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GERMPLASM PROGRAM CEREALS

Annual Report for 1996

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.

CGIAR

The CGIAR is an international group of representatives of donor agencies, eminent agricultural scientists, and institutional administrators from developed and developing countries who guide and support its work. The CGIAR receives support from 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.

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

The World Bank, the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), and the 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 1996

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.

From 1986 to 1993 this report was published under the title "Cereal Improvement Program Annual Report." Starting with the 1994 issue, it changed its title to "Germplasm Program: Cereals Annual Report."

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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, 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) with a strong 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, Jindiress, 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 1995/96 season are shown in Figure 1.1 for two typically dry sites (Bouider and Breda) with long term rainfall of 235 and 268 mm, respectively, and in Figure 1.2 for two typically wet sites (Tel Hadya and Terbol) with long term average rainfall of 329 and 555 mm respectively. In all four locations, the total seasonal precipitation in the 1995-96 cropping season was higher than the long term average (316, 360, 404 and 578 mm, respectively). In Bouider there was a dry start to the season followed by five months with rainfall well above the average, particularly in March. Breda showed a similar pattern except that starting from November every month was wetter than usual except February. Tel Hadya had a dry start and a dry finish with a severely cold February and an exceptionally wet March. Terbol had a very irregular distribution with a dry spell between December and February. In all the four sites grain filling coincided with maximum temperatures higher than usual, but this affected negatively yields more in Tel Hadya and Terbol than in Breda and Bouider because of rainfall distribution.

One of the major events in 1996 has been the new agreement between CIMMYT and ICARDA for Wheat Improvement in West Asia and North Africa (WANA), signed by the two Directors General in El Batan on September 18, 1996. The agreement recognizes that ICARDA has a regional responsibility for wheat improvement in WANA, that wheat improvement activities in WANA are a joint CIMMYT/ICARDA Wheat Improvement Program, and that the program leader of ICARDA's Germplasm Improvement Program has the overall responsibility of implementing the joint program in consultation with the Director of the CIMMYT's Wheat Program (Fig. 1.3).

Another major event was the Center Commissioned External Review (CCER) of the legume projects, held in Aleppo in early March 1996. Overall, the CCER produced an excellent, well-balanced report which showed a depth of understanding of our research on legumes and gave constructive ideas for change. The CCER made the following four key recommendations regarding legume research:

1. Establish a single, well-resourced, well-coordinated Food Legume Improvement Project to include chickpea, lentil, faba bean and peas.
2. Re-establish the faba bean project at ICARDA.

3. Remodel food legume improvement projects to emphasize decentralized breeding methodology. Some projects such as lentil, as indicated in the CCER report, are already using a decentralized breeding mode. It was suggested that the improvement projects of the other legumes move in this direction.
4. Focus forage legume work on innovative types of *V. sativa*, species for high altitudes, and low ODAP-*Lathyrus sativus*.

The program accepted these recommendations and has started to make the necessary changes during 1996.

Most of 1996 went into the preparation of the Medium Term Plan 1998-2001, while during the latter part of 1996 the cereal projects as well as the plant protection group made the necessary arrangements for the Center Commissioned External Review of cereals and integrated pest and disease management projects.

During the year the following changes in staff occurred:

a. in January 1996, Dr. S. Ceccarelli was appointed Acting program leader of the program and Dr. W. Erskine associate program leader;
b. in April 1996, Dr. M. El-Bouhssini was appointed as consultant Entomologist and Dr. S. Khalil was appointed as consultant for Faba Bean improvement.
c. in October 1996, Dr. M. Tahir, the winter and facultative winter barley breeder, took a new position in Tehran (Iran) as leader of the Iran/ICARDA collaborative project. As a consequence of this, the spring barley project and the winter and facultative barley project were *de facto* merged at the end of 1996;
d. in the fall of 1996 Dr. J. Peacock, the crop physiologist, was appointed Regional Coordinator for the Arabian

Peninsula;

e. Dr. K. B. Singh, the chickpea breeder, completed his consultancy, and left ICARDA after nearly 10 years service in the Center and Dr. R.S. Malhotra was appointed acting chickpea breeder.

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 1996:

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. **The use of Biotechnology for Development of ICARDA Mandated crops** supported by UNDP (person in charge F. Weigand)
4. **Improving Yield and Yield Stability of Barley in Stress Environments**, supported by the Government of Italy (person in charge S. Grando)
5. **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)

6. **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)
7. **Resistance to nematodes in lentil and chickpea,** in collaboration with the Institute of Nematology of Bari, (persons in charge R.S. Malhotra)
8. **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)
9. **Fusarium Wilt in Chickpea**, supported by the Government of Spain and in collaboration with INIA (person in charge R.S. Malhotra)
10. **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)
11. **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)
12. **Coordinated Improvement Program for Australian Lentils**, supported by Grains Research Development Council (GRDC) (person in charge W. Erskine)
13. **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)

14. **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)
15. **West Asia and North Africa Dryland Durum Improvement Network (WANADDIN)** supported by IFAD (person in charge M. Nachit)
16. **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)
17. **Integrated Management of Pest and Diseases**, supported by BMZ (person in charge K. Makkouk)
18. **Durum Wheat Improvement** supported by the Australian Centre for International Agricultural Research (ACIAR)(person in charge M. Nachit)
19. **Kabuli Chickpea** supported by the Australian Centre for International Agricultural Research (ACIAR)(person in charge R.S. Malhotra)

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

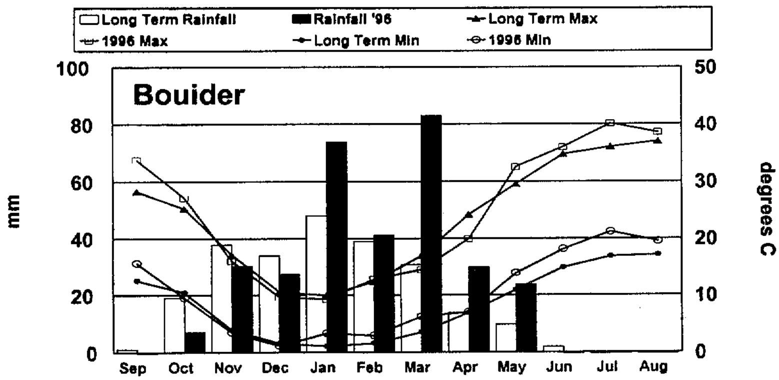
Mashreq and Maghreb (M&M) Project
Mediterranean Highland Project
Barley Improvement Project in Ethiopia
Problem-solving Regional Network Project in Egypt Ethiopia, Sudan and Yemen
Matrouh Resource Management Project in Egypt

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 1995-96 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.

S. Ceccarelli



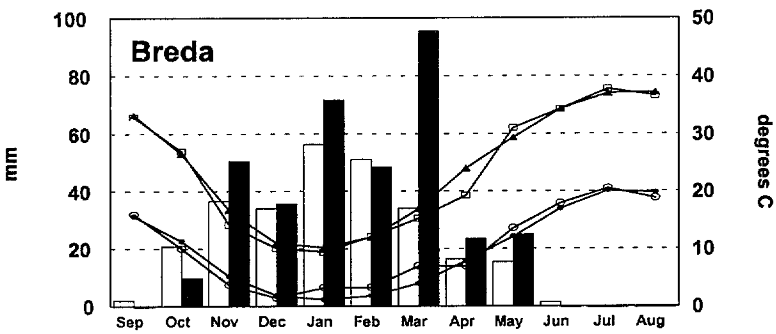


Fig. 1.1. Weather conditions at Bouider and Breda during 1995-96.

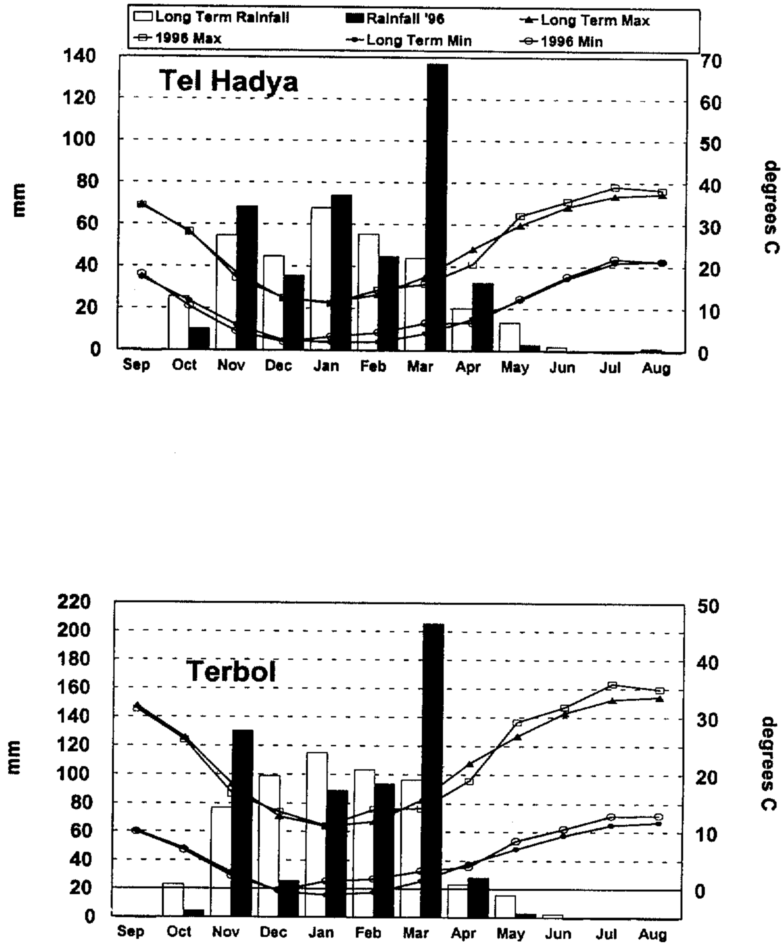


Fig. 1.2. Weather conditions at Tel Hadya and Terbol during 1995-96.

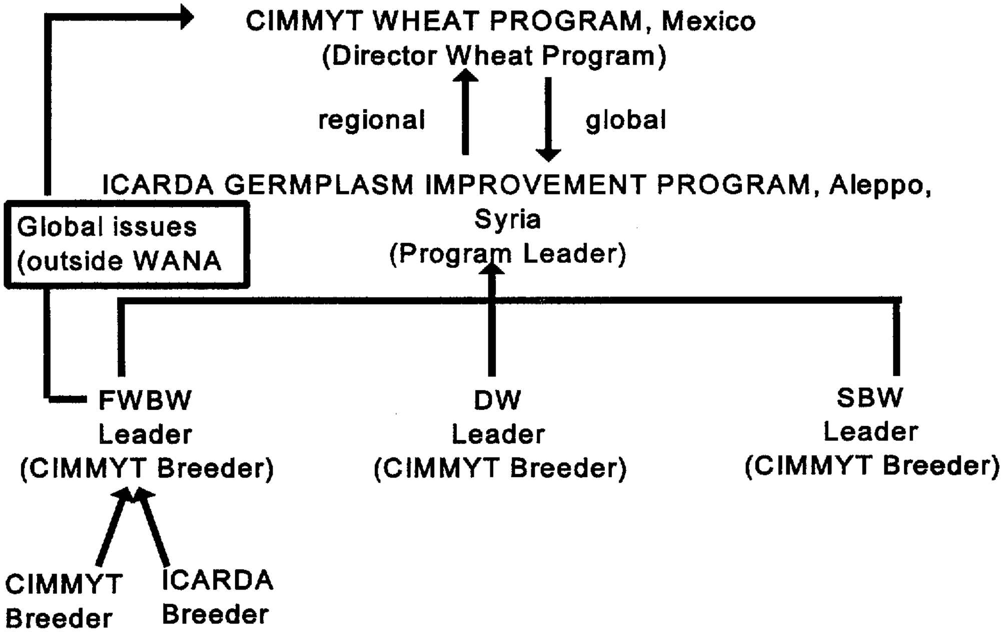


Fig. 1.3. Reporting arrangements for CIMMYT/ICARDA Scientists in the joint Wheat Improvement Program

2. BARLEY IMPROVEMENT

Introduction

Barley (*Hordeum vulgare* L. emend. Bowden) was first domesticated in the Fertile Crescent in the Near East, at one or more site not far from where today ICARDA' headquarters are located, and almost certainly from the wild *Hordeum spontaneum* before 7000 B.C. The main difference between cultivated barley and *Hordeum spontaneum* is the fragile (brittle) rachis of the wild progenitor.

Barley is grown over a broader environmental range than any other cereal from 70°N in Norway to 46°S in Chile. Also, in Tibet, Ethiopia and the Andes, it is cultivated higher on the mountain slopes than other cereals. Barley is considered to be a drought resistant crop and in many areas of North Africa, the Near East, Afghanistan, Pakistan, Eritrea, Yemen, and others it is often the only possible rainfed crop. Actually, barley is probably more drought escaping than drought resistant because its early flowering permits to reach maturity before the soil moisture is exhausted.

Today barley is grown on about 73 million hectares[1] as average of the last five years (Table 2.1). The area has grown from about 59 million hectares in the period 1961-65 to a maximum of more than 80 million hectares in the period 1976-80. The largest barley growing areas are in the CIS republics (almost 29 million hectares), and in western and eastern Europe (about 15 million hectares). There are 18.4 million hectares of barley in developing countries, most of which in Asia and Africa.

The world production of barley reached a maximum in the period 1985-90 with an average of more than 170 million tonnes, and decreased by more that ten tonnes to around 160

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1 The source of the statistical data on barley in the 1995 FAO yearbook

million tonnes, the same production of fifteen years ago, but on eight million hectares less (Table 2.2).

Table 2.1 Area of barley (million hectares)by regions.

Region	61-65	66-70	71-75	76-80	81-85	86-90	91-95
Africa	4.20	4.33	4.36	4.85	4.93	5.29	5.18
Asia	14.85	12.99	11.72	10.86	11.64	12.48	12.51
N.America	7.04	7.70	8.96	8.07	9.22	8.58	7.23
S.America	1.14	1.04	1.03	0.84	0.56	0.63	0.66
Europe	12.90	15.58	17.79	19.95	19.36	18.14	15.77
USSR	18.30	20.33	28.37	34.00	30.52	28.50	28.70
Oceania	0.87	1.39	2.15	2.57	3.00	2.31	2.94
World	59.40	63.40	74.47	81.21	79.33	76.04	73.06

Table 2.2 Production of barley (million tonnes) by regions.

Region	61-65	66-70	71-75	76-80	81-85	86-90	91-95
Africa	3.03	3.39	3.80	4.20	4.16	5.41	4.99
Asia	17.29	15.44	14.67	16.08	17.27	18.65	20.24
N.America	12.71	16.31	19.53	19.74	24.35	23.04	21.52
S.America	1.26	1.063	1.19	1.039	0.69	1.00	1.14
Europe	33.78	44.82	57.17	66.80	70.90	71.20	60.55
USSR	18.69	28.02	39.82	50.80	40.54	48.15	47.21
Oceania	0.98	1.58	2.57	3.12	4.13	3.67	4.97
World	87.85	110.81	139.04	162.04	162.49	171.54	161.02

Table 2.3 Yield of barley (kg/ha) by regions.

Region	61-65	66-70	71-75	76-80	81-85	86-90	91-95
Africa	0.72	0.78	0.87	0.86	0.84	1.03	0.96
Asia	1.16	1.19	1.25	1.48	1.48	1.5	1.62
N.America	1.82	2.11	2.17	2.45	2.64	2.67	2.98
S.America	1.1	1.02	1.15	1.23	1.25	1.58	1.72
Europe	2.6	2.87	3.21	3.34	3.67	3.93	3.84
USSR	1.02	1.37	1.41	1.51	1.33	1.7	1.64
Oceania	1.13	1.14	1.2	1.22	1.34	1.58	1.66
World	1.48	1.74	1.87	1.99	2.05	2.26	2.2

The decline in total production is entirely due to the decline in the area during the last twenty years because yields have increased in almost every region except Africa (Table 2.3). In fact, while globally yield of barley increased by 2.4 kg/ha/year in the last 35 years, in Africa the increase has been 0.8 kg/ha/year, in Asia 1.6 kg/ha/year, in USSR 1.7 kg/ha/year, and in Europe 4.5 kg/ha/year.

Barley grain is used as feed for animals, malt and human food. Barley straw is used as animal feed in the Near East, North Africa, Ethiopia, Eritrea, Yemen, in the Andean region and the Far East. Barley straw is also used for animal bedding and as cover material for huts roofs. After combine-harvesting barley stubble are grazed in summer in large areas of Near East and North Africa. Barley also is used as animal feed at the vegetative stage (green grazing) or is cut before maturity and either directly fed to the animal or used for silage.

Malt is the second largest use of barley, and malting barley is grown as cash crop in a number of developing countries.

In the highlands of Tibet, Nepal, Ethiopia, of the Andean countries of South America, but also in North Africa, Afghanistan, India and Russia, barley is still used as human food either as bread (usually mixed with bread wheat) or for specific recipes.

In many developing countries barley is a typical crop of marginal, low input, stressful environments, and in many areas of West Asia and North Africa (WANA) barley is often the only possible rainfed crop, and the last crop before the areas which are too dry to sustain rainfed agriculture.

The fifteen developing countries with the largest barley growing area are shown in Table 2.4 together with production and yield.

With the exception of China, Ethiopia and India, the developing countries with the largest area of barley are either in WANA or in Central Asia.

The two main agroecological environments where barley is grown in WANA and Central Asia are the dry, continental dry lowlands mostly with cold winters, and the continental dry highlands with very cold winters.

A third agroclimatic environment is represented by the tropical highlands (Andes, Ethiopia, Himalayan countries). This is not very large in area but is inhabited by some of poorest people of the world for whom barley is one of the main source of calories.

Table 2.4 Area, production and yield (kg/ha) of barley, in the developing countries (including CIS) with the largest barley growing area (the data are averages of the period 1991-1995).

Country	Area (million ha)	Production (million t)	Yield (kg/ha)
Russian Fed.	15.289	24.168	1.58
Kazakhstan	5.890	5.936	0.99
Ukraine	4.286	11.950	2.80
Turkey	3.488	7.340	2.11
Morocco	2.180	1.938	0.83
Syria	2.105	1.353	0.65
Iran	1.972	3.074	1.57
Iraq	1.680	1.137	0.67
China	1.290	3.220	2.51
Belarus	1.146	2.953	2.58
Ethiopia	1.053	1.232	1.16
Algeria	1.014	0.878	0.78
India	0.903	1.531	1.69
Lithuania	0.602	1.132	1.88
Tunisia	0.406	0.399	0.87

In India barley is usually grown as rainfed crop on residual moisture. In many of these situations barley yields have not significantly increased and vary mostly in response to fluctuations in climatic conditions.

In most developing countries barley is often a poor man's crop, and the only crop able to give some yield in environments unsuitable to other crops. Different types of biotic and abiotic stresses, and low or no use of inputs are the causes of low yields in most developing countries.

The overall objective of the project is to contribute to increase barley production in less developed countries thus contributing to alleviation of poverty. This objective is pursued with different strategies depending on the strength of different national programs, and ranges from the development of finished varieties to the development of breeding methodologies.

Barley improvement at ICARDA was organized in three projects: a) spring barley, b) winter and facultative barley, and c) Latin America regional program. In October 1996, the first two projects were merged in one barley improvement project. The Latin America regional program is a joint ICARDA/CIMMYT project and it is based in Mexico.

2.1. The Crossing Program

To maximize specific adaptation the barley project develops new germplasm starting with targeted crosses. A recent example of such a targeting is given in Table 2.5 for the crosses made in the project in 1996.

Crosses with landraces are not listed separately as most of the crosses for Syria, many of those for North Africa, for Iraq, for high elevation, with naked and with *H. spontaneum* have a landrace as one of the parents.

In the past we have made mostly single crosses. Recently we began to use systematically top crosses, 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 probability of recombination.

Table 2.5. Number and type of crosses done in 1996 in the barley project.

Country/Objective	Number of crosses
Algeria	72
Egypt	45
Iraq	35
Libya	88
Morocco	119
Tunisia	53
Syria	127
Vietnam	54
Lebanon	29
High Elevations	840
Disease resistance	59
BYDV	28
Russian Wheat Aphid resistance	8
Crosses with naked barley	32
Crosses with *H. spontaneum*	52
Total	**1641**

2.2. The Yield Trials 1996

In all yield trials in 1996 we use the α-lattice designs: randomization and analysis were performed using ALPHANAL (AFRC Statistics, Edinburgh).

2.2.1. Initial Yield Trials

The initial yield trials in 1996 comprised 858 new breeding lines and eleven checks, some of which were used for the first time. Average yield was 2.3 t/ha in Breda and 3.3 t/ha in Tel Hadya, a difference much lower than usual. The drought intensity index, as defined by Fischer and Maurer (1978)[2] was only 0.283 on a scale from 0=absence of stress to 1=maximum stress. This was the consequence of the relatively small difference in rainfall (about 45 mm). In Tables 2.6 and 2.7 we only show the ten best lines in Tel Hadya and in Breda.

Only 22 entries (2.6% of the total) out yielded the best check in Tel Hadya (Rihane-03) and the yield advantage of the best line was about 16% (Table 2.6). Lodging was an important factor affecting grain yield in Tel Hadya and this explains the poor performance of some of the checks (Arta, Tadmor, Zanbaka and A. Aswad) which yielded more at Breda than at Tel Hadya.

Because of the relatively wetter season, a number of six row breeding lines, which usually perform poorly in Breda, were in the top yielding group. However, even in these conditions, the top yielding was a pure line derived from a landrace, which out yielded the best check (Arta) by almost 1 t/ha (or 35%). Some crosses with another pure line derived from a landrace (SLB 05-96), which has performed well in the Mashreq-Maghreb Project, were amongst the top yielding.

2.2.2. Preliminary Yield Trials

The preliminary yield trials comprised 329 breeding lines in the second year of testing and eleven checks. As observed in the initial yield trials, grain yields at Tel Hadya and Breda were very similar (3374 and 2441 kg/ha, respectively) with a drought intensity index of 0.278.

Mean yield in Tel Hadya were lower than normal (Table 2.8) and, as expected in a wet year, Rihane-03 was the best check. The highest yielding lines were all six-row types with yield gains over the best check ranging from 10 to 25%.

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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.

Table 2.6. The ten best lines in the Initial Yield Trials in Tel Hadya. Heading date and lodging (1=resistant, 5= susceptible) were scored in Tel Hadya, while plant height was scored in Breda.

				Grain Yield (kg/ha)		
Entry Nr.[a]	Row Type	Heading	Plant height	Breda	Tel Hadya	Lodging
2280	6	124	71	2360	**5903**	1
2321	6	121	76	2752	**5759**	1
2102	6	119	76	2373	**5696**	1
2065	6	124	77	3068	**5628**	1
2221	6	122	69	2967	**5586**	1
2392	6	128	72	1715	**5452**	1
2274	6	122	70	3402	**5415**	1
2330	6	125	63	2837	**5396**	1
2303	6	126	63	1897	**5383**	1
2304	6	125	67	2822	**5338**	1
Checks						
Arabi Abiad	2	124	57	2008	2618	2
Arabi Aswad	2	123	76	2250	2154	3
Arta	2	120	63	2705	2436	4
Rihane-03	6	124	80	2659	5103	1
Tadmor	2	124	69	2564	2559	4
Zanbaka	2	122	80	2539	2067	3
SLB 5-96	2	117	66	2216	3754	2
Mean		119	72	2309	3226	2
s.e.		0.18	0.4	13	33	0.04
N		869	869	869	869	869
Max		132	106	3675	5903	5
Min		63	47	480	134	1

[a]Entry Name
2280 =Saida//H 85-6 (Rihane'=S'=/LM4448-1)
2321 =Arar/Rihane-03
2102 =Rihane-03/3/Deir Alla 106//7028/2759
2065 =NK1207/3/Api/CM67//Mona/4/Aths/Lignee 686
2221 =Lignee 640/Lignee 527//Arar
2392 =CI 01021/4/CM67/U.Sask.1800//Pro/CM67/3/DL70/5/Gizeh 134/Apm//Aths
2274 =Hyb 85-6//As46/Aths*2
2330 =Lignee527/NK1272/4/Lignee527//Bahtim/DL71/3/Api/CM67 //Mzq
2303 =Deir Alla106//DL71/Strain205/3/F4 Bulk//Sutter*2/Numar
2304 =DeirAlla106//DL71/Strain 205/3/F4 Bulk//Sutter*2/Numar

Table 2.7. The ten best lines in the Initial Yield Trials in Breda. Heading date and lodging (1=resistant, 5= susceptible) were scored in Tel Hadya, while plant height was scored in Breda.

				Grain Yield (kg/ha)		
Entry Nr.[a]	Row Type	Heading	Plant Height	Breda	Tel Hadya	Lodging
1042	2	119	64	3675	3030	3
2274	**6**	**122**	**70**	**3402**	**5415**	**1**
2324	6	118	83	3310	4062	2
2151	6	124	78	3302	3772	1
2085	6	117	82	3275	3836	2
2071	6	104	72	3227	3846	2
1281	2	119	73	3225	2495	3
1284	2	124	69	3219	2584	2
2268	**6**	**125**	**74**	**3208**	**5216**	**1**
2165	6	105	93	3200	2714	2
Checks						
Arabi Abiad	2	124	57	2008	2618	2
Arabi Aswad	2	123	76	2250	2154	3
Arta	2	120	63	2705	2436	4
Rihane-03	6	124	80	2659	5103	1
Tadmor	2	124	69	2564	2559	4
Zanbaka	2	122	80	2539	2067	3
SLB 5-96	2	117	66	2216	3754	2
Mean		119	72	2309	3226	2
s.e.		0.18	0.4	13	33	0.04
N		869	869	869	869	869
Max		132	106	3675	5903	5
Min		63	47	480	134	1

[a]Entry Name

1042 =SLB 32-36
2274 =Hyb 85-6//As46/Aths*2
2324 =Mari/Aths*2/3/Deir Alla 106//7028/2759
2151 =DeirAlla106//DL71/Strain205/3/CM67/Apro//Sv.02109/Mari
2085 =Mari/Aths*2/3/Deir Alla 106/Strain 205//Rihane-03
2071 =Aths/Lignee686/3/Lignee527/Chaaran-01//Lignee 640/Badia
1281 =WI2291/SLB 05-96
1284 =SLB 05-06/Arta
2268 =Rihane-03/4/Lignee 527//Bahtim/DL71/3/Api/CM67//Mzq
2165 =Arar/PI 386540//Giza 121/Pue/4/Arar/3/Giza//Apm/Gva

Table 2.8. The ten best lines in the Preliminary Yield Trials in Tel Hadya. Heading date and lodging (1=resistant, 5= susceptible) were scored in Tel Hadya, while plant height was scored in Breda.

				Grain Yield (kg/ha)		
Entry Nr.[a]	Row Type	Head.	Plant Height	Breda	Tel Hadya	Lodg.
41	6	123	80	2368	5713	1
69	6	122	84	2614	5437	1
53	6	120	86	3150	5435	1
31	6	120	73	2768	5381	1
50	6	124	70	3124	5360	1
40	6	117	73	2321	5211	1
37	6	117	90	3128	5142	1
22	6	121	90	2923	5071	1
63	6	109	67	3066	5020	1
6	6	114	67	2237	4991	1
Checks						
Arabi Abiad	2	123	68	2552	3082	2
Arabi Aswad	2	124	87	2445	2537	4
Arta	2	120	70	2642	2713	3
Harmal	2	116	74	2109	3543	2
Rihane-03	6	123	86	2706	4550	1
Zanbaka	2	123	87	2373	2126	4
Tadmor	2	122	75	2705	2622	4
Means		119	78	2441	3374	2
s.e.		0.6	0.7	21	47	0.1
N		340	340	340	340	340
Max		128	110	3481	5713	5
Min		0	0	0	0	0

[a] Entry Names

41 =As46/Aths*2//Aths/Lignee 686
69 =DMR27/WI2197/3/Deir Alla 106//Mzq/DL71
53 =Aths/Lignee 686/3/Deir Alla 106/Lignee 527//Assala
31 =Hyb 85-6//As46/Aths*2
50 =M126/CM67//As/Pro/3/Lignee 527/Arar
40 =Aths/Lignee 686/4/Rihane-03/3/Bc/Rihane//Ky63-1294
37 =Baca'=S'=/3/AC253//CI 08887/CI 05761/4/JLB 70-01
22 =As46/Aths*2/6/F6-4-Kf= Por/5/Api/CM 67/3/Apm/Dwarf II-1Y//Por/Kn27/4/RM1508/11012-2
63 =Arar/PI 386540
6 =CI08887/CI05761//Lignee640/7/Api/CM67//Harma-03/4/Cq /Cm//Apm/3/RM1508/5/Attiki/6/Mari/Aths*2

In Breda, and like observed in the initial yield trials, six row genotypes were amongst the top yielders. However, a number of landraces and/or crosses with landraces (such as entry 313) yielded up to 20% more than Arta (Table 2.9).

Although yield levels were not very different, the highest yielding lines in Tel Hadya did not appear among the top yielders in Breda, and viceversa, a pattern which has shown a high degree of repeatability over the years.

2.2.3. Advanced Yield Trials

The advanced yield trials comprised 137 breeding lines in the third year of testing and seven checks. As observed in the initial yield trials, grain yields at Tel Hadya and Breda were very similar (3770 and 3031 kg/ha, respectively) with a drought intensity index of only 0.196.

None of the lines out yielded significantly Rihane-03 for yield potential estimated as average yield in Tel Hadya (1994, 1995 and 1996) and in Terbol and Kfardane in 1996 (Table 2.10). However, line 5 (Aths/Lignee 686/3/Deir Alla 106/Lignee 527//Assala) had a higher yield under stress (YD) than the checks and a smaller coefficient of variation across locations (higher stability).

In Breda the highest yielding entry over a period of three cropping seasons was the cross between Arta and the pure-line SLB 45-58 (Table 2.11). It had a yield advantage of about 24% and a better stability across years. Although its yield potential was lower than that of varieties such as Rihane-03, it was higher than that of the best landraces.

Table 2.9. The ten best lines in the Preliminary Yield Trials in Breda. Heading date and plant height were scored in Tel Hadya and Breda, respectively.

Entry Nr.	Row Type	Head.	Plant height	Grain yield Breda	Grain yield Tel Hadya	Lodg.
313	2	120	76	3212	3368	3
53	6	120	86	3150	5435	1
4	6	115	86	3108	4410	2
247	2	126	78	3069	2805	2
267	2	126	79	3059	2694	4
5	6	114	83	3034	4551	2
140	2	116	92	3018	2369	4
19	6	115	84	2986	4115	1
70	6	109	81	2937	4054	2
20	6	119	77	2928	3947	1
Checks						
Arabi Abiad	2	123	68	2552	3082	2
Arabi Aswad	2	124	87	2445	2537	4
Arta	2	120	70	2642	2713	3
Harmal	2	116	74	2109	3543	2
Rihane-03	6	123	86	2706	4550	1
Zanbaka	2	123	87	2373	2126	4
Tadmor	2	122	75	2705	2622	4
Means		119	79	2447	3387	0
s.e.		0.43	0.6	20	46	0.1
N		340	340	340	340	340
Max		128	110	3481	5713	6
Min		0	43	1426	1460	0

[a] Entry Names

313 =Tadmor//ER/Apm
53 =Aths/Lignee 686/3/Deir Alla 106/Lignee 527//Assala
4 =Deir Alla 106//7028/2759/3/Arimar/Aths
247 =SLB 27-99
267 =SLB 29-90
5 =Aths/Lignee 686//Arimar/Aths
140 =SLB 45-40/H.spont.41-5//SLB 05-96
19 =NK1272/Moroc 9-75/3/Arimar/Aths//Orge 905/Lignee 686
70 =Harma-02//11012-2/CM67/3/Arar
20 =Arimar/Aths/3/Deir Alla 106//7028/2759

Table 2.10. The ten best lines in the Advanced Yield Trials in Tel Hadya. YD is the average grain yield in Breda (1994, 1995 and 1996) and in Bouider 1996, YP is the average grain yield in Tel Hadya (1994, 1995 and 1996, and in Terbol and Kfardane in 1996).

Entry Nr[a]	RT	YD	CV% (YD)	YP	CV% (YP)
5	6	1974	0.50	4704	0.29
39	6	1892	0.57	4586	0.21
1	6	1639	0.72	4558	0.33
36	6	1642	0.88	4524	0.29
52	6	1648	0.77	4512	0.22
6	6	1786	0.61	4475	0.18
10	6	1639	0.82	4439	0.23
66	2	1552	0.63	4403	0.21
35	6	1632	0.89	4396	0.22
49	6	1544	0.78	4386	0.19
Checks					
Arabi Abiad	2	1578	0.60	3353	0.14
Arabi Aswad	2	1714	0.72	2678	0.12
Arta	2	1718	0.71	3471	0.17
Rihane-03	6	1784	0.72	4668	0.31
Harmal	2	1460	0.54	3968	0.20
Zanbaka	2	1648	0.77	2518	0.13
Means		1600	0.63	3806	0.19
s.e.		15	0.01	41	0.01
N		144	144.00	144	144.00
Max		2134	1.08	4704	0.35
Min		1087	0.31	2327	0.04

[a] Entry Names

5 =Aths/Lignee 686/3/Deir Alla 106/Lignee 527//Assala
39 =Rihane-03/3/Roho//Alger/Ceres 362-1-1
1 =Rihane-03/3/Arizona 5908/Aths//Mari/Aths*2
36 =Assala-02//Giza 121/Pue
52 =Th.Unk.23//M6/Robur-35-6-3
6 =Aths/Lignee 686//Gloria'S'/Copal'S'
10 =Arizona 5908/Aths//Lignee 640/3/Lignee 640/Harma-01
66 =WI2291/Bgs/5/Cq/Cm//Apm/3/12410/4/Gizeh 134-2L
35 =H272/Bgs/3/Mzq/Gva//PI 002917/4/As46/Aths*2
49 =M126/CM67//As/Pro/3/Arizona 5908/Aths//Lignee 640

Table 2.11. The ten best lines in the Advanced Yield Trials in Breda. YD is the average grain yield in Breda (1994, 1995 and 1996) and in Bouider 1996, YP is the average grain yield in Tel Hadya (1994, 1995 and 1996, and in Terbol and Kfardane in 1996).

Entry Nr[a]	RT	YD	CV% (YD)	YP	CV% (YP)
122	2	2134	0.52	3712	0.11
5	6	1974	0.50	4704	0.29
4	6	1969	0.59	4376	0.20
38	6	1959	0.57	3561	0.18
100	2	1908	0.68	3041	0.16
69	2	1902	0.54	3690	0.10
74	2	1902	0.69	4378	0.16
3	6	1898	0.58	4368	0.21
126	2	1895	0.47	2650	0.17
137	2	1892	0.56	3649	0.06
Checks					
Arabi Abiad	2	1578	0.60	3353	0.14
Arabi Aswad	2	1714	0.72	2678	0.12
Arta	2	1718	0.71	3471	0.17
Rihane-03	6	1784	0.72	4668	0.31
Harmal	2	1460	0.54	3968	0.20
Zanbaka	2	1648	0.77	2518	0.13
Means		1600	0.63	3806	0.19
s.e.		15	0.01	41	0.01
N		144	144.00	144	144.00
Max		2134	1.08	4704	0.35
Min		1087	0.31	2327	0.04

[a] Entry Names

122= SLB 45-58/Arta
5= Aths/Lignee 686/3/Deir Alla 106/Lignee 527//Assala
4= Aths/Lignee 686/3/Deir Alla 106/Lignee 527//Assala
38= M64-76/Bon//Jo/York/3/M5/Galt//As46/4/Hj 34-80/Astrix/5/Aths
100= WI2291/Tadmor
69= Roho/Kv/6/Pld10342//Cr.115/Por/3/Bahtim9/4/Ds/Apro/5/WI2291
74= Harmal-02/5/WI2291/4/Avt/Ki//Avt/3/TolI/Bz
3= Aths/Lignee 686/3/Deir Alla 106/Lignee 527//Assala
126= SLB 22-25
137= SLB 24-53

2.3. Barley Breeding for North Africa

As described in previous Annual Reports, barley breeding for North Africa (Egypt, Libya, Tunisia, Algeria and Morocco) takes place in a decentralized mode, i.e. crosses are made at ICARDA, while selection and testing, beginning with F_3 bulks, is done by NARS scientists in the five North African countries. Identification of parents and designing of crosses are done in collaboration between NARS scientists and ICARDA's breeders.

During 1995-96 the nurseries specifically targeted for North Africa were grown in between 17 and 19 locations in five countries (Table 2.12).

Table 2.12. Number of entries evaluated in different nurseries[a] for North Africa during 1995-96 (in parenthesis number of locations for each nursery in each country).

Country	SEGMAG96	NURMAG96	YT96
Algeria	285 (2)	207 (2)	84 (4)
Egypt	285 (5)	207 (5)	96 (4)
Libya	285 (3)	207 (3)	72 (4)
Morocco	285 (3)	207 (3)	60 (4)
Tunisia	285 (4)	207 (4)	42 (3)

[a] SEGMAG96 (Segregating populations for North Africa made of F_3 bulks), NURMAG96 (Nursery for North Africa made of F_4 bulks), YT96 (Yield Trials for North Africa made of F_5 bulks)

From the SEGMAG96, sixty-six entries were selected in Algeria, ninety in Egypt and Libya, 126 in Morocco, and 117 in Tunisia on the basis of agronomic performance and disease resistance. Only three entries were commonly selected in the five countries (names shown in Table 2.13). Thirty-one were selected in four countries, 73 in three, 57 in two, and 17 in one country. A total of 181 entries were promoted to the second cycle of selection in the NURMAG97.

Table 2.13. Names and pedigrees of three entries in SEGMAG96 selected in all the five countries.

Entry	Cross	Pedigree
105	Lignee527/5/As54/Tra//Cer*2/TolI/3/Avt/TolI//Bz/4/Vt/Pro//TolI/6/Arizona 5908/Aths//Lignee 640	ICB93-0372-0AP
123	F2CC33MS/CI7555/3/Arizona 5908/Aths//Lignee 640	ICB93-0436-0AP
241	Lignee527/5/As54/Tra//Cer*2/TolI/3/Avt/TolI//Bz/4/Vt/Pro//TolI/6/Arar//Comp.Cr.29/C63	ICB93-0946-0AP

A total of 170 entries were selected from NURMAG96. Four entries were selected in all the five countries (Table 2.14), 18 were selected in four countries, 42 in three, 57 in two, and 52 in only one country. Morocco had the highest number of selected entries (108 or more than 50%). Eighty-three entries were selected in Egypt (40%), seventy-seven in Libya (37.2%), fifty-one in Tunisia (24.6%), and fifty in Algeria (24.6%). Based on the lines selected from the nursery in each country, five different yield trials were prepared to be tested in 1997.

Table 2.14. Name and pedigrees of four entries in NURMAG96 selected in all the five countries.

Entry	NAME/PEDIGREE/ORIGIN
123	Lignee 527//Bahtim/DL71/3/Api/CM67//Mzq/4/Rhn-03 ICB91-0501-5APP-0AP
124	Lignee ICB91-0502-13AP-0AP
96	Lignee 527//Bahtim/DL71/3/Api/CM67//Mzq/4/CI ICB91-0478-11AP-0AP
161	Hyb 85-6//As46/Aths*2 ICB91-0736-18AP-0AP

2.3.1. Analysis of the 1995-96 North African Yield Trials

Algeria

Table 2.15 shows the yield levels of some of the highest yielding bulks identified in Algeria during 1995-96 cropping season, compared with the two widely grown landraces Tichedrette and Saida.

Table 2.15. Grain yield (t/ha) in four locations in Algeria of promising barley lines and two checks.

Line [a]	Grain yield (t/ha)			
	El Khroub	Ouled	Setif	Tiaret
7	4.0	3.0	3.5	4.1
12	2.5	3.2	3.8	5.9
20	2.3	3.1	4.8	4.7
22	3.1	4.3	4.7	3.6
30	4.2	3.0	2.0	3.5
49	2.1	3.3	5.4	5.6
79	3.4	4.8	1.6	2.5
Tichedrette	3.3	2.3	2.8	5.2
Saida	3.4	3.7	3.4	4.3

[a] Names and pedigree

7= 80 - 5013/5/Cr.115/Pro//Bc/3/Api/CM67/4/Giza 120/6/CI 08887/CI 05761//Lignee640
ICB91-0480-3AP-0TR-0AP

12= Rihane-03/Asse
ICB85-0406-2AP-2AP-0TR-3AP-0TR-0AP-0AP-2AP-0TR-OAP

20= 80-5145/N-Acc4000-301-80
ICB88-1153-4AP-0AP-1AP-0TR-0AP

22= Man/4/Bal.16/Pro//Apm/DwII-1Y/3/Api/CM 67/5/Comp.Cr. 229//As46/Pro
ICB91-0018-0AP-0AP

30= M66-69-1/M65-94//70-22109/3/Apm/IB65/4/Glda'S'/5/CM 67/Centeno//Cam/6/Api/CM67//Aths*3
ICB91-0132-0AP-0AP

49= U.Sask.1766/Api//Cel/3/Weeah/4/Lignee527/NK1272
ICB91-0544-0AP-0AP

79= Comp.Cr.229//As46/Pro/3/DeirAlla106//Mzq/DL71
ICB92-0574-0AP

Tichedrette was the best check in Tiaret, Saida in the other locations. Only line 49 was in the top yielding group in two locations. All other lines were specifically adapted to the different locations.

Morocco

In Table 2.16 are listed the highest yielding bulks identified in Morocco. Manal 92, a six-row variety proposed for release in Tunisia for favorable environments, was the best check in Merchouch and it was slightly out yielded by only one line. Rihane-03 was the best check in Jemaat Shaim, Athenais in Tessaout, ER/Apm in Sidi el Aidi. All five lines listed in Table 2.16 had an average grain yield higher than the checks.

Table 2.16. Grain yield (t/ha) in four locations in Morocco of promising barley bulks and five checks.

Line [a]	Grain yield (t/ha)			
	Merchouch	Jemaat Shaim	Tessaout	Sidi el Aidi
2	5.2	2.8	6.0	2.3
3	4.6	2.7	5.1	2.8
12	4.1	3.0	4.9	1.9
18	3.8	2.8	6.1	2.3
39	5.0	2.8	5.2	1.8
Manal 92	5.0	2.6	4.4	1.3
Rihane-03	4.0	2.9	4.7	1.5
Athenais	3.3	2.6	5.0	1.4
Harmal	3.9	2.8	3.5	1.3
ER/Apm	4.6	2.8	4.7	2.0

[a] Names and pedigree

2= Arizona 5908/Aths//Lignee 640/3/Arizona 5908/Aths// Lignee 640
ICB89-0840-8LAP-2AP-0TR-0AP

3= Arizona 5908/Aths//Lignee 640/3/Arizona 5908/Aths// Lignee 640
ICB89-0840-8LAP-1AP-0TR-0AP

12= Ac253/Emir//Katade

ICB82-0395-2BJ-11BJ-10BJ-4BJ-2KF-0KF-3AP-0TR-0AP
18= Lignee527/NK1272/6/Cita'S'/4/Apm/Rl//Manker/3/Maswi/Bon/5/ Copal'S'
ICB91-0172-0AP-0AP
39= Ramage Composite 4/Rihane
ICB91-1022-0AP-0AP

The largest yield increase were obtained in both the highest yielding (Tessaut) and the lowest yielding location (Sidi el Aidi) where the superiority of the best bulk over the best check was 22% and 40%, respectively.

Tunisia

In Tunisia (Table 2.17) lines 15 and 27 outyielded all checks in three locations. Lines 3 and 8 outyielded the three checks in Tadjerouine, line 24 was the top yielder in Beja. Lines 3, 8, and 24 were also resistant to powdery mildew and net blotch. Eventually lines 2 and 3 were in common with those selected in Morocco.

Table 2.17. Grain yield (t/ha) in three locations in Tunisia of promising barley bulks and three checks.

Line [a]	Grain yield (t/ha)		
	El Kef	Beja	Tadjerouine
2	5.3	7.1	3.5
3	4.4	7.1	4.4
8	4.4	7.2	4.5
15	5.5	7.7	4.7
24	4.7	8.4	3.4
27	5.6	7.4	4.6
Rihane-03	5.4	6.0	2.8
Manal 92	5.1	6.9	3.0
Martin	3.9	7.2	3.7

[a] Names and pedigree

2= Arizona 5908/Aths//Lignee 640/3/Arizona 5908/Aths// Lignee 640
ICB89-0840-8LAP-2AP-0TR-0AP

3= Arizona 5908/Aths//Lignee 640/3/Arizona 5908/Aths //Lignee 640
ICB89-0840-8LAP-1AP-0TR-0AP

8= Mr25-84/Attiki/3/Arizona5908/Aths//Lignee640
ICB89-0274-2AP-1AP-2AP-0TR-0AP

15= M126/CM67//As/Pro/3/Lignee527/Arar
ICB89-0873-1LAP-6AP-0AP

24= Lignee527/Chaaran-01//Lignee527/NK1272
ICB91-0490-0AP-0AP

27= Arizona5908/Aths//Lignee640/3/Lignee640/Lignee527
ICB91-0523-0AP-0AP

Libya

Table 2.18 shows the grain yield of the best bulks identified in Libya, compared with the two commonly grown cultivars California Mariout and Athenais, and with the promising line Mari/Aths*2. Line 17 was in the top yielding group in all locations, always outyielding the three checks. Line 5 was the best performing in El Marj and in Azizia. Line 3 was selected in both El Marj and Misurata, lines 8 and 25 in both Azizia and Misurata.

Table 2.18. Grain yield (t/ha) in three locations in Libya of promising barley bulks and three checks.

Line [a]	Grain yield (t/ha)		
	El Marj	Azizia	Misurata
3	3.5	3.7	3.5
5	3.8	5.0	3.4
8	3.1	4.5	3.7
17	3.6	4.5	3.8
25	3.1	4.5	3.5
California Mariout	2.4	2.7	3.2
Athenais	2.7	3.6	2.4
Mari/Aths*2	3.4	2.9	3.1

[a] Names and pedigree

3 Rihane-01/Harmal-01
ICB84-0003-11AP-0AP-38APH-0AP-1AP-0TR-0AP

5 Ager//Api/CM67/3/Cel/WI2269//Ore/4/Arizona5908/Aths//Lignee640
ICB89-0312-4BO-1AP-1AP-0TR-0AP

8 SLB34-65/Arar
ICB88-0043-16AP-0AP-3AP-0AP

17 Comp.Cr.229//As46/Pro/3/DeirAlla106//DL71/Strain205
ICB91-0053-0AP-0AP

25 AlgerianSelection DZ21-3/3/CM67/Apro//Sv.02109/Mari
ICB92-0541-0AP

All lines selected from the yield trials have been included in the crossing block for the 1997 crossing program.

Egypt

The special yield trial for Egypt included 91 lines and 5 checks, namely Rihane-03, ER/Apm, Athenais, California Mariout and Giza 126 as national check. Table 2.19 shows the lines with the highest average grain yield across the three locations. The table suggests that highest yielding lines were identified both at Sakha and Ismailia, but not in Rafah where the crop was grown under the most severe stress.

Table 2.19. Grain yield (t/ha) in three locations in Egypt (Sakha, Ismailia and Rafah) and average grain yields of promising barley bulks and five checks. Lines in bold were among the top ten in that particular location.

