GERMPLASM PROGRAM CEREALS

Annual Report for 1998

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.

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International Center for Agricultural Research in the Dry Areas
P.O. Box 5466, Aleppo, Syria
1999

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.

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1. INTRODUCTION

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

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

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

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

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

The weather conditions during the 1997/98 season are shown in Figure 1.1 for two dry sites (Bouider and Breda), and in Figure 1.2 for relatively wetter sites (Tel Hadya and Terbol). The total precipitation during the season was higher than the long term average in Bouider and Tel Hadya, and lower in Breda; no variation occurred as regards Terbol. On average, temperatures were above the long term average (about 1°C for maximum and 5°C for the minimum).

In Bouider, the total precipitation was 23% above the long term average (279 mm versus 227 mm). The highest monthly precipitation deviations from the long term average occurred in October, January and April (positive deviations), and in February (negative deviation). The average maximum temperature during the 1997/98 cropping season was 2°C below the long term average, while the minimum temperature was 8°C above the average. The monthly mean maximum temperature during the cropping season ranged from 9 to 35°C, and the minimum from 1 to 17°C.

In Breda, the total precipitation was 11% below the long term average (227 mm versus 254 mm). The highest monthly precipitation deviations from the average were negative and occurred in November and February. The average maximum temperature during the 1997/98 cropping season was 2°C above the long term average, while the minimum temperature was 5°C above the average. The monthly mean maximum temperature during the cropping season ranged from 9 to 36°C, and the minimum from 2 to 17°C.

In Tel Hadya, the total precipitation was 21% above the long term average (411 mm versus 340 mm). The highest monthly precipitation deviations from the average occurred in January and April (positive deviations), and in February (negative deviation). The average maximum temperature during the 1997/98 cropping season was 3°C above the long term average, while no variation occurred regarding the minimum temperature. The monthly mean maximum temperature during the cropping season ranged from 11 to 36°C, and the minimum from 1 to 18°C.

In Terbol, the total precipitation was 533 mm, and was inline with the long term average. The highest monthly precipitation deviations from the average occurred in December, January and March (positive deviations), and in November and February (negative deviation). The average maximum temperature during the 1997/98 cropping season was 1°C above the long term average, while the minimum temperature was 9°C above the average. The monthly mean maximum temperature during the cropping season ranged from 11 to 32°C, and the minimum from -1 to 9°C.

During the year the following changes in senior staff occurred:

a. Dr Willie Erskine was selected through international recruitment as the Leader of Germplasm Program. He was the lentil breeder also until the end of 1998.

B. Dr Amor Yahyaoui joined as the Senior Cereal Pathologist in the Program.

b. Dr Stefania Grando was recruited internationally as the Barley Breeder. She was earlier filling a lower international position.

c. Mr Issam Naji (Agronomist/Crop Physiologist) resigned.

d. Dr Mustapha Labhilili (Post-Doctoral Fellow / Biotechnology) resigned.

e. Dr Hala Toubia-Rahme (Post-Doctoral Fellow / Pathology) resigned.

f. Dr Wafa Choumane (Post-Doctoral Fellow / Biotechnology) resigned.

g. Mr Soren T. Jorgensen (Junior Professional Officer - Barley) resigned.

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 1998:

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 (scientist 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 (scientist in charge: M. Baum)
3. **Improving yield and yield stability of barley in stress environments** supported by the Government of Italy (scientist in charge: S. Grando)
4. **Farmer participation and use of local knowledge in breeding barley for specific adaptation** supported by BMZ and in collaboration with University of Hohenheim (scientist in charge: S. Ceccarelli)
5. **Increasing the relevance of breeding to small farmers: Farmer participation and local knowledge in breeding barley for specific adaptation to dry areas of North Africa** supported by IDRC and in collaboration with IRESA (Tunisia) and INRA (Morocco) (scientist in charge: S. Ceccarelli)
6. **Resistance to nematodes in lentil and chickpea** in collaboration with the Institute of Nematology of Bari (scientist in charge: R.S. Malhotra)
7. **Development of chickpea resistant to biotic and abiotic stresses using interspecific hybridization and genetic transformation** supported by the Government of Italy and in collaboration with ENEA, University of Napoli and the University of Tuscia in Viterbo (scientist in charge: R.S. Malhotra)
8. **Fusarium wilt in chickpea** supported by the Government of Spain and in collaboration with INIA, Spain (scientist in charge: R.S. Malhotra)
9. **International durum wheat improvement** supported by GRDC, Australia in collaboration with the New South Wales Department of Agriculture (scientist in charge: M. Nachit)
10. **Coordinated improvement program for Australian lentils** supported by GRDC, Australia (scientist in charge: W.

