not afford going through this kind of nursery many times. For MORYT97, at Merchouch farmer site, the selection rates varied from 14 to 64 lines out of the 112 lines tested and five checks (Table 2.52). The two breeders selected respectively 36 (breeder1) and 21 (breeder 2) lines. Twenty one lines out-yielded the best check. Farmers 1 and 2 selected more than 70% of the lines selected on the basis of grain yield. The breeder selected 61% and the rest of farmers selected 50% or less of the lines selected based on grain yield. The breeders selected the 4 and 5 lines out of the best six high yielding lines. The farmers 1 and 2 identified 3 high yielding lines and this can be explained by their low selection pressures since they selected respectively 57% and 47% of the tested lines. The rest of the farmers selected only one of the six lines.

Table 2.52. Total number of lines selected by the farmers and by the breeders, lines in common with the breeder and with selections made on grain yield and number of best selected lines at Merchouch (Morocco).

	Total selections	Common with breeder	Common with grain yield selections	Numb of best selected lines[a]
Farmer 1	64	31	17	3
Farmer 2	53	25	15	3
Farmer 3	25	22	11	2
Farmer 4	14	5	4	1
Farmer 5	43	11	8	0
Farmer 6	18	5	4	1
Farmer 7	42	11	8	1
Farmer 8	27	6	5	1
Breeder 1	36	36	13	4
Breeder 2	21	16	9	5

[a] number of best yielding lines

Only 12 lines were not selected by any of the farmers and breeders, and 26% of the lines were selected by at least four farmers (Table 2.53). Out of the 36 lines selected by breeder 1, only two lines were not selected by any of the farmers and the two lines were among the group selected on the basis of grain yield. 83% of the lines selected by the breeder and 89% of the lines selected on the basis of grain yield were also selected by at least two farmers.

Table 2.53. Number of lines selected by farmers, breeders and on the basis of grain yield at Merchouch (Morocco) in the MORYT97 trial.

	Farmers only	Farmers + breeders	Farmers + Grain yield selection
One farmer	24	5	2
Two farmers	28	9	2
Three farmers	22	8	7
Four farmers	12	5	2
Five farmers	10	6	2
Six farmers	4	1	2
Seven farmers	3	1	2
Eight farmers	0	0	0
Breeder only	-	2	2
Not selected	14	12	12

The correlations between the selections made by the breeders, the farmers and on the basis of grain yield are presented in Table 2.54.

These correlations confirmed that only the farmers 1, 2 and 3 selected most of the lines in common with the breeders and with the lines selected based on grain yield. Farmer 3 was the most efficient in selection since he had the highest correlation coefficient together with the highest selection pressure. His selections were also highly correlated with the selection made by the breeder at the experiment station while only 30% of these lines were in common with the selections made by the same breeder in the farmer field.

The three farmers and the breeder selected a similar number of lines from the MORYT97 evaluated in the farmer field near Jemaa Shaim. Out of the 41 lines selected by the breeder, 23, 27 and 24 were common respectively with the selections made by farmers 1, 2 and 3 (Table 2.55).

Table 2.54. Correlations between selections made by breeders and on the basis of grain yield with selections made by the farmers within the MORYT97 nursery grown in the farmer field and at the experiment station.

	breeder 1/farm	breeder 2/farm	GYLD/farm	breeder 1/station
Farmer 1 (64)	0.403 (0.0001)	0.326 (0.0005)	0.231 (0.014)	0.066 (0.487)
Farmer 2 (53)	0.343 (0.0002)	0.232 (0.014)	0.186 (0.049)	0.176 (0.061)
Farmer 3 (25)	0.641 (0.0001)	0.347 (0.0002)	0.347 (0.0002)	0.249 (0.008)
Farmer 4 (14)	0.0289 (0.762)	0.0259 (0.786)	0.095 (0.318)	-0.150 (0.115)
Farmer 5 (43)	-0.1109 (0.244)	-0.003 (0.975)	-0.003 (0.975)	0.0113 (0.235)
Farmer 6 (18)	-0.041 (0.668)	0.039 (0.684)	0.039 (0.683)	0.09 (0.322)
Farmer 7 (42)	-0.099 (0.300)	0.06 (0.951)	0.006 (0.951)	0.124 (0.193)
Farmer 8 (27)	-0.120 (0.208)	-0.110 (0.247)	-0.003 (0.972)	0.024 (0.82)

GYLD: Selection on grain yield basis

Table 2.55. Number of selected lines, lines in common with the breeder and with selections based on grain yield, and number of best selected lines at Jemaa Shaim (Morocco).

	Total selections	Common with breeder	Common with GYLD	Num. of best selected lines[a]
Farmer 1	44	23	10	2
Farmer 2	39	27	11	1
Farmer 3	43	24	12	1
Breeder	41	41	14	2

[a] number of lines with highest grain yield.

These farmers selected respectively 10, 11 and 12 lines among the 21 lines that out-yielded the best check. The breeder selected 14 lines from the group of high yielding lines and was able to pick up 2 out of 4 best yielding lines. Farmer 1 selected 2 of the best yielding lines while the other farmers selected only one of the four best yielding lines. Forty three lines were selected neither by the farmers nor by the breeder, or on the basis of grain yield (Table 2.56). Forty one lines were selected by at least two farmers out of which 25 lines were also selected by the breeder. The results in Table 2.55 confirmed the significant correlations existing between the selections made by the farmers themselves and by the breeder at the farmer site. The selections in the farmers' fields were not significantly correlated with the selections made by the breeder at the experiment station. However, the selections made by the breeder at the farmer field and at the experiment station were highly correlated with the selections made on the basis of grain yield at the farmer site (Table 2.57).

At Jemaa Shaim, the farmers mainly used long spikes, plant density, plant height, and earliness along with the visual estimation of grain and straw yields as selection criteria. Few farmers used the tillering ability, lodging resistance and kernel size and some of the farmers selected

Table 2.56. Number of lines selected by farmers, breeders and the basis of grain yield at Jemaa Shaim (Morocco) in MORYT97 trial during 1996-97 Season.

	Farmers only	Farmers + Breeders	Farmers + Grain yield selection
One farmer	18	6	2
Two farmers	15	7	3
Three farmers	26	18	8
Breeder only	-	10	-
Not selected	53	43	46

few lines on the basis of local adaptation (phenotypic similarity with the landraces) and on the overall agronomic aspect. The white colored straw was mentioned by all farmers during the selection of few lines. The breeder selected mostly for agronomic score, disease resistance, earliness and plant height (tall). Some of the lines were also selected on the basis of long spikes, tillering ability, kernel size and the visual estimation of straw yield.

Table 2.57. Correlations between farmers and breeders selections in farmers' fields and the experiment station in Jemaa Shaim (Morocco).

	Far1.F	Far2.F	Far3.F	A.S	A.F	GYLDF
Number of selections	44	39	43	15	41	21
Far1.F	-	0.448 (0.0001)	0.568 (0.0001)	-0.102 (0.286)	0.2616 (0.005)	0.129 (0.176)
Far2.F		-	0.733 (0.0001)	0.098 (0.305)	0.495 (0.0001)	0.177 (0.06)
Far3.F			-	0.013 (0.89)	0.315 (0.0007)	0.185 (0.051)
A.S				-	0.028 (0.772)	0.281 (0.002)
A.F					-	0.299 (0.001)

Farm.F: Farmer selection done at the farmer field
A.F: Selections made by breeder A at the farmer site.
A.S: Selections made by breeder A at the experiment station
GYLDF: Selections made on the basis of grain yield at farmer field

At both locations, the farmers used mainly yield components such as plant density and spike length that are not very often correlated with grain yield. Farmers seldom mentioned diseases as a factor in their selection pressure even though leaf rust and BYDV infections were abundant. Earliness was mentioned at the semi-arid site of Jemaa Shaim, while only one farmer selected early genotypes at Merchouch. All the farmers ignored the two-row types even though some of them were good. The breeder used mainly the overall agronomic score and disease resistance and included the two-row types in his selections.

Table 2.58. Selection criteria used by farmers (F) and breeder (Br) at Merchouch and Jemaa Shaim (Morocco) and their occurrence number.

Selection criteria	Merchouch				Jemaa Shaim			
	F 1	F 2	F3	Br	F 1	F 2	F 3	Br
Tillering	1	0	0	3	0	3	2	16
Plant density	48	20	25	0	17	9	20	0
Plant height (tall)	10	13	0	25	15	5	10	30
Earliness	10	1	0	10	7	18	7	22
Long spike	31	4	17	10	23	15	19	15
Lodging resistance	0	2	0	0	0	1	0	0
Disease resistance	3	2	0	27	0	0	0	23
Grain yield	25	43	0	0	2	12	26	0
Straw yield	12	17	7	0	5	16	26	0
Straw color	0	0	0	0	4	9	7	0
Large kernel	0	0	0	12	0	3	1	9
Overall aspect	1	0	0	31	11	4	1	36
Local adaptation	0	0	0	0	1	2	5	0
Total selected lines	64	53	43	39	25	36	43	41

In the past, some farmers have been asked to judge the newly released varieties during their evaluation in the demonstration trials. The participatory approach initiated by this project has allowed to know better the traits preferred by farmers through their participation to the selection process in their site. Such a methodology provide additional experiment sites for the breeders since no correlations were found between grain yields obtained at farmer fields and those obtained at the neighboring experiment stations (Table 2.59). It also allows to advance lines approved by most of the farmers which will be easily adopted by farmers in the region. The approach should be extended to allow farmers to select within heterogeneous populations (F_4 or F_5 bulks) but the participating farmers should be aware of the effects of the remaining genetic segregation and soil heterogeneity.

Table 2.59. Correlations between grain yields at farmer sites and at the experiment stations

	GYLDM F	GYLDJS S	GYLDJS F
GYLDM S	0.070	0.1756	0.102
	(0.459)	(0.064)	(0.886)
GYLDM F	-	-0.102	0.115
		(0.284)	(0.228)
GYLDJS S		-	-0.007
			(0.944)

GYLD: Grain yield, M: Merchouch region, JS: Jemaa Shaim
F: Farmer site, S: Experiment station.

(A. Amri, A. Yayhaoui, F. Nassif, M. El-Bouhssini, S. Lhaloui, S. Grando, S. Ceccarelli)

2.5. East Africa and Yemen

During 1997 we have expanded our collaboration with Ethiopia and we have started new collaboration with Eritrea and Yemen.

2.5.1 Ethiopia

The interaction of the barley project with the Ethiopian national programs started in 1984. It has been strengthened considerably through a special project funded by the Government of the Netherlands for the last five years. The project has determined a considerable change in breeding strategies with more attention given to landraces, and more recently to farmer participation.

The work on landraces has led to the identification of a new variety, Shege, released in 1996, and lately of a second variety (3307-10) recommended for Gojam and Gonder regions. An example of the yield advantage of some of the more recently released cultivars over the local landrace is shown in Table 2.60.

Table 2.60. Grain yield (kg/ha) of two improved cultivars and of the local cultivar under low (LM) and high (HM) management practices in west (Degem) and northwest (Jeldu) Shewa.

Cultivar	Degem			Jeldu		
	LM	HM	% increase	LM	HM	% increase
HB 42	1717	2502	45.7	2363	3421	44.8
Shege	1618	2306	42.5	2758	3419	24.0
Local	1268	1747	37.8	2391	2799	17.1

Also some promising lines for the late barley system in Shewa, Arsi and Gonder have been identified and will be further tested.

The participation in a traveling workshop in October 1997 has been very beneficial to the interaction with Ethiopia and to the development of new initiatives for a more efficient germplasm development for different areas within such a diverse country. These are (1) the preparation of a special nursery for Tigray composed of landraces, F_2's between landraces and between landraces and exotic germplasm; (2) the evaluation of a collection of landraces from Ecuador and other south American countries; (3) the execution of targeted crosses using Ethiopian landraces and distribution of F_2 populations to targeted regions through Holetta headquarters;

(4) the regular training of one Ethiopian scientist each year in the headquarters; (5) the organization in 1999 of an International Barley Traveling Workshop with the participation of barley breeders from 10-15 different countries, as one of the activities of the second phase of the barley project.

A major effort is currently done at the headquarters to incorporate resistance to Russian Wheat Aphid, which causes losses up to 37% (Table 2.61), and to BYDV, as second priority, into adapted germplasm from Ethiopia.

Table 2.61. Estimated yield losses of barley due to Russian Wheat Aphid in unsprayed (U) and sprayed (S) plots in two zones of Ethiopia.

Trait	South Gonder			Jeldu		
	U	S	% losses	U	S	% losses
Biomass	3.15	4.87	35.7	-	-	-
Grain Yield (t/ha)	1.14	1.51	24.7	0.54	0.87	37.9
Kernel weight	38.6	39.2	1.5	-	-	-

(F. Alemanyu, B. Lakew, A. Asefa, S. Grando, S. Ceccarelli)

2.5.2. Eritrea

Based on 1995 data, the area planted with barley in Eritrea is 43,000 hectares, which represent approximately 12% of the total area presently cultivated in Eritrea (about 350,000 hectares). Barley production represents 20% of the total agricultural production. Average yield is 650 kg/ha.

The most important areas for barley are the provinces of Hamassien (nearly 17,000 ha), Akele Guzai (7,000 ha), Sahel (2000 ha) and Seraye (2000 ha).

The interaction between the barley project and the Eritrean national program has been supported through a project on "Seed Development" funded by the Government of

Denmark. The project has supported a new collection of barley landraces that was conducted in September 1997 across the country: in each of 37 sites 50 spikes were collected together with one kg of bulk seed.

In collaboration with Eritrean scientists we have developed a five-year barley breeding program which will begin to be implemented in 1998. At the same time we have started a degree training program with a MSc student conducting his thesis on "Genetic structure of barley landraces adapted to dryland agriculture" in Aleppo under the joint supervision of the ICARDA barley breeders and of the Royal Agricultural and Veterinary University of Copenhagen (KVL).

(S. Grando, S. Ceccarelli)

2.5.3. Yemen

During 1997 we have initiated a specific collaboration on barley breeding with Yemen, a country previously neglected. In the course of two visits during 1997 the following activities were discussed and planned with the scientists of the Agricultural Research and Extension Authority (AREA): 1. An inventory of Genetic Resources to assess how many collections have been made, where the collections are kept and which preliminary evaluation and characterization has been conducted; 2. An inventory of breeders' use of Genetic Resources in barley breeding; 3. An evaluation of landraces by breeders on both research stations and on farm. 4. Estimate genetic variability within landraces; 5. Start a decentralized breeding approach in barley breeding with ICARDA's assistance. In the case of barley, crosses with *H. spontaneum* are also requested. 6. Develop two special projects, one on participatory breeding and one on landrace evaluation.

During the second part of 1997 parental material from the AREA barley breeding program as well as a number of landraces have been introduced in the crossing block to start developing the segregating populations which will represent the starting point of the decentralized selection.

(S. Ceccarelli)

2.6. Central Asia and Russia

During 1997 we established new collaboration with Kazakhstan, Kyrgyzhstan, Tadjikistan, Turkmenistan, and Uzbekistan, and we strengthened our collaboration with the Lukyanenko Research Institute in Krasnodar (Russia).

These countries grow approximately 29 million hectares of barley of which nearly 16 million is in Russia and 5 million in Kazakhstan.

The collaboration with Kazakhstan, Kyrgyzhstan, Tadjikistan, Turkmenistan, Uzbekistan consisted on one side in the development of collaborative research projects on "Collection, Conservation and Utilization of Agricultural Biodiversity" and on "Adaptation to Drought and Temperature Stress of Barley and Wheat with Molecular Techniques", and on the other in the exchange of a number of exploratory nurseries to begin executing targeted crosses.

The collaboration with the Lukyanenko Research Institute in Krasnodar has been a long and successful one, and in 1997 has been formalized with an official Agreement for the development of winter and spring barley for the temperate environments of Central Asia, Eastern States of the Former Soviet Union, and eastern and Central Europe.

A number of nurseries were supplied for the first time to scientists of the Central Asian States (Table 2.62). During 1998 we plan to have sufficient information from these nurseries to start large scale testing of promising lines and to start producing specifically adapted material for different areas of the Central Asian States.

In the Russian Federation a new winter barley variety Dobrinya, developed by the Krasnodar Research Institute of Agriculture, was submitted for official state trials in all regions of the north Caucasus, as well as some countries of the former Soviet Union. The new variety combines very good level of cold tolerance with resistance to lodging and high yield potential (Table 2.63).

The new variety Dobrinya could be a very good source of good adaptation and productivity for extremely cold sites of Highland Region.

Table 2.62. New collaborators in barley breeding in the Central Asian States.

Nursery	Scientist	Institution
ISBYT-LRA, ISBYT-MRA, ISBON-LRC, ISBON-MRA, IWBYT, IFBYT, IWFHBON, IWFFBON, ISBYDGP, ISBNBGP, ISBSCGP, ISBPMGP	Dr. R. Urazaliev	Kazakh Research Institute of Agriculture, Almalybak Kazakhstan
BYLW, BYM, BCB, BONLC, ISBYDGP, ISBNBGP, ISBSCGP, ISBPMGP	Dr. N. Kravchenko	Kazakh Research Institute of Seed Production, Akmola, Kazakhstan
IFBYT, IFBON	Dr. A. Amanov	Uzbeck Research Institute of Grain, Uzbekistan
IFBYT, IFBON	Dr. T. Bessonova	Breeding Department, Kyrgyz Agrarian Academy, Kyrgyzstan
Naked Barley	Dr. B. Sanginov	Tajik Academy of Agricultural Sciences, Dushanbe, Tajikistan

Table 2.63. Characteristics of winter barley variety Dobrinya. 1995-1997.

Variety	Cold tolerance (%)	Grain yield (kg/ha)	% increase
Bastion (check)	84.2	5860	100
Vavilon (check)	30.4	6420	109
Dobrinya	98.3	7390	126
L.S.D. (P=0.05)	8-10	350-420	

(V. Shevtsov, S. Ceccarelli)

2.7. Far East

In the Far East barley is an important crop in China, India, North Korea, Vietnam and Nepal. The total area of barley in this region is estimated to be around 3.5 million hectares. Our interaction with the countries within this region has been largely limited, until recently, to the dispatch of international nurseries.

(S. Ceccarelli)

2.7.1 India

In India the area under barley declined from 3 million hectares to about 1 million hectares, mostly due to the expansion of irrigation, and hence of the wheat area.

Most of our collaboration has been with the Hissar Agricultural University where lines derived from crosses with *H. spontaneum* introduced from ICARDA have been used to develop hybrid barley because of their ability to extrude the anthers before shedding the pollen. Also a restorer gene[5] has

5 Singh, D., 1996. Identification of maintainer and restorer lines for heterotyc hybrids in barley. Proceedings of the V International Oat Conference and of the VII International Barley Genetics Symposium (A.

been identified in an ICARDA line which is able to restore the fertility of the cytoplasmic male sterile lines msm1 and msm2.

More recently we have developed special nurseries for the Far East (distributed to India, Vietnam, Korea and China), and in 1997 we have distributed a nursery of early genotypes for India, Vietnam and Bangladesh.

The major problem with these nurseries has been the poor return of data which has not yet made it possible to develop a truly decentralized approach.

In the case of the nursery for the Far East sent in 1996 to 5 different countries, data on grain yield and selection records were received from three and two locations in India.

Generally our germplasm is not sufficiently early for the Indian sub-continent, and this applies also to Vietnam. Even though lines performing better than the checks can be easily found, they are very specifically adapted to individual locations. In fact only few lines performed better than the check in two locations (the name of those is indicated at the bottom of Table 2.64) and none in all three.

Recently the collaboration with India has been formalized through an agreement to (1) jointly develop high yielding rust resistant barley varieties, (2) identify high malting quality types, and (3) exchange germplasm with specific traits.

(S. Ceccarelli)

2.7.2. China

In China barley is grown in three different agroecological environments where winter types, spring types and naked types

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Slinkard, G. Scoles and B. Rossnagel, eds.): 571-573.

Table 2.64. Grain Yield (relative to the mean of the checks) in three locations in India of the highest yielding barley lines in a special nursery for the Far East (only the names of the entries performing well in at least two locations are given at the bottom).

			Grain yield (check = 100)			
Entry[a]	RT	Heading	Karnal	Kanpur	Hissar	mean
Best in Karnal						
6	2	95	217	81	89	122
5	2	94	143	73	112	109
31	6	100	140	113	60	99
34	6	89	139	121	76	107
16	6	94	137	65	111	104
45	6	84	129	73	60	83
37	6	89	127	56	86	88
3	2	98	125	97	89	102
25	2	96	124	89	99	103
Best in Kanpur						
63	6	91	49	153	121	111
9	6	97	88	145	82	103
14	6	97	89	137	87	103
64	6	91	62	137	71	89
46	2	101	68	137	76	93
29	2	100	111	137	16	80
13	6	91	111	137	98	114
61	6	94	77	129	77	93
7	2	91	114	121	91	106
34	6	89	139	121	76	107
Best in Hissar						
63	6	91	49	153	121	111
5	2	94	143	73	112	109
15	6	90	107	56	112	94
19	2	98	99	73	112	96
16	6	94	137	65	111	104
18	2	98	97	97	109	102
51	6	56	66	28	109	72
55	6	98	75	56	105	82
11	6	93	101	81	100	95
Nat. Check mean		**68**	100	100	100	100

[a] Entry Name

5 ER/Apm//WI2291/Bus

15 Aths/Lignee 686

34 WI2197/CI 13540//Arar

63 Baca'S'/3/AC253//CI 08887/CI 05761//Mari/Aths*2//M-Att-73-337-1

predominate.

As in many other countries, barley is grown for different purposes. The two rising uses are animal feed and malt.

The interaction with China is mostly through our Mexico-based project. This is because one of the most important diseases affecting barley in China is head scab caused by *Fusarium graminearum* on which the Mexico-based project has been working in collaboration with breeders in U.S.A.

Other important barley diseases are rust, powdery mildew and barley yellow mosaic virus and one important area of collaboration is the exchange of sources of resistance to these diseases.

(S. Ceccarelli)

2.7.2.1. Screening for Resistance against Head Scab

The epidemic of Head Scab on barley in the upper Midwest of the United States continues to be a problem for the fifth consecutive year. In cooperation with US scientist from North Dakota State University and Professor Liu Zongzhen from the Shanghai Academy of Agricultural Sciences in China, a screening network was established to test barley germplasm.

During 1997, the Shanghai field screening was affected by lodging caused by five rain storms, Professor Liu Zongzhen nonetheless scored the trials and sent back information on a set of F5 lines from the ICARDA-CIMMYT barley program. The same set of lines were simultaneously grown at CIANO Experiment Station, a scab free environment, where they were scored for anther extrusion. Most of the lines had null or very limited anther extrusion recorded, meaning that selection for head scab in this population has skewed the population toward plants that do not extrude anthers or, if they do, it is a few at the tip of the spike.

During the summer of 1997 a rather large number of F6 lines were provided to Dr. Lucy Gilchrist for field testing against *Fusarium graminearum* with artificial inoculation for Type I (hyphae penetration) and Type II (spreading). The number of resistant entries are presented on Table 2.65. MPYT is an abbreviation for Micro plot yield trial, MCLA correspond to the line Maris Canon/Laurel//Aleli and ADCA for the Alpha/Durra//Coraqle/3/Aleli.

The 24 lines resistant to both types (I and II) will be sent to Professor Liu Zongzhen, Shangha, China for field testing against *Fusarium* in 1998. Inoculated grain, harvested at Toluca, from one hundred ten lines will be sent to North Dakota State University for toxin analysis Deoxynivalenol (DON).

Table 2.65. Resistant F6 barley lines to Head Scab *Fusarium graminearum*, Type I (Hyphae penetration), Type II (spreading) and a combination to both resistant mechanism artificially screened at the Toluca Experiment Station, Mexico in 1997.

Population	Resistant mechanism			Total number of plants
	I	II	I-II	
Resistant x Susceptible				
MPYT/Gobernadora	1	4	2	14
Atahualpa/MPYT	1	7	0	16
Atahualpa/MCLA	9	11	1	90
MCLA/Zhedar2	68	10	13	176
ADCA/Gobernadora	0	0	0	10
Resistant x Resistant				
Atahualpa/Gobernadora	14	17	7	76
Susceptible x Susceptible				
MCLA/MPYT	5	1	1	24

The resistant entries were seed graded, those with poor grain characteristics were discarded. A further characterization of

Head Scab resistant lines will be done at CIANO and Toluca in 1998.

The goal of the Program is to develop Head scab resistant lines that in addition are resistant to other diseases prevalent in the region. In order to achieve this objective, thirty F5 lines, resistant to Fusarium, stripe and leaf rust, were artificial inoculated with three BYD biotypes at the Toluca Experiment Station, after the final evaluation, six F5 lines from the cross Atahualpa/Maris Canon//Laurel/3/Aleli, were identified to carry resistance to BYD biotypes PAV and MAV.

(H. Vivar)

2.8. Central and Latin America

In America, barley diseases cause severe losses in the crop; often disease could be managed by farmers with resistant varieties or chemical fungicides. Varieties are preferred because they do involve no extra cost and are environmentally benign.

Stripe rust showed up in Colombia in 1976 and for the last two decades has been the main concern for breeders, pathologists and farmers in the Andean Region. To arrest yield losses caused by the disease a constant breeding effort by NARS is needed, only resistant varieties must be released in the area to check spreading the disease in South America.

In two countries, Mexico and the United States, where the disease came in 1987 and 1991 respectively there is a need for further development of stripe rust resistant varieties.

On breeding for stripe rust in America there are several aspects to be considered. The disease is important but by no means the only one present in the region. In Colombia the release of Quibenras, a stripe rust resistant variety, resulted in a short lived variety, since disease losses caused by leaf rust on Quibenras were not acceptable to Colombian farmers. Breeding barley with multiple disease resistance in Mexico, was a response to regional needs: it started in 1982 and continued until now. Several varieties that originated from ICARDA/CIMMYT germplasm, carrying multiple disease resistance were released by NARS in the region during this period. These varieties have proved valuable in farmers' fields.

The most popular varieties with the largest area on commercial production in Bolivia, Ecuador and Peru were released in the two-year period 1978 to 1980, remaining resistant for seventeen and nineteen years. The durability of the resistance to stripe rust on commercial varieties in the Andean Region is of some concern, since the resistance may not last for ever. In nature there is a constant pathogen evolution to develop new pathogen races that might become virulent on the varieties commonly used by farmers.

The NARS in the Andean Region have released several barley varieties as a preventive measure against a sudden chance on pathogen virulence, this strategy might result in a rapid identification of a resistant variety capable to replace immediately the susceptible one, that is if the nature of the resistance on the new variety proved to be different. Very little information exists on the genetics of the stripe rust on the Andean Region barley varieties.

In cooperation with Oregon State University, stripe rust resistance variability present on commercial Ecuadorian varieties were studied using biotechnology, in two out of three Ecuadorian barley varieties (Shyri and Calicuchima). It took more than four years to map stripe rust genes with molecular markers (RFLP, AFLP) but the results clearly show that resistant genes on Calicuchima located on chromosomes 4 and 7 are different from that present on Shyri located on the long arm of chromosome 5. Varieties with different genes for resistance against stripe rust represent an insurance against possible disease losses caused by yellow rust in the country. Similar studies could be done in Bolivia, Mexico and Peru to produce a catalog of stripe rust resistant genes deployed in Latin America varieties.

Durability of the resistance could also result from the use of partial (quantitative) resistance, a term coined by Dr. Van den Plank, which is based on the interaction of several minor genes for resistance. In a study conducted by Sandoval in Mexico (1997), where five hundred advanced lines from the ICARDA/CIMMYT barley germplasm were analyzed, a large percentage (63 %) of the lines had some levels of partial resistance to stripe rust. Therefore, NARS, by selecting for partial resistance to stripe rust, enhance the durability of the resistance to the disease in new barley varieties released in the region.

(H. Vivar)

2.8.1. Yield Potential

2.8.1.1. Hulled Trials

The main aim of the breeding program is to incorporate multiple disease resistance into high yielding barley germplasm. In the yield trials, lines carrying multiple disease resistance but with low yield potential are normally discarded.

During the last two years we had received reports from NARS in Peru and Chile who had record yields. Chile identified a barley line, Gloria/Come// Esperanza, with yields as high as 11.2 tons per hectare. The line originated from a cross made to incorporate Russian Wheat Aphid resistance into a susceptible Mexican variety Esperanza. In Peru, the variety UNA-94 was reported to have reached 11 t/ha in one small seed increase. The high yields are not restricted to Latin America, since countries like Egypt reported 10.4 t/ha in yield trials conducted under irrigation.

The yield trials conducted in the winter of 1996-97, at the CIANO Experimental Station located in north west of Mexico, were conducted under irrigation where three sowing systems were compared (basin, 2 row-bed and 3-row bed). The plots received a moderate fertilization (150 kg N).

The highest yields at CIANO were found on plots sown on a basin with yields up to 9.3 t/ha, in plots where border effect was eliminated and grain moisture kept at 12 %. The number in parenthesis is a lodging score on scale 1 to 9, where 1 is a cultivar with stiff straw and 9 is a cultivar that lodges badly. The lodging score was lower when cultivars were sown in 2-row on beds, was higher in plots sown with 3-row on beds and the highest when the planting was on a basin (Table 2.66).

Table 2.66. Grain yield (t/ha) and lodging score (in parenthesis) for seven hulled barley cultivars sown in three planting systems (basin, 3-row beds and 2-row beds) at CIANO Experiment Station, Mexico, during the winter of 1996-97.

Cultivar name	Basin	3-row bed	2-row bed
Tocte	6.1 (8)	7.8 (5)	6.7 (3)
Capa/Api/CM67/Mzq/Esperanza/ Quina	9.3 (6)	8.3 (5)	7.1 (4)
" " "	8.2 (6)	8.3 (3)	7.4 (4)
Cln/80.5138/Gloria/Copal/Sen/ Quina	8.2 (9)	8.1 (7)	6.7 (7
" "	8.0 (9)	8.2 (6)	7.4 (4)
Abeto/Gloria/Come/Sen/Mja/ Violeta	8.0 (5)	7.2 (3)	7.1 (3)
Mja/Esperanza/Gloria/Come	7.2 (9)	6.7 (6)	7.1 (3)

The yield trials conducted during the summer at El Batan Experiment Station located at 2,200 meters above sea level, received supplemental irrigation during dry periods, the fertilization used was an split application of 225 kg of N. The objective of the experiment was to study yield potential and lodging resistance on selected hulled and hull-less barley genotypes that in previous trials were identified for their high yield potential.

Despite that El Batan trials were affected by a hail storm that caused a moderate grain loss, specially affecting early maturity genotypes such as the cultivar Tocte 5.7 t/ha in 1997 compared to 8.5 t/ha in 1996.

The hulled barley cultivar Abeto//Gloria/Come/3/Sen /4/Mja/5/Violeta yielded 9.6 t/ha. In the same trial nine cultivars had yields of 9 t/ha or higher. Most of the high yielding lines are six-rowed cultivars with the exception of one cultivar that is a two-rowed type (Roland/Eh11//ESC.II.72.83.3E.7E.5E.1E/ 3/Arupo*2/Abn/4/Aleli). Grain yield and lodging are shown on Table 2.67.

Table 2.67. Grain yield (t/ha) and lodging score of the best hulled cultivars sown at El Batan Experiment Station, Mexico, during the summer of 1997.