		Grain yield (t/ha)			
Entries[a]	RT	Sakha	Ismailia	Rafah	Mean yield
57	6	**6.7**	**3.3**	1.1	**3.7**
17	6	**6.6**	**3.4**	0.9	**3.6**
5	6	**7.2**	**2.5**	1.1	**3.6**
13	6	**7.2**	2.4	1.0	**3.5**
56	6	6.2	**2.7**	1.0	**3.3**
89	6	6.4	2.2	1.2	**3.3**
68	6	6.5	2.4	0.9	**3.3**
91	6	6.4	2.3	1.0	**3.2**
52	6	**6.5**	2.2	0.9	**3.2**
36	6	6.3	2.1	1.1	**3.2**
Checks					
Rihane-03	6	6.2	2.0	1.1	3.1
National check	6	4.4	**2.7**	1.0	2.7
ER/Apm	2	5.3	1.7	1.2	2.7
Athenais	6	5.1	1.3	0.9	2.4
California Mariout	6	5.9	1.5	1.4	2.9

[a] Names and pedigree

57= Arizona5908/Aths//Lignee640/3/Lignee640/Lignee527
ICB91-0523-0AP-0AP

17= Cr.115/Pro//Bc/3/Api/CM67/4/Giza 120/5/Satter 2/Numar
ICB85-1058-3AP-3AP-0TR-3AP-0TR-0AP-0AP-1AP-0TR-0A

5= M126/CM67//C63/4/Ager//Api/CM67/3/Cel/WI2269//Ore
ICB89-0867-10AP-1AP-1AP-0TR-0AP

13= Baca'S'/3/AC253//CI 08887/CI 05761/4/JLB 70-01
ICB90-0294-5B0-0TR-0AP

56= Arizona 5908/Aths//Lignee 640/4/Lignee 527/ /Bahtim/ DL71 /3/Api/CM 67//Mzq
ICB91-0522-0AP-0AP

89= As46/Aths*2//H85-6(Rihane'S'/LM4448-1)
ICB91-0732-0AP-0AP

68= Multan/M23/4/HopRo/3/Md/AT//CM/5/Arig8
ICB91-1007-0AP-0AP

91= DL529/Dijon3-2-5 ICB91-0812-0AP-0AP

52= Arimar/Aths/3/Bal.16/Api//DeirAlla106
ICB91-0377-0AP-0AP

36= Lignee527/DL529
ICB91-0061-0AP-0AP

However, as shown in Table 2.20 the highest yielding lines in Rafah do show a considerable yield advantage over the best checks both in terms of total biological yield (combined with taller plants) and of grain yield. However, their average grain yield is always lower than that of the best check as a result of their lower yield potential.

Table 2.20. Plant height (cm) total biological yield and grain yield (t/ha) of the highest yielding lines at Rafah (Egypt) and their average grain yields in three locations.

Entry[a]	Plant height	Biological Yield	Grain Yield	Average Grain Yield
80	**92**	6.4	2.0	2.7
40	64	5.6	1.7	2.8
3	53	4.3	1.6	2.7
22	62	4.7	1.5	3.0
15	**76**	6.9	1.5	2.8
4	58	4.7	1.5	2.7
62	**76**	4.5	1.4	2.6
61	62	4.4	1.4	2.9
8	57	4.7	1.4	2.8
6	68	5.2	1.4	2.9
Checks				
California	61	3.7	1.4	2.9
Athenais	70	3.1	0.9	2.4
ER/Apm	53	4.7	1.2	2.7
National check	60	4.8	1.0	2.7
Rihane-03	59	4.8	1.1	3.1

[a] Names and pedigree

80= As57/DL530
ICB91-0840-0AP-0AP

40= Lignee 527/NK 1272/6/Cita'S'/4/Apm/Rl//Manker/3/Maswi/Bon/5/Copal'S'
ICB91-0172-0AP-0AP

3 Arizona 5908/Aths//Lignee 640/3/Arizona 5908/Aths//Lignee 640
ICB89-0840-8LAP-2AP-0TR-0AP

22 Unknown
4AP-0TR-0AP-22AP-0TR-OA

15 Arar/Rihane-03
ICB85-0624-3AP-5AP-0TR-5AP-0TR-0AP-0AP-3AP-0TR-OA

4 Arizona 5908/Aths//Lignee 640/3/Arizona 5908/Aths// Lignee 640
ICB89-0840-8LAP-1AP-0TR-0AP

62 DL531//Arimar/Aths
ICB91-0850-0AP-0AP

61 As57/DL531
ICB91-0841-0AP-0AP

8 Lignee 640/Lignee 527//Mo.B1337/WI2291
ICB89-0911-2AP-1AP-1AP-0TR-0AP

6 Arizona 5908/Aths//Lignee 640/3/Lignee 527/Arar
ICB89-0829-4LAP-2AP-0TR-0AP

2.4. Stay-Green

Stay-green, or delay of leaf senescence, has been described as a mechanism of resistance to post-flowering water stress. In crops adapted to semiarid areas such as sorghum, genotypes with delayed senescence retain their leaves in an active photosynthetic state during the grain filling period and do not need to retranslocate stored assimilates from the stem into the developing grains. Therefore, the ability to "stay-green" has been considered to be a desirable trait in the presence of terminal water stress. However, it has been found in at least two cases that delayed senescence and utilization of stem reserves by retranslocation may be mutually exclusive[3]. Since grain filling through retranslocation is an important mechanism for high grain yield under stress, it is important to determine whether the stay-green character is of advantage or of disadvantage in barley, where very little is known about this trait.

During 1996 we conducted a preliminary screening using a collection of landraces from Spain, where we expect a large variation for the stay green trait based on previous field

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3 Blum, 1996. The role of mobilized stem reserves in stress tolerance. Proceedings of the V International Oat Conference and of the VII International Barley Genetics Symposium (A. Slinkard, G. Scoles and B. Rossnagel, eds.): 267-275.

observations. A collection of 208 accessions provided by the Genetic Resources Unit (GRU) was grown unreplicated at Breda and Tel Hadya. Total chlorophyll content was measured in intact leaves in the field using a portable chlorophyll meter [SPAD-502, Soil-Plant Analysis Development (SPAD) Section, Minolta Camera Co., Osaka, Japan] on three consecutive dates in both locations. There was a drastic decline of chlorophyll content both in Tel Hadya and Breda, with SPAD readings dropping from above 40 in the first date, to around 30 in the second, and to around 5 in the third (Table 2.21). There was also a considerable variation between the 208 accessions as shown by the range, which indicates that some accessions lost their chlorophyll much earlier than others during the season.

Table 2.21. Chlorophyll content (SPAD readings) at three different dates and two different locations of 208 barley accessions from Spain and grain yield (g/plot) in Tel Hadya

	Breda			Tel Hadya			Grain Yield
	1st date	2nd date	3rd date	1st date	2nd date	3rd date	
Mean	42.3	30.4	5.3	43.9	32.8	5.6	609
s.e.	0.3	0.9	0.8	0.3	0.9	0.8	11
Min	22	6.1	0	30.8	3.9	0	219
Max	57	54.8	40.02	53.7	59.5	50.1	1021

Based on the rate of chlorophyll disappearance, we selected the seven lines with the fastest rate of chlorophyll disappearance and the seven lines with the slowest rate of chlorophyll disappearance (Table 2.22).

The non senescent lines only had a small decrease in chlorophyll content of about 20% both in Breda and in Tel Hadya. By contrast, the senescent lines had completely yellow leaves by the time of the third reading. There was an average difference of about 160 g/plot between senescent and non senescent accessions, but also considerable variation within groups.

Table 2.22. Chlorophyll content of non-senescent (NS), or stay-green, and senescent (S) barley accessions selected for further testing in 1996/97.

	Breda			Tel Hadya			
Lines	1st date	2nd date	3rd date	1st date	2nd date	3rd date	Yield
NS	40.1	33.5	38.0	50.8	48.7	35.6	516
NS	37.5	46.6	29.9	45.9	39.4	36.0	477
NS	49.5	50.4	36.0	44.8	45.4	40.3	415
NS	44.8	52.0	34.2	45.0	48.1	38.5	512
NS	41.2	50.1	32.1	46.6	44.7	35.5	546
NS	45.0	38.8	40.0	43.2	46.3	35.6	397
NS	42.8	46.5	31.7	40.2	41.2	35.1	466
Mean NS	**43.0**	**45.4**	**34.6**	**45.2**	**44.8**	**36.7**	**475**
S	46.0	9.7	0	38.6	7.1	0	669
S	36.2	8.4	0	48.1	6.5	0	615
S	33.1	15.0	0	39.8	7.4	0	670
S	38.3	13.7	0	43.1	8.2	0	827
S	51.2	7.7	0	44.7	4.8	0	461
S	42.4	6.6	0	39.2	8.1	0	621
S	41.2	12.5	0	43.8	7.6	0	597
Mean S	**41.2**	**10.5**	**0.0**	**42.5**	**7.1**	**0.0**	**637**

2.5. Mixtures

As indicated in previous Annual Reports, the long term objective in exploiting the variability within landraces is to use the best genotypes selected within landraces to constitute mixtures. The use of mixtures rather than homogeneous varieties has been suggested by several authors as a means to promote yield stability.

In addition to testing mixtures for their stability of performance across years and locations, in 1996 we started a study is to evaluate methods to construct more stable mixtures through a study of :

(I) the physiology of the constituents of the mixture;

(ii) the population dynamics of the mixture;

(iii) the environment it is growing in.

We used three pure lines of barley in pure stands and in mixture. Each pure line was selected from landraces of three climatically/ecologically different regions in Syria and Jordan. The three pure lines, Arta, Zanbaka and Wadi Hassa are different for both morphological characters and molecular markers. The materials were planted in two locations in Syria (Tel-Hadya and Breda), one location in Jordan (Deir Alla) characterized by warm winters, and one location in Turkey (Diyarbakir) characterized by colder winters than Syria. The materials were:

- the three pure stands of the three lines a=Arta, b=Zanbaka and c=Wadi Hassa
- a mixture of the three lines with a, b, c in the proportions 1:1:1
- a mixture of the three lines with a, b, c in the proportions 2:1:1
- a mixture of the three lines with a, b, c in the proportions 1:2:1
- a mixture of the three lines with a, b, c in the proportions 1:1:2
- the three populations (A, B, C) from which the three lines were selected.

The experiment design is a 5 x 2 α-lattice with 4 replicates and plots 1.6 m wide (8 rows 20 cm apart)and 6.5 m long. The results in 1996 did not reveal any significant difference. However, this first year was useful to establish all the physiological measurements, and the experiment will be repeated in 1997.

2.6. Boron Toxicity Tolerance

2.6.1. Seedling Test

Screening for B-toxicity tolerance was conducted as indicated in the previous Annual reports Foliar B-toxicity symptom scores were taken visually 4 to 6 weeks after sowing using a 0 to 5 scale (0=no symptoms, 5=all leaves with symptoms) indicating the level of B-toxicity tolerance.

2.6.1.1. Jordanian and Syrian landrace

Last year data showed that there is large variation in B-toxicity tolerance among pure-line selections within two collection sites. The 1996 study expanded the analysis to a larger number of collection sites. This information may help to locate sites or areas where high B soils may occur, where B-toxicity tolerant varieties may be needed or where sources of tolerance may be found. Ten random pure-line selections from 24 selection sites were screened.

There were highly significant ($P<0.001$) differences in mean B-toxicity symptom scores between the collection sites. The names and mean symptom scores of these sites are given in Table 2.23 Pure lines selected from site 37 had the lowest symptom score on average. Sites 38, 8, 36 also had low mean scores. Sites 9, 30, 67, 66, and 12 had the highest mean scores.

Significant differences in B-toxicity symptom scores existed between the selections. Six selections had symptom scores comparable to the moderately tolerant check, Galleon. These selections came from different collection sites (Sites 37, 10, 34, 3, 45, and 22) with different mean scores. None of the selection was as sensitive as the very sensitive check, Pirate.

(S.K. Yau, S. Grando, S. Ceccarelli)

Table 2.23. Codes of the collections sites and mean B-toxicity scores of pure-line selections of 24 collection sites in Syria.

Site Code	Mean Score
03	3.5
05	4.0
06	2.8
07	2.9
08	2.6
09	4.1
10	2.9
12	4.0
19	3.4
22	3.2
30	4.0
32	3.8
34	3.0
36	2.7
37	2.1
38	2.5
39	3.8
40	4.0
42	3
45	3.9
58	3.8
66	4.0
67	4.0
68	3.5

2.6.1.2. Afghanistan Accessions

This evaluation of Afghanistan barley accessions was prompted by the identification of very tolerant durum wheat accessions from Afghanistan in 1995[4]. Two hundred and twenty-seven random accessions from the GRU were screened. Seedling growth was visually scored besides symptom severity. Fifty-nine accessions (26.0%) had better symptom-plus-growth score than the tolerant check, Galleon. The most tolerant accessions were ICB 104046, 104047, 104169, 104057, 109017, and 121968. None of the accessions had a poorer score than the very sensitive check, Pirate. This finding on Afghanistan barley, agreed with that in durum wheat **(see 3.3)**, and in bread wheat[5]. The high frequency of tolerant lines found in germplasm collections indicates that many soils in Afghanistan might have high levels of B.

(S.K. Yau, J. Valkoun)

2.6.1.3. Turkish Barley

Under the ICARDA/Turkey mini-project on B-toxicity, 105 Turkish advanced lines were screened. There was highly significant variation between entries. Most of the materials were fairly tolerant. Forty-four entries had symptom scores non-significantly different from the tolerant checks, Sahara 3769 and Tokak, and only two entries were non-significantly different from the very sensitive check, Pirate.

(S.K. Yau, H. Tosun, A. Çildir)

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4 ICARDA, 1995. Germplasm Program Annual Report for 1995: Cereals. ICARDA, Syria.

5 Moody, D.B., Rathjen, A.J., Cartwright, J.G., Paull and J. Lewis, 1988. Genetic diversity and geographical distribution of tolerance to high levels of soil boron. In: T.E. Miller and R.M.D. Koebner (Ed.), Proc. of 7th International Wheat Genetics Symposium, vol. 2, pp. 859-865. Inst. Plant Sci. Res., Cambridge, U.K.

2.6.1.4. Observation Nurseries for Low Rainfall Areas

There was a large variation in response to the high B soil among the entries in the two 1995/96 observation nurseries for low rainfall areas. In the Low Rainfall (Cool Winters) Observation Nursery, seven entries (no. 19, 27, 45, 58, 68, 71 and 95) had less symptoms than the tolerant check, ER/Apm//Salmas// Arar/PI386540//Giza 121/Pue/3/Comp.Cr.229// Mzq/DL71 (Entry no. 79) had higher, and Harmal-02/Roho/4/ER/Apm/3/WI2291//Apm/PI 000046 (entry no. 31) had similar symptom score as the very sensitive check, Robur/Hor728//F3 Bulk Hip/3/Harma-02//M480/Gva. As there is evidence that genotypes relatively tolerant to boron toxicity are also relatively sensitive to boron deficiency and vice versa[6] (Nable et al. 1989), the boron-toxicity sensitive entries are expected to be tolerant to boron deficiency.

Sixteen entries (no. 8, 11, 16, 39, 97, 128, 161, 165, 175, 177, 181, 183, 187, 197, and 236) had less symptoms than the tolerant check, ER/Apm//Salmas, in the Low Rainfall (Mild Winters) Observation Nursery. Among them, entry 187 (Deir Alla 106//Api/EB89-8-2-15-4/4/Deir Alla 106/Cel/3/Bco.Mr/Mzq//Apm/5106) had the least symptom score. Seven entries (no. 37, 63, 64, 93, 118, 189 and 225) had similar or higher symptom scores than the very sensitive check.

(S.K. Yau, S. Ceccarelli, S. Grando)

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6 Nable, R.O., B. Cartwright, and R.C.M. Lance, 1989. Genotypic differences in boron accumulation in barley: relative susceptibilities to boron deficiency and toxicity. In pages 243-251, N. El Bassam et al. eds., Genetic Aspects of Plant Mineral Nutrition. Kluwer, The Netherlands.

2.6.1.5. The 1995/96 International Winter and Facultative Nurseries

There was a large variation between entries of the two observation nurseries and the crossing block in their response to the high B soil. The most tolerant or sensitive entries to B toxicity in the three nurseries are given in Table 2.24. The tolerant entries had symptom scores lower than the tolerant check, Tokak, while the sensitive entries had symptom scores as high or higher than the very sensitive check, Pirate.

(S.K. Yau, M. Tahir)

Table 2.24. Entries with the lowest or highest symptom scores in three of the 1995/96 international nurseries.

Lowest symptom scores	Highest symptom scores
Intern. Winter & Facultative Barley Obs. Nursery (IWFBON):	
no. 17, 42, 88, 116	no. 14, 44, 45, 72, 99, 103, 121, 126, 136
Intern. Facultative Barley Observation Nursery (IFBON):	
no. 12, 27, 40, 45	no. 2, 8, 28, 48, 52, 55, 63, 64, 74, 79, 81, 95, 99, 113
Intern. Winter & Facult. Barley Crossing Block (IWFBCB):	
no. 8, 15, 62, 63, 68, 77, 132, 142, 144, 150	no. 29, 34, 46, 74, 75, 92, 99

2.6.2. Level, Pattern and Time of B Application

In most of the studies on B toxicity, B was introduced into the growing medium before sowing. Thus, toxic effects of excess B were imposed right from germination. However, in many field situations, high B concentrations occur in subsoils, and plant roots reach this layer some time after germination. This experiment was conducted to study the timing of B supply on grain yield of barley.

A pot experiment with two replicates was conducted in a plastic house. Each pot consisted of two sections of PVC pipe, each of 20 cm in height holding 2.4 kg of soil. The second section was added to the bottom of top section at specific time after seeds were sown into the top section. A factorial design of three levels of B supply, three timings of B supply, and two barley lines was used. The three levels of B supply were: no B added (-/-), B added to second section only (-/+), and B added to both sections (+/+). The soil contained 0.7 ppm hot-water soluble B. After adding B (50 mg/kg soil), the soil had 21 ppm. The second section was added to the top section at the tillering, elongation, or booting stage. Two 2-row barley lines, Arar/Arabic Aswad (ICB84-1730-1AP-1AP-4AP-0AP-0AP) and Harmal, were tested. The former had less severe symptoms than the latter in previous year's seedling test. The pots were watered twice a week with ample of water.

There were highly significant differences in grain yield between the three levels of B supply [(-/-) > (-/+) >> (+/+)]. Delay in adding the second section also decreased yield, and there was no interaction between the two factors. Figure 2.1 shows that Harmal had a significant yield reduction when B was added to the second section of the pot, but there was no yield reduction for the more B-toxicity tolerant Arar/Arabic Aswad. This difference decreased when B was added to both first and second sections.

Three implications can be drawn from the results of this study. First, the screening of seedling for severity of B-toxicity symptoms at high B levels is able to differentiate the responses of genotypes to high B. Second, subjecting plants to high B soils from germination to maturity exaggerates the effects of B on rainfed crops in the fields, where high B levels usually occur in subsoils. Third, high

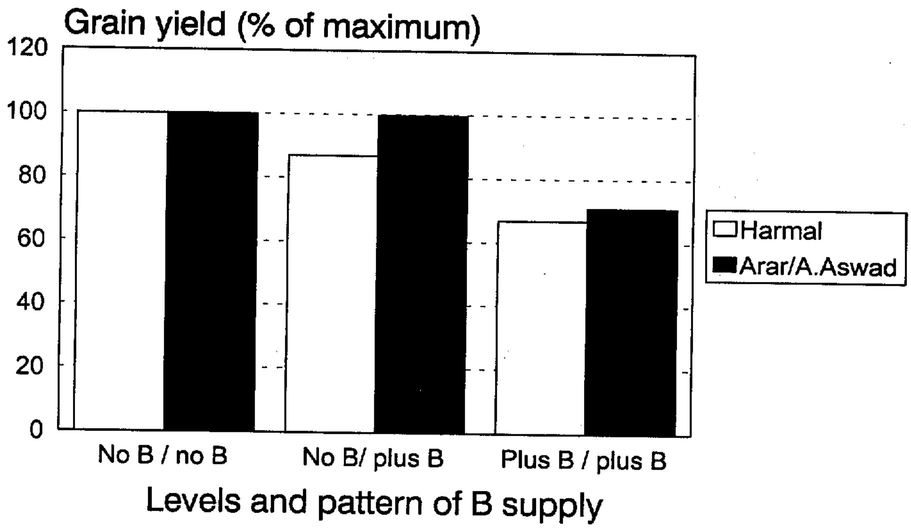


Fig. 2.1. Effects of the levels and pattern of B supply on grain yield of two barley lines. (@/#, @ and # indicates the treatment of the top and bottom section of the pot, respectively.)

subsoil boron levels can cause yield reduction even when roots reach it at the booting stage.

(S.K. Yau)

2.7. Response to Selection

Barley lines were selected for either high yield under stress (YS), or high yield under non-stress (YNS), or for average performance (AP) during three breeding cycles (cohorts) of three years each. The lines were then tested in a total of 21 year-location combinations (from 1991 to 1994) with average grain yields ranging from a minimum of 0.35 t/ha to a maximum of 4.86 t/ha. Some preliminary data were reported in the Annual Report for 1994.

The yield under stress of the YS lines was between 27% and 56% higher than the YNS lines, with the top YS lines yielding between 16% and 30% more than the top YNS lines under stress (Table 2.25).

Table 2.25. Mean and range of grain yield (t/ha) under stress of the selection groups and the checks, yield advantage of YS lines over YNS lines, yield advantage of the best YS line over the best YNS line, and yield advantage of the best line in each group over the best check.

Entries	GYS ± s.e.	Range	Top YS/Top YNS[b]	Top Line/Best check[c]
YS88	0.63±.02	0.51-0.67	1.16	0.84
YNS88	0.41±.05	0.16-0.58		0.73
AP88	0.56±.03	0.38-0.66		0.82
YS89	0.73±.05	0.50-0.84	1.30	1.05
YNS89	0.52±.04	0.41-0.65		0.81
AP89	0.67±.06	0.56-0.82		1.02
YS90	0.80±.03	0.73-0.92	1.28	1.14
YNS90	0.63±.02	0.54-0.72		0.90
Checks				
Rihane-03	0.54			
Mari/Aths*2	0.65			
ER/Apm	0.72			
Harmal	0.77			
A. Abiad	0.75			
A.Aswad	0.80			

Realized heritability was between 0.35 and 0.67 when selection was under stress and was significant in all the three cohorts. On the contrary, selection under non-stress was significant in only one cohort, and its efficiency in improving yield under stress was significantly lower than selection under stress. The best YNS line ranked only 19th for yield under stress. The two highest yielding lines under stress were not only selected under stress, but were also landraces collected in very dry areas. This confirms earlier findings and suggests that the most effective way to improve productivity of crops grown in less-favored conditions is to use locally adapted germplasm and to select in the target environment (s).

2.8. Quality

The two best known uses of barley are malting, used in the brewing industry, and as feed, in animal feeding. However, barley was probably the first cereal crop to be cultivated, and therefore, barley for human consumption was prepared and used since many thousand of years in particular in the Fertile Crescent.

Barley is mainly used as a source of carbohydrate, even though protein content is also important. As food can be used in many different ways such as soup, porridge, bread (using composite flour), and also several different types of beverages.

In Europe and in particular in the Mediterranean region, barley has always enjoyed a "healthy image" since it has been the basis of numerous herbal remedies. For instance, barley grain and palm oil are the richest natural source of vitamin E, and people whose diet is rich in cereal grains tend to suffer less from atherosclerosis.

Recently, it has been discovered that the presence of mixed linked (1-3) (1-4)-β-D-glucans in barley can lower blood serum cholesterol levels in humans. This component is present in the endosperm and is define as non-starch polysaccharides.

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

In response to the request from several national programs (Nepal, Ethiopia, Morocco, Tunisia, etc) the Barley Breeding Program at ICARDA started working for the improvement and utilization of barley as food screening its germplasm for different characters associated with grain food quality. Traits such as protein content, thousand kernel weight (TKW), hardness, lysine and beta-glucan content can be analyzed routinely at the Cereal Quality Lab.

Despite the development in recent years of chemical methods to estimate beta-glucan content, there is no generally accepted, quick and simple screening procedure which can be used in a breeding program. ICARDA developed several calibrations to predict beta-glucan content using an advanced near-infrared analyzer "NIRSystem 5000". The best equation provided a multiple correlation coefficient (r^2) of 0.72, and a standard error of predictions of 0.33. Our preliminary results in normal barley are already very close to world level accuracy and we believe that the calibration could be improved in the near future.

The near-infrared calibration has been used to determine the beta-glucan content of 180 lines derived from landraces of 16 countries (Table 2.26)

Hardness is another important character for food barley. Today, ICARDA is able to predict this trait using NIRS; its calibration is actually going on and preliminary results are encouraging to work further on this direction.

In our Germplasm Quality Laboratory 250 samples for three barley grain quality traits can be screened by NIRS in a day. Those traits are: protein content, beta-glucan and hardness. This imply an important reduction in labor costs, chemicals and time.

(A. Impiglia and F. Jaby El-Haramein)

Table 2.26. 1000 kernel weight, protein content and beta-glucan content of barley landraces from 16 countries.

ORIGIN	NO.LINES	TKW (g)	PC (%)	β-GLUC (%)
AFG	8	35.9	9.5	4.2
		28.6-43.7	8.1-10.6	3.21-4.94
ALG	8	44.1	10.7	4.7
		40.5-48.7	9.7-13.6	4.38-5.21
AUS	9	31.9	10.4	3.9
		21.1-39.3	9.7-11.7	2.69-5.43
BRA	1	24.9	12.2	3.87
		24.9	12.2	3.87
CHI	4	32.1	10.6	3.89
		25.7-37.1	10.4-10.7	3.4-4.48
EGY	10	35.5	10.6	4.6
		26.5-45.4	9.9-11.4	3.42-5.27
ETH (1)	10	35.4	9.8	4.11
		26.8-43.2	8.3-10.5	3.19-4.99
GER	3	31.5	10.3	3.9
		29.6-33.4	9.9-10.7	3.43-4.76
IRN	10	28.5	10.6	4.2
		23.9-38.2	10-11.5	3.22-4.8
IRQ	10	34.9	10.9	4.3
		27.2-44	9.7-12.5	3.83-5.3
LYB	11	31.4	10	4.21
		23.6-37.9	9.2-11	3.55-4.79
PAK	10	28.6	9.61	4.31
		26.8-31.2	7.7-10.4	3.57-5.61
SSR	10	37.9	10.3	4.1
		31.9-46.5	9.8-11	3.47-5.54
TUN	10	40.2	11.9	5
		22.4-45.7	9.6-12.5	3.88-5.22
TUR	11	34.9	9.7	4.2
		26.8-43.3	8.1-10.6	3.58-4.91
YEM	9	40	10.1	4.1
		34.7-49.2	9.7-10.4	2.92-4.54
ETH (2)	46	42.4	10.4	4.95
		31.2-51.5	8.7-12.1	4.02-6.15

2.9. Farmer Participation

During 1995 we recognized that decentralization to national programs will not necessarily respond to the needs of resource-poor farmers if it is only a decentralization from ICARDA's research stations to NARS' research stations. Moreover, decentralization to NARS will continue to ignore the potential benefits of indigenous knowledge existing in farmers' communities. Therefore, we concluded that to exploit the potential gains from specific adaptation, selection needs to be practiced by farmers under their own conditions in what it may be considered as an extreme type of decentralization.

In 1996 we started implementing two special projects, one in Syria and one in Tunisia and Morocco, with the financial support of Der Bundesminister für Wirtschaftliche Zusammenarbeit (BMZ) and by the International Development Research Center (IDRC).

Both projects test a novel breeding approach for barley improvement in low potential, marginal rainfall environments of northern Syria, Southern Tunisia and both the dry areas and the Mountains of Morocco. The new approach is based on: (a) early selection and testing under real farmer conditions, (b) use of farmers' selection criteria, (c) use of market derived economic criteria during both selection and testing, and (d) validation and quantification of grain and straw qualities used as selection criteria. The research will utilize the subjective assessments of producers and consumers to establish objective indicators of crop quality. The new breeding program, targeted at marginal conditions and low-input agriculture, will move selection and testing work outside experiment stations and put breeding into the hands of farmers. We expect that, even in a relatively small geographical area, farmers will tend to exploit specific adaptation. Specific adaptation benefits biodiversity through selection and spreading of a number of different cultivars, instead of the few, often closely related, cultivars characteristic of conventional breeding for wide adaptation.

From a breeding point of view some of the most important questions that will be answered are:

1. Do farmers and breeders use similar or different selection criteria?
2. Which is more important – the environment where the material is grown or the person who does the selection? In other words, what is the key factor in increasing breeding efficiency: decentralization or participation?
3. Does participation increase the number of varieties adopted and the rate and the speed of adoption more than decentralization?

The answers to these questions will provide the basis for a decentralized-participatory plant breeding, characterized by a continuum between the formal breeder, with the capacity to generate large amount of variability, and the farmer, with the comparative advantage in exploiting that variability in his/her own farming system and for his/her specific needs.

The project in Syria, called "Farmer Participation and Use of Local Knowledge in Breeding Barley for Specific Adaptation" is conducted in collaboration with the Agricultural Research Center, Ministry of Agriculture and Agrarian Reform, Syria and the University of Hohenheim, Germany.

During 1996 the project began by planting 208 different barley populations in eight villages in the farm of the eight farmers listed in Table 2.27 together with the name of the location, the climatic zone (zone B, with long term average annual rainfall of 300 mm, and zone C, with long term average annual rainfall of 250 mm) and the administrative province. The same 208 populations have been also planted in the three sites in Northern Syria, Tel Hadya, Breda and Bouider, which have been used by the barley breeding program during the last ten years.

Table 2.27. Farmers' participation in Syria: name, location, climatic zone and province of the eight farmers hosting 208 barley populations that will be used in participatory breeding.

Farmer Name	Location	Zone	Province
Abdo Shikho	Al Bab	B	Aleppo
Mohamed Al Issa	Bailounan	C	Raqqa
Ahmed Al Saleh	Aljern Al Aswad	B	Raqqa
George Kaleonjy	Tel Brak	B	Hassakeh
Sulaiman M. Al	Mailabieh	C	Hassakeh
Abdul L. Al Hasan	Suran	B	Hama
Hasan Dalla	Salamieh	C	Hama
Shakeeb Basha	Ebla	B	Idleb

The barley populations planted in each village include:

50 high yielding lines unrelated to Syrian landraces (25 six-row and 25 two-row)

50 segregating populations from crosses between high yielding lines unrelated to Syrian landraces (25 six-row and 25 two-row)

50 pure lines extracted from Syrian landraces (25 with black seed and 25 with white seed)

50 segregating populations from crosses between two-row high yielding lines and Syrian landraces (25 with black seed and 25 with white seed)

8 farmers' cultivars from seed purchased from each of the eight farmers.

The use of both pure lines and heterogeneous populations will test the attitude of farmers towards heterogeneity, as opposed to the conventional breeders' propensity for homogeneity. Selection will be conducted in the three experiment sites (Breda, Bouider and Tel Hadya) and in each host farmer's field both by the breeders from the Agricultural Research Center in Damascus and by the host farmers.

The eight farmers will also invite neighbors to make selections from the set of barley populations. The selection will be conducted in such a way as to reveal the criteria being used by members of the groups when they make their choices. There will be detailed discussions regarding the cultivars selected and the criteria used in selection, farmer observations, expected performance, and crop management practices.

The project in Tunisia and Morocco, called "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 conceptually similar in the sense that a common set of lines and populations (including the farmers' cultivars) will be grown in a typically well-managed experiment station (Merchouch in Morocco and Beja in Tunisia) and in one farmer's field at each of three locations in Morocco and four locations in Tunisia) under farmer's management practices (fertilizer use, rotations, date and method of sowing, land preparation, etc.). The main difference with the project conducted in Syria, is the participation of women farmers.

(S. Ceccarelli, S. Grando. R. Tutwiler, A. Goodchild, M. Martini, H. Salahieh, M. Michael)

2.9.1. Farmer Participation in Tunisia

One of the special nurseries distributed to Tunisia as part of the decentralized barley breeding (see pg. 26), was planted near Tejerouine, a village in southern Tunisia close to the border with Algeria.

The nursery included 207 barleys, mostly early segregating populations, together with check varieties. These were both the landraces grown in North Africa, such as Martin from Tunisia, Saida and Tichedrette from Algeria, Arig 8 from Morocco, and California Mariout and Athenais from Libya, some improved varieties (Rihane-03, released in Morocco, Tunisia and Algeria, and ER/Apm released in Morocco), and one promising Tunisian variety, Manal 92. A check variety was planted every 10 entries, therefore each check variety was present more than once as indicated below:

Check variety	Nr. of times present
Rihane-03	3
ER/Apm	2
Manal 92	3
Martin	2
California Mariout	3
Athenais	2
Saida	3
Tichedrette	2
Arig 8	2

Visual selection was conducted by Dr. A. Yahyaoui, barley breeder at l'Ecole Supérieure d'Agriculture de Kef, and, in his presence, by the host farmer and his wife with the results indicated in Table 2.28.

The data suggest that farmers could be more selective than breeders. This is expected since breeders usually select not only lines that could become varieties, but also those which some useful specific traits, while farmers are presumably only interested in lines which could become cultivars.

Table 2.28. Number and % of lines selected by a breeder, a farmer and the farmer's wife, from a nursery of 207 barley breeding lines (Tejerouine, Tunisia, 1996)

Selected by	Nr. (%)	In common with:	
		farmer	farmer's wife
breeder	40 (19.3)	2	3
farmer	13 (6.3)	-	0
farmer's wife	14 (6.8)	-	-

The type of material selected was of interest. Martin, the local landrace, was present once among the 40 lines selected by the breeder, twice among the 13 lines selected by the farmer, and was never selected by the farmer's wife. She was the only one to selected, twice, one of the two Algerian landraces, Tichedrette and once the other Algerian landrace, Saida. The farmer also selected Saida twice, but from the two plots not selected from his wife (Saida was present three times in the nursery).

Therefore, although chosen from different plots, the farmer and his wife eventually agreed on at least one cultivar.

(A. Yahyaoui)

2.10. International Nurseries

The number of international spring barley nurseries available for distribution to cooperators was the same as in 1995. The names, abbreviations, and numbers of entries for the nurseries and numbers of sets distributed from ICARDA, Syria, are given in Table 2.29. There was no seed shortage. In response to requests from NARS, a total of 327 nursery sets were distributed. Special yield trials, observation nurseries and segregating populations were continued to be sent to the five North African countries (Algeria, Egypt, Libya, Morocco and Tunisia) instead of the regular international nurseries. These special nurseries are not included in the number given above.

(S.K. Yau, S. Ceccarelli, S. Grando)

Table 2.29. International spring barley nurseries for 1996-97.

Nursery	Abbreviation[a]	No. of entries	No. of sets distributed
Regular Nurseries			
Crossing block	ISBCB	165	22
Segregating Populations	ISBSP	193	15
Observation Nurseries:			
- Low Rainfall (Mild Winter)	ISBON-LRA (M1)	18	16
- Low Rainfall (Cool Winter)	ISBON-LRA (C)	90	10
- Moderate Rainfall	ISBON-MRA	88	27
Yield Trials:			
- Low Rainfall (Mild Winter)	ISBYT-LRA (M)	24	23
- Low Rainfall (Cool Winter)	ISBYT-LRA (C)	24	26
- Moderate Rainfall	ISBYT-MRA	24	33
Specific-trait Nurseries			
Boron-Toxicity Differential	ISBBTD	18	20
Naked Barley	ISNBON	50	36
Germplasm Pools			
BYDV Resistance	ISBYDVGP	50	21
Net Blotch Resistance	ISBNBGP	9	28
Scald Resistance	ISBSCGP	22	26
Powdery Mildew Resistance	ISBPMGP	18	34

[a] ISB - International Spring Barley

Two new specific-trait nurseries, the International Winter and Facultative Hulless Barley Observation Nursery and the Forage Barley Observation Nursery, were prepared in 1996 in addition to the six regular winter/facultative international barley nurseries (Table 2.30). A total of 239 nursery sets were sent to national scientists upon their requests. The demand for the two yield trials, the facultative observation nursery, and forage barley observation nursery was higher than anticipated, thus resulting in a minor seed shortage.

(S.K.Yau, M. Tahir)

Table 2.30. International winter/facultative barley nurseries for 1996-97.

Nursery	Abbre-viation1	No. of entries	No. of sets distributed
Regular			
Crossing block	IWFBCB[1]	95	18
Segregating Populations	IWFBSP	150	22
Observation Nurseries:			
Intl. Winter & Facultative	IWFBON	150	41
Intl. Facultative	IFBON[2]	150	36
Yield Trials:			
Intl. Winter & Facultative	IWFBYT	24	39
Intl. Facultative	IFBYT	24	27
Specific-trait Nurseries			
Boron-Toxicity Differential	IWFBBTD	12	16
Observation Nurseries:			
Hulless Barley	IWFHBON	50	18
Forage Barley	IWFFBON	46	22

[1] IWF - International Winter and Facultative
[2] IF - International Facultative

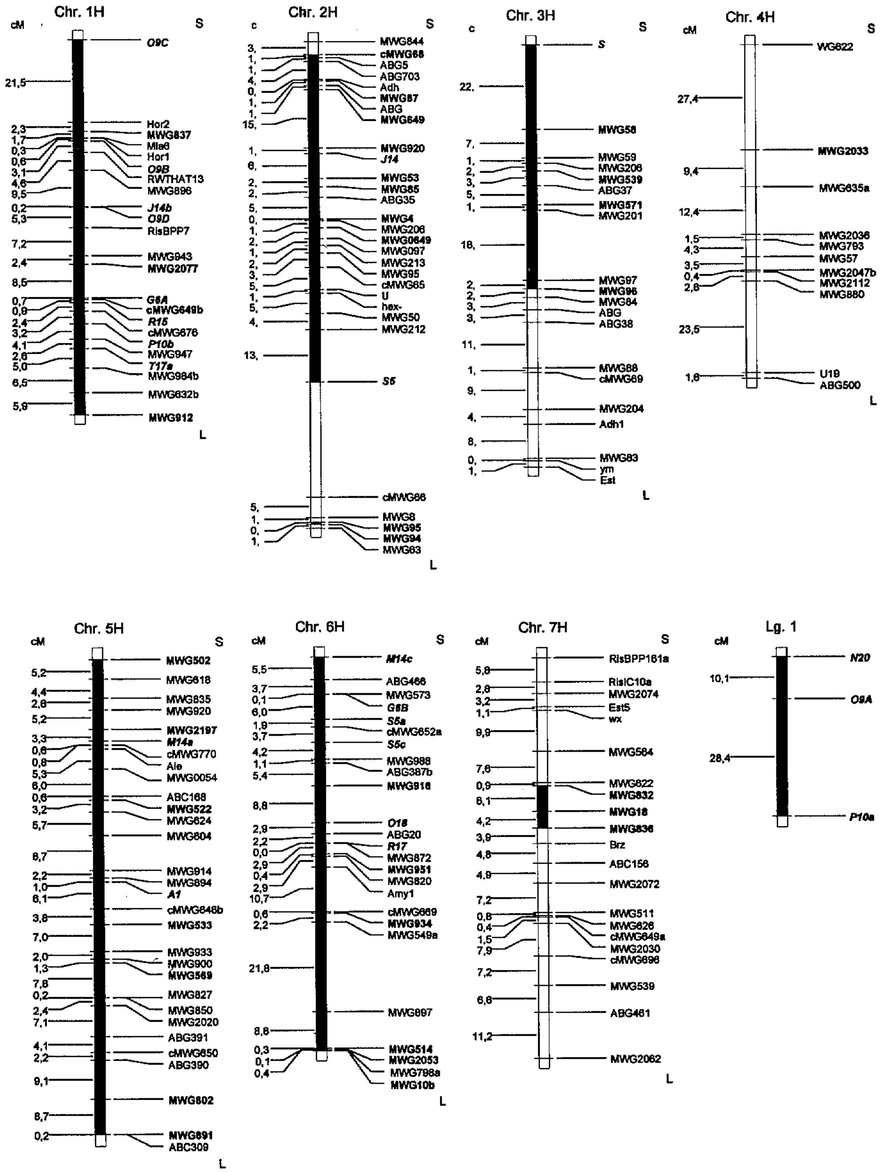
2.11. Biotechnology

2.11.1. Mapping of the cross Tadmor/WI2291

The cross Tadmor/WI2291 was performed to combine the resistance to powdery mildew of WI2291 (a Waite Institute line) with the resistance to scald of Tadmor (a pure line selection from a black seed landrace collected near Palmyra. The cross segregates for seed color, vernalization requirement, growth habit, leaf color and lodging resistance.

An integrated genetic map of barley crosses Tadmor/WI2291 and Igri/Franka consisting of 160 marker loci has been constructed using the computer package JoinMap Version 1.4. (Fig. 2.2). While the segregation data set of Igri/Franka was downloaded from the publicly available GrainGenes database, mapping of the cross Tadmor/WI2291 was performed at the Technical University of Munich and ICARDA. Here, segregation data of 48 RFLP and 31 RAPD markers were obtained for the 260 individuals of the cross. Common markers between populations are a prerequisite and backbone for an

Genetic linkage map from Tadmor x WI2991 (260 RI-lines) joined with Igri x Franka (70 DH-lines)



shadowed chromosome segment = QTL analysis in Tadmor x WI2991 possible in this intervall

bold = RFLP-marker from Tadmor x WI2991

bold/italic = RAPD-marker from Tadmor x WI2991

Fig. 2.2. Genetic linkage map from Tadmor/WI2991 (260 RI-lines) joined with Igri/Franka (70 DH-lines).

integrated map. To find out if markers with the same core name are targetting the same locus, a pre-integrated map was calculated. Markers mapping in a 5 cM distance were considered to represent only one locus and their names were adjusted accordingly.

Having standardized the different marker symbols, 26 markers were found to be common to the two populations (Table 2.31). These markers were evenly distributed over and in the linkage groups hence allowing unambiguous integration of the two data sets. Marker orders on the integrated map were identical to the orders of the two component maps. Except for chromosome 4H and 7H, all other chromosomes were well populated with molecular markers, comprising in total 58 intervals in which a QTL analysis in the cross Tadmor/WI2291 is feasible.

Table 2.31. The number of markers shared by the two populations[a]

Mapping Populations	Chromosome							
	1H	2H	3H	4H	5H	6H	7H	Total
T/WI and I/F	MWG 837 2077 c649b 912	MWG c682 878 858 950 949	MWG 584 571a 961	MWG 2033	MWG 502 522 533 602 891	MWG 916 951 934 514 2053 10c	MWG 832 836	
Total	4	5	3	1	5	6	2	26

[a]T/WI and I/F represent Tadmor/WI2291 and Igri/Franka, the prefix c indicates cDNA-clones.

2.11.2. Analysis of agronomical and physiological traits in the Tadmor/WI2291 cross

Traits were evaluated during seed increase in double rows in 1995 in Tel Hadya, and in 1996 in replicate field trials at Tel Hadya and Breda (Table 2.32). Marker data and field data were analyzed with PLABQTL for QTLs (Table 2.33). The analysis has revealed a QTL explaining around 15% of the variation for reaction to powdery mildew. This indicates a possible quantitative inheritance of the powdery mildew resistance. The QTL has been located on chromosome 5S near marker M2197. The QTL was stable in Tel Hadya in 1994 and 1995, therefore the mean of the powdery mildew evaluation also showing the QTL explaining the same amount of variation. Further genome intervalls contributing only little more to the powdery mildew resistance. For scald (*Rynchosporium secalis*) a QTL has been identified linked to the additional linkage group link 1. This QTL explained between 25 and 31% of the variation between the two different testings. With a high LOD score of 30 and 34, respectivly, it can be concluded that a major gene is involved in the resistance at this locus.

However, linkage groups for chromosomes 1,5 and 6 can be considered complete (Fig. 2.2), 2 and 3 around 75% complete, and 4 and 7 are so far only very scarcely covered with markers.

For other agronomic traits, QTLs could be determined with a high significance (high LOD score). However, in most cases these QTLs explain only a small proportion of the variation. For several physiological traits cofactors could be identified, which explain some of the variation of the trait.

The original objective for which the cross was made has been reached as lines with combined resistance to scald and powdery mildew have been identified. For both traits molecular markers have been identified which can explain some

Table 2.32. Variation of traits evaluated in the population (2 reps, 2 locations).

NAME	Tadmor	WI	Min	MAX	Mean
Seed color	Black	White	-	-	-
PM TH*'94	90	10	0	95	44.4
PM TH**'95	47.5	1	0	57.5	22.4
AveragePM	68.75	5.5	0.25	72.5	33.31
Scald1 TH'95	1	4	0	4	1.0
Scald2 TH'95	2	4	0	4	1.5
Average scald	1.5	4	0	3.75	1.5
Gr. habit TH'95	4	1	1	5	3.1
Gr. habit TH'96	4.40	1.07	0.95	4.89	2.8
Gr. vigor TH'95	1	1	1	4	1.6
Gr. vigor TH'96	2.5	2.5	1	5	2.7
Gr. vigor BR'96	3	2.5	1.5	5	2.9
D to head TH'95	28	26	17	35	27.3
Plant height 96	85	73	49	100	72.6
Plant heigTH'96	90	94	40	100	73.2
Tiller no.BR'96	166	48	11	237	115
Tiller no.TH'96	120	102	11	320	144.4
Grain yield BR	740	953	455	1292	940.1
Grain yield TH'96	1000	1131	299	1661	1167
Lodging TH'95	4	1	1	4	2.7
Lodging TH'96	5	1	1	5	1.7
Leaf color TH'96	27.2	44.1	19.3	42	31.2
Leaf color BR'95	28.5	50.9	24.2	45	33.9
SPAD TH'95	36.6	50.7	31.9	47.10	38.25
leaf area(cm^2)	16.39	22.97	10.93	31.87	17.47
Spec Leaf Dry	40.22	44.61	28.89	53.30	39.97
SPAD/SLW	0.90	1.136	0.72	1.24	0.96

TH*= Tel Hadya BR**= Breda

Table 2.33. Results of the QTL Localization

Locati	QTL	Chromo	Marker	r(xi,y	LOD	%add
Powder	1	chr.5h	M2197	0.374	9.78	13.68
Tel	2	chr.6h	M0934	-0.204	3.73	3.42
Powder	1	chr.5h	M2197	0.411	10.44	16.53
Powder	1	chr.5h	M2197	0.434	19.9	14.82
	2	chr.6h	M0934	-0.216	6.4	7.16
Ryncho	1	link 1	O9A	0.565	30.75	31.29
Ryncho	1	link 1	O9A	0.513	34.58	25.79
Lodgin	1	chr.6h	S5a	0.242	3.7	5.0
Leaf	1	chr.1h	M2077	-0.189	6.3	3.4
	2	chr.6h	G6D	-0.189	7.4	6.1
SPAD,	1	chr.6h	O18	0.226	7.4	5.0
Leaf	1	chr.1h	O9b	-0.191	5.4	3.1
Leaf	1	chr.6h	G6B	0.195	6.0	3.7
Additional Cofactors identified						
C13	1	chr.5h	M0891	0.412	-	16.68
Tel	2	chr.1h	M2077	0.251	-	6.36
	3	chr.2h	M649c	-0.27	-	4.66
C13-	1	chr.2h	U7	-0.288	-	8.13
Tel	2	chr.5h	M0891	-0.286	-	8.08
	3	link1	O9A	-0.276	-	5.71
Spec.1	1	chr.5h	A1	0.244	-	5.84
Tel	2	chr.5h	M0891	0.223	-	6.64
	3	chr.7h	M0832	-0.221	-	5.82
Nitrog	1	chr.5h	M0533	0.373	-	13.67
Tel	2	chr.7h	M0832	0.291	-	11.76

of the variation of the trait. For many other agronomical and physiological characters the variation observed is relatively less than for the disease resistance genes. Therefore, QTLs or cofactors identified explaining only smaller proportion of the variation observed.

(V. Mohler, G. Backes, A. Jahhoor, G. Fischbeck, A. Sabbagh, S. Grando, S. Ceccarelli and M. Baum)

2.12. Virology

2.12.1. Evaluation of Best Performing Barley Genotypes from Previous Seasons

Re-evaluation of barley lines obtained from collaboration between ICARDA and Agriculture Canada at Sainte Foy and Laval University, Quebec, Canada, identified some barley entries which are good yielders and highly tolerant to BYDV as their yield was not affected by virus infection e.g. entries CAN-B-94-75, CAN-B-94-118 and BQ-94-28. Results obtained on the best performing entries are summarized in Table 2.34.

2.12.2. Evaluation of ICARDA Cereal Nurseries for their Reaction to BYDV Infection

Evaluation of 1446 lines from barley nurseries, on the basis of symptoms produced indicated that 81 lines (5.6%) were tolerant to infection (Table 2.35). The best performing lines will be evaluated next season on the basis of yield loss due to infection in addition to symptoms severity.

(K.M. Makkouk and W. Ghulam)

Table 2.34. Best performing barley lines after re-evaluation for their reaction to BYDV after artificial inoculation with the virus, on the basis of symptoms disease index, grain yield, and yield loss (%), during the 1995/96 growing season.

Entry	D.I.	G.WT (g)	Yield loss(%)
CAN-B-94-67	4	149.6	0.0
CAN-B-94-75	3	191.5	0.8
CAN-B-94-97	4	174.9	11.4
CAN-B-94-118	4	193.4	0.8
CAN-B-94-122(Susc)	7	54.3	60.4
BQ-94-28	2	192.1	0.0
BQ-94-30	2	172.1	16.1
BQ-94-30	2	193.4	8.1
BQ-94-61	2	169.0	8.7
Tadmor (landrace)	6	72.2	31.1

(CAN-B) = Barley lines developed at Agriculture Canada Laval University, Quebec, Canada.
(BQ-94) = Lines derived from the cross Tadmor (landrace) x Canadian - Quebec barley.

Table 2.35. Evaluation of barley germplasm for tolerance to BYDV resistance after artificial inoculation with the virus during the 1995/96 growing season.

Nursery	No. of lines tested	Lines with tolerance to infection[a]
BIT-1996 Trial 1	440	18, 30, 32, 34, 35, 40, 42, 45, 49, 55, 80, 153, 177, 226, 238, 255, 259, 288, 352, 356, 371
BIT-1996 Trial 2	440	96, 98, 135, 195, 201, 202, 203, 206, 227, 267, 282, 285, 288, 289, 291, 293, 295, 296, 297, 299, 307, 313, 315, 316, 334, 361, 385, 391, 392, 393, 416
IFBON-1996	144	29, 40, 46, 98, 111
IWBON-1996	144	88, 110, 116, 118, 120, 123
WBCB-1996	150	17, 22, 33, 62, 85
HBON-1996	80	38, 48, 53, 61, 64, 68, 70
IFBYT-1996	24	7, 17, 18
IWBYT-1996	24	5, 7, 17

[a] Numbers refer to ICARDA nursery serial number (e.g. 18 is 1 BIT-96-18).

2.13. Latin America Regional Program

2.13.1. Introduction

The development of improved barley germplasm in the Latin America Regional Program is oriented to the needs of the national programs in Latin America. The countries are divided into two groups: the Andean Region which includes Bolivia, Ecuador, Peru and Colombia, and a second group including Mexico, Argentina, Brazil, Chile and Uruguay. The first group has a with a large rural population utilizing barley for food, while in the second barley is mostly used for malt with a small area sown to barley for feed. Although barley production in the two groups of countries has different objectives, farmers' needs are similar, and both groups require disease resistant barley cultivars to avoid grain yield losses caused by pathogens that thrive in high rainfall environments.

The main diseases in the Andean Region are stripe rust caused by *Puccinia striiformis*, leaf rust caused by *P. hordei* and barley yellow dwarf (BYD). Diseases such as head scab (*Fusarium spp.*) are present on susceptible cultivars and symptom expression increases in rainy years. Head scab is more important in southern Colombia and in higher rainfall areas of central and northern Ecuador.

In the Southern Cone of South America, the main diseases are more diverse. Scald caused by Rynchosporium secalis and stripe rust are important in Chile, while net blotch caused by *Pyrenophora teres*, leaf rust and head scab are factors limiting barley production in Brazil and Uruguay.

In Mexico, stripe rust continues to be a problem in the central highlands. In the US, the disease has spread throughout the Pacific Northwest, reaching Oregon and Washington States in epiphytotic form in 1996. Mexican farmers control the disease with tolerant varieties that often need one fungicide application to achieve complete rust control.

Hull-less barley in Latin America is becoming more important. Five countries have released hull-less cultivars: Bolivia, Brazil, Chile, Ecuador and Peru. In North America, Canada is the leader in hull-less barley production, with a large area under cultivation. Within Canada, Alberta Province expanded hull-less barley cultivation to half a million hectares in 1996. In North and South America, the observed trend toward expanding the barley area will increase when high yielding hull-less cultivars with superior quality will be made available to farmers. Cooperation between the

ICARDA/CIMMYT barley program and two Canadian provinces, Alberta and Saskatchewan, will increase in the near future and will focus on searching for better quality hull-less barley.

Our 1988 annual report stated that after the development of resistant cultivars, new areas of research, such as crop management, seed multiplication and distribution, and industrial quality will become more important. In the present report the result of preliminary work conducted in southern Ecuador in collaboration with INIAP and 13 small farmers in a remote village (Saraguro) will be mentioned as the beginning of our involvement in areas other than traditional breeding.

Our interaction with advanced institutions in the developed world has increased. As a result of collaborative work with Oregon State University on marker assisted selection for stripe rust resistance, this resistance was successfully transferred into the susceptible cultivar Steptoe. Several genes were mapped and others are being mapped in different sets of doubled haploid populations. At the last meeting of the North American Barley Genome Mapping Project in October, it was decided that genes controlling resistance to *Fusarium* head scab in a set of doubled haploids from the Gobernadora/CMB643 cross should be mapped. The population was screened for head scab in Mexico and China in the last two years.

In 1996, invited papers were presented at the 7th International Barley Genetics Symposium held in Saskatoon, Canada, and at the 2nd Latin American Malting Barley Conference held in Temuco, Chile.

2.13.2. New Sources of Scab Resistance

The screening of barley germplasm for head scab is done at Toluca experiment station. After two years of screening, new sources of resistance have been identified and inoculation techniques have been improved.

There are three types of head scab resistance based on the following mechanisms:

Type I. Resistance to initial penetration by the fungus,

Type II. Resistance to the spread of hyphae within the spike.

Type III. Presence of toxin-degrading enzymes in resistant cultivars.

2.13.3. Screening for *Fusarium graminearum*

The 11 test cultivars included eight cultivars identified as resistant in 1995 and three cultivars with moderate to susceptible disease reactions. The experimental design used was a randomized complete block design (RCBD) with four replications and two planting dates. The number of spikes inoculated by aspersion (type I) per entry totaled 56 and 40 for spread within the spike (typeII).

Field screening for type I was conducted by spraying cultivars with a water suspension containing 50,000 *F. graminearum* spores, and for type II, by inserting a small cotton plug soaked in a spore suspension of similar concentration into the floret. Inoculated spikes were covered with glassine bag for 30 days until evaluation. Evaluation involved counting the number of infected kernels and the total number of kernels per spike. The resistant cultivar Gobernadora was used as check.

Several cultivars were identified as having head scab resistance similar to the check Gobernadora. For resistance type I, cultivars Shyri and Arupo/K8755//Mora had the highest percent of non infected kernels but these values were not different to those of Gobernadora (Table 2.36).

Only on genotype, Gob/Humai-10 (early), had 61.74% non infected grain, which is superior to Gobernadora (60.80%) for resistance type II (spreading). This could mean that by crossing two head scab resistant sources (Gobernadora with Humai-10), there was an slight improvement over Gobernadora's original resistance of both types I and II in two years screening. The other cultivars tested had values that were significantly lower than Gobernadora for percent of non infected kernels for type II resistance.

Table 2.36. Percent of non infected kernels of barley cultivars compared to Gobernadora, a head scab resistant check at Toluca, Mexico, inoculated with a 50,000-spore suspension of *Fusarium graminearum* during 1996.

Cultivar name	1996	
	Type I	Type II
Gobernadora/Humai-10 (early)	96.38	61.74**
Gobernadora	96.06	60.80
Shyri	97.26	60.59ns
Atahualpa	96.14	59.51**
Gobernadora/Humai-10 (Dwarf)	96.26	59.13**
Arupo/K8755//Mora	97.03	58.32**
CMB90.694-H-1B-3Y-1M-0Y		
Moderate Susceptible check (CMB643)	93.55	55.43

** P<0.01
ns non significant

There were some differences between 1995 and 1996 data. The cultivar Shyri was statistically different from Gobernadora in 1995 for resistance type II, which means that there was year x cultivar interaction. The degree of resistance varies according to the environment. In Toluca the 1995 rainfall was higher than in 1996. The resistance of Shyri and Gobernadora were differentiated under severe climatic conditions; in contrast, under relatively mild conditions (less rain) the differences between these cultivars are less clear. In any case, Shyri is an outstanding source of both types of resistance. Infected kernel samples (10 g) of Shyri were sent to the USDA laboratory for deoxynivalenol (DON) analysis, to determine whether type III resistance is present in the cultivar. Shyri is the most popular cultivar among farmers in Ecuador.

2.13.4. Doubled haploids from Gobernadora/CMB643

The doubled haploid (DH) set produced by the *bulbosum* method at Oregon State University in 1995 was tested against *F. graminearum* in 1995 and 1996 at Toluca experiment station in Mexico.

The 98 DH were sown in a RCBD with four replicates on two planting dates; the total number of replications was eight. The inoculation methods consisted of spraying the spikes with 50,000 spore concentration and inserting a cotton plug into one central floret for testing for type I and type II resistance, respectively. Evaluation was done 30 days after inoculation by counting the number of infected grain and total number of grains per spike.

DH lines carrying type I and type II resistance were found. The DH line 96 was ranked eight for type I and two for type II resistance, a pattern similar to that of the resistance parent Gobernadora (Table 2.37).

Data presented in Table 2.37 must be considered preliminary information, since resistance to penetration (type I) was determined in this population for the first time in 1996.

Resistance to both fungal penetration and spread within the spike (types I and II) was identified in DH-96, with resistance levels similar to those observed in Gobernadora. DH-24 and DH-82 had good type II resistance but were intermediate for type I resistance, and they ranked 54 and 28, respectively, in the Mexican test. Although no statistical analysis conducted on the Chinese data, the averages of two replications are presented. In general there was good agreement in the resistance at both locations, when top resistant lines were compared across locations (Table 2.38).

Table 2.37. Relative rank of seven doubled haploid lines and of their parents for type I fusarium head scab resistance (fungal penetration), type II resistance (hyphae spread), or a combination of both, at Toluca Experiment Station in 1996.

Cultivar	Type I	Type II
DH-12	3	10
DH-83	5	71
DH-96	8	2
DH-98	9	87
DH-16	14	3
DH-91	26	50
DH-82	28	5
DH-52	50	1
DH-24	54	8
DH-89	98	25
Gobernadora	1	6
CMB-643	45	5

Table 2.38. Percent of non infected kernels in doubled haploid lines as compared to Gobernadora (resistant check), screened for type II (spread) fusarium head scab resistance in Toluca, 1995 and 1996, and Shanghai, 1995-96.

Cultivar	1995 Mex	1996 Mex	1995-96 China
24	87*	93 ns	96
82	87*	93 ns	97
96	87*	95 ns	96
89	86	89 ns	93
91	85	86**	96
Gobernadora	93	93	97
29 Susceptible check	76*	76*	78

P<0.05; ns=Non Significant

Type I and II resistance are governed by different genetic mechanisms, and we suggest that a separate mapping must be done for each mechanism. Mexican and Chinese tests showed reversals in reactions in 1995; some Dhs were found to be resistant in Mexico but susceptible in China. These examples are better explained by close observation of the reaction to both types of resistance. DH-89 was identified as resistant (type II) in 1995 (Table 2.36 but was found susceptible in China. Additional screening for type I resistance in Mexico in 1996 revealed that DH-89 was extremely susceptible (Table 2.37).

2.13.5. Effect of Morphological Traits on Resistance to Head Scab

Spike morphology is thought to influence the mechanisms of resistance in barley. After screening 5,000 accessions from the world collection in Japan, Takeda and Heta (1989) found all resistant sources to be two-rowed barleys. Results in China and Mexico confirmed the hypothesis that two-rowed barley has better head scab resistance than six-rowed barley.

The Gobernadora/CMB643) DH set is a two-rowed population with marked differences in lateral glume size. This allows individual DH to be classified into five groups based on visual differences in the spike deficience(no lateral glumes), short, medium, large and very large.

The frequency distribution of head scab resistance and susceptibility in DHs has a normal distribution curve. A comparison between the 20 most resistant and the 20 most susceptible DH lines was done based on lateral glumes. The resistant DHs clustered into the deficient and short glume categories, while susceptible DHs clustered into the large and very large glume categories. The efficient and short categories were statistically different from the large and very large categories. The results presented in Figure 2.3 are a clear indication of how the environment influences disease expression. Deficient spikes or with short lateral glumes dry fast because they do not retain free water, compared to cultivars with a morphology that allows water retention. The practical application of these results in our breeding program will result in discarding plants with large to very large lateral glumes.

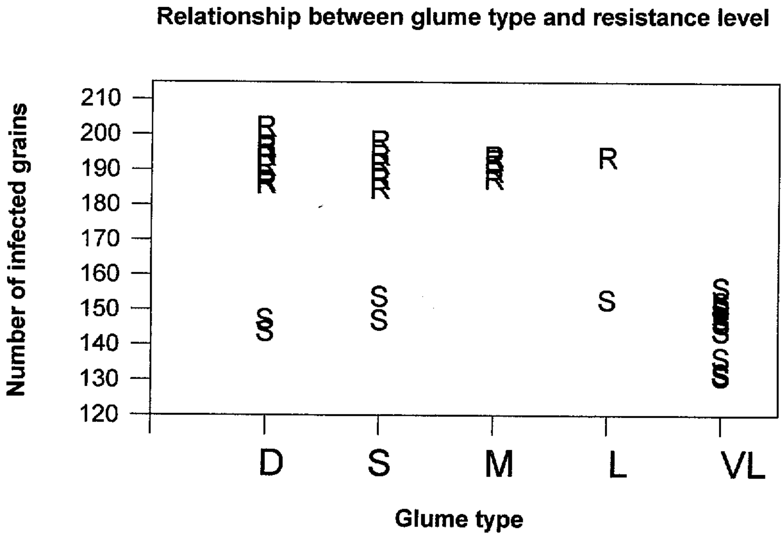


Fig. 2.3. Relationship between lateral glume size and head scab resistant DH lines, and the 20 most susceptible DH lines from the cross Gobernadora/CMB643 screened for *Fusarium graminearum* at Toluca, Mexico, in 1996.

Analysis of toxin content was done at North Dakota State University on grain samples of DH lines introduced to US from China. Information on DON is available for a few of these. Results of the analysis showed relative low values (2.8 ppm) for resistant DHs and high values (29.6 ppm) for susceptible DHs (Table 2.39).

The yield potential of head scab resistant DH lines was estimated using a RCB design with three replications under irrigated conditions in the Yaqui Valley in 1995-96. The highest yielding line (DH-91) had a grain yield of 5.8 t/ha and a relatively low DON content. DH-96 combines resistance to three diseases, stripe rust caused by *Puccinia striiformis* f.sp. *Hordei*/race 24, leaf rust caused by *P. Hordei*, and both types (I and I) of fusarium head scab. DON analysis was conducted only on 17 DH lines because of the high cost involved (US$25 per sample). DON content in the full set will be analyzed in 1997.

Table 2.39. Grain yield of head scab resistant DH lines from the cross Gobernadora/CMB643 in trials conducted at CIANO Experimental Station in 1995-96. Disease data was scored in Mexico (stripe rust and leaf rust) and toxin content deoxynivalenol (DON) was evaluated in the US.

Cultivar	Yield (t/ha)	Stripe	rust[a]	Leaf	rust[a]	DON ppm[b]
DH-91	5.8	40	MS	80	MS	4.9
DH-96	5.2		TMS		R	
DH-24	4.3	20	S	80	MS	7.0
DH-82	4.9	90	S	95	S	
DH-89	4.6	40	MS		R	
Governadora	-	90	S	70	S	7.6
DH-29 Susc. Check	-	9	0s	100	s	29.6

[a] The modified Cobb scale was used to score stripe rust in Toluca and leaf rust in CIANO. MS=moderately susceptible; S=susceptible.

[b] DON content determined in NDSU from heavily inoculated plots in Shanghai, China. The lowest DON content was 2.8 ppm, for DH-54.

In 1996-97, 59 F_5 resistant to head scab lines were sent to China for screening against *Fusarium*. Included in this group were 12 F_5 lines originating from a cross between two sources of head scab resistance, Atahualpa and Gobernadora.

Preliminary results in Toluca with these lines indicate the progress which was made by improving the disease level of either parent. If the resistance observed in Mexico is confirmed in China, the lines will be chosen as parents for crossing to scab resistant sources other than Gobernadora and Atahualpa.

2.13.6. Barley Yellow Dwarf

In 1996, research on barley yellow dwarf (BYD)aimed to characterize accessions for their individual reaction to three BYD biotypes: MAV, PAV, and RPV. Artificial inoculation with greenhouse reared aphids was done under field conditions in Toluca, Mexico. The work was done on the following populations:

1. A population of 100 doubled haploids from the cross Shyri/Galena
2. High yielding genotypes screened for BYD for the first time
3. Sources of BYD resistance used in the program.

The DH population was sown in two replications on different planting dates. Each entry had four individual plots inoculated with three biotypes in isolation. The fourth plot was the check, kept free from aphids by frequent insecticide application.

The 100 DH lines from Shyri/Galena were susceptible to PAV and RPV in two years (1995 and 1996) of test. The population segregated 48 MAV resistant and 52 MAV susceptible DHs, a 1:1 ratio that indicates that resistance is governed by one gene. The gene conferring MAV resistance in Shyri is different from the *Yd2* gene, since *Yd2* present in Atals 57 was included in the trial and provided resistance against all biotypes (MAV, PAV and RPV). The resistance gene in Shyri is being mapped in cooperation with Oregon State University as part of a PhD thesis.

The second population allowed the identification of BYD resistance in cultivars already known for their high yield potential and resistance to other disease such as stripe rust, leaf rust and scald.

Four hull-less barley cultivars and their reaction to three BYD biotypes and to leaf and stripe rust are presented in Table 2.40. Tow Petunia-1 sister lines, resistant to the three BYD biotypes, inherited the *Yd2* gene from their resistant parent CM-67 (California Mariout).

Table 2.40. Yield and disease reaction of four hull-less cultivars to leaf rust, stripe rust, and three BYDV biotypes (MAV, PAV, and RPV) under artificial field inoculation with greenhouse reared aphids in Toluca, Mexico, 1996.

Hull-less cultivar	MAV	PAV	RPV	Yield T/ha	Leaf rust	Stripe Rust
Petunia-I CMB93-855-G-15Y-1M-0Y	R	R	R	5.5	R	R
Petunia-1 CMB93.855-G-14Y-2M-0Y	R	R	R	6.2	R	R
Petunia-1 CMB93.855-C-IY-15M-0YRabano/Falcon/3/Agave	R	S	S	6.1	R	R
/Cin//Zarza CMB93.784-E-4Y-1M-0Y	R	S	S	6.3	R	R

The *Yd2* gene provided resistance to MAV, PAV, and RPV in the Mexican trial.

Yield and disease reactions of four covered cultivars are presented in Table 2.41. Data was obtained from trials similar to those described for the hull-less cultivars. Grain yield appears to be somewhat higher than yield of the hull-less types, but it should be noted that the highest yielding hull-less cultivar was not included in the table due to its BYD susceptibility.

High yielding covered cultivars also resistant to the three BYD biotypes have not been found so far. This suggests that resistance incorporated in these cultivars is different fro that conferred by the *Yd2* gene. The MAV resistant barley line Post//Gloria/Come has the winter cultivar Post as a parent[7] and carried a gene different from *Yd2*. The Latin America barley program aims to diversify the BYD resistance by gradually accumulating genes conferring resistance to different biotypes.

Traditional sources of BYD resistance in the program were sorted out according to their reactions to MAV, PAV and RPV under Mexican conditions. This information could help focus the crossing program toward deploying barley resistance sources based on the presence or absence of a particular biotype in a region. Webby et al.[8] published the results of a world survey where different biotypes and their frequency in many countries are described.

Breeding for scab and BYD resistance is a more complex operation than we visualized when the work started in 1982. Both diseases need to be looked at in more detail, and perhaps the breeding should focus on resistance components such as types I, II and III in head scab and five different BYD biotypes.

Another interesting observation is the lack of protection against BYD observed in winter lines. For example, seed treatment with the insecticide Gaucho (Bayer) failed to prevent BYD symposiums in plants sown at Toluca in 1996. The product is effective when used as a seed treatment against the Russian wheat aphid on small grain cereals.

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7 Grafton, K.F., Poehlman, J.M., Sechler, D.T., and Sehagi, O.P. (1982). Effect of barley yellow dwarf virus infection on winter survival and other agronomic traits in barley. Crop Science 22: 596-600.

8 Webby, G.N., Lister, R.M., and Burnett, P.A. (1993). The occurrence of barley yellow dwarf virus in CIMMYT bread nurseries and associated cereal crops during 1988-1990. Annals of Applied Biology 123, 63-74.

Table 2.41. Yield and diseases reaction of four covered cultivars to scald, leaf rust, stripe rust, and three BYD biotypes (MAV, PAV, RPV) under artificial field inoculation with greenhouse reared aphids at Toluca, Mexico, 1996.

Covered cultivar	MAV	PAV	RPV	Yield t/ha	Leaf Rust	Stripe Rust	Scald
Quina//Cel/CI3909.2 CMB92A.83-1M-1Y-1B-0Y	R	S	R	7.4	TR	R	MS
Silo/Robust//Quina CMB92A-C-2M-2Y-1B-0Y	R	S	R	7.3	TR	MS	-
Post/Copal//Gloria/Come CMB85A.916-I-2M-1Y-1M-0Y	R	S	S	-	TR	S	TR
Capa/3/Api/Cm67//Mzq/4/CI14032/ 5/Esperanza/6/Quina CMB92A.1426-B-3M-1Y-2B-0Y	S	S	R	7.8	R	MR	MS

The *Yrd2* gene provided MAV, PAV and RPV resistance in the Mexican trial.

2.13.7. The Crossing Program

There are two main crossing programs: winter x spring and spring x spring. Winter x spring crosses are conducted in Toluca in the winter time, when temperatures are low enough to allow natural vernalization of winter cultivars. Spring x spring crosses are done at tow locations, CIANO and Toluca. In 1996, the total number of crosses made were 851 spring x spring and 72 spring x winter.

Breeding for multiple disease resistance started by building templates by combining resistance to scald and to leaf rust in 1982. Once lines resistant to both diseases were developed, they were used in crosses aimed at incorporating an additional resistance (stripe rust) and so on. In 1996, the aim was to combine together resistance against eight diseases: leaf rust, stripe rust, stem rust, scald, BYD, net blotch, spot blotch and head scab.

High yielding spring cultivars with multiple disease resistance were identified from ICARDA/CIMMYT germplasm by national programs and released as commercial cultivars. The National Agrarian University in Peru released UNA-94, a line which yielded 11 t/ha in a relatively small area used for seed increase[9]. The hull-less cultivar Falcon yielded 8.5 t/ha, the all-time record for hull-less cultivars in farmers's field in Canada. We feel the need to make a greater number of crosses per year, to get these unique combinations that will allow further improvement.

Results of five yield trials (harvested before the hail storm that destroyed most yield trials in 1996) are presented for three different categories: early maturing barley, hooded barley for hay and grain, and normally maturing covered barley.

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9 UNA La Molina-94. (1995). Nueva Variedad de cebada. La Molima, Lima, Peru, Boletin.

2.13.8. Early Maturity Barley

Early maturity cultivars have been released in several countries: Australia, US, Kenya, Vietnam, and Chine. More recently, a relatively large number of early maturing genotypes was sent to North Korea to be tested for use as a catch crop during the short period of time the land remains idle.

The grain yields of the top five early maturing barley liens, tested in a lattice design 8x8 with two replications, are presented in Table 2.42. The highest yield observed was 5 t/ha for the cultivar Macro/Fragile//Matnan/EH 165/3/Cardo.

Table 2.42. Yield and disease resistance of the top five early maturing cultivars in yield trials conducted at El Batan, Mexico, 1996.

Cultivar name	Yield t/ha	Leaf Rust	Stripe Rust
Marco/Fragile//Matnan/EH165/3/Cardo	5.0	R	R
Hlla/Gob/Hlla/Aleli/4/CI5791/Cal607//Shyri	4.9	R	R
Hlla/Gob/Hlla/Aleli/4/CI5791/Cal607//Shyri	4.8	R	R
Escoba/Maradilla/Mora	4.8	R	R
Maris/Canon/4/Zhhedar-2/3/Hlla/Gob/Hlla/Gob/Hlla/5/Aleli	4.8	R	R

2.13.9. Forage Barley

The hooded trait was introduced into early maturing types for planting in association with grasses: barley-medic or barley-rye grass. Demonstration trials were conducted on farmer's fields in the Yaqui Valley, Sonora, and Apan, Hidalgo.

Typically, the flowering time for barley was 45 days. Cattle or sheep grazed the barley for short periods (mob grazing). Grazing by many animals resulted in less competition for light and nutrients for the rye grass or medic. As a result of several years of trials, the grazing period was lengthened and total biomass increased. More importantly, pasture was made available at a critical time, when there was a feed shortage.

Ranchers who had experience with short barley used for grazing purposes felt that a relatively small amount of dry matter was produced and plants became too short during the growing season, when there was relatively low rainfall. Tall hooded barley for hay production were developed and tested at the experiment station and under farmers' conditions in Apan. The hooded lines are resistant to stripe rust, leaf rust, and scald to insure high forage quality.

Dry matter production in hooded barley was similar to that of oats, but was obtained in a shorter period of time (Table 2.43). Grain yield is not an objective, but for seed producers the amount and quality of the grain is an important consideration. For this reason, additional information for grain was obtained. Lines with a yield potential 5.6 t/ha were identified.

Table 2.43. Dry matter production of hooded barley cut the dough stage in a farmer's field in Chimaplpa (Apan) and at CIANO Experiment Station in northwestern Mexico, 1995 and 1996.

Cultivar name	Days to cut	Dry matter t/ha	
		Chimalpaa	CIANO
Macro/Fragile	45	5.3	3.2
CC-51	63	10.0	11.1
CC-132	72	9.2	12.2
OATS check	90	-	7.6

Yield of barley lines in three harvested experiments allowed the identification of five cultivars with yields between 7.5 and 8.1 t/ha, similar to the high yielding cultivar Tocte used as check.

Table 2.44. Grain yield of four barley cultivars at El Batan experiment station during 1996.

Cultivar name	GRAIN YIELD T/HA
Tocte (check)	8.5
Minn Desc-3/4/Gloria/Come//Lignee604/3/ S.P/5/Quina	8.1
Gloria/Copal//Shyri/Dc/3/Aloe/Rue	8.0
Escoba/Tocte	7.5
Arrayan/Robust/4/L.B.Iran/UNA80/Lignee640/3/ Gloria/Come	7.5
Aliso/Karan/Tocte	7.5

2.13.10. International Cooperation

The following nurseries were planted in the Toluca and CIANO Experiment Stations, Mexico, for disease evaluation.

Winter DH from Oregon State University
Colter/Kold stripe rust screening

2.13.10.1. Spring DH from Oregon

Populations	No sowing dates	Disease screening
Shyri/Galena	2	BYD
Shyri/Galena	3	Stripe rust
Shyri/Galena	3	Net blotch
Shyri/Galena	3	Scald
CI10587/Galena	1	Stripe rust

Harrington BC	1	Stripe rust
Steptoe conversions	2	Stripe rust
Colter conversions	2	Stripe rust
Gobernadora/CMB643	2	Head scab
Gobernadora/CMB643	3	Stripe rust
Gobernadora/CMB643	3	Leaf rust

Accessions from Colorado University
One planting date for stripe rust evaluation

2.13.10.2. Seed production in Ecuador

Jorge Coronel from the National Research Institute (INIAP) in southern Ecuador continues to work on a program aimed at producting barley seed of the two cultivars Atahualpa and Shyri in farmers' fields. In 1996, 13 farmers in a remote village received loans of certified seed, fertilizer and herbicide. Farmers harvested yields of 2.1 to 4.5 t/ha, a three- to six-fold increase over the national average. Twelve of thirteen farmers rapid the loan after harvest and will become part of the 107 families willing to participate in this program in 1997. Funds from ICARDA, CIMMYT, Oregon State University and Colorado State University, made available to the Latin America barley program, are used to finance the purchase of seed, equipment, and inputs required for the national program.

3. DURUM IMPROVEMENT

3.1. Durum Breeding

The largest durum growing countries in WANA region are Turkey, Morocco, Algeria, and Syria. In the Middle East, particularly in Turkey and Jordan, most of the durum growing areas (over 70%) are located in the dryland with less than 350 mm. Whereas, in the Maghreb region, most of the durum growing areas (over 70%) are located in the favorable environments (more than 350 mm). Countries with less than 30% of the durum areas in the low rainfall areas with less than 350 mm are Lebanon, Algeria, and Morocco. However, countries with large irrigated areas are Egypt, Lebanon, Syria, Libya, and Morocco. The countries with the highest proportion of durum dryland were those that have released the newly developed durum cultivars with drought resistance such as Korifla and Omrabi5. These data also indicate the future emphasis on collaboration with NARSs in dryland research. The CIMMYT/ICARDA durum program will continue to work with NARSs on abiotic stress, particularly on drought resistance. However, the collaboration will be more targeted to the main agro-ecological zones (continental, temperate, and high altitude areas). Concerning the strategy for breeding and screening, in the Middle East region the focus will be on drought resistance research and temperature extremes; whereas in the Atlas countries on the biotic stresses (diseases and insects). The development of genetic stocks of resistance to the different constraints will continue to get high priority. The research for drought resistance will continue to be given the highest priority, followed by terminal stress and cold, for basic understanding of resistance mechanisms and development of genetic stocks. Whereas the research for biotic stresses will be mainly made to continue broadening the genetic base for resistance to diseases and insects of the genetic stocks.

Table 3.1. Durum area, % of total wheat area, and production conditions in WANA.

Country	Area (M.ha)	Area (%) total wheat	Production conditions (%)		
			<350mm	>350mm	irr.
Turkey	2.5	25	80	20	-
Syria	1.3	85	30	60	10
Jordan	0.08	95	60	40	-
Lebanon	0.02	45	20	50	30
Cyprus	0.004	70	-	100	-
Egypt	0.02	3	-	-	100
Lybia	0.1	50	40	50	10
Tunisia	0.7	90	30	70	-
Algeria	1.3	70	25	75	-
Morocco	1.3	65	20	75	5

CIMMYT/ICARDA: M.M. Nachit, A. Belaid, M. Azrak, A. Asbati, N. Rbeiz, Z. Younes.

3.2.1. Widening the Genetic Base

The crosses with the wild relatives showed under cold and hot environments different selection pressure for the different crosses (Table 3.2). In the winter cycle (cold environment) the most selected crosses derived from durum x T. dicoccum, durum x T. carthlicum, and durum x T. dicoccoides. Whereas in the summer cycle (hot environment), the most selected crosses derived from durum x Aegilops Spp. and durum x T. monococcum. Further, studies on abiotic and biotic stresses and quality traits are under progress. In addition, the studies on quality traits of *T. dicoccoides* in two genome mapping populations are initiated.

Table 3.2. Selection (%) for Resistance to Biotic and Abiotic Stresses in Durum x Wild Relatives Crosses.

Durum X Species	Winter	Summer
	YR, ST, WSSF, C, D	LR, SR, H
Aegilops Spp.	40.5%	63.0%
T. monococcum	31.2%	55.0%
T. dicoccoides	57.9%	38.5%
T. dicoccum	81.0%	32.0%
T. carthlicum	62.1%	32.0%
T. polonicum	20.3%	33.3%
T. araraticum	15.7%	25.0%
T.persicum (carthlicum)	39.3%	12.5%

YR= yellow rust, ST= Septoria tritici, WSSF= Wheat stem sawfly, C= cold, D= drought, LR= leaf rust, SR= stem rust, H= heat.

CIMMYT/ICARDA: M.M. Nachit, M. Azrak, A. Asbati, N. Rbeiz, Z. Younes.

3.2.2. Biotic Stress Research

Concerning the resistance to powdery mildew, the Atlas countries durum landraces collection was screened for powdery mildew resistance, a genetic stock for resistance to powdery mildew was assembled (Table 3.3). This genetic stock used in 1995 and 1996 cycles in the crossing program to upgrade the resistance of the durum drought resistant genotypes. The derived crosses are now in F2 and F4 generations. Further, in the mapping population JK/Chm1, chromosomal location of resistance for powdery mildew is planned during 1997/98 studies.

Further, the genetic stock of resistance to biotic stresses for the Continental Mediterranean Dryland shows the progress made in combining resistance to yellow rust and common bunt, and incorporating these resistance in advanced dryland genotypes (Table 3.4). The progress made in yellow rust resistance is reflected in the high scores of resistance incorporated in the advanced test lines: 62.7% of all lines included in the ADYT had less than 5% ACI for yellow rust.

Table 3.3. Powdery Mildew resistant durum cultivars.

Cultivars	Origin
ICDW 7196-MAR	Morocco
ICDW 7199-MAR	Morocco
ICDW 9535-MAR	Morocco
ICDW 10329-MAR	Morocco
ICDW 6835 Biskri Glabre AC 2	Algeria
ICDW 6837 Biskri Glabre AP 2	Algeria
ICDW 7020 Mahmoudi	Tunisia
ICDW 9795 BD 1548	Tunisia
ICDW 6856 Jennah Khetifa Ap4	Tunisia

As for common bunt, 12.9% of the test lines had less than 5% infection; the resistant check Haurani had 4.5%. Lines with nil infection were also identified, these lines were derived from the crosses with *T. Dicoccoides* (Brachoua/T.dicoccoides20017//Haucan and Omrabi/Omguer4, and Zeina lines).

Table 3.4. Reaction of Advanced Durum Lines to Yellow Rust and Common Bunt.

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

* ACI = Average Coefficient of Infection.

In the Continental Mediterranean dryland, combined resistance to common bunt and yellow is required. Several advanced durum genotypes were developed with nil 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 aims 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 high level of resistance (Table 3.5). All these genotypes surpass in resistance the resistant landrace Haurani. Further, solid stem resistance was also identified in the Moroccan landraces. These landraces are used extensively in the crossing program.

Table 3.5. Resistant Durum Lines to Common bunt(CB) and Yellow Rust (YR). 1995/96.

ADYT-Entry	CB infection (%)	YR reaction (ACI)
212 Heican	0.0	5.0
220 Brach/T.dicoccoides20017// Haucan	0.0	1.5
613 GdoVZ/Cit//Ruff/Fg /3/Ente/Mario//Cando	0.0	3.5
1108 Zeina-3	0.0	4.5
1110 Zeina-2	0.0	4.5
1113 Zeina-4	0.0	2.5
Haurani (CB resistant check)	4.5	54.0
Cham-1 (YR resistant check)	51.3	3.5

*ACI= Average Coefficient of Infection (0-100%)

Table 3.6. Resistant durum genotypes to Sawfly.

Cross	Pedigree	Infection (%)
Awal2/Bit	ICD84-0322-ABL-7AP-TR-AP-21AP-OTR	0.27
Ru/Mrb 15	ICD84-1257-8AP-OTR	0.55
Awalbit-6	ICB84-0322-ABL-5AP-TR-AP-151AP-OTR	0.63
Mrb11//Snipe/Magh	ICD85-0538-ABL-TR-9AP-OTR	0.83
Bit/Creso	ICD84-34346-2TR-2AP-1AP-0AP	0.83
Marrout	ICD84-52612-7AP-4AP-0AP	0.83
D-2/Bit	ICD84-20796-4AP-6AP-2AP-0AP	1.11
IC19939 (Moroccan landrace)		1.69
Rufom-4	ICD84-1257-14AP-TR-13AP-0TR	2.22
Heider//Mt/Ho	ICD86-0414-ABL-TR-2AP-TR-10AP	4.12
IC16143 (Moroccan landrace, solid stem)		4.44
Haurani		11.75

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 resistance was made with the cross SD8036/Omtel1//Awalbit (Table 3.7). From this cross, three lines were identified with resistance above 80%. Further, under dry and terminal stress conditions, their grain yields surpassed Cham1 and Stork checks by more than 30%. The cross was conducted in 1991 and selection for resistance was made under field and lab 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

(Set= Settat, INRA-Morocco).

Table 3.7. Durum advanced genotypes combining Hessian fly resistance with heat and drought tolerance, 1995/96.

Pedigree	Resistance (%)	Grain Yield
35) SD8036/Omtel 1//Awalbit 3* ICD91-0558-AB-2AP-0AP-2AP-0AP-2AP	81	1770
47) SD8036/Omtel 1//Awalbit 3** ICD91-0558-AB-2AP-0AP-7AP-0AP-2AP	94	1866
48) SD8036/Omtel 1//Awalbit 3*** ICD91-0558-AB-2AP-0AP-2AP-0AP-3AP	91	1805
Cham 1	0	1377
Stork	0	1293
LSD (0.05)	-	448

* Telset 1; ** Telset 2; *** Telset 3

The biotic stresses of the Temperate Dry Areas of WANA showed during the last decade, a progress in incorporating and combining resistance to leaf rust and septoria tritici (Table 3.8). Durum advanced genotypes originated from the CIMMYT/ICARDA show now high levels of resistance to these diseases. These sources of resistance for both diseases (leaf rust and *Septoria tritici*) are effective to leaf rust races in WANA and Mexico. These sources of resistance are: Bicre/Guerrou, Cham1/Brachoua, Outrob, Stj/Mrb3, and DL95. Further, the genotypes Outrob4 and Outrob2 combine leaf rust resistance with *Septoria tritici* resistance, 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 for *Septoria tritici* of 7.8; Cham1 of 35.7 and 8; and Cham3 of 43.0 and 7.8, respectively. The test lines which equaled or were less than 5% represented 8% of the total ADYT-lines. As for the Septoria tritici resistance with equal or less score than 5%, the percentage was 3.3%. It was shown above when considering the performance of the checks, the *Septoria tritici* was very severe in the screening site during 1996. Yet, several lines could be identified with high scores for *Septoria tritici* resistance. This is encouraging, as all commercial varieties grown in the WANA region are susceptible to septoria tritici, however, *Septoria tritici* is limited to the high-rainfall of the temperate areas of the Atlas region.

Table 3.8. Reaction of advanced durum lines of 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
*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

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

CIMMYT/ICARDA: M.M. Nachit, O. Mamluk, M. El-Bouhssini, M. Azrak, A. Asbati, N. Rbeiz, Z. Younes.

3.2.3. Drought Research

Relationship of RFLP markers with drought tolerance traits
Heritability of a the phenotype of a molecular marker is 1.0, i.e, genotype equals phenotype. The use of molecular markers as indirect selection criteria for traits associated with drought tolerance is under study (Table 3.9). The direct selection for a molecular marker loci is expected to result in a correlated response by increasing the frequency of favorable alleles associated with stress tolerance. Several traits showed relationship with RFLP markers. In our studies,

dryland productivity and several traits related with drought resistance were found to be associated with molecular markers located the short arms of chromosomes 2; these traits include a.m. leaf rolling, canopy temperature, leaf color, waxiness, apex development, leaf water potential, early vigor, chlorophyll b and fertile tillering ability under water stress.

Table 3.9. Relationship of Grain yield and morpho-physiological traits with RFLP markers under drought conditions, Breda, 1995/96

Trait	Markers
Grain yield	KSUH4/26a, CDO10902i, KSUG48/8e, MWG733/9n, BCD347/45c, MWG733/10n,
Δ(‰)	KSUH4/26a, CDO347/43d, BCD348 BCD347/45c, CDO482m, BCD873, WG380
Photosynthesis	KSUH4/26a, BCD348/27m, BCD347/45c
Plant Performance Index	KSUH4/26a, BCD347/45c
Fertile tillers	BCD200/14f, BCD347/45c
Spike fertility	CDO1090/2i,2j; MWG733/9,MWG733/10n
1000 kernel weight	MWG733/9n,MWG733/10n
Peduncle length	MWG733/10h,MWG733/10n
Early growth vigor	WG996/4a,KSUG48/8b

In another extended study conducted with 144 durum genotypes, we found that some molecular markers are highly associated with several characters, such as grain yield under moisture deficit, photosynthesis, carbon isotope discrimination. Also, it is of interest to note that grain yield showed strong associations with several molecular markers. In fact, most the molecular markers which associated with the other traits, particularly the carbon isotopic discrimination, the photosynthesis, and the plant performance index were also associated with grain yield. In addition, several markers which were associated, are also associated with the performance of the yield components, early growth vigor, and peduncle length. These results demonstrate clearly that molecular markers studies, are useful tools that can be used in the drought resistance breeding. The advantage of the molecular markers technique is once a marker is identified as desirable, it could screened for with 100% precision, as it is heritability is 1. However, because of environmental variation, its contribution to yield will undoubtedly vary from site to site and season to season.

Further, concerning the genetic gain made in the Mediterranean dryland (280 mm), the accumulated results over 10 years (Table 3.10) showed that the average annual grain yield increase due to breeding over the local variety Haurani was 50 kg per annum, i.e. 500 kg over 10 years (40% increase over Haurani). Whereas the average annual maximum increase is 136 kg per annum, i.e. 1360 over 10 years (110% increase over Haurani)

Table 3.10. Performance (kg/ha) of Durum at Breda during the last 10 years, compared with the check Haurani.

Season	Rainfall (mm)	ADYT Entries		Haurani
		Min.	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
Mean	284	1735	2595	1235

As for the morphophysiology that was effective under the dryland conditions of 1995/96, the spike fertility (number of fertile spikelets and florets) showed the highest values in explaining yields (Table 3.11). In addition, the carbon isotopic discrimination (Δ‰) and the relative water content (RWC) showed also strong relationship with grain yields in dryland.

Table 3.11. Association of morpho-physiological traits with dryland yields

Traits	Contribution (%)
Spike fertility	42.4
Δ‰	8.3
RWC	7.8
Fertile tillering	3.5
Kernel size	2.9
Fluorescence parameters:	
- T1/2	0.5
- Fo	0.3
- Fm	0.4
- Fv	0.3

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3.2.4. Grain Quality

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

The *T. dicoccoides* is highly variable for HMW glutenin subunits encoded at the *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.

3.2.4.2. LMW-1 and LMW-2 in advanced durum material

In the breeding advanced material, more than 90% of the total lines included in the advanced trials targeted to the Mediterranean continental areas show strong gluten content (Table 3.12). 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 developed at ICARDA. Further, the use of PCR-markers

Table 3.12. Frequency (%) of DNA LMW 1/LMW 2 in the durum advance lines targeted to Mediterranean Continental Areas (MCA), 1993/94, 1994/95, and 1995/96.

Glutenin type	ADYT-MCA		
	1994	1995	1996
LMW 1	9.2	6.8	8.6
LMW 2	90.8	90.7	90.6
LMW 1/LMW2	0.0	2.5	0.8

As for the Mediterranean temperate dryland, the results showed that the genetic progress made during the last 3 years to improve gluten strength in the durum material targeted to temperate dryland (Table 3.13). The good grain quality, LMW-2, is has been from 69 to almost 90%. These results demonstrate the genetic progress made in grain quality.

Table 3.13. Frequency (%) of DNA LMW 1/LMW 2 in the durum advanced lines targeted to Mediterranean Temperate Areas (MTA), 1993/94, 1994/95, and 1995/96.

Glutenin type	ADYT-MCA		
	1994	1995	1996
LMW 1	30.8	20.8	9.1
LMW 2	69.3	79.2	89.8
LMW 1/LMW2	0.0	0.0	1.1

Tables 3.14 and 3.15 show the grain quality traits for the advanced durum yield trials for continental (ADYT-C) and for temperate (ADYT-T) Mediterranean dryland. The highest values for protein content and sedimentation test were achieved under late planting conditions and the lowest under rainfed and Early Planting conditions. Breda has also showed relatively high values. The largest range for quality traits was also found in the rainfed conditions. Therefore, the rainfed conditions are more adequate to use as selection site for durum grain quality.

Table 3.14. Minimum, maximum, and mean of some quality for ADYT-C in different environments:

Statistics	Protein	SDS	SDSi	SDSni	Vitereous-ness	Yellow pigment	TKW	Ash
1) Breda								
Min	10.46	27.43	2.21	2.89	82	2.41	22.1	1.71
Max	17.81	53.18	3.43	8.82	100	8.31	37.1	2.2
Mean	14.21	40.4	2.84	5.81	98.3	5.35	28.21	1.89
2) Rainfed								
Min	8.20	14	1.6	1.2	12	1.3	25.4	1.57
Max	16.5	46	2.9	7.3	100	7.3	51.0	2.18
Mean	10.32	23	2.2	2.4	74.1	4.3	39.4	2.0
3) Late-Planting								
Min	13	35	2	5	78	2	24	2
Max	18	56	3	10	100	7	40	2
Mean	15.4	44.5	2.9	6.9	99	4.8	31.2	2.1
4) Early Planting								
Min	9	16	1.69	1.55	31	1.1	25.2	1.61
Max	15.4	42	3.07	5.75	100	6.2	52.4	2.07
Mean	11.8	28.05	2.36	3.37	85.8	4.9	40.45	1.88

Table 3.15. Minimum, maximum, and mean of some quality for ADYT-T in different environments: in different environments:

Statistics	Protein	SDS	SDSi	SDSni	Viter-eousness	Yellow pigment	TKW	Ash
1) Breda								
Min	9.28	19.63	2.12	1.82	39.00	2.92	21.60	1.64
Max	17.24	58.32	3.41	10.05	100	8.46	39.30	2.07
Mean	11.68	32.86	2.81	3.89	93.52	5.61	30.42	1.81
2) Rainfed								
Min	7.80	9.00	1.12	0.74	3	2.1	29.90	1.55
Max	15.60	43.00	2.97	6.73	100	9.90	53.80	2.04
Mean	9.86	20.87	2.09	2.14	61.86	4.21	41.55	1.76
3) Late-Planting								
Min	13	34	2	4	92	3	23	2
Max	18	53	3	10	100	7	41	2
Mean	14.80	42.62	2.88	6.34	99.23	4.63	31.91	2.04
4) Early Planting								
Min	9	16	1.69	1.55	31	1.10	25.2	1.61
Max	15.4	42	3.07	5.75	100	6.20	52.4	2.07
Mean	11.81	28.05	2.36	3.37	85.85	4.01	40.45	1.88

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3.2.5. Yield Stability

Twenty sites were used to analyze the relative stability of the DYT-CA (Table 3.16). The average grain yield was 4529 kg/ha. The site maximum yield was 8944 kg/ha and it was achieved at Sids in Egypt, while the site minimum yield was 1048 kg/ha and it was attained in Late Planting conditions at

Tel Hadya in Syria. For the Temperate Areas, Cham1 shows a high yield stability in this environment. Omrabi6, Omrabi5, and Boy/Yav//PI also showed promising results for yield stability. Further, these cultivars are also showing more yield stability than the national checks. It is of interest to notice that these genotypes showed similar results in the high altitude areas (see results for stability in the high altitude section). These results are a clear indication that durum germplasm with wide adaptation and multiple resistance to abiotic and biotic stresses can be generated. This material will be more adapted to the areas with erratic and fluctuable climatic conditions. Although this material is difficult to generate, the CIMMYT/ICARDA durum breeding program will continue to upgrade and pyramid the stress resistances, in order to produce durum genotypes with less environmental sensitivities.

Table 3.16. Stability of Grain Yield (kg/ha) of Improved Stress Tolerant Durum Genotypes, Mediterranean Continental Dryland Areas, 1996.

			Relative Stability of	
No.	Cross/Genotype	Mean Yield	Waha	National Check
18	Heider//Ch67//Cando	3206	172	180
20	Ombar6	3091	142	149
4	Omrabi3	3208	140	147
22	Massaral	3076	122	128
17	H.Mouline/Chahba88	3119	121	126
6	Sebah	3072	115	120

MDMYL = Mean of Difference from maximum highest yielder at each Location divided by location mean. Relative stability(%) = (MDMYL of Check Entry/MDMYL of Test Entry) x 100.

In contrast to the yield stability of the genetic stock for the Mediterranean Continental Dryland (Table 3.17), few lines showed better yield stability than Waha (Cham1) in the temperate dryland. The stability in the temperate requires specific traits, such as combined drought tolerance with root rot and Hessian fly resistance. The results also indicate that the genetic improvement of durum is relatively slower than for the continental areas. This is mainly due to the fact that the breeding for temperate dryland was given less emphasis (30% in time and effort), compared to the 60% for the continental dryland during the period 1983-1993.

Table 3.17. Stability of Grain Yield of Improved Stress Tolerant Durum Genotypes, Mediterranean Temperate Dryland Areas, 1996.