Cultivar Name	Yield	Lodging
Abeto//Gloria/Come/3/Sen/4/Mja/5/Violeta	9.6	3
Calicuchima/Quina/2/Sen	9.4	5
Sunfillo/Robust//Quina	9.3	2
Milagrosa/Cardo//Quina	9.1	8
Minn Desc1//Cen/*2Cal92/3/Quina	9.0	3
Roland/EH11//ESC.II.72.83.7E.5E.1E/3/Arupo*2 /Abn/4/Aleli	9.0	6
Rhodes/CI14100//Lignee527/3/CI10622/CI5824/4 /Quina	9.0	1
Cln/80.5138//Gloria/Copal/3/Sen/4/Quina	9.0	4
Tocte/4/Astrix/3/11012.2/Mzq/Cel/5/Cen/*2Cal 92	9.0	1

Barley is the most susceptible among the small grain cereals to lodging, in previous years yield trials received a relative low amount of nitrogen fertilizer to avoid lodging. However, with the identification of Sen, a cultivar resistant to lodging it has been possible to increase the tolerance to lodging among high yielding cultivars, at CIANO with fertilization of 150 kg of N and at El Batan with 225 kg of N the cultivar Abeto//Gloria/Come/3/Sen/4/mja/5/Violeta had relative low lodging scores (3) and only at CIANO when sown a basin had an intermediate score (5).

2.8.1.2. Hull-less Yield Trials

During 1997, at CIANO and El Batan Experiment Stations yield trials were conducted on similar conditions as described for hulled barley, the grain yields obtained with hull-less cultivars reached on both locations record levels 7.4 t/ha for CIANO and 8.3 t/ha for El Batan respectively. However, none of top hull-less cultivars reached the highest grain production obtained with the top hulled cultivars.

Hull-less breeding has some unique traits that needs to be considered, among these the variation among genotypes for their threshing ability, it is important that genotypes thresh free, that is the lemma and palea separates easily for the grain. Canada has set standards for adhering hulls in no more than 15 percent for two reasons: 1) to present a consistent product for the feed industry, and 2) the nutrient value (energy content) decreases with a greater amount of adhering hulls (Hickling, 1995). The cultivars Petunia 1 and 2 (Table 2.68) thresh free in both environments, they had a white grain color that meets the farmer's preference in the Andean region.

Yield trials conducted at El Batan Experiment Station with a split application of a relatively heavy fertilization (225 kg of nitrogen) and with supplemental irrigation produced higher yields than at CIANO. The lower temperatures during the growing cycle at El Batan Experiment Station and the extra fertilization as compared to CIANO (150 kg N) are the main factors to explain the high yields obtained in this location, despite light damage caused by a hail storm. All high yielding hull-less cultivars presented on Table 2.69 are six-rowed types.

Table 2.68. Grain yield (t/ha) and lodging score for seven hull-less barley cultivars compared at three different sowing systems (basin, 2-row beds and 3-row beds) at the CIANO Experiment Station, Mexico during the winter season 1996-97.

Cultivar name	Basin	3-row bed	2-row bed
Rabano/CM67/Cent/Cam/Row906.73/Gloria/Come/Lino	7.4 (4)	6.2 (4)	6.7 (2)
Petunia 1	7.3 (3)	5.9 (2)	6.0 (2)
Petunia 1	7.1 (4)	6.7 (2)	6.8 (2)
Petunia 2	6.6 (3)	6.1 (2)	6.6 (2)
Petunia 2	6.6 (7)	5.6 (7)	5.2 (5)
Petunia 2	6.0 (7)	5.8 (5)	5.3 (4)
Petunia 2	6.0 (3)	6.0 (2)	6.5 (2)

Table 2.69. Grain yield (t/ha) and lodging score for nine hull-less cultivars sown at El Batan Experiment Station during the summer of 1997.

Cultivar name	Yield	Lodging
Zarza/Bermejo/4/DS4931/Gloria/Copal/3/Sen/5/Ayarosa	8.3	6
Petunia 2	8.0	7
Zarza/Bermejo/4/DS4931/Gloria/Copal/3/Sen/5/Ayarosa	7.5	5
Higo/Lino	7.2	3
Petunia 2	7.0	5
Zarza/Bermejo/4/DS4931/Gloria/Copal/3/Sen/5/Ayarosa	7.0	8
CI10590/Cedro//Olmo/5/CM67/Centeno//Cam/3/Row906.73/4/Gloria	6.9	2
Petunia 2	6.9	1
Petunia 1	6.9	4
L.S.D. 0.05	0.3	-

Hull-less barley has a 59% reduction in the content of the toxin Deoxynivalenol (DON) caused by Fusarium6. The reduction is caused by the elimination of hulls at threshing with toxins remaining on the hull. Clears' results indicate the feasibility to use six-rowed barley cultivars in areas of the world where Head Scab caused by Fusarium is a problem. Until now the best resistance sources to Fusarium are two-rowed barley in most countries dealing with the head scab problem. Researchers from INIAP, Ecuador had favorable preliminary information on adaptation to conditions similar to Santa Catalina Experiment Station from several Petunia sister lines, these lines were sown for seed increase at the Chuquipata Experiment Station in southern Ecuador during the off-season to produce seed for more extensive testing in 1998. Petunia sister lines with their high yield potential, relatively large, white colored grain are good candidates to replace Atahualpa, a two-rowed hull-less variety with yield potential of only 5 t/ha.

(H. Vivar)

2.8.1.3. Early Maturity Barley

The grain yield for the top five early maturing barley lines in RCBD with three replications is presented in Table 2.70. The highest yielding cultivar was 6.9 t/ha with 47 days from germination to heading.

Early maturing barley is promoted in several countries as a catch crop. The line Marco/Fragile, an early maturity hooded barley line, has been extensively tested in forage trials in association with ryegrass in several Mexican States. Researchers from ICAMEX have sown three hectares with

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6 Clear, R.M., Patrick, S.K., Mowicki, T., Gaba, D., Edney, M. and Babb, J.C., 1997. The effect of hull removal and pearling on Fusarium species and Trichotheceness in hull-less barley. Can.J. Pl.Sci., 77:161-166.

the line Marco/Fragil for seed increase previous to the release as a Mexican variety.

Hooded lines taller than Marco/Fragil, with large dry matter content were tested at El Batan during the summer of 1997 for forage production in association with Melilotus. Entry CC-20 produced 7.5 tons of dry matter in 78 days. Dry matter production was the result of a relatively dry year, it could be expected an increase in dry matter production in a year with higher precipitation during the early part of the growing season.

Table 2.70. Grain yield t/ha of five early maturing cultivars sown in 2-row bed at El Batan Experiment Station in Mexico, during the summer of 1997.

Cultivar Name	Yield
Agave/Cln//Zarza/4/NC155.77//Matnan/Eh165 /3/Poleo//Brea/D170/5/Cen/2*Cal92	6.9
M9878/Tocte//Cen/2*Cal92	6.7
Abeto/Gloria/Come/3/Sen/4/Motan/SMF7.75.36 //Quibenras/5/ Cent/2*Cal92	5.8
Abeto/Gloria/Come/3/Sen/4/Motan/SMF7.75.36 //Quibenras/5/ Cent/2*Cal92	5.7
Tocte/Encino//Cent/2*Cal92	5.6
L.S.D. 0.05	0.7

In response to request of NARS interested only in two-rowed barley cultivars, a separation between two and six-rowed germplasm was made for the first time at The Batan Experiment Station. A total of 290 two-rowed advanced lines were tested using a Lattice Design 8x8 with 2 replications, each entry was sown on 4,5 meters long plots in two beds (2-rows per bed), the fertilization was 70 kg of N applied previous to planting time. The top yield performers were the checks with an average of 6 t/ha in all five experiments. Advanced lines with yields superior to 4.5 t/ha, resistant to stripe rust, leaf rust and scald will be send internationally in the IBON.

The preliminary yield testing of 232 six-rowed lines in similar conditions as described for the two-rowed types, resulted in the identification of one line with 7.4 t/ha yield. Data from CIANO and El Batan presented in this report, confirmed the limitation on yield expression to a 7 t/ha limit for hulled cultivars and 6 t/ha for hull-less lines when sown in 2-rows beds, none the less, this planting system is useful by reducing lodging and area needed for sowing the yield trials. However, it allows for the identification of high yielding cultivars that later on are tested more carefully.

Hail cause damage at El Batan in 1997, but it was not as severe as the hail storm that destroyed the yield trials in the same experiment Station the year before. At CIANO April high temperature was one degree lower than the long term average, and might have some effect on grain filling. Thirty one yield trials conducted by the Barley Program were planted on land that was recently leveled, the movement of top soil resulted in lower yields. Data reported on Tables 2.66 and 2.68 were obtained by CIMMYT's Agronomist Dr. Ken Sayre in a piece of land that was not leveled.

(H. Vivar)

2.8.2. BYDV Screening

Screening top yielding advanced lines for their reaction to Barley Yellow Dwarf (BYD), using greenhouse reared aphids to inoculate three BYD biotypes MAV, RPV AND PAV under field conditions was conducted at the Toluca Experiment Station.

Fifty six high yielding lines identified at CIANO were selected for field screening during the summer of 1997 at the Toluca Experiment Station, together with two checks (Atlas 57 - susceptible, and Atlas 68 with the Yd2 resistance gene) were sown at two planting dates. Each entry consisted of four plots, one plot was kept as check, free of virus infection by constant insecticide application during the entire growing cycle, and three plots inoculated independently with each biotype. When most entries were at the milk stage they were scored for dwarfing, tiller reduction and yellowing as compared to the check. Seventeen advanced lines were identified as resistant to the virus, from this total 2 were resistant to all three biotypes (MAV-RPV-PAV), 12 to (MAV), 2 to (MAV-PAV), 1 to (RPV-MAV). The six-rowed barley line Abeto/Gloria/Come/3/Sen/4/Mja/5/Violeta had 9.6 t/ha at El Batan Experiment Station and it is resistant to BYD (MAV and PAV), leaf rust, stem rust, stripe rust, scald. It was observed susceptible to bacteria (*Pseudoma*) at CIANO Experiment Station. Roland/EH11//ESC.II.72.83.3E.7E.5E.1E /3/Arupo*2/Abn/4/Aleli, a two-rowed barley line yielded 9.0 t/ha at El Batan Experiment Station. The line in two years screening have shown resistance to BYD biotypes tested under Mexican conditions (MAV-RPV and PAV). The line is resistant to stripe rust, leaf rust, scald but it was identified as susceptible to net blotch at El Batan Experiment Station during the summer of 1997 in plots under artificial inoculation with *Pyrenophora teres*. Crosses addressed to correct the susceptibility to net blotch were made this summer.

The Peruvian variety UNA-94 a high yielding cultivar (11 t/ha) under Peruvian conditions, was found resistant to MAV. In a BYD survey the predominant biotype in Bolivia, Ecuador and Peru was MAV, while in Chile was PAV.

2.8.2.1 Characterization of BYD Resistant Lines

Crosses between winter x spring germplasm are made at the Toluca Experiment Station. during the winter season, In 1996-97 there was a severe natural BYD epidemic in the barley nurseries. Thirty six cultivars were identified tolerant to the virus, these cultivars were sown at two planting dates during the summer and were artificially inoculated with three BYD biotypes at the same Experiment Station.

A total of 33 cultivars were found resistant to the virus, sixteen were resistant to (MAV-RPV-PAV), seven to (MAV-PAV), two to (RPV-MAV) and eight to MAV. The resistant cultivars will be studied by ELISA to detect the virus titres content on shoot and roots on inoculated seedlings grown in the greenhouse. This work is carried out in cooperation of Monique Henry CIMMYT's virologist.

In the two growing seasons at CIANO and Toluca Experiment Stations a major emphasis was made to incorporate BYD resistance in hull-less germplasm, a large number of crosses were made to combine parents with different biotypes resistance.

2.9. Aknowledgements

In addition to core funding, the activities of the barley program are supported by:

OPEC Funds for International Development
The Government of Italy
The Government of the Netherlands
The Government of Denmark
Der Bundesminister für Wirtschaftliche Zusammenarbeit (BMZ)
The International Development Research Centre (IDRC)
The United States Agency for International Development

The financial support of these donors is gratefully aknowledged.

2.10. Entomology

2.10.1. Russian Wheat Aphid

A total of 2332 barley lines were screened in the field at Tel Hadya for resistance to RWA. The promising lines from this field test (score < 3 in the Du Toit scale from 1-6) were also screened in the greenhouse for confirmation. The methods of infestation and evaluation were similar to those described in the wheat section. Five breeding lines from ICARDA and 18 lines from USDA-ARS, Stillwater, Oklahoma, USA showed a very good level of resistance. These lines will be used in the breeding program to develop RWA-resistant varieties.

(M. El Bouhssini, S. Grando, S. Ceccarelli)

2.10.2. Barley Stem Gall Midge

The barley stem gall midge (BSGM), *Mayetiola hordei* Keiffer, is a destructive pest of barley across the Mediterranean region. In Morocco, this insect causes losses in barley grain yield of up to 35% each year. A total of 3270 barley lines from ICARDA have been screened in the greenhouse at INRA (Institut National de la Recherche Agronomique), Settat, Morocco, for resistance to the BSGM. Seeds were sown in rows (ca. 30 seeds per row) in a standard greenhouse flat (54 x 36 x 8 cm) containing a mixture of soil, vermiculite and peat. Flats containing plants at the one leaf-stage were placed under a cheese cloth tent along with infested plants containing mature pupae of Hessian fly. When adults emerged, females were allowed to lay eggs on the seedlings for two days. Plant reactions to larval feeding were determined 20 days after egg hatch. Susceptible and resistant plants were separated on the basis of symptoms. Susceptible plants were stunted and dark green, whereas resistant plants were not stunted and retained their light green color.

The results showed that 30 lines expressed various degrees of tolerance, and one line (1974) was heterogeneous for antibiosis, whereby first instar larvae die after they fed on the resistant plants. This is the first source of resistance, with antibiosis as a mechanism of resistance, identified for this pest. These sources of resistance will be used in the barley-breeding program to develop BSGM-resistant varieties in North Africa.

(S. Lhaloui (INRA, Settat, Morocco), M. El Bouhssini, S. Grando, S. Ceccarelli)

3. DURUM WHEAT IMPROVEMENT

3.1. Durum Breeding

The CIMMYT/ICARDA durum program for the Mediterranean dryland region in 1997 emphasized the upgrading and broadening of the genetic base for abiotic stress tolerance (drought, cold, heat, and terminal stress); biotic stress resistance, particularly for leaf rust and Hessian fly; quality traits, particularly gluten strength and yellow pigment; and for the development of genetic stocks of resistance to different stresses continue to have high priority in the program.

3.1.1. Widening the Genetic Base

To broaden the genetic base of durum, crosses were made with landraces from Turkey, Morocco, Spain, and Greece, and varieties from USA and France, in order to enhance adaptation to Mediterranean drylands, improve resistance to boron toxicity, root rots, grain quality, and yield potential.

The durum x wild relatives hybridization program continues to show promising sources of resistance to biotic and abiotic stresses, particularly to drought and heat stress, leaf rust, and Hessian fly resistance. In the 1997 season, the selection percentage made from crosses/ populations derived from durum x wild relatives was as follows: *T. dicoccoides* (47%), *A. kotschii* (7.9%), *T. monococum* (7.7%), *A. peregrinacylindros* (7.4), *A. vavilovii* (5.9%), *T. carthlicum* (5.4%), *T. urartu* (4.0%), *A. biuncialis* (3.2%), *T. dicoccum* (2.8%), *T. ovata* (2.6%), *T. compactum* (2.5%), *T. polonicum* (1.8%), *A. triuncialis* (0.5%), *A. umbellulata* (0.2%), and *A. squarrosa* (0.2%).

3.1.2. Biotic Stress Resistance

Genetic stocks from the Ibero-Maghreb region for powdery mildew resistance were assembled and used in the crossing program to upgrade the resistance in the drought resistant genotypes. One resistant accession is used as a parent in the mapping population Jennah Khetifa/ Cham 1.

Further, breeding for resistance to biotic stresses in the Continental Mediterranean Dryland has resulted in generating the combination of resistance to yellow rust and common bunt, and incorporation of these resistances in productive dryland genotypes. The progress made in yellow rust resistance is reflected by the high scores for resistance in the advanced test lines: 62.7% of all lines included in the Advanced Durum Yield Trials (ADYT) had less than 5% Average Coefficient of Infection (ACI) for yellow rust. As for common bunt, 12.9% of the test lines had less than 5% infection; the resistant check Haurani had 4.5%. Lines with 0% infection were also identified, these lines were derived from crosses with *Triticum dicoccoides* (Brachoua/*T.dicds*20017//Haucan and crosses of Omrabi/Omguer-4, and Zeina lines).

In the Continental Mediterranean Dryland (Table 3.1), combined resistance to common bunt and yellow is required. Several advanced durum genotypes were developed with 0 % infection for common bunt and with low ACI (<5%) for yellow rust. These genotypes also have good resistance to *Septoria tritici* and leaf rust. The use of *T. dicoccoides* in the hybridization program is to widen the genetic base for yellow rust and *Septoria tritici* resistance.

Resistance to sawfly is required in the Continental Dry Areas of WANA. Several advanced genotypes were identified with a high level of resistance (Table 3.2). All these genotypes surpass in resistance the resistant landrace Haurani. Further, solid stem resistance was also identified among Moroccan landraces. These landraces are being used extensively in the crossing program.

(M.M. Nachit, O.F. Mamluk, M. El-Bouhssini, M. Azrak, A. Asbati)

Table 3.1. Reaction of Advanced Durum Lines to Yellow Rust and Common Bunt.

Disease	Year	Average	Min.	Max.
Yellow rust (ACI)*	1994	4.1	0.2	44.0
	1995	3.7	0.2	55.0
	1996	8.9	1.5	32.0
	1997	7.5	0.1	34
Common bunt (%)	1994	25.6	1.4	66.2
	1995	45.3	23.1	97.5
	1996	20.5	0.0	65.1
	1997	19.5	0.0	60.7

* ACI = Average Coefficient of Infection.

Table 3.2. Resistant durum genotypes to Sawfly.

Cross	Pedigree	Infection (%)
Awalbit	ICD84-0322-ABL-7AP-TR-AP-21AP-OTR	0.3
Rufom	ICD84-1257-8AP-OTR	0.5
Awalbit-6	ICB84-0322-ABL-5AP-TR-AP-151AP-OTR	0.6
Omsnima	ICD85-0538-ABL-TR-9AP-OTR	0.8
Bicre	ICD84-34346-2TR-2AP-1AP-OAP	0.8
Marrout	MICD84-52612-7AP-4AP-0AP	0.8
D-2/Bit	ICD84-20796-4AP-6AP-2AP-0AP	1.1
IC19939 (MA. Landrace		1.7
Rufom-4	ICD84-1257-14AP-TR-13AP-0TR	2.2
IC16143 (MA landrace, Solid stem)		4.4
Haurani		11.7
LSD		2.4

As for the resistance to Hessian fly in the Temperate Dry Areas of WANA, the genetic resistance was incorporated for the first time in durum, by using the resistance gene H5 from SD8036 (a South Dakota bread wheat line, released in Morocco as Saada). The transfer of resistance was made with the cross SD8036/Omtel 1//Awalbit (Table 3.3). From this cross, three lines were identified with resistance above 80%. Further, under dry and terminal stress conditions, their grain yields surpassed Cham 1 and Stork checks in 1996 and 1997. The cross was done in 1991 and selection for resistance was made under field and laboratory conditions. The lines combining resistance with high yield under dry and terminal stress conditions were named Telset: a reference to the sites where the cross for Hessian fly resistance and selection for resistance to drought and terminal stresses were made (Tel=Tel Hadya, ICARDA's main station); and the site where screening for Hessian fly resistance confirmation was made (Settat, INRA-Morocco).

Table 3.3. Durum advanced genotypes combining Hessian fly resistance with heat and drought tolerance, in 1995/96 and 1996/97.

Pedigree	Resistance (%)	Grain Yield 97	Grain Yield 97
35) Telset 1	81	1770	2035
47) Telset 2	94	1866	2330
48) Telset 3	91	1805	2297
Cham 1	0	1377	1560
Stork	0	1293	1470
LSD (0.05)	-	448	567

(M.M. Nachit, N. Nserallah, M. El-Bouhssini, S. Lahlou, A. Asbati, M. Azrak)

During the last decade progress in incorporating and combining resistance to leaf rust been made for leaf rust, while for *Septoria tritici* very the resistance is still lacking (Table 3.4). Durum advanced genotypes from the CIMMYT/ICARDA now show high levels of resistance to leaf rust. The sources of resistance for leaf rust is effective to leaf rust races in WANA and Mexico. These sources of resistance are: Bicre/Guerrou, Cham 1/Brachoua, Outrob, Stj/Mrb3, and DL95. Further, the genotypes Outrob 4 and Outrob 2 combine leaf rust resistance with some resistance/ tolerance to *Septoria tritici*, with an ACI of 1.1 for leaf rust and a score of 3.0 for *Septoria tritici*. In comparison with the checks, Haurani had an ACI for leaf rust of 35.7 and a score of 7.8; Cham 1 of 35.7 and 8; and Cham 3 of 43.0 and 7.8, respectively. *Septoria tritici* usually is not a major constraint in the dry areas, however it is important in the high-rainfall areas of the temperate areas of the Maghreb region. During the last two seasons *Septoria tritici* attack was very high in the high rainfall areas of WANA region.

Table 3.4. Reaction of advanced durum lines to Leaf rust and *Septoria tritici*.

Disease Reaction		Average (ACI)	Min.	Max.
Leaf rust (ACI)	1993/94	25.2	1.5	48.3
	1994/95	20.1	0.4	55.7
	1995/96	23.2	0.7	43.7
	1996/97	18.9	0.3	38.9
*Septoria tritici**	1993/94	3.7	2.0	6.5
	1994/95	3.4	1.5	8.5
	1995/96	7.3	3.0	8.0
	1996/97	7.0	3.0	8.2

Rating is on 1-9 scale (1=very resistant, 9=very susceptible).

(M.M. Nachit, O.F. Mamluk, M. Azrak, A. Asbati)

In 1996/97 season, cold was severe in the Continental Drylands. At Breda, the highest yielding lines were those which combined cold with drought resistance. Several lines were identified which over-yielded Haurani under dryland by almost one ton per hectare (Table 3.5). These results show the continuous progress made during the last decade to improve productivity in dryland.

Table 3.5. Performance (kg/ha) of Durum at Breda during the last 12 years, compared with the check Haurani.

Season	Rainfall (mm)	ADYT Entries		Haurani
		Mean	Max.	
1985/86	218	1224	1697	1014
1986/87	245	1127	2500	1066
1987/88	408	3608	4372	3066
1988/89	186	758	1237	503
1989/90	179	494	1420	695
1990/91	181	930	1248	846
1991/92	270	1324	1936	1150
1992/93	284	2447	3166	2385
1993/94	291	1860	2610	1848
1994/95	244	1345	2269	992
1995/96	332	2231	3497	1849
1996/97	280	1504	2259	1490
Mean	260	1571	2351	1409

The traits most associated with performance under the dryland conditions of 1996/97 was the score for agronomic performance, it explained up to 57.9% of the total variability of grain yield at Breda station. The scores for cold resistance, early growth vigor, and leaf rolling indices were also important in 1996/97 season.

(M.M. Nachit, M. Azrak, A. Asbati, Z. Younes)

3.1.3. Grain Quality

3.1.3.1. Introgression of Quality Genes from *T. dicoccoides*

T. dicoccoides is highly variable for High Molecular Weight (HMW) glutenin subunits encoded at the locus *Glu-A1*. The *T. dicoccoides* alleles at the *Glu-A1, Glu-B1, and Glu-B3* loci are uncommon in durum. The durum x *T. dicoccoides* progenies have allelic variants at *Glu-A1*, *Glu-B1*, *Gli-B1*, and *Glu-B3* loci, which are not usually present in durum. The progenies with the best quality contained the *Glu-A1* (HMW) allele from *T. dicoccoides* and the *Glu-B3* allele (LMW-2) from durum. In the mapping populations Korifla/*T. dicoccoides*//Korifla and Omrabi5/*T.dicoccoides*//Omrabi5, several recombinants were identified with HMW components from dicoccoides and LMW from durum. This material was also identified for dual use for pasta/ burghul/ couscous products and breadmaking.

(M.M. Nachit, I. Elouafi, A. Saleh)

3.1.3.2. Low Molecular Weight (LMW-1 and LMW-2) in Advanced Durum Material

Also 1996/97 results show that more than 90% of the total lines included in the advanced trials targeted to Mediterranean Continental Areas carry strong gluten content (Table 3.6). LMW-2 is highly associated with gluten strength. This high percentage for LMW-2 indicates the progress made in improving the gluten strength in the productive and stress tolerant durum genotypes using PCR-markers.

(M.M. Nachit, M. Labhilili, A. Saleh, I. Elouafi)

Table 3.6. Frequency (%) of DNA LMW 1/LMW 2 in the durum advance lines targeted to Mediterranean Continental Areas (MCA), *1994, 1995, 1996,* and *1997.*

Glutenin type	1994	1995	1996	1997
LMW 1	9.2	6.8	8.6	6.5
LMW 2	90.8	90.7	90.6	91.2
LMW 1 + LMW 2	0.0	2.5	0.8	2.3

As for the Mediterranean temperate dryland, the results showed continuous genetic progress made during the last 4 years in improving gluten strength (Table 3.7).

Table 3.7. Frequency (%) of DNA LMW 1/LMW 2 in the durum advanced lines targeted to Mediterranean Temperate Areas (MTA), 1994, 1995, 1996, 1997.

Glutenin type	1994	1995	1996	1997
LMW 1	30.8	20.8	9.1	6.7
LMW 2	69.3	79.2	89.8	90.3
LMW 1 + LMW 2	0.0	0.0	1.1	3.0

Table 3.8 shows the traits of the grain quality for the Advanced Durum Yield Trials for Continental Areas (ADYT) of 1996/97. The highest values for protein content and sedimentation test (SDS) were achieved under Breda conditions and the lowest under Tel Hadya. Breda has also showed relatively high values for grain quality traits. The largest range for quality traits was also found in this season at Tel Hadya. Therefore, the rain-fed conditions are more adequate to use in the future as selection site for grain quality.

3.1.4. Associations of RFLP-Markers with Grain Yield and Morpho-Physiological Traits under Dryland Conditions, Breda, 1996/97

The associations of RFLP markers with grain yield and some morpho-physiological traits of the Durum Core Collection (DCC, 144 entries) tested under dryland conditions are shown in Table 3.9. Several RFLPs showed strong association with grain yields under Breda environment. In 1996, different RFLPs were found to be associated with dryland yields than in 1997 season. This indicates that the

Table 3.8. Minimum, maximum, and mean of some quality traits for ADYT in Mediterranean severe (Breda) and moderate (Tel Hadya Rain-fed) dry conditions, 1996/97.

Breda

Statistics	Protein content	SDS[1]	SDSi[2]	SDSni[3]	Vitreousness	Yellow pigment	TKW	Ash content
Min	12.8	50.2	2.6	6.5	91.0	1.9	13.0	1.4
Max	20.6	78.5	4.6	15.2	100	8.0	31.1	1.9
Mean	17.4	62.7	3.6	10.9	98.4	4.9	22.4	1.7

Rainfed

Statistics	Protein	SDS[1]	SDSi[2]	SDSni[3]	Vitreousness	Yellow pigment	TKW	Ash Content
Min	9.4	24.5	2.1	2.5	39.5	2.1	15.5	1.5
Max	21.6	66.4	3.5	14.3	100	9.8	40.3	2.1
Mean	12.9	37.6	2.9	5.0	87.4	6.1	28.4	1.8

1) SDS= Sedimentation test, 2) SDIi = SDS-Index (SDS/protein content), 3) SDS-New index = (SDSxProtein content)/100.

Table 3.9. Association of RFLPs with grain yield under Mediterranean Drylands, Breda, 1996/97.

RFLP marker/ Trait	No. of genotypes with		Means of genotypes with		Mean Difference	t-Test
	1	0	1	0		
WG996/4E						
Grain yield	54	86	1430.463	1588.996	-158.534	2.295*
CDO270/5K						
Grain yield	9	131	1784.092	1510.243	273.850	2.435*
BCD348/27A						
Grain yield	120	20	1561.911	1323.466	238.445	2.384*
BCD348/27B						
Cold tolerance	18	122	9.022	8.718	0.304	2.328*
Grain yield	18	122	1362.240	1552.281	-190.041	2.214*
BCD348/27G						
Cold tolerance	74	66	7.236	7.986	-0.750	2.638**
Leaf color	74	66	7.222	8.118	-0.897	3.145**
Plant height	74	66	80.841	87.216	-6.375	2.537*
Grain yield	74	66	1438.302	1628.247	-189.945	2.939**
BCD348/27O						
Leaf roll. P.m	29	111	4.810	5.873	-1.063	2.314*
Grain yield	29	111	1346.672	1575.181	-228.509	2.668**
CDO482/30E						
Grain yield	132	8	1540.131	1325.167	214.965	2.150*
KSUD23/42B						
Grain yield	25	115	1706.220	1489.071	217.149	2.686**
KSUD23/42D						

RFLP marker/ Trait	No. of genotypes with		Means of genotypes with		Mean Difference	t-Test
Grain yield	12	128	1828.111	1499.698	328.413	3.612***
KSUD23/42J						
Grain yield	18	122	1789.796	1489.199	300.597	3.948***
CDO347/43C						
Leaf color	83	57	7.411	7.984	-0.573	2.036*
Cold tolerance	83	57	8.598	8.989	-0.392	2.705**
Heading date	83	57	148.963	150.310	-1.347	2.578**
Leaf roll. Am	83	57	5.998	5.222	0.776	2.104*
Leaf roll. P.m	83	57	5.994	5.156	0.838	2.247*
Maturity date	83	57	177.723	178.614	-0.891	2.302*
Plant height	83	57	81.631	87.072	-5.441	2.074*
Grain yield	83	57	1589.548	1438.003	151.545	2.181*
BCD450/46A						
Cold tolerance	13	127	8.273	7.520	0.753	2.034*
Plant height	13	127	92.740	82.936	9.804	2.002*
Grain yield	13	127	1696.936	1510.539	186.397	2.293*

formation of grain yield in dry areas is under the control of complex physiological pathways that are dependent on annual environmental conditions. Further, some of the RFLP markers were also found to be associated with several morpho-physiological traits. Consequently, the scope for improving dryland yields using molecular markers will require more time and extensive testing. However, the accumulated data will improve the basic understanding for yield formation and development under dryland.

(M.M. Nachit, M. Sorrells, A. Asbati, M. Azrak, A. Saleh, I. Elouafi)

3.1.5. Performance of Crosses Derived from Abiotic Stress Tolerant Genotypes and Wild Relatives

Under terminal stress, several lines derived from crosses between drought resistance x drought resistance and drought resistance x landraces have shown grain yield superiority over the checks. The best material for the drought x heat stress tolerance originated from the material developed for the Mediterranean Temperate Dryland (TD). The highest yielding test entries out-yielded the best checks by more than a half ton/ha (Table 3.10). For terminal stress tolerance, the best parental genotypes are Omrabi 5, Awalbit, and Genil. The largest contribution (%) to grain yield variability was made by date to heading, agronomic score, and plant height, 78.6%, 3.9%, and 2.0%, respectively. There is no doubt that earliness continues to play a major role in durum yields in areas with heat and drought stress.

The durum crosses with the landrace Shihani and *T. dicoccoides* are showing the best performance under drought conditions (Table 3.11). The main contribution (%) to grain yield variability under Continental Dryland were agronomic score (33.5%), cold tolerance (3.6%), early vigor (1.7%), and date to maturing (3.8%).

Table 3.10. Grain Yield (kg/ha) of durum genotypes targeted to Mediterranean Drylands, Tel Hadya, ADYT, 1996/97.