No.	Cross/Genotype	Mean Yield (Rank)	Relative Stability of Waha	Relative Stability of National Check
19	Chahba 88/Deraa ICD89-0664-ABL--6AP-0AP	5476 (1)	102.4	135.8
18	Chahba 88/Deraa ICD89-0664-ABL--4AP-0AP	5365 (2)	91.0	120.7
6	Omrabi 6	5131 (5)	86.2	114.3

MDMYL = Mean of Difference from maximum highest yielder at each Location divided by location mean. Relative stability(%) = (MDMYL of Check Entry/MDMYL of Test Entry) x 100.

In contrast, although the durum breeding for the High Altitude Areas is a recent development, several lines carrying cold resistance and originating from crosses targeted to the Mediterranean Continental Areas were included in the nurseries and trials of High Altitude areas. Table 18 shows the productivity and stability of these cultivars in comparison to Cham1, Cakmak, and Kunduru. These genotypes had exceeded in productivity and stability all included checks in the high altitude trials. Omrabi6 is released for the Atlas mountains of Morocco, whereas Omrabi

5 is released in Turkey, Iraq, and Iran. These cultivars also show the hardening effect when the low temperature gradually are lowering. This effect is important in the cold areas of WANA. However, there are genotypes, such as Awalbit9, that are also resistant to abrupt disease in temperature. The results in different trials show that several durum genotypes are performing very well in different agro-ecological environments. This indicates that a high level of combining traits of productivity and adaptability has been reached. This also have also implication on future assembling and dispatches of nurseries and trials. Although the program will continue and reinforce the targeted testing and use of landraces and wild relatives from the different agro-ecological zones.

Table 3.18. Stability of Grain Yield of Improved Stress Tolerant Durum Genotypes, Mediterranean High Altitude Areas, 1996

	Productivity		Relative Stability (%)		
No.	Genotype	Kg/ha	Cham-1	Cakmak 79	Kunduru
21	Omrabi6	4564	263.4	268.8	516.0
2	Omrabi5	4385	136.7	139.4	267.7
19	Awalbit9	4361	108.2	110.4	212.0

MDMYL = Mean of Difference from maximum highest yielder at each Location divided by location mean. Relative stability(%) = (MDMYL of Check Entry/MDMYL of Test Entry) x 100.

Several genotypes were developed combining the traits productivity (high grain yield), yield stability, and stress tolerance, particularly drought resistance. Further these lines are showing improved resistance to the most diseases including leaf rust. The durum grain yield stability has been improved greatly during the last years. These results show that stress tolerance can be combined with yield and stability. These results also demonstrate that productivity and resistance to stresses (which reflects increased yield), can be combined; as also refute the claiming that productivity and resistance to abiotic stresses are incompatible. Our results also indicate that there is a synergistic effects between productivity and resistance to abiotic stresses.

CIMMYT/ICARDA: M.M. Nachit, M. Azrak, A. Asbati, Z. Younes. NARSs of WANA: Morocco, Algeria, Tunisia, Egypt, Jordan, Lebanon, Syria, Turkey.

3.2.6. Contribution of RFLPs under Different Environments

The contributions of the 10 most associated RFLP markers with grain yield under dryland conditions (Table 3.19), have contributed over 55 %. The highest contributing RFLP markers were associated with: the presence of KSUG48/8E on the long arm of Chromosome 6A, of WG380/37G on the long arms of chromosomes 7A and 7B, and of MWG 733/9I on the long arm of 1A; and with the absence of KSUH/26A on the short arms of

Table 3.19. Contribution of RFLP-markers to Grain Yield under Dryland Conditions, Breda, 1995/1996.

RFLP marker	Chromosomal location	Marker presence	R2(acc.)	Contribution(%)
KSUG 48/8E	6AL 6DS	+	0.131	13.130
KSUH 4/26A	6AS 6BS	-	0.224	9.276
CDO 1312/20C	4BL 4DL	-	0.298	7.395
WG 380/37G	7AL 7BS	+	0.370	7.223
MWG 733/9I	1AL	+	0.422	5.170
CDO 347/43D	7AL 7AS 7	+	0.451	2.871
BCD 2001/14D	1 BL	-	0.486	3.527
WG 996/4B	2 BL	+	0.513	2.662
BCD 1434/25D	1DS	-	0.538	2.545
CDO 1387/12A	4AS 4BL 4	-	0.553	1.532

chromosome 6A and 6B and of CDO 1312/20C on the long arms of 4B. As for the other RFLP markers, their individual contribution was less than 5%.

The contributions of RFLP markers to grain yield under supplementary irrigated conditions showed that the contributions of the highest 10 associated markers with grain yield contributed over 41 % (Table 3.20). The most contributing RFLP markers were associated with: the presence of BCD1821/24H on the long arm of Chromosome 6A, with the presence of WG380/37G on the long arms of chromosomes 7A and 7B, and with the absence of KSUG48/8F on the long arm of chromosome 6A. As for the other RFLP markers, their individual contribution was less than 5%.

Table 3.20. Contribution of RFLP-markers to Grain Yield under Supplementary Irrigated Conditions, Tel Hadya, 1995/1996.

RFLP marker	Chromosomal location	Marker presence	R2(acc.)	Contribution(%)
BCD 1821/24H	6AL	+	0.109	10.865
KSUG 48/8F	6AL 6DS	-	0.207	9.788
WG380/37G	7AL 7BL	+	0.257	5.066
MWG733/9N	1AL	+	0.284	2.728
BCD348/27M	2AL	-	0.309	2.467
CDO412/31A	5AL 5BL	+	0.337	2.747
BCD200/14E	1BL	-	0.358	2.138
CDO270/5F	6AL 6DS	-	0.378	2.002
BCD357/45I	6BL 6DS	-	0.396	1.807
CDO347/43C	7AL 7AS	+	0.411	1.464

The contributions of RFLP markers to grain yield under terminal stress conditions showed that the highest 10 associated markers with grain yield contributed 42 % to the total grain yield variability (Table 3.21). The most contributing RFLP markers were associated: with the absence of CDO482/30H on the long arm of Chromosome 3A, with the presence of WG380/37G on the long and short arms of chromosome 7A, and with the presence of BCD348/27I on the long arm of chromosome 2A. As for the other RFL markers, their individual contribution was less than 5%.

Table 3.21. Contribution of RFLP-markers to Grain Yield under Terminal Stress Conditions, Tel Hadya, 1995/1996.

RFLP marker	Chromosomal location	Marker presence	R2	Contribution (%)
CDO482/30H	3AL	-	0.097	9.729
WG380/37G	7AL 7AS	+	0.170	7.288
BCD348/27I	2AL	+	0.220	4.942
WG719/1E	7AL 7BL	+	0.258	3.875
BCD1095/34A	2 AS 2BL	-	0.294	3.523
BCD115/16C	3AL	+	0.321	2.752
CDO1090/2B	2AL 5AL	+	0.357	3.612
CDO1081/47C	4BL 4DL	+	0.382	2.441
KSUH4/26G	6AS 6BS	+	0.406	2.396
KSUG48/8F	6AL 6DS	-	0.420	1.402

The contributions of RFLP markers to grain yield under moderate water deficit conditions showed that the contributions of the most 10 associated markers with grain yield contributed around 47 % to the grain yield variability (Table 3.22). The most contributing RFLP markers were associated with: the absence of BCD1434/25J and with the presence of BCD 1821/24H. As for the other RFLP markers, their individual contribution was less than 5%.

Table 3.22. Contribution of RFLP markers to grain yield under moderate rainfall conditions (Rainfed), Tel Hadya, 1995/1996.

RFLP marker	Chromosomal location	Marker Presence	R2 (acc.)	Contribution (%)
BCD 1434/25J	1DS	-	0.140	13.995
BCD 1821/24H	6AL	+	0.227	8.704
CDO 347/43H	7AL 7AS	+	0.273	4.643
CDO 1090/2G	2AL 5AL	-	0.317	4.383
CDO 1090/2B	2AL 5AL	+	0.351	3.386
CDO 460/17E	3AS 3BS	-	0.374	2.261
CDO 347/43B	7AL 7AS	+	0.398	2.442
MWG 634/10F	4AL 4BS	-	0.424	2.612
KSUD 23/42B	2BL 2DL	+	0.445	2.071
KSUG 48/8F	6AL 6DS	-	0.473	2.766

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3.2.7. 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 (Table 3.23). For the drought resistance, the best parental genotypes are Omrabi5, Brachoua, Bicre, and Cham1. As for the durum landraces Shihani and Haurani Nawawi are showing the best performance under terminal stress conditions.

Table 3.23. Grain Yield (kg/ha) of durum genotypes targeted to continental dryland derived from crosses with drought tolerant x drought tolerant and with drought x landraces, terminal stress, Tel Hadya, Late-Planting, PDYT, 1995/96.

No.	Cross/Pedigree	Grain Yield (kg/ha)	Rank
719	Mrb5/Rufom-6 ICD92-1013-CABL-11AP-0TR	2186	1
721	Mrb5/Rufom-6 ICD92-1013-CABL-14AP-0TR	2076	3
101	Shihani/Brach ICD92-0223-CABL-8AP-4AP-0TR	2032	4
724	Mrb5//Ch1/Mrb SH ICD92-1014-CABL-11AP-0TR	2030	5
923	Bicre/3/Ch1//Gta/Stk/4/Bicre/Louko s 4 ICD92-0150-CABL-11AP-7AP-0TR	1998	6
917	Bicre/3/Ch1//Gta/Stk/4/Bicre/Louko s 4 ICD92-0150-CABL-7AP-5AP-0TR	1982	7
917	Bicre/3/Ch1//Gta/Stk/4/Bicre/Louko s 4 ICD92-0150-CABL-7AP-5AP-0TR	1982	7
615	Haurani Nawawi/Brach ICD92-0213-CABL-0AP-1AP-0TR	1831	9
102	Mrb5	1551	100
107	Hau	1062	193
111	Korifla	1533	109
116	Waha	1614	78
	Average of the yield trial	1549	
	LSD	194	
	CV (%)	13.8	

The average grain yield for PDYT was 2349 kg/ha and the range was between 1417 and 3308 kg/ha. Korifla and Omrabi5 yielded higher than Haurani. The highest yielding test entries had outyielded the best checks by more than one ton/ha (Table 3.24). These results are encouraging and show the continuous progress made in enhancing durum productivity under dryland conditions. Further, it is of interest to notice that the enhanced productivity in the Mediterranean dryland was reflected in the use of crosses between genotypes carrying drought resistance x drought resistance, drought resistance x landraces, and also drought resistance x high input; and the selection under representative Mediterranean dryland.

Table 3.24. Grain Yield (kg/ha) of durum genotypes targeted to continental dryland, Breda, PDYT, 1995/96.

Entry No.	Cross/Name	Grain Yield	Rank
601	Khb1/4/Rabi/3/Gs/AA//Plc/5/Genil-3 ICD92-0002-CABL-0AP-11AP-0TR	3308	1
508	Edm/Kia//Ch1 ICD91-MABL-0124-2AP-0AP-4AP-0TR	3283	2
724	Mrb5//Ch1/Mrb SH ICD92-1014-CABL-0AP-11AP-0TR	3083	3
609	Lahn//Gs/Stk/3/Genil-4 ICD92-0098-CABL-0AP-6AP-0TR	3058	5
617	Chen/Altar84//Genil-4 ICD92-0233-CABL-0AP-17AP-0TR	3058	5
619	Chen/Altar84//Genil-4 ICD92-0233-CABL-0AP-19AP-0TR	3058	5
518	LLOYD/Kia//Ch1 ICD91-0109-MABL-3AP-4AP-0TR	3033	8
405	20048 Traikia/Ch1//Genil-3 ICD92-0512-MABL-0AP-5AP-0TR	3025	9
102	Omrabi5	2196	135
107	Haurani	1779	182
111	Korifla	2204	131
	Mean yield of the trial	2349	
	LSD	203	
	CV (%)	9.6	

The checks Waha, Korifla, and Omrabi5 yielded higher than Haurani (Table 3.25). The highest yielding test entry had outyielded the best checks by more 30%. These results are encouraging and show the progress made in enhancing and widening the genetic base for durum productivity under dryland conditions. It is also of interest to notice that different Aegilops ssp., *T. araraticum, T. dicoccoides* are among these crosses.

Table 3.25. Grain Yield (kg/ha) of durum genotypes targeted to continental dryland derived from crosses with wild relatives, terminal stress conditions, Tel Hadya- Late Planting, PDYT, 1995/96.

Entry No.	Cross/Genotype	Grain Yield	Rank
123	Rufom-5/*T. araraticum* 500140//Carzio ICD92-0764-WABL-1AP-0TR	2139	2
119	Sbl1/*T. dicoccoides* 600545//Omguer-1 ICD92-0750-WABL-2AP-0TR	1946	8
319	Haucan/*Aeg. columnaris* 400020//Omtel-1/3/Omlahn-3 ICD91-0604-WABL-11AP-4AP-0TR	1939	9
323	Haucan/*Aeg. columnaris* 400020//Omtel-1/3/Omlahn-3 ICD91-0604-WABL-13AP-5AP-0TR	1936	10
102	Mrb5	1551	100
107	Haurani	1062	193
111	Korifla	1533	109
116	Waha	1614	78
	LSD	194	
	CV (%)	13.8	

The average yield of PDYT in Breda for the crosses with wild relatives was 2349 kg/ha. The range varied between 1417 to 2833 kg/ha. These demonstrate that the crosses with wild relatives could be also of interest to improve productivity in the severe dry areas. Some of these lines were also crossed to both landraces and wild relatives. Further, two genotypes from the recurrent selection populations (RSP) with wild relatives crosses are among the best yielders.

Table 3.26. Grain Yield (kg/ha) of durum genotypes derived from crosses with wild relatives and/or landraces, targeted to continental dryland, PDYT, Breda, 1995/96.

No.	Pedigree	Grain Yield (kg/ha)	Increase (%) over Haurani
24	RSP *T.Monococcum*	2883	162
17	Krf/Baladia Hamra//krf/3/*T.Monococcum* 5566/4/Carzio	2883	162
21	Tift1//Ch1/A.Vavilovii IC400236/3/Mrb3	2800	157
38	Krf/Baladia Hamra//krf/3/*T.Monococcum* 5566	2858	161
85	20093-Morocco-landrace/krf	2783	156
179	RSP *T.Dicoccoides*	2775	156
107	Haurani	1779	100
111	Korifla	2204	
	Mean yield of the trial	2349	
	LSD	203	
	CV (%)	9.6	

The Early Planting conditions represent the Mediterranean Continental Areas, particularly for screening to cold, yield potential, and associated biotic stresses. The Average grain yield achieved under the Early Planting conditions of Tel Hadya was 3664 kg/ha (Table 3.27); it ranged from 178 to 5731 kg/ha.

Table 3.27. Performance of some promising durum lines (PDYT) under cold conditions, early planting, 1996.

No.	Pedigree	Grain Yield
624	Ouassel1/Gedifla ICD92-0940-CABL-0AP-5AP-0TR	5731
701	Ouassel1/Rufom-6 ICD92-0958-CABL-0AP-5AP-0TR	5638
614	Haurani Nawawi/Stj4 ICD92-0212-CABL-0AP-12AP-0TR	5465
615	Haurani Nawawi/Brach ICD92-0213-CABL-0AP-1AP-0TR	5398
1012	Arthur 71/Bicre//Mrb3 ICD91-0565-MABL-0AP-2AP-0AP-7AP-0TR	5381
623	Ouassel-1//Ru/Mrb15 ICD92-0938-CABL-0AP-9AP-0TR	5298
618	Chen/Altar84//Genil-4 ICD92-0233-CABL-0AP-18AP-0TR	5231
814	Stj4/Gallareta ICD92-1185-CABL-0AP-3AP-0TR	5218
515	LLOYD/Kia//Ch1 ICD91-0109-MABL-0AP-2AP-0TR	5178
721	Mrb5/Rufom-6 ICD92-1013-CABL-0AP-14AP-0TR	5171
102	Omrabi5	4170
107	Haurani	4143
111	Korifla	3958
116	Waha	3390
122	Massara-1	3730
	Mean yield of the trial	3664
	LSD	316
	CV (%)	10.1

Grain yield under Early Planting conditions was associated positively with plant height (+0.315, <p= 0.01 and cold tolerance score (+0.522, < p= 0.001); however, it was associated negatively with the profuse erect growth habit (-0.404, < p= 0.01) and the expression of pale color during the early stage growth (-0.436, <p= 0.01). Consequently, the grain yield for 1995/96 under Early Planting conditions was explained up to 52.2% by tolerance to cold damage, 3.13% by

growth habit, 0.56% by leaf color during the vegetative stage, and 0.31% by plant height. In 1996, although the weather conditions of 1996 were mild, the screening scores taken in Early Planting allowed to differentiate among the test genotypes for cold tolerance. These results show the usefulness of this test.

Under terminal stress conditions of Kfardan / Lebanon, the crosses with *T. monococcum* and the landraces (Baladia Hamra, Shihani, and Traikia) showed large grain advantage over the checks (Table 3.28). The average grain yield for PDYT was 2031 kg/ha and ranged for the test entries between 149 and 3829 kg/ha.

The dryland weather conditions of Tel Hadya in 1995/96 were mild and had an average rainfall amount (340 mm). The average grain yield for PDYT was 3543 kg/ha and ranged for the test entries between 2290 and 4637 kg/ha. The best checks were Waha, Korifla, and Massara 1. Several newly developed lines showed high performance under dryland (Table 3.29), particularly the lines with crosses deriving from stress tolerant productive genotypes, such as Brachoua with the landraces such as Haurani Nawawi and Shihani. These results indicate that the backcrosses to durum landraces and selection and dryland can further generate genotypes with high productivity. The Cross with Lloyd/Kia// Cham1 and NN90E-17 from Morocco with Omrabi5 (selected under the Mediterranean continental areas) showed high yields under the environmental conditions of 1996. Additionally, the crosses between stress tolerant and high input genotypes are producing lines with good productivity to the Mediterranean dryland, such Omrabi, Awalbit, and Genil with Chen/Altar and Gallareta.

Table 3.28. Performance of Durum Lines Derived from Crosses with Wild Relatives and Landraces under Terminal Stress, Kfardan, PDYT, 1996.

No.	Pedigree	Grain Yield
217	Krf/Baladia Hamra//Krf/3/T.mon 5566 ICD91-0351-WABL-0AP-5AP-0AP-1AP-0TR	1914
1015	Shihani/Brach ICD92-0223-CABL-8AP-0AP-4AP-0TR	1887
1003	RSP *T. monoccum* RSP92-0004-0AP-1AP-4AP-0AP	1854
912	Wadalmez2/Omtel-2 ICD92-1313-CABL-0AP-2AP-0TR	1841
308	Mrb5/*T. monoccum* 5221//Chah88/3/Omguer-1 ICD91-0579-WABL-0AP-4AP-0AP-5AP-0TR	1741.33
420	Altar 84/Stn//Wadalmez-2 ICD92-MABL-0238-3AP-0AP-2AP-0TR	1701
301	Mrb5/*T.monoccum* 5221//Chah88/3/Omguer-1 ICD91-0579-WABL-0AP-2AP-0AP-4AP-0TR	1674
705	Mrb5/Albit1 ICD92-1006-CABL-0AP-11AP-0TR	1674
405	Traikia/Ch1//Genil-3 ICD92-0512-MABL-0AP-5AP-0TR	1667
218	Krf/Baladia Hamra//Krf/3/*T. mon* 5566 ICD91-0351-WABL-0AP-5AP-0AP-2AP-0TR	1647
102	Omrabi5	1066
107	Haurani	1106
111	Korifla	906
116	Waha	1046
122	Massara-1	1179
	Mean yield of the trial	2031
	LSD	631
	CV (%)	17.2

The PDYT average grain yield was 3941 kg/ha and range was between 1560 and 5600 kg/ha. The checks Massara1 and Omrabi5 outyielded the other checks (Haurani, Korifla, and Waha) by more than one ton per hectare (Table 3.30). Several promising lines of the PDYT showed high yield potential than the Omrabi5 and Massara1. The highest yielding lines were mainly those derived from crosses between abiotic stress tolerant and high input lines, e.g. Omrabi5, stojocri, and

Table 3.29. Grain Yield (kg/ha) of some Promising Durum Lines (PDYT) under Rainfed conditions, Tel Hadya, 1996

Entry	Pedigree	Grain Yield
515	LLOYD/Kia//Ch1 ICD91-0109-MABL-0AP-3AP-0AP-2AP-0TR	4637
618	Chen/Altar84//Genil-4 ICD92-0233-CABL-0AP-18AP-0TR	4490
803	Mrb5/Gallareta ICD92-1016-CABL-0AP-6AP-0TR	4350
613	Bicre//Fg/Snipe/3/GdoVZ578/Swan//Deraa 2 ICD92-0175-CABL-0AP-10AP-0TR	4340
1015	Shihani/Brach ICD92-0223-CABL-8AP-0AP-4AP-0TR	4304
619	Chen/Altar84//Genil-4 ICD92-0233-CABL-0AP-19AP-0TR	4240
514	LLOYD/Kia//Ch1 ICD91-0109-MABL-0AP-1AP-0AP-2AP-0TR	4187
523	NN90E4-17/Mrb5 ICD91-0301-MABL-0AP-4AP-0AP-2AP-0TR	4187
615	Haurani Nawawi/Brach ICD92-0213-CABL-0AP-1AP-0TR	4157
705	Mrb5/Albit1 ICD92-1006-CABL-0AP-11AP-0TR	4154
102	Omrabi5	3495
107	Haurani	3425
111	Korifla	3692
116	Waha	3872
122	Massara-1	3685
	Mean yield of the trial	3543
	LSD	309
	CV (%)	9.6

Gallareta. However, there was also lines derived from crosses between the abiotic stress lines, e.g. Omrabi , Awalbit, Rufom, and Bicre: Further crosses with *T. monococcum* were also among the highest yielding genotypes in Terbol.

Table 3.30. Grain Yield (kg/ha) of some Promising Durum Lines (PDYT) under Terbol conditions, 1996.

Entry No.	Pedigree	Grain Yield
824	Albit2/Albit5 ICD92-1226-CABL-0AP-2AP-0TR	5600
803	Mrb5/Gallareta ICD92-1016-CABL-0AP-6AP-0TR	5167
705	Mrb5/Albit1 ICD92-1006-CABL-0AP-11AP-0TR	5067
1003	RSP T. *monococcum* RSP92-0004-0AP-1AP-4AP-0AP	4993
503	NN90E3-33/Albit3//Ch1 ICD92-MABL-0696-4AP-0AP-5AP-0TR	4987
804	Rufom10/Mrb3 ICD92-1101-CABL-0AP-3AP-0TR	4967
919	Bicre/3/Ch1//Gta/Stk/4/Bicre/Louk os 4	4940
801	ICD92-0150-CABL-7AP-0AP-7AP-0TR Mrb5/Gallareta	4933
814	ICD92-1016-CABL-0AP-3AP-0TR Stj4/Gallareta ICD92-1185-CABL-0AP-3AP-0TR	4933
	Check :	
102	Omrabi5	4867
107	Haurani	3350
111	Korifla	3647
116	Waha	3843
122	Massara1	4893
	Mean yield of the trial	3941
	LSD	472
	CV (%)	12.6

During 1995/96, the average grain yield of ADYT was 2232 kg/ha and the range for the test entries varied between 1305 and 3497 kg/ha. The highest grain yielding check was achieved by Waha, it has exceeded all other checks, including Cham3 and Omrabi5 (Table 3.31). This is surprising, as in the other seasons, Cham1 was the lowest Check under Breda conditions.

Table 3.31. Grain Yield of some Promising Durum Lines (ADYT) under Breda, dryland conditions, 1996.

No.	Pedigree	Grain Yield
609T	Moulsabil-2 ICD89-0263-AL-4AP-0AP-5AP-0AP	3497
617T	Hadj-Mouline/Chah88 ICD89-0264-AL-4AP-0AP-1AP-0AP	3455
618T	Heid//Ch67/Cando ICD88-1169-ABL-0TR-10AP-0AP-4AP-0AP	3122
117C	Gdo VZ512/Cit//Ruff/Fg/3/Brach ICD88-1251-ABL-0TR-1BR-0TR-4AP-0AP	3080
417C	Gedifla/Guerou 1 ICD91-0980-AB-5AP-0AP-1AP-0AP	3064
709T	Chah88/Deraa ICD89-0664-ABL-0AP-4AP-0AP	3047
301C	Mrb5/Genil-2 ICD91-0400-AB-17AP-0AP-4AP-0AP	3005
115C	Heid//Ch67/Cando ICD88-1169-ABL-0TR-10AP-0AP-4AP-0AP	2997
608T	Boy/Yav//PI 330551 SWD945-0GH-1YRC-1M-0REC	2955
104C	Zeina-5 ICD88-1233-ABL-9AP-0AP-2AP-0AP	2914
102	Omrabi5	1890
107	Haurani	1848
111	Korifla	1898
116	Waha	2898
122	Massara-1	1909
	Mean yield of the trial	2232
	LSD	408
	CV (%)	7.9

This can be explained by the mild weather conditions of last season. However, it is known that Cham1 has a good adaptation to temperate dryland and also as our results have shown earlier, Cham1 has a high values for osmotic adjustment under moisture stress conditions. Further, several promising lines were found to outyield Cham1 under last season conditions, such as Hadj-Mouline, Chahba88, Heider, and Omrabi5 crosses.

The frequency for the lines targeted to the temperate areas among the highest yielders was similar to those of the continental areas (5:5). The largest traits contributors to grain yield were plant height (7.6%), the score for biomass and high fertile tillering (6.1%), and kernel weight (5.9%). In the lines of temperate areas lines, the traits with the large contributions were the score for biomass and high fertile tillering (8.2%) and the kernel weight (7.2%). Whereas in the lines of continental areas, plant height (13.1%), the score for biomass and high fertile tillering (7.4%), peduncle length (2.3%), and kernel weight (1.7%).

Under Early Planting conditions of Tel Hadya, the average grain yield was 3789 kg/ha and its range was between 1470 and 5890 kg/ha. The entries were subjected at an advanced growth stage to low temperature conditions. The frequency for the lines targeted to the temperate areas among the highest yielders was very high when compared with the lines targeted to the continental areas (9:1). Omrabi5 was the highest yielding check; it has outyielded all other checks by more than one ton/ha (Table 3.32). However, the highest grain yielding test lines exceeded the grain yield of Omrabi5 by also more than one ton/ha. However, Omrabi3 (Cham 5) showed also high grain yield under these conditions. Most of the lines carry parental material that was produced in the breeding program for the Mediterranean continental areas.

Table 3.32. Grain Yield (kg/ha)of some Promising Durum Lines (ADYT) under Tel Hadya, Early Planting Conditions (Cold), 1996.

No.	Pedigree	Grain Yield
1119T	Chah88/Deraa ICD89-0664-ABL-0AP-6AP-0AP	5890
1109T	Lagost-2 ICD86-0471-ABL-0TR-8AP-0TR-20AP-0TR	5806
714T	Hadj-Mouline (Mor)Sbl2 ICD89-0263-AL-4AP-0AP-9AP-0AP	5610
310C	Mrb3/4/Mrb SH/3/Rabi//Gs/Cr ICD91-0755-AB-5AP-0AP-7AP-0AP	5543
1104T	Mrb3	5490
710T	Chah88/Deraa ICD89-0664-ABL-0AP-6AP-0AP	5376
920T	Sbl1/4/Gdo VZ512/Cit//Ruff/Fg/3/Pin/Gre//Trob ICD91-0778-AB-3AP-0A	5363
1019T	Mrb3/Albit-3 ICD91-0751-AB-5AP-0AP-3AP-0AP	5256
1121T	Quadalete//Erp/Mal/3/Unknown ICD87-0993-ABL-1AP-0TR-7AP-0TR	5223
1005T	Mrbl1//Snipe/Magh/3/Rufom-7 ICD91-1251-AB-3AP-0AP-6AP-0AP	5223
102	Omrabi5	4718
107	Haurani	3729
111	Korifla	3689
116	Waha	3359
	Mean yield of the trial	3789
	LCD	398
	CV (%)	11.6

The score for the ability to produce high biomass and fertile tillering ability has explained 63.0% of the total grain yield variability under the cold conditions of the Early Planting test. Whereas, the deep green leaf color during the vegetative stage has explained 3.5%. The contributions of the other traits such as plant height, growth habit, and score for symptoms due to frost damage were very low. However, the cold damage was not expressed at the winterhardiness kill level. Further, the grain yield of the durum entries for the continental areas was slightly less (5.6%) explained by the score for the ability to produce high biomass and fertile tillering ability than in the durum entries targeted to the areas with temperate climates. The contribution of the deep green color in the durum entries for temperate areas was more important (7.0%) than for the continental areas (0.2%).

Under the severe terminal stress conditions (sirocco) of Kfardan (Lebanon), the trial yield average was 808 kg/ha and the test entries range between 46 and 2393 kg/ha. The frequency for the lines targeted to the temperate areas among the highest yielders was lower than the lines targeted to the continental areas (4:7). Omrabi5 showed the best grain yield among the checks (Table 3.33), it was more 3 times higher than Haurani and double higher than Korifla (Cham3) and Waha (Cham1).However the maximum grain yields achieved by the some test lines were almost double than that of Omrabi5. The best lines were the crosses between Omrabi and Awalbit, Ombar, and Ouassel lines. Further, these lines also carry the leaf rust resistance.

Table 3.33. Grain Yield (kg/ha) of some Promising Durum Lines (ADYT) under Terminal Stress, Kfardan, Lebanon, 1996.

No.	Pedigree	Grain Yield
804T	Heican-1	2393
1020T	Mrb3/Albit-3 ICD91-0751-AB-5AP-0AP-5AP-0AP	2285
620C	Mrb16/3/Ente/Mario//P66-270/4/Ren/Bar ICD87-0786-ABL-0AP-7AP-0TR-6	2105
1003T	Ouassel-1/4/Gdo VZ512/Cit//Ruff/Fg/3/Pin/Gre//Trob ICD91-0811-AB-	2052
123C	Mrb16/3/Ente/Mario//P66-270/4/Ren/Bar ICD87-0786-ABL-0AP-7AP-0TR-1	2025
303C	Mrb3/4/BYE*2/TC//ZB/W/3/Cit/5/Ru/Pelissier ICD91-0418-AB-4AP-0AP-7	2005
503C	Edm/Mia//Krf ICD91-0125-AB-4AP-0AP-7AP-0AP	1972
423C	Kia/Vic//Brach ICD91-0083-AB-2AP-0AP-14AP-0AP	1898
1019T	Mrb3/Awallbit3 ICD91-0751-AB-5AP-0AP-3AP-0AP	1785
619C	Mrb16/3/Ente/Mario//P66-270/4/Ren/Bar ICD87-0786-ABL-0AP-7AP-0TR-1	1772
122C	Massara-1	1703
102	Omrabi5	1197
107	Haurani	321
111	Korifla	667
116	Waha	570
	Mean yield of the trial	808
	LSD	214
	CV (%)	15.9

Under terminal stress (drought and heat) conditions, the best highest yielding check was Korifla (Cham3), followed by Omrabi5 and Haurani. However, the yield achieved by Korifla was similar to the yield trial mean. The yield trial mean was 1499 kg/ha and the range was between 420 and 2278 kg/ha (Table 3.34). The frequency for the lines targeted to the temperate areas among the highest yielders was lower than the lines targeted to the continental areas (2:8). The highest yielding lines under these conditions were the crosses with the genotypes Brachoua, Omrabi, Genil, Heider, and lines with leaf rust resistance such as the cross with Ouassel and the

Table 3.34. Grain Yield of some Promising Durum Lines under Terminal Stress, Late Planting, Tel Hadya, 1995/96.

No.	Pedigree	Grain Yield
117C	Gdo VZ512/Cit//Ruff/Fg/3/Brach	2278
	ICD88-1251-ABL-0TR-1BR-0TR-4AP-0AP	
118C	Gdo VZ512/Cit//Ruff/Fg/3/Brach	2245
	ICD88-1251-ABL-0TR-1BR-0TR-7AP-0AP	
815T	Mrb5/Genil-2	2217
	ICD91-0400-AB-1AP-0AP-4AP-0AP	
221C	Mrb5/Genil2	2133
	ICD91-0400-AB-1AP-0AP-1AP-0AP	
120C	Heid/Lahn-SH	2115
	ICD88-1325-ABL-0TR-4BR-0TR-6AP-0AP	
105C	Gdo	2098
	VZ512/Cit//Ruff/Fg/3/Ente/Mario//Cando	
	ICD88-1383-ABL-11AP-0AP	2065
113C	Moulsabil2	
	ICD89-0263-AL-4AP-0AP-5AP-0AP	
604T	Mrb3	2035
115C	Heid//Ch67/Cando	1992
	ICD88-1169-ABL-0TR-10AP-0AP-4AP-0AP	
121C	Ouassel1/7/Brk/6/Plc/CII/Jo/RD119/5/Cit/	1992
	Mca/4/Pg/Gl1/3/Lds//56-1	
102	Omrabi5	1293
107	Haurani	1026
111	Korifla	1457
	Mean yield of the trial	1499
	LSD	411
	CV (%)	11.9

Moroccan variety Hadj-Mouline. This material is targeted to the areas with temperate dryland and terminal stress conditions; the combination with leaf rust resistance was successfully combined with the performance under drought x heat climates.

As it was shown in the previous seasons, number of days to maturity is the most trait associated with grain yield (-0.74, p= 0.001) under Late Planting conditions of Tel Hadya. Number of days to maturity explained 54.8% of the total grain variability under these conditions, and with the score for biomass and high fertile tillering 5.9%. As for the germplasm area specificity, for the lines targeted to the temperate areas, the maturity contributed more (60,5%) to final grain yield than for those targeted to the continental areas. However, the score for biomass and high fertile tillering was more important in the lines for continental areas (12.1%) for the lines for temperate areas (4.1%).

Under dryland conditions of Tel Hadya station, the average grain yield of the advanced durum yield trials was 3425 kg/ha; the entries yield ranged from 2518 to 4579 kg/ha. The frequency for the lines targeted to temperate areas among the highest yielders was relatively higher than to continental areas (6:4). Omrabi5 was the best check, better than Korifla (Cham3) and Haurani. The most frequent high yielding lines were achieved by the cross Awali2/Bit (Table 3.35). However, the highest yielding lines were the cross Korifla (Cham3) with Edmore (a cultivar from North America) and the second highest line was achieved by the cross with Chahba88 / Deraa, two lines originated from the durum breeding program at ICARDA and were found to have good dryland performance. Further, crosses between Awalbit and Omrabi, with *T. dicoccoides* (Korifdi) showed good performance under dryland conditions of Northern Syria. These results demonstrate the progress made in widening the genetic background for the continental dryland.

Table 3.35. Grain Yield (kg/ha) of Promising Durum Lines in Rainfed, ADYT, Tel Hadya, 1995/96

No.	Pedigree	Grain Yield
424C	Edkorif ICD91-0125-AB-1AP-0AP-7AP-0AP	4568
1118T	Chah88/Deraa ICD89-0664-ABL-0AP-4AP-0AP	4358
1019T	Mrb3/Albit-3 ICD91-0751-AB-5AP-0AP-3AP-0AP	4195
1020T	Mrb3/Albit-3 ICD91-0751-AB-5AP-0AP-5AP-0AP	4195
1119T	Chah88/Deraa ICD89-0664-ABL-0AP-6AP-0AP	4175
614C	Awl2/Bit ICD84-0322-ABL-5AP-TR-AP-6AP-TR-3AP-0TR	4175
1113T	Zeina-4 ICD88-1233-ABL-8AP-0AP-6AP-0AP	4125
421C	Wabrach2 ICD91-0083-AB-1AP-0AP-5AP-0AP	4101
506C	Mrb3/3/Mrb11//Snipe/Magh ICD91-0760-AB-9AP-0AP-6AP-0AP	4071
1115T	Korifdi ICD87-1253-ABL-8AP-0TR-5AP-0TR	4041
102	Omrabi5	3574
107	Haurani	3205
111	Korifla	3492
	Mean yield of the trial	3425
	LSD	296
	CV (%)	10.0

The study of the morphophysiological traits contribution to grain yield under the rainfed conditions showed the following: fertile tillers explained 5.6%, photosynthetic traits (quantum yield= 4.9%, photosynthetic active radiation = 4.6%), and leaf color during the vegetative stage 1.5%. As for area specific germplasm, the grain yields of the lines targeted to temperate areas are mainly explained by the photosynthetic traits (quantum yield 27.1% and photosynthetic active radiation = 1.9%), fertile tillering 7.9%, leaf color during the generative phase 1.7%, spike fertility 1.7%, and number of days to maturity 1.1%. Whereas for the lines targeted to continental areas, the score for biomass and high fertile tillering accounted for 7.5% of the total grain yield variability, followed by the early growth vigor 3.7%, and the photosynthetic traits (quantum yield = 2.9% and plant performance index= 2.6%).

At the high input environment (Terbol, Lebanon), The average yield of the ADYT trial was 3670 (Table 3.36) and the range for the test entries was between 970 and 5524 kg/ha. The frequency for the lines targeted to temperate and to continental areas among the highest yielders was almost similar (3:4). Among the checks, the highest yield was achieved by Omrabi5, followed by Cham1, and Haurani. The test durum lines produced, such as Sbl1/Lahn and Mrb5/Genil2 produced almost one ton more grain yield than the best check Omrabi5. The pedigree of most of the high yielding test lines are carrying parental material of Lahn and Omrabi lines, the former was identified as a genotype with high yield potential and the later ones with stress tolerance a high productivity under dryland conditions. The results show the potential of combining parental material with stress tolerance and high productivity without loosing yield capacity.

Table 3.36. Grain yield (kg/ha) of promising Durum Lines in Favorable Highland, ADYT, Terbol, 1995/96

No.	Pedigree	Grain Yield
321C	Sb11/Lahn ICD91-0774-AB-9AP-0AP-5AP-0AP	5524
301C	Mrb5/Genil-2 ICD91-0400-AB-17AP-0AP-4AP-0AP	5457
810T	Omlahn-1/NN 90E14-9 ICD90-1122-8AP-0AP-4AP-0AP	5050
1013T	Mrb11//Snipe/Magh/3/Rufom-7 ICD91-1251-AB-8AP-0AP-11AP-0AP	5017
1101T	Ombar ICD87-0786-ABL-7AP-0TR-5AP-0AP	4964
501C	Edm/Mia//Krf ICD91-0125-AB-1AP-10AP-0AP	4857
303C	Mrb3/4/BYE*2/TC//ZB/W/3/Cit/5/Ru/Pelissier ICD91-0418-AB-4AP-0AP	4824
102	Omrabi5	4379
107	Haurani	3145
116	Waha	3661
	Mean yield of the trial	3414
	LSD	494
	CV (%)	15.6

CIMMYT/ICARDA: M.M. Nachit, M. Azrak, A. Asbati, Z. Younes, I. Elouafi.

3.2.8. Conclusion

During the last decade the major adaptation patterns required for the main three agro-ecological zones and their corresponding genetic pools for resistance to the constraints encountered in each zone of WANA region were developed.

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

Similarly, for the continental dryland agro-ecological zone, the genetic pools carrying resistance to yellow rust, wheat stem sawl, cold, drought, and terminal stress. Nurseries with appropriate patterns such as early growth vigor, strong tillering and spike fertility, in addition to grain quality parameters.

As for the high altitude areas: Resistance to cold, boron toxicity, BYDV, yellow, leaf, and stem rusts, good grain quality, etc. Accordingly nurseries with the appropriate morpho-physiological patterns were developed and distributed to the concerned NARS.

Further to upgrade NARS capabilities, training at levels and follow up visits were made. In addition, joint activities with NARS were developed and later projects were written and presented for donors. Further, interaction among NARSs in different agro-ecological zones were established. This has lead to develop WANADDIN project: to strengthen NARSs research and staff training.

After this the program at ICARDA will in the future place more emphasis on the abiotic stresses and grain quality, particularly on moisture stress and yield stability; and incorporate jointly with NARS the resistance and stability to the specific germplasm of the different agro-ecological zones.

CIMMYT/ICARDA: M.M. Nachit, M. Azrak, A. Asbati, Z. Younes.

3.3. Boron Toxicity Tolerance

3.3.1. Seedling Test

Screening for B-toxicity tolerance was conducted under a plastic house in soil mixed evenly with boric acid at the rate of 100 mg B/kg soil (giving a hot water extract of 2 8 ppm B). Foliar B-toxicity symptom scores were taken 4 to 6 weeks after sowing.

Observation Nursery and Yield Trial

Among the 57 advanced durum lines from the 1995/96 CIMMYT/ICARDA Regional Observation Nursery for High Altitude Areas, there was only moderate, though significant, variation between entries in symptom score and growth score. All lines had poorer growth than the tolerant bread wheat check, Halberd. Entries 3, 4, and 39 had the least symptom scores and best growth among the tested materials, while entries 51, 14, 17, and 25 had the poorest growth. As there is evidence that genotypes relatively tolerant to boron toxicity are also relatively susceptible to boron deficiency and vice versa (Nable et al. 1989), the boron-toxicity sensitive entries are expected to be tolerant to boron deficiency.

Similar results were obtained for the 24 entries in the 1995/96 CIMMYT/ICARDA Regional Durum Wheat Yield Trial for High Altitude Areas. Entries 13 and 17 had the best growth, while entry 11 was the poorest.

(S.K.Yau, M.M. Nachit)

Germplasm Accessions

Starting from last year, germplasm accessions were screened for B-toxicity tolerance. The aim is to find parental materials having high tolerance to B toxicity as the Australia bread wheat cultivar, Halberd.

From the 50 random accessions of four countries in North Africa (Algeria, Libya, Morocco and Tunisia), no accessions had a symptom score as low as Halberd. With the exception of the five most sensitive accessions (ICDW 5676, 5739, 6347, 6778, and 6782), all accessions had symptom scores non-significantly different from the moderately-tolerant check, Oued Zenati. Besides, there were no significant differences in accessions' B-toxicity symptom scores between the four countries.

Based on results of the preliminary screening of random accessions from WANA, a screening of accessions from countries which had a higher percentage of tolerant accessions was conducted. A total of 234 accessions held at ICARDA's gene bank from Afghanistan (80), Iran (73), Iraq (56) and Turkey (25; due to large numbers of Turkish accessions, only those from the Konya Province in the Anatolian Plateau were selected) were screened. There were significant differences in accessions' B-toxicity symptom scores between individual accessions and between the four countries. A few days after emergence, tolerant accessions, by having normal green color, could be distinguished from the less tolerant ones, which were yellowish to yellowish-green. Twenty-four accessions had a performance score (symptom score plus growth) equal to or better than Halberd, and significantly better than Oued Zenati (Table 3.37). Twenty-two out of the 24 were accessions from Afghanistan, suggesting that high B soils may be common in that country. On average, Afghanistan accessions had the lowest symptom scores, followed by Iraq, Iran, and Turkey (Konya) in that order. Three accessions (ICDW 9209, 6746 and 6433) performed significantly poorer than the sensitive check, Kunduru.

(S.K. Yau, J. Valkoun)

Table 3.37. Germplasm accessions from West Asia having B-toxicity symptom and growth scores equal to or better than the bread wheat check, Halberd, in a high-B soil.

Accession No.	Country of Origin	Accession No.	Country of Origin
ICDW 9834	Afghanistan	ICDW 13966	Afghanistan
ICDW 9833	Afghanistan	ICDW 13964	Afghanistan
ICDW 9762	Afghanistan	ICDW 9198	Afghanistan
ICDW 10759	Afghanistan	ICDW 13175	Afghanistan
ICDW 10754	Afghanistan	ICDW 13174	Afghanistan
ICDW 13942	Afghanistan	ICDW 13963	Afghanistan
ICDW 22200	Afghanistan	ICDW 13971	Afghanistan
ICDW 13941	Afghanistan	ICDW 13172	Afghanistan
ICDW 13169	Afghanistan	ICDW 13173	Afghanistan
ICDW 13968	Afghanistan	ICDW 13171	Afghanistan
ICDW 13965	Afghanistan	ICDW 13170	Afghanistan
ICDW 9221	Afghanistan	ICDW 7743	Iran

3.3.2. Yield Testing

Out of the advanced lines and germplasm accessions screened last season, 23 lines/accessions with low B-toxicity symptom scores were grown in pots to maturity under a plastic house. There were two B treatments: control (0.7 ppm hot water extractable B) and +B (50 mg B/kg soil, giving a hot water extract of 21 ppm B). The experiment was in a randomized complete block design with two replications.

Table 3.38. gives the performance of five durum entries whose grain yield increased by 30-50% under the +B treatment over the control, despite having significantly higher shoot-B concentrations and B-toxicity symptom scores than the bread wheat check, Halberd. Grain yield of the sensitive checks, Cham-1 (durum) and Onslow (barley), was highly reduced as expected.

(S.K. Yau)

Table 3.38. Mean B-toxicity symptom score, and shoot-B concentration at the +B treatment, grain yield under the two B treatments, and percentage yield reduction at the +B treatment relative to the control.

Name/cross	B Toxicity Symptom score[1]	Shoot B conc. (ppm)	Grain yield		
			Control (a)	+B (b)	Reduction% (a-b)/a
ICDW 8560 (Syr)	3.0	972	2.53	4.01	-58
CD 21760/[2]	2.5	1220	1.71	2.42	-42
ICDW 6268 (Iran)	3.8	1128	3.03	4.28	-41
ICDW 9261 (Jor)	3.0	1041	2.83	3.93	-39
ICDW 20868 (Tur)	3.3	1178	3.01	4.10	-36
Checks:					
Halberd (bread w)	1.0	573	4.58	3.89	15
Kristal	3.0	946	4.01	4.09	-2
Cham-1	3.3	1375	2.77	1.49	46
Onslow (barley)	8.8	1062	4.33	1.75	60
LSD	1.2	209	1.37	1.48	

[1] based on % of first leaf affected
[2] CD 21760/T.dic.-1Q55132//Cham 1/3/Tourus-1/4/Shwa/Pt 1 ICI86-0071-4AP-1AP-0AP

3.3.3. International Nurseries

The 1996/97 durum wheat nurseries prepared at ICARDA are given in Table 3.39. The Crossing Block, which is prepared every 2-3 years, was assembled this year. The two specific-trait nurseries, the drought and heat tolerance, and drought and cold tolerance observation nurseries, were discontinued, as the two regular observation nurseries contain advanced lines with adequate drought and cold, or drought and heat tolerance. The four germplasm pools for sources of resistance to yellow, stem, or leaf rusts, or Septoria tritici blotch, were assembled for the second year for those cooperators who missed requesting them last year. There was a seed shortage for the high-elevation observation nursery and yield trial, and for the three segregating populations. A total of 348 sets of nurseries were distributed this year.

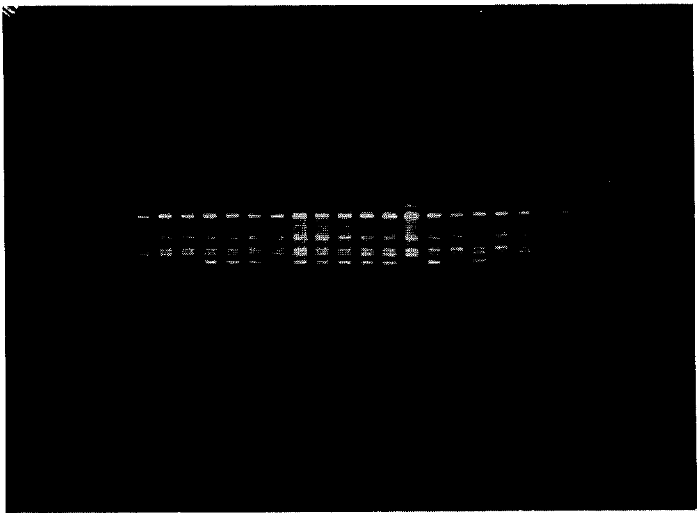
(S.K. Yau, M.M. Nachit)

Table 3.39. Durum wheat nurseries for 1996/97.