Entry number	Cross/ Name	Grain yield (Kg/ha)
CD301	Gidara	5159
CD224	Sbl1//Khb1/Amareljo de Barba Branco	4789
CD223	Sbl1/Mgr1	4353
TA701	Ossl1/Blrn	4172
CD324	Mrb5/Rfm6	4118
CD203	Sbl/Lhn	3855
CD201	Sbl/Lhn	3816
Checks		
2	Omrabi5	3634
7	Haurani	2946
11	Cham 3	1994
16	Cham 1	2443
22	Massara	3055
	LSD (5%)	411
	CV(%)	11.1

3.1.6. Conclusion

Improved durum germplasm has been generated with the adaptation required for the main target agro-ecological zones. Gene pools for resistance to the constraints encountered in each zone of WANA region were developed with improved resistance to biotic and abiotic stresses and for grain quality.

For the temperate dryland agro-ecological zone, gene pools with resistance to leaf and stem rusts, Hessian fly, tan spot, root rot, and *Septoria tritici* have been generated and these gene pools were distributed to NARSs. Durum nurseries with appropriate adaptation patterns, such as earliness, medium plant height, high tillering capacity, spike fertility, kernel size, grain quality traits, tolerance to drought, heat, and terminal stresses.

Table 3.11. Grain Yield (kg/ha) of durum genotypes targeted to Continental Dryland, Breda, ADYT, 1996/67

Entry number	Cross/ Name	Grain yield (Kg/ha)
CD320	Mrb5/Albit1	2259
CD415	Bcr/3/Ch1//Gta/Stk/4/Bcr/Lks4	2138
CD519	Outrob4	2074
CD315	Awl2/Bit	2053
CD423	Shihani/Brch	2046
CD109	Zeina	2033
TD917	Ossl1//Ru/Mrb15	1975
TD610	Zeina8	1949
TD918	Ossl/Gdfl1	1921
CD117	Brch/*T. dicoccoides*//Hcn	1908
Checks		
2	Omrabi5	1500
7	Haurani	1150
11	Korifla	1236
16	Waha	1670
22	Massara	1485
	LSD (5%)	349
	CV(%)	9.1

Similarly, for the Continental Dryland agro-ecological zone and high altitude areas, the gene pools carrying resistance to yellow rust, wheat stem sawfly, cold, drought, and terminal stress have been developed. Nurseries with appropriate patterns such as early growth vigor, strong tillering and spike fertility, in addition to grain quality parameters have been distributed. Further, socio-economics studies have shown that durum production in high altitude areas is limited. In addition, the material produced for continental areas appears to be adapted to Mediterranean highlands. Therefore, in the future the two nurseries will be emerged.

Further to upgrade NARS capabilities, training and follow-up visits were made. In addition, joint activities with NARSs were developed and later projects were written and presented for donors. Further, interaction among NARSs in different agro-ecological zones were established. The WANADDIN project is now in its third year.

In the future the CIMMYT/ICARDA program will place more emphasis on the abiotic stresses and grain quality, particularly on moisture stress and yield stability; and incorporate jointly with NARS, various resistances into the specific germplasm for the different agro-ecological zones

3.2. Durum Biotechnology

3.2.1. Interspecific Hybridization in Durum Wheat

Some *Aegilops* species possess biotic and abiotic stress resistance genes that are not found in *Triticum durum*. However, *Aegilops* species are not easily crossed with durum wheat. We have tried to obtain hybrids through detached tiller culture with subsequent embryo-rescue.

Five lines of durum wheat; Brachoua, Cham-1, Genil-3, Lahn and Omrabi-5 and one bread wheat variety; AC-pollet were grown in the plastic house. Spikes from different *Aegilops* species were collected from 100 entries of an *Aegilops* collection planted in the field that had previously been screened for resistance to Hessian fly.

Crosses and reciprocal crosses between durum and *Aegilops* were made in the laboratory. Spikes were emasculated in the laboratory. Emasculated spikes were covered with plastic bags and placed in either solution SM or J1. After 2-3 days the plastic bags were removed and the spikes dried and covered with a white paper bag. After 5-10 minutes spikes were pollinated. The spikes used for pollination were collected before or just after sunrise and then transferred to the laboratory. They were placed under a lamp with white fluorescent light until anthers started to dehisce. After pollination the spikes were placed back either in SM and J1, or placed in the solution SMG and J2 (SM and J1 with 2,4D). Solutions were changed every three days. After 10-12 days the spikes placed in SMG and J2 were transferred into SM or J1. Spikes were checked for seed development after 10-12 days. Seeds that developed were opened after +/- 20 days and embryos rescued and cultured on different media (2 MS, 2 MS+, U3, MA, MG, and Re2). The embryos on media were placed in the dark at 25 E C. When the embryo had developed into plantlets with roots and shoot they were placed in the light and after 1 week transferred to 2 MS medium. When plantlets were big enough in size they were transferred to 2 MS in tubes, lateron to sterilized peatmoss and slowly hardened before being transferred to the plastic house. When the putative hybrids developed spikes they were backcrosses with durum originating from the mother plant. When pollen from the putative hybrid was sterile, reciprocal crosses were made. Some spikes of the hybrids are taken to perform immature inflorescence culture to maintain the hybrids. In (Table 3.12) the number of hybrids are listed.

(B. van Dorrestein, M. Baum, M.M. Nachit)

3.3. Durum Entomology

3.3.1. Wheat

3.3.1.1. Russian Wheat Aphid (RWA)

Russian wheat aphid, *Diuraphis noxia* (Mordvilko), causes serious damage to wheat and barley in North Africa and

Ethiopia, mostly in dry years. The aphid injects a toxin into the plant that destroys the chloroplast membrane, causing longitudinal chlorotic streaks to develop. Host plant resistance is the most practical and economical means of controlling this pest.

Table 3.12. Successful crosses between *Durum* and *Aegilops*

Female Parent	Male Parent	No.of Plants
AC-pollet	*Ae.triuncialis*	2
AC-pollet (25A)	*Ae. triuncialis* (46)	7
AC-pollet (36)	*Ae. triuncialis* (60)	2
Cham-1 (15)	*Ae. caudata* (7)	1
Genil-3	*Ae. biuncialis* 400984 (1)	2
Genil-3	*Ae. geniculata* 401657 (99)	3
Genil-3	*Ae. ovata* (49)	2
Genil-3 (5)	*Ae. triuncialis* 400221(95)	4
Genil-3 (5B)	*Ae. speltoides* (83)	1
Lahn	*Ae. ovata* 89E 150 (89)	1
Omrabi-5 (71B)	*Ae. speltoides* 400081 (83)	2
Ae. caudata (7)	APCB 88	7
Ae. ovata (69)	APCB 85	2
Ae. ovata (69)	APCB 90	4
Ae. ovata (69)	APCB 10APCB 100	6
Ae. ovata (70)	APCB 11APCB 112	3
Ae. ovata 88E211(67)	APCB 98APCB 98	11
Ae. triaristata (67)	APCB 98	7
Ae. triaristata (67)	APCB 100	1
Ae. triuncialis (24)	APCB 25	3
Ae. triuncialis (46)	APCB 86	2
Ae. triuncialis (16)	APCB 90	3
Ae. triuncialis (46)	APCB 91	20
Ae. Triuncialis (16)	APCB 92	1
Ae. triuncialis (24)	APCB 92	12
Ae. triuncialis (26)	APCB 98	4
Ae. triuncialis (24)	APCB 102	34
Total no. of plants		147

3.3.1.1.1. Screening for Resistance

A total of 585 lines of winter wheat, 117 of spring bread wheat and 432 of durum wheat were screened in the field at Tel Hadya for resistance to RWA. The entries were planted in hill plots, 10 seeds/ hill in a randomized complete block design with 2 replications. One susceptible check for each crop species was used every 10 entries. This field experiment was infested at tillering stage with about 10 aphids per plant using an aphid Pazoka. The evaluation was done three times at three weeks intervals using DuToit scale from 1-6, where 1=small isolated chlorotic spots on the leaves and 6=severe white/yellow streaks and tightly rolled leaves. The promising lines (score < 3) were also tested under artificial infestation in the greenhouse for confirmation. The method of infestation and evaluation was similar to that of the field, except that only two aphids per plant were used for the infestation.

The results showed that 2 durum wheat lines and 14 accessions of *Aegilops* and *Triticum* from CIMMYT/ICARDA durum wheat breeding program, 2 bread wheat lines from ICARDA winter wheat breeding program, 2 bread wheat and 2 durum wheat lines from Kansas State University showed good level of resistance (score < 3 in the Du Toit scale). These sources of resistance will be used in the breeding program to develop RWA-resistant varieties.

(M. El-Bouhssini, M.M. Nachit, H. Ketata, G. Ortiz-Ferrara, I. Ghannoum)

3.3.1.1.2. Study of Mechanisms of Resistance to RWA in Durum Wheat and *Aegilops* spp.

Two durum wheat lines and three accessions of *Aegilops* that were identified as resistant to RWA were studied for their mechanisms of resistance (antibiosis, antixenosis and tolerance). The antibiosis test consisted of assessing the reproductive rate of RWA on the resistant genotypes compared to a susceptible check. Nymphs produced from a single adult reared on a single plant were counted daily until the aphid stops reproducing. The antixenosis or nonpreference test consisted of determining which of the genotypes is the most preferred host. The entries including the susceptible check were planted in equidistant hills in a circular pattern in a 28-cm diameter pots. 60 aphids (10/plant) were placed in the middle of the pot, and after 24, 48 and 72 hours the number of aphids per plant was recorded. The tolerance test was similar to the antibiosis test, except that a set of control plants was kept uninfested as control for each entry. Also each entry was infested with 10 adults, a level which was maintained throughout the test period (30 days). Three parameters were measured, the degree of damage by the aphid, plant height and dry weight.

The results showed *significant differences among* genotypes in antibiosis, antixenosis and tolerance. However, antibiosis and antixenosis were the two most important mechanisms in the resistant accessions (Tables 3.13, 3.14 & 3.15). It was also interesting to note that some of the lines combine two mechanisms, antibiosis and tolerance. This information is very useful for the management of resistance genes. Sources of resistance combining different mechanisms should be used in breeding for resistance to insects, as these should slow down biotype development.

(I. Ghannoum, M. El-Bouhssini, M.M. Nachit)

3.3.1.1.3. Genetic Variation among Populations of Russian Wheat Aphid

The genetic variation prevailing among populations of Russian wheat aphid (*Diuraphis noxia* Mordvilko) from Syria,

Table 3.13. Fecundity, life span of RWA on durum wheat lines and *Aegilops* accessions

Entry	Fecundity	Life span (days)
A. biuncialis 400004	4.2 a	13.7
Haucan/Ae.400020//Omtel-1/3/Omlahn-3	26.6 b	24.6
RSP car	33.0 bc	26.6
A. ovata 401650	29.5 b	25.5
Korifla (Susceptible check)	54.1 c	30.6
LSD (0.01)	21.7	

Table 3.14. Antixenosis effect of durum wheat lines and *Aegilops* accessions on RWA.

Entry	24 hours	48 hours	72 hours
A.biuncialis 400004	11.7 b	9.0 b	4.9 ab
Haucan/Ae.400020//Omtel-1/3/Omlahn-3	4.6 a	4.2 a	4.3 a
RSP car	10.3 b	9.7 b	8.9 bc
A. ovata 401650	7.4 ab	7.6 ab	7.5 abc
Korifla (Susceptible check)	11.2 b	10.7 b	11.8 c
LSD (0.05)	4.3	4.6	4.3

Lebanon, Morocco and USA were assessed using RAPD-PCR technique. A total of 42 different primers of arbitrary nucleotide sequence were used to amplify DNA segments (genetic fingerprints) from the genomic DNA (bulk of 25 individuals each) of 11 aphid populations (10 of RWA and one of *Metopolophium dirhodum* Walker).

Out of these 42 primers, only 21 (50%) primers gave reproducible and satisfactory amplification of the PCR products (107 loci) among the 11 populations. Polymorphism revealed by different primers also varied greatly (Fig.3.1 & 3.2).

The genetic distance ranged from 0.016 (between USA and Morocco) to 1.621 (between Haush Harim, and Kfardan in Lebanon). In general, higher genetic distance was estimated

Table 3.15. Damage score and percent loss in plant height and dry weight of durum wheat and *Aegilops* accessions, due to RWA feeding.

Entry	Plant height			Dry weight			Damage score
	Infested	Non Infested	% loss	Infested	Non infested	% loss	
A. biuncialis 400004	12	16	25.0	0.28	0.38	26.3	1.4
Haucan/Ae.400020//Omtel-1/3/Omlahn-3	21	30	30.0	0.47	0.71	33.8	2.2
RSP car	25	37	32.4	0.43	0.85	49.4	2.5
A. ovata 401650	10	13	23.0	0.33	0.42	21.4	1.4
Korifla (Susceptible check)	20	28	28.5	0.50	0.69	27.5	2.9

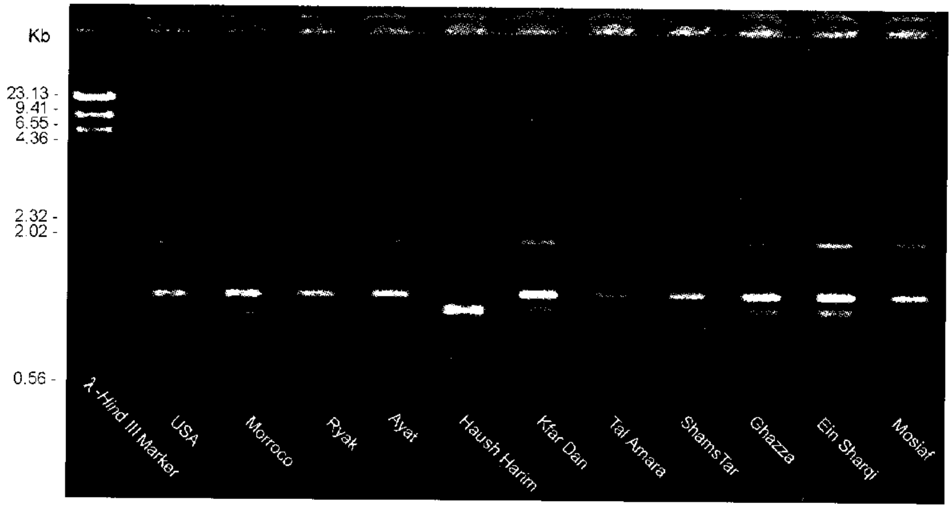


Fig. 3.1. RAPD-PCR analysis of RWA populations with primer, OPC-14.

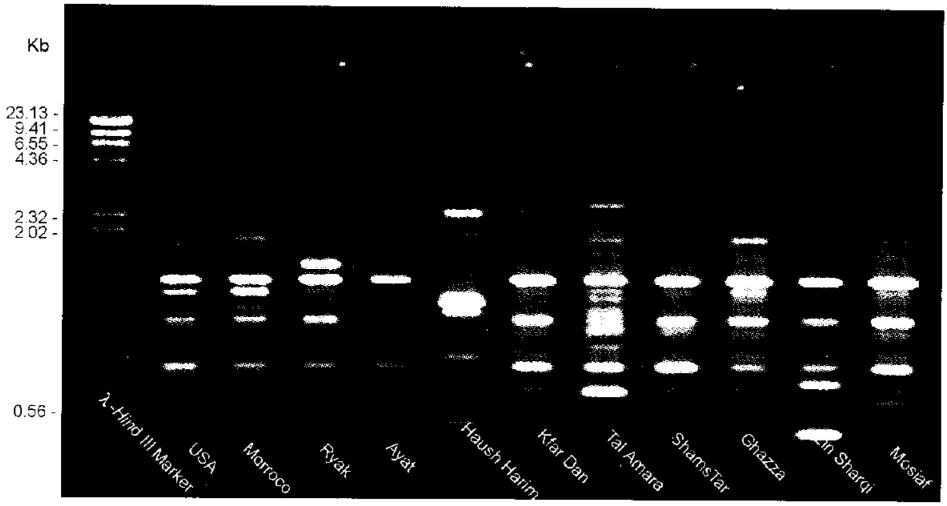


Fig. 3.2. RAPD-PCR analysis of RWA populations with primer, OPC-6.

between *M. dirhodum* population and the rest of the RWA populations (the genetic distance ranged from 1.404 to 1.621). No correlation between genetic distance and geographical distance was observed.

Genetic relatedness among the populations was determined by cluster analysis (both UPGMA and NJM) based on the genetic distances. The analysis grouped the populations into 11 distinct clusters (genotypes). The population of Haush Harim, Lebanon (*M. dirhodum*) clearly out-lied from the other RWA populations. At 75% similarity levels, all the populations could be classified into 9 groups; the populations from Lebanon formed 4 groups, from that of Syria two groups, and the population from USA and Morocco formed two groups. *M. dirhodum* population formed a separate group. Distribution map of different genotypes of RWA along with their biotypes will help in deployment of suitable resistant cultivars.

(I. Ghannoum, M. El-Bouhssini, M.M. Nachit, S.M. Udupa, M. Baum)

3.3.1.2. Hessian Fly

Hessian fly, *Mayetiola destructor* (say), is the most destructive pest of wheat in North Africa. In Morocco, yield losses due to this pest have been estimated at 32% and 36% for durum wheat and bread wheat respectively.

RAPD-PCR technique was used to study genetic variation within and among geographical populations of the Hessian fly, *Mayetiola destructor* (Say), from Morocco (5 populations) and Syria (one population). RAPD-PCR analysis could distinguish all 10 individuals from each of the population, indicating very high degree of genetic variability within the populations. However, the extent of genetic variability within the populations varied (Fig.3.3).

To study genetic variability among the populations, bulking strategy (20 individuals per population) was used. RAPD-PCR analysis with these bulks revealed population specific DNA fingerprints. Based on these DNA fingerprints, Nei's genetic distance was estimated.

The genetic distance ranged from 0.156 (between Abda and B.Mellal) to 1.977 (between Marchouch and Syria). Cluster analysis of the genetic distances among the populations identified the Syrian population as an outlier population. A highly significant correlation (r=0.81) was observed between the genetic distance and geographic distance among the populations. This result and cluster analysis, indicate dispersion of this insect from Syria to Morocco.

There was also a significant difference across locations in the level of virulence to the resistance genes H5, H13 and H22. The level of virulence to H13 was high in Abda, Marchouch and Beni Mellal and low in the other locations, whereas virulence to H22 gene was high in Fes and Marchouch and low in the other locations (Table 3.16). The existence of genetic variation among and within Hessian fly populations as revealed by RAPD analysis, and the difference in the level of virulence detected in the different locations of Morocco using the differentials show the potential of biotype development once resistant cultivars are deployed in large scale. Thus additional sources of resistance will be needed to stay ahead of biotype development.

(N. Naber (University of El Jadida, Morocco), M. El-Bouhssini, M. Labhilili, S.M. Udupa, M.M. Nachit, M. Baum, S. Lhaloui (INRA, Settat, Morocco))

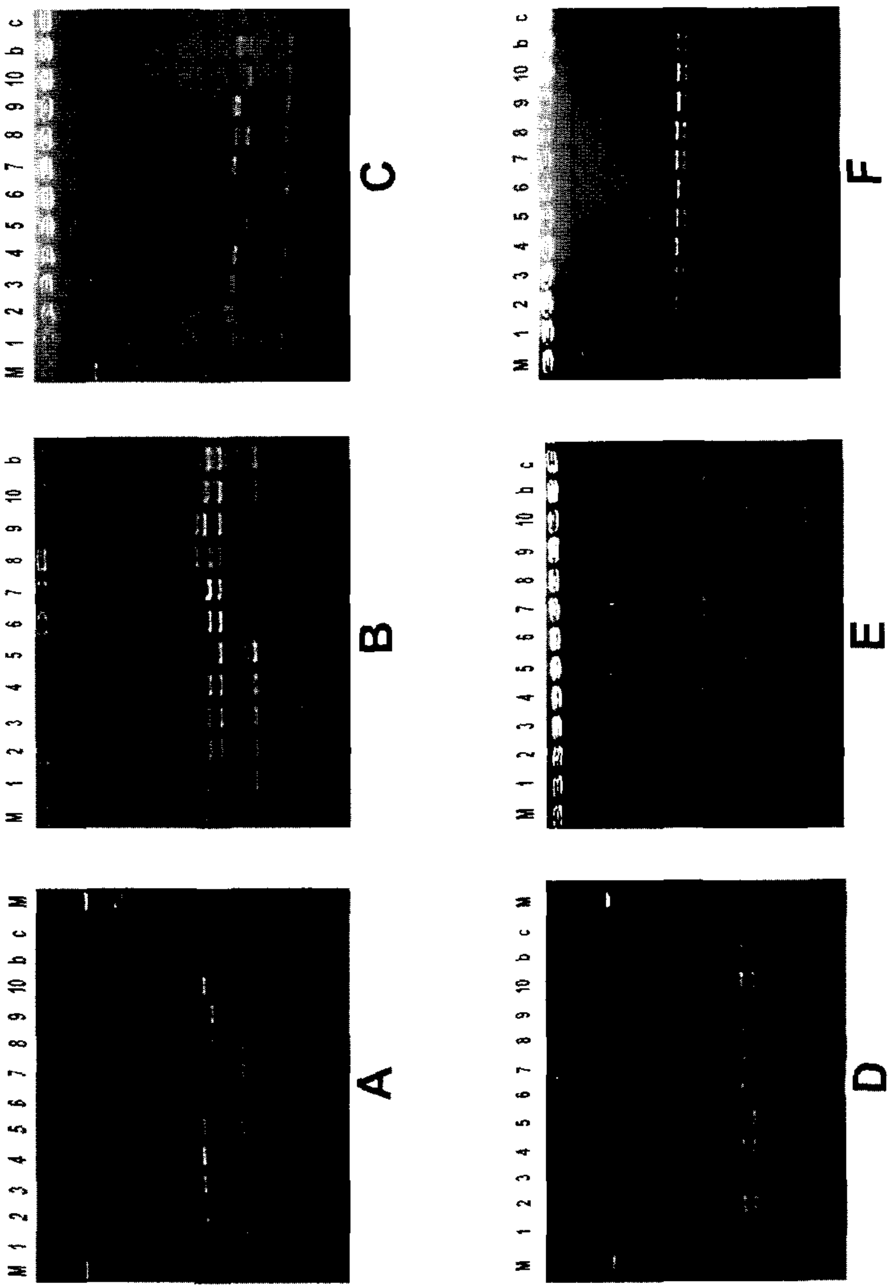


Fig. 3.3. RAPD-PCR analysis of Hessian fly populations from Morocco and Syria by operon primer OPKI. A: Marchouch, B.Fes, C: Abda, D: Eeni Mellal, E: Chaouia, F: Syria. Lanl: bulk of 20 insects, lanes 2-11: are individual insects, c: is blank and M: lambda DNA molecular marker III

Table 3.16. Field reaction of the resistance genes H5, H13 and H22 for resistance to the Hessian fly in 5 locations in Morocco.

Plant genotype	Resistance genes	Percent resistant plants				
		Chaouia	Fes	Abda	Marchouch	BeniMellal
Saada	H5	67.1 Aa	90.0 Aa	80.3 Aa	90.0 Aa	82.4 Aa
KS89H98	H13	79.8 Aa	90.0 Aa	60.7 Ba	58.7 Ba	58.8 Ab
BT1615*3//14-2	H22	79.1 Aa	57.6 Bc	90.0 Aa	61.5 Bc	90.0 Ba
Nasma(Susc. Check)		14.7 Ba	0.0 Ca	12.7 Ca	10.6 Ca	0.0 Ca

Means followed by the same letter in horizontal rows (lower case) and in columns (upper case) are not significantly different (P=0.05; LSD).

3.3.1.3. Sunn Pest

Sunn pest is one of the most serious pests of wheat and barley in West Asia, where over US$ 42 million is spent annually for its control. Yield loss from its damage is commonly estimated at 20-30% in barley and 50-90% in wheat.

Several parasitized egg masses of Sunn pest (*Eurygaster integriceps* Puton) were collected from Ghab and Hassakeh regions in Syria. 84% of the eggs hatched, and 91% of the adult parasitoids were females. Some biological parameters of these adult parasitoids were studied under laboratory condition (23°C, 60-70% Humidity and a photoperiod of 16:8 (L: D) h. The results showed that the life span of the female is 19 days. On average, one female parasitized 111 eggs of Sunn pest. The percent egg hatch was 84%, and the generation time was 15.2 and 17.6 days respectively for the male and the female.

We also reared these parasitoids on eggs of two alternate hosts, *Nezara viridula* and *Dolycoris baccarum*. The percent parasitism of the *Nezara* eggs was 78%, however, none of the parasitized eggs hatched. On the other hand, the percent parasitism of *Dolycoris* eggs as well as the egg hatch was 100%. These results are very encouraging, and show the potential of mass rearing Sunn pest parasitoids and release them when the pest arrives to wheat fields and starts laying eggs.

Adult parasitoids from 7 populations collected from different regions in Syria were sent to France (Laboratoire de Lutte Biologique, INRA, Lyon) and British museum for species identification. We also made crosses and reciprocal crosses between adults of the Iranian parasitoid, *Trissolcus grandis* Thomson, and adults of one Syrian population. The mating occurred between the adults of the two populations, and fertile eggs were produced. On average, the percent egg hatch was respectively 92% and 77%

from the cross and the reciprocal cross between the Syrian female and the Iranian male. These results indicate that the Syrian population belongs to the same species as that of Iran, which is *Trissolcus grandis* Thomson. Results of the identification by the British museum and INRA France also confirmed that it is *Trissolcus grandis*.

(M. Abdel Lhay, M. El-Bouhssini, A. Babi, N. Al-Salti (University of Aleppo, Syria))

4. SPRING BREAD WHEAT IMPROVEMENT

4.1. Spring Bread Wheat Breeding

4.1.1. Introduction

The Project is evolving and has gone recently through budget and manpower reductions. Based on these constraints, and on research experiences obtained so far, the Project has further focussed its long-term and short-term objectives. In this report we present updated data highlighting the importance of the crop, the Project's current refined breeding methodology, results of international testing and interaction with NARS.

(G. Ortiz Ferrara, O.S. Abdalla)

4.1.2. Importance of Bread Wheat in WANA

Nearly one-third of the area planted to bread wheat in developing countries is located in marginal environments characterized by frequent drought stress during the growing season. Although marginal environments are widely distributed across the developing world, most of these areas are concentrated in West Asia and North Africa (WANA) region. It is estimated that about 50 % of the total dryland wheat area in developing countries is located in the WANA region.

In WANA, bread wheat is the principal food source for the majority of the population where average consumption is about 185 kg/capita/year, the highest consumption in the world. This crop provides over half the calories consumed by people in the region and sometimes half the protein of their daily diet. However, total wheat production in WANA is highly variable and it is generally low and does not meet the increasing demand. In partnership with NARS, the joint CIMMYT/ICARDA wheat program has made major efforts to increase the productivity of wheat in WANA. Nonetheless, at the farm level average yields are low due to several production constraints, including many abiotic and biotic stresses. In fact, with the exception of a few, most countries in WANA are net importers of bread wheat, even in the best production years, and this trend is on the rise. Thus the importance of bread wheat in the diet and the economy of West Asia and North Africa cannot be under-estimated.

(G. Ortiz Ferrara, O.S. Abdalla)

4.1.3. Wheat Production Environments in WANA

In WANA, bread wheat is grown in three different agroclimatic zones based on moisture availability and temperature regimes. These are:

1. Areas of low rainfall associated with low temperatures (LRT, annual rainfall <400 mm).
2. Areas of moderate rainfall with moderate to high temperatures (MRT, annual rainfall between 400-500 mm); and,
3. Irrigated areas.

In WANA, bread wheat is grown and harvested where both rainfall and temperatures fluctuate significantly. Typically, the crop is sown in the fall, where its early growth and development occurs during the coolest months under adequate moisture and grain ripening occurs under drought stress during the warmest months. In addition to drought stress, extreme temperatures, cold and heat, are common abiotic stress factors during the cropping season.

Frequently a complex interaction between temperature and moisture deficit develops. In addition to the abiotic stresses mentioned above, biotic stresses, such as disease and insect pests, are also important constraints of wheat production in the region.

The joint CIMMYT/ICARDA Spring Bread Wheat Project emphasizes research for the dry areas (zones 1 and 2), while CIMMYT-Mexico concentrates in developing germplasm and technologies for the more optimum environments of the region. These include irrigated and high rainfall (>500 mm annual rainfall) areas.

Grain yield and yield stability, in addition to disease and pests resistance, are the most important factors to consider in developing germplasm adapted to Zone 1 (low rainfall associated with low temperature). On the other hand, yield potential and disease resistance are important factors responsible for wheat adaptation in Zone 2 (moderate rainfall with moderate to high temperatures).

(G. Ortiz Ferrara, O.S. Abdalla, M. Asaad Mousa, A. Yaljarouka)

4.1.4. Breeding Methodology

A refined breeding methodology has been developed by the joint CIMMYT/ICARDA Spring Bread Wheat Project to enable it achieve its goals. The methodology emphasizes increased use of multilocation testing, targeting of germplasm to where the product is intended, and selective use of wild progenitors and landraces. In addition to conventional breeding methodologies, the project makes efficient use of the new biotechnological tools as well.

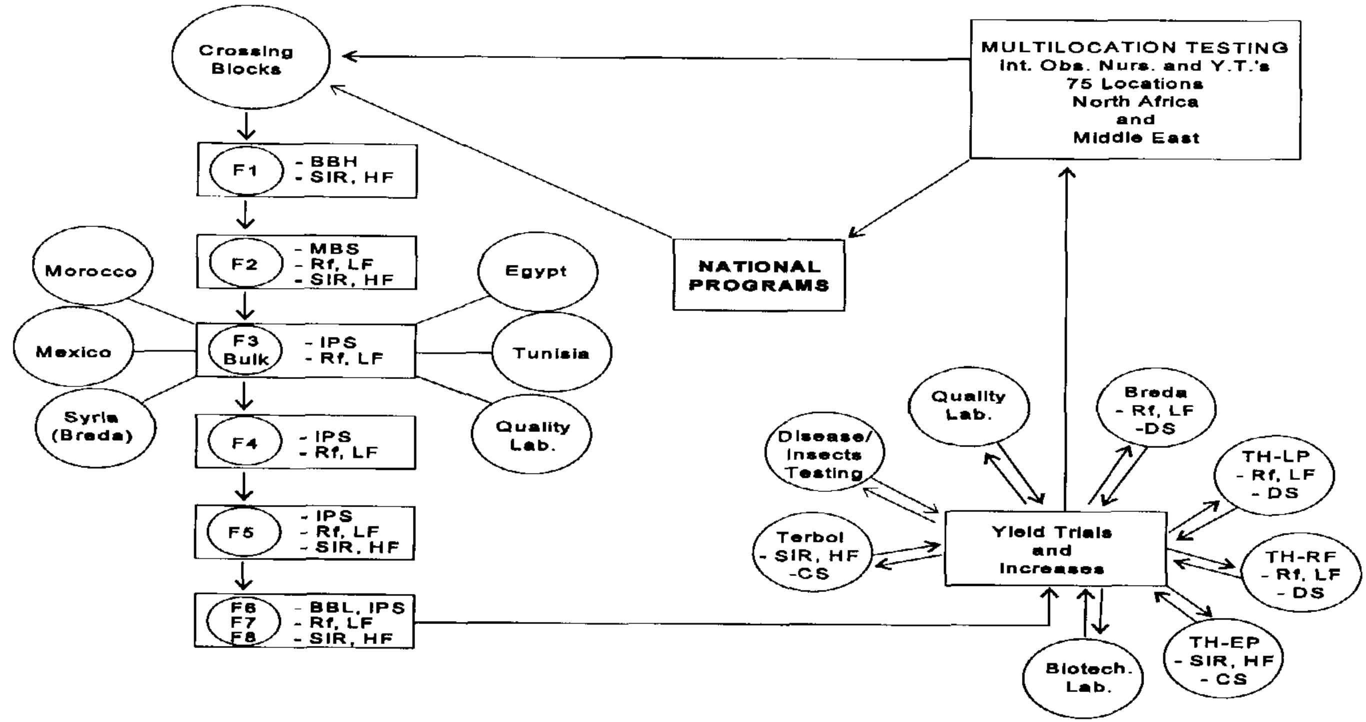
The project focuses its research to breeding and identifying parental material possessing high grain yield and stability, with tolerance to abiotic stresses such as terminal drought, cold and terminal heat, and to biotic stresses such as yellow rust, Septoria blotch, barley yellow dwarf (caused by BYDV), common bunt, sawfly, Hessian fly, Sunn pest and aphids. The project's approach has been to combine high yielding and stable germplasm with donors of other important traits to produce the desired genotypes.