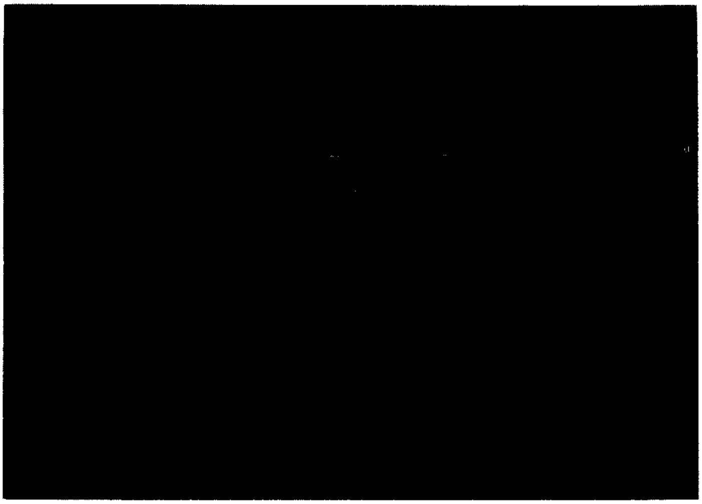
Nursery	Abbre-viation	No. of entries	No. of sets distributed
Mediterranean Continental Areas:			
Segregating Populations	DSP-CA	45	13
Observation Nursery	DON-CA	120	33
Yield Trial	DYT-CA	24	35
Mediterranean Temperate Areas:			
Segregating Populations	DSP-CA	50	13
Observation Nursery	DON-CA	120	44
Yield Trial	DYT-CA	24	49
Crossing Block (for both continental and temperate areas)	DCB	58	28
Mediterranean High Altitude Areas:			
Segregating Populations	DSP-HAA	35	11
Observation Nursery	DON-HAA	96	22
Yield Trial	DYT-HAA	24	19
Germplasm Pools (same as 1995/96)			
Yellow Rust Resistance	DYRGP	12	20
Leaf Rust Resistance	DLRGP	18	20
Stem Rust Resistance	DSRGP	12	20
Septoria Tritici Blotch Res.	DSTGP	15	21

3.4. Durum Biotechnology

The durum programs at ICARDA is developing several mapping populations for the different agro-ecological zones of the Mediterranean region. The population Jenaha Ketifa x Cham1 has been chosen for the development of a durum linkage map through a collaborative effort. At Cornell University, 142 genomic clones (barley, wheat and oat clones) were tested for polymorphisms on the parents J.K/Cham1. So far, 25 polymorphic clones have been mapped in the population. At ICARDA and the University of Tuscia, Italy the non radioactive RFLP method is used to find further polymorphisms. 17 clones from 70 barley or oat genomic clones show polymorphism on the parents at ICARDA. Furthermore, a total of 450 Operon primers were screened in J.K/Cham1 from which 20% were polymorphic see e.g. (Fig. 3.1). 15 polymorphic primers were amplified in 112 lines of population Jenaha Ketifa/Cham leading to 27 loci. 19 were linked and grouped in 8 linkage groups. In each group their are 2 , 3 or 4 locus (Table 3.40). Specific primer for quality (LMW) were also used for the genetic mapping of the J.K/Cham1 population. Plants heterozygot for LMW-glutenin 2 and 1 were also detected (Fig. 3.2). This specific PCR primer detects (like RFLP marker) co-dominant genes and can be used for genes tagging or for marker assisted selection.



OPB1



OPB 4

Fig. 3.1. OPB1 and OPB4 RAPD (Random Amplify polymorphic DNA) PCR screening in durum wheat population Jenaha Ketifa X Cham 1.

Table 3.40. Random Operon primer in 112 lines of the population Jenaha ketifa/Cham1. Linkage group at minimum LOD score 3.0, maximum distance 50.0.

Group	Primer	Map genetic (cM)
	LMW2	0
	LMW1	
2	OPB2 band1	4.4
	OPU13 band1	
3	OPX16 band1	3.2
	OPX16 band2	
4	OPQ20 band1	0.0
	OPA14 band1	19.0
	OPQ4 band1	3.6
	OPQ4 band2	5.4

		28.1
1	OPQ20 band 3	0.0
	OPH11 band1	18.5
	OPA16	26.6

		45.1
6	OPC9 band1	8.0
	OPC9 band2	
7	OPC9 band3	29.8
	OPC10 band3	
8	OPC10 band1	3.7
	OPC10 band2	
unlinked	OPB2 band1, OPB4 band1, PQ20 band2, OPR6 band1, OPR6 band2, OPC3 band1, OPA14 band2, OPU13 band2	

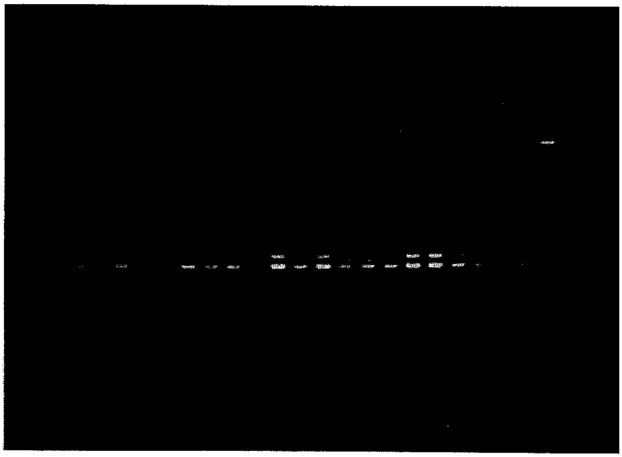


Fig. 3.2. PCR screening for quality in durum wheat population Jenaha ketifa X Cham 1. Primers 2 for LMW glutenin are used. First higher band is glutenin LMW 2 or 1. Glutenin LMW 2 is higher than glutenin LMW 1 by 50bp. In heterozygote lines the two bands for glutenin LMW2 and LMW1 are present.

3.4.1. Screening for pasta quality in durum wheat

Gliadin and glutenin are the major groups of protein in the durum seed. Their presence is associated with pasta quality. Gliadin 45 are associated with glutenin low molecular weight 2 and gliadin 42 are associated with glutenin low molecular weight glutenin 1.

To select for pasta quality, PCR amplification by using specific primers is adopted as new tools in breeding program selection. The primers used for this PCR amplification are:

1- Primers 1 for LMW-glutenin
5' ATg AAg ACC TTC CTC gTC TT 3'

5' CAA CgC CgA ATg gCA CAC TA 3'

2- Primers 2 for LMW-Glutenin
5' CgT TgC ggC gAC AAg TgC AA 3'
5' gTA ggC ACC AAC TCC ggT gC 3'

3- Primers for Gamma-gliadin
5' ATg AAg ACC TTA CTC ATC CT 3'
5' ACA TAC ACg TTg CAC ATg g

The advance durum yield trials 94, 95 and 96 were analyzed with these PCR primers. ADYT 94 was screen for glutenin by using primers 1 for LMW-glutenin. The PCR amplification shows three bands with the higher band being specific for LMW glutenin 2 or for Low molecular weight glutenin 1. By using primers 2 for LMW-glutenin, the PCR amplification generates only two bands, the higher band again being specific for low molecular weight glutenin 2 or 1 (Fig.3.3). In heterozygote genotypes, both bands for LMW-gultenin 2 and LMW-glutenin 1 are present. For the gliadin only one set of primers is used for screening. The PCR amplification show 4 bands. The second higher band is specific for gliadin 45 or gliadin 42 (Fig. 3.4).

The screening of 380 lines from ADYT '94, 240 lines from ADYT '95 for gliadin (Fig. 3.5) show that more than 89% of lines have gliadin 45, less than 10% have gliadin 42 and 2.5% of lines are heterozygoses lines. For glutenins, the screening of the same lines shows the same percentages (Fig. 3.6) as gliadin. The screening of ADYT 96 (Fig. 3.7) shows similar results as ADYT 94 and ADYT 95. 88.9% of lines have genotypes with good quality and less than 8.7% of lines have genotypes with bad quality and 2.4% were heterozygotes. This result show that more than 90% of lines cultivated in this area has genotypes with low molecular weight glutenin 2 and gliadin 45. This results from intensive selection conducted for many years.

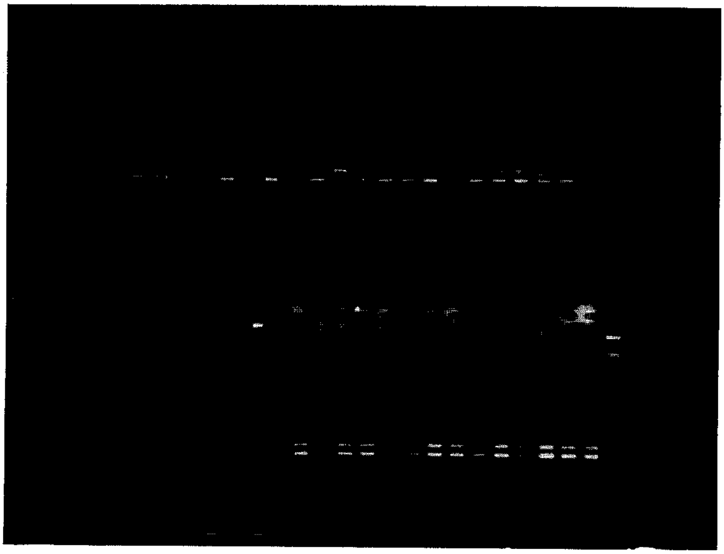


Fig. 3.3. PCR screening for quality in durum wheat ADYT genotypes. Primer 2 for LMW glutenin are used. First higher band is glutenin LMW 2 or 1. Glutenin LMW 2 is higher than glutenin LMW 1 by 50bp. In heterozygote lines the two bands for glutenin LMW2 and LMW1 are present.

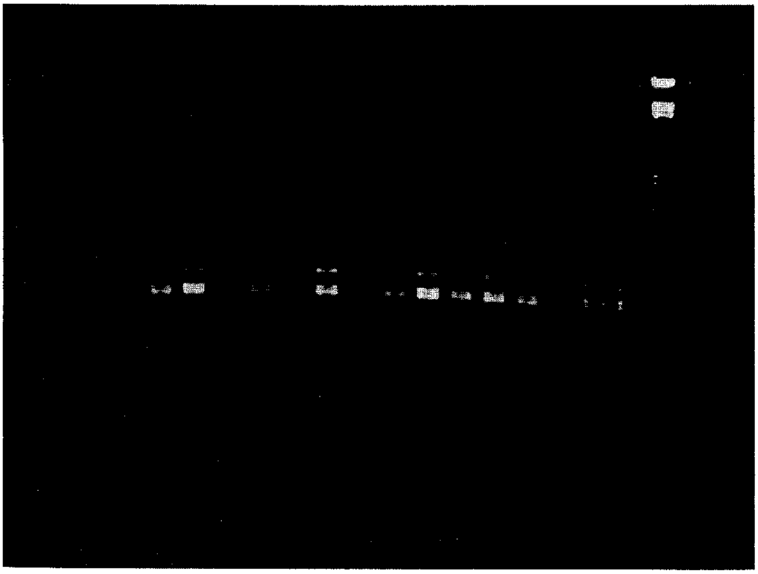


Fig. 3.4. PCR screening for quality in ADYT96 durum wheat genotypes. Primers for gliadin are used. Second higher band is gliadin 45 or gliadin 42. Gliadin 45 is higher than gliadin 42 by 50bp.

The screening of the ADYT for glutenins and gliadins have so far not identified true recombinants. From this results it can be concluded that the screening for gliadin is not necessary (if only technological pasta quality is concerned).

(M. Labhilili, M. Baalbaki, M. Baum, M. Nachit)

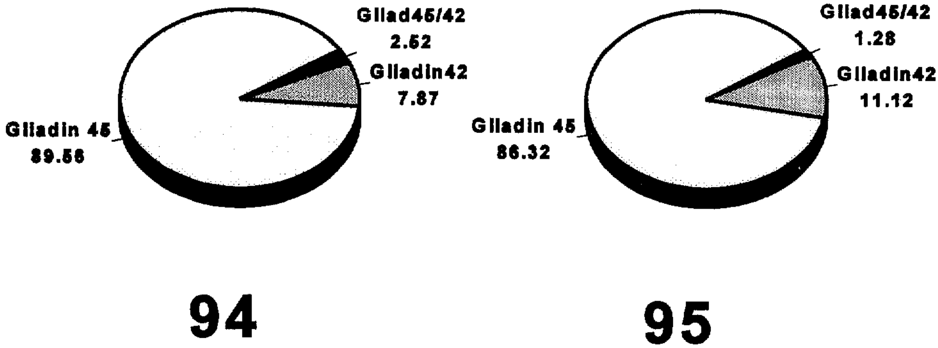


Fig. 3.5. Evaluation of gliadin 45/42 in ADYT94 (screening of 380 lines) and 95 (screening of 240 lines).

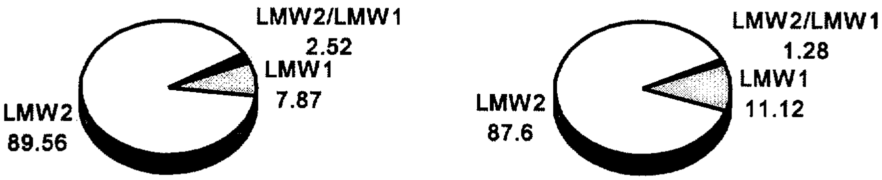


Fig. 3.6. Evaluation of glutenin LMW2/LMW1 in ADYT94 (screening of 380 lines) and 95 (screening of 240 lines).

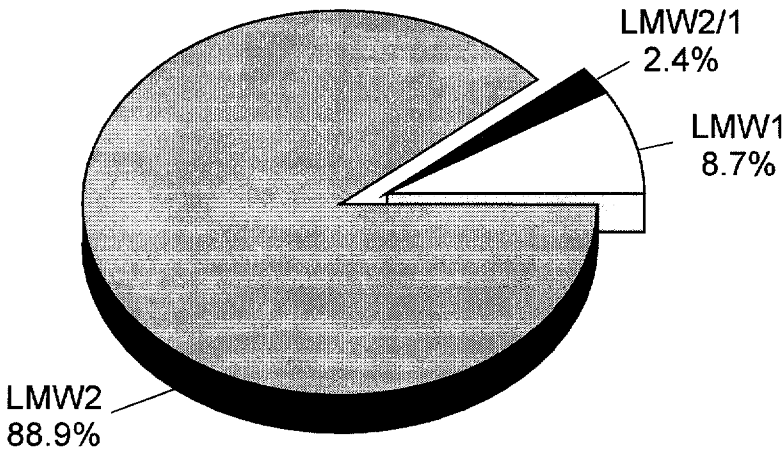


Fig. 3.7. Glutenin in ADYT96.

3.4.2. Isolated Microspores Derived and Floating Anther Cultures in Bread and Durum Wheat.

Collaborative research has been developed between the ICARDA GP and Laboratoire de Morphogenese Vegetale Expérimentale University Paris South Orsay (France) to develop efficient methods to produce doubled haploid plants and also to develop embryogenic haploid cells systems suitable for future genetic manipulations in bread and durum wheat.

An elegant and recent approach is represented by isolated microspore cultures which provide researchers with an in vitro system without constraints of somatic tissues, with a rapid regeneration ability and an haploid level of ploidy.

These techniques are carried out for different purposes: breeding, genetic manipulations by biolistic bombardment in bread and durum wheat, genetic mapping in durum wheat and studies of proteins involved in signal transduction pathways (G-proteins, arrestin-like proteins, NDPKinases). Described below are attempts to perform efficient isolated microspores culture and anther culture systems in bread and durum wheat.

3.4.2.1. Isolated Microspores

Isolated microspores are obtained at the rate of 60,000 to 300,000 microspores per spike, by microblending, filtration and centrifugation. They are cultivated in 35mm diameter petri dishes each containing 1,5 ml of a modified Chu liquid medium with 0.26M of glucose (CHB2) or maltose (CHB3), at the concentration of 50,000 microspores.ml-1, with or without ovaries, in the dark and at 25°C.

In bread wheat, isolated microspores derived embryos were obtained directly (without starvation) from genotypes such as Pavon, Veery S, DH112,107, HJA but only by co-culture with ovaries. Great differences are observed between experiments with same genotype. In the best experiment, more 800 embryos are obtained from 8 spikes isolated microspores. On a standard regeneration medium, these embryos regenerate green and albino plants at different rates depending on the time of transfer and on the genotype. Great differences were observed between experiments with the same genotype.The better embryo rate was observed for the cultivar Pavon with near than 1 embryo for 1000 microspores. A positive effect of cold treatment duration have been observed with better results with 3 weeks of cold treatments. These embryos have shown high regeneration potentialities Chlorophyllian (rate: 13 to 17 %) and albinos (rate: 26 to 73,6 %) plantlets were obtained. Glucose seems to be a little more favourable for green plant regeneration whereas maltose promotes higher embryos rates.

In durum wheat recently identical results have been obtained in these conditions. The levels of embryo rate reached 100 embryos for 50,000 microspores and we obtained 5 green plantlets recently (Orsay) from F1 crosses of Jennah Khetifa x Cham1 .

3.4.2.2. Float Anther Cultures

The same modified Chu liquid media (CHB2 and CHB3) were used in direct anther float cultures and gave high levels of embryos production in bread wheat tested genotypes with better results for CHB3 (maltose), with respect to the embryo shape. For example, the genotype HJA produced regularly an average of approximately 500 embryos per spike with 72 cultivated anthers plated in 9 ml CHB3 medium. A maximum of 3500 embryos per spike has been observed in one case. These embryos regenerate green and albina plants. In durum wheat same results have been obtained also with 2 varieties (Cham1and Jennah Khetifa) and their bulk F3. The average rate of embryo production reached more than 100 embryos per spike (72 anthers) for Jennah Khetifa with a maximum at 200. These embryos are frequently looking like zygotic embryos with scutellum, coleoptile and coleorhize. In this case no green plantlets have been obtained but only albinos regeneration.

(E. Picard, J de Buyser and R Haicour)

References

Nable, R.O., B. Cartwright, and R.C.M. Lance. 1989. Genotypic differences in boron accumulation in barley: relative susceptibilities to boron deficiency and toxicity. In pages 243-251, N. El Bassam et al. eds., Genetic Aspects of Plant Mineral Nutrition. Kluwer, The Netherlands.

4. SPRING BREAD WHEAT IMPROVEMENT

4.1. Spring Bread Wheat Breeding

4.1.1. Introduction

Detailed weather conditions during 1995-96 crop season at Tel Hadya and Breda (our main experimental stations in Syria), are reported in other sections of ICARDA's Germplasm Program annual report. Grain yield losses in farmer's fields due to foliar diseases such as yellow rust, Septoria tritici blotch and powdery mildew were reported in most countries in WANA. This was due to the more favourable rainfall experienced during the season. Many areas in these countries experienced also an irregular distribution of rainfall resulting in yield losses due to prolonged periods of drought and heat, especially towards the end of the season.

This report presents results achieved, by working in close partnership with NARS in WANA, in developing and identifying spring bread wheat germplasm with tolerance to the abiotic and biotic stresses of importance in the region. We also highlight the Project's achievements to meet the specific research objectives set in ICARDA's Medium-Term Plan (1994-98).

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. We present updated data highlighting the importance of the crop, the Project's current research philosophy and refined breeding methodology, its interaction with NARS and advanced Institutes, as well as the future trusts that will guide the joint CIMMYT/ICARDA Dryland Bread Wheat Project into the new Century.

(G. Ortiz Ferrara)

4.1.2. Importance of Bread Wheat in WANA

Bread wheat ranks first among the cereals grown in West Asia and North Africa (WANA). About 10 %, or approximately 47.8 million metric tonnes, of the total world wheat was produced in this region during 1993. Of this, approximately 37.1 million metric tonnes was bread wheat while the balance was durum wheat (Byerlee and Morris, 1993).

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 (Byerlee and Morris 1993). Although marginal environments are widely distributed across the developing world, most of these areas are concentrated in West Asia and North Africa. Of the total 28.5 million hectares of bread wheat grown under drought in developing countries, 12.5 million hectares, or approximately 63 % of the total wheat area, were planted in the WANA region (Table 4.1). Because the total area planted to bread wheat is much larger than the planted to durum, in absolute terms the area planted to bread wheat in marginal environments is much larger than the area planted to durum wheat in such environments.

Table 4.1. Area and percentage of bread wheat and durum in the low-rainfall zones in the developing world during the mid-1980s.

Region	LRBW area (M ha)	% Total BW area in region	LRDW area (M ha)	% Total DW area in region
WANA	**12.5**	**63**	**5.9**	**74**
South Asia	6.8	23	1.5	94
East Asia	4.7	16	0.0	0
South America	4.5	50	0.1	16
Developing Countries Total	28.5	32	7.5	72

LRBW = Low rainfall bread wheat; LRDW = Low rainfall durum wheat.
Source: Byerlee and Morris (1993).

The dominant role of bread wheat in the economy of West Asia and North Africa cannot be exaggerated. In WANA, bread wheat is the principal food source for a majority of the population, which, on average, consumes more than 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. Countries in this region are substantial net importers of bread wheat and this trend is on the rise. The projected total wheat consumption to that date will be 95 million tonnes with an increased average per capita consumption of 219 kg/year (Table 4.2). The projections of future bread wheat imports are alarming, 50 million tons of bread wheat alone by the year 2000 if current rates of demand are maintained.

4.1.3. Philosophy of the Project

The long-term objective of the spring bread wheat project is: to increase the productivity of spring bread wheat in the low-rainfall areas of West Asia and of North Africa in a stable and sustainable way, in close partnership with NARS, and for the benefit of resource-poor farmers of the region.

This main objective is met through the application of the following specific objectives:
1.) To develop spring bread wheat germplasm with high yield and yield stability, with acceptable disease and insect pest resistance, tolerant to nutrient deficiencies and other abiotic stresses and with good processing qualities; 2.) Development of breeding methodologies for more effective identification and selection of superior spring bread wheat germplasm for low-rainfall (<400 mm rainfall) areas; and, 3.) To upgrade the research and production capabilities of national programs of the region.

As dictated by the crop regional mandate given to

Table 4.2. Projections of wheat consumption by region to the year 2000.

Region	Growth rate 1985-2000: Food wheat (%/yr)	Growth rate 1985-2000: Feed wheat (%/yr)	Total consumption 2000 (million t)	Per capita consumption 2000 (kg/yr)	Percent used for feed, 2000
Sub-Saharan Africa	5.2	3.1	14	21	1
W. Asia/North Africa	2.8	4.2	**95**	**219**	**7**
Asia	2.8	5.2	249	73	5
Latin America	2.7	4.1	42	68	10
Developing countries	2.9	4.7	401	78	6
Developed countries	0.6	2.2	293	129	42
World	2.1	2.6	693	89	21

Source: CIMMYT, 1989. 1987-88 CIMMYT World Wheat Facts and Trends.

(G. Ortiz Ferrara, M.Asaad Mousa and A. Yaljarouka)

ICARDA by the Technical Advisory Committee (TAC) of the CGIAR, the spring bread wheat project focus its research efforts to develop and identified suitable-adapted spring bread wheat germplasm for the low-rainfall areas of WANA. The overall aim is to complement the world-mandated wheat improvement efforts of CIMMYT by using the available resources from both Centers in the most effective way for research in the region. The joint CIMMYT/ICARDA project emphasizes research for the dry areas, while CIMMYT-Mexico concentrates in developing germplasm and technologies for the more optimum environments of the region.

(G. Ortiz Ferrara, M.Asaad Mousa and A. Yaljarouka)

4.1.4. Interaction with NARS

The strength of the CIMMYT/ICARDA spring bread wheat project is its close interaction with national programs in WANA. Table 4.3 summarizes this collaboration. Besides training and the extensive network of germplasm exchange and testing, there are many other important but less well known ways in which the project is helping strengthen national research. Each year, for example, the project brings senior national scientists to ICARDA. In certain areas of particular interest, other scientists are sponsored to visit CIMMYT Mexico or to attend international conferences in the region. They learn about our activities, and we discuss their own research needs and areas of possible collaboration. Likewise, the spring bread wheat breeder and other senior staff in the project are invited every year to attend national and regional coordination meetings to review national program activities, develop research workplans, and suggest changes to accelerate the pace of research results. We are also frequently asked to lecture to national research staff and university students and to help supervise MSc and PhD candidates in their thesis work.

Table 4.3. Areas of research collaboration between the spring bread wheat project and NARS in WANA.

Area (s) of collaboration:	Country (s)/ Region:	Funding:
Exchange of germplasm, Intl. nursery testing	WANA (+)	Core
Training Visisting Scientists, Workshops	WANA	Core, Special Project
Farmers field verification trials	WANA	Core
Transfer of technology	WANA	Core, Special Project
Seed production	WANA	Core, Special Project
Research planning and implementation	WANA	Core, Special Project
Regional networks (foliar diseases, viruses, heat tolerance, WUE)	NVRSRP	Special Project
Decentralized entomology research (HF, RWA)	Morocco	Core
Epidemiological studies and development of yellow rust (and other foliar diseases)-durable resistance	Iran, Egypt	Core, Special Project
Wheat adaption studies	Syria, Lebanon Turkey, Tunisia Morocco, Algeria	Core, Special Project
Breeding for HF, Septoria and RWA	Morocco, Tunisia	Core
Breeding for long spike, heat, disease resistance	Egypt	Special Project
Farmer's participation	Turkey. Lebanon	Core
germplasm charaterization (P x V, diseases)	Tunisia, Turkey	Core
Double haploid breeding	Morocco	Core

In some NARS, the lack of modest equipment, like a pickup truck or plot thresher, computers, and supplies like envelopes, crossing bags, labels and simple spare parts can severely hamstring the efforts of national scientists. Where appropriate, the spring bread wheat project supplies critically needed equipment, sometimes making the difference between a struggling and dynamic research program.

As a consequence of this partnership, some NARS in WANA are gradually changing from recipients of technology and training to full partners in the research process, supporting the project and colleagues in other countries. For example, Morocco is helping the project identify sources of resistance to Hessian fly (HF) and Russian Wheat Aphids (RWA). They are 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, NARS collaborators, Outreach staff, M.Asaad Mousa and A. Yaljarouka)

4.1.5. Interaction with Advanced Institutions

Since the spring bread wheat project does not presently have the optimum facilities, and human/ financial resources, to delve into certain basic research topics, it is turning to universities and other research organizations in developed countries for support. A list of collaborative projects is highlighted in Table 4.4. In most cases, these research institutions contribute the research at their expense or are supported by national development programs. This represents a major contribution to the project's and the NARS's research agenda.

Table 4.4. Collaborative projects between the spring bread wheat project and advanced institutes.

Institution:	Project:	Status:
Plant Breeding Institute, The I.A. Watson Wheat Research Center, Univ. of Sydney, Australia	Wheat adaptation studies in the dry areas of Australia and WANA	Supported by GRDC, support was recently extended until December 1997
Dept. of Plant Ecology and Evolutionary Biology, Utrecht University, The Netherlands	Morphophysiological studies	Supported by the Government of the Netherlands. Ongoing
Plant Breeding Institute, Cobbity, The University of Sydney, Australia	Epidemiological studies and development of yellow rust-durable resistance bread wheats	Ongoing
University of Paris-sud, France	Improvement of double haploid methods	Informal-ongoing
Agronomic Department, Colorado State University, USA	Heat and drought research	Ongoing
University of Hohenheim, Germany	Improvement of double haploid methods	Informal-ongoing
ACSAD	Drought screening	Ongoing
CIMMYT	Exchange of germplasm, drought tolerance, synthetics, adaptation studies	Ongoing
CIMMYT	Global Heat Network	Supported by ODA. Ongoing
USAID/USDA-ARS,submitted Beltsville, MD, USA	Development of high-yielding, Long-pike bread wheat cultivars with high tillering, rust resistance, and heat tolerance, facilitated by microsatellite DNA markers	ATUT-Egypt project,
USAID/USDA-Oklahoma submitted State University, USA	Integrated pest management of wheat aphids	ATUT-Egypt project

(G. Ortiz Ferrara, Advanced Institutes Cooperators)

4.1.6. Summary of Achievements

During the past 10 years, the CIMMYT/ICARDA Spring bread wheat improvement project has made significant progress in the following areas of research:

4.1.6.1. Describing the Target Environment

Three major agroecological zones in WANA, and their main biotic and abiotic stresses responsible for reduced yields, have been identified. The environments of countries in West Asia and North Africa are characterized as being highly variable and unpredictable with regard to moisture availability, temperature regimes, soil fertility and pH conditions, disease and insect pests, and also management factors. In WANA, bread wheat is grown in three different agroclimatological zones based on moisture availability and temperature regimes. These are:

* Areas of low rainfall associated with low temperatures (LRT, annual rainfall <400 mm).

* Areas of moderate rainfall with moderate to high temperatures (MRT, annual rainfall between 400-600 mm); and,

* Irrigated areas.

Bread wheat is grown and harvested where temperatures fluctuate significantly. Typically, however, the crop is sown in the fall, wherein its early growth and development occur during the coolest months and grain ripening occurs during the warmest months. Extreme temperatures, cold and heat, are common abiotic stress factors during the crop season and frequently a complex interaction between them and moisture deficits develops. Other biotic stresses, such as disease and insect pests, are also important constraints of wheat production in the region (Ortiz Ferrara et al. 1987).

Research results (Ortiz Ferrara et al. 1985) confirm that the region's semi-arid rainfed sites (rainfall less than 400 mm), where most of the bread wheat is grown, are more dissimilar and variable in terms of moisture availability and temperature than the sites with adequate moisture supply (rainfall more than 400 mm or irrigated). The semi-arid, low-temperature rainfed sites are characterized by a longer maturity duration, shorter plant height, and lower grain yield when compared to the mild winters adequate moisture sites.

Faced with such large variations in climate, weather, and stresses in the dryland areas of the region, the spring bread wheat project places special emphasis on developing cultivars suitable to these marginal environments.

(G. Ortiz Ferrara, M.Asaad Mousa and A. Yaljarouka)

4.1.6.2. Developing Breeding Methodologies

A refined breeding methodology has been developed which emphasizes increased use of multilocation testing, the targeting of germplasm to where the product is intended, the selective use of wild progenitors and landraces, and that makes efficient use of new biotechnological tools.

The project focusses 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, BYDV, common bunt, sawflies, Hessian fly, Sunn pest and aphids. In the project's approach, high yielding and stable germplasm is used to combine with other important traits to produce desired genotypes.

High grain yield and yield stability over years and locations, important characteristics needed in the rainfed areas of the region, are derived through the application of the following strategies:

a) Continuous evaluation of potential parents.

b) Targeted crosses.

c) Multilocation selection and testing, and

d) Targeted distribution of improved germplasm to national programs in the region.

These strategies are visualized in Figure 4.1, where the overall breeding system 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, ie. terminal drought and/or cold tolerance, disease resistance, insect pest tolerance, etc.

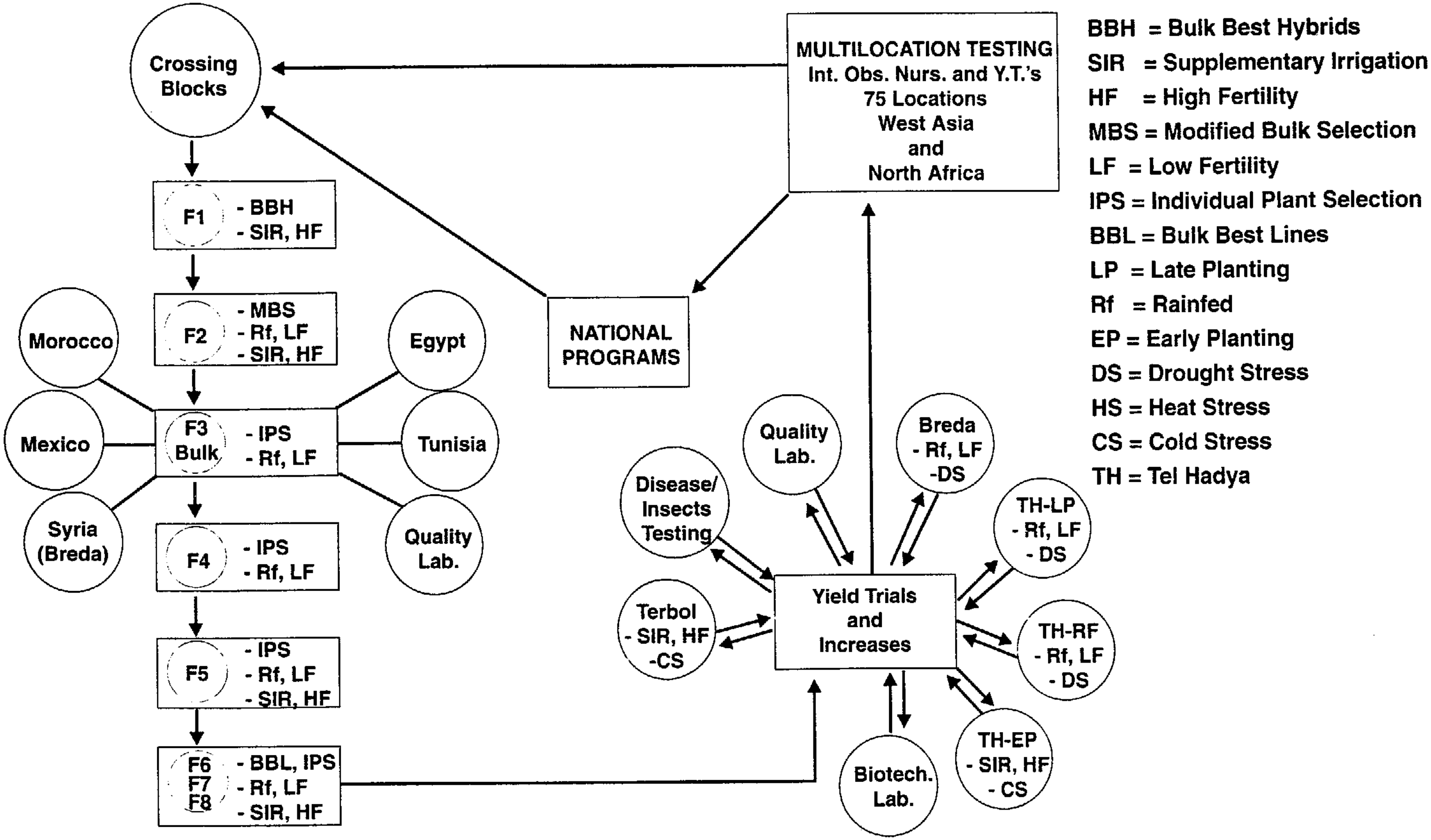


Fig. 1. Breeding methcdology of the CIMMYT/ICARDA spring bread wheat improvement program for the dryland areas of WANA.

a) Continuous Evaluation of Potential Parents:

National crop improvement programs in WANA, which grow and evaluate CIMMYT/ICARDA spring bread wheat international nurseries, provide vital information on germplasm performance. Through this system, the project identifies promising material carrying desirable genes for specific stresses found in the rainfed areas of the region. Tables 4.5 and 4.6, for example, highlight the spring bread wheat lines that had the highest frequency of selection and grain yield in the Wheat Observation Nursery for Semi Arid Areas (WON-SA, Table 4.5) and in the Wheat Observation Nursery for Favourable Areas (WON-FA, Table 4.6) of 1995-96 across 22 and 27 rainfed locations respectively in WANA. These lines combine the grain yield and yield stability as well as other desirable traits such as disease and insect pest resistance and good grain quality. They have been included in the Project's crossing blocks for further crossing and use as parental material.

Similarly, genetic material is also received from national programs. This material, received in the form of collections, includes local varieties and landraces which carry desirable genes for resistance to different stresses. After evaluation, outstanding lines are also included in the crossing block for parental usage and recycling. Since 1980, an average of approximately 21 % of incoming materials has been evaluated and used by the project. This germplasm provides additional genetic variability needed in the project to meet the demands of the harsh environments found in West Asia and North Africa.

b) Targeted Crosses:

Targeted F1's, simple and top crosses, are designed to recombine high yield and stability with important traits

Table 4.5. Spring bread wheat lines with the highest average grain yield and frequency of selection in 22 low-rainfall locations in WANA. Wheat Observation Nursery for Semi Arid Areas (WON-SA) 1995-96.

Cross and Pedigree:	Grain Yield (kg/ha)	Sum. Sel.	Disease Reaction YR	LR	SR
Bocro-3 CM69599-4AP-2AP-3AP-3AP-0AP	4695	10	R	5MR	R
Seri/Sudan No. 1 ICW89-0028-4AP-0AP-0Br-1AP-0TS-0AP	4491	10	5M	5MS	R
Gv/4/D6301/Nai//Wrm/3/Cno*3 /Chr.... ICW87-0274-0AP-5AP-0L-1AP-0L-3AP-0Br-0AP	4343	7	R	5MR	5MR
Pvn'S'/Sprw'S' CM46702-2AP-0AP-2AP-1AP-0AP	4274	7	5MR	20MR	5MS
Tsi/Vee#5//Kauz'S' ICW91-0295-4AP-0TS-2A-0AP	4269	9	10MR	R	5MS
Vee/Nac CM67575-7AP-3AP-1AP-2AP-1AP-300L-0AP	4161	8	R	10MS	R
National Check	3842	3	-	-	-

Sum. Sel.= No. of times a line was visually selected based on agronomic type and adaptation.
YR=Yellow rust; LR=Leaf rust; SR=Stem rust.

Table 4.6. Spring bread wheat lines with the highest grain yield and frequency of selection in 27 rainfed, moderate rainfall locations of WANA. Wheat Observation Nursery for Favorable Areas (WON-FA) 1995-96.

Cross and Pedigree:	Grain Yield (kg/ha)	Sum. Sel.	Disease Reaction YR	LR	SR
Tsi/Vee#5//Kauz'S' ICW91-0295-4AP-0TS-1AP-0TS-0AP	4763	9	5MR	20MR	5MS
4777(2)//Fkn/Gb/3/Vee'S'/4 /Buc'S'... ICW89-0111-3AP-0L-4AP-0AP-0Br-2AP-0AP	4658	9	5M	5MS	R
Kauz'S'/3/Ana/Maya//Tan'S' CM104110-0AP-0L-1AP-0AP-0Br-1AP-0AP	4550	8	R	5R	5MS
Psn'S'/Bow'S'//Kauz'S' CM101432-0AP-0L-8AP-0AP-0Br-2AP-0AP	4512	8	5MR	R	20MS
4777(2)//Fkn/Gb/3/Vee'S'/4 /Buc'S'... ICW89-0111-3AP-0L-4AP-0AP-0Br-1AP-0AP	4470	8	20MR	10MS	5MR
Fow-1 SWM11147-1AP-2AP-1AP-1AP-0AP	4317	10	R	10MR	5R
W3918A/Jup//GRU90-201736 ICW91-0147-0TS-5AP-0TS-0AP	4260	12	10MR	5MS	5MS
Prew CM59377-3AP-1AP-3AP-2AP-1AP-0AP	4191	9	R	10MS	R

Sum. Sel.= No. of times a line was visually selected based on agronomic type and adaptation.
YR=Yellow rust; LR=Leaf rust; SR=Stem rust.

needed in the region. Evaluation of international screening nurseries, international yield trials and F2 and F3 nurseries are made in approximately 75 locations in WANA. Data from these nurseries help guide future crosses. During the last seven years (1991-97), an average of 839 crosses have been made yearly to cope with different agroclimatic regions (Table 4.7.).

Table 4.7. Type and average number of crosses made during the last seven years (1991-97) in the spring bread wheat crossing project.

Purpose of the cross	Average No. of crosses per year	% of total
Abiotic stress tolerance		40
Terminal drought	167	
Gold	95	
Terminal heat	72	
Biotic stress resistance		39
Yellow rust	119	
Leaf rust	35	
Stem rust	25	
Septoria leaf blotch	50	
Common bunt	27	
Wheat stem sawfly	27	
Hessian fly	27	
Barley yellow dwarf virus	20	
Bread making quality	83	10
Special purpose		11
Selected landraces/wild progenitors	92	
Total	839	100

Approximately 40 % of the project's crossing program is directed towards abiotic stress tolerance; 39 % for biotic stress problems; 10 % to upgrade the bread making quality; and 11 % to increase the genetic variability by exploiting desirable traits from landraces and wild progenitors.

c) Multilocation Selection and Testing:

Multilocation testing, the project's most important strategy for selection and identification of material tolerant to different stresses, is done at two different levels: (a) international multilocation testing, in which data from 50 to

75 locations in the region is obtained through the CIMMYT/ICARDA international nurseries system, and (b) regional multilocation testing, consisting of five different environments in Syria and Lebanon. The latter constitutes the hub of the screening program in which segregating populations and advanced lines are selected and tested under different moisture, and temperature conditions. These five environments are:

* Breda - RF : long-term average rainfall 283 mm; low fertility
* TH - LP - RF : long-term average rainfall 300 mm; low fertility
* TH - NP - RF : long-term average rainfall 342 mm; low fertility
* TH - EP - SIR: supplementary irrigation 450 mm; good fertility
* Terbol - SIR : supplementary irrigation 600 mm; good fertility

Where: TH = Tel Hadya; LP = Late planting; NP = Normal planting; EP = Early planting;
SIR = Supplementary irrigation; RF = Rainfed.

Breda and Terbol represent the extremes in environmental conditions in terms of moisture availability and soil fertility, while the three simulated environments at Tel Hadya help to screen germplasm under different moisture and temperature regimes. By shifting planting dates of segregating populations and advanced lines, the germplasm is exposed to low or high temperatures during critical stages of plant development. The combination of early planting supplementary irrigation and high fertility is done to induce better selection for frost tolerance, enhanced disease development and more efficient selection for earliness. The late planting environment under low moisture conditions helps to identify germplasm with heat tolerance and earliness, tolerance to premature desiccation and better translocation of stem assimilates to grain. This material is also exposed to yellow rust, septoria, leaf rust and other diseases/insect pests of economic importance in the region.

d) Targeted Distribution of Improved Germplasm to NARS in the region:

Table 4.8. summarizes the breeding methodology used to select and identify genetic material suitable to the variable environments of WANA. Promising advanced lines identified

Table 4.8. Descriptive breeding methodology for the rainfed areas of West Asia and North Africa.

Trait:	Low rainfall Cool temperature Diseases Quality	Moderate rainfall Moderate to high temperature Diseases Quality
Environments:	Breda-RF TH-NP-RF TH-EP-SIR	Terbol-SIR TH-LP-SIR TH-NP-RF
Segregating populations:	F2-F8	F2-F8
Yield trials:	Preliminary Advanced	Preliminary Advanced
International nurseries:	WON-SA RWYT-SA KLDN	WON-FA RWYT-FA KLDN

NP=Normal planting; EP=Early planting; LP=Late planting; TH=Tel Hadya; RF=Rainfed; SIR=Supplementary irrigation; WON-SA=Wheat observation nursery for semi-arid areas;
WON-FA=Wheat observation nursery for favorable areas; RWYT-SA=Regional Wheat yield trial for semi-arid areas; RWYT-FA=Regional wheat yield trial for favorable areas; KLDN=Key location disease nursery.

using this procedure are further distributed to NARS in the region through the international nursery system. The distribution of these nurseries is carefully planned and targeted to those areas for which the final product is intended.

(G. Ortiz Ferrara, M. Asaad Mousa and A. Yaljarouka)

4.1.6.3. Other improvement methods and strategic research

The project pays attention to develop and verify other breeding methodologies applicable in the rainfed areas of WANA. The single seed descent (SSD) method of selection is used to complement our efforts in breeding for specific qualitative traits such as yellow rust and Hessian fly; and, as described before, the modified bulk to enhance adaptation (Ortiz Ferrara and Deghaiz, 1988) . For the last 6 years, the project has used certain biotechnological tools, such as double haploid production, to incorporate in the shortest period of time, important traits needed in the project (ie. insects and/or disease resistance, etc). This method has proved to be useful in the project (Ortiz Ferrara et al., 1995), and the methodology was published in Lashermes et al. 1991. Several double haploids, developed using these techniques, are in the latest stages of release in some countries of the region such as Morocco.

The role of photoperiod and vernalization in the adaptation of spring bread wheat in the rainfed areas of WANA has been studied extensively (Ortiz Ferrara et al., 1995, Mosaad et al. 1995, Ortiz Ferrara et al, 1996). Screening techniques have been developed and used in the project to characterize elite local and improved germplasm, and to target germplasm to where the product is intended in the region. For the last 12 years, the project has also grown and tested germplasm in the summer nursery facilities available in Terbol, Lebanon. This methodology has been successful in speeding up the number of generations per year and for testing against BYDV, leaf and stem rust resistance (see pathology section in this report). New techniques of virus detection and of disease screening have been developed and they have been extremely useful in the project. These techniques are described in detail in the IPM MTP project of ICARDA. The project has conducted in depth analysis of the international trials and results have been published in international journals. New nutritional and industrial quality techniques (ie. Near-Infrared Spectroscopy, etc.) as well as modern methods of seed production, have been developed and used by the project. More promising lines and varieties have been identified and released by NARS by the implementation of these complementary improvement techniques.

(G. Ortiz Ferrara, O.F. Mamluk, K. Makkouk, M. Baum, M. El-Bouhssini, F.J. El-Haramein, M.Asaad Musa and A. Yaljarouka)

4.1.6.4. Boron Toxicity Research in Bread Wheat

The Boron toxicity problem has been extensively investigated as well. During 1995/96, the bread wheat crossing block was tested for B-toxicity tolerance. The screening was conducted under a plastic house in soil mixed evenly with boric acid at the rate of 100 mg B/kg soil (giving a hot water extract of 23 ppm B). Seedling growth was scored visually 5 weeks after sowing. The most boron-toxicity tolerant (best growth) and sensitive (worst growth) entries are given in Table 4.9. As there is evidence that genotypes relatively tolerant to boron toxicity are also relatively susceptible to boron deficiency and vice versa (Nable et al. 1989), the boron-toxicity sensitive entries are expected to be tolerant to boron deficiency.

Table 4.9. Boron-toxicity tolerant or sensitive entries in the 1995/96 CIMMYT/ICARDA Bread Wheat Crossing Block (grown in soil to which boric acid was mixed at a rate of 100 mg B/kg soil).

Entry	Name/Cross	
Tolerant:		
14	Shi#4414/Crow's'	1.0
43	Bolal	1.75
23	Shi#4414/Crow's'	2.0
60	Shuha-4	2.0
79	Portugal Old Variety-19	2.0
116	GRU90-205266 (Tunisia)	2.0
Sensitive:		
51	Dovin-1	4.75
17	Bacanora 86	4.5
39	69-148/Hys/3/Au/Up301//Gll/Sx/4/Pch//Kt54Ae/ Nar/3/A	4.5
47	Sudan#8	4.5
50	Peg's'//HD2206/Hork's'	4.5
64	Dorghal	4.5
73	Tadinia	4.5
Checks:		
	G61450 (Very Tolerant)	1.25
	Halberd (Tolerant)	2.0
	Mexipak 65 (Moderately Sensitive)	3.0

(S.K. Yau and G. Ortiz Ferrara)

4.1.6.5. Enhancing Germplasm Development and Distribution

Close interaction between CIMMYT, ICARDA and key national program staff in WANA has resulted in a number of improved genetic stocks being identified. These stocks are assembled as parental material having desirable traits and are distributed yearly, upon request, to NARS for use in their breeding programs (Table 4.10). A total of 1735 accessions have been distributed during the last ten years. This activity assists in decentralizing our breeding activities and encourage national programs to take more responsibility for generating new sources of genetic variability.

Table 4.10. Number of bread wheat lines with desirable genetic traits distributed to national programs as genetic stocks during the last ten years. 1987-1996.

Genetic traits	Average No. Per year	Total over Ten years
High yield and stability:	38	380
Abiotic stress tolerance:		
Terminal drought	23	229
Cold	14	135
Terminal heat	14	137
Biotic stress resistance:		
Yellow rust	14	138
Leaf rust	10	93
Stem rust	6	55
Septoria leaf blotch	12	115
Common bunt	11	109
Wheat stem sawfly	14	138
Hessian fly	5	50
Selected landraces:	8	78
Bread making quality:	8	78
Total		**1735**

In addition to these gene pools and other improved, semi-finished germplasm, the bread wheat breeding project has also distributed early segregating populations (F2's and F3's) to NARS in WANA. This operation started in 1979 with the objectives of a) providing increased genetic variability and b) allowing national programs to select breeding material under their local conditions. Table 4.11 lists the number of F2 and F3 segregating populations that have been distributed to NARS in WANA, and the number of locations where these crosses have been tested during the last 14 years (1983-1996).

Table 4.11. Early segregating populations distributed to national programs in WANA during 1983 to 1996.