High grain yield and yield stability over years and locations are important characteristics needed in the rainfed areas of the region. Such traits are developed through the application of the following strategies:

a) Continuous evaluation of potential parents.
b) Targeted crossing program.
c) Multilocation testing and selection, and
d) Targeted distribution of improved germplasm to national programs in the region.

The above strategies are visualized in Figure 4.1, where the overall breeding methodology of the joint CIMMYT/ICARDA Spring Bread Wheat Project is presented. The philosophy behind this approach reflects the project's interest in improving crop production under a wide range of growing conditions by developing and identifying high yielding and stable cultivars. Of course, within this breeding context, the project emphasizes site-specific breeding activities. The orientation of these special efforts, however, is always towards overcoming one or more limiting environmental factors by incorporating into adapted germplasm the specific genetic traits needed to further improve its performance in certain locations, i.e. terminal drought and/or cold tolerance, disease resistance, insect pest tolerance, etc.

(G. Ortiz Ferrara, NARS Collaborators, M.Asaad Mousa, A. Yaljarouka, S.K. Yau, H. Rahme, K. Makkouk, M. Baum, M. El Bouhssini, and F.J. El Haramein)



BBH = Bulk Best Hybrids
SIR = Supplementary Irrigation
HF = High Fertility
MBS = Modified Bulk Selection

LF = Low Fertility
IPS = Individual Plant Selection
BBL = Bulk Best Lines
LP = Late Planting
Rf = Rainfed

EP = Early Planting
DS = Drought Stress
HS = Heat Stress
CS = Cold Stress
TH = Tel Hadya

Fig. 4.1. Breeding methodology of the CIMMYT/ICARDA spring bread wheat improvement program for the dryland areas of WANA.

4.1.5. Multilocation Testing and Selection

Multilocation testing is the main strategy followed by CIMMYT/ICARDA Spring Wheat Project for the identification and selection of germplasm adapted to the different agroclimatic conditions in WANA. Multilocation testing exposes the germplasm to a wide range of pathotypes of the prevailing diseases in the region and hence enhances the level of disease resistance. Similarly, if exposes the germplasm to the variable abiotic stresses prevailing in the region. Multilocation testing is carried out at the regional level (mainly at ICARDA's experimental stations at Tel Hadya, Breda and Terbol) as well as international level.

4.1.5.1. Results of Advance Yield Trials

In 1997/98 season a total of four trials each of Advance Wheat Yield Trial-Favorable Areas (AWYT-FA) and Advance Wheat Yield Trial-Semi-Arid (AWYT-SA) were conducted at ICARDA main research stations at Tel Hadya and Breda in Syria, and Terbol station in Lebanon. The objective of these trials was to identify superior candidates for Regional Wheat Observation Nursery (WON) that is distributed to NARS in WANA region. The test stations used represent a gradient in moisture and temperature stresses. Breda represents continental areas with sever drought (long-term average rainfall 283 mm) and cold stress, Tel Hadya is moderately dry (long-term average rainfall 342 mm) and cold, while Terbol represents moderate/high rainfall (long-term average rainfall 450 mm) and cool temperature. Table 4.1 lists some of the top yielding lines in AWYT-FA and AWYT-SA and shows their grain yield performance relative to the checks.

(G. Ortiz Ferrara, O.S. Abdalla, M. Asaad Mousa, A. Yaljarouka)

Table 4.1. High Yielding Lines from Advance Wheat Yield Trials (AWYT), Terbol and Breda, 1996/97.

Nursery / Entry	Name / Pedigree	MYLD* (kg/ha)	Yld % Check-1
AWYT-FA 1996/97			
205	CHAM 4/SHUHA'S'	5417	110
223	MAYON//CROW'S'/VEE'S'	5217	106
212	DOVIN-1	5167	105
117	W3918A/JUP//SHUHA'S'	5167	105
416	W3918A/JUP//TRT'S'	5117	104
420	TSI/VEE#5//KAUZ'S'	5117	104
		MYLD** (kg/ha)	Yld % Check-2
AWYT-SA 1996/97			
410	KASYON/GENARO 81//CHAM 4	2208	130
218	TSI/VEE#5//CROW'S'/VEE'S'	2058	121
418	W3918A/JUP//SHUHA'S'	1959	115
423	TSI/VEE#5//KAUZ'S'	1934	114
113	AO41/EMU'S'//TSI/VEE#5	1917	113

FA= Favorable Areas, SA = Semi-Arid; MYLD* = Mean Yield in Terbol; MYLD**=Mean Yield in Breda; Check-1 = Cham-4, Check-2 = Cham-6.

4.1.5.2. Results of Regional Wheat Observation Nurseries (WON)

This activity is coordinated by the international nurseries and is carried out in collaboration with NARS.

Table 4.2 lists promising bread wheat lines from Wheat Observation Nursery for Semi-arid Areas (WON-SA), 1996/97, that were selected in 33% to 43% of the test sties. Higher frequency of selection is an indication of wide adaptation. The yield presented in the Table 4.2 is from small unreplicated plots and therefore the data should be considered with caution. However, the higher the number of test sites used give some degree of confidence in the results. Similarly, Table 4.3 lists promising bread wheat

Table 4.2. Mean Grain Yield and Frequency of Selection in 21 Sites, Wheat Observation Nursery for Semi-arid Areas (WON-SA); 1996/97.

WON-SA 1996/97 ENTRY #	Name / Pedigree	Selection Frequency	Yield (kg/ha)
10	Pvn'S'/Sprw'S'	9	3819
99	Vee'S'/Tsi/6/21931/3/Ch53/An//Gbs/4/An64/5/Iwp501	9	3938
98	KAUZ'S'/657CI.23R-3-6-2-2-1-2	7	3957
137	Maya74'S'/On//II60.147/3/Bb/Gll/4/Chat'S'/5/Crow'S'/Vee'S'	7	3912
65	C182.24/C168.3/3/Cno*2/7c//Cc/Tob/4/Bage/Hork//Aldan	7	3637
23	Irena	7	3339

Table 4.3. Mean Grain Yield and Frequency of Selection in 15 Sites, Wheat Observation Nursery for Favorable Areas (WON-FA); 1996/97.

WON-FA 1996/97 ENTRY #	Name / Pedigree	Selection Frequency	Yield (kg/ha)
61	Tsi/Vee#5'S'//Vee's'/Pvn'S'	7	5377
112	Mayon//Crow'S'/Vee'S'	7	5099
2	Bocro-6	6	5213
63	Shouha's'/Seri 82	6	4944
21	Glen//Maya/Nac	6	4855
32	Myna/Vul//Turaco/3/Turaco	6	4663
4	Dovin-1	6	4585
14	Fong Chan#3/Trt'S'//Vee#9/3/Cook/Vee'S'//Dove'S'/Seri	6	4188

lines from Wheat Observation Nursery for Favorable Areas (WON-FA), 1996/97, that were selected in 45% to 47% of the test sites. Promising lines identified from such multi-site nurseries, constitute potential are considered as candidates for further testing in regional replicated yield trials.

(G. Ortiz Ferrara, O.S. Abdalla, M. Asaad Mousa, A. Yaljarouka, NARS Collaborators, Outreach Staff)

4.1.6. Yield Stability and Adaptation in the Mediterranean Drylands

4.1.6.1. Results of Regional Bread Wheat Yield Trial, Semi-Arid Areas (RWYT-SA)

The main goal of CIMMYT/ICARDA Spring Bread Wheat Program for the WANA Region is to enhance the adaptation and productivity of the crop in dry areas of WANA to meet food security demands of the region. In achieving this goal, through close partnership with NARS in WANA, the program also aims at supporting resource-poor farmers in the region, protecting the environment and strengthening collaboration NARS.

To achieve its goal the spring bread wheat improvement program provides NARS in WANA with germplasm sets that combine high yield potential with biotic and abiotic stress resistance that are specifically targeted to the Mediterranean drylands. The semi-arid areas (SA) set was targeted for rainfed environments with low rainfall (annual rainfall 250-400 mm) and relatively low winter temperatures. Germplasm targeted to such areas combine drought tolerance, cold tolerance and high yield potential. The major biotic stresses in such areas include yellow rust, common bunt, Hessian fly and wheat stem sawfly.

Results of regional yield trials give a good indication about the adaptation of CIMMYT/ICARDA germplasm in WANA region. Figure 4.2 summarizes the results of the Regional Bread Wheat Yield Trial for Semi-arid Areas (RWYT-SA), 1995/96. The trial was conducted in 1995/96 season, but the results from cooperators were compiled and analyzed in 1997. Figure 4.2 presents the mean yield of the three top-yielding cultivars in each test site, expressed as a percentage of the local check yield, across all locations of the Regional Bread Wheat Yield Trial for Semi-arid Areas (RWYT-SA), 1995/96. The local check performance is indicative of site-specific adaptation. The results show that the three top-yielding cultivars derived from CIMMYT/ICARDA germplasm yielded more than the locally adapted checks across test sites ranging in yield from 385 kg/ha (AF05= Jalalabad, Afghanistan) to 3228 kg/ha (SY11= Tel Hadya, Syria). The three top-yielding cultivars exhibited mean yield advantage ranging from 13% in Hassakeh, Syria (SY72) to 73% in Barani, Pakistan (PA08). These results indicate that CIMMYT/ICARDA spring bread wheat improvement program has been successful in providing NARS in WANA semi-arid areas with adapted high-yielding germplasm with potential for release as new varieties to enhance wheat production.

Figure 4.3 shows grain yield response of the cultivar "Tracha-1", entry no. 15, across the 15 test sites of the Regional Bread Wheat Yield Trial for Semi-arid Areas (RWYT-SA) 1995/96. "Tracha-1" mean yield was regressed over site mean yield across all semi-arid locations used in the trial. At most sites, the yield of "Tracha-1" was higher than the site mean yield. This shows that "Tracha-1" combine high yield potential and wide adaptation and as a consequence, yield stability, a feature common in many cultivars derived from CIMMYT/ICARDA germplasm.

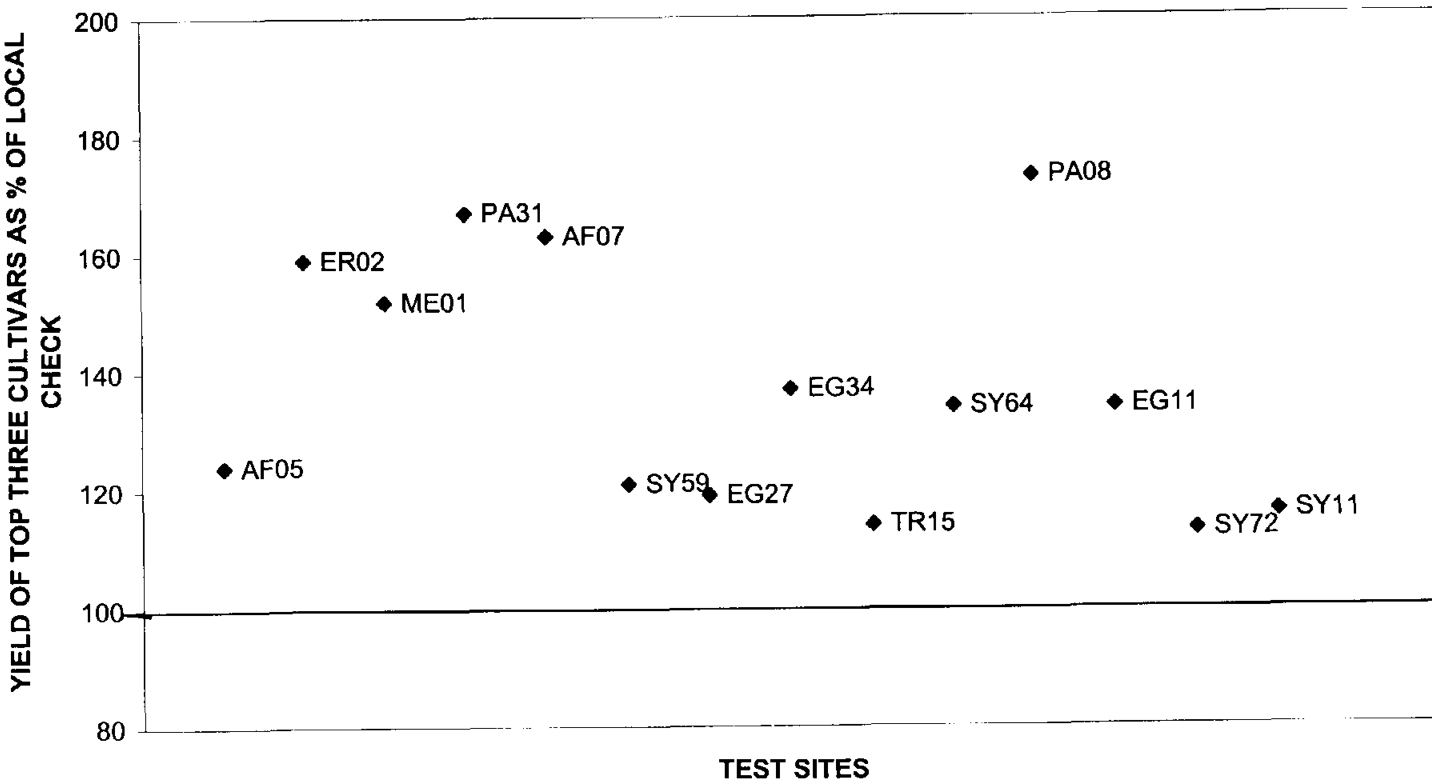


Fig. 4.2. Performance of the three top-yielding cultivars relative to the local checks in Semi-arid areas of WANA, RWYT-SA, 1995/96.

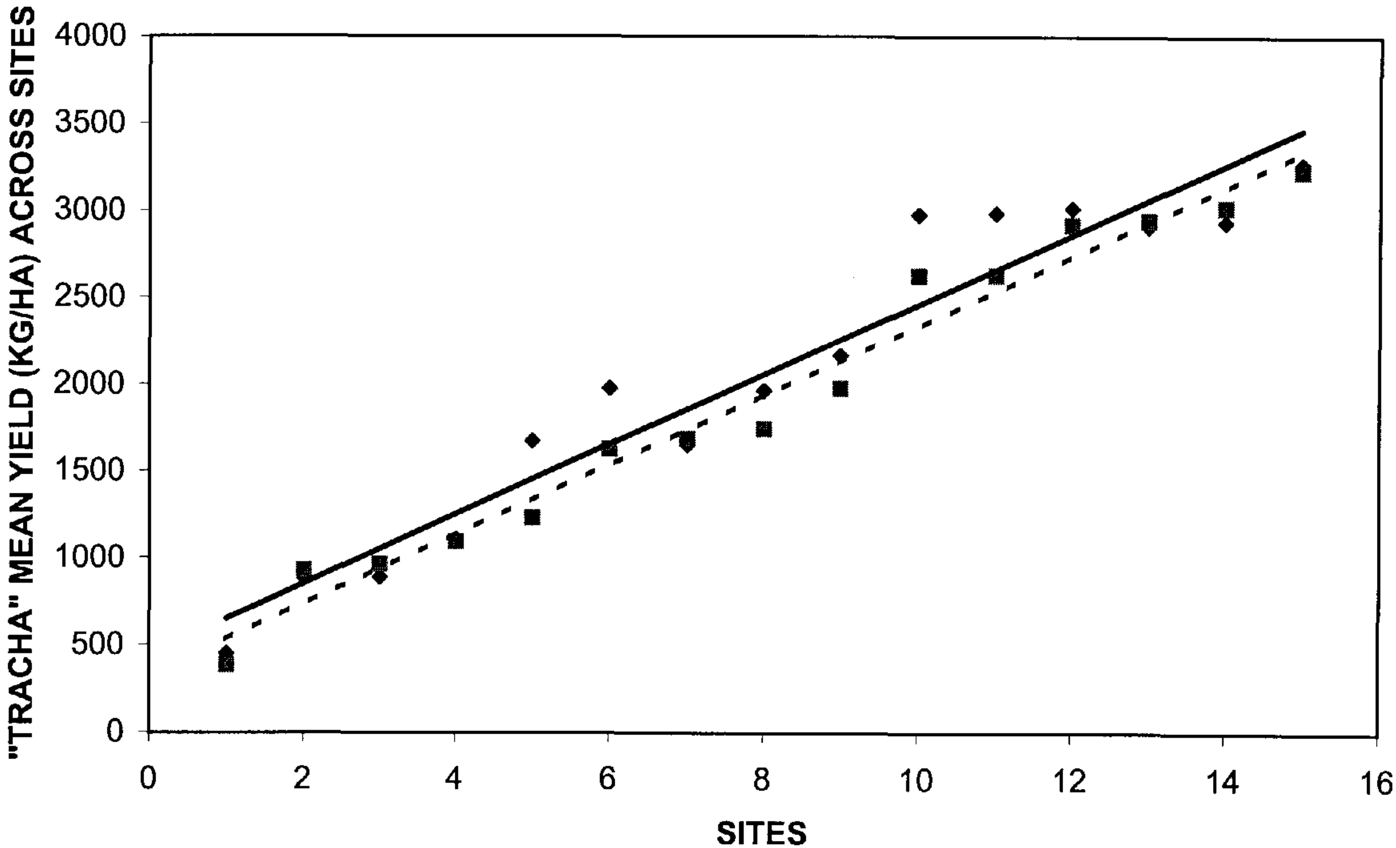


Fig. 4.3. Performance of "TRACHA-1" across WANA dryland sites, RWYT-SA, 1995/96.

4.1.6.2. Results of Regional Bread Wheat Yield Trial, Favorable Areas (RWYT-FA)

The favorable Areas (FA) Regional Bread Wheat Yield Trial was targeted to environments with moderate to high rainfall (annual rainfall >400 mm) or irrigation, with relatively mild winters and high fertility level. The major biotic stresses in those areas include leaf rust, septoria blotch, tan spot, BYDV and Hessian fly.

Figure 4.4 presents the mean yield of the three top-yielding cultivars in each test site, expressed as a percentage of the local check yield, across all locations of the Regional Bread Wheat Yield Trial for Favorable Areas (RWYT-FA), 1995/96. The local check performance is indicative of site-specific adaptation. The results show that the three top-yielding cultivars derived from CIMMYT/ICARDA germplasm yielded more than the locally adapted checks across test sites ranging in yield from 2194 kg/ha (EG35= Tag El-Ezz, Dakhalia, Egypt) to 7798 kg/ha (EG02= Shandaweel, Sohag, Egypt). The three top-yielding cultivars exhibited mean yield advantage ranging from only 2% in Tag El-Ezz, Dakhalia, Egypt (EG35) to 38% in El-Zahra, Libya (LB15). These results indicate that CIMMYT/ICARDA spring bread wheat improvement program has been successful in providing NARS in WANA semi-arid areas with adapted high-yielding germplasm with potential for release as new varieties to enhance wheat production.

A number of entries in the Regional Wheat Yield Trial, for Favorable Areas (RWYT-FA) have exhibited high yield potential and wide adaptation. In Figure 4.5 the mean yield of the cultivar "BLOYKA" was regressed over site mean yield across 19 test sites used in RWYT. At most sites "BLOYKA" exhibited higher yield than site mean yield, an indication of yield stability and wide adaptation.

(O.S. Abdalla, G. Ortiz Ferrara, M. Asaad Mousa, A. Yaljarouka, NARS Collaborators, Outreach Staff)

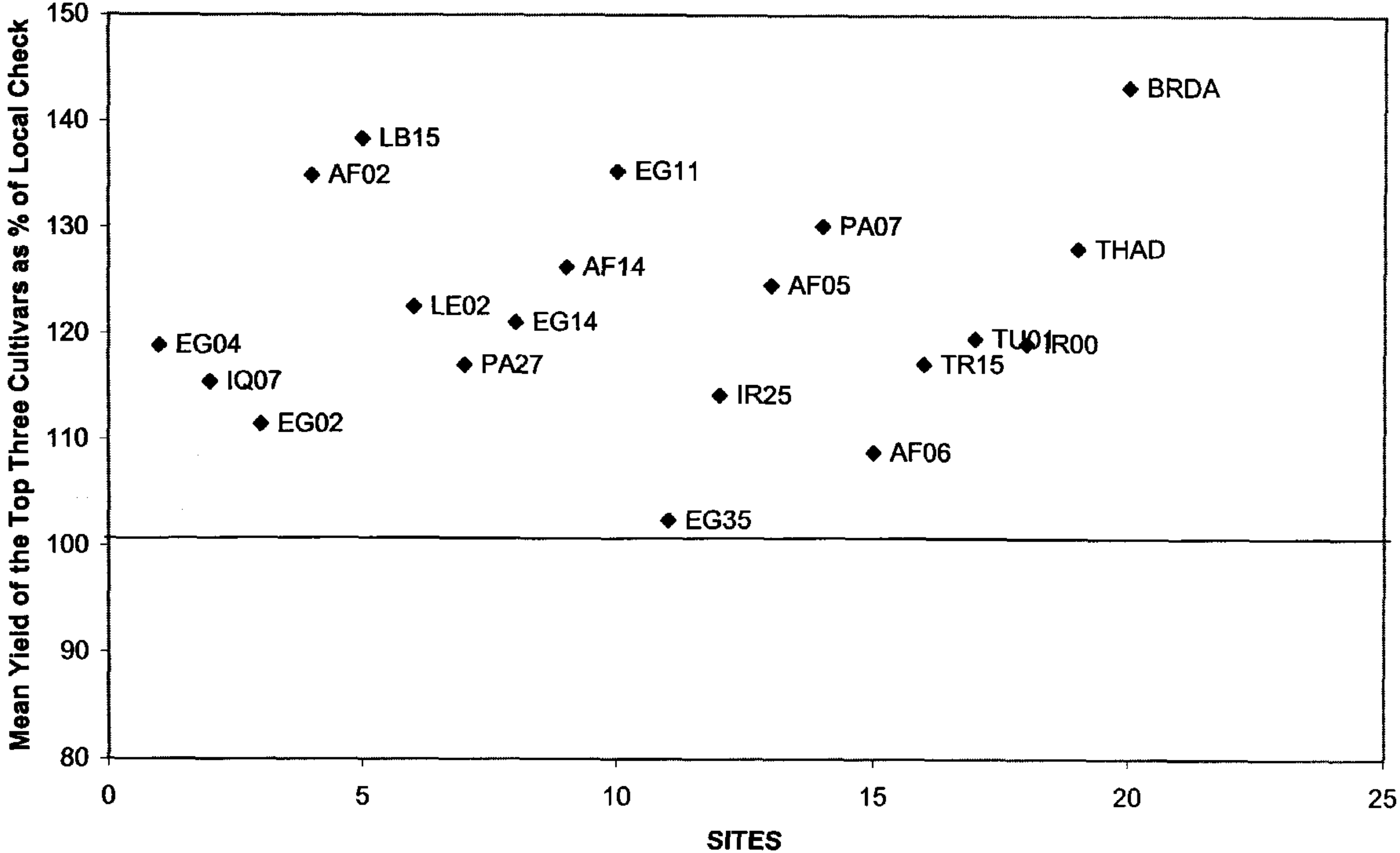


Fig. 4.4. Performance of the three top-yielding cultivars relative to the local check in each test site, RWYT-FA, 1995/96.

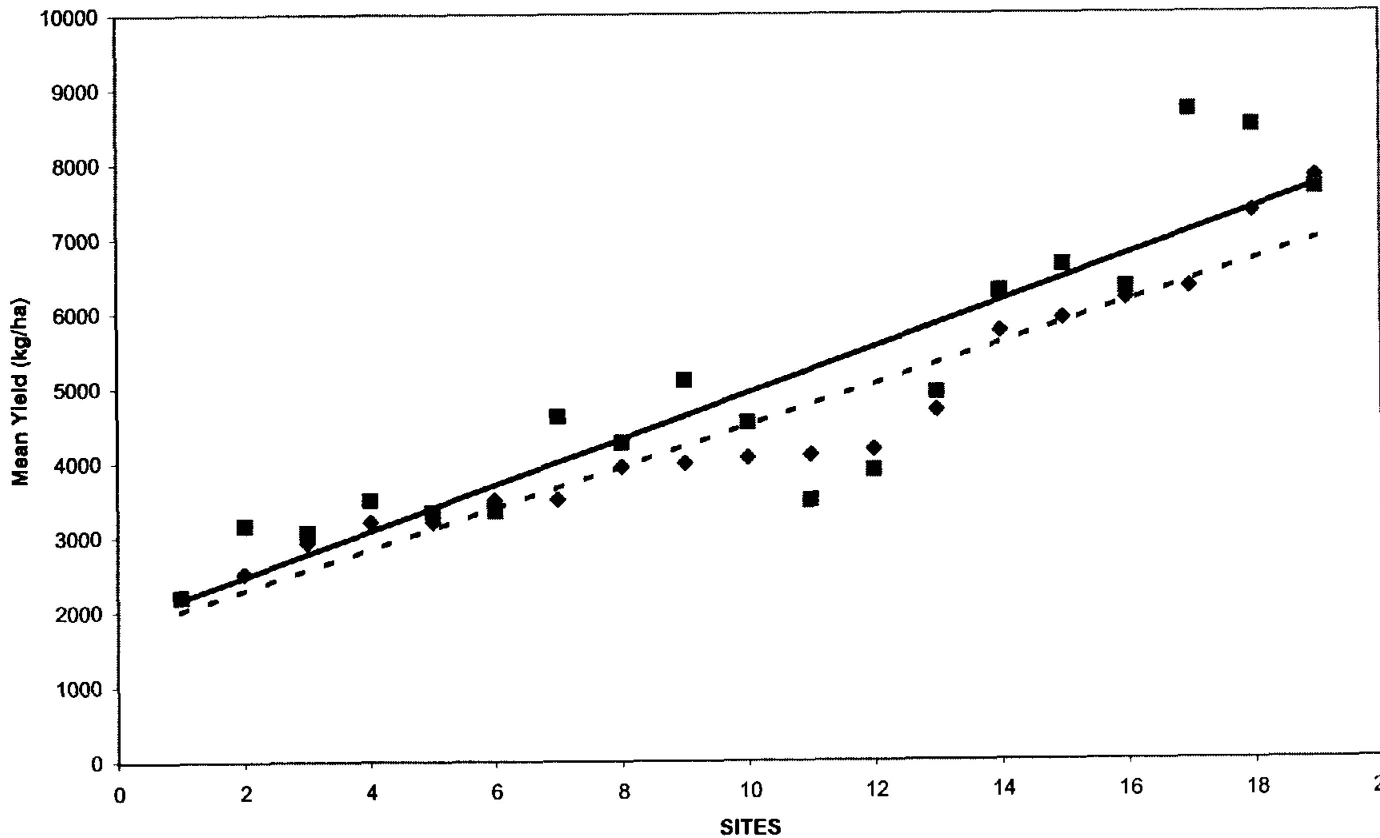


Fig. 4.5. Yield performance of "BLOYKA" across WANA favorable areas, RWYT-FA, 1995/96.

4.1.7. Interaction with NARS

The relationship with some NARS in WANA is gradually changing from recipients of technology and training to full partners in the research process. For example, Morocco is collaborating with the project in identifying sources of resistance to Hessian fly (HF) and Russian Wheat Aphids (RWA). The National Agricultural Research Institute of Morocco (INRA-Morocco) of Morocco is taking the lead in distributing to other North African countries, genetic stocks with sources of resistance to these insect pests. Egypt, in collaboration with other Nile Valley countries, has identified heat tolerant bread wheat varieties. Some of these varieties, such as Wad El Nil, Giza 164 and others, are also grown in Yemen and Sudan.

(G. Ortiz Ferrara, M. Asaad Mousa, A. Yaljarouka, NARS Collaborators, Outreach Staff)

5. FACULTATIVE AND WINTER WHEAT

Introduction

Improvement of facultative and winter wheat at ICARDA is conducted with the Turkish national wheat research program and CIMMYT, within the framework of the joint International Winter Wheat Improvement Program, IWWIP, and in collaboration with several NARS's from Central and West Asia and North Africa (CWANA) including Iran, Pakistan, Afghanistan, Azerbaijan, Armenia, Georgia, Turkmenistan, Uzbekistan, Kyrghyzstan, Tajikistan, Kazakhstan, Morocco, Algeria, and Syria.

This year marks the beginning of a stronger partnership among ICARDA, CIMMYT, and the Turkish Program, following the new CIMMYT-ICARDA agreement of 1996, and the subsequent posting in Turkey of the ICARDA breeder in May 1997. The evolution of the work relations between the two CG Centers was commented on favorably by the Center-Commissioned External Review (CCER) of ICARDA's cereal research (February 1997).

The major breeding component is conducted in Turkey, where crosses are made at Izmir, and screening and yield testing are carried out at Konya and Cumra (major sites), at Eskisehir, and other sites, including Haymana (emphasis on disease screening), Erzurum (emphasis on cold tolerance), Diyarbakir (drought, facultative-wheat environment), and Edirne (higher rainfall site).

The research component at ICARDA, Syria, is focussed on (a) enhancing the genetic variability of IWWIP materials through crossing with land races and specific germplasm from the region's highlands and cold areas, and (b) germplasm screening for diseases (mainly yellow rust and common bunt), insects (Russian wheat aphid, wheat stem sawfly, Hessian fly), BYDV, boron toxicity, and for bread-making quality; desired types are identified through 2-year repetitive testing before inclusion in genetic stocks for specific traits that are made available to requestors through IWWIP. Specific studies are also conducted to support the breeding work.

This year's report summarizes the major results of work conducted within the framework of the joint Turkey-CIMMYT-ICARDA partnership, with more details on the component conducted at ICARDA.

(H. Ketata)

5.1. Growing Conditions

Climatic conditions in Turkey were marked by a relatively mild winter and moderately favorable rainfall in most of the Central Anatolian Plateau. However, drought prevailed in November 1996 and during February through April 1997 in Konya and Cumra, and in November and March in Haymana. Seasonal rainfall totals in Konya, Cumra, and Haymana were 380, 358, and 491 mm, respectively. Terminal drought occurred in Diyarbakir (370 mm) and neighboring provinces, while severe cold affected the IWWIP and other materials grown at the rainfed site of Ilica in the Erzurum region, where durum wheat and barley did not survive the severe winter. Research plots at Cumra were damaged by hail at grain filling. Diseases generally were not a problem in farmers' fields in Turkey this season, although yellow rust was observed in certain irrigated bread wheat fields in Southeastern Anatolia (Elazig district) and yellow rust epidemics were successfully created in CRIFC (Central Research Institute for Field Crops) research fields at Haymana, and at TZARI (Transitional Zone Agricultural Research Institute), Eskisehir. A very heavy infestation of sunn pest was observed in several wheat fields in Diyarbakir, Elazig and Malatya provinces.