Year	No. of accessions		Total	No. of locations	
	F2	F3		F2	F3
1983	150	_	150	32	_
1984	150	918	1068	30	6
1985	150	600	750	15	7
1986	87	126	213	50	6
1987	150	425	575	26	6
1988	128	455	583	26	6
1989	102	155	257	29	5
1990	120	848	968	30	6
1991	116	471	587	30	6
1992	122	362	484	25	5
1993	135	350	485	40	5
1994	130	282	412	30	5
1995	123	180	303	20	3
1996	121	_	121	25	0
Total	**1784**	**5172**	**6956**	**408**	**66**

A total of 6956 early segregating populations have been distributed to 474 location-years within the region. The experienced obtained so far is that most NARS have released more varieties from directly introduced, semi-finished material than from early segregating populations. This trend is in agreement with results that have been documented in a recent survey carried out by the economics program of CIMMYT (Byerlee and Moya 1993). Research infrastructure, budget availability, trained manpower, and overall strength of NARS are the main factors accounting for these differences.

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

Improved bread wheat germplasm is also distributed in other forms to national programs in West Asia and North Africa upon request with the goal of: 1) providing promising lines for potential release as commercial varieties in those countries, and 2) collecting information on the adaptation of the lines in the region. Table 4.12. shows the regional spring bread wheat nurseries for 1996/97 assembled by the joint CIMMYT/ICARDA bread wheat Project. Five new germplasm pools for sources of resistance to yellow, leaf and stem rust, septoria tritici blotch, and loose smut were prepared and distributed for the next crop cycle. There was no seed shortage except for the Segregating Populations. A total of 507 nursery sets were distributed in response to cooperators' requests.

(S.K. Yau, Nadia Fadel, G. Ortiz Ferrara, M. Asaad Mousa and A. Yaljarouka)

Table 4.12. CIMMYT/ICARDA Regional Spring Bread Wheat Nurseries for 1996-97.

Nursery	Abbreviation	No. of entries	No. of sets distributed
Regular Nurseries			
Crossing Block	WCB	117	36
Segregating Populations	WSP	129	32
Observation Nurseries:			
- Semi-arid Areas	WON-SA	200	41
- Favorable Areas	WON-FA	143	54
Yield Trials:			
- Semi-arid Areas	WYT-SA	24	45
- Favorable Areas	WYT-FA	24	60
Specific-trait Nurseries			
Heat and Drought Tolerance Observation Nursery	HDTON	50	57
Germplasm Pools for Sources of Disease Resistance			
Yellow Rust Resistance	WYRGP	8	46
Leaf Rust Resistance	WLRGP	11	49
Stem Rust Resistance	WSRGP	18	34
Septoria Tritici Blotch Res.	WSTGP	11	34
Loose Smut Resistance	WLSGP	11	19
Total			**507**

4.1.6.6. Enhancing Germplasm Adaptation.

Three major agroecological zones have been identified in WANA based on moisture availability and temperature regimes. These are: 1) areas of low rainfall associated with low temperatures, 2) areas of moderate rainfall with moderate to high temperatures, and 3) irrigated areas. The CIMMYT/ICARDA spring bread wheat Project places special emphasis on developing germplasm suitable for zones 1 and 2.

Grain yield and yield stability are the most important factors to consider in Zone 1 (low rainfall associated with low temperature). Table 4.13 shows the performance of elite bread wheat lines in selected Zone 1 locations of West Asia and North Africa. All the six lines shown in this Table were significantly higher (P`0.05) than the national check. This is significant considering that the national check is an improved-commercial variety grown at each particular location. A considerable number of other lines in the trial also yielded significantly higher than the national check. The yield superiority ranged from 15% (Breda, Syria) to 84% (Chakwal, Pakistan). All these lines are under extensive testing and multiplication in those countries.

Yield potential and disease resistance are the most important factors responsible for the adaptation of wheat in Zone 2 (moderate rainfall with moderate to high temperatures). Table 4.14 shows the grain yield, stability of performance, and yellow rust disease reaction of promising bread wheat lines in selected locations of Zone 2.
It is interesting to note not only the yield advantage over the improved and long-term checks, but also the better yellow rust disease resistance in those lines. Yellow rust has become the number one foliar disease, especially in countries in West Asia. This Disease has caused considerable yield losses during the last three years in countries such as Iran, Turkey, Lebanon, Syria, Afghanistan, Iraq and Pakistan. Seed of these and other disease resistant lines have been made

available to those countries during 1996.

Table 4.13. Performance (*) of bread wheat germplasm in the rainfed (less than 400 mm) and temperate areas of WANA. Regional Wheat Yield Trial for Semi-arid Areas 1994-95.

Country (Site)	Top Yielding Line	Grain Yield (kg/ha)	% Over NC	LSD. 05 CV (%)	F
West Asia: Afghanistan (Khost)	Prew'S' CM59377-3AP-1AP-3AP-2AP-1AP-0AP	2444	131	410 16	1
	NC	1871			
Syria (Breda)	Florkwa'S' ICW84-0250-09AP-300L-2AP-300L-0AP	2552	115	627 17	2
	NC	2228			
Pakistan (Chakwal)	BocrO-1 CM67430-1AP-1AP-1AP-1AP-0AP	2508	184	217 10	9
	NC	1361			
Lebanon (Tel Amara)	Pvn'S'/Sprw'S CM46702-2AP-0AP-2AP-1AP-0AP	3856	128	810 19	1
	NC	3017			
North Africa: Morocco (Merchouch)	Kaby'S' SWM11027-2AP-2AP-2AP-1AP-0AP	1333	129	253 18	2
	NC	1033			
Egypt (Ismailia)	Cham 6	2637	116	770 29	1
	NC	2266			

* = Based on its statistical superiority over the national check variety at each location.

F = Number of lines yielding significantly higher (p`0.05) than the national check.

NC = National check.

Table 4.14. Overall performance for grain yield and stability of promising CIMMYT/ICARDA bread wheat lines in 36 locations of West Asia and North Africa. Regional Wheat Yield Trial-Favorable Areas (RWYT-FA) 1994-95.

Pedigree	Mean Yield (kg/ha)	Reg. coef.	Top 5*	Over NC	YR
Kauz'S' CM67458-4Y-1M-3Y-1M-4Y-OB	5450	1.056	17	12	R
Bocro 3 CM69599-4AP-2AP-3AP-3AP-0AP	5266	1.190	15	11	5MR
Cham 4	5254	1.126	15	6	5MR
Bloyka ICW84-0008-013AP-300L-3AP-300L-0AP	5136	1.142	13	7	5MR
Dovuc 2 CM58808-1AP-2AP-1AP-4AP-0AP	5061	1.108	8	9	R
Cham 2/Vee'S' ICW85-0049-03AP-300AP-300L-2AP-0L-0AP	5037	1.086	5	5	5MR
Mexipak (long-term check)	4338	0.749	5	2	100 S

* = Total number of times that each entry ranks fifth or less. Over NC = Number of times that the entry exceeds the national check (LSD test, P=0.05, 1-sided test). YR = Yellow rust disease reaction at Tel Hadya under artificial inoculation.

(G. Ortiz Ferrara, NARS Collaborators, Outreach Staff, S.K. Yau, M. Asaad Musa and A. Yaljarouka)

4.1.6.7. Enhancing the Germplasm's Rate of Adoption

Improved cultivars must be tested by farmers before they can be released. On-farm trials are run by National Programs in

Syria, Algeria, Sudan, Lebanon, Morocco, Tunisia, Yemen, and Jordan. These activities aim to substitute the un-improved, local varieties with improved ones. A number of bread wheat varieties have been released as a result (ICARDA's Annual Report 1996). Many countries requested and obtained small amounts of newly bred cultivars registered in the region.

Collaborative research with the Syrian national program is attempting to develop new bread wheat cultivars with better yield, yield stability, quality, disease resistance and tolerance to abiotic stresses than Cham 4 and other improved varieties. Results from our joint on-farm verification yield trials in the country show three new promising bread wheat lines Ghurab-2 (SWM 11623-9AP-3AP-7AP-2AP-1AP-0AP), and DOUMA 11670 (=Shuha-5, SWM11508-1AP-1AP-5AP-1AP-0AP), and Memof-22 (=Kauz, a semi-dwarf Mexican line of CIMMYT-Mexico origin but with unknown selection number) which are higher yielding, with improved bread making quality and have better disease resistance than the local check. They are currently under large scale testing and multiplication in farmers fields.

The two percent, two-years average yield advantage of Ghurab 2 over the improved check Cham 6 (Table 4.15), and the small yield advantage of Memof-22 over the improved checks Cham 4 and Bohouth 6 may not be so impressive (Table 4.16).

Table 4.15. Performance of Ghurab 2, promising CIMMYT/ICARDA spring bread wheat lines in on-farm verification trials planted in the rainfed, low-rainfall areas of Syria during 1994-95 and 1995-96.

Variety	grain Yield 1994/95	(kg/ha) 1995/96	Average	%Over Cham 6
Ghurab 2	2201	3153	2752	102
Cham 6 (IC)	2183	2814	2703	100
Site Mean	2026	2856	2565	

IC = Improved check.

However, because of the different genes for yellow rust resistance and the much better grain quality of Ghurab 2 and Memof-22, the National Program of Syria will consider these lines as possible candidates for commercial release. The CIMMYT/ICARDA program supports the idea of diversifying the number of bread wheat varieties offered to farmers in order to minimize potential disease outbreaks and epidemics.

Table 4.16. Grain yield and yellow rust resistance of Memof-22 (Kauz'S'), promising CIMMYT-Mexico bread wheat line under irrigated and high-rainfall conditions in Syria. Farmer's Verification Yield Trials 1995 and 1996.

Cultivar	Grain Yield (Kg/ha) 1995	Grain Yield (Kg/ha) 1996	Average Yield (Kg/ha)	% over Improved Checks	YR
Irrigated:					
Memof-22	7779	7504	7642	105	5MR
Bohouth 6 (IC)	7697	7261	7479	102	50MS
Cham 4 (IC)	7408	7191	7300	100	10MR
Site mean	7371	6847	7109	97	-
High Rainfall:					
Memof-22	-	4689	4689	113	5MR
Cham 4 (IC)	-	4374	4374	105	10MR
Bohouth 6 (IC)	-	4156	4156	100	50MS
Site mean	-	4260	4260	102	-

Similar results were obtained from farmer verification yield trials conducted during 1995-96 in the rainfed areas of Lebanon. Two CIMMYT/ICARDA bread wheat lines yielded more than the local check variety Baalbek. These were: Roomy (Pvn/Cli, CM 52139-2AP-2AP-1AP-4AP-1AP-0AP), and Nesser, also known in Syria as Cham 6. On average, these varieties yielded 17 and 15%, respectively more than the local check at two locations in Lebanon (Terbol and Kfardan). Nesser was released three years ago by the Lebanese national program and has now replaced the susceptible low-yielding local varieties in farmers fields. Roomy was released for commercial production in 1995 and it is expected to be widely adopted by farmers due to its better yellow rust resistance and grain quality.

Due to the success, the use of the on-farm verification trials system (including enhanced farmer's participation in the evaluation of bread wheat germplasm), has been emphasized and strengthened over the last seven years with several countries in WANA.

As a result of this, more than 102 varieties have been released in 21 countries of the region (Germplasm Program Annual Report 1995). These improved varieties have now replaced the old, low-yielding varieties in several countries such as Syria, Lebanon, Sudan, Iran, Egypt, Morocco, Tunisia, and others. Other countries outside the targeted region have also released varieties originating from this joint project (ie. China).

These results have significantly contributed to increase the spring bread wheat production of countries such as Syria, Sudan, Egypt, Tunisia, Morocco and others. As an example, the host country Syria has made tremendous increases in wheat production by replacing the old, low-yielding, disease susceptible cultivars from farmer's fields, with the new-improved and stable varieties.

As an example, Figure 4.2 shows the amount of seed multiplied and distributed by the General Organization of Seed Multiplication of Syria (GOSM), of the spring bread wheat commercial varieties released in the country since 1983. Assuming a seed rate of 150 kg/ha, this would amount to a coverage of approximately 241,00 ha during 1992-93 crop season, about 200,000 ha during 1993-94, approximately 279,000 ha in 1994-95, about 436,000 ha in 1995-96, and 433,000 ha in 1996-97 with the improved spring bread wheat varieties. The actual area covered may be more because many farmers in Syria retain their own seed for the next crop cycle.

During the last five years, the improved spring bread wheat varieties have replaced the local wheat variety Mexipak 65. Cham 6 (Nesser), an improved bread wheat variety released by the Syrian national program in collaboration with this joint project for the rainfed, low-rainfall areas of the country, has become the leading variety grown by farmers (Figure 4.2). Cham 4 (Flk 'S'/Hork 'S'), another spring bread wheat variety jointly identified and released for farmers in the moderate rainfall and irrigated areas of the country, continues to increase in area too. The approximate amount of Cham 6 seed multiplied by GOSM has increased from 4,000 tons in 1992 to 27,314 tons in 1996, a six fold increase. Similar trends are occurring in other countries such as Lebanon, Algeria and Jordan, where this variety has also been released for commercial production.

The impact of these and other durum varieties to the economy of Syrian farmers has been assessed with most precision in a 1991 survey conducted by ICARDA (FRMP Annual Report 1991). It has been calculated that the value of all these varieties amounted to US$31 million in the 1990-91 season in terms of increased production. The cost effectiveness of this project is amply demonstrated by the impact study quoted above, which indicates the benefits from only one country in the region in one year.

(G. Ortiz Ferrara, A. Shehade, M. Moaheldin, M.A. Antoun, N. Rbeiz, N. Haddad, O.F. Mamluk, M. Michael, M.Asaad Mousa and A. Yaljarouka)

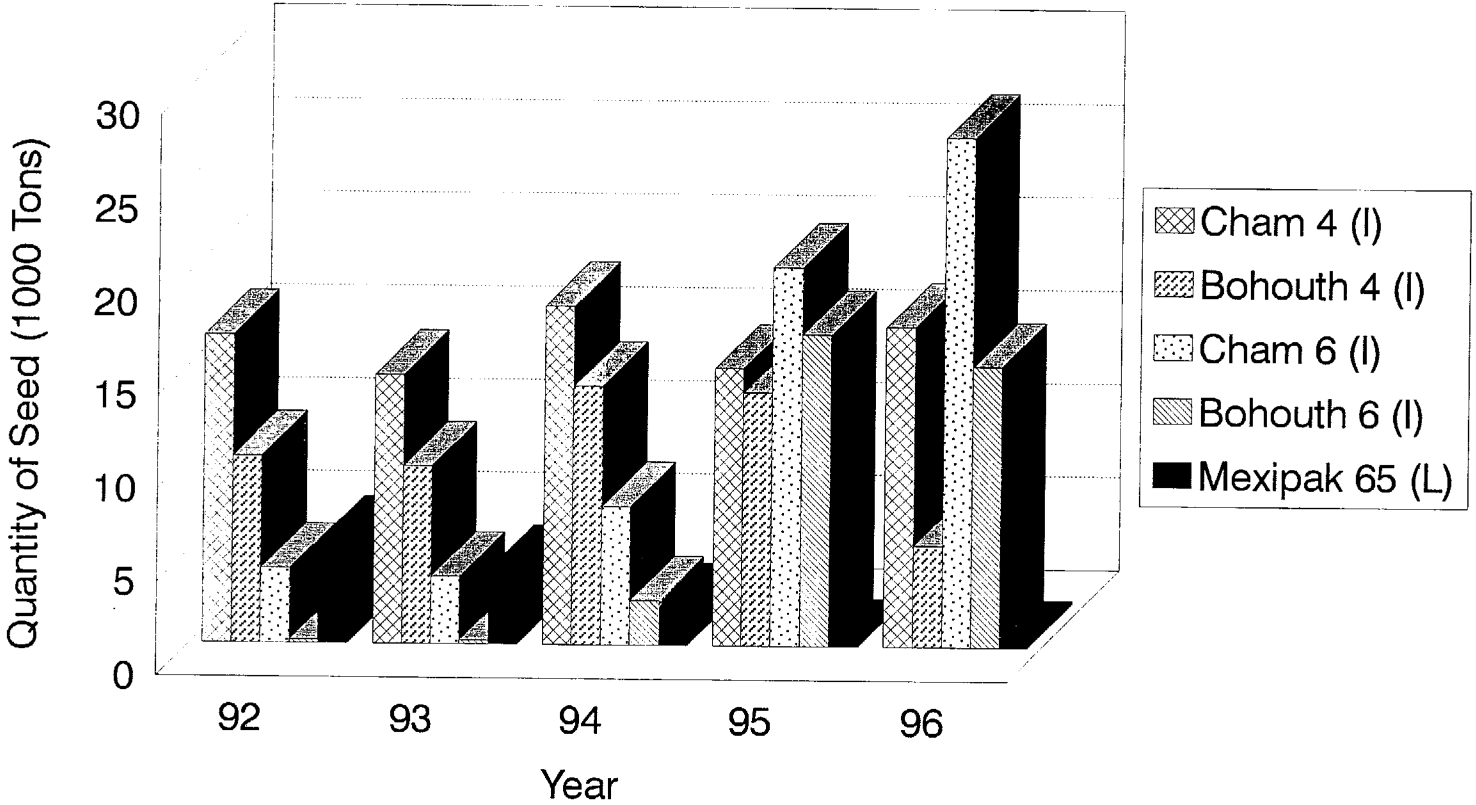


Fig. 4.2. Seed of improved (I) and local (L) bread wheat varieties produced by the Government Organization for Seed Multiplication (GOSM) of Syria and distributed to farmers during the last 5 years (1992-96).

4.1.6.8. The Future

The future direction of the joint CIMMYT/ICARDA Spring Bread Wheat Improvement Project is documented in the new MTP of ICARDA. The title, as well as the new code number, for this project in the new MTP is: "CIMMYT/ICARDA Spring Bread Wheat Germplasm Improvement for Increased Productivity, Yield Stability and Grain Quality in Dry Areas", Project 1.3.

Changes in direction and emphasis:

Table 4.17 presents the joint spring bread wheat project's research priorities (1994-2000). The rainfed, low-rainfall areas of the region will continue receiving greater attention.

In doing so, the project's philosophical approach will continue to closely cooperate and interact with the different research support disciplines available at both Centers. Also, It will continue collaborating with advanced mentor institutes in areas of special interest (ie. physiology, yellow rust, BYDV, breeding, etc). More importantly, the project will maintain close partnership with strong NARS in the region by decentralizing those research activities where NARS have a comparative advantage (ie. Hessian fly and RWA in Morocco; aphids and foliar disease screening in Egypt; heat research in Sudan, etc).

Finally, due to the success experienced during the last 5 years, the Project will re-emphasize the use of certain biotechnological techniques such as the production of double haploid, as a tool to develop germplasm in a short period of time, combining desirable traits needed in the dryland areas of the region.

Table 4.17. List of research priorities in the CIMMYT/ICARDA spring bread wheat improvement project (1994-2000).

Research activity	Production zone		
Priority	LRT (<400mm)	MRT (400-600mm)	IRR
Breeding			
Yield	****	*	D
Yield	****	*	D
Stresses			
Terminal	****	*	D
Cold	****	D	D
Heat	***	*	*
Salinity	**	*	*
Methodology			
Selection methods	****	**	D
Multilocation testing	****	*	D
Strategies	****	*	D
Pathology			
Foliar diseases	*	***	*
Seed borne diseases	***	D	D
Viruses	***	**	*
Entomology			
Insect pests	****	*	*
Agronomy	***	*	D
Physiology	****	*	D
Biotechnology	***	*	D
Quality			
Bread making	****	*	D
Nutritional	****	*	D
Training	****	**	D
Regional activities	****	****	****

LRT = Low rainfall, low temperature areas; MRT = Moderate rainfall with moderate to high temperature areas; IRR = Irrigated areas.
Priority: * Low; ** Medium; *** High; **** Very high. D = Discontinued.

(G. Ortiz Ferrara, O.F. Mamluk, K. Makkouk, M. Baum, M. El Bouhssini, F.J. El Haramein, M.Asaad Musa and A. Yaljarouka)

4.2. Double haploid line production in spring bread wheat

During 1996 we have screened spring wheat germplasm to assess its capacity of androgenesis. The F1 material used (Table 4.18) combines yellow rust resistance with good agronomic performance. The F1 of 22 spring wheat crosses were analyzed for their green plantlet regeneration capacity under the same experimental conditions (growing conditions of donor plants 15°C, day 10°C night with 16 h day length, 8 h night in growth chambers, using the same induction media, BAD1 and regeneration media (R9). The crosses with a high number of induced calli and even more importantly, with a high conversion rate of calli into green plants, yield an acceptable number of green plants per 100 cultured anthers.

Analysis of variance has shown that there are significant differences for genotypes and temperatures. In general, it seems to be most important to collect induced calli in due time (6 weeks after plating anthers) and subject calli to light on regeneration media. If this can be done, a high rate of conversion of calli into green plants is achieved. During 1996 a total of 1000 green plants, and due to the *in vitro* cloning procedure used afterwards, almost the same number of lines will be produced.

(S. Tawkaz, M. Hamameh, G. Ortiz-Ferrara and M. Baum)

Table 4.18. Response of F1 plants to androgenesis using two temperature regimes (15°C and 18°C) donor plants:cross, number of calli per hundred anthers (calli), number of green plants per hundred anthers (green plants).

Cross	Calli %	Green Plant %	Cross	Calli %	Green Plant %
21	44.7	11.0	14	38.66	6.1
15	58.7	6.0	8	16.2	4.8
18	25.7	2.9	15	37.2	3.2
4	13.1	2.9	20	17.9	2.5
7	9.1	2.4	10	4.2	2.4
20	32.3	2.0	7	11.0	1.5
11	29.8	1.4	1	18.0	1.5
3	24.0	1.4	16	7.2	1.3
16	29.2	1.9	12	25.8	1.0
14	5.7	1.0	3	28.7	0.9
17	5.8	1.0	4	8.5	0.9
10	17.1	1.0	21	17.1	0.9
12	22.2	0.9	9	11.5	0.6
2	0.8	1.1	8	0.8	0.5
8	5.5	0.8	2	8.7	0.4
1	0.7	1.3	24	0.6	0.4
5	5.1	0.7	17	12.3	0.3
6	8.0	0.7	19	12.0	0.3
13	6.8	0.6	5	4.2	0
19	6.4	0.5	6	2.3	0
9	22.3	0.4	18	14.9	0

4.3. Seedling Boron-Toxicity Tolerance

The 1995/96 Bread Wheat Crossing Block was tested for B-toxicity tolerance. The screening was conducted under a plastic house in soil mixed evenly with boric acid at the rate of 100 mg B/kg soil (giving a hot water extract of 28 ppm B). Seedling growth was scored visually 5 weeks after sowing. The most boron-toxicity tolerant (best growth) and sensitive (worst growth) entries are given in Table 4.19. As there is evidence that genotypes relatively tolerant to boron toxicity are also relatively susceptible to boron deficiency and vice versa (Nable et al. 1989), the boron-toxicity sensitive entries are expected to be tolerant to boron deficiency.

(S.K. Yau, G. Ortiz Ferrara)

Table 4.19. Boron-toxicity tolerant or sensitive entries in the 1995/96 Bread Wheat Crossing Block (grown in soil to which boric acid was mixed at a rate of 100 mg B/kg soil).

Entry No.	Name/Cross	B-toxicity Score
Tolerant:		
14	Shi#4414/Crow's'	1.0
43	Bolal	1.75
23	Shi#4414/Crow's'	2.0
60	Shuha-4	2.0
79	Portugal Old Variety-19	2.0
116	GRU90-205266 (Tunisia)	2.0
Sensitive:		
51	Dove's'/Inia/4/4777(2)//Fkn/Gb/3/Pvn's'	4.75
17	Bacanora 86	4.5
39	69-148/Hys/3/Au/Up301//G11/Sx/4/Pch//Kt54Ae/Nar/3/A	4.5
47	Sudan #8	4.5
50	Peg's'//HD2206/Hork's'	4.5
64	Dorghal	4.5
73	Tadinia	4.5
Checks:		
	G61450 (Very Tolerant)	1.25
	Halberd (Tolerant)	2.0
	Mexipak (Moderately Sensitive)	3.0

4.3.1. International Nurseries Distribution

Regional bread wheat nurseries for 1996/97 assembled by the joint CIMMYT/ICARDA bread wheat project at ICARDA are given in Table 4.20. Five new germplasm pools for sources of resistance to yellow, leaf and stem rust, septoria tritici blotch, and loose smut were prepared. There was no seed shortage except for the Segregating Populations. A total of 507 nursery sets were distributed in response to cooperators' requests.

(S.K. Yau, G. Ortiz-Ferrara)

Table 4.20. Regional spring bread wheat nurseries for 1996-97.

Nursery	Abbre-viation	No. of entries	No. of sets distributed
Regular Nurseries			
Crossing block	WCB	117	36
Segregating Populations	WSP	129	32
Observation Nurseries:			
Semi-arid Areas	WON-SA	200	41
Favorable Areas	WON-FA	143	54
Yield Trials:			
Semi-arid Areas	WYT-SA	24	45
Favorable Areas	WYT-FA	24	60
Specific-trait Nurseries			
Heat and Drought Tolerance Observation Nursery	HDTON	50	57
Germplasm Pools for Sources of Disease Resistance	WYRGP	8	46
Yellow Rust Resistance	WLRGP	11	49
Leaf Rust Resistance	WSRGP	18	34
Stem Rust Resistance	WSTGP	11	34
Septoria Tritici Blotch Res.	WLSGP	11	19
Loose Smut Resistance			

4.4. Entomology

4.4.1. Wheat Stem Saw Fly

The screening for resistance to Wheat stem saw fly was carried out in a farmer field at Sarakeb and under augmented caged infestations at Tel Hadya. However, results from the cages were not considered due to the very low level of infestation. A total of 2263 lines were evaluated at Sarakeb: 181 of winter bread wheat, 231 of spring bread wheat and 1851 of barley. 26 lines were selected out of winter bread wheat, 32 of spring bread wheat and 53 of barley; all of these lines had 0 infested plants. Only these field selected lines will go to cage testing in the 1996/97 season to confirm field results. They will also be re-tested in the field, in the same hot spot location at Sarakeb.

(M. El Bouhssini, N. Sharaf Eldin, S. Caccarelli, S. Grando, H. Ketata, G. Ortiz-Ferrara and A. Joubi)

4.4.2. Russian Wheat Aphid

The screening for resistance to RWA was carried out in the field at Tel Hadya and in the plastic house. A total of 2518 lines of barley, 181 of winter bread wheat, 231 of spring bread wheat, 72 of durum wheat and 144 of *Aegilops* spp. were screened in the field under artificial infestation. 29 barley, three Aegilops accessions and two durum wheat lines were selected from the field and were tested in the plastic house to confirm their reaction. Other special nurseries were also tested in the plastic house: 5 winter bread wheat from Colorado State University (USA)and 17 accessions of wild species from INRA (France).

Of the 29 barley lines, 11 showed a very good level of resistance to RWA (score <3 in DUTOIT scale from 1-6). six of these lines are crosses with *Hordeum spontaneum*. The three Aegilops accessions and the two durum wheat lines were also resistant (score < 3) in the plastic house. These durum wheat lines are crosses with *Aegilops spp*. Two of the five winter wheat lines from Colorado were also very resistant (Table 4.21). The fact that only two of the five are resistant, indicates the existence of biotypic variation in RWA populations (Table 4.22). This was also supported by differential reactions of six barley lines that were all resistant to RWA in Morocco, but only five were resistant to RWA in Syria (Table 4.23). The wild species from INRA France were all very resistant to RWA (score of 2), 13 are *Triticum monococcum* and three are *T. boeoticum* (Table 4.21).

Table 4.21. New sources of resistance to Russian wheat, Tel Hadya, 1996.

Species	No. accessions tested	No. resistant accessions
T. aestivum	416	2
T. Turgidum	72	2
H. vulgare	2434	29
T. monococcum	12	12
T. boeoticum	3	3
Aegilops spp.	144	3

Table 4.22. Biotypic variation in Russian wheat aphid populations (Bread wheat differentials), Tel Hadya, 1996.

Line	RWA(North America)	RWA(West Asia)
F96PYN3-1838	R	S
F96PYN3-1828	R	R
F96AYN2-321-DN5	R	S
F96AYN2-315-DN6	R	R
Halt-DN4	R	S

Table 4.23. Biotypic variation in Russian wheat aphid populations (Barley differentials), Tel Hadya, 1996.

Line	RWA(N.Africa)	RWA(W.Asia)	RWA(N.America)
Ciho-1412	R	R	R
Ciho-9897	R	R	R
PI366447	R	R	R
PI366449	R	S	R
PI366450	R	R	R
PI366453	R	R	R

(M. El Bouhssini, N. Sharaf Eldin, S. Caccarelli, S. Grando, I.Ghannoum, M.M. Nachit, J. Quick (Colorado State University), C.A. Dedryver (INRA, France) and A. Joubi)

4.4.3. Hessian Fly

The work on Hessian fly was carried out at the Dryland Agricultural Research Center (INRA, Settat, Morocco). During the 1995/96 season, we evaluated 149 accessions of a Moroccan collection of wild species. This collection was evaluated in the greenhouse using a heterogenous Hessian fly population.

Three species from the Moroccan collection showed homogenous resistance reaction, *Ae. geniculata*, *Ae. neglecta* and *Ae. ventricosa*. This latter seems to be a good reservoir of resistance to this insect; 86% of the accessions tested were resistant (Table 4.24). All the resistant accessions had

Table 4.24. Reaction of a Moroccan collection of *Aegilops* for resistance to Hessian fly, greenhouse test, Settat, Morocco, 1996.

Species and Genome	NO. accessions tested	NO. resistant accessions
Ae.geniculata (UM)	109	8
Ae.neglecta (UM)	3	1
Ae.triuncialis (UC)	15	0
Ae.ventricosa (DUn)	7	6

dead first instar larvae, indicating that antibiosis is the mechanism responsible for their resistance. These sources of resistance are being used in the CIMMYT/ICARDA durum wheat breeding program.

(M. El Bouhssini, O. Benlhabib (IAV Hassan II), M.M. Nachit and S. Lhaloui (INRA, Morocco))

30 double haploid spring bread wheat lines were evaluated for resistance to Hessian fly at Jemaa Shaim station, Morocco. This field evaluation confirmed that H5 gene was successfully transferred from SD8036 to three bread wheat lines. These results corroborate those of last year's in the greenhouse, Settat, Morocco. Two of these lines that showed good agronomic type will be in advanced yield trials in the 1996/97 season (Table 4.25).

Table 4.25. Reaction of double-haploid spring bread wheat lines for resistance to Hessian fly, Jemaa shaim, Morocco, 1996.

Entry number/pedigree	No.plants tested	% resistant plants
Vee 'S'/SD8036 461-91HBW5-1	54	92
Vee 'S'/SD8036 461-91HBW5-1	71	96
Vee 'S'/SD8036 461-91HBW5-1	53	94
Saada (resistant check)	65	100
Cham-6(susceptible check)	62	0

(M. El Bouhssini, G-Ortiz Ferrara, M. Baum, M. Mergoum, N. Nsarellah, A. Amri and S. Lhaloui (INRA, Morocco))

4.4.4. Cereal Insect Survey in Libya

This survey was carried out from 13-17 April, and covered costal areas from Sabrata to Masrata. A total of 62 fields (11 of bread wheat, 9 of durum wheat, and 35 of barley) were surveyed. Seven Oat fields were also surveyed in the eastern area from Tripoli to Sabrata.

The Shoot fly and Russian wheat aphid damage were difficult to assess at this late period of time. Apparently, the shoot fly is causing heavy damage to barley; most of the farmers we talked to had to re-plant their fields. This fly is known as the "sowing fly" (Diptera: Anthomyiidae, *Delia platura* (Meigen). This species is synonymous to *Hylemia cilicrura* Rond, and is probably the same that occurs in Ethiopia.

The barley stem gall midge, *Mayetiola hordei* (Keiffer), seems to be the second most damaging insect a long the costal central areas of Libya. Across all the barley infested fields, the average percent infestation was 70%.

The most surprising finding is that Hessian fly, *Mayetiola destructor* (Say), was not found in all the surveyed areas in Libya. This insect occurs in all the Mediterranean countries, Morocco, Algeria, Tunisia, Spain and Portugal. Another survey, covering the costal area from east to West, is necessary to confirm this finding.

(M. El Bouhssini, O. Mamluk, O. Yahyaoui,(INRAT, Tunisia), F.S. El Bakkoush and E.M. Alsoul(ARC,Libya))

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5. FACULTATIVE AND WINTER WHEAT

Introduction

This year's activities cover the joint work conducted by breeders, pathologists, entomologists, virologists, and other scientists from ICARDA and its partners from Turkey, CIMMYT, Iran, and other countries from North Africa and West-Central Asia.

Growing conditions in the 1995-1996 season were generally favorable in Turkey, Morocco and Algeria where rainfall was above average in most areas of those countries. In Iran, the season was dry and cereal stands were thin in the rainfed highlands. In Syria, rainfall was relatively high in Tel Hadya (404 mm) and Breda (360 mm), the two sites used to screen the facultative and winter wheat (fww) materials for diseases, insect pests, and for drought tolerance, and at Sarghaya, a high elevation (1450 m) site with much in common with highland environments in North Africa, Lebanon, and parts of Turkey (Fig. 5.1).

Emphasis in the project continues to be placed on the development and testing of fww germplasm in the target environments of the highlands and continental areas of North Africa and West-Central Asia, for use by NARS, with the goal of enhancing productivity in those areas.

(H. Ketata)

5.1. Generation and Management of Germplasm

In 1996, around 900 crosses were made each at Izmir, Turkey and Tel Hadya, Syria. In Turkey, the crossing(60% single- and 40% top crosses) benefits from the large number of introductions planted at the Izmir Research Institute. In Syria (80% single- and 20% three-way crosses) the greenhouse facilities made it possible to conduct over half of the hybridizations under controlled conditions, thus resulting in time saving and good seed set and size. At Tel Hadya, all single crosses involved at least one parent resistant to yellow rust. Most of the single crosses were of the winter-facultative or winter-winter types, while the majority of three-way crosses involved at least one facultative parent. Spring-winter crosses represented 10% of all crosses, and this will increase in the future. Already, spring materials are included in the crossing block and are evaluated for cold tolerance. Also were included in the crossing block at Tel Hadya, GRU collections (390 entries) of both cultivated bread wheat, and wild species from the region and abroad, all of which were tested for yellow rust and the resistant entries used in the crossing program. One hundred single crosses were advanced through the summer with 2-week vernalization, and supplemental light in Nov. to hasten maturity, of which the F_2 seed were harvested and planted in Dec 1996. Around 750 F_1 families were planted in 1-m rows at Tel Hadya, infected with yellow rust and used in three-way crossing.

Segregating materials generated at Tel Hadya are first screened for diseases before being sent to Eskisehir, Turkey, at the F_3 stage for cold and winter-environment testing. The general flow of germplasm follows the pathway outlined in last season's report, except that the F_2 this year are also bulk-screened for diseases (3 rusts) at Haymana, Turkey. F_3 populations at Eskisehir experienced a moderate level of yellow rust infection, and F_4 , F_5 head rows were adequately infected with yellow rust at Cumra, Turkey.

(H. Ketata, H. Braun, A. Morgounov, H. Ekiz, M. Keser, M. Jarrah)

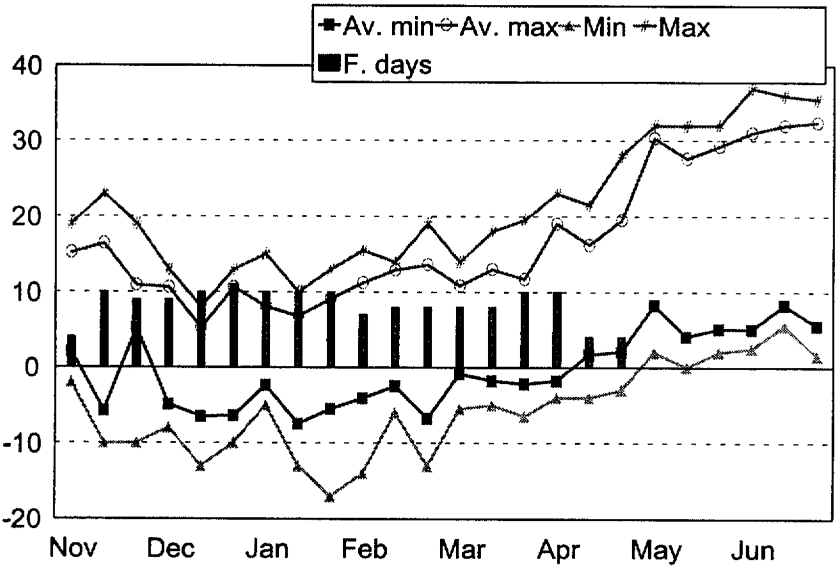

Fig. 5.1. Ten-day average and absolute temperature minima/maxima, and number of frost days at Sarghaya (36 20'E, 33 10'N; 1450 m.a.s.l.), 1995-96.

5.2. Yield Testing

Preliminary yield trials (PYT) comprised 1400 families that were tested at Cumra for yield performance, and at other sites in Turkey (Haymana, Izmir) and Syria (Tel Hadya) for diseases, mainly yellow rust and common bunt. The majority of PYT entries are F_5 F_3-derived families and therefore still contain a non-negligible amount of segregating material. Individual reselection within the promising families will lessen the difficulty of assessing the value of the families. Nevertheless, 304 families were selected this season to enter the YT-stage in 1997. A number of entries combined resistance to both yellow rust and common bunt, along with an acceptable or high yield at Cumra (Table 5.1).

Table 5.1. Promising PYT entries combining resistance to yellow rust and common bunt at Tel Hadya and good or adequate yield at Cumra, 1996.

Entry name	Ent.no.	GH*	LR*	SR*	Protein*
BJN837/GRK	5043	W	R	S	11.6
TSI/VEE//2*TRK13	5100	W	S	R	14.0
PVN/CLI//TAM200/3/SHI44/CROW.	5155	W	R	R	12.8
MEX COMP3/4/SB360	5159	W	R	R	13.8
4777*2//FKN/GB/3/VEE/4/BUC...	5185	F	S	R	13.0
DOVE/BUC//GRK79/6/LOM11/SON..	5194	W	S	R	14.0
130L1.11/TAM200//JI5418	5241	F	R	R	13.1
UT1556.68/VEE9//AK702/3/UNKN	5263	F	R	S	12.1
GRK/5/RRV/WW15/3/BJ/2*ON//BON.	5303	F	S	R	13.3
TX81V6614/5/RRV/WW15/3/BJ/2*O.	5316	W	R	S	12.8
6720.11//MDA38/WRM/3/69.148/..	5457	F	S	S	12.5
RPB868/CHRC//UT1567.121/3/..	5461	F	S	S	12.2
JING411/TAM200	5593	F	S	R	12.1
58.182/DRC//SPN/3/KATYA/4/BJ..	5694	F	S	R	13.7

* GH = growth habit (W=winter, F=facultative), LR = leaf rust; SR = stem rust (R=resistant, S=susceptible). Grain protein is expressed in percent dry weight.

Promising entries from intermediate yield trials(or in short, yield trials, YT) and advanced yield trials (AYT) are shown in Tables 5.2 and 5.3. Yield performance is primarily based on testing at Cumra under both irrigated and rainfed conditions (350 mm annual rainfall) and at Eskisehir under rainfed conditions (363 mm). Among the more advanced lines, ID800994.W/VEE and TIRCHMIR1/LCO confirmed their previous superiority and therefore will be advanced to international testing. The lines PTZ NISKA/UT1556-170 have high yield but are susceptible to yellow rust, a characteristic still dominant in the AYT material. In contrast, the more recent YT germplasm has a larger proportion of resistant lines. A fairly large number of breeding lines in all trials had a facultative type of growth habit. Provided cold tolerance is incorporated into the germplasm, this type of growth habit seems most appropriate to the majority of the wheat growing areas in the highlands of the Region.

The testing of breeding materials under both irrigated (i.e. semi-irrigated) and rainfed conditions continued at Tel Hadya and was started for the first time at Cumra. This procedure presents the triple advantage of (1)evaluating the yield potential of the test lines, (2)determining genotype-environment interaction, thus allowing a better targeting of germplasm, and(3)assessing their response to heavy versus low-or-no yellow rust pressure (refer to the section titled "yellow rust" in this chapter). In general, a yield depression of 30-40% was noted at Cumra when the materials were grown under rainfed conditions, as compared to only 3% at Tel Hadya where the disease pressure was much higher and susceptible cultivars yielded more than resistant ones under low disease pressure. Both the AYT's and the YT's are screened for yellow rust in observation plots at Tel Hadya and Haymana.

Table 5.2. Selected entries with superior performance in intermediate yield testing (YT), 1996.

Entry name	Entry number	Ave. yield*	Growth habit	Heading	Shattering	Yellow rust
338-K1-1//ANB/BUC	7073	5048	SP	M	R	MR
LINFEN875072/KAUZ	7052	4453	F	M	R	S
OK82282//BOW/NKT	7057	4617	W	M	R	MR
RAN/NE701136//CI13449/CTK/7/SOTY...	7124	5040	W	M	R	R
NWT/3/TAST/SPRW//TAW12399.75	7120	4342	W	M	R	MS
MANNING/SDV1//DOGU88	7270	4343	W	M	R	MS
TX69A5092//BBY2/FOX/3/TK13/5/C126-15..	7263	4466	F	L	R	MS
88 ZHONG 257//CNO79/PRL	7076	5116	SP	ME	R	R
CA8055/GRK	7116	4376	W	ME	R	R
88 ZHONG 257//CNO79/PRL	7082	4842	FS	M	MR	R
AU/CO652337//2*CA8055	7192	4600	W	M	S	MR
OK82282//BOW/NKT	7054	4625	FS	M	R	R
CA8055/KUTLUK	7184	5308	W	M	MR	R

* Based on data from 3 (Turkey) or 4(Turkey and Syria) sites. Significantly superior to the check in 1 or more sites.

R = resistant, S = susceptible, MS = moderately susceptible, MR = moderately resistant, M = medium, ME = mid-early, W = winter, F = facultative, SP = spring, FS = facultative-to-spring.

Table 5.3. Selected entries with superior performance in advanced yield testing (AYT), 1996.

Entry name	Entry number	Ave. yield*	Growth habit	Heading	Shattering	Yellow rust	Leaf rust	Grain protein (%)
ID800994.W/VEE	9107	5264	W	ML	R	MSMR	R	12.0
TIRCHMIR1/LCO	9194	4238	FW	E	MR	R	S	11.6
LOV26//LFN/SDY(ES84-24)/3/SE.	9012	4907	FS	ME	MR	MS	R	12.1
PTZ NISKA/UT1556-170	9146	5110	W	M	MS	S	R	12.0
VORONA/HD2402	9123	4052	F	ML	R	R	R	12.7
EGL//BUC/PVN	9184	4588	F	VL	R	S	R	12.3
PTZ NISKA/UT1556-170	9144	5145	W	ME	R	S	R	11.6
PTZ NISKA/UT1556-170	9150	4923	W	ML	R	S	R	12.7

* Based on data from 3 (Turkey) or 4 (Turkey and Syria) sites. Significantly superior to the check in 1 or more sites.
R = resistant, S = susceptible, MS = moderately susceptible, MR = moderately resistant, M = medium, ME = mid-early, ML = mid-late, VL = very late, W = winter, F = facultative, WF = winter-to-facultative, FS = facultative-to-spring.

In 1996, relatively strong winds blew at Tel Hadya at harvest time, which allowed an effective screening against shattering. Large differences were observed among genotypes, grain loss per spike varying between zero and 70%, with a much higher frequency of susceptible types in the YT's as compared to the AYT's. Shattering types are generally selected out indirectly through grain yield assessment, which explains the better performance of the more advanced material; however, bread wheat breeders may benefit more, by decreasing the number of entries to test in advanced trials, if they discard shattering types in earlier generations.

Yield data are primarily generated at Cumra and Eskisehir. Although the two sites are generally adequate for testing fww, they do not expose the materials to severe cold; in addition, specific soil-related problems are yearly observed at both sites (micronutrients, soil-borne diseases: root rot and nematodes) which may or may not be important in other areas. Multilocational testing is consequently needed to better assess the value of the germplasm. Yield tests are therefore conducted on the advanced materials at Tel Hadya (a spring-facultative wheat environment, generally adequate for assessing the yielding value of facultative types, targeted for Morocco and Pakistan), Dyarbakir (a facultative wheat environment), Erzurum and Maragha-Iran- both being cold winter environments.

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

5.3. International Nurseries

Data on the fourth FAWWON were received from 50 cooperators, including 18 from the ICARDA Region, i.e. in Afghanistan, Algeria, Azerbaijan, Iran, Lebanon, Syria, Turkey and Uzbekistan. The data included evaluation of grain yield, winterkill, days to heading, plant height, lodging, and diseases (yellow rust, leaf rust, powdery mildew, and others). Cooperators from the Region selected 14-34 entries depending on their local conditions. A line that performed well across the testing sites is: "1D13.1/MLT" (entry 69) that was both high yielding and tolerant to yellow rust. A large variability of response to yellow rust was observed across sites, among and within countries (e.g. Iran). However, a few entries showed resistance across all testing sites; these were: entries 66 (90ZHONG150), 68 (90ZHONG557), 65 (90ZHONG58), and 34 (F130L1.1321). A number of other entries showed moderate resistance across sites. In general, however, the nursery had a majority of entries susceptible to yellow rust, and often agronomically unadapted to the local conditions, warranting a better targeting of the entries for different ecologies in the future, e.g. entries for severe cold versus milder areas, and for high rainfall versus drier rainfed areas.

The 5th FAWWON was grown in 1996 by about 30 cooperators in the ICARDA Region (and 140 outside the Region). While complete results will be reported in 1997, once data are received from cooperators, data from a few sites already indicate a general improvement over the 4th FAWWON. However, the nursery still contains a large amount of materials unadapted to the Region's environments. A further improvement is needed and pursued.

Two elite yield trials, one for the rainfed areas (1st FWWEYT-RF) and another for the irrigated areas(1st FWWEYT-IR), each made of 25 entries, were distributed to 20 cooperators in the Region. Data were received from 16 cooperators for the rainfed trial and from 14 for the irrigated trial. Results were compiled, analyzed, and distributed to the cooperators. Although the major trait was grain yield, other evaluated traits included: reaction to diseases (3 rusts and powdery mildew), days to heading, plant height, grain quality (mainly grain color, test weight, kernel weight, protein content, SDS value, and farinograph values) and cold tolerance. Certain entries showed good yield performance, including the lines KS82142/CUPE (entry 9913) and ZAR/71ST2959//CROW (entry 9924), but no line had an acceptable yellow rust resistance that would make it a viable commercial cultivar.

A disease resistance nursery (DRN) was assembled for the first time and distributed to a limited number of cooperators. The nursery is comprised of 281 entries consisting mainly of AYT, YT, and PYT lines possessing resistance to yellow rust plus one or more of the following: leaf rust, stem rust, common bunt, and powdery mildew. Certain entries will be retested by the pathologist for confirmation, to build genetic stocks for specific diseases or disease combinations.

Other nurseries (e.g. CB, AYT, YT, segregating populations) have been distributed, upon request, to a small number of cooperators, mainly in Iran and Turkey, but also in Azerbaijan, Turkmenistan, Kyrghyzstan, and Kazakhstan.

(H. Ketata, H. Braun, A. Morgounov, H. Ekiz, G. Marcucci)

5.4. Yellow Rust

Segregating populations and advanced breeding materials were screened for yellow rust resistance at Tel Hadya-Syria, and at Haymana (Ankara), Izmir, Eskisehir, and Cumra in Turkey. Infection level was high at Tel Hadya, moderately high at Izmir and Haymana, and medium at Cumra and Eskisehir. This is complemented by data from Iran and other testing sites in the Region (and outside the Region, through the International nurseries). The multi-locational testing (particularly in Turkey, Syria and Iran) proved useful because of the variability in pathogen races and virulence spectrum across and within countries.

The recent spread of yellow rust in the Region is primarily attributed to the predominance of commercial varieties possessing the 1B/1R translocation that provided a specific resistance (Yr9) which broke down in 1989-1990. Presently, the program is using multiple sources of resistance by bringing in germplasm from all over the world, and using resistance of wheat wild relatives, where available. Materials from China were noted for their high frequency in resistant entries. Over 90% of the crosses made in Syria in 1996 involve at least one resistant parent. No cross had two highly susceptible parents.