In Syria, despite a high seasonal rainfall (434 mm), growing conditions at Tel Hadya, were marked by drought throughout the grain filling period (no rain from heading on) coupled with high temperatures during the same period (mid and upper 30's and up to 41°C), resulting in low yields and very shriveled grains. Early in the season, a 10-week cold spell (45 frost days, with an average minimum temperature of -5.6°C during January-March) severely damaged the spring types and enabled a good screening of facultative types for frost tolerance. Temperature pattern was similar at Breda, but the lower rainfall (231 mm) at this site explains the 50% yield reduction as compared to Tel Hadya (2 t/ha vs 3.8 t/ha). At Sarghaya, a highland - 1450m- elevation site, northwest of Damascus, there were 146 frost days, with a minimum of -19°C recorded in early February, and an average minimum temperature of -7°C over the period Oct through April. Natural epidemics of yellow rust, leaf rust, and stem rust were enhanced with one irrigation in May. While the Tel Hadya environment provides enough cold to vernalize all winter wheat types, the cold period falls short of the true winter-wheat environments. On the other hand, Sarghaya, with a longer vegetative growth period, and lower winter temperatures, compares well with testing sites in winter-wheat areas of the Region, although spring is much warmer (Table 5.1). The site therefore was used to screen facultative and winter wheat germplasm for adaptation to highland environments similar to those of mountainous areas in Pakistan, Lebanon and North Africa, where facultative wheat could be successfully grown.

(H. Ketata)

5.2. Germplasm Development and Screening

A total of 1849 crosses were successfully made in 1997, at both Izmir(437 singles plus 522 top crosses) and Tel Hadya

Table 5.1. Climatic characteristics of testing sites for winter and facultative wheat, 1997.

Site	Abs. Min. temp. (°C)	# Days<0 °C	Temp.>30 °C starting	Rainfall total (mm)
Haymana, Turkey	-16.9 °C early Feb	111	Late June	491
Konya, Turkey	-16 °C mid-Feb	n.a.	Early June	380
Maragheh, Iran	-24.5 °C mid-Feb	144	Late June	270
Sarghaya, Syria	-19 °C late January	146	Mid-May	538
Tel Hadya, Syria	-8.3 °C early Feb	45	Late April	434

(715 singles plus 175 top crosses). Table 5.2 lists the number of entries in different nurseries developed and/or screened in each of Turkey and Syria. The entries are different across the two sites for the F1, F2, and F3 nurseries, as different crosses are made at each of the two sites.

Observations on the F1 nursery at Tel Hadya showed the following parents to be associated with hybrid nechrosis: Iranian land races, wheat wild relatives, and such entries as CA8055/GRK; BJN C.79; SABALAN; KS82142/SERI; TAST/SPRW//ZAR; CO693591/CTK; 89ZHONG2; VORONA/HD2402; PONY/OPATA; LOV26//LFN/ SDY(ES84-24)/3/SERI/4/SERI. In the same nursery, resistance to yellow rust was dominant over susceptibility, especially when the donor parent was highly resistant. Good parents included: MV17; SADOVO1; KS82W409/SPN; 90ZHONG657; YAN7578.128 and other Chinese genotypes. About 68% of the F1 hybrids were tolerant to frost, although all spring checks were severely damaged or completely killed. Among the parents associated with frost susceptibility were: SN64//SKE/2*ANE /3/SX/4/BEZ/5/SERI; ZCL/3/PGFN//CNO67/SON64…; TEMU39.76/CHAT// CUPE; ENKOY; ESDA/LIRA; SPADA; 89ZHONG2; SHANG111; FENG15.

Table 5.2. Number of entries in different nurseries grown in Turkey and Syria, in the 1996/97 season.

Nursery	Turkey	Syria
F1	1289	1087
F2	746	751
F3	495	475
Head rows (HR)	30,000	-
PYT	1594	1594
YT	450	450
AYT	225	163

Although there was an obvious association between winter growth habit and cold tolerance, there were a few exceptions of spring tolerant or winter susceptible types.

Among the best combiners in the F2 generation, the following parents were associated with resistance to yellow rust: VRZ/3/ORF1.148/TDL//BLO; MV17; PONY/OPATA; KS82W409/SPN; TIRCHMIR1/LCO; CA8055; BUL PREDELA; BJN C.31; 90ZHONG657; 89ZHONG2; FANJAI5; PJ/HN4//GLL/3/PRL/VEE#6; F130-L-1-12; ES84-24; ES85/24.

Of the 751 F2 populations screened at Tel Hadya, 296 were selected for F3 bulk testing in 1998 at Eskisehir, Turkey and Maragheh, Iran.

The 1997 at Eskisehir F3 populations were again grown in large (10-m long) plots, and effectively screened for yellow rust resistance, and single spikes were selected from the retained populations.

Head rows (HR), derived mainly from selection within F3, F4 and other generations at Eskisehir, are only grown at Cumra, Turkey. However, no yellow rust developed there, and selection was based on root rot symptoms, earliness, tillering, and other phenotypic attributes.

Selected families from the HR's enter the preliminary yield testing (PYT), then intermediate yield testing (YT), before reaching the advanced yield testing (AYT) stage. PYT are evaluated for yield at Cumra and Eskisehir (Hamidiye) and for diseases at Haymana, Izmir, and Eskisehir in

Turkey, and for yellow rust, common bunt, and grain quality in Syria. Yield evaluation of YT and AYT is conducted in Cumra, Konya, and Eskisehir, and at Tel Hadya, Syria (under rainfed and irrigated conditions). Results accumulated through years point to the usefulness of this Tel Hadya testing for the milder highlands of the region. All fixed materials are screened for diseases (yellow rust, leaf rust, powdery mildew, common bunt) at Izmir, for diseases (yellow rust, leaf rust, stem rust) and cold at Haymana, for yellow rust, leaf rust, boron toxicity and cold at Eskisehir, for cold and root rot at Cumra, and for cold at Erzurum and Konya. Increases of entries in different nurseries are grown at B.D. MIKHAM, Konya, where new irrigation facilities have been added by the Institute.

Some of the most promising entries from the PYT, YT, and AYT are included in Tables 5.3, 5.4, and 5.5. Yield data from Cumra were not taken into consideration because of the hail damage at this site. The comparison of the different trials shows the steady improvement in yellow rust resistance of the IWWIP germplasm from PYT to AYT. This improvement is due to consistent disease pressure and elimination of highly susceptible entries in the developed germplasm. Such a trend is again clear across years, within the same type of nursery (Fig. 5.1).

However, selection of improved germplasm does not exclude moderately susceptible (MS) genotypes that possess other desirable attributes. In fact our results show: (a) a high frequency of MS types among the highest yielding entries, and (b) yield reduction due to yellow rust is negligible or inexistant below 30% leaf infection by the disease.

(H. Ketata, H. Braun, A. Morgounov, H. Ekiz, M. Keser, L.Cetin, A. Atli, F. J. El Haramein)

Table 5.3. Characteristics of selected entries among superior PYT facultative/winter wheat lines, in the 1996/97 season.

Entry	Name	YR-HA	YR-TH	CB-TH	TKW(g)	Protein%	PSI%
5097	8023.16.1.1/KAUZ	MR	R	R	40	13.8	41
5182	BTY/BOW//KS82142	MR	R	R	39	12.2	57
5343	ES84.24//KS82W409/SPN	MR	MR	MS	38	12.9	54
5411	FDL4/KAUZ	MR	R	MS	38	12.3	38
5459	MNCH/5/BLL/F72.23/4/TLLA//2*FR/KAD/3/ 2GB	R	R	MS	44	12.3	51
5483	JI5418/HATUSHA	MR	R	MS	42	12.3	42
5592	RECITAL/VORONA//HATUSHA	MR	R	MS	39	11.9	43
6115	ES84.24/3/RAN/NE701136//CI13449/CTK	MS	R	MS	40	13.9	46
6414	SNB/PCH//KAL/BB/3/CA8055/4/YE2453	MR	MR	MS	44	13.9	45
	Greck	S	S	MS	31	-	-

YR: yellow rust; CB: common bunt; HA: Haymana; TH: Tel Hadya; TKW: 1000-kernel weight; PSI: particle size index; R: resistant; MR: moderately resistant; MS: moderately susceptible.

Table 5.4. Promising bread wheat lines from the yield trials (YT), in the 1996/97 season.

Entry	Name	YR	CB	Yield(kg/ha - %Check)			
				Eskisehir	Konya	TH-RF	TH-IR
7375	494J6.LL/ROLLER	50MS	R	5308-107	7275-118	3474-143	4068-119
7221	ZCL/3/PGFN//CNO67/SON64(ES86-8) /4/SERI/5/UA-2837	0R	S	6150-117	5852-95	2613-108	3052-89
7223	ZCL/3/PGFN//CNO67/SON64(ES86-8) /4/SERI/5/UA-2837	0R	MS	5833-111	6550-106	2704-111	2501-73
7350	GRK/5/RRV/WW15/3/BJ/2*ON//BON/4 /NAC/6/KATIA1	30MS	R	5525-100	6724-109	3223-133	4451-130
7173	NAI60/HNVII//BUC/3/F59.71/GHK	10MS	S	5100-103	6630-107	-	-
7172	NAI60/HNVII//BUC/3/F59.71/GHK	10MS	S	5033-102	6485-105	3133-112	4005-93
7248	TCD/6/MEXCOMP1/7/WN156/NSD//MT7 73	30S	S	5725-102	5818-94	3517-145	4033-118
7327	OK82282//BOW/NKT/3/F4105W2.1	20MS	MR	5717-103	5463-88	2457-101	4479-131
7126	S148/PCHS//SPN	20MR	R	6775-110	4644-75	3908-139	5269-122
7007	DYBR1982-83/842ABVD C-50// KAUZ /3/PLK70/LIRA	0R	R	7058-115	4043-65	3644-130	4953-115
96-6228	TX81V6614/OPATA	20MS	R	6983-117	7623-124	3847-137	5212-120

Table 5.5. Characteristics of facultative and winter wheat entries with superior performance in AYT, in the 1996/97 season.

Entry	Name	YR	LR	GH	Yield level		
					Eskisehir	Konya	Tel Hadya
9013	CNO/GLL//BACA/3/VONA/4/885-K1-1	S	R	2	H	M	H
9031	VORONA/TAM105//OK82282	S	R	3	H	H	H
9037	OK82282//BOW/NKT	MS	R	3	H	M	H
9077	NVSR3/5/BEZ/TVR/5/CFN/BEZ//SU92/CI13 645/3/NAI60/4/EMU/7/KATYA A1	MS	MS	3	H	H	M
9100	SDY/OK78047/4/NAI60/HN7//BUC/3/F59.7 1/GHK/5/SAULESKU#17	MS	R	3	H	L	M
9103	TAST/SPRW//BLL/7/SOTY/SUT//LER/4/2*R FN/3/FR//KAD/GB/5/TMP64	MR	S	2	H	H	H
9107	VORONA/HD2402	R	R	3	H	H	M
9167	NWT/3/TAST/SPRW//TAW12399.75	R	R	2	M	H	H

YR: yellow rust; LR: leaf rust; GH: growth habit, 1-5 scale: 1=winter,... 5=spring; R: resistant; MR: moderately resistant; MS: moderately susceptible; M: medium, L: low; H: high

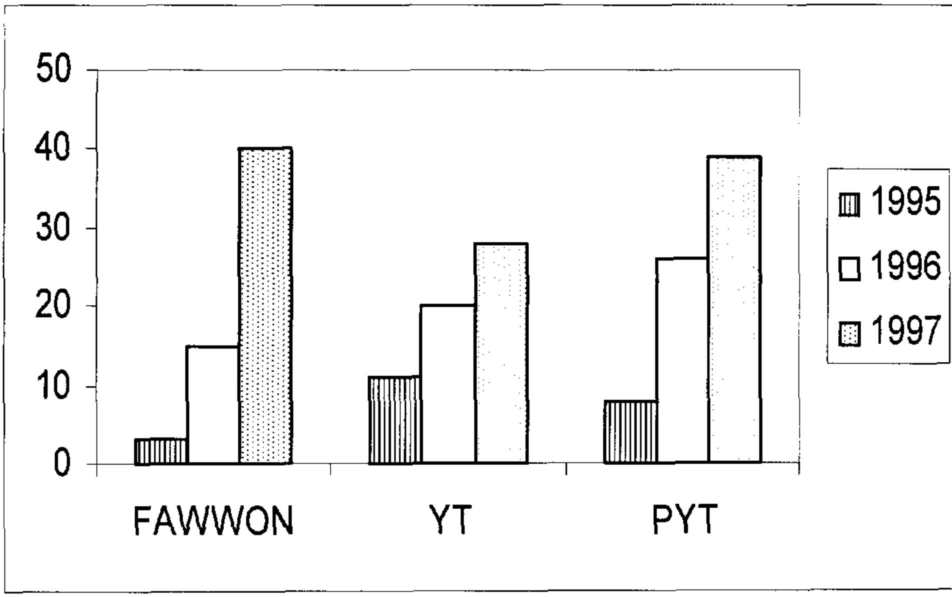


Fig. 5.1. Percent resistant entries in three nurseries (FAWWON, YT, and PYT) across three seasons.

5.3. Genetic Stocks

Advanced breeding lines were screened under controlled conditions for boron (B) toxicity, and under field conditions for BYDV and yellow rust (with artificial inoculation) and for cold tolerance. Certain entries combined tolerance to more than one stress and have good yield potential (Table 5.6). These lines are included in a special nursery for use by breeders. Demand for such a germplasm is increasing, due to the intrinsic value for breeding, and to demand by biotechnologists.

(H. Ketata, O.F. Mamluk, K. Makkouk, M. El Bouhssini, S.K. Yau)

Table 5.6. Advanced facultative/winter wheat lines with tolerance to biotic or abiotic stresses, 1997.

Entry	Name	Stress(es)
97-9154	CA8055/GRK	B-BYDV-YR-C
97-9032	1D13.1/MLT//KAUZ	B-BYDV-YR-C
96-7093	AE.VENTRIC//T.TURG/2*MOS/3/BOW/NKT	B-BYDV-YR
97-9031*	VORONA/TAM105//OK82282	B-BYDV-YR
97-9084	VORONA/KAUZ	B-YR-C
97-9077*	NVR3/6/BEZ/TVR/5/CFN/BEZ//SU92/CI13 645.	B-YR-C
97-9044	TAST/SPRW//LT176.73/7/SOTY/SUT//LER /4/.	B-YR-C
97-9402	VORONA/HD2402	BYDV-YR
97-9168	OK82282//BOW/NKT	B-YR
97-9009	AE.VENTRIC//T.TURG/2*MOS/3/BOW/NKT	B-YR
97-9088	AE.VENTRIC//T.TURG/2*MOS/3/BOW/NKT	B-YR
97-9053	BOW/PRL//F12.71/BEZ/3/OK82282	B-YR
FOBS-161	DARI-96.8	RWA-C
FOBS-123	PIOPIO.4	RWA
96-9069	BEZ//CNO/GLL/3/RSK//CNO/GLL	BYDV

* High-yielding line. B = boron toxicity, BYDV = barley yellow dwarf virus, YR = yellow rust, C = cold, RWA = Russian wheat aphid.

5.4. Germplasm Characterization and Targeting

Special studies on vernalization and photoperiod were conducted to characterize wheat germplasm, understand adaptation to the highlands and cold areas of the CWANA region, and target the germplasm to specific megaenvironments. Forty eight wheat cultivars and breeding lines from different parts of the world were subjected to vernalization treatments (vernalized for 6 weeks at 2°C versus unvernalized) and grown at Tel Hadya, ICARDA in two greenhouses that differed in photoperiod (1. Natural daylength 2. Supplemental light - 15-hr total photoperiod). Natural daylength varied between 9-13 hours during the vegetative phase. Daily air temperature was similar (±2°C) in the two greenhouses, varying in a sinusoidal manner between 7 and 14°C from planting (end November) through

February, 12-18 °C during March through April and 14-24 °C through mid-May. The phenology of the wheat entries was observed throughout the season. The number of days from planting to heading (DH) was significantly reduced by both vernalization and longer photoperiod. In general, the reduction was of 40 days by vernalization and 29 days by photoperiod. Although the genotypes responded differently to the two treatments; the trend was qualitatively the same, with a more pronounced effect of vernalization across cultivars, as compared to photoperiod.

Three major wheat groups were distinguished (Figure 5.2):

(Group 1) Entries with high requirement and response to vernalization and low day-length effect. The average value for DH (unvernalized, short daylength) was 168 days, which was reduced by 59 days by vernalization and 26 days by longer photoperiod. All entries remained in rosette and did not head when field-grown in the summer at Tel Hadya. This group represents pure winter types that probably possess the *vrn1* gene. It includes the cultivars KARL, DOGU 88, SADOVO 1, MV 17, CA 8055, and a number of breeding lines.

(Group 2) Entries with moderate requirement and response to vernalization and moderate daylength effect. DH under unvernalized and short-day conditions was 151 days, reduced by 41 and 36 days through vernalization and increased daylength, respectively. Heading did not take place in summer planting, but certain entries entered the reproductive phase in spring (April) planting. Included in this group are VRATSA, BJN C.31, FANDANGO, BJN C. 79, CHN41284, SXL/GLENNSON, SABALAN, and SABALAN-cross lines.

(Group 3) Entries with low response to vernalization and moderate light effect. When plants were unvernalized and grown in the greenhouse under regular daylength, they headed in 125 days on the average, and headed 24 days earlier if vernalized or 34 days earlier if grown under 15-

hr daylength. These entries either have headed or approached heading in summer planting, and therefore are either pure spring types with dominant *Vrn* genes, or semi-winter (or facultative) types lacking *vrn1*. The advantageous earliness of this group is offset by its higher susceptibility to cold, as compared to the previous two groups. In the highlands and continental areas of Central and West Asia and North Africa (CWANA), cold is, after drought, a major stress to wheat growth and development. Although very severe winter cold (with -20°C or below) is confined to limited areas, primarily in eastern Turkey and northwestern Iran, moderate cold (-4°C to -10°C) may be even more damaging, if it occurs, as it often does, at or past stem elongation. The damage is more severe in late-spring frost on earlier cultivars. This situation is more common and more widespread than severe winter cold, across the region, both in the milder environments (e.g. North Africa and Pakistan highlands) as well as in the traditional winter wheat regions of West and Central Asia. Successful cultivars that withstand this type of stress for years are land races such as Sardari in Iran, and Achoura and Kirik in eastern Turkey. These and other original land races possess adequate levels of winter hardiness, vernalization and photoperiod requirements commensurate with the prevailing winter weather which make them go dormant throughout the cold months, enter the reproductive stage as soon as the frost risk is over, and quickly complete grain filling before the onset of the drought/heat terminal stress, a characteristic of the Mediterranean climate. Most of the entries in the Group 2, referred to above, have attributes similar to those of the land races, and should be more useful to the majority of highland and continental areas of Central and West Asia and North Africa. Wheat types in Group 1 are targeted to the more restricted severe-winter areas, whereas those of Group 3 provide sources of intrinsic earliness, and resistance to biotic stresses. Crosses are made, using parents of the three types of pools (pure winter, facultative or semi-winter, and spring) including land races, to generate genetic diversity, and improve resistance to biotic stresses, including yellow rust, and other desired traits, in wheat germplasm targeted for the various agroecologies of the highlands and continental areas of the region.

(H. Ketata, M. Jarrah)

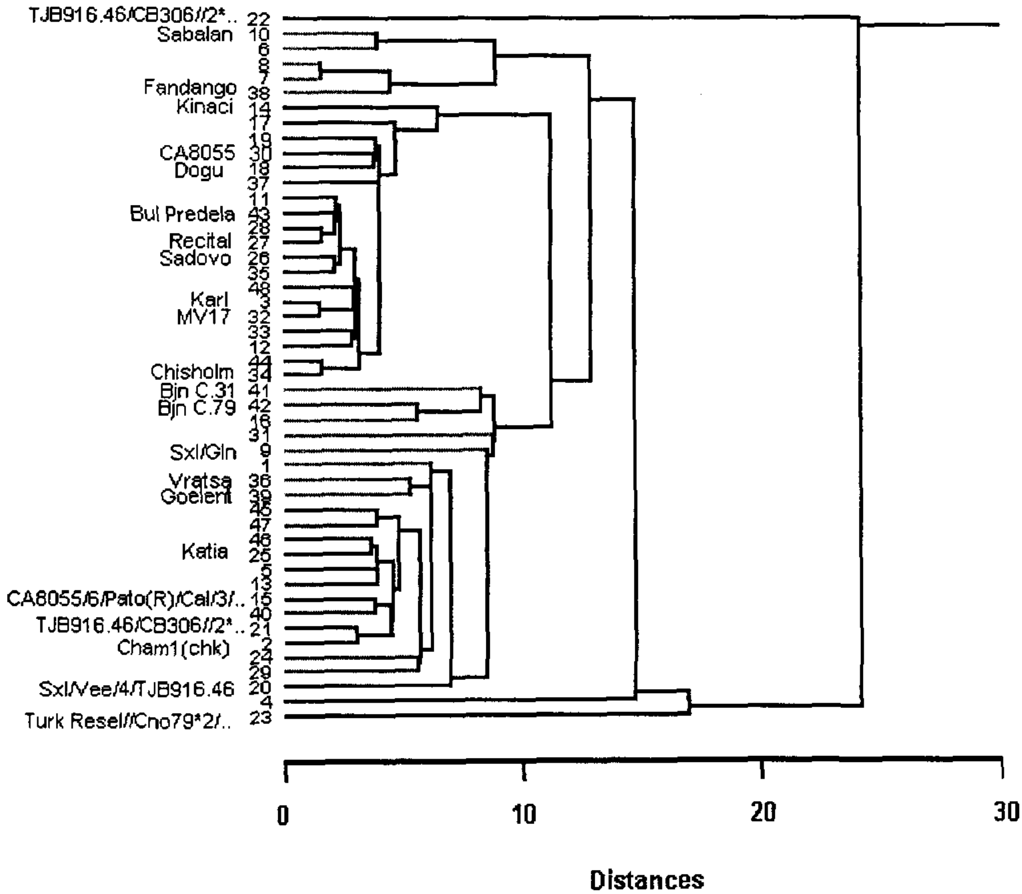


Fig. 5.2. Dendogram of wheat cultivars based on response to vernalization and photoperiod.

5.5. Regional Cooperation

5.5.1. International Nurseries

Data of the Fifth Facultative and Winter Wheat Observation Nursery (5th FAWWON), returned from 88 cooperators (29 from the CWANA Region) were analyzed and published in a separate report in 1997. The nursery comprised a wealth of genetic variability for several traits, including growth habit, cold tolerance, maturity, plant height, grain yield (based on unreplicated 2-row plot), 1000-kernel weight, grain color, and reaction to diseases. The 210 entries of the 5^{th} FAWWON originated from: IWWIP, Turkey, Bulgaria, Hungary, Romania, Iran, South Africa, USA, and Ukraine. Although no entry was best everywhere, certain entries were selected more frequently than others (Table 5.7). In comparison to introduced germplasm, the IWWIP materials were frequently selected, particularly in the CWANA Region, but they suffer from susceptibility to cold and to leaf rust. Tolerance to yellow rust in our materials is still insufficient. Germplasm from Switzerland and China are valuable sources of resistance to yellow rust.

Data of the 1st Facultative and Winter Wheat Trial for Rainfed Areas (1st FWWEYT-RF) and of the 1st FWWEYT-IR were returned from 14 and 16 cooperators, respectively. Although some variability was observed for yield and other measured traits, no entry possessed acceptable yield and dual resistance to yellow and leaf rust, two major diseases of the CWANA region. This was to be expected, as the number of entries (25) in each trial was limited, and the germplasm included was not previously exposed to a large spectrum of environments in the region. As the project advances, this is expected to change.

(H. Braun, A. Morgounov, H. Ketata, H. Ekiz, M. Keser, L. Cetin, A. Atli, G. Marcucci, and cooperators from Turkey, Iran and other countries)

Table 5.7. Performance of frequently selected entries from the 5th FAWWON, 1996.

Entry	Name	GH	SEL	Rank			
				YLD	CT	YR	LR
31	KAREE/TEGELA	W	17	107	51	54	44
36	HIM/CNDR//CA8055	WF	17	137	89	39	145
37	ORE F1.158/FDL//BLO/3/	F	17	56	157	18	112
39	TIRCHMIR2/HUNZA2	SF	12	83	195	4	142
41	TIRCHMIR1/LCO	W	9	189	141	9	100
52	RAN/NE701136//CI13449/	WF	17	16	130	27	126
53	NEMURA/PRL	FS	17	190	188	76	127
76	CO724377/NAC//SERI	SF	18	135	186	7	114
104	7C/CNO//CAL/3/YMH/4/TA	WF	14	2	102	87	144
111	TEMU39.76/CHAT//CUPE/3	S	20	121	201	70	98
126	BUL6186.6	F	19	92	159	52	131
132	BUL6687.12	WF	26*	46	129	3	13
146	PATMARES/KAVKAZ	W	16	11	50	22	166
157	F474S10.1	WF	17	27	69	5	3
170	VONA//KS75210/TAM101	WF	17	23	36	34	73
176	SB-360-5	F	6	151	161	6	4

GH=growth habit(W:winter, F:facultative, S:spring), SEL=frequency of selection (the highest frequency in the nursery is 26), YLD=grain yield, CT=cold tolerance, YR=yellow rust, LR=leaf rust.

5.5.2. Iran

Collaboration with Iran was enhanced with the posting of Dr. M. Tahir in Tehran. New controlled-environment facilities were established at Maragheh to complement field research.

The season was dry throughout the cold areas of Iran (273 mm at Maragheh, 374 mm at Kermanshah, 238mm at Sanandaj, 263 mm at Zanjan). Early maturing types were favored, and Sardari performed very well in most of the testing sites. The breeding line SXL/GLENNSON was finally discarded because of its excessive susceptibility to dwarf bunt, despite its earliness and high yield potential in rainfed environments. However, three new lines were identified for adoption and release: (1)KVZ/TM71/3/ MAYA'S'

//BB/INIA/4/SEFID, SBN/1-27-56/4; and (3) ANZA/3/PI/HYS// SEFID. These lines have good resistance to both yellow rust and bunt and have equivalent or better yield than Sardari in most testing sites. All 3 lines have an Iranian parent in their pedigree. Many of the Turkey-CIMMYT-ICARDA test entries were late or too short (particularly those of 6th FAWWON), likely because of slow fall growth and intrinsic shortness. Rainfed cold areas such as Maragheh require taller plant stature than other winter wheat areas, such as Ankara, Eskisehir or Konya. Results from different DARI sites were jointly reviewed, and a plan of work for 1998 drawn, and published in a separate report.

(H. Ketata, M. Tahir, A. Amiri, M. Rostai, D. Sadeghzadeh)

5.5.3. Morocco

Observations in June revealed that winter types have no advantage over spring types in most of the Middle Atlas (1000-1600 m elevation). However, little research has been conducted in the High Atlas todate (generally 2000-2500 m and above) where winter and facultative wheats should find niches. Collaboration therefore was initiated with NARS to explore avenues of testing facultative and winter wheat germplasm in view of its possible adoption by poor farmers in the Atlas region, with an emphasis on higher-elevation areas.

(M. Jlibene, H. Ketata)

5.5.4. Turkey

Collaboration was initiated with the Southeastern Anatolia Agricultural Research Institute, Diyarbakir to test facultative and winter wheat in facultative wheat environments, with an emphasis on farmer participation. From observations and discussion with farmers in the Elazig and Malatya districts, two major problems emerged: (a) lack of improved cultivars in farmers' fields, which were mostly sown with land races (Achoure), and (b) high infestation of wheat fields with suni bug (up to 10 insects/m^2). Both aspects will be emphasized in the coming years, in joint work with the Institute scientists, and other specialists.

(H. Ketata, I. Ozberk, F. Ozberk)

6. PATHOLOGY

6.1. Introduction

Major wheat diseases in WANA are smuts, rusts, and Septoria blotches, whereas the most prevailing diseases on barley are smuts, barley leaf stripe, powdery mildew and scald. For wheat and barley, root rots and nematodes are gaining more importance in many countries of WANA due to monoculturing. Several control measures were evaluated during 1996/97 season. Host plant resistance remains the major component in controlling cereal diseases. Other control measures were investigated such as the use of local organic nutrients to control common bunt of wheat and the use of cultivar mixtures to control *yellow rust and Septoria tritici* blotch on wheat and scald on barley.

Agronomic practices play a major role in managing soil-borne diseases. The development of an economically acceptable integrated management program for the control of root rots and nematodes will depend on the optimum utilization of agronomic practices that influence the inoculum density in the soil. Evaluation of the different cereal production systems in different agro-ecological zones of Syria as well as the long-term rotation trials of the Natural Resource Management Program (NRMP) was undertaken to identify the factors involved on the development of common root rot and cereal cyst nematodes.

(H. Toubia-Rahme)

6.2. Survey

In Syria, scald and powdery mildew were the most prevalent barley diseases in 1996/97 season. Those of wheat were Septoria blotches (*Septoria tritici* and *S. nodorum*), which have been present in combinations in some fields. *S. nodorum* was not reported in Syria in past years it has begun to appear in the last 2 years where it was encountered in one field during a survey in 1996 season in combination with *S. tritici* and in 7 fields in 1997 season alone or in combinations with *S. tritici*.

In Tunisia, the major barley diseases were powdery mildew and net blotch. *Septoria tritici* blotch was the most encountered disease on wheat.

(S. Ahmed, (S. Hakim, H. Obeido, U. of Aleppo), H. Toubia-Rahme)

6.3. Host Resistance

6.3.1. Screening for Disease Resistance

Identification of sources of resistance to the major cereal diseases prevailing in WANA is approached through screening wheat and barley germplasm developed by breeders as well as the wild species in hot spots with artificially created epidemics. Resistant lines screened from any cereal nurseries are retested in the respective special purpose disease nurseries for 3 years to confirm their resistance and are then combined to form germplasm pools for sources of resistance (GPPLs). GPPLs are furnished to collaborators in WANA and beyond for their use in breeding programs.

6.3.1.1. Barley Pathology

Spring and winter/facultative barley germplasm developed by breeders were screened for the 5 barley diseases prevailing in WANA region: scald, powdery mildew, barley leaf stripe, covered smut and loose smut. The screening sites were: Tel Hadya and Terbol for scald, Tel Hadya (plastic house) and Latakia for powdery mildew and Tel Hadya for barley leaf stripe, covered smut, and loose smut. The selection criteria used in the screening for resistance to foliar diseases were 4 and 1, both on 0-9 scale, for the vertical development of the disease and disease severity, respectively. Selection criteria for barley leaf stripe and for covered smut and loose smut were 0% infected plants and 0% head infection, respectively.

Screening for barley leaf stripe and loose smut was restricted to the parental (spring barley) and crossing block (winter barley) germplasm as field screening is laborious and requires 2 years. The results for both diseases are those of the 96 nurseries.

6.3.1.1.1. Spring Barley Germplasm

The spring barley germplasm evaluated for their performance against diseases were: Parental Germplasm (PARE, 292 entries), North Maghrebian Nursery (NMAG, 287 entries), Barley Initial Increases (BIIN, 4450 entries), Barley Initial Yield Trials (BIT, 440 entries), Barley Advanced Yield Trials (BAT, 100 entries), Farmers Field Verification Trials (FFVTs, 25 entries), and Special Purpose Disease Nurseries: Spring Barley Scald Nursery (SBSC, 123 entries), Spring Barley Powdery Mildew Nursery (SBPM, 45 entries), Spring Barley Leaf Stripe Nursery (SBST, 32 entries), Spring Barley Covered Smut Nursery (SBCS, 44 entries), and Spring Barley Loose Smut Nursery (SBLS, 32 entries).

The percentage of resistant lines in each nursery is shown in Fig. 6.1. For scald, the highest percentage of resistant lines (73%) was found in the SBSC followed by BIIN (27%). The remaining germplasm had very low performance (<8%

resistant lines). For powdery mildew, BAT showed the highest percentage of resistant lines (72%) followed by SBPM (67%), PARE (45%) and NMAG (38%).

For covered smut, the performance of the different nurseries was 86% resistant lines in SBCS, 57% in PARE, and 29% in BAT.

Fifty nine percent and 68% resistant lines for barley leaf stripe and loose smut respectively were found in PARE 95. The results of the germplasm screened for this year against both diseases will be reported next year.

Some lines showed multiple disease resistance to several diseases. Eight lines were resistant to scald, powdery mildew and covered smut [PARE 96 (#39, 36, 43, 42, 121, 124), BAT 97 (#24, 27)], 8 lines to scald and powdery mildew [PARE 96 (#27, 33, 103, 112, 163, 221), NMAG 97 (#171), BAT 97 (#20)], 4 lines to scald and covered smut [PARE 96 (#97, 98, 266), BAT 97 (#99)], 103 lines to powdery mildew and covered smut [BAT 96 (22 lines), PARE 96 (81 lines)] and 14 lines to barley leaf stripe and loose smut (PARE 95).

6.3.1.1.2. Winter/Facultative Barley Germplasm

The germplasm evaluated for its performance to diseases included: Winter Barley Observation Nursery (WBON, 150 entries), Facultative Barley Observation Nursery (FBON, 150 entries), Winter Barley Yield Trials (WBYT, 24 entries), Facultative Barley Yield Trials (FBYT, 24 entries), and Special Purpose Disease Nurseries: Winter Barley Powdery Mildew Nursery (WBPM, 12 entries), Winter Barley Leaf Stripe Nursery (WBST, 14 entries), Winter Barley Covered Smut Nursery (WBCS, 14 entries), and Winter Barley Loose Smut Nursery (WBLS, 12 entries).

The performance of the different germplasm is presented in Fig. 6.2. The highest percentage of resistant lines was

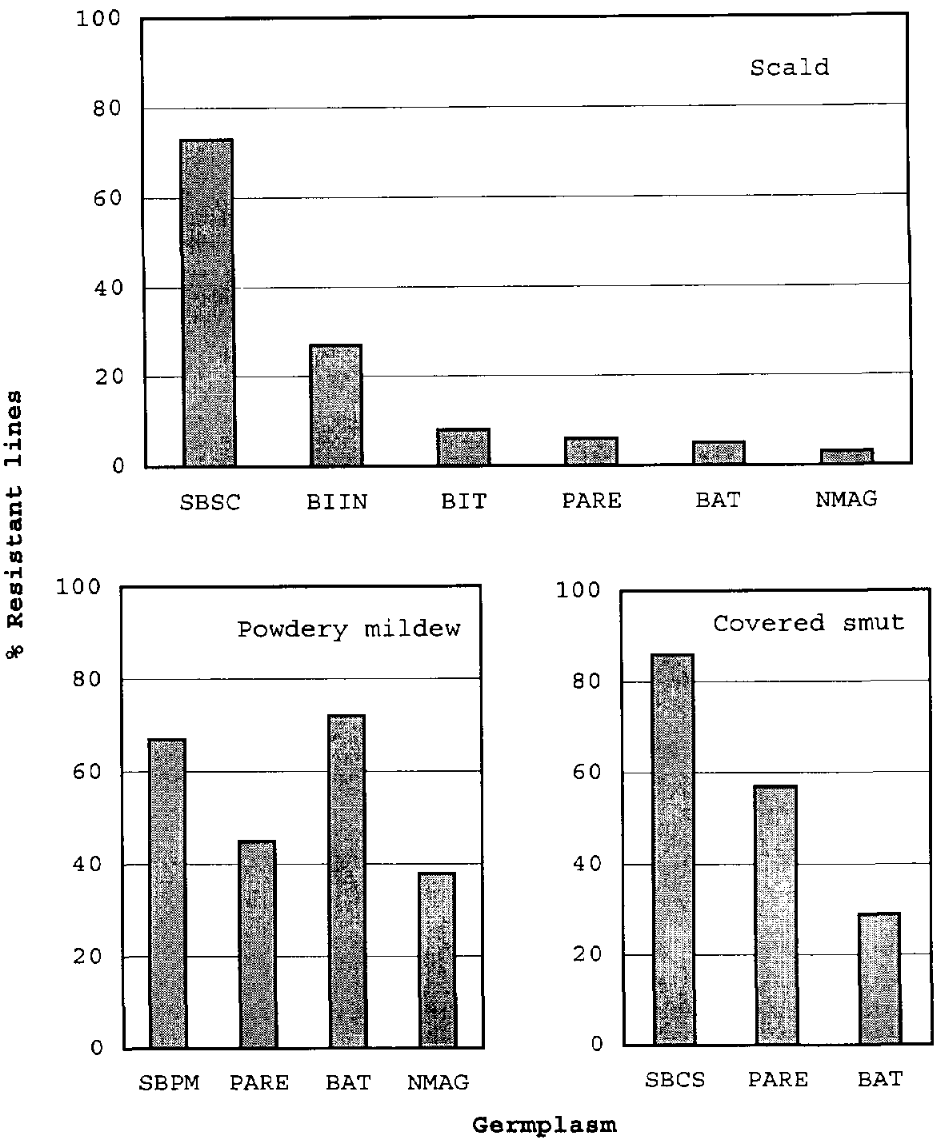


Fig. 6.1. The performance of spring barley germplasm against different diseases.

found in the special purpose disease nurseries with 75% and 93% resistant lines for powdery mildew in WBPM and covered smut in WBCS respectively. The germplasm tested for scald was included in the following nurseries: WBYT, FBYT, WBON and FBON and the results were 25%, 35%, 65% and 68% resistant lines respectively. In WBYT and FBYT germplasm, a high percentage of resistant lines was recorded for both powdery mildew and covered smut ranging from 50 to 65%. The results available for barley leaf stripe and loose smut are those of the winter/facultative crossing block (WFBCB96) with 93% and 89% resistant lines respectively.

In WBYT and FBYT germplasm, some lines showed multiple disease resistance for scald, powdery mildew and covered smut [WBYT97 (#2), FBYT 97 (14, 19, 20)], for scald and powdery mildew [WBYT 97 (#3, 9, 21)], for scald and covered smut [WBYT (#10), FBYT 97 (#4, 21)], and for powdery mildew and covered smut [WBYT 97 (#11, 14, 15, 20), FBYT 97 (#5, 10, 17)] and 37 lines for barley leaf stripe and loose smut in WFBCB 96.

(H. Toubia-Rahme, Z. Alamdar, I. Maaz, M. Ahmad)

6.3.1.2. Wheat Pathology

Spring, winter/facultative bread wheat and durum wheat germplasm was screened against the following diseases: yellow, leaf and stem rusts, *Septoria tritici* blotch and common bunt. The screening sites were: Tel Hadya and Terbol for yellow rust, Tel Hadya (plastic house) and Terbol/summer cycle for leaf and stem rusts, Tel Hadya and Latakia for *Septoria tritici* blotch and Tel Hadya for common bunt. Selection criteria were <5 ACI for rusts in multilocations; <2 CI for yellow and leaf rusts, <4 CI for stem rust (one location); <5 score (on 0-9 scale) for Septoria tritici blotch and 10% head infection for common bunt.

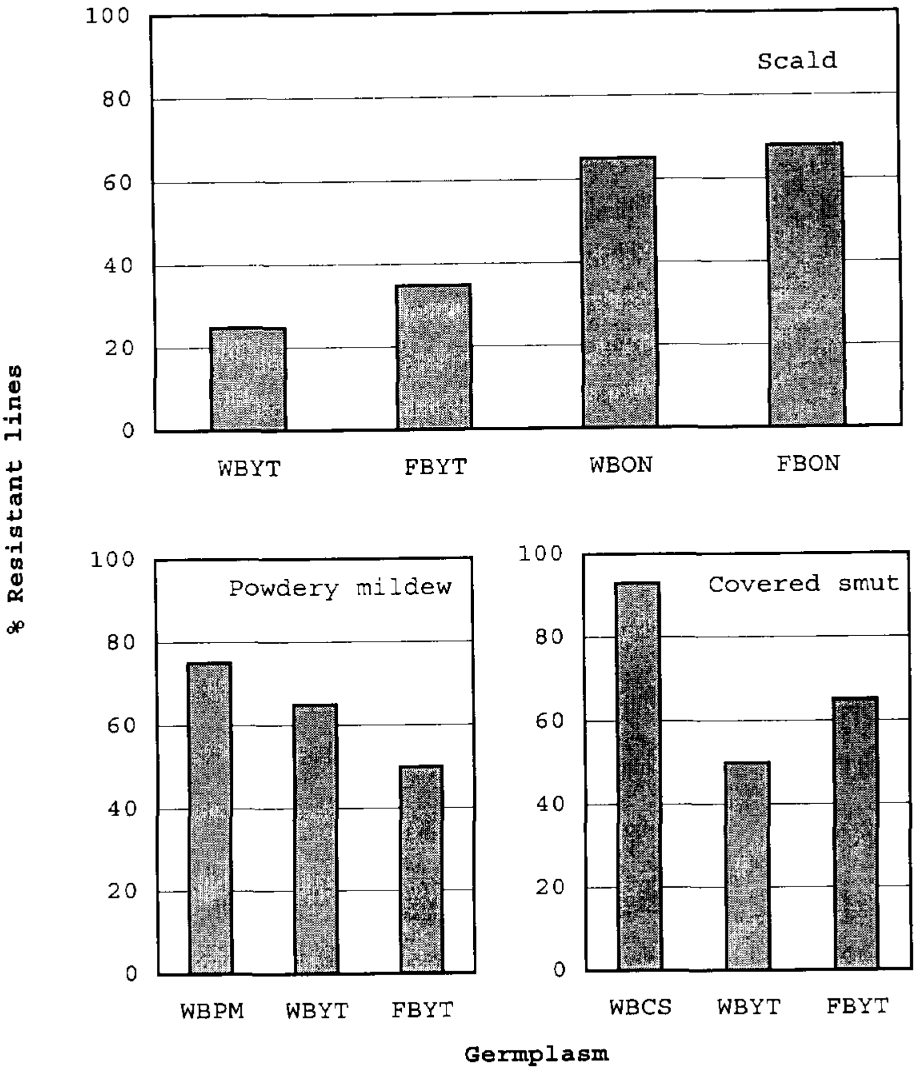


Fig. 6.2. The performance of winter/facultative barley germplasm against different diseases.

6.3.1.2.1. Spring, Winter/Facultative Bread Wheat Germplasm

The germplasm screened for resistance to diseases are the following: Wheat Preliminary Disease Nursery (WPD, 441 entries), Wheat Key Location Disease Nursery (WKL, 180 entries), Wheat Aleppo Crossing Block (WACB, 156 entries), Winter/Facultative Yellow Rust Common Bunt Nursery (WFYRCB, 27 entries), the different Special Purpose Disease Nurseries: Wheat Yellow Rust Nursery (WYR, 36 entries), Wheat Leaf Rust Nursery (WLR, 40 entries), Wheat Stem Rust Nursery (WSR, 27 entries) and Wheat Septoria Nursery (WST, 40 entries).

Figure 6.3 gives an overview of the performance of the different germplasm against the different diseases. A high percentage of resistant lines to yellow and leaf rusts ranged from 60 to 94% was found in all germplasm tested except in the WACB for yellow rust (24%). WSR exhibited the highest performance towards stem rust (96%) followed by WKL (54%), WACB and WPD (37%). For *Septoria tritici* blotch, two germplasm nurseries had an acceptable level of resistant lines WST (53%) and WACB (38%), the other nurseries had a weak performance (<13%). For common bunt, a very low percentage of resistant lines was found in all nurseries (<9%).

Some lines had multiple resistance to several diseases. The following entries were resistant to yellow, leaf and stem rusts and *Septoria tritici* blotch [WACB 97 (#113, 130, 140), WKL 97 (#41, 91, 93, 197, 199), WPD 97 (#8, 113, 398),]. In WACB 97 nursery, one line was resistant to yellow, leaf and stem rusts and common bunt (#123) and another line was resistant to leaf rust, stem rust, *Septoria tritici* blotch and common bunt (#137). 126 lines from the different wheat nurseries were resistant to the 3 rusts.

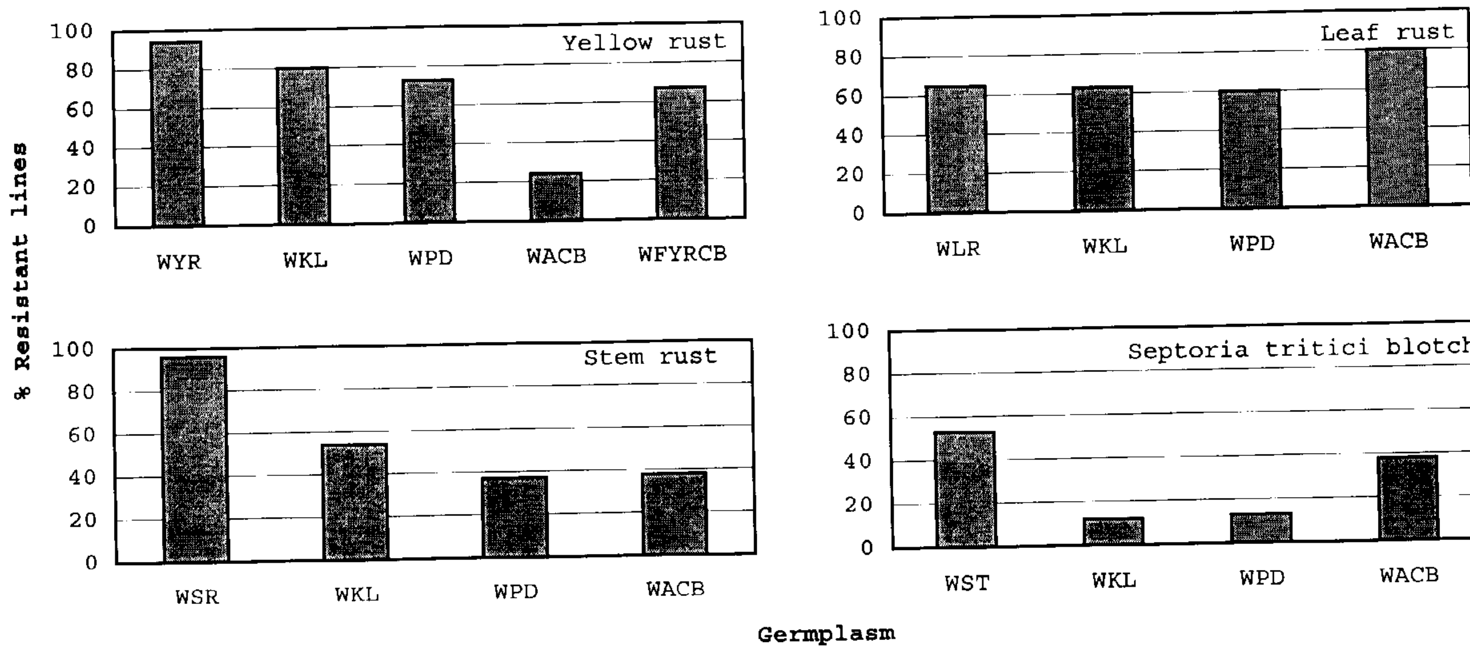


Fig 6.3. The performance of bread wheat germplasm against different diseases.

6.3.1.2.2. Durum Wheat Germplasm

The following durum wheat germplasm was screened for its performance to diseases: Durum Key Location Disease Nursery (DKL, 216 entries), Durum Preliminary Disease Nursery (DPD, 396 entries), Durum Aleppo Crossing Block (DACB, 97 entries), Durum Core Collection Nursery (DCC, 150 entries) and the Special Purpose Disease Nurseries: Durum Yellow Rust Nursery (DYR, 32 entries), Durum Leaf Rust Nursery (DLR, 32 entries), Durum Stem Rust Nursery (DSR, 12 entries) and Durum Septoria Nursery (DST, 31 entries).

The performance of the different germplasm towards the diseases is shown in Figure 6.4. The best performance of lines towards the three rusts was in the special purpose disease nurseries with 97%, 91% and 100% resistant lines in DYR, DLR and DSR respectively. In general, the percentage of resistant lines was high for yellow and stem rusts in the different nurseries (>48%) except in DCC. However, the performance of lines towards leaf rust, *Septoria tritici* blotch and common bunt was low in general.

Some lines exhibited a multiple disease resistance. Two lines (DKL97 #26, 158) were resistant to the 3 rusts and *Septoria tritici* blotch, 1 line to yellow and stem rusts, *Septoria tritici* blotch and common bunt (DACB 97 #30), 34 lines from different nurseries were resistant to the 3 rusts.

(O. F. Mamluk, H. Toubia-Rahme, M. Naimi, I. Maaz)

6.3.2. Screening Wild *Triticum* for Resistance to Wheat Diseases

A total of 177 accessions of wild Triticum (76 *T. monococcum* subsp. *boeoticum*, 53 *T. urartu*, 37 *T. turgidum* subsp. *dicoccoides*, 11 *T. timopheevi* subsp. *araraticum*) were screened for yellow, leaf and stem rusts, *Septoria tritici* blotch and common bunt.

T. monococcum subsp. *boeoticum*: 67 accessions were resistant to yellow rust, 43 to leaf rust, 2 to stem rust, all to *Septoria tritici* blotch and 37 to common bunt.

T. urartu: 12 accessions were resistant to yellow rust, 19 resistant to leaf rust, 1 resistant to stem rust, all resistant to *Septoria tritici* blotch, 29 resistant to common bunt.

T. turgidum subsp. *dicoccoides*: 4 accessions were resistant to yellow rust, none to leaf and stem rusts, all except one to *Septoria tritici* blotch and 29 to common bunt.

T. timopheevi subsp. *araraticum*: 7 accessions were resistant to yellow rust, none for leaf and stem rusts, all to Septoria tritici blotch and 10 to common bunt.

(O. F. Mamluk, H. Toubia-Rahme, J. Valkoun (GRU), M. Naimi, I. Maaz)

6.3.3. Germplasm Pools for Sources of Resistance (GPPLs)

Seven germplasm pools for sources of resistance to the different diseases were developed this year (four durum wheat GPPLs and two spring barley GPPLs). These are: DYRGP-97 for yellow rust (10 lines), DLRGP-97 for leaf rust (10 lines), DSRGP-97 for stem rust (5 lines), DSTGP-97 for *Septoria tritici* blotch (7 lines), SBSCGP-97 for scald (18 lines), SBPMGP-97 for powdery mildew (19 lines). These pools were distributed in 220 sets to the collaborators in WANA and beyond for the use in their breeding programs.

(O. F. Mamluk, H. Toubia-Rahme, M. Naimi, Z. Alamdar)

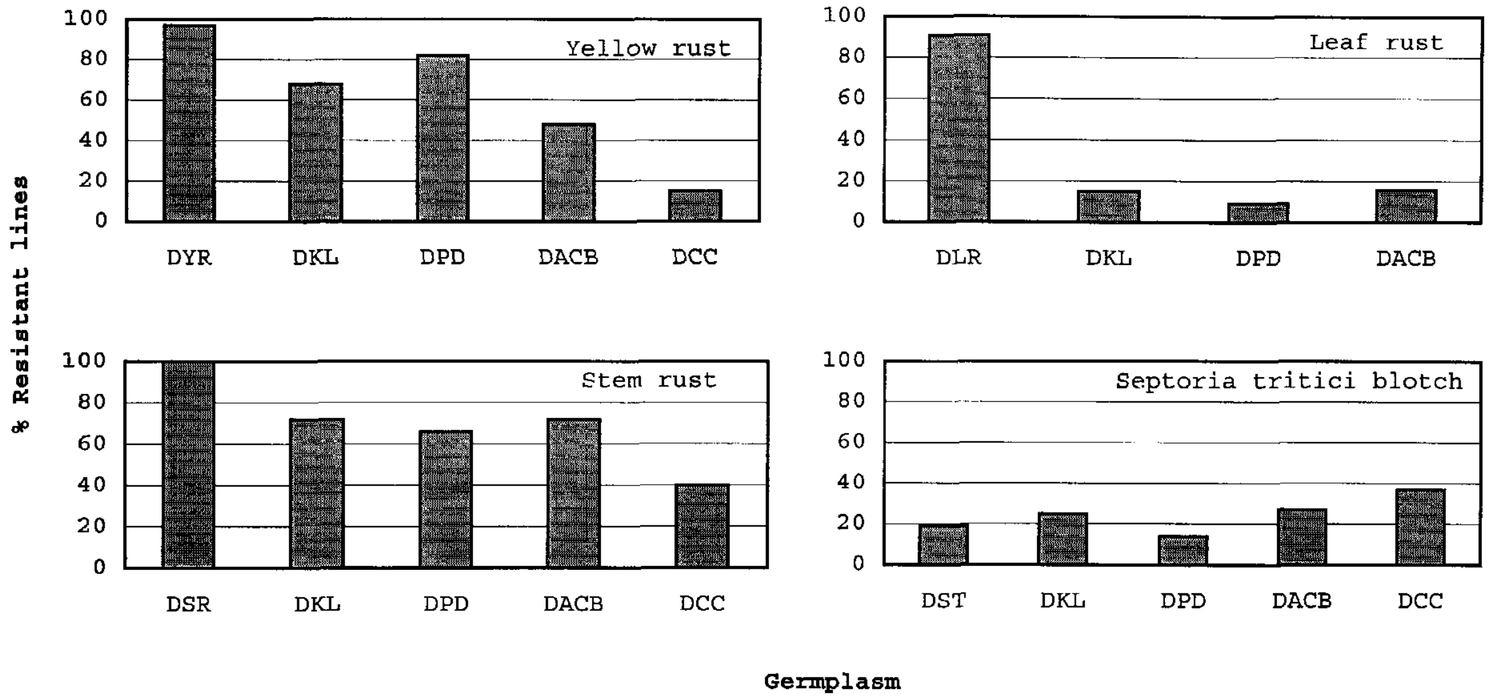


Fig. 6.4. The performance of durum wheat germplasm against different diseases.

6.3.4. Identification and Localization of Resistant Genes Using Molecular Markers

Genetic resistance can be most fully utilized using knowledge of the identity of resistant genes in commonly used parental germplasm and released cultivars. Identification of resistant genes allows for efficient incorporation of different genes into germplasm pools, thus helping to avoid the release of cultivars that are genetically uniform. In recent years, the advent of molecular markers has provided tools suitable for rapid and detailed genetic analyses of agricultural species. For this purpose, mapping populations for bread wheat, durum wheat and barley segregating to yellow rust, leaf rust and barley leaf stripe respectively are under development at ICARDA to determine the genetic background and the diversity of sources of resistance identified.

(H. Toubia-Rahme)

6.4. Race Identification and Virulence Analysis for Wheat Yellow and Leaf Rusts

Yellow rust variability and detection of any possible shift in pathogen population in Syria and Lebanon is monitored using an internationally recognized set of yellow rust differentials.

Yellow rust samples collected from Syria and Lebanon were analyzed. Two new races 18E0 and 134E16 have been reported for the first time in Syria. Race 18E0 is virulent on *Yr*7 and *Yr*10 and race 134E16 is virulent to *Yr* (2, 6, 7, 8, 9, 9^{+}, 18 and A). These 2 new races are not carrying any additional virulence to the virulences present in Syria.

The analysis of the inoculum bulk collected from Lebanon showed the presence of the following *Yr* virulence genes *Yr*

(2, 3^v, 6, 6^+, 7, 7^+, 8, 9, 9^+, 18, A and SD). No new races were identified this year.

A study on virulence analysis of wheat leaf rust was initiated this season. Leaf rust inoculum bulk collected from Tel Hadya was analyzed for its virulence to *Lr* genes. The inoculum collected from the bread wheat had virulences to *Lr* (2B, 2C, 3ka, 3Bg, 10, 11, 17, 18, 20, 21, 23, 30, 32) and the one collected from the durum wheat had virulences to *Lr* (2B, 2C, 3ka, 3Bg, 10, 11, 17, 18, 21, 23, 32).

(S. Hakim (U. of Aleppo), O.F. Mamluk, H. Toubia-Rahme, M. Naimi)

6.5. Crop Loss Assessment for Wheat Yellow Rust

Sixteen cultivars (6 bread wheat and 10 durum wheat) from the farmers field verification trials (ICARDA and DASR collaborative program) were tested in a crop loss assessment trial for the acute losses caused by yellow rust. The treatments comprised two systemic foliar fungicides, triadimenol (Bayfidan) and propiconazole (Tilt) and one untreated treatment. Artificial inoculation was performed to ensure a uniform inoculum in the plots. Cultivars performance was assessed for average coefficient of infection (ACI), grain yield/ha, number of tillers/m, number of seeds/spike and thousand kernel weight (1000 KW). Results are shown in Table 6.1. Square root transformation was applied for ACI values. Interaction between treatments and cultivars was only significant (P = 0.05) for ACI and TKW. Both fungicides significantly reduced the ACI for all lines tested but this was not always reflected by an increase in yield.

(O.F. Mamluk, H. Toubia-Rahme, M. Naimi, M. Singh (CBSU))

6.6. Etiological Studies on Septoriosis of Wheat in Syria

The primary sources of infection of *Septoria tritici* blotch were studied in research plots, previously planted to wheat at Tel Hadya for two seasons (1995/96-1996/97) using susceptible wheat cultivars. Spores released from infected wheat stubble were trapped for identification and quantification by two spore-trap methods (wood box trap and Burchard spore trap). Spore counts were correlated with rainfall data at the research station. The first occurrence of symptoms on volunteer wheat plants was recorded and correlated with the different kinds of spores trapped by the two methods, to determine the primary source(s) of inoculum for the early infections. Two-celled colorless ascospores of *Mycosphaerella* spp. were recorded together with pycnidiospores of *Septoria tritici*. After germination, the ascospores yielded *Cladosporium* spp. (teleomorph: *Mycosphaerella* spp.) which is a weak parasite on wheat. It appears that the primary source of inoculum for *Septoria tritici* blotch in Syria originates mainly from pycnidiospores released from the stubble.

(O. F. Mamluk, H. Obeido (U. of Aleppo))

6.7. Root Rot Diseases

Field surveys were conducted in the three agro-ecological zones of Syria in order to evaluate the effect of cropping practices and agro-ecologies on disease incidence and intensity of common root rot (CRR) of barley and wheat associated with diseased plants and to determine their frequency of occurrence. Limited survey results are also included from central Anatolia of Turkey.

Table 6.1. Effect of yellow rust (*Puccinia striiformis* f. sp. *tritici*) on yield and yield components of bread and durum wheat at Tel Hadya.

	Yld[a]	No.	No.	ACI			TKW (g)		
Cultivar	t/ha	til/m	sd/S	T1	T2	T3	T1	T2	T3
DOUMA 20601	3.92[b]	85.4	36.0	16.9	2.0	3.3	34.6	36.3	33.8
SEBAH	3.72	88.3	36.3	2.5	1.5	1.5	33.1	32.8	32.8
BOHOTH 5	3.54	96.1	34.8	18.6	1.5	2.0	36.4	36.1	35.6
DOUMA 20603	3.65	100.2	40.8	1.5	1.5	2.6	26.6	25.8	26.5
ACSAD 357	3.81	91.6	33.2	40.5	2.0	2.6	39	36.9	36.3
ACSAD 299	3.74	94.7	33.9	19.8	1.5	3.3	30.3	31.2	29.2
OM RUF 3	3.69	98.0	36.0	9.0	1.0	1.5	28.4	28.8	27.5
MOUL CHAHBA 1	3.31	91.3	36.8	1.5	1.0	2.0	27.2	25.8	25.6
CHAM 5	4.13	101.4	35.2	6.0	1.5	2.5	32.7	32.5	32.8
OM GENIL	3.89	99.4	34.4	4.9	1.5	1.5	32.2	32.9	31.6
CHAM 4	3.64	131.0	32.3	5	1.5	1.5	24.5	21	22.9
BOCRO 1	3.83	125.0	28.7	9	1.5	2	26.7	28.8	28.2
ACSAD 305	3.22	97.6	33.6	64.5	2	8.4	26.1	27.4	28.5
BOCRO 4	3.71	135.0	29.6	9	1.5	2.7	28.4	28.1	27.3
DOUMA 11670	3.50	118.6	39.9	19.8	1.5	2	22.6	21	22.3
MEXIPAK 65	2.73	99.3	32.4	90	4	16.7	20.5	27.4	26.9
SE1	0.16	4.51	0.97				1.52*		
SE2							1.00		
CV%	13.2	13.1	8.4				5.9		

[a] Yld=Yield, No.till=Number of tillers, No.sd/S=Number of seeds/spike, ACI=Average of coefficient of infection, TKW=Thousand Kernel Weight, T1=inoculated, T2=treated with triadimenol (Bayfidan EC 250), 0.5 l/ha, T3=treated with propiconazole (Tilt EC 250), 0.5 l/ha.

[b] Except for TKW, The values for all yield components are the means over treatment as there was no significant difference between treatments.

* in the case of TKW, SE1 to compare treatment at same or different levels of cultivars, SE2 to compare cultivars at same level of treatments.

Experimental design: Split Plot in RCBD with treatment as main plot and cultivar as sub-plot, plot size: 7.2 m^2, harvested: 3.6 m^2, 3 replications, $P = 0.05$

6.7.1. Evaluation of Farmers Fields

The main rotation practices were fallow, summer crops (mainly cotton), lentil and continuous cereals. In both crops, land races and improved cultivars were grown but most of the barley fields were planted with land races.

6.7.1.1. Barley

The growth stage of barley at the time of visit ranged from early to late dough based on Zadoks *et al.* scale. Based on root rot symptoms, CRR was recorded in all fields with varying levels of incidence and intensity. The differences could be due to cropping practices, geographical location and cultivars grown by farmers. The incidence of CRR ranged from 26 to 100% and intensity ranged from 4 to 24%. The highest incidence and intensity were observed in continuous barley fields and the lowest when barley was followed by summer crops. Moreover, CRR incidence was high in irrigated fields, however, the intensity was high in non-irrigated fields.

The pathogens associated with barley roots were *Cochliobolus sativus*, *Fusarium culmorum*, *F. nivale* and other *Fusarium* species. The isolation frequencies (n= 380 pieces of SCI) for *C. sativus*, *F. culmorum* and *F. nivale* were 18.2, 10.9 and 0.3% respectively. The isolation results showed that *C. sativus* is the major pathogen involved in root rot complex in Syria.

6.7.1.2. Wheat

CRR occurred in all wheat fields surveyed and its incidence ranged from 10 to 90%. The severity was very low and 65% of the fields showed rating of below 1 on a 6-point rating scale. The highest CRR incidence (71%) was observed when wheat was followed by legumes and the lowest (43%) was when it was followed by summer crops. The highest disease intensity (17%) was observed when wheat was followed by fallow and lowest (7%) when it was followed by summer crops.

There was no significant differences in CRR intensity between irrigated and non-irrigated wheat fields.

The pathogens that were isolated from wheat roots were *C. sativus, F. nivale, F. culmorum, F. avenaceum* and other *Fusarium* spp. The isolation frequencies (n= 778 SCI pieces) for *C. sativus*, *F. culmorum*, *F. avenaceum* and *F. nivale* were 8.7, 6.4, 0.4 and 0.3%, respectively.

In Turkey, 5 barley and 6 wheat fields were inspected at harvest time and isolations were made to determine the causal agents. The pathogens identified were *C. sativus*, *Fusarium nivale* and other *Fusarium* spp. The isolation frequencies (n=105 barley SCI) for *C. sativus* and *F. nivale* were 59 and 6%, respectively. In wheat, the isolation frequencies (n= 87 Wheat SCI) for *C. sativus* and *F. nivale* were 16.5 and 9%, respectively. The result showed that *C. sativus* is the major contributor of the root rot complex on wheat and barley.

6.7.2. Evaluation of Long-term Rotation Trials

The main objective of assessing long-term rotation trials was to determine the effect of treatments on root rots of barley and wheat that are being tested at different production zones. In this report, only results of the evaluations are presented. The detailed materials and methods for the long term rotation trials used in this study can be found from FRMP Annual Reports.