Two years ago, most of the fww germplasm grown at Tel Hadya was susceptible or highly so. Severe screening under successfully created epiphytotics led to the improvement of the degree and extent of resistance in the IWWIP germplasm (Figure 5.2). Results (Table 5.4) of new germplasm (260 YT lines) tested at Tel Hadya showed that yellow rust decreased yield significantly, by 25% under rainfed (404 mm) conditions and by 31% under supplementary irrigation (rainfall plus 40 mm). The small difference between these two figures (25 vs 31) and the larger effect on yield of yellow rust in 1995 as compared to 1996 are attributed to the higher rainfall in 1996 (404 mm, as compared to 313 mm in 1995). A more controlled experiment, where the disease was controlled with a fungicide, showed that the percent yield reduction (y) is related to the percent leaf coverage (x) by the following equation:

$$y = 0.46 x + 1.77 \qquad (R^2 = 0.88^{**})$$

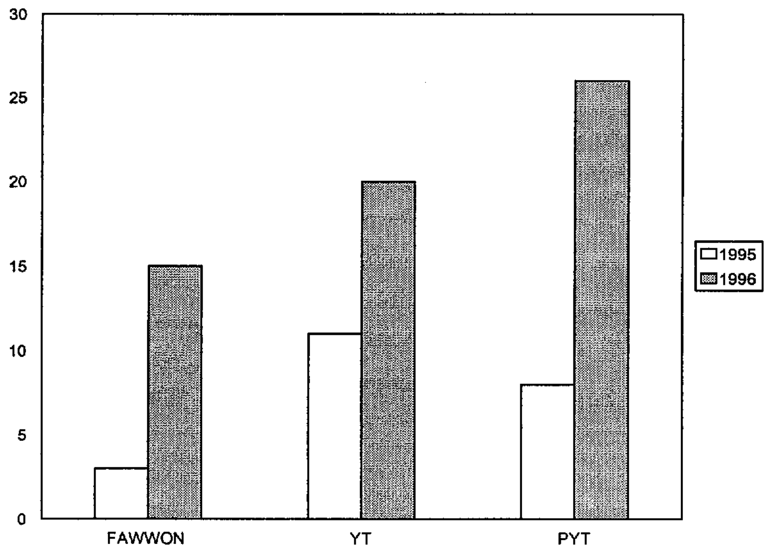

Fig. 5.2. Percent resistant plants in three nurseries across two seasons.

The study showed that leaf coverage rather than reaction type, is the primary factor causing yield reduction.

Table 5.4. Mean grain yield of facultative/winter bread wheat lines grouped into 5 categories of yellow rust score, and grown under supplementary irrigation (SIR) and rainfed (RF) conditions at ICARDA, Tel Hadya, Syria, 1995-1996.

Y. rust score*	No. of lines	Grain yield (kg/ha)**	
		SIR	RF
1	39	4302 a	4098 a
2	20	4581 a	4222 a
3	17	4226 a	4241 a
4	149	3792 b	3691 b
5	35	2980 c	3054 c
Average	(260)	3848	3743

* 1 = resistant,..., 5 = highly susceptible.

** Means followed by the same letter are not significantly (P=0.05) different.

(H. Ketata, L. Cetin, F. Ducenseli, O. Mamluk, N. Bolat, H. Braun, A. Morgounov)

5.5. Other Biotic Stresses

Viruses

In highland areas, BYDV, and soil-borne viruses are frequent and can cause sizeable yield losses.

In 1996, around 160 advanced fww lines were tested for their reaction to BYDV under artificial infection at Tel Hadya. Evaluation was based on visual observations made at heading and at dough stage, and an average score was assigned to the test lines, using a symptom scale of 0-9 (Table 5.5). While no cultivar was immune, certain entries showed an acceptable level of tolerance, some of which have a good yield performance in Turkey, e.g. entries 9122 and 9133.

Grain yield in Turkey is depressed to varying degrees in certain areas of the Central Anatolian Plateau (Eskisehir, Konya), but little is known about the causal agents, except that they are soil-borne pathogens/viruses. Various root rots and nematodes also may be involved.

Table 5.5. Advanced facultative/winter wheat breeding lines possessing tolerance to BYDV, ICARDA, Tel Hadya, 1996.

Entry name	Entry ID number	BYDV score*
ATAY/GALVEZ87	9117	4
VORONA/HD2402	9119	4
VORONA/HD2402	9122	5
C-126-15-COFN/N10B-P14//PI01/.	9183	5
SN64//SKE/2*ANE/3/SX/4/BEZ/5/.	9131	5
SN64//SKE/2*ANE/3/SX/4/BEZ/5/.	9133	5
BEZ//CNO/GLL/3/RSK//CNO/GLL	9069	5
MNCH/5/JCAM/EMU//CHRC/4/IAS20.	9089	5
ANZA/VRZ	9022	5
PJ/HN4//GLL/3/SERI	9920	5
ABN/JUN	9811	5
KS82142/CUPE	9812	5
BJN C.76	CHINA	5
PJ/HW4//GLL/3/PRL/VEE#6	5TH FAWWON-55	4
TAST/SPRW//ZAR	5TH FAWWON-35	5
BEZOSTAYA1 (CHECK)	RUSSIA	6

* Scale: 0-9, 0=resistant, 9=highly susceptible.

(K. Makkouk, H. Ketata)

Insect Pests

About 160 advanced fww breeding lines were evaluated for their response to wheat stem sawfly (WSS) under field conditions and to Russian wheat aphid (RWA) in cages and in the field. Although 26 lines were found tolerant to WSS and 12 tolerant to RWA, only those in Table 5.6 possessed an acceptable level of resistance to yellow rust. It should be noted that two of the lines, entries 9012 and 9194, also had an excellent overall performance, across sites in Turkey and Syria. Confirmative testing will be conducted in 1997.

Table 5.6. Characteristics of fww advanced lines tolerant to wheat stem sawfly (WSS) and Russian wheat aphid (RWA), ICARDA, Tel Hadya, Syria, 1996.

Line name	Line number	Response to YR*	Yield level*
WSS:			
TEMU39.76/CHAT//CUPE/3/M12.	9071	MS-S	M
UNKNOWN	9076	MR	H
VORONA/HD2402	9122	MR-R	M
PTZ NISKA/UT1556-170	9147	MS	M
KS82W428/SWM754308	9159	MR	L
LOV26//LFN//SDY(ES84-24)/3/	9171	MS	M
TIRCHMIR1/LCO	9194	R	M-H
RWA:			
F10S-1	9004	MS-MR	H
LOV26//LFN/SDY(ES84-24)/3/.	9012	MS	H
DYBR1982-83/842ABVD C-50//.	9019	MS-MR	H
MNCH//TX71A374-4/TX71A1039.	9021	MS	M-H

*Abbreviations for response to yellow rust: as indicated in previous tables. For yield level: H = high, M = medium, L = low.

Early in the season, damage was observed on seedlings at the 3-5 leaf stage, in field A33 at Tel Hadya. Affected seedlings either were yellow, or died. The causal agent was identified as a wireworm (0.5 cm long). The damage was more evident on certain cultivars, while others were resistant. The winter wheat Gerek79 was particularly sensitive.

(M. El Bouhssini, H. Ketata, S. Sharaf Eddin)

5.6. Micronutrients

Boron

About 270 advanced fww lines and cultivars were tested for their tolerance to boron toxicity in the soil, using 2 boron concentrations (50 mg B/kg soil and 100 mg B/kg soil)in metal boxes arranged in a plastic house at Tel Hadya. Readings were made in 2 reps on 1-month seedlings. A visual score was made, based on the area of first leaf affected. Results (Table 5.7) showed 8 entries to have a very good tolerance that equaled or surpassed that of the resistant Australian checks. However, only 3 were also resistant to yellow rust. But other entries with acceptable B-tolerance were higher yielding and more tolerant to yellow rust; this included:F10S-1 (ent. 9004), UNKNOWN (ent. 9076), and VORONA/HD2404 (ent. 9121).

Table 5.7. Advanced fww breeding lines tolerant to boron toxicity, ICARDA, Tel Hadya, 1996.

Entry name	Entry no.	Sympt. score[1]	Y.rust
JUP/4/CLLF/3/II14.53/ODIN//CI...	CB96-18	1.5*	MR
FKG15//TAST/SPRW	CB96-129	1.8*	S
BOLAL	CB96-43	1.4*	S
		0.7**	
LOV26//LFN/SDY(ES84-24)/3/SERI..	6FAWW-39	0.3**	S
HAW19/5/CNN/KRV//KC66/SKP35/4/..	AYT-9029	0.9**	MR
SN64//SKE/2*ANE/3/SX/BZ/5/SERI	AYT-9073	1.0**	S
KS82W422/SWM754308//KS831182/KS.	AYT-9074	1.0**	MS
1D13.1/MLT/3/BEZ/NAD//KZM	AYT-9191	1.0**	S
Checks: HALBERD		1.4*	
		1.2**	
GREEK G61450		1.4*	
		0.8**	

1: symptom score: 0-9 (0 = no symptoms).
* test with 100 mg B/kg soil, ** test with 50 mg B/kg soil.

(S.K. Yau, H. Ketata, J. Ryan)

Zinc

Zinc deficiency is a frequent phenomenum in areas of the CAP. The Turkish national program has conducted surveys and active research during the last few years, which shed light on the mode the deficiency affects plant growth, on its economic importance, and on the way to alleviate it. Also, routine screening is conducted at the Bahri Dagdas Institute, Konya. Certain cultivars and breeding lines were found to possess the ability to grow better and yield higher at low Zn concentrations than others. Table 5.8 shows a number of Zn efficient entries, from the CB of the IWWIP for 1995. These entries are used in targeted crosses for the affected areas.

Zinc deficiency symptoms were also observed on wheat in Iran (Maragheh) both in 1995 and 1996, and in Azerbaijian in 1996.

(H. Ekiz, H. Braun, H. Ketata, A. Morgounov)

Table 5.8. Entries of the fww crossing block (CBW-95) with tolerance to zinc deficiency (zinc test by I. Cakmak, Turkey).

Entry name	Entry no.	Origin	Y.rust
602-156-22	93	Bulgaria	S
4206/3/911B8.10/K351//SAD1/MXP	92	Bulgaria	S
YAN7578.128	105	China	R
ZOMBOR	99	Hungary	S
AGRI/BJY//VEE	22	Mexico	MR
F134.71/NAC	27	Mexico	R
KATIA1	95	Bulgaria	S
SADOVO1	98	Bulgaria	R
F130-L-1-12	76	Romania	MR
2103/CO652142//MARA/SUT/4/CERCO	139	Turkey	S
DAGDAS	20	Turkey	S
F4549-W2-1	83	Romania	MS

5.7. Vernalization

Thirty bread wheat entries were grown in the greenhouse following seddlings vernalization at 2° C for 0, 10, 20, 30, 40, and 50 days. Normal daylight with day/night temperatures of 10/15 °C for 2.5 months and 17/22 °C were used. The experiment was terminated 126 days after planting. The results led to an easy categorization of the entries into spring types (no vernalization effect on heading) versus winter types (not headed when unvernalized). However, a wide class comprised a relatively large number of entries with different degrees of vernalization requirement, where vernalization hastened heading by 9-35 days, as compared to 0-3 days for the spring types and beyond 40 days for the winter types. Most of the facultative types required 30-40 days of vernalization, while certain winter types have not headed when the experiment was completed, even for the 50 day vernalization.

As the sample of experimental lines represents genotypes generally adapted to the highlands of the ICARDA Region, it may be concluded that facultative types form an important group of bread wheat for those areas.

As fww germplasm is generated through hybridization of a wide range of parents, it is very useful to characterize the parents and derived germplasm for growth habit. Such characterization is essential for an effective planning of the hybridizations and targeting of the derived materials.

Summer planting was used to categorize fww germplasm for growth habit; 512 entries (CBAP: 173, 5thFAWWON: 201, selected YT lines: 138) were planted towards the end of June 1996 at Tel Hadya, and heading recorded around end-September. The plants therefore were not exposed to temperatures below 25 °C, such that most of the entries were scored as winter, and facultative types were underestimated. The picture is reversed when spring (early March) planting is used (Table 5.9), as there is large enough a chilling period in March and April that will meet the requirements of facultative types, and some of the winter types. It is concluded that the most appropriate planting time for growth habit determination at Tel Hadya is around early April. If only two types (winter vs spring) need to be distinguished, then summer planting is adequate.

(H. Ketata, M. Jarrah)

Table 5.9. Frequencies of winter, facultative and spring wheat types in three nurseries as determined through summer or spring planting, Tel Hadya, Syria, 1996.

Nursery	Planting	Growth habit			
		Winter	Facultative*	Spring	Total
CBAP96					
	summer	122	26	25	173
	Spring	22	73	78	173
5thFAWWON					
	summer	159	19	23	201
YT96					
	summer	79	26	33	138

* Facultative types are those that headed very late or only approached heading in summer planting, and were mid-late in spring planting.

5.8. Decentralization

Our breeding strategy is built upon the reasoning that the most effective way to develop germplasm that would be adapted to the specific environments of the Region and that would be adopted by farmers is to work within those environments in partnership with researchers and collaboration with farmers. A new Agreement between CIMMYT and ICARDA on the joint work on wheat in the Region, signed in September 1996, called for a tripartite partnership involving Turkey, CIMMYT and ICARDA for the improvement of fww in the Region. As part of the Agreement, the ICARDA wheat breeder will move to Turkey to work more closely with his Turkish and CIMMYT colleagues in a more representative environment, rather than by frequent visits from ICARDA's Headquarters in Syria. The bulk of the breeding work will be conducted by the three parties at Turkish research sites, while back-up activities (pathology, grain quality, entomology, virology, biotechnology, physiology/agronomy, etc.) will be maintained at ICARDA's HQ in Syria, only 7-8 hr-drive from major testing sites in Turkey.

However, as no site can represent all environments in the Region, work also needs to be conducted *in situ* in collaboration with other NARS as well. In 1996, field visits were made to Iran, Azerbaijan and Morocco.

Iran

Weather conditions in 1996 were generally unfavorable for the wheat crops. In rainfed cold areas, yellow rust did not develop, except in research plots, where it was generally of limited extent, apart from Moghan, Orumieh, and Ardebil.

The cultivar Sardari outyielded most of other cultivars and test lines in rainfed environments. However, yields in farmers'fields did not exceed 1 t/ha, although twice that yield could be achieved with this variety by improved agronomic practices.

Researchers in different DARI stations implemented successfully the planned experiments in breeding, pathology, and agronomy.

The breeders identified several promising fww lines, among which are the following: KVZ/TM71/3/MAYA'S'//BB/INIA /4/SEFID; FENKANG15/SEFID; ANZA/3/PI/HYS//SEFID; SBN//TRM /K253; AND OGESTA/SEFID. A number of lines have been selected from the IWWIP materials, including AYT96, 5thFAWWON, and EYT96RF.

The pathologists screened breeders'advanced materials for major diseases, with an emphasis on yellow rust and bunt. For yellow rust, seedling tests were conducted at SPII, Karaj, in greenhouse conditions, and field tests were carried out by DARI in Moghan, Orumieh, and Maragheh, although the infection intensity was only good in Moghan and Orumieh. High readings were also noted at Ardebil. New races of common bunt (3) and dwarf bunt (4) were identified in western and northwestern Iran. Among the best sources of resistance to dwarf bunt are those listed in Table 5.10.

Table 5.10. Facultative and winter wheat entries resistant to dwarf bunt, Maragheh, Iran, 1996*.

Name	Source
KVZ/TI71/3/MAYA'S'.../HYS	IWWIP
ANZA/3/PI/NAR//HYS/4/ALBORZ	IRAN
1-32-1317//II-5017//Y50E/CNO	IRAN
KREMENA/LOV29....	TURKEY
DAGDAS	TURKEY
2-35-1104	IRAN
1-32-1107	IRAN
ZARGOON	PAKISTAN
JCAM/EMU//DOVE	IWWIP

* Test results of H. Hassanpour, DARI, Maragheh.

The URWYT was grown at Maragheh under "rainfed, normal planting (early Nov)" and under "one irrigation at an earlier planting (early Oct)". The new technology (one irrigation at early planting) proved much useful, as it led the crop to an earlier maturity and lower incidence of bunt in the trial. But because of inadequate soil management that was detrimental to the new technology only, no conclusive results could be obtained for yield differences.

(A. Amiri, S. Mahfoozi, M. Rostai, D. Sadekzadeh, M. Torabi, H. Hassanpour, M. Tahir, H. Ketata)

Azerbaijan

Four IWWIP scientists visited Azerbaijan during 10-14 May 1996 to observe research and production systems in major cereal growing areas of this country, and exchange scientific information with Azeri researchers. The country is producing about half of its needs in cereal grains and working to reach self-sufficiency. Although the natural resources are favorable, there is a real need and willingness for collaboration with outside institutions to achieve that goal. Facultative and winter bread wheat is replacing durum in most of the country. Yellow rust, followed by smut, were the major wheat diseases observed in research plots and farmers'fields. Wheat germplasm from IWWIP is needed that possesses tolerance to cold, drought, heat, salinity, and diseases. IWWIP nurseries (FAWWON, FWWEYT's) were provided for the 1996-97 season.

(H. Ketata, A. Morgounov, M. Keser, F. Ozberk)

Morocco

Rainfall was 30% or more above average in most of Morocco. Leaf rust and yellow rust were frequent on bread wheat, and septoria was the major disease on durum. Hessian fly and Russian wheat aphid were observed at lower altitude. Targetted crosses were made by NARS to develop germplasm for the highland areas. In general, bread wheat yielded better than durum wheat in the Middle-Atlas. However, suitable varieties are still lacking for the upper mountain range of the Haut Atlas.

A travelling workshop was organized in May, 1996 by INRA in collaboration with ICARDA within the framework of the EC/ICARDA Mediterranean Highland Project. Scientists from Morocco (9), Algeria (4), Tunisia (3), Turkey (5) and ICARDA (4) visited research sites and farmers'fields in the Middle-Atlas and exchanged views and information on how to improve production in the highlands.

(A. Amri, M. Jlibene, H. Ketata, S. Beniwal)

5.9. Training, Visits and Conferences

Visits were exchanged with scientists from Iran, Morocco, Turkey, and Azerbaijan. Two students from Aleppo University and one from Switzerland were trained for 4 months at Tel Hadya/ Aleppo, on breeding of facultative bread wheat.

ICARDA participated in the coorganization of the 5th International Wheat Conference on 10-14 June 1996, at Ankara, Turkey. Several ICARDA scientists made presentations at the Conference, and a number of scientists from WANA and Central Asia were sponsored to participate.

A regional workshop on "Wheat Yellow Rust Networking in West and Central Asian Countries" was co-organized at Karaj, Iran, during 19-31 May 1996. The workshop called for the close collaboration among the various countries of the Region to exchange germplasm, information and visits, with the objective of controlling this major wheat disease in the Region.

(H. Ketata)

5.10. Boron Toxicity Tolerance

Similar to previous two years, screening for B-toxicity tolerance was conducted under a plastic house in soil mixed evenly with boric acid at the rate of 100 mg B/kg soil (giving a hot water extract of about 28 ppm B). Foliar B-toxicity symptom scores were taken 4 to 6 weeks after sowing.

One hundred and eigthy-one entries from the crossing block were tested. There was a large variation between entries in growth and B-toxicity symptom score. Names and scores for the most tolerant and sensitive entries are given in Table 5.11. As there is evidence that genotypes relatively tolerant to boron toxicity are also relatively susceptible to boron deficiency and vice versa (Nable et al. 1989), the boron-toxicity sensitive entries are expected to be tolerant to boron deficiency.

Table 5.11. Entries in the 1995/96 crossing block having the best or the worst performance in soil to which 100 mg B/kg soil was added.

Entry No.	Name/cross	Growth score[1]	Symptom score[2]
B-toxicity tolerant:			
18	JUP/4/CLLF/3/II14-53/ODIN// CI134431/SEL6425/WA00477	1.0	1.5
43	Bolal	1.0	1.4
129	FKG15//TAST/SPRW	1.0	1.8
B-toxicity sensitive:			
83	GREENBUG RL 132/NWT//NWT/3/PRL	4.5	4.8
84	GREENBUG RL 132/NWT//NWT/3/PRL	4.0	4.5
121	AU2*/TAM101/3/VPM/MOS83.11.4.8// PEW	3.5	4.5
Checks:			
	Helberd	2.2	1.4
	Greek G61450	1.2	1.4

[1] 1 to 5 scale: 1 = good growth with green shoot
[2] 0 to 9 scale: 0 = no symptoms

The 1995/96 advance yield trials consisting of 103 entries were also screened. Entries 76, 96, 97, 16 and 95 had the least symptoms. Entries 87, 51, 69 and 77 had the worst symptom scores.

(S.K. Yau, H. Ketata)

References

Nable, R.O., B. Cartwright, and R.C.M. Lance. 1989. Genotypic differences in boron accumulation in barley: relative susceptibilities to boron deficiency and toxicity. In pages 243-251, N. El Bassam et al. eds., Genetic Aspects of Plant Mineral Nutrition. Kluwer, The Netherlands.

6. PATHOLOGY

6.1. General

6.1.1. General Disease Development during 1995/96 Season

In Syria, the mostly spread diseases of barley were scald and Abu Ulaiwi (Head Sterility) in Bab-Djerablous-Mounbej area, net blotch in Gezireh area and powdery mildew in Aleppo and Euphrates areas. On wheat, septoria tritici blotch and loose smut were the prevalent diseases in Bab-Djerablous-Mounbej and Gezireh areas and leaf rust in Euphrates areas.

In Morocco, major barley diseases encountered during this year's survey were net blotch and scald in Marchouch area and leaf rust in Meknês. Septoria nodorum blotch and tan spot were the most prevalent diseases of wheat in Marchouch area, leaf rust on durum wheat and yellow rust on bread wheat in Meknês.

In Libya, powdery mildew, net blotch and barley yellow dwarf virus were the mostly encountered barley diseases on a disease survey during April 1996. Those of wheat were barley yellow dwarf virus, powdery mildew and leaf rust.

In our screening sites, most barley and wheat diseases created by artificial inoculation developed well and enabled us to screen for disease resistance to yellow rust of wheat and scald of barley at Tel Hadya and Terbol, septoria tritici blotch at Tel Hadya and Lattakia, leaf and stem rusts of wheat and powdery mildew of barley in the plastic houses at Tel Hadya, and common bunt at Tel Hadya. During the summer cycle in Terbol, leaf rust development was moderate and stem rust was in scattered traces.

(O.F. Mamluk; H. Toubia-Rahme)

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

The screening included 219 accessions of wild *Triticum* (67 *T. monococcom*, 28 *T. urartu*, 13 *T. boeoticum* and 111 *T. turgidum*) screened for yellow, leaf, and stem rusts, septoria tritici blotch and common bunt. Considering the selection criteria, 10R-MR for rusts, <3 score (on a 0-9 scale) for septoria tritici blotch and 15% head infection for common bunt, the performance of these species can be summarized as follows:

* *T. monococcom*: all accessions were resistant to yellow rust, 18 to leaf rust and only 1 to stem rust. All, except one accession, were resistant to septoria blotch and 17 accessions were resistant to common bunt.
* *T. urartu:* all accessions, except 2, were resistant to yellow rust, 9 to leaf rust and only 1 to stem rust. All were resistant to septoria blotch, and 19 to common bunt.
* *T. boeoticum:* all accessions were resistant to yellow rust and septoria blotch, but only 1 and 3, respectively to leaf rust and stem rust. Resistance to common bunt was found in 7 accessions.
* *T.turgidum:* 60 accessions were resistant to yellow rust, none to leaf rust or stem rust. All accessions were resistant to septoria blotch and 48 to common bunt (See also Genetic Resources Unit, Ann. Report 1996).

(O.F. Mamluk; J. Valkoun (GRU); M. Naimi; I. Maaz)

6.1.3. Crop Loss Assessment Trials

In the 1995/96 season 8 cultivar/lines (3 bread wheat and 5 durum wheat) from the FFVTs (ICARDA and DSAR Collaborative Program) were tested in a crop loss assessment trial for the acute losses caused by yellow rust. Rust control treatments were two fungicides, triadimenol (Bayfidan) and propiconazole (Tilt), each applied twice and one untreated (infected). Cultivar performance was assessed for Average Coefficient of Infection (ACI), grain yield/ha, tiller/m, seed/spike and thousand kernel weight (1000 KW). Interaction between cultivar and fungicide treatment was significant ($P<0.01$) for ACI, grain yield, and 1000 KW, but not for tiller/m and seed/spike. Data for bread wheat (Table 6.2) and for durum wheat (Table 6.3) are presented in separate sections, 6.5. and 6.6, respectively.

(O.F. Mamluk; M. Singh (CBSU))

6.1.4. Organic Seed-Treatment Substituting Chemical Seed-Treatment

Results from this season trials were added to those of last season (Ann. Rept. 1995) and are presented in Table 6.1. The two common bunt susceptible cultivars, Sebou (durum wheat) and Bau (bread wheat) showed 86 and 87% head infection, respectively in 1994/95 and 55 and 83% in 1995/96 when inoculated with the two pathogens (*T. tritici* and *T. laevis*) mixed in the ratio of 1:1. Seed-treatment with carboxin + thiram (Vitavax-200®) reduced the common bunt infection to 1 and 2% on Sebou and Bau respectively, in 1994/95 season and to 3 and 9% in 1995/96. The skimmed milk treatment reduced it to 7 and 10% and to 3 and 2%, respectively on both cultivars and in both seasons. Similar effects on the reduction of head infection via treatment with skimmed milk occurred when seeds were inoculated with each of the common bunt pathogens separately, *Tilletia tritici* and *T. laevis*. Results will be verified in the coming season (1996/97) and other organic nutrients, locally produced, will be tested.

(O.F. Mamluk; M. Naimi; I. Maaz)

Table 6.1. The effect of organic seed-treatment (skimmed milk) on the control of common bunt of wheat (*Tilletia tritici* and *T. laevis*) as compared to chemical seed-treatment (vitavax-200).

Treatment	Season	% head infection 1994/95		% head infection 1995/96	
	Cultivar	Sebou	Bau	Sebou	Bau
T. tritici & *T. laevis* (check)		86	87	55	83
T. tritici & *T. laevis* + vitavax-200		1	2	3	9
T. tritici & *T. laevis* + skimmed milk		7	10	3	2
T. tritici (check)		nt	nt	69	60
T. tritici + vitavax-200		0	1	4	1
T. tritici + skimmed milk		6	8	5	1
T. laevis (check)		nt	nt	43	67
T. laevis + vitavax-200		0	1	2	0
T. laevis + skimmed milk		3	1	2	2

nt = not tested

6.1.5. Initiated Studies on Foot and Root Rot Diseases in the Dry Areas

Studies on foot-and root diseases in the dry areas started with the appointment of a PDF, May 1996. Field surveys were conducted in three agro-ecological zones of Syria and isolation of the pathogens and soil-antagonisms from collected samples were done. Results showed that *Cochliobolus sativus* and *Fusarium* spp. were frequently isolated from crowns and subcrown internodes of randomly collected samples. Incidence of isolates ranged from 7 to 19% for *C. sativus* and from 16 to 88% for *Fusarium* spp. depending largely on the previous year crop. Among the antagonisms isolated, with proven inhibitory effect to *C. sativus,* were *Trichoderma* and *Gliocladium* spp., in addition to some bacterial strains.

(S. Kamal)

6.1.6. Host Preference in the Pathogen of Wheat Yellow Rust, *Puccinia striiformis*

The host-preference phenomenon has been investigated in a passage-effect test of the yellow rust pathogen over three generations on different host plants. This test has been conducted in the greenhouse at Tel Hadya during the period January-May 1996. A bulk of yellow rust spores, collected at Tel Hadya from all infected wheat lines and cultivars, was used to inoculate seedlings (10-12 days old) of 3 bread wheat cultivars ('Gomam', 'Mexipak', 'Nesser'), 3 durum wheat cultivars ('Raj 1555', 'Baladi Dakar', 'Haurani') and 3 *Aegilops* spp. (*Ae. crassa* accession # 4007006, *Ae. taushii* accession # 400504, *Ae. taushii* accession # 400624). The bulk of spores used for the first inoculation was adjusted to have spores collected from bread wheat and durum wheat in the ratio of 1:1. It included races 6E0, 6E134, 6E148, 6E150, 20E148, 38E150, 134E146, 166E150 and 82E16, with 12 virulences to *Yr7*, *Yr6*, *Yr10*, *YrSD*, *YrSU*, *Yr9*$^+$, *Yr7*, *Yr6*$^+$, *Yr8*, *Yr2*$^+$, *Yr9*, and *YrA*$^+$. At each passage, species groups were scored (17 days after inoculation) for disease reaction on a 0-9 scale. In addition, the virulence of spore inoculum of the bulk and of each generation were analyzed separately using a set of 22 yellow rust differentials. Results indicated loss in the virulence through the passage-effect. The passage of the initial inoculum, with 12 virulences, over only one specific host species shows that the largest number of lost virulences (11) is in durum wheat, followed by *Aegilops* (8) and bread wheat (5). After the 3 passages on durum wheat, the only virulence that survived was *Yr* 6. On *Aegilops*, the 4 surviving virulences were *Yr* 6, 10, 6+ and 2+, whereas on bread wheat the surviving 7 were *Yr* 6, 7, 9+, 7+, 8, 2+ and 9. Excluding the differences in the genetic background of the bread wheat and durum wheat, the above results indicate that a kind of host-preference of the yellow rust pathogen towards bread wheat exists. Results were published in the Proceedings of 9th European and Mediterranean Cereal Rusts and Powdery Mildews Conference, 2-6 September 1996, Lunteren, The Netherlands.

(O.F. Mamluk; S. Hakim (University of Aleppo); M. Naimi)

6.1.7. Measure the Diversity of Sources of Resistance Using Molecular Techniques

Sources of resistance to the major cereal diseases in WANA have been identified at ICARDA but no information is known on the genetic background and the diversity of these sources of resistance. In recent years, the burgeoning field of molecular biology has provided tools suitable for rapid and detailed genetic analyses of agricultural species. The development of molecular markers appears to be a valuable and accurate tool to study the genetics of resistance.

The postulation of resistant genes for yellow rust (bread wheat), leaf rust (durum wheat) and barley leaf stripe (barley) is investigated at present by using molecular techniques. The crosses selected to carry out these experiments are:

for barley-barley leaf stripe:

Arta (susceptible) X SLB 39-05 (resistant)

for bread wheat-yellow rust

Mexipak 65 (susceptible) X WYRGP96 # 4 (resistant)

for durum wheat-leaf rust

Heican-1 (susceptible) X DLRGP95 # 14 (resistant)

These crosses were selected based on their contrasting levels of resistance to the respective disease. The resistant lines were selected from the germplasm pools identified at ICARDA over the past years. As with PCR-based techniques, RAPDs, AFLPs, and Microsatellite based markers appear to be taken up for crops such as barley and wheat, these techniques will be used to identify and localize resistant genes. This work will be done in close collaboration with the Biotechnology Lab. at ICARDA. Parts of the work which can not be conducted at ICARDA, will be performed at the University of Munich (Germany). This study will allow us to estimate how many distinct sources of resistance are represented in the germplasm pools for sources of resistance and provide a useful indication of the genetic relationship between the resistant accessions. It also allows the breeder to select accessions representing the greatest diversity.

(H. Toubia-Rahme)

6.2. Collaboration with NARSs

Routine and general collaboration with NARSs includes the exchange and testing of germplasm, training (see under Training....) and providing NARSs with pools of sources of resistance to diseases (see 6.5.4) and special traits lines, (Differentials). Eight sets of the newly developed "Yellow Rust Differentials", with 45 lines, were distributed to Pakistan, Iran, Lebanon, Syria, Yemen, Ethiopia, Egypt and Morocco. In addition, one set of the Common Bunt Differentials was furnished to NARS in Syria. Specific areas of collaboration with NARSs follow in 6.2.1 to 6.2.5.

(O.F. Mamluk)

6.2.1. The Nile Valley & Red Sea Wheat Rusts Network; The Sub-Network on Wheat Yellow Rust in Ethiopia and Yemen

Achievements of the 1995/96 season were presented during the Nile Valley and Red Sea Coordination Program, Sana'a and are highlighted in the Program Workplan for 1996/97. Emphasis is laid on the write up of accumulated data of the past five years. To decentralize distribution of Trap Nurseries, NVRSRTN and EYYRTN, it was decided that starting the 1996/97 season there will be no central distribution of the trap nurseries from Egypt and Kulumsa. Each Nursery will be increased and distributed for planting at the different locations in each country by the respective collaborator.

(O.F. Mamluk, Y. El-Daoudi (ARC/Egypt), Eshetu Bekele and Ayele Badebo (IAR/Ethiopia))

6.2.2. Central and West Asian Yellow Rust Network

Precipitation from the "Workshop on Wheat Rusts" held at SPII, Karaj, Iran, 19-23 May 1996, a project has been developed on a Central and West Asian Yellow Rust Network.

The Network includes Pakistan, Iran, Turkey, Syria, Azerbaijan, Turkmenistan and Uzbekistan in collaboration with ICARDA, CIMMYT and the University of Sydney. ICARDA is seeking fund for this Network and a trap nursery for yellow rust is already composed and planted (December 1996) for multiplication at Tel Hadya. This Central and West Asia Yellow Rust Trap Nursery (CWAYRTN-97) includes 91 lines, 45 differentials and 46 commercially grown cultivars originating from Ukraine (18), Russia (15), Iran (9) and Turkey (4).

(O.F. Mamluk, M. Torabi (SPII/Iran), C.R. Wellings (PBI/Sydney))

6.2.3. Aleppo University, Aleppo, Syria

6.2.3.1. Yellow Rust

Yellow rust samples (32 from Syria and 10 from Lebanon) were analyzed in this season. Races identified in Syria were: 6E0, 6E134, 6E150, 20E148, 38E134, 38E150, 134E146, 166E150 from Tel Hadya; 6E18 from Tel Jebein; 38E128 from Lattakia; 4E0, 6E0, 6E16, 6E20, 38E134 from Izra'a; 6E0, 38E134 from El-Ghab; and 6E18, 134E146, 38E150 from Himo. One race, 6E20 from Izra'a, is reported for the first time from Syria. However, this race did not bring any additional virulence to the virulences used at our screening site at Tel Hadya. From our Sub-station at Terbol, Lebanon, following races were identified 6E0, 38E134, 38E16, 166E150, 172E146 and 182E150. The latter two races (172E146 and 182E150) are reported here to occur for the first time in Lebanon. Race 172E146 has virulence on *Yr* 6, 3^V , SD, 9^+, 7^+, 8, 2^+, A, and 9. Virulence on *Yr*3^V is new to Lebanon and Syria.

(O.F. Mamluk; M.S. Hakim (University of Aleppo); M. Naimi)

6.2.3.2. Head Sterility in Barley

In the first year of our collaboration with the University of Aleppo on "Head Sterility in Barley" and "Seed-gall Nematodes of Wheat and Barley", several important results were achieved. Incidence of Head Sterility in the 30 fields surveyed of the Bab-Djerablous-Mounbej area varies between 9.6 and 57%. Actual grain losses estimated ranged from 2.4 to 43% and an average loss of 11.4% in any of the fields surveyed. Head Sterility does not correlate with the height of the plants or the presence of seed-gall nematode. Head Sterility prevails in short plants, normal, as well as in tall plants. A large percentage of sterile plants did not have nematodes. Morphological and biological studies and pathogenicity tests were initiated on wheat and barley seed-gall nematodes. Preliminary results show that the seed-gall nematode of barley is a different species from that of wheat (*Anguina tritici*). Specimens were sent to IACR-Rothamsted, UK, for confirmation. The reaction of wheat and barley cultivars tested in pot experiments showed that Bohouth-1 (durum wheat), Cham-4 and Bohouth-4 (bread wheat) were resistant to the wheat seed-gall nematodes; whereas Bohouth-5, ACSAD-65, Jori (durum wheat) and Cham-6 (bread wheat) were susceptible. In the test of barley cultivars, A. Aswad, Arta, Wadi Hassa and SLB 39/10 were resistant to the barley seed-gall nematodes, whereas Mathnan, Rihane-5, Assala, Emir/Apm and Irisnapols were susceptible.

(O.F. Mamluk; H. Zainab and F. Khatib (University of Aleppo); Z. Alamdar)

6.2.4. Directorate for Scientific Agricultural Research (DSAR), Damascus, Syria

Collaboration with DSAR involved the testing and evaluation of DSAR's promising lines (42 lines of wheat evaluated for yellow rust, septoria and common bunt and 75 lines of barley evaluated for powdery mildew, scald and covered smut).

Also FFVTs lines from the joint collaborative program ICARDA/DSAR (45 wheat and 25 barley lines) were evaluated for their resistance to the major wheat diseases (yellow, leaf and stem rusts, septoria and common bunt) and to barley diseases (scald, powdery mildew and covered smut), respectively. The testing and evaluation was done under artificially created epiphytotics at Tel Hadya and in our Sub-site at Lattakia. Candidates lines for release, also from the joint collaborative program, were in addition tested for actual losses due to yellow rust in crop loss assessment trials (16 lines including checks).

(O.F. Mamluk; M. Naimi; Z. Alamdar; I. Maaz)

6.2.5. Collaboration with IAV Hassan-II, Rabat, Morocco

Wheat leaf rust samples, collected 1993-1995 from Iran, Cyprus, Lebanon, Syria, Yemen, Egypt, Ethiopia and Morocco, were analyzed at IAV Hassan-II for pathotypes of the pathogen (virulence analysis). Results obtained showed that *P. recondita* f.sp. *tritici* is highly variable in the WANA region. Similarities of pathotypes of the pathogen are found in neighboring countries. The overall effectiveness of the *Lr* genes tested can be subdivided into four groups. Group 1: effective genes across the region, *Lr19* and *Lr24*. Group 2: partially effective genes, *Lr9* and *Lr26*. Group 3: effectiveness variable in the same country, *Lr1, Lr2a, Lr2c, Lr3, Lr3ka, Lr11, Lr16* and *Lr17*. Group 4: totally ineffective genes, *Lr10 and Lr34*. Detailed information on the virulence analysis have been passed on to concerned collaborators and are in preparation for publication.

Due to flooding of the screening site at Safi during

Spring 1996, it was not possible to screen any of the germplasm for leaf rust under naturally developed epiphytotics. The value of this screening site lays in the presence of the alternate host that grows naturally. However, our special purpose disease nurseries (DLR-96 and WLR-96) were evaluated in the seedling stage at Rabat against 3 pathotypes of the leaf rust pathogen from Ethiopia, Morocco and Syria.

(O.F. Mamluk; B. Ezzahiri (IAV Hassan-II))

6.3. Collaboration with Advanced Institutions

6.3.1. Collaboration with Plant Breeding Institute (PBI) University of Sydney

Our joint effort to setup and test new lines with adult plant resistance as field differentials were successful. The newly composed "Yellow Rust Differentials" with lines developed at PBI/Cobbitty, has been sent for 1996/97 season to Pakistan, Iran, Egypt, Ethiopia, Yemen and Lebanon and it is planted at three sites in Syria.

A project proposal "Near-Isogenic Lines for Assessment of Pathogenic Variation in the Wheat Stripe (Yellow) Rust Pathogen" involving PBI, CIMMYT and ICARDA has been submitted to ACIAR, Australia for funding.

(O.F. Mamluk; C.R. Wellings (PBI, Cobbitty, Australia))

6.3.2. Collaboration with the "Institut für Pflanzenkrankheiten", University of Bonn, Germany

Our collaboration with Bonn focuses on the cereal cyst nematode (CCN), *Heterodera latipons*, with an Ph.D student.

Biological aspects of the nematode, the interaction with root rot pathogens and soil-antagonisms in the soil-ecosystem are the main objective of this collaboration. Results obtained so far showed: the optimal hatching temperature in tap water after five months was 10 and 5°C, where 28 and 26% of the cysts, respectively hatched. No hatching was recorded at 20 or 25°C. Host plants for this nematode are all two row barley land races. Barley varieties like Varde and KVL 191 of the international differential set for pathotyping of *H. avenae* are much better host plants than the barley land races. Among spring barley landraces and cultivars, Arta, Zanbaka, Tadmor and A. Aswad were highly susceptible to *H. latipons*, whereas A. Abiad was resistant and Rihane immune. Out of the four winter barley tested, Tokak and Astrix were immune to the nematode. None of the tested bread and durum wheat cultivars (Haurani, Omrabi-5, Cham-2, Cham-3, Cham-5, Cham-6) were susceptible to the nematode.

In the fields, the higher discoloration of the subcrown internode (SCI) of barley caused by root rot (*Cochliobolus sativus* and *Fusarium nivale*) as well as the higher nematode densities in soil, were correlated with monoculturing of barley. Comparing eight barley lines in three different rainfall zones, Coho*cross and Rihane showed the lowest discoloration of SCI and the lowest nematode densities. A pot experiment showed different reaction of two *C. sativus* isolates under water stress conditions causing discoloration of SCI. Trials to estimate losses caused by the CCN were planted for the 1996/97 season.

(U. Scholz (University of Bonn); O.F. Mamluk; Z. Alamdar; M. Ahmad; I. Maaz)

6.4. Barley Pathology

Spring and winter/facultative barley germplasm developed by breeders were screened for the 5 major barley diseases in WANA region: scald, powdery mildew, barley leaf stripe, covered smut and loose smut. In addition, screening have been done for special purpose disease nurseries which were composed of resistant lines selected from the previous year from different nurseries for the corresponding disease. The screening sites were: T. Hadya and Terbol for scald, T. Hadya (plastic house) and Lattakia for powdery mildew and T. 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.

6.4.1. The Performance of Spring Barley Germplasm to Diseases; 1995/96

The spring barley germplasm evaluated for their performance against diseases were: Parental Germplasm (PARE, 260 entries), North Maghrebian Nursery (NMAG, 185 entries), Barley Initial Increases (BIIN, 3270 entries), Barley Initial Yield Trials (BIT, 869 entries), Barley Advanced Yield Trials (BAT, 132 entries), Farmers Field Verification Trials (FFVTs, 25 entries), and Special Purpose Disease Nurseries: Spring Barley Scald Nursery (SBSC, 246 entries), Spring Barley Powdery Mildew Nursery (SBPM, 124 entries), Spring Barley Barley Leaf Stripe Nursery (SBST, 23 entries), Spring Barley Covered Smut Nursery (SBCS, 59 entries), and Spring Barley Loose Smut Nursery (SBLS, 32 entries).

The performance of the different germplasm towards the diseases is shown in Fig. 6.1. None of the lines tested in the farmers fields verification trials (FFVTs) showed resistant to either scald or powdery mildew. The highest percentage of resistant lines were found in the special purpose disease nurseries with 37% resistant lines for scald (SBSC), 46% for powdery mildew (SBPM), 52% for barley leaf stripe (SBST), 54% for covered smut (SBCS) and 34% for loose smut (SBLS). The percentage of resistant lines in the other disease nurseries was very low and did not exceed 5% except for BAT95 germplasm tested for barley leaf stripe and loose smut where the percentage of resistant lines were 64% and 83% respectively. These lines will be retested next year to confirm first year's results. Some lines in PARE-95 showed multiple disease resistance for scald and powdery mildew (# 55, 120, 218, 225), for scald and covered smut (# 76, 85), and for powdery mildew and covered smut (# 51, 56, 79). One line in NMAG (# 202) was resistant to scald and powdery mildew.

(H. Toubia-Rahme; O.F. Mamluk; Z. Alamdar; I. Maaz)

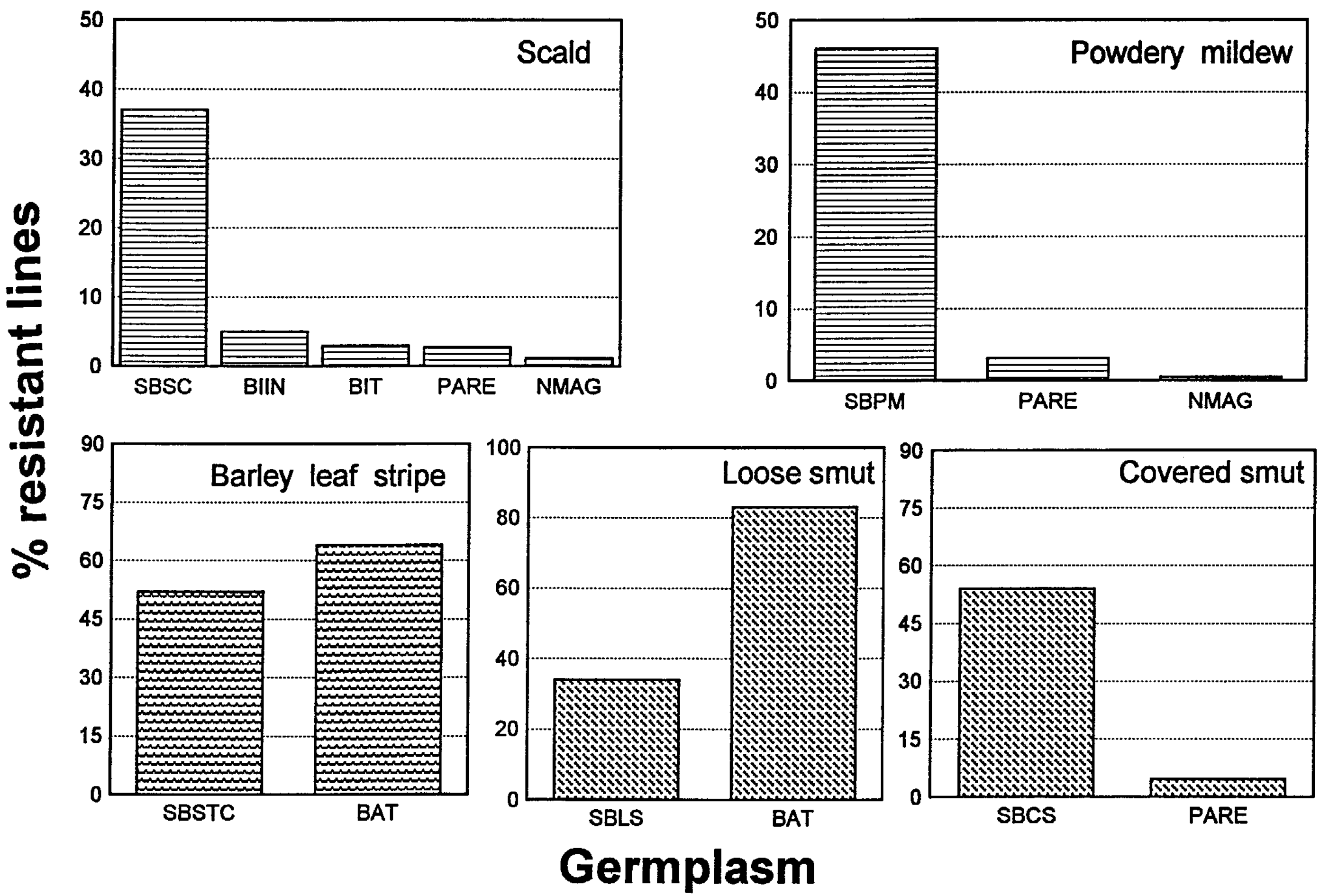

Fig.6.1. The performance of spring barley germplasm against different diseases; 1995/96.

6.4.2. The Performance of Winter/Facultative Barley Germplasm to Diseases; 1995/96

The winter/facultative barley germplasm evaluated for its performance to diseases were: Winter Barley Observation Nursery (WBON, 129 entries), Facultative Barley Observation Nursery (FBON, 136 entries), Hulless Barley Observation Nurseries (HBON, 129 entries), Winter Barley Yield Trials (WBYT, 20 entries), Facultative Barley Yield Trials (FBYT, 20 entries), Winter/Facultative Barley Crossing Block (WFBCB, 150 entries), and Russian germplasm (RUSS-94, 12 entries). The performance of these germplasm is presented in Fig. 6.2. A high percentage of resistant lines for scald (42%) and powdery mildew (58%) was shown in the RUSS-94 germplasm. HBON germplasm was tested for these 2 diseases and the results were 4% resistant lines for scald and 2% for powdery mildew. In WBCB nursery, 8% of resistant lines were found for scald and covered smut. The following germplasm were tested for their performance to scald: FBON, WFBYT, FBYT, and WBON and the % of resistant lines was 21%, 25%, 20%, and 26% respectively. For barley leaf stripe and loose smut 52 lines (24 WBYT95 and 24 FBYT95 + Checks) were tested. Results will be confirmed next year. Some lines showed multiple disease resistance for scald, powdery mildew and barley leaf stripe (RUSS-94; # 1), for scald and powdery mildew (RUSS-94; # 1, 2, 3, 7, 12), for scald and covered smut (WFBCB-96; # 33, 37, 44, 78).