6.7.2.1. Barley-Based Long-term Rotations

This trial was established at Tel Hadya and Breda stations. At Tel Hadya, legume rotation showed a reduction of CRR incidence and intensity (85 and 17%, respectively) compared to continuous barley or barley followed by fallow (92 and 23%

respectively). Above ground symptoms were observed in continuous barley plots without fertilization and the average incidence was 20%.

At Breda, both disease incidence and intensity were high in continuous barley (89 and 23%, respectively) and low when barley was followed by forage legumes (46 and 6.7%, respectively). Nitrogen application generally showed high CRR incidence and intensity, however, phosphorus reduced incidence and intensity at both locations.

Fungi isolated from roots collected from the experimental plots at Tel Hadya were *C. sativus, F. nivale, F. culmorum, F. solani, Rhizoctonia bataticola* and other *Fusarium* spp. The highest frequency of isolation was with *C. sativus* indicating that it is the major contributor to the root rot complex. Some of the fungi isolated were legume root pathogens and, they probably they infected barley roots without showing any symptoms. The implication may be that barley is a symptomless carrier to some of these pathogens.

6.7.2.2. Stubble Management Trial

This experiment was established at Breda. In the continuous barley experiment, significant differences ($p<0.05$) were observed among N levels and their interactions with straw/stubble managements for CRR incidence and intensity. The highest CRR incidence (87%) and intensity (29%) were observed when straw was removed, stubble left in the field and plowing was done in October. The lowest values of the two disease parameters were observed when straw was removed and no plowing was practiced. High incidence and intensity of CRR was observed in plots fertilized with nitrogen.

In the barley/vetch rotation experiment, no significant differences were observed among treatments and their interactions in affecting CRR incidence and intensity. The highest incidence and intensity were observed when straw was removed, stubble left and plowed in October. The lowest values were observed when no plowing and no stubble removal were applied. Both incidence and intensity were high in plots fertilized with nitrogen. In both experiments non-tilled plots showed low levels of CRR.

The fungi associated with infected roots collected from the experimental plots in the two experiments were *C. sativus, F. nivale, F. culmorum, F. solani, R. bataticola* and other *Fusarium* spp. The highest frequency of isolation was *C. sativus* (Range: 7-22%) followed by *F. nivale* (average isolation frequency of 7%).

6.7.2.3. Wheat-Based Rotation Trial

This experiment is established at Tel Hadya. Significant differences ($p<0.05$) among nitrogen levels and their interactions with rotation were observed for disease incidence. For intensity, only nitrogen levels showed significant differences. The highest average percent CRR incidence (91%) was observed when wheat followed fallow and the lowest (43%) when wheat followed chickpea (Table 6.2). CRR intensity was high when wheat followed lentil and fallow (average 17%) and low when followed by chickpea. Nitrogen fertilizer tends to increase both CRR incidence and intensity.

The fungi associated with wheat roots were *C. sativus, F. nivale, F. culmorum, F. solani* and other *Fusarium* spp.

6.7.3. Biological Control

Two antagonistic fungal species (*Trichoderma* and *Gliocladium* spp.) and bacterial strains were tested against *Cochliobolus* *sativus*. The interaction between the antagonistic organisms and the test pathogen was tested on PDA.

There was significant difference ($p<0.05$) among strains of the two fungal antagonists in inhibiting the radial growth of the pathogen. The percent inhibition ranged from 67 to 90%. All the strains were kept for further evaluations in the plastic house. The bacterial strains also showed significant difference ($p<0.05$) in percent inhibition and the values ranged from 7 to 77% in Test 1 (21 strains) and 43 to 80% in Test 2 (19 strains). Only bacterial strains that showed more than 70% inhibitions were kept for further evaluations in the plastic house. Additional antagonists (fungal and bacterial) will be collected and evaluated in the laboratory.

(S. Ahmed)

Table 6.2. Mean[1] percent incidence and intensity of common root rot (CRR) of wheat, Tel Hadya, 1996/97

Crop sequence	% CRR incidence	% CRR intensity	%isolation frequency	Nb of SCI plated on PDA
Wheat-Wheat	67	13.7	20.2	213
Chickpea-Wheat	43	5.8	16	105
Fallow-Wheat	91	17.5	39.2	102
Medic-Wheat	70	10.5	20	85
Water Melon-Wheat	68	11.6	46.1	155
Lentil-Wheat	80	17.9	40.7	191
Vetch-Wheat	85	15.5	NT[3]	NT
Mean	72	13.2	30.4	

[1] Averaged over four fertility levels and two replications.
[2] Isolation of *C. sativus* from sub crown internodes (SCIs) on potato dextrose agar (PDA).
[3] Not tested.

6.8. Cereal Cyst Nematodes

The biology of the cereal cyst nematode (*Heterodera latipons*), its interaction with root rot pathogens and soil-antagonists in the soil-ecosystem are the main objectives of this collaborative study with the University of Bonn.

6.8.1. Evaluation of Long-term Rotation Trials

Several long-term trials focusing on agricultural practices and their influence on the incidence of the cereal cyst nematode *H. latipons* as well as on the egg parasitic fungi of the cyst content as possible antagonists at ICARDA research stations in two agro-ecological zones have been investigated.

The infection by *H. latipons* was in general higher in the drier areas. The application of nitrogen increased the nematode population under barley monoculture. The rotation of vetch did not reduce the *H. latipons* populations in the dry areas, whereas rotation with vetch in wetter areas had an impact on the reduction of *H. latipons*. Non-tillage treatment in both agro-ecological zones reduced the infection by the nematode compared with tillage. Similar results were obtained in the last two seasons.

In general, the parasitation rate of cyst content of *H. latipons* cysts is relatively low (10%) compared with higher rainfall areas in Europe. Despite that, in the more dry zone with an average annual rainfall below 250 mm, as well as under barley monoculture, a higher activity of antagonistic fungi was recorded compared with the more wet zone (250-350 mm average annual rainfall) and rotation with vetch respectively. The highest infection rate (34%) of cyst content with egg parasitic fungi was detected under barley monoculture and no nitrogen fertilization.

In two other trials in the more wet area the parasitation rate did not exceed 1% regardless the factors tillage or non-tillage and monoculture versus rotation with legumes (mainly vetch).

6.8.2. Crop Loss Assessment

A yield loss trial under field conditions during the 1996/1997 season and another one under plastic house conditions (maximal water supply) showed the economic importance of *H. latipons*. A susceptible barley variety Arta was used. Under field conditions, an average relative low inoculum of 500 eggs and juvenile/100g dry soil caused a significant 20% reduction of straw yield. The grain yield was not reduced. Under greenhouse conditions with a maximum water supply, *H. latipons* (1400 eggs and juvenile/100g dry soil) significantly reduced plant height by 30%, grain yield by 42% and straw yield by 69%.

6.8.3. Interaction between Cereal Cyst Nematodes and Root Rot

To study a possible interaction between *H. latipons* and *Cochliobolus sativus* in barley monoculture systems, which could not be detected until now by investigating ICARDA long-term trials, a pot experiment was carried out. An interaction trial between *H. latipons* (500 eggs and juveniles/100g soil) and *C. sativus* (300 conidia/g soil) on barley in a greenhouse experiment showed the major impact of the nematode on yield reduction, whereas *C. sativus* had only an additional effect on yield decline. The simultaneous presence of the fungus with *H. latipons* resulted in a non-significant 14 % reduction of grain yield related to the treatment *C. sativus* alone. A significant reduction of 38% of the grain yield occurred when the plants were attacked first by the nematode and nine weeks later by *C. sativus* compared with *C. sativus* alone. The presence of *H. latipons* simultaneously with *C. sativus* significantly increased the infection of the subcrown internode, seminal and nodal roots with *C. sativus* compared to *C. sativus* alone. *H. latipons* also predisposed the roots for the infection with *C. sativus* applied nine weeks later, The infection of the crown, subcrown internode, seminal and nodal roots with *C. sativus* was still higher compared to the treatment *C. sativus* alone, but not significantly different. In general, *C. sativus* reduces the population increase of *H. latipons*.

(U. Scholz (U. of Bonn), O. F. Mamluk, M. Ahmad)

6.9. Head Sterility in Barley and Seed-Gall Nematodes of Wheat and Barley

A survey in the main barley growing areas of Syria was undertaken for the second year in order to quantify the incidence of head sterility in farmers' fields and its relation to the seed-gall nematodes. The incidence of head sterility on barley varies from 6 to 47%. Grain losses up to 21 % were observed. The results indicated, that the head sterility does not correlate with plant height. The same result was obtained last year. Investigations of soil samples indicated the presence of *Tylenchorhynchus* spp., *Pratylenchus* spp., *Helicotylenchus* spp. and *Heterodera* spp.

The results of last season demonstrated that seed-gall nematodes of barley are a different species from that of wheat (*Anguina tritici*) (Annual Report, 1996). A cross inoculation test using wheat seed-gall nematodes and barley seed-gall nematodes was carried out to study the host range of these two pathogens. The results indicated that wheat seed-gall nematodes infect *Triticum aestivum, T. durum, T.*

boeoticum, *T. dicoccoides*, *Aegilops crassa* and triticale. The barley seed-gall nematodes infect *Hordeum vulgare* and *H. spontaneum*.

Reaction of wheat and barley cultivars to seed-gall nematodes has been tested in pot experiments under field conditions. Results showed that all the cultivars tested were susceptible to moderately susceptible.

(H. Zainab and F. Khatib (U. of Aleppo), O.F. Mamluk, Z. Alamdar)

6.10. Organic Seed-Treatment as Substitute for Chemical Seed-Treatment to Control Common Bunt of Wheat

The use of skimmed milk as organic seed-treatment to control common bunt of wheat under field conditions was very effective during the last three seasons 1994/95-1996/97. This season, in addition to the skimmed milk, other locally produced organic nutrients (huket-local skimmed milk and wheat flour) were tested. Results are presented in Table 6.3. The interaction between varieties and treatments was highly significant. Common bunt head infection was reduced to 99%, 98%, 93% and 74% when the seeds were inoculated with the two pathogens (*Tilletia tritici* and *T. laevis*) mixed in the ratio 1:1 and treated with vitavax, skimmed milk, huket and wheat flour respectively, compared to the inoculated, untreated control. Moreover, the reduction by skimmed milk and huket was not significantly different from the chemical seed-treatment. Similar results were obtained when seeds were inoculated with each of the common bunt pathogens separately.

(O. F. Mamluk, H. Toubia-Rahme, M. Naimi, I. Maaz, M. Ahmad)

Table 6.3. The effect of organic seed-treatment [skimmed milk, hucket (local skimmed milk) and flour] on the control of common bunt of wheat (*Tilletia laevis* and *T. tritici*) as compared to chemical seed-treatment (vitavax-200) at Tel Hadya.

Treatment	% head infection	
	Bau	Sebou
T. laevis & *T. tritici* (check)	49.6a*	36.2a
T. laevis & *T. tritici* + vitavax-200	0e	0e
T. laevis & *T. tritici* + skimmed milk	0.7e	0.3e
T. laevis & *T. tritici* + flour	12.8bc	10.3cd
T. laevis & *T. tritici* + hucket	1.9de	4.3de
T. laevis (check)	21.5b	10.5cd
T. laevis + vitavax-200	0e	0e
T. laevis + skimmed milk	0e	0e
T. laevis + flour	11.7bc	2.5de
T. laevis + hucket	0.9e	0e
T. tritici (check)	36.7a	40.1a
T. tritici + vitavax-200	0.3e	2.6de
T. tritici + skimmed milk	0.2e	2.8de
T. tritici + flour	4.7d	21.8b
T. tritici + hucket	0.8e	2.1de
Clean seeds (disinfected)	0e	0e

*Values in a column followed by the same letter are not significantly different at $P = 0.05$
Experimental design: CRB with three replications, Plot size: 0.6 m^2, harvested: 0.3 m^2

6.11. Use of Cultivar Mixtures to Control Air-Borne Diseases

The large scale use of individual resistant varieties usually rapidly leads to selection of new pathogen races able to overcome resistance. To reduce or avoid the problems created by crop monoculture, the integration of resistant varieties in mixtures serves as a biological barrier for the dissemination of pathogen inoculum and reduces the selection for complex races of pathogens. The use of cultivar mixtures to control yellow rust and *Septoria tritici* blotch of wheat, and scald of barley was investigated this season.

Three cultivars which differ in their reaction to the respective disease (1 resistant, 1 moderately susceptible and 1 susceptible) were used for each experiment as a pure stand and as mixtures with 2 ratios (1:1:1, 1:1:2). The control plots were protected by chemical foliar spray to determine the potential yield of each cultivar and mixture. An artificial inoculation was performed to ensure a uniform inoculum in the plots. Results are shown in Table 6.4. The disease intensity on the susceptible non-treated cultivars was very high with 92%, 86% and 93% for yellow rust, *Septoria tritici* blotch and scald respectively. Overall disease intensity in all mixtures was significantly lower than the one of susceptible cultivars in pure stands except for *Septoria tritici* blotch and the mixture (1:1:2).

(O.F. Mamluk, H. Toubia-Rahme, M. Naimi)

Table 6.4. Effect of cultivar mixtures on disease development of yellow rust (YR), *Septoria tritici* blotch (ST) of wheat and scald (SC) of barley and on grain yield.

Crop/disease	Cultivars[1]	% disease		Yield t/ha	
		I[2]	C	I	C
Wheat/YR	1-Bocro-2	2	2	4.86	5.27
	2-Nesser	20	1	5.25	5.23
	3-Seri-82	92	6	3.48	5.42
	4-Mix 1:1:1	61	1	4.54	5.03
	5-Mix 1:1:2	72	2	4.31	5.6
	LSD[3]	4.4		0.24	
Wheat/ST	1-WSTGP93 #4	37	0	3.27	4.36
	2-Bocro-2	76	1	3.07	3.14
	3-Towpee	86	1	2.71	3.12
	4-Mix 1:1:1	76	1	3.08	3.1
	5-Mix 1:1:2	85	1	3.36	3.08
	LSD	4.53		0.51	
Barley/SC	1-Tadmor	11	1	4.12	5.71
	2-Arta	68	6	3.54	4.78
	3-WI2291	93	6	4.13	5.44
	4-Mix 1:1:1	74	5	4.1	5.1
	5-Mix 1:1:2	81	6	4.19	5.13
	LSD	6.14		1.68	

[1] 1- Resistant cultivars for the corresponding disease, 2- Moderately susceptible, 3- Susceptible, 4- Mixture with equal ratio of the 3 cultivars, 5- Mixture with 50% susceptible cultivars and 25% for each of the remaining cultivars.
[2] I= Inoculated, C= Control, treatment with fungicides.
[3] Experimental design: Split Plot in RCBD with treatment as main plot and cultivar as sub-plot, 3 replications. Plot size: 7.2 m^2, harvested: 3.6 m^2, $P = 0.05$

7. VIROLOGY

7.1. Cereal Viruses

Evaluation of interspecific hybrids for their resistance to barley yellow dwarf virus (BYDV) was continued during 1996. In addition, a survey for cereal viruses in Yemen was conducted in collaboration with colleagues in National Programs of Nile Valley and Red Sea countries. Results of this survey is included in the Legume section as part of a survey on legume and cereal viruses in Yemen (6.3).

7.1.1. Evaluation of Wheat Wild Relatives

A total of 220 accessions of wheat wild relatives were evaluated for their reaction to BYDV. Because symptoms expression was mild, selection of resistant accessions was based on intensity of plant invasion with the virus as elucidated by the tissue-blot immunoassay. Twenty-five accessions (Table 7.1) were found as relatively resistant and these will be evaluated again during the next growing season. More information on the 25 resistant accessions are provided in Table 7.2.

7.1.2. Evaluation of Wheat Interspecific Hybrids for their Reaction to BYDV

The cereal wild relatives *Thinopyrum intermedium* and *Aegilops* spp. are reported to have a high tolerance to BYDV infection, and efforts in different laboratories are made to transfer this trait to cultivated wheat. Around twenty-six lines derived from the crosses bread wheat x *T. intermedium* and bread wheat x *Aegilops* spp. were evaluated

Table 7.1. Reaction of *Aegilops* and *Triticum* species to infection with BYDV, when plants were artificially inoculated with BYDV during the 1996-97 growing season.

Species	Total no. of Accessions tested	Average and range of virus conc. index[a]	No. of accessions selected as resistant
Ae. biuncialis	8	1.46 (1.00-1.87)	1
Ae. caudata	2	1.09 (1.00-1.17)	1
Ae. columnaris	6	1.63 (1.11-2.10)	1
Ae. crassa	4	2.12 (2.00-2.27)	
Ae. cylindrica	7	1.68 (1.38-1.92)	
Ae. geniculata	2	1.59 (1.42-1.75)	
Ae. kotschii	1	1.91	
Ae. Longissima	2	1.23 (0.88-1.57)	1
Ae. muticum	1	2.33	
Ae. neglecta	2	1.54 (1.50-1.58)	
Ae. peregrina	2	1.99 (1.86-2.13)	
Ae. searsii	4	1.62 (1.30-2.00)	
Ae. speltoides	30	1.71 (1.00-2.29)	1
Ae. tauschii	3	1.98 (1.70-2.40)	
Ae. triuncialis	13	1.84 (1.22-2.33)	1
Ae. ventricosa	1	1.80	
Ae. vavilovii	10	1.89 (1.64-2.14)	
T. monococcum	63	1.42 (0.78-2.31)	12
T. turgidum	34	1.52 (0.79-2.25)	5
T. urartu	25	1.91 (1.00-2.50)	2
Total	**220**		**25**

[a] virus concentration index was based on a 0-4 scale devived from the number of stained phloem bundles by TBIA test.

for their reaction to BYDV infection. The performance of these lines was based on symptoms severity index, grain yield and grain yield loss as compared to a healthy control. Some of these lines were characterized by mild symptoms upon virus inoculation, and low yield loss (e.g. Can-96-12). Few lines showed no significant yield loss due to BYDV infection inspite of relatively high disease index score (e.g. W-Thin-DL-6). Results of best performing lines are presented in Table 7.3. The performance of selected lines in two successive years is presented in Table 7.4. It is worth noting that yield loss due to BYDV infection in BYDV tolerant lines is less in the year when conditions permitted higher grain yield.

Table 7.2. *Aegilops* and *Triticum* Accessions resistant to BYDV-PAV, based on testing during the 1996-97 growing season.

Germplasm	ICARDA Accession number	Source country	Virus conc. index[a]
Ae. biuncialis	401819	Bulgaria	1.00
Ae. caudata	402255	Syria	1.00
Ae. columnaris	402179	Syria	1.11
Ae. longissima	402059	Palestine	0.88
Ae. speltoides	401763	Bulgaria	1.00
Ae. trunicialis	402586	Iran	1.22
T. monococcum	500556	Iran	0.92
T. monococcum	500560	Iran	1.00
T. monococcum	500632	Turkey	0.93
T. monococcum	300193	Turkey	1.00
T. monococcum	500630	Turkey	1.00
T. monococcum	500552	Iran	1.00
T. monococcum	500595	Iran	1.00
T. monococcum	300190	Turkey	1.00
T. monococcum	500582	Iran	1.00
T. monococcum	500583	Iran	1.00
T. monococcum	500588	Iran	1.00
T. monococcum	600915	Jordan	0.78
T. turgidum	600982	Syria	0.79
T. turgidum	600958	Syria	0.82
T. turgidum	601103	Turkey	1.08
T. turgidum	601106	Turkey	1.09
T. turgidum	601051	Iraq	1.00
T. urartu	500608	Turkey	1.10
T. urartu	500606	Turkey	1.00

[a] virus concentration index was based on a 0-4 scale and derived from the number of stained phloem bundles by BIA test.

Table 7.3. Best performing lines derived from wheat interspecific crosses re-evaluated for their reaction to BYDV after artificial inoculation with the virus. Evaluation was based on symptoms disease index (DI), grain yield (Gr. wt.) and yield loss (%) in responce to infection, during the 1996-97 growing season.

Entry	D.I. (0-9)	Gr.wt. (g/m)	Yield loss (%)
Bread Wheat x *Thynopirum intermedium* derived lines			
Origin: CIMMYT			
W-Thin-DL-4	8	92	21
W-Thin-DL-6	6	126	3
W-Thin-DL-69	5	93	27
W-Thin-DL-217	7	64	39
Origin:Australia			
TC14.289X	6	92	3
TC14.290J	6	74	10
TC14.289M	6	103	20
Bread Wheat x *Aegilops* derived lines			
Can-96-7	4	105	9
Can-96-8	4	96	28
Can-96-11	3	69	34
Can-96-12	3	142	1
SAB-94-5	6	54	22
SAB-94-158	5	59	9
SAB-94-245	4	74	34
Can-93-14	5	102	24
Can-93-21	6	115	6

7.1.3. Evaluation of Best Performing Cereal Genotypes from Previous Seasons

Re-evaluation of 52 barley lines from previous seasons identified some entries which are highly tolerant to BYDV as their yield was not affected by virus infection e.g. entries 2BIT-96-307, 2BIT-96-385, 1BIT-96-40 and HBON-96-53. Results obtained on the best performing entries are summarized in Tables 7.5 and 7.6.

Table 7.4. Best performing lines derived from wheat interspecific crosses re-evaluated for their reaction to BYDV after artificial inoculation with the virus, during the last two years. Disease index (D.I.), grain yield (Gr.wt.)

Entry	Disease index (D.I.) (0-9)		Grain yield (Gr. wt.) (g/m)		Yield loss (%)	
	1996	*1997*	*1996*	*1997*	*1996*	*1997*
Wheat x *Thynopirum intermedium* derived lines						
W.Thi-6	7	6	68	126	41	3
W.Thi-68	5	6	129	87	4	25
W.Thi-69	5	5	100	93	17	27
W.Thi-83	6	5	127	84	3	45
W.Thi-217	7	7	133	64	8	39
W.Thi-240	8	7	115	59	1	22
W.Thi-249	9	8	51	60	47	24
Wheat x *Aegilops* derived lines						
SAB-94-5	3	6	104	54	2	22
SAB-94-158	3	5	110	59	2	9
SAB-94-245	3	4	147	74	26	34
CAN-93-14	3	5	133	102	11	24
CAN-93-21	4	6	123	115	17	6

Re-evaluation of 23 durum wheat lines showed that a number of breeding lines were highly tolerant to BYDV infection (e.g. DOT-96-46 and DOC-96-49) (Table 7.7). Similarly 40 bread wheat genotypes were evaluated, many (e.g. WKL-96-164, WCB-96-48, SEL-STR-96-13, EYT-RF-96-6 and EY-95-18) were highly tolerant to BYDV infection (Table 7.8).

7.1.4. Evaluation of ICARDA Cereal Nurseries for their Reaction to BYDV Infection

Evaluation of 1378 lines of barley nurseries in 30 cm short rows, on the basis of symptoms produced indicated that 121

Table 7.5. Best performing spring barley lines after re-evaluation of their reaction to BYDV infection after artificial inoculation with the virus, on the basis of symptoms disease index (D.I.), grain yield (Gr.wt.) and yield loss (%), during the *1996-97 growing season*.

Entry	D.I. (0-9)	Gr. wt. (g/m)	Yield loss (%)
1BIT-96-18	5	148	32
1BIT-96-30	4	132	20
1BIT-96-34	6	108	12
1BIT-96-40	6	197	1
1BIT-96-45	6	172	18
1BIT-96-153	5	192	8
1BIT-96-255	7	153	7
2BIT-96-135	6	100	16
2BIT-96-206	4	160	15
2BIT-96-282	5	166	19
2BIT-96-291	6	137	8
2BIT-96-293	5	182	6
2BIT-96-296	4	177	4
2BIT-96-307	3	282	3
2BIT-96-313	3	140	11
2BIT-96-334	5	198	7
2BIT-96-385	3	300	20
2BIT-96-416	6	147	34
BKL-85-237	5	114	12
BON-MRA-89-4	5	184	7
Can-B-94-75	5	109	23
Can-B-94-97	6	119	22
Can-B-94-118	5	191	3
Can-B-94-120	6	193	3
BQ-94-28	5	183	7
BQ-94-30	6	164	7
BQ-94-39	6	194	4
BQ-94-61	6	197	4
Corris	5	162	10
Atlas-68	5	152	26
Abee	7	122	27

lines (8.8%) were tolerant to infection (Table 7.9). The best performing lines will be evaluated next season on the basis of yield loss due to infection in addition to symptoms severity.

Table 7.6. Best performing winter barley lines after re-evaluation of their reaction to BYDV infection after artificial inoculation with the virus, on the basis of symptoms disease index (D.I.), grain yield (Gr. wt.) and yield loss (%), during the 1996-97 growing season.

Entry	D.I. (0-9)	Gr. wt. (g/m)	Yield loss (%)
IFBON-96-40	3	192	1
IFBON-96-98	5	106	35
IFBON-96-111	4	223	23
IWBON-96-116	4	171	7
IWBON-96-118	5	143	14
IWBON-96-123	4	205	0
HBON-96-64	4	172	12
HBON-96-53	4	254	2
WBCB-96-33	6	201	20
WBCB-96-85	5	191	20
IFBYT-96-18	6	239	5
Sutter	3	158	19
Wysor	3	206	0

Similarly, 961 wheat lines were evaluated in 30 cm short rows based on the symptoms produced following BYDV inoculation. Results obtained suggested that 123 lines (12.7%) were tolerant to infection (Table 7.10).

When 76 spring barley, 35 winter barley, 51 durum wheat and 67 bread wheat lines, which have been tested in the previous season in 30 cm short rows, were evaluated for their reaction to BYDV in 1-m long rows during the 1996/97 growing season, some lines showed high tolerance to BYDV infection. Results of the best performing lines are presented in Tables 7.11, 7.12, 7.13 and 7.14, respectively.

(K. Makkouk, W. Ghulam)

Table 7.7. Best performing durum wheat lines re-evaluation of their reaction to BYDV infection after artificial inoculation with the virus, on the basis of symptoms disease index (D.I.), grain yield (Gr.wt.) and yield loss (%), during the 1996-97 growing season.

Entry	D.I. (0-9)	Gr. wt. (g/m)	Yield loss (%)
DKL-96-16	5	114	33
DKL-96-131	5	120	11
DKL-96-239	5	100	39
DOH-96-32	6	102	34
DOH-96-46	6	125	37
DOH-96-49	6	86	10
DOT-96-5	4	74	13
DOT-96-43	6	129	26
DOT-96-46	6	154	2
DOC-96-38	5	151	30
DOC-96-49	6	161	9
DOC-96-50	5	133	26
DOC-96-58	6	148	16
12th IDSN 227	5	117	15
12th IDSN 74	8	98	21
DKL-92-225	4	106	0
DKL-93-156	5	123	0
DON-LRA-86-25	4	98	3
DKL-91-164	5	92	11
DCC-HAA-90-152	4	66	14
C-YD-DW-90-27	6	58	24

Table 7.8. Best performing bread wheat lines after re-evaluation of their reaction to BYDV infection after artificial inoculation with the virus, on the basis of symptoms disease index (D.I.), grain yield (Gr.wt.), and yield loss (%), during the 1996-97 growing season.

Entry	D.I. (0-9)	Gr.wt. (g/m)	Yield loss (%)
Spring Wheat			
WKL-96-27	6	76	25
WKL-96-37	6	78	19
WKL-96-48	5	121	15
WKL-96-105	6	117	8
WKL-96-153	5	139	7
WKL-96-156	5	118	0
WKL-96-164	5	133	0
WCB-96-37	6	124	17
WCB-96-41	2	120	15
WCB-96-48	5	141	1
Maringa	6	71	24
WKL-93-11	6	112	13
WKL-93-23	5	72	22
WKL-93-125	5	71	10
ANZA	5	78	18
7Lacos-40	5	73	3
12th-IBWSN-459	8	57	41
Winter Wheat			
SEL-STR-96-13	4	119	8
SEL-STR-96-21	4	131	16
SEL-STR-96-22	5	118	17
EYT-RF-96-6	5	120	8
EYT-RF-96-17	6	67	8
EYT-IRR-96-12	4	58	44
EYT-IRR-96-13	3	102	16
AYT-96-33	2	74	8
AYT-96-34	5	75	24
AYT-96-54	3	109	29
EY-95-18	5	123	7
HF-94-33	6	111	13

Table 7.9. Evaluation of barley germplasm for tolerance to BYDV infection after artificial inoculation with the virus during the 1996/1997 growing season.

Nursery	Number of lines tested	Lines with tolerance to infection
Spring barley		
1 BIT-1997	440	5, 13, 18, 53, 74, 126, 185, 206, 303, 321, 371, 375, 381, 390, 396, 397, 398, 405, 407, 410, 420, 423, 425, 428, 429
2 BIT-1997	440	1, 12, 91, 92, 103, 129, 145, 154, 176, 179, 180, 210, 221, 222, 225, 256, 267, 284, 309, 326, 336, 347, 359, 360, 361, 371, 379, 388, 389, 393, 397, 399, 400, 413, 422
BAT-1997	100	12, 27, 34, 71, 80, 86, 100
Winter barley		
IFBON-1997	150	7, 15, 19, 20, 26, 27, 29, 30, 31, 33, 68, 82, 86, 97, 109, 112, 115, 119, 122, 124, 139
IWBON-1997	150	11, 16, 19, 37, 39, 44, 54, 66, 94, 96, 97, 113, 114, 122, 142
HBON-1997	50	1, 3, 13, 26, 45
IFBYT-1997	24	2, 8, 17
IWBYT-1997	24	1, 2, 6, 9, 12, 13, 15, 17, 18, 20

Table 7.10. Evaluation of wheat germplasm for tolerance to BYDV infection after artificial inoculation with the virus during the 1996/1997 growing season.

Cereal nursery	Number of Lines tested	Lines with tolerance to infection
Durum Wheat		
DKL-1997	240	6, 8, 22, 26, 33, 34, 64, 65, 66, 68, 69, 74, 96, 101, 129, 131, 142, 151, 162, 171, 174, 191, 195, 197
DCC-1997	192	15, 21, 23, 37, 38, 52, 63, 68, 71, 73, 77, 85, 99, 105, 106, 110, 114, 123, 125, 128, 130, 132, 133, 138, 143, 185
WANA-DW-97	85	1, 2, 3, 17, 19, 20, 27, 28, 34, 35, 42, 44, 46, 48, 49
Bread Wheat		
WKL-1997	200	3, 6, 9, 17, 28, 31, 41, 47, 57, 61, 68, 84, 94, 97, 144, 151, 153, 163, 165, 169, 176, 177, 178, 183, 186, 188
Insect Germplasm-97 PS-97	73	5, 7, 14, 16, 17, 19, 24, 27, 30, 31, 32, 33, 34, 35, 38, 55, 57, 62, 72
WW-1997 (winter wheat)	171	9, 10, 19, 20, 22, 31, 63, 74, 75, 76, 150, 156, 160

Table 7.11. Performance of selected spring barley lines provided by barley breeders at ICARDA and planted in 1-m long rows showing tolerance to infection after re-evaluation, during the 1996-97 growing season.

Entry	Disease index (D.I.) (0-9)	Grain yield (Gr.wt.) (g/m)
1BIT-96-18	3	153.9
1BIT-96-30	5	104.8
1BIT-96-34	5	104.2
1BIT-96-35	5	111.5
1BIT-96-45	5	170.0
1BIT-96-49	5	246.2
1BIT-96-55	5	197.2
1BIT-96-80	4	149.6
1BIT-96-153	5	139.8
2BIT-96-96	5	170.8
2BIT-96-120	5	118.9
2BIT-96-135	5	120.6
2BIT-96-190	4	145.3
2BIT-96-195	5	130.7
2BIT-96-203	3	199.4
2BIT-96-206	5	160.8
2BIT-96-267	5	140.9
2BIT-96-282	5	189.7
2BIT-96-284	5	110.7
2BIT-96-285	5	132.4
2BIT-96-289	5	214.7
2BIT-96-291	5	121.5
2BIT-96-295	5	209.5
2BIT-96-296	5	190.9
2BIT-96-307	4	286.3
2BIT-96-313	5	207.0
2BIT-96-315	5	191.0
2BIT-96-316	5	238.8
2BIT-96-334	5	200.3
2BIT-96-340	5	155.6
2BIT-96-361	5	121.3
2BIT-96-385	4	232.4
2BIT-96-393	5	208.8
2BIT-96-419	5	134.3
2BIT-96-374 (Susc. Check)	6	33.1

Table 7.12. Performance of selected winter barley lines provided by barley breeders at ICARDA and planted in 1-m long rows showing tolerance to infection after re-evaluation, during the 1996-97 growing season.

Entry	Disease index (D.I.) (0-9)	Grain yield (Gr.wt.) (g/m)
IFBYT-96-7	5	203.4
IFBYT-96-17	6	106.8
IFBYT-96-18	6	153.0
IWBYT-96-5	4	124.9
IWBYT-96-7	6	120.4
IWBYT-96-14	6	117.6
IWBYT-96-17	6	105.1
IWBON-96-88	2	122.0
IWBON-96-110	6	155.2
IWBON-96-116	4	160.7
IWBON-96-118	5	155.1
IWBON-96-120	4	188.4
IWBON-96-123	3	174.3
HBON-96-38	6	100.3
HBON-96-68	5	42.5
IFBON-96-40	4	154.1
IFBON-96-70	6	132.1
IFBON-96-77	6	110.1
IFBON-96-111	5	136.5
WBCB-96-17	6	114.9
WBCB-96-22	6	114.9
WBCB-96-85	3	199.3
WBCB-96-37 (Susc. Check)	7	13.9

Table 7.13. Performance of selected durum wheat lines provided by durum wheat breeders at ICARDA and planted in 1-m long rows showing tolerance to infection after re-evaluation, during the 1996-97 growing season.

Entry	Disease index (D.I.) (0-9)	Grain yield (Gr.wt.) (g/m)
DKL-96-47	6	105.5
DKL-96-146	6	118.6
DKL-96-175	6	111.8
DKL-96-192	6	103.4
DKL-96-195	6	105.9
DKL-96-161	8	51.9
DOT-96-16	6	111.5
DOT-96-43	6	102.8
DOT-96-73	6	128.6
DOT-96-77	6	101.3
DOT-96-39	8	40.8
DOH-96-5	6	110.5
DOH-96-24	6	108.5
DOH-96-31	5	135.5
DOH-96-46	5	117.4
DOH-96-49	6	74.4
DOC-96-32	6	104.1
DOC-96-49	5	148.6
DOC-96-50	6	106.6
DOC-96-93	5	120.6
DOC-96-135	6	103.6
DOC-96-87 (Susc. Check)	7	70.5

Table 7.14. Performance of selected bread wheat lines provided by bread wheat breeders at ICARDA and planted in 1-m long rows showing tolerance to infection after re-evaluation, during the 1996-97 growing season.

Entry	Disease index (D.I.) (0-9)	Grain yield (Gr. Wt.) (g/m)
Spring Wheat		
WKL-96-4	6	96.4
WKL-96-30	5	107.2
WKL-96-109	5	85.3
WKL-96-110	6	92.0
WKL-96-170	6	101.5
WKL-96-198	6	88.1
WCB-96-9	6	108.3
WCB-96-26	6	96.6
WCB-96-41	4	103.3
WCB-96-96	6	89.2
Winter Wheat		
SEL-STR-96-2	5	104.8
SEL-STR-96-15	6	102.2
SEL-STR-96-18	5	109.3
SEL-STR-96-21	5	123.5
SEL-STR-96-22	5	115.5
EYT-RF-96-6	6	113.2
EYT-RF-96-10	5	113.8
EYT-RF-96-17	5	39.0
EYT-RF-96-18	5	62.5
EYT-IRR-96-12	5	76.4
EYT-IRR-96-13	5	117.8
EYT-IRR-96-18	5	106.1
EYT-IRR-96-22	5	79.2
AYT-96-12	5	70.6
AYT-96-25	6	115.4
AYT-96-33	4	96.5
AYT-96-34	5	60.4
AYT-96-35	6	92.4
AYT-96-51	5	91.8
AYT-96-54	4	107.8
AYT-96-55	4	115.0
AYT-96-58	5	93.4
AYT-96-84	5	91.1
WCB-96-49 (Susc. Check)	7	25.8

8. TRAINING AND VISITS

Training activities in Germplasm Program aim to assist researchers in NARS to develop their competencies in recognizing the breeding problems of cereals and legumes and applying modern techniques to solve these problems. The trainees are taught to design and manage conventional experiments in the various aspects of breeding, hybridization, note taking, diseases scoring, selection, analyzing and interpretation of experimental data and preparation of short technical reports; the trainees mainly are familiarized with practical application in the field as well as some lectures. Round table discussions take place in specialized short-term group training courses. A method for evaluating progress is developed to measure the performance of trainees and the impact of their training on agricultural research in their countries. The following training activities were conducted during 1997.

8.1. Long-term Training Course in Cereal Improvement

This course is conducted at ICARDA's principal research station at Tel Hadya as a major training activity of the program. Nine participants from 6 countries: Algeria (2), Libya (1), Morocco (1), Pakistan (1), Palestine (1), and Syria (3), were trained for 4 months (16 March-10 July 1997) on cereal improvement with emphasis on genetic improvement of barley, bread wheat and durum wheat. Both, spring and winter/facultative types of these cereals, were covered. Emphasis is laid on breeding for harsh environments and on enhancing tolerance/resistance to biotic and abiotic, nutrient deficiency and toxicity stresses. The course was organized through lectures, field work, seminar, informal discussions and assigned research experiment with a "learning by doing" methodology. The evaluation of the course was very good, and all the trainees expressed that the subjects of the course were very relevant to their jobs, and the new knowledge acquired was very considerable.

8.2. Short Courses

8.2.1. Integrated Management of Cereal and Food Legume Insect Pests

A short-term course offered by ICARDA in Aleppo, Syria (27 April to 8 May, 1997). The course aims to strengthen the region's network of legume and cereal entomology through staff training in entomology research techniques. At the end of the course, the participants were able to assess insect infestation and damage, sample and monitor insects populations, screen for host plant resistance, collect and preserve insects and to apply skills in biological control research. This content was presented through theoretical class-room lectures, field and laboratory practical activities. Twelve researchers representing 11 countries (Egypt, Lebanon, Libya, Iran, Jordan, Morocco, Sudan, Syria, Tunisia, Turkey and Yemen) in WANA region participated in this course. They mentioned that a big improvement in their entomology skills was obtained. The overall mean performance between pretest and final test went from 34% to 76% at the end of the course.

8.2.2. DNA Molecular Marker Techniques for Crop Improvement

The course was again strongly requested by NARSs and other Mediterranean countries. ICARDA and CIHEAM jointly sponsored

Table 8.1. Attendance at DNA Molecular Marker Techniques short course - 1997.

Name	Country	Degree	Profession	Institution
Ms. Dalila Khendek	Algeria	M.Sc	Agronomist	ITGC
Ms. Mouna Taghouti	Morocco	M.Sc	Breeder	INRA
Ms. Louiza Bouabdauah	Algeria	M.Sc	Professor	Oran univ.
Mr. Cuma Akinci	Turkey	M.Sc	Breeder	Dicle univ.
Mr. Nafiz Geliktas	Turkey	M.Sc	Biotechnologist	Cukurova univ.
Mr. Zouheer Ayyoubi	Syria	P.Sc	Breeder	A.E.C.
Mr. Raad Mohamed Salman	Iraq	Ph.D	Breeder	ARC
Mr. Ibrahim Ahmed Imbaby	Egypt	Ph.D	Plant pathology	ARC
Ms. Graca Pereira	Portugal	M.Sc	Agronomist	ENMP
Mr. Dixit Girish Prasad	India	Ph.D	Plant breeder	IFPR
Mr. Abdallah Youse Akhond	Bangladesh	M.Sc	Plant breeder	ARC

this two-week (14-25 September 1997) specialized short training course. 11 participants from 9 countries (Table 8.1) attended lectures on genetics and current research issues in biotechnology, and spend most of their times working in the laboratory (RFLP, PCR) and application of these techniques for germplasm identification, evaluation and improvement. The course was well received by the trainees, most of them were experienced in breeding or biotechnology. Two professors from Germany participated in lecturing. All the trainees expressed their satisfaction with the new knowledge they acquired.

8.2.3. Cereal Diseases and Insects

A sub-regional course on cereal diseases and insects was held in El-Kef/Tunisia at the "Ecole Supérieure d'Agriculture" from 17 to 26 March 1997. Eight Libyan and six Tunisian trainees participated in this course. Instructors included scientists from ICARDA and scientists from NARSs. Classroom lectures laboratory application, and practical field visit were given. Lectures covered the major insects pests and diseases infecting wheat and barley in North Africa, and emphasized the importance of resistant cultivars as a means of controlling disease. All participants appreciated the practical nature of the course which they found useful and informative.

8.2.4. Pedigree Management

A regional course on pedigree and data base management for cereal breeders was conducted on 24-28 February, 1997 in Tunis/Tunisia in collaboration with NARS's. The course was attended by eleven participants representing four countries (Egypt, Libya, Algeria and Tunisia). It was a practical course for using the computer for data management (randomization, data entry, selection based on multilocation/interpretation data analysis, multiyear) using QPRO or AGROBASE. Most of the time was devoted to practical training in computer laboratory. All trainees said that the course met its objectives.

8.3. Individual Training

8.3.1. Individual Non-degree Training

Training in specific areas was provided to 43 researchers from 16 countries who spent periods ranging between of two weeks to three months in cereal breeding, legume breeding, diseases, insects, virology, grain quality or DNA techniques. Individual training is most suitable for scientists who have undertaken research for a reasonable period of time, so their training programs were tailored to meet the specific needs of NARSs.

8.3.2. Graduate Research Training

The Germplasm Program continued to support 31 students from within and outside the region. During 1997, eleven ICARDA-supported students completed their thesis research or graduated, While seven new students started thesis research work at ICARDA. In addition two Ph.D students from France and Finland spent four months at ICARDA as part of their thesis research work.

8.4. Visits

Visits between the Germplasm Program and NARS is on effective tool for transferring scientific information and research experiences, In 1997, eight visiting scientists from Egypt, Sudan, Morocco other 5 researchers from Central Asia countries, (Azarbaijan, Kazakhstan, Kyrghistan, Turkmenistan and Uzbekistan) visited the Germplasm Program, and have an overviews on breeding activities on the improvement of mandate crops and get acquainted with breeding methodologic at ICARDA. More that 50 scientists were invited for a short periods to discuss joint projects, selected germplasm, lectures in training courses, discuss graduate student research, or gathered information on Germplasm Program activities and results. In addition, around 220 farmers and students from Syrian universities came to the Program for one day visit.

(A.J. Sabouni, GP Scientists)

8.5. Facultative and Winter Wheat

8.5.1. Training and Visits

One researcher from NWFP/Pakistan was trained at ICARDA on facultative/winter wheat improvement for 3.5 months, including 2 weeks in Turkey. He participated effectively in field work, including hybridization, disease scoring and selection. Five researchers from Central Asia, one each from Azerbaijan, Kazakhstan, Kirghystan, Turkmenistan, and Uzbekistan attended a 3-month course on wheat improvement. Although the course base was Eskisehir, they did visit other institutions in Turkey (institutes at Izmir, Konya, and Ankara, and other non-research organizations, e.g. state farms, mills, etc.). During their one week visit to Syria, they had lectures on wheat improvement, seed health, pathology, entomology, virology, and biotechnology, and spent one day in the fields and 4 half-day's in the biotech lab.

(Turkish, CIMMYT, ICARDA Scientists)

9. PUBLICATIONS

9.1. Journal Articles

Araus, J.L, J. Bort, S. Ceccarelli and S. Grando. Relationship between leaf structure and carbon isotope discrimination in field grown barley. Plant Physiol. Biochem., 1997, 35 (7), 533-541.

Araus, J.L., T. Amaro, Y. Zuhair & M.M. Nachit. Effect of leaf structure and water status on carbon isotope discrimination in field-grown durum wheat. Plant, Cell and Environment (1997) 20, 1484-1494.

Makkouk, K.M. and S.G. Kumari. 1997. Natural Occurrence of wheat streak mosaic virus on wheat in Syria. Rachis Newsletter 16(1/2): 74-76.

Yau, S.K., Nachit, M. M. and Ryan, J. Variation in growth, development and yield of durum wheat in response to high soil boron. II. Phenotypic differences between genotypes. Aust. J. Agric. Res., 1997, 48, 951-957.

9.2. Conference Papers

Baum, M., H. Sayed, S. Grando, S. Ceccarelli, G. Backes, V. Mohler, A. Jahoor and G. Fischbeck (1997). What have we learned from mapping in barley landraces? In: 5th Plant and Animal Genome Conference, San Diego, 15-17 January 1997.

Baum, M., H. Sayed, S. Grando, S. Ceccarelli, J.L. Araus, G. Backes, V. Mohler, A. *Jahoor and G. Fischbeck* (1997). Mapping disease resistances and other agronomic important characters in barley with molecular markers. In: 7th ITMI Public Workshop, 25-27th June, Clermont-Ferrand, France.

Choumane W., Ashtar S. and Weigand F. (1997). Biodiversity in barley evaluated by molecular markers. "Biotechnology: presence and future perspective" Symposium. 7-8 April, Amman, Jordan.

Choumane W., Ashtar S. Valkoun J. and Weigand F. (1997). The use of DNA markers in the study of biodiversity in barley. The Third International Triticeae Symposium, IPGRI, 4-8 May. Aleppo, Syria.

Hamameh, M., A. Bassett-Almouslem, S. Tawkaz and M. Baum (1997) Doubled haploid line production in spring bread wheat. "Biotechnology: presence and future perspective" Symposium. 7-8 April, Amman, Jordan.

Impiglia, A., Nachit, M.M., Saleh A., Lafiandra, D., and Porceddu, E. 1997. Occurrence of unusual storage proteins electrophoretic patterns in durum wheat and their effect on gluten strength. 5th International Wheat Conference, 10-14 June, 1996, Ankara. Book of abstracts, p. 68.

Makkouk, K.M. and W. Ghulam. 1997. Interspecific hybrids as sources of resistance to barley yellow dwarf luteovirus. Sixth Arab Congress of Plant Protection, Beirut, Lebanon, 27-31 October, 1997, No. V36, p 212.

Nachit, M.M. 1997. Durum integrated research network for Mediterranean dryland. 5th International Wheat Conference, 10-14 June, 1996, Ankara, Turkey. Book of abstracts, p. 458.

Pagnotta, M.A, A. Impiglia, O.A. Tanzarella, O.A., M.M.Nachit, E. Porceddu. 1997. Variability present in durum wheat landrace Haurani. 5th International Wheat Conference, 10-14 June, Ankara. Book of abstracts, p. 67.

9.3. Book Chapters

S.K., Yau, M. M. Nachit & J. Ryan. Variation in boron-toxicity tolerance in a durum wheat core collection. R.W. and B. Rerkasem (eds.), Boron in Soils and Plants, 117-120.

10. CEREAL VARIETIES RELEASED BY NATIONAL PROGRAMS

Crop	Country	Year of release	Variety
Barley	Algeria	1987	Harmal
Barley	Algeria	1992	Badia
Barley	Algeria	1993	Rihane-03
Barley	Australia	1989	Yagan
Barley	Australia	1991	High
Barley	Australia	1993	Kaputar
Barley	Australia	1993	Namoi
Barley	Bolivia	1991	Kantuta
Barley	Bolivia	1993	Kolla
Barley	Bolivia	1994	San Lorenzo
Barley	Brazil	1989	Acumai
Barley	Canada	1992	Seebe
Barley	Canada	1993	Falcon
Barley	Canada	1994	Tukwa
Barley	Canada	1995	Kasota
Barley	Chile	1989	Leo/Inia/Ccu
Barley	Chile	1989	Centauro
Barley	China	1988	Zhenmai 1
Barley	China	1989	V-24
Barley	China	1989	Api/CM67//B1
Barley	China	1989	CT-16
Barley	Cyprus	1980	Kantara
Barley	Cyprus	1989	Mari/Aths*
Barley	Cyprus	1994	Mia Milia
Barley	Cyprus	1994	Achera
Barley	Cyprus	1995	Lefkonoiko
Barley	Cyprus	1995	Sanokrithi-79
Barley	Cyprus	1995	Lysi
Barley	Ecuador	1989	Shyri
Barley	Ecuador	1992	Calicuchima-92

Crop	Country	Year of release	Variety
Barley	Ecuador	1992	Atahualpa-92
Barley	Egypt	1993	Giza 125
Barley	Egypt	1993	Giza 126
Barley	Egypt	1996	Giza 127
Barley	Egypt	1996	Giza 128
Barley	Ethiopia	1973	Beka
Barley	Ethiopia	1975	IAR/H/485
Barley	Ethiopia	1979	Holkr
Barley	Ethiopia	1980	Ardu 12-60B
Barley	Ethiopia	1985	HB-42
Barley	Ethiopia	1986	HB-120
Barley	Ethiopia	1994	Shege
Barley	Ethiopia	1996	Misratch
Barley	Iran	1986	Aras
Barley	Iran	1990	Kavir
Barley	Iran	1990	Star (Makui)
Barley	Iran	1997	Izeh
Barley	Iran	1997	Sahand (=Tokak)
Barley	Iran	1997	Ganub
Barley	Iraq	1994	Rihane-03
Barley	Iraq	1994	IPA 7
Barley	Iraq	1994	IPA 9
Barley	Iraq	1994	IPA 265
Barley	Italy	1992	Salus
Barley	Italy	1992	Digersano
Barley	Jordan	1984	Rum
Barley	Kenya	1984	Bima
Barley	Kenya	1993	Ngao
Barley	Lebanon	1989	Rihane-03
Barley	Lebanon	1997	Assy
Barley	Lebanon	1997	ER/Apm
Barley	Libya	1992	Wadi Kuf

Crop	Country	Year of release	Variety
Barley	Libya	1992	Wadi Gattara
Barley	Libya	1997	Borjouj
Barley	Libya	1997	Maknesa
Barley	Libya	1997	Ariel
Barley	Libya	1997	Irawen
Barley	Mexico	1986	Mona/Mzq/DL71
Barley	Morocco	1984	Asni
Barley	Morocco	1984	Tamellat
Barley	Morocco	1984	Tissa
Barley	Morocco	1988	Tessaout
Barley	Morocco	1988	Aglou
Barley	Morocco	1988	Annaceur
Barley	Morocco	1988	Tiddas
Barley	Morocco	1997	Igrane
Barley	Morocco	1997	Safia
Barley	Morocco	1997	Aguilal
Barley	Nepal	1987	Bonus
Barley	Pakistan	1985	Jau-83
Barley	Pakistan	1987	Jau-87
Barley	Pakistan	1987	Frontier 87
Barley	Pakistan	1993	Jau-93
Barley	Pakistan	1995	AZRI-95
Barley	Pakistan	1996	Sariab
Barley	Pakistan	1997	Sanober-96
Barley	Peru	1987	Una 87
Barley	Peru	1987	Nana 87
Barley	Peru	1989	Buenavista
Barley	Peru	1994	Una-94
Barley	Peru	1996	Una-96
Barley	Portugal	1982	Sereia
Barley	Portugal	1982	Enxara
Barley	Portugal	1982	Campones

Crop	Country	Year of release	Variety
Barley	Portugal	1983	CE 8302
Barley	Portugal	1990	Ancora
Barley	Qatar	1982	Gulf
Barley	Qatar	1983	Harma
Barley	S. Arabia	1985	Gusto
Barley	Spain	1987	Resana
Barley	Syria	1987	Furat 1113
Barley	Syria	1991	Furat 2
Barley	Syria	1994	Arta
Barley	Tanzania	1991	Kibo
Barley	Thailand	1987	Semang 1
Barley	Thailand	1987	Semang 2
Barley	Thailand	1987	BRB-8
Barley	Tunisia	1985	Taj
Barley	Tunisia	1985	Faiz
Barley	Tunisia	1985	Roho
Barley	Tunisia	1987	Rihane-03
Barley	Tunisia	1992	Manel 92
Barley	Turkey	1993	Tarm 92
Barley	Turkey	1993	Yesevi
Barley	Turkey	1995	Orza
Barley	Vietnam	1989	Api/CM67//B1
Barley	Yemen	1986	Arafat
Barley	Yemen	1986	Beecher
Durum Wheat	Algeria	1982	ZB S FG'S''/LUKS GO
Durum Wheat	Algeria	1984	Timgad
Durum Wheat	Algeria	1986	Sahl
Durum Wheat	Algeria	1986	Waha
Durum Wheat	Algeria	1991	Korifla
Durum Wheat	Algeria	1992	Om Rabi 6
Durum Wheat	Algeria	1993	Belikh 2
Durum Wheat	Algeria	1993	Haidar

Crop	Country	Year of release	Variety
Durum Wheat	Algeria	1993	Kabir 1
Durum Wheat	Algeria	1993	Om Rabi 9
Durum Wheat	Cyprus	1982	Mesoaria
Durum Wheat	Cyprus	1984	Karpasia
Durum Wheat	Cyprus	1994	Macedonia
Durum Wheat	Egypt	1979	Sohag I
Durum Wheat	Egypt	1988	Beni Suef
Durum Wheat	Egypt	1988	Sohag II
Durum Wheat	Egypt	1990	Beni Suef I
Durum Wheat	Egypt	1990	Sohag III
Durum Wheat	Greece	1982	Selas
Durum Wheat	Greece	1983	Sapfo
Durum Wheat	Greece	1984	Skiti
Durum Wheat	Greece	1985	Samos
Durum Wheat	Greece	1985	Syros
Durum Wheat	Iran	1997	Seimareh=Om Rabi 5
Durum Wheat	Iran	1997	Korifla
Durum Wheat	Iran	1997	Heider
Durum Wheat	Iraq	1996	Waha Iraq
Durum Wheat	Iraq	1997	Om Rabi 5
Durum Wheat	Iraq	1997	Korifla
Durum Wheat	Jordan	1988	Maru=Cham 1
Durum Wheat	Jordan	1988	Petra=Korifla
Durum Wheat	Jordan	1988	Amra=N-432
Durum Wheat	Jordan	1988	Stork=ACSAD75
Durum Wheat	Lebanon	1987	Belikh 2
Durum Wheat	Lebanon	1989	Sebou
Durum Wheat	Lebanon	1994	Waha=Cham 1
Durum Wheat	Libya	1985	Baraka
Durum Wheat	Libya	1985	Fazan
Durum Wheat	Libya	1985	Ghuodwa
Durum Wheat	Libya	1985	Marjawi

Crop	Country	Year of release	Variety
Durum Wheat	Libya	1985	Qara
Durum Wheat	Libya	1985	Zorda
Durum Wheat	Libya	1991	Zahra 1
Durum Wheat	Libya	1992	Khiar 92
Durum Wheat	Libya	1993	Zahra 3
Durum Wheat	Libya	1993	Zahra 5=Korifla
Durum Wheat	Libya	1995	Zahra 7
Durum Wheat	Libya	1995	Zahra 9
Durum Wheat	Morocco	1984	Marzak
Durum Wheat	Morocco	1989	Sebou
Durum Wheat	Morocco	1991	Tensif
Durum Wheat	Morocco	1994	Anouar
Durum Wheat	Morocco	1994	Jawhar
Durum Wheat	Morocco	1995	Om Rabi 6
Durum Wheat	Morocco	1997	Telset
Durum Wheat	Pakistan	1985	Wadhanak
Durum Wheat	Portugal	1983	Celta
Durum Wheat	Portugal	1983	Timpanas
Durum Wheat	Portugal	1984	Castico
Durum Wheat	Portugal	1985	Heluio
Durum Wheat	Saudi Arabia	1987	Cham 1
Durum Wheat	Spain	1983	Mexa
Durum Wheat	Spain	1985	Nuna
Durum Wheat	Spain	1989	Jabato
Durum Wheat	Spain	1991	Anton
Durum Wheat	Spain	1991	Roqueno
Durum Wheat	Sudan	1997	Waha
Durum Wheat	Syria	1984	Cham 1
Durum Wheat	Syria	1987	Bohouth 5
Durum Wheat	Syria	1987	Cham 3
Durum Wheat	Syria	1993	Om Rabi 3
Durum Wheat	Syria	1994	Cham 5

Crop	Country	Year of release	Variety
Durum Wheat	Tunisia	1987	Razzak
Durum Wheat	Tunisia	1993	Khiar
Durum Wheat	Tunisia	1993	Om Rabi 3
Durum Wheat	Turkey	1984	Susf bird
Durum Wheat	Turkey	1985	Balcili
Durum Wheat	Turkey	1988	EGE 88
Durum Wheat	Turkey	1990	Sam 1=Cham 1
Durum Wheat	Turkey	1991	Kiziltan
Durum Wheat	Turkey	1994	Aydin
Durum Wheat	Turkey	1994	Firat 93
Durum Wheat	Turkey	1997	Haran=Omrabi 5
Bread Wheat	Algeria	1982	Setif 82
Bread Wheat	Algeria	1982	HD 1220
Bread Wheat	Algeria	1989	Zidane 89
Bread Wheat	Algeria	1992	Nesser = Cham 6
Bread Wheat	Algeria	1992	Sidi Okba=Cham 4
Bread Wheat	Algeria	1992	Rhumel=Siete Cerros
Bread Wheat	Algeria	1992	Alondra=21AD
Bread Wheat	Algeria	1992	Soummam=DouggaXBJ
Bread Wheat	Algeria	1992	ACSAD 59=40DNA
Bread Wheat	Algeria	1994	Mimouni
Bread Wheat	Algeria	1994	Ain Abid
Bread Wheat	China	1994	Mayon 1=Dong Feng 1
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	Sids 1

Crop	Country	Year of release	Variety
Bread Wheat	Egypt	1994	Sids 2
Bread Wheat	Egypt	1994	Sids 3
Bread Wheat	Egypt	1994	Giza 166
Bread Wheat	Egypt	1994	Giza 167
Bread Wheat	Egypt	1994	Benesuef-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	1984	Dashen
Bread Wheat	Ethiopia	1984	Batu
Bread Wheat	Ethiopia	1984	Gara
Bread Wheat	Greece	1983	Louros
Bread Wheat	Greece	1983	Pinios
Bread Wheat	Greece	1983	Arachthos
Bread Wheat	Iran	1986	Golestan
Bread Wheat	Iran	1986	Azadi
Bread Wheat	Iran	1988	Darab
Bread Wheat	Iran	1988	Sabalan
Bread Wheat	Iran	1988	Quds
Bread Wheat	Iran	1990	Falat
Bread Wheat	Iran	1995	Tajan
Bread Wheat	Iran	1995	Nicknejad
Bread Wheat	Iran	1995	Mahdabi
Bread Wheat	Iran	1995	Darab 2
Bread Wheat	Iran	1997	Gaher
Bread Wheat	Iran	1997	Zagross
Bread Wheat	Iran	1997	Zareen
Bread Wheat	Iran	1997	Alrand
Bread Wheat	Iran	1997	Atrak
Bread Wheat	Iran	1997	Alement

Crop	Country	Year of release	Variety
Bread Wheat	Iran	1997	Chamran
Bread Wheat	Iraq	1989	Es14
Bread Wheat	Iraq	1994	Hamra
Bread Wheat	Iraq	1994	Adnanya
Bread Wheat	Iraq	1994	Abu Ghraib
Bread Wheat	Jordan	1988	Nasma=Jubeiha
Bread Wheat	Jordan	1988	L88=Rabba
Bread Wheat	Jordan	1990	Nesser
Bread Wheat	Lebanon	1990	Seri
Bread Wheat	Lebanon	1991	Nesser=Cham 6
Bread Wheat	Lebanon	1995	Roomy
Bread Wheat	Libya	1985	Zellaf
Bread Wheat	Libya	1985	Sheba
Bread Wheat	Libya	1985	Germa
Bread Wheat	Morocco	1984	Jouda
Bread Wheat	Morocco	1984	Merchouche
Bread Wheat	Morocco	1986	Saada
Bread Wheat	Morocco	1989	Saba
Bread Wheat	Morocco	1989	Kanz
Bread Wheat	Oman	1987	Wadi Quriyat 151
Bread Wheat	Oman	1987	Wadi Quriyat 160
Bread Wheat	Pakistan	1986	Sutlej 86
Bread Wheat	Portugal	1986	LIZ 1
Bread Wheat	Portugal	1986	LIZ 2
Bread Wheat	Qatar	1988	Doha 88
Bread Wheat	Sudan	1985	Debeira
Bread Wheat	Sudan	1987	Wadi El Neel
Bread Wheat	Sudan	1991	Neelain
Bread Wheat	Sudan	1992	Sasarieb
Bread Wheat	Syria	1984	Cham 2
Bread Wheat	Syria	1984	Bohouth 2
Bread Wheat	Syria	1986	Cham 4

Crop	Country	Year of release	Variety
Bread Wheat	Syria	1987	Bohouth 4
Bread Wheat	Syria	1991	Cham 6
Bread Wheat	Syria	1991	Bohouth 6
Bread Wheat	Tanzania	1983	T-VIRI-Veery 'S'
Bread Wheat	Tanzania	1983	69/BD
Bread Wheat	Tunisia	1983	T-DUMA-D6811-Inrat
Bread Wheat	Tunisia	1987	Byrsa
Bread Wheat	Tunisia	1987	Salambo
Bread Wheat	Tunisia	1992	Vaga 92
Bread Wheat	Turkey	1986	Dogankent-1 (Cham 4)
Bread Wheat	Turkey	1988	Kaklic 88
Bread Wheat	Turkey	1988	Kop
Bread Wheat	Turkey	1988	Dogu 88
Bread Wheat	Turkey	1989	Es14
Bread Wheat	Turkey	1990	Yuregir
Bread Wheat	Turkey	1990	Karasu 90
Bread Wheat	Turkey	1990	Katia 1
Bread Wheat	Turkey	1994	Sultan 94
Bread Wheat	Turkey	1995	Kasifbey 95
Bread Wheat	Turkey	1995	Basribey 95
Bread Wheat	Turkey	1995	F//68.44NZT/3/CUC'5'
Bread Wheat	UAE	1995	Cham 2
Bread Wheat	UAE	1995	Seyhan 95
Bread Wheat	UAE	1995	Kirgiz 95
Bread Wheat	Yemen	1983	Marib 1
Bread Wheat	Yemen	1983	Ahgaf
Bread Wheat	Yemen	1988	Mukhtar
Bread Wheat	Yemen	1988	Aziz
Bread Wheat	Yemen	1988	Dhumran
Bread Wheat	Yemen	1988	SW/83/2
Bread Wheat	Yemen	1995	Radfan
Bread Wheat	Yemen	1995	SW/88/7

Crop	Country	Year of release	Variety
Bread Wheat	Yemen	1995	SW/88/8
Bread Wheat	Yemen	1995	SW/88/6
Bread Wheat	Yemen	1995	SW/89/3
Bread Wheat	Yemen	1995	SW/89/7

11. STAFF LIST

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9.	Dr Abderrezak Belaid*	Socioeconomist (Tunisia)
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12.	Mr Issam Naji	Agronomist/Crop Physiologist
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37. Mr Alaa Yaljarouka	Senior Research Technician
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57. Ms Raghad Rahwan*	Secretary

Consultant

58. Dr Hisham Al Zainab	Cereal Pathologist
59. Dr Mohamed Shafik Hakim	Cereal Pathologist

***Left the Program during 1997**

****Joined the Program during 1997**

المركز الدولي للبحوث الزراعية في المناطق الجافة

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ICARDA-020/1400/December 1999