(H. Toubia-Rahme; O.F. Mamluk; Z. Alamdar; I. Maaz)

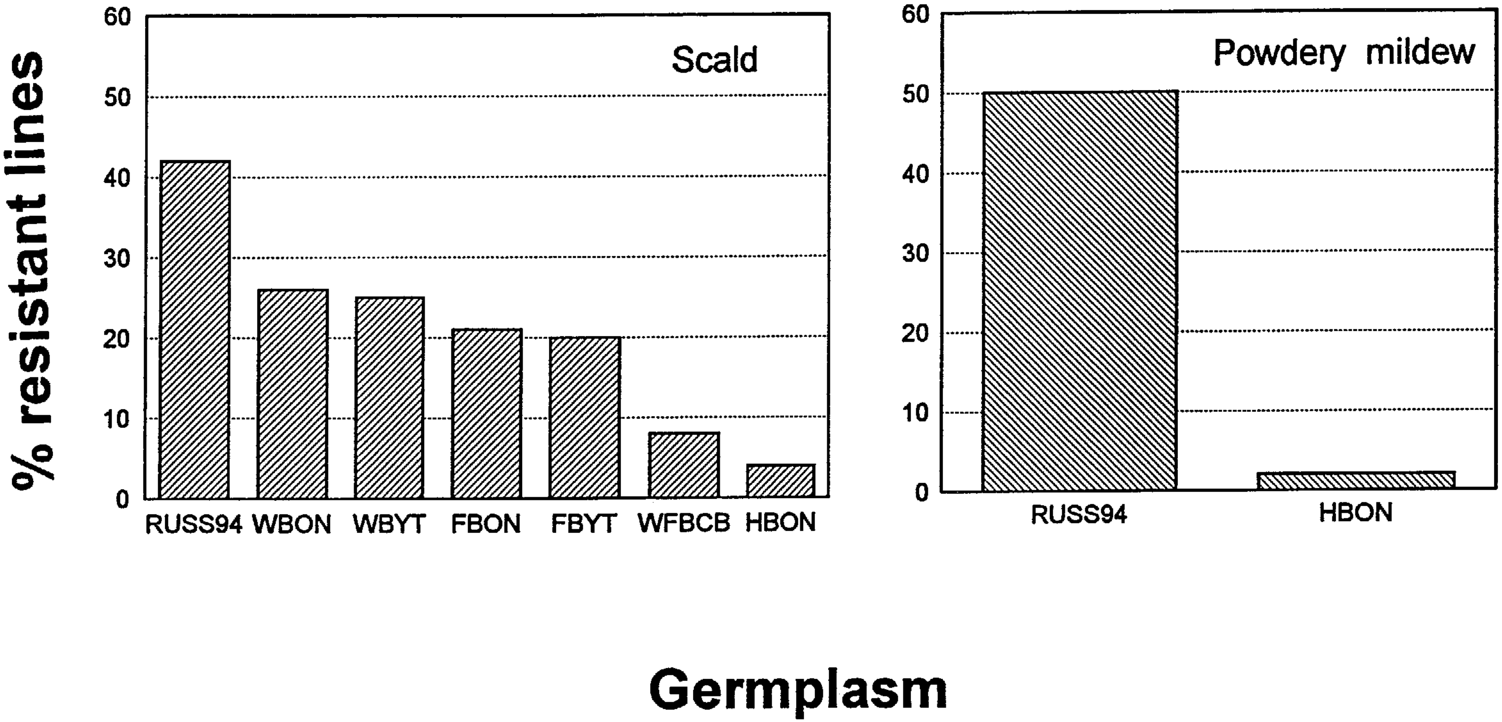

Fig. 6.2. The performance of winter/facultative barley germplasm against diffrent diseases; 1995/96.

6.5. Bread Wheat Pathology

6.5.1. Summary of Disease Data on the Key Location Disease Nursery (WKL-95)

By March 1996 we received all data expected on the WKL-95. Information used were obtained from T. Hadya/Syria and Sakha/Egypt for yellow rust, from T. Hadya, Terbol-Summer cycle/Lebanon, Sakha, Zarzora/Egypt and Ciano/Mexico for leaf rust, from T. Hadya, Sakha and Gemmeiza/Egypt for stem rust, from T. Hadya and D. Zeit/Ethiopia for septoria tritici blotch; and from T. Hadya for common bunt. Selection criteria were <5 ACI for rusts, <5 score (on 0-9) for septoria blotch and 15% head infection for common bunt. Excluding checks and markers, there were 144 lines in the WKL-95. Out of the tested lines, 42, 22, 52 and 40% were resistant to yellow rust, leaf rust, stem rust and septoria, respectively. Seven lines (WKL-95, # 113, 118, 126, 134, 135, 136, 155) have multiple resistant to the three rusts. None of the lines tested has resistance to common bunt.

(O.F. Mamluk; M. Naimi; A. Saleh; I. Maaz)

6.5.2. The Performance of Bread Wheat Germplasm to Wheat Diseases; 1995/96

The germplasm screened for resistance to diseases constituted of the Wheat Preliminary Disease Nursery (WPD, 320 entries = Wheat Preliminary Yield Trials), Wheat Key Location Disease Nursery (WKL, 200 entries = Wheat Advanced Yield Trials), Wheat Regional Crossing Block (WRCB, 117 entries), the different Special Purpose Disease Nurseries: Wheat Yellow Rust Nursery (WYR, 30 entries), Wheat Leaf Rust Nursery (WLR, 55 entries), Wheat Stem Rust Nursery (WSR, 30 entries) and Wheat Septoria Nursery (WST, 50 entries), as well as other germplasm from the Bread Wheat Programs: Winter/Facultative Yellow Rust Common Bunt Nursery (WFYRCB, 21 entries), Yellow Rust for High Elevation (YRHE, 15 entries), Facultative and Winter Wheat Yellow Rust (FWYR, 100 entries), germplasm from Tunis (Tunis, 18 entries) and Australian Material in the Advanced Yield Trials (AYT-AUS, 64 entries). Selection criteria were <5 ACI/CI for yellow rust, <3 ACI/CI for leaf and stem rusts, <5 score on a 0-9 scale for septoria blotch and <15% head infection for common bunt.

Fig. 6.3 shows the performance of the different wheat germplasm against the different foliar diseases screened in a relevant number of screening sites during the 1995/96 season. The highest percentage of yellow rust resistant lines (97%) was found in the YRHE, followed by the WPD and WYR with 51 and 50%, respectively. Other germplasm except TUN (17%) and AYT-AUS (9%) showed a percentage of resistant lines between 30 and 43%.

For leaf rust the four germplasm screened, showed a relatively high percentage of resistant lines, ranging from 52 to 83%, with the highest being in the WRCB.

For stem rust, one germplasm showed a high percentage of resistant lines (WSR) and the remaining tested germplasm have had less than 30% resistant lines.

For septoria tritici blotch, again only one germplasm, (WST) showed a high percentage of resistant lines (33%) and the remaining germplasm were weak in their performance towards the disease.

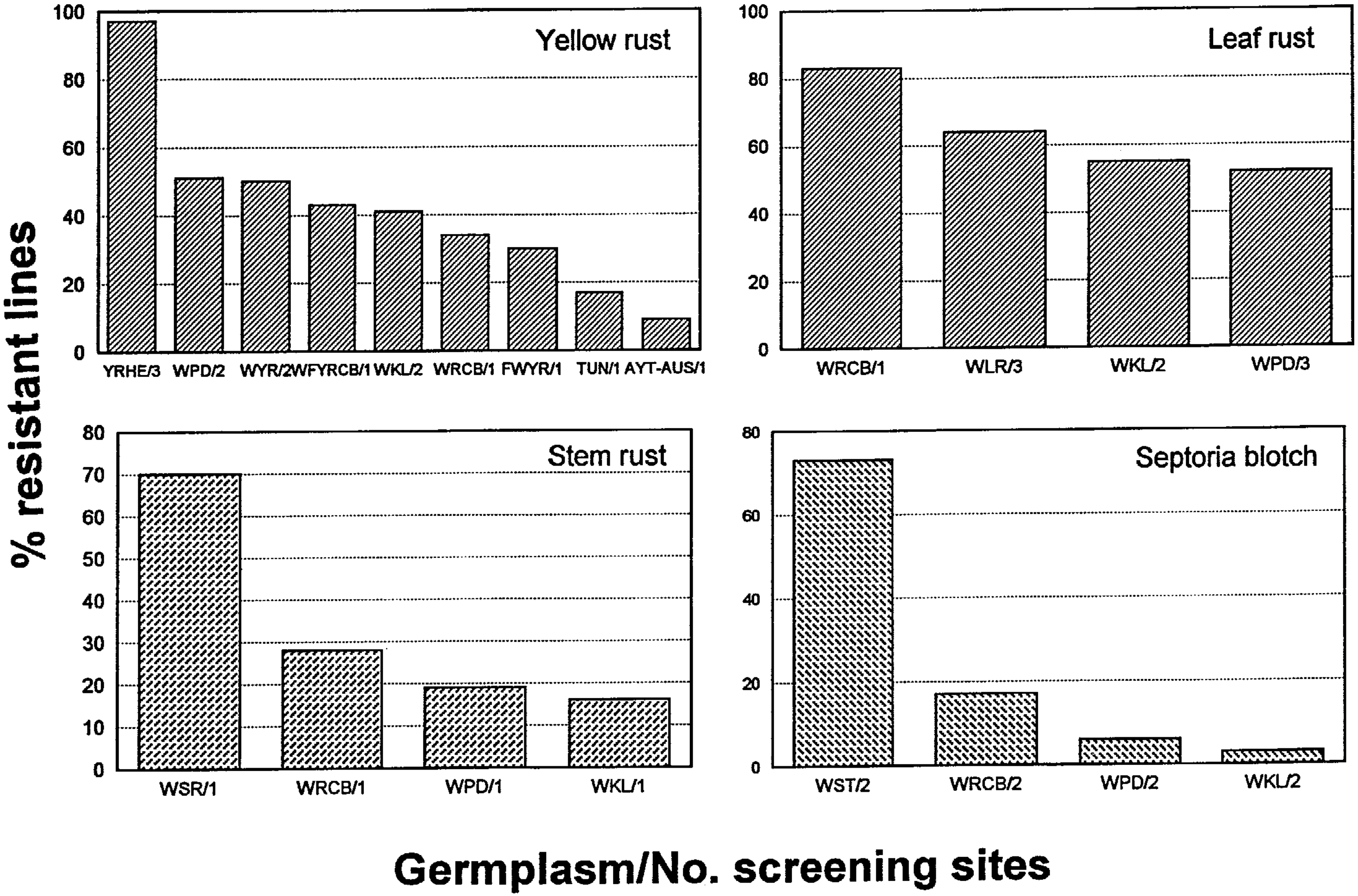

Fig. 6.3. The performance of bread wheat germplasm against different diseases; 1995/96

The germplasm screened for common bunt were WKL and FWYRCB in addition to two lines (Repeat Testing Bunt-95) tested in the Common Bunt II (CBII-96) against ten different isolates of common bunt from the region. Where none of the lines in the WKL showed resistance to the disease, 12 out of 21 lines in the FWYRCB were resistant to common bunt. The two lines testet in the CB-II expressed a high level of resistance to all isolates showing an average head infection of 2.8% (CBII-96 # 7) and 4.1% (CB-96 # 8).

6.5.3. Crop Losses due to Yellow Rust

Results from crop loss assessment trials are presented in Table. 6.2. Fungicide I, triadimenol, reduced ACI in Mexipak from 85.0 to 19.0 and resulted in a highly significant increase in yield. This could be due to the increased number of seed/spike or 1000 KW, as compared to the control. Although both fungicides suppressed the development of yellow rust in cultivar FWWQ-AYT95-125, this was not reflected in a significant yield increase.

(O.F. Mamluk; M. Singh (CBSU); M. Naimi; A. Saleh; I. Maaz)

Table 6.2. Effect of yellow rust (*Puccinia striiformis*) on yield and yield components of bread wheat cultivars; Tel Hadya, Syria 1996.

Cultivar	Treatment	Yellow rust		Yield t/ha	% Yield increase	No.tillers per m	No.seed per spike	1000 KW (gr.)
		Score	ACI					
Mexipak	Infected	85.0 S	85.0	1.85		76.0	33.7	20.5
	Fungicide I	31.7 M	19.0	4.65	151.4	80.0	52.7	30.3
	Fungicide II	60.0 MS-M	44.3	3.11	68.1	79.3	41.7	28.1
ACSAD 529	Infected	5.0 R-MR	1.3	3.84		78.7	44.3	29.6
	Fungicide I	5.0 R	1.0	4.24	10.4	97.7	44.7	32.1
	Fungicide II	5.0 R	1.0	4.45	15.9	104.0	40.3	29.1
FWW-AYT95-129	Infected	75.0 MS-M	55.0	3.72		75.0	51.0	27.7
	Fungicide I	25.0 M	15.0	4.33	16.4	83.7	54.7	29.9
	Fungicide II	20.0 M-MR	11.0	4.01	7.8	75.3	50.0	28.6
	SE 1			±0.25		±6.63	1.94	1.13
	SE 2			±0.24		±6.78	2.00	1.05
	CV%			10%		14%	8%	5.4%

Figures = mean of 3 rep. each 7.2 m^2, harvested 3.6 m^2, from RCBD (treatment as main-plot factor, cultivar as sub-plot). Infected = artificial inoculation applied twice. Fungicide I = triadimenol (Bayfidan EC 250), 0.5 l/ha, applied twice. Fungicide II = propiconazole (Tilt EC 250), 0.5 ml/ha, applied twice. SE 1 to compare treatment at same or different levels of cultivars; SE 2 to compare cultivars at same level of treatments.

6.5.4. Germplasm Pools for Sources of Resistance

Five germplasm pools for sources of resistance to the different diseases were developed, WYRGP-96 for yellow rust (8 lines), WLRGP-96 for leaf rust (11 lines), WSRGP-96 for stem rust (18 lines), WSTGP-96 for septoria tritici blotch (11 lines), and WLSGP-96 for loose smut (11 lines). These Pools were distributed in 210 sets for planting in 1996/97 to collaborators in WANA and beyond.

(O.F. Mamluk; M. Naimi)

6.6. Durum Wheat Pathology

6.6.1. Summary of Disease Data on the Key Location Disease Nursery (DKL-95)

Useful information on the DKL-95 for yellow rust were received from T. Hadya/Syria; on leaf rust from T. Hadya, Terbol-Summer cycle/Lebanon and Safi/Morocco; on stem rust and septoria blotch from T. Hadya and D. Zeit/Ethiopia; and on common bunt from T. Hadya. Selection criteria were <3 CI for yellow rust, <5 ACI for leaf rust and stem rust, <5 score (on 0-9 scale) for septoria blotch and <15% head infection for common bunt. There were 171 lines in the DKL-95, checks and markers excluded. Percentage resistant lines found were 67, 9, 13, 10 and 0% for yellow rust, leaf rust, stem rust, septoria blotch and common bunt, respectively. One line (DKL-95 # 166) was resistant to the three rusts.

6.6.2. The Performance of Durum Wheat Germplasm to Wheat Diseases; 1995/96

Following durum wheat germplasm was tested for its performance to diseases: Durum Key Location Disease Nursery (DKL-96, 240 entries = Durum Advanced Yield Trials), Durum Preliminary Disease Nursery (DPD-96, 220 lines = Durum Preliminary Yield Trials), Durum Aleppo Crossing Block (DACB, 132 entries) and the Special Purpose Disease Nurseries: Durum Yellow Rust Nursery (DYR, 20 entries), Durum Leaf Rust Nursery (DLR, 15 entries), Durum Stem Rust Nursery (DSR, 10 entries) and Durum Septoria Nursery (DST, 15 entries). Selection criteria were <3 ACI/CI for yellow and stem rusts, <5 ACI/CI for leaf rust, <5 score (on 0-9 scale) and <15% head infection for common bunt.

The performance of the germplasm tested against the different diseases with the respective number of screening sites is shown in Fig. 6.4. The highest percentage (67%) resistant lines for yellow rust was found in the DYR, followed by 62% in the DACB. DPD and DKL exhibited a relatively low percentage of resistant lines, 29 and 17%, respectively. For leaf rust, only the DLR had a very high percentage (97%) resistant lines, the remaining germplasm, DPD, DACB and DKL, showed very low percentages of resistant lines, 14, 13 and 8%, respectively. For stem rust, the highest percentage resistant lines (33%) was found in the DSR followed by the DACB with 24%. DKL and PDP exhibited percentage of resistant lines of 15 and 11%, respectively. For septoria blotch, again the special purpose disease nursery, DST, exhibited the highest percentage (79%) resistant lines. DPD, DACB and DKL performed weakly and showed only 10, 8 and 2% resistant lines, respectively.

The screening for common bunt yielded high percentage, 89 and 71% resistant lines in the germplasm tested DKL and DACB, respectively. In the Common Bunt II (CBII-96), 1 out of the 6 lines (Repeat Testing Bunt) tested against ten isolates from WANA showed an average infection of 1.3% (CBII-96 # 6).

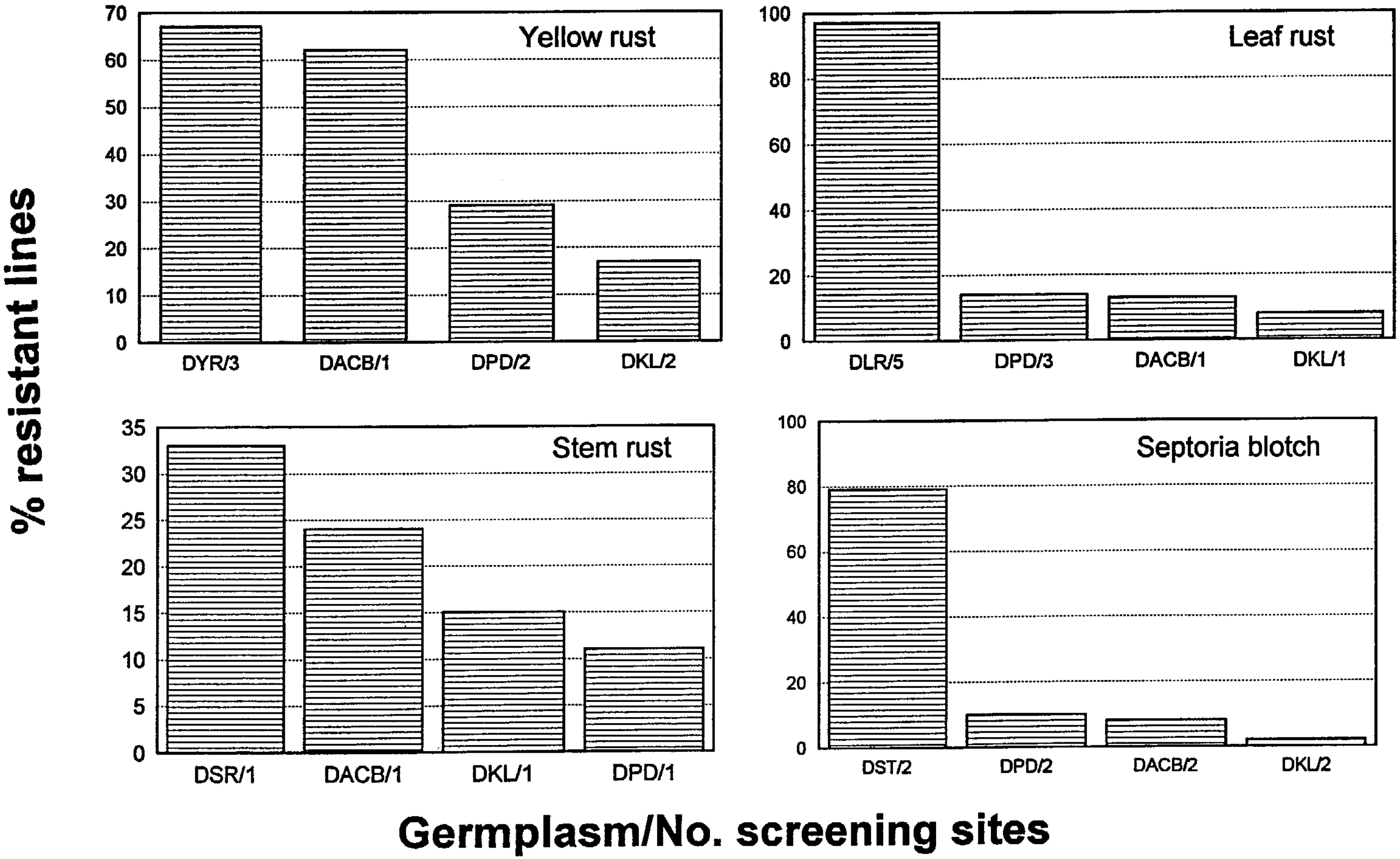

Fig. 6.4. The performance of durum wheat germplasm against different diseases; 1995/96.

6.6.3. Crop Losses due to Yellow Rust

Result on crop loss assessment trials are presented in Table 6.3. Results show that both the fungicides suppressed the development of yellow rust in cultivars Haurani and ACSAD 363 substantially. Higher and significant yield increase was observed in cultivar Chanst (19%) and Douma 20014 (24%) when rust was controlled by triadimenol and in Massara 1 (20%) by propiconazole. Such an increase in yield may be due to reduction of ACI in Massara and Douma 20014. However, this increase in yield of Chanst appears to be due to an increase in number of tillers/m.

(O.F. Mamluk; M. Singh (CBSU); M. Naimi; A. Saleh; I. Maaz)

Table 6.3. Effect of yellow rust (*Puccinia striiformis*) on yield and yield components of durum wheat cultivars; Tel Hadya, Syria 1996.

Cultivar	Treatment	Yellow rust		Yield t/ha	% Yield increase	No.tillers per m	No.seed per spike	1000 KW (gr.)
		Score	ACI					
Haurani 27	Infected	33.3 MS	26.7	3.17		67.3	37.3	34.5
	Fungicide I	6.7 MR	2.7	3.40	7.3	81.7	35.0	36.6
	Fungicide II	11.7 MR-M	5.3	3.16	-0.3	88.0	35.7	35.4
Massara 1	Infected	16.7 MR-M	8.0	3.79		85.0	42.3	34.9
	Fungicide I	5.0 MR-M	1.7	4.53	19.5	83.3	42.7	35.0
	Fungicide II	5.0 MR-M	1.7	4.57	20.6	91.7	42.3	33.3
Chanst	Infected	5.0 R	1.0	4.10		87.7	31.7	38.8
	Fungicide I	5.0 R	1.0	4.89	19.3	105.3	32.7	42.1
	Fungicide II	5.0 R	1.0	4.77	16.3	97.0	32.7	42.5
Douma 20014	Infected	10.0 MR	4.0	4.24		94.0	39.7	35.9
	Fungicide I	5.0 R-MR	1.3	5.27	24.3	90.7	41.3	40.4
	Fungicide II	5.0 R	1.0	4.22	-0.5	85.3	41.7	35.1
ACSAD 363	Infected	30.0 M-MS	20.7	3.96		81.3	41.0	38.2
	Fungicide I	5.0 MR-R	1.7	4.58	15.7	91.0	40.0	38.4
	Fungicide II	6.7 R-MR	2.0	4.55	14.9	91.3	37.7	39.4
	SE 1			±0.25		±6.63	1.94	1.13
	SE 2			±0.24		±6.68	2.00	1.05
	CV%			10%		14%	8%	5.4

Figures = mean of 3 rep. each 7.2 m^2, harvested 3.6 m^2, from RCBD (treatment as main-plot factor, cultivar as sub-plot). Infected = artificial inoculation applied twice. Fungicide I = triadimenol (Bayfidan EC 250), 0.5 l/ha, applied twice. Fungicide II = propiconazole (Tilt EC 250), 0.5 ml/ha, applied twice. SE 1 to compare treatment at same or different levels of cultivars; SE 2 to compare cultivars at same level of treatments.

7. TRAINING AND VISITS

Training was geared improve the capabilities of the technicians and researchers to meet NARS needs by increasing their practical knowledge and skills to identify and overcome constraints that limit food production.

The following training activities were conducted during 1996.
- Group training
- Individual training

7.1. Long-term Course in Cereal Improvement

The annual training long-term group course on cereal improvement was conducted from March 10 through July 10, 1996 for the benefit of 11 participants from 8 countries (Algeria, Eritrea, Iran, Libya, Lebanon, S. Arabia, Syria and Tunisia). Participants were generally junior researchers working on cereal crops in their countries. The course objectives were achieved through (lectures 25% of the schedule), field work, seminars, informal discussions and assigned research experiments. Emphasis focused on "learnig by doing" mostly in problem oriented research. Topics continued to be centered around breeding including breeding-related disciplines of pathology, entomology, grain quality, biotechnology, physiology, seed production, and experimental design. Participants were generally very satisfied and all demonstrated acceptable participation in all training activities, this course was jointly sponsored by ICARDA and AOAD.

7.2. Biometrical Methods in Agricultural Research

This course was held at Tel Hadya during 3-14 March 1996, with participation of 13 trainees from 4 countries (Algeria, Iraq, Syria, and United Arab Emirates). Instructors were from Germplasm Program and Computer and Biometric Service Unit. The course covered experimental desing and statistical methods and their application using PC's (data entry and analysis, ANOVA for single and combined experiments, correlation and regression, with interpretation of results). The impact of trainees was positive and suggestions were made for an advanced computer application course in the coming year.

7.3. DNA Molecular Marker Techniques

This course was jointly conducted this year by ICARDA, Syria and CIHEAM, Spain during 15-26 September 1996 at Tel Hadya. Instructors were two from Germany and one from Spain with participation of 5 biotechnologists from ICARDA. Participants were twelve experienced researchers from 11 countries (Table 7.1). The course covered current and future uses of DNA technology in plant breeding, gene indentification, genome mapping, application of genetic engineering, with a special emphasis on practical laboratory application (DNA extraction and purification, gel electrophoresis, RFLP and PCR). The trainees evaluated the course as highly successful and useful. It is expected that the course will be again conducted the coming season.

Table 7.1. Participants of the ICARDA/CIHEAM course on DNA molecular marker techniques, 15-26 September, 1996.

Name/country	Degree
Ms Nebeche Saida/Algeria	MSc
Dr Harsh Kumar Dikshit/India	PhD
Ms Wajida Khaza Zaarawi/Iraq	PhD
Mr Mohamed Sadegh Najafi/Iran	PhD
Mr Nidal Nanich/Jordan	MSc
Mr Iftikhar Ahmed/Pakistan	MSc
Dr Olinda Pinto Carnide/Portugal	PhD
Ms Meryem Alaoui/Morocco	MSc
Dr Angeles Moraleja Vidal/Spain	PhD
Mr Mohamed Jawher/Syria	BSc
Mr Kamel Ridha Maoui/Tunisia	MSc
Mr Neji Tarchoun/Tunisia	PhD
Instructors	
Prof. Dr G. Kahl, Frankfurt/Germany	Lecturer
Dr D. Struss Gatersleben/Germany	Lecturer
Dr M. Perez de la Vega/Spain	Lecturer

7.4. Individual Training

Based on NARSs requests, non-degree training on an individual basis was offered to 45 participants from 16 countries. The syllabus were tailored to meet the specific needs of individual NARSs participants, and the academic background and performance objectives of the participants. Skills covered and countries represented are given in Table 7.2. The duration of training varied between 2 weeks and 4 months. In addition, two trainees from Germany and Switzerland conducted research as part of their requirements for a university degree; also 3 students from Aleppo University worked at GP as part of their graduation project on biotechnology and breeding. Graduate-degree training is being strengthened with 30 students (19 Msc and 11 PhD

Table 7.2. Individual non-degree Trainees at GP, 1996.

	Name/Country	Topic	Duration
1.	Mr Dawood Sadegh Zadeh/Iran	Cereal Quality	01/02 - 15/02
2.	Ms Shafia Larouk/Algeria	Durum Wheat Quality/Biotechnology	26/02 - 05/05
3.	Mr Hassan El-Khatib/Lebanon	Cereal Pathology	11/02 - 15/02
4.	Mr Mohamed RazaviIran	Cereal Pathology	29/02 - 29/05
5.	Mr Jihad Orabi/Syria	Cereal Pathology	03/03 - 30/06
6.	Dr Atya Arab/Syria	Cereal Quality/Biotechnology	03/03 - 28/03
7.	Ms Carina Moller/Germany	Durum Wheat Quality	25/02 - 25/06
8.	Mr Lukas Ruttimann/Switzerland	Cereal and Legume Improvement	28/02 - 28/05
9.	Mr Silo Sito Murad/Iraq	Barley Germplasm	22/03 - 04/04
10.	Mr Khaled Taha/Syria	Forage Legume Improvement	31/03 - 25/04
11.	Mr Abdel Ali Badawi/Egypt	Cereal Stress Physiology	01/04 - 28/04
12.	Ms Moris Korieh/Syria	Bread Wheat Breeding	01/04 - 30/07
13.	Mr Hamoud Alwan/Syria	Durum Wheat Breeding	01/04 - 30/07
14.	Mr Husni Abu Khaled/Syria	Lentil Breeding	01/04 - 25/04
15.	Mr Mohamed Ouissou/Syria	Barley Breeding	03/03 - 27/06
16.	Ms Oula Mustapha /Syria	Cereal Stress Physiology	01/04 - 28/04
17.	Mr Darioch Shahryari/Iran	Legume Diseases	01/04 - 27/04
18.	Mr Fathi Tahir Abdel Hamid/Libya	Cereal Virology	01/04 - 27/04
19.	Mr Turkey Muften Saad/Iraq	Virology in Chickpea	07/04 - 18/04
20.	Ms Hiyam Dayaub/Syria	Legume Virology	07/04 - 25/04
21.	Mr Jamal Mandau/Syria	Interspecific Hybridization	07/04 - 25/04
22.	Mr Ziad Hallaq/Syria	Interspecific hybridization	07/04 - 18/04
23.	Mr Mohamed Mukhtar/Egypt	Durum Wheat Breeding	05/04- 28/04

Table 7.2. Cont'd/...

Name/Country	Topic	Duration
24. Mr Abdalah Salem Ahmed/UAE	Cereal Virology	13/04 - 27/04
25. Mr Fayez Al Anbar/Syria	Food Legume Hybridization	14/04 - 25/04
26. Ms Safaa Kaylani/Syria	Food Legume Hybridization	14/04 - 25/04
27. Mr Ali Shattou/Morocco	Ascochyta Screening in Lentil/Chickpea	14/04 - 25/04
28. Mr Farouk El Yassin/Syria	Chickpea Breeding	14/04 - 14/05
29. Mr Pawan Karki/Nepal	Lentil Breeding	16/04 - 16/05
30. Mr Mohamed Reza Shehab/Iran	Chickpea Breeding	19/04 - 17/05
31. Mr Adel Jahanjiri/Iran	Chickpea Breeding	19/04 - 17/05
32. Mr Sami El Esse/Syria	Lentil Diseases	14/04 - 25/04
33. Mr Zia El Din Ahmed/Bangladesh	Lentil Breeding	10/05 - 07/05
34. Mr Salah El Din Abdel Magid/Egypt	Bread Wheat Breeding	01/05 - 13/06
35. Ms Belgin Gocmen/Turkey	Molecular Markers	05/05 - 30/05
36. Mr Ahmed Al-Bouachi/Libya	Chickpea Breeding	07/05 - 23/05
37. Ms Sadia Bekal/Algeria	Cereal Cyst/nematode	17/05 - 24/05
38. Mr Fawzi Al-Ghaith/Syria	Mechanical Harvesting of Legumes	09/06 - 13/06
39. Mr Halim Amo/Syria	Mechanical Harvesting of Legumes	09/06 - 13/06
40. Mr Fouad Ashkar/Syria	Mechanical Harvesting of Legumes	09/06 - 13/06
41. Mr Mufid Al-Omar/Syria	Mechanical Harvesting of Legumes	09/06 - 13/06
42. Mr Demissie Mitiku/Ethiopia	Durum Wheat Breeding	14/06 - 25/06
43. Mr Izzedin Samani/Saudi Arabia	Virology Techniques	14/07 - 01/08
44. Mr Fadi Kanawati/Lebanon	Legume Microbiology	14/07 - 25/07
45. Mr Jamshid Fatehi/Iran	Legume Diseases	24/05 - 06/06

candidates) from eight countries supported by GP (Table 7.3). Graduate-degree training is valued by NARSs and ICARDA scientists and is expected to get an even higher priority in the future.

Seven of the students from the list were awarded degree and 6 are writing their thesis at their University.

7.5. Visits

Visits between the Germplasm Program and NARSs was an effective tool for transferring information and research experience. In 1996, seventy scientists from twenty one countries visited the program to become acquainted with or participate in the program research activities.

The following visiting scientists visited the program for longer periods and worked with their ICARDA colleagues on research topics of mutual interest (Table 7.4).

In addition, around 140 students from Aleppo university and Tichreeen University came to the program on a one-day study visit to gain practical knowledge in breeding ad related disciplines.

(H. Ketata and A.J. Sabouni)

Table 7.3. Graduate students at GP, ICARDA, 1996.

Name	Degree	Research Area	Country	University
Mr Kenneth Street*	Ph.D	Legume breeding	Australia	West Australia
Mr Mohsen Shehata*	Ph.D	Bread wheat breeding	Egypt	Ain Shams
Mr Ahmed Shawki El Sebae*	M.Sc	Wheat breeding	Egypt	Suez Canal
Mr Berhane Lakew	M.Sc	Prog. Crop Science	Ethiopia	Wageningen
Mr Alfredo Impiglia	Ph.D	Barley breeding	Italy	Cordoba
Mr AbdelMajid Adlan	M.Sc	Legume virology	Sudan	A.U.B.
Mr El Tahir Ahmed A.A.	M.Sc	Crop physiology	Sudan	Jordanian
Mr Mohamed Ibrahim Ismail	M.Sc	Soil-water-plant relationship	Sudan	Jordanian
Mr Imad Mahmoud	Ph.D	Legume biotechnology	Sudan	Helsinki
Mr Sleiman Raad	Ph.D	Wheat quality	Syria	Damascus
Ms Huda Nassan	M.Sc	Legume viruses	Syria	Aleppo
Mr Ramez Mahmoud	M.Sc	Cereal quality	Syria	Aleppo
Mr Seid Hassan	M.Sc	Legume pathology	Syria	Aleppo
Mr Ghassan Naesa*	Ph.D	Barley breeding	Syria	Aleppo
Mr George Ghandour	M.Sc	Legume physiology	Turkey	Aleppo
Mr Zuhair Wasouf*	M.Sc	Durum wheat quality	Syria	Aleppo
Mr Housameddin Jan	M.Sc	Legume breeding	Syria	Aleppo
Mr Hussam Abeido	M.Sc	Septorioris in wheat	Syria	Aleppo
Mr Naser Heloubi	Ph.D	Forage Legume breeding	Syria	Aleppo
Mr Izzat Ghannoum	M.Sc	Cereal Entomology	Syria	Cukurova
Mr Ala'a El Din Hamwieh	M.Sc	Bacterial blight of pea	Syria	Aleppo
Mr Fateh El Khatib	M.Sc	Barley pathology	Syria	Aleppo
Mr Uwe Sholz	Ph.D	Cereal Cyst nematode	Germany	Bonne
Mr Abdel Jawad Sabouni	Ph.D	Human resource development	Syria	Nottingham
Ms Mayson Hamameh	M.Sc	Cereal biotechnology	Syria	Aleppo
Ms Hana Hassan	M.Sc	Legume viruses	Syria	Aleppo
Mr Ahmed Al Kaderi	M.Sc	Durum wheat improvement	Syria	Aleppo
Mr Clause Einfeldt	Ph.D	Barley improvement	Germany	Hahenlein
Ms Suha Achtar	M.Sc	Biotechnology	Syria	Aleppo

* Completed their research training in 1996.

Table 7.4. Visiting scientists to Germplasm Program, 1996

Scientist's Name	Country	Period	Research Areas
Dr Mamdouh El-Sayed	Egypt	30/4 - 30/5	Bread wheat breeding
Dr Mohamed H. Iskandar	Egypt	5/5 - 30/5	Cereal Stress Physiology
Dr Mahfooz Abdel Hamid	Egypt	6/4 - 19/4	Barley Breeding
Dr M. Hisham Zeinab	Syria	1/5 - 31/12	Cereal Cyst Namatode
Mr V. Mardoukhi	Iran	30/5 - 14/6	Cereal Pathology
Dr Hussein Zaid	Egypt	12/4 - 18/4	Durum Wheat Breeding

8. PUBLICATIONS

8.1. Journal Articles

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8.2. Conference papers

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8.4 Others

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9. CEREAL VARIETIES RELEASED BY NATIONAL PROGRAMS.

Crop	Country	Year of release	Variety
Barley	Algeria	1987	Harmal
		1992	Badia
		1993	Rihane-03
	Australia	1989	Yagan
		1991	High
		1993	Kaputar
		1993	Namoi
	Bolivia	1991	Kantuta
		1993	Kolla
	Brazil	1989	Acumai
	Canada	1992	Seebe
		1993	Falcon
		1994	Tukwa
		1995	Kasota
	Chile	1989	Leo
		1989	Centauro
	China	1988	Zhenmai 1
		1989	V-24
		-	Api/CM67//B1
		1989	CT-16
	Cyprus	1980	Kantara
		1989	Mari/Aths*
	Ecuador	1989	Shyri
		1992	Calicuchima-92
		1992	Atahualpa-92
	Egypt	1993	Giza 125
	Ethiopia	1981	BSH 15
		1984	BSH 42
		1985	Ardu
	Iran	1986	Aras
		1990	Kavir
		1990	Star
	Iraq	1994	Rihane-03
		1994	IPA 7
		1994	IPA 9
		1994	IPA 265
	Jordan	1984	Rum
	Kenya	1984	Bima
		1993	Ngao
	Lebanon	1989	Rihane-03
	Libya	1992	Wadi Kuf

Cont'd/...

Crop	Country	Year of release	Variety
Barley			
	Libya	1992	Wadi Gattara
	Mexico	1986	Mona/Mzq/DL71
	Morocco	1984	Asni
		1984	Tamellat
		1984	Tissa
		1988	Tessaout
		1988	Aglou
		1988	Annaceur
		1988	Tiddas
	Nepal	1987	Bonus
	Pakistan	1985	Jau-83
		1987	Jau-87
		1987	Frontier 87
		1993	Jau-93
		1995	AZRI-95
	Peru	1987	Una 87
		1987	Nana 87
		1989	Buenavista
		1984	Una-94
	Portugal	1982	Sereia
		1983	CE. 8302
		1990	Ancora
	Qatar	1982	Gulf
		1983	Harma
	S. Arabia	1985	Gustoe
	Spain	1987	Resana
	Syria	1987	Furat 1113
		1991	Furat 2
		1994	Impr.A. Abiad
	Tanzania	1991	Kibo
	Thailand	1987	Semang 1
		1987	Semang 2
		-	BRB-8
		1985	Taj
	Tunisia	1985	Faiz
		1985	Roho
		1987	Rihane-03
		1992	Manel 92
	Turkey	1993	Tarm 92
		1993	Yesevi 93

Cont'd/...

Crop	Country	Year of release	Variety
Barley			
	Turkey	-	Orza
	U.S.A.	-	Poco
		-	Micah
	Vietnam	1989	Api/CM67//B1
	Yemen	1986	Arafat
		1986	Beecher
Durum wheat	Yemen AR	1986	Arafat
		1986	Beecher
	Algeria	1986	Sahl
		1986	Waha
		1992	Korifla
		1992	Omrabi 6
		1984	Timgad
		1993	Heider
		1993	Kabir 1
		1993	Omrabi 9
		1993	Belikh 2
	Cyprus	1982	Mesoaria
		1984	Karpasia
	Egypt	1979	Sohag I
		1988	Sohag II
		1988	Beni Suef
		1990	Sohag III
		1990	Beni Suef I
	Greece	1982	Selas
		1983	Sapfo
		1984	Skiti
		1985	Samos
		1985	Syros
	Iraq	1994	'Waha Iraq'
	Jordan	1988	Korifla=Petra
		1988	N-432=Amra
		1988	Cham1=Maru
		1988	Stork=ACSAD75
	Lebanon	1987	Belikh 2
		1989	Sebou
	Libya	1985	Marjawi
		1985	Ghuodwa
		1985	Zorda
		1985	Baraka

Cont'd/...

Crop	Country	Year of release	Variety
Durum wheat			
	Libya	1985	Qara
		1985	Fazan
		1992	Khiar 92
		1993	Zahra 5
	Morocco	1984	Marzak
		1989	Sebou
		1989	Omrabi
		1991	Tensif
		1992	Brachoua
		1992	Omrabi 5
		1995	Omrabi 6
	Pakistan	1985	Wadhanak
	Portugal	1983	Celta
		1983	Timpanas
		1984	Castico
		1985	Heluio
	Saudi Arabia	1987	Cham 1
	Spain	1983	Mexa
		1985	Nuna
		1989	Jabato
		1991	Anton
		1991	Roqueno
	Syria	1984	Cham 1
		1987	Cham 3
		1987	Bohouth 5
		1994	Cham 5
	Tunisia	1987	Razzak
		1993	Omrabi 3
		1993	Khiar
	Turkey	1984	Susf bird
		1985	Balcili
		1988	EGE 88
		1990	Cham 1
		1991	Kizilton
		1994	Firat 93
		1994	Aydin 93
		1995	Haran=Omrabi 5
Bread Wheat			
	Algeria	1982	Setif 82
		1982	HD 1220

Cont'd/...

Crop	Country	Year of release	Variety
Bread Wheat			
	Algeria	1989	Zidane 89
		1992	Nesser = Cham 6
		1992	Cham 4=Sidi Okba
		1992	Rhumel
		1992	Alondra=21AD
		1992	Soummam
		1992	ACSAD 59=40DNA
		1994	Mimouni
		1994	Ain Abid
	China	1994	Mayoun 1
		1995	Dong Feng-1
	Egypt	1982	Giza 160
		1988	Giza 162
		1988	Giza 163
		1988	Giza 164
		1988	Sakha 92
		1991	Gammeiza 1
		1991	Giza 165
		1993	Sahel 1
		1994	Sids 1
		1994	Sids 2
		1994	Sids 3
	Egypt	1994	Giza 166
		1994	Giza 167
		1995	Giza 167
		1995	Sids 4
		1995	Sids 5
		1995	Sids 6
		1995	Sids 7
		1995	Sids 8
	Ethiopia	1984	Dashen
		1984	Batu
		1984	Gara
	Greece	1983	Louros
		1983	Pinios
		1983	Arachthos
	Iran	1986	Golestan
		1986	Azadi
		1988	Darab
		1988	Sabalan

Cont'd/...

Crop	Country	Year of release	Variety
Bread Wheat			
	Iran	1988	Quds
		1990	Falat
		1995	Tajan
		1995	Nicknejad
		1995	Mahdabi
		1995	Darab 2
	Iraq	1989	Es14
		1994	Hamra
		1994	Abu Ghraib
	Jordan	1988	NASMA=Jubeiha
		1988	L88=Rabba
		1988	Nesser
	Lebanon	1990	Seri
		1991	Nesser
		1995	Roomy
	Libya	1985	Zellaf
		1985	Sheba
		1985	Germa
	Morocco	1984	Jouda
		1984	Merchouche
		1986	Saada
		1989	Saba
		1989	Kanz
	Oman	1987	Wadi Quriyat 151
		1987	Wadi Quriyat 160
	Pakistan	1986	Sutlej 86
	Portugal	1986	LIZ 1
		1986	LIZ 2
	Qatar	1988	Doha 88
	Sudan	1985	Debeira
		1987	Wadi El Neel
		1991	Neelain
		1993	Sasarieb
	Syria	1984	Cham 2
		1984	Bohouth 2
		1986	Cham 4
		1987	Bohouth 4
		1991	Cham 6
		1991	Bohouth 6
	Tanzania	1983	T-VIRI-Veery 'S'

Cont'd/...

Crop	Country	Year of release	Variety
Bread Wheat			
	Tanzania	1983	69/BD
	Tunisia	1987	Byrsa
		1987	Salambo
		1992	Vaga 92
	Turkey	1986	Dogankent-1
		1988	Kaklic 88
		1988	Kop
		1988	Dogu 88
		1989	Es14
		1990	Yuregir
		1990	Karasu 90
		1990	Katia 1
		1995	Kasifbey
		1995	Basribey
	Yemen	1983	Marib 1
		1983	Ahgaf
		1988	Mukhtar
		1988	Aziz
		1988	Dhumran
		1988	SW/83/2

10. STAFF LIST 1996 - Cereals

1.	Dr Salvatore Ceccarelli	Acting Leader & Spring Barley Breeder
2.	Dr Guillermo Ortiz-Ferrara	Bread Wheat Breeder (CIMMYT)
3.	Dr Miloudi Nachit	Durum Wheat Breeder (CIMMYT)
4.	Dr Hugo Vivar	Barley Breeder, LARP (Mexico)
5.	Dr Mohammad Tahir*	Winter/Facultative Barley Breeder
6.	Dr Habib Ketata	Winter/Facultative Wheat Breeder
7.	Dr Omar F. Mamluk	Wheat Pathologist
8.	Dr John M. Peacock*	Ecophysiologist
9.	Dr Franz Weigand	Biotechnologist
10.	Dr Stefania Grando	Barley Breeder
11.	Dr Sui Kwong Yau	International Trials Scientist
12.	Mr Issam Naji	Agronomist/Crop Physiologist
13.	Dr Mustafa Labhilili	Post-Doctoral Fellow
14.	Dr Hala Toubia-Rahmé	Post-Doctoral Fellow
15.	Dr Wafa Choumane	Post-Doctoral Fellow
16.	Dr Alfredo Impiglia	Research Associate
17.	Mr Mohamed A. Mousa	Research Associate
18.	Mr Michael Michael	Research Associate
19.	Mr Antoine P. Asbati	Research Associate
20.	Mr Munzer Naimi	Research Associate
21.	Mr Abdel Jawad Sabouni	Training Assistant
22.	Mr Fouad Jaby El-Haramein	Research Assistant
23.	Mr Adonis Kourieh	Research Assistant
24.	Mr Mohamed Mushref	Research Assistant
25.	Mr Henry Pashayani	Research Assistant
26.	Mr Mazen Jarrah	Research Assistant
27.	Mr George Kashour	Research Assistant
28.	Mr Mahmoud Hamza	Research Assistant
29.	Mr Nicolas Rbeiz	Research Assistant (Terbol)
30.	Mr Ziad Alamdar	Senior Research Technician
31.	Mr Mohamed Azrak	Senior Research Technician
32.	Mr Adnan Ayyan	Senior Research Technician
33.	Mr Bassam Shammo	Senior Research Technician
34.	Mr Ala'a Yaljarouka	Senior Research Technician

35. Mr Joseph Aziz	Research Technician (Terbol)
36. Mr Zuhair Haj Younes	Research Technician
37. Mr Salem Farrouh	Research Technician
38. Mr Hani Hazzam	Research Technician
39. Ms Nadia Fadel	Research Technician
40. Mrs Wafa'a Haj Juma'a	Research Technician
41. Mr Ahmed El-Saleh	Research Technician
42. Ms Sawsan Tawkaz	Research Technician
43. Ms Iman Maaz	Research Technician
44. Ms Aman Sabbagh	Research Technician
45. Mrs Mouna Ba'albaki	Research Technician
46. Mr Asaad El-Jasem	Labour Foreman
47. Mr Abdalla Steif	Assistant Technician
48. Mr Hasan El-Khatib	Assistant Technician (Terbol)
49. Mr Michael Abou Nakad	Assistant Technician (Terbol)
50. Mr Obeid El-Jasem	Farm Labourer
51. Ms Rita Nalbandian	Executive Secretary
52. Mrs Sossi Toutounji	Secretary
53. Ms Raghad Rahwan	Secretary

Consultant

54. Dr Mustafa El-Bouhssini	Entomologist

*** Left the Program during 1996**