Erskine)

11. **Improvement of drought and disease resistance in lentils in Nepal, Pakistan and Australia** supported by ACIAR, Australia (scientist in charge: W. Erskine)
12. **Central and West Asia rusts network-enhanced regional food security through the development of wheat varieties with durable resistance to yellow rust** (scientist in charge: H.T. Rahme)
13. **West Asia and North Africa Dryland Durum Improvement Network (WANADDIN)** supported by IFAD, Italy (scientist in charge: M. Machit)
14. **Faba bean in China** supported by the ACIAR, Australia and in collaboration with the Genetic Resources Unit (scientist in charge: L. Robertson)
15. **Integrated management of pest and diseases** supported by BMZ, Germany (scientist in charge: K. Makkouk)
16. **Durum wheat improvement** supported by ACIAR, Australia (scientist in charge: M. Nachit)
17. **Kabuli chickpea** supported by ACIAR, Australia (scientist in charge: R.S. Malhotra)
18. **Development and use of molecular genetic markers for enhancing the feeding value of cereal crop residues for ruminants** supported by ACIAR, Australia (scientist in charge: S. Ceccarelli)
19. **Application of molecular genetics for development of durum wheat varieties possessing high yield potential, rust resistance, stress tolerance, and improved grain quality** supported by Agricultural Technology, Utilization and Transfer Project-ATUT) (scientist in charge: M. Nachit).
20. **Development of high yielding, long spike bread wheat cultivars possessing high tiller, number, rust resistance and heat tolerance facilitated by microsatellite DNA-markers** supported by Agricultural Technology, Utilization and Transfer Project-ATUT (scientist in charge: O. Abdalla)

21. **Genetic transformation of barley for improved stress resistance** supported by CGIAR (scientist in charge: M. Baum).
22. **Adaptation of barley to drought and temperature stress using molecular markers** supported by USDA, Texas Tech University, U.S.A. (scientist in charge: S. Ceccarelli)
23. **Inheritance and linkage of winter hardiness in lentil** supported by USDA, Washington State University, U.S.A. (scientist in charge: W. Erskine)
24. **Use of entomopathogenic fungi for the control of Sunn pest** supported by USDA, University of Vermont, U.S.A. (scientist in charge: M. El-Bouhssini)
25. **Legume resistance to Luteoviruses** supported by GRDC, Australia (scientist in charge: K. Makkouk) (started in October 1998)
26. **Development of biotechnological research in the Arab States** supported by Arab Fund for Economic Social Development (AFESD) (scientist in charge: M. Baum)
27. **Improvement of lentil and grasspea in Bangladesh** supported by ACIAR (scientist in charge: A. Sarker)
28. **Pulse transformation technology transfer** supported by ACIAR, Australia (scientist in charge: M. Baum)
29. **Decentralized barley breeding with farmers' participation in North Africa** supported by OPEC (scientist in charge: S. Grando)

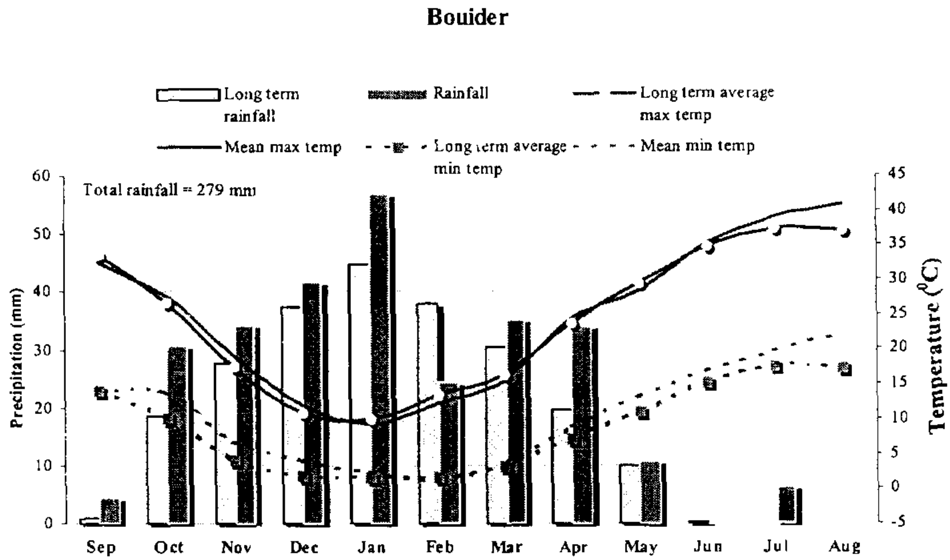
In addition the program is actively involved in the activities of the six Regional Programs and in the following special projects:

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

This report is published in 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 1997-98 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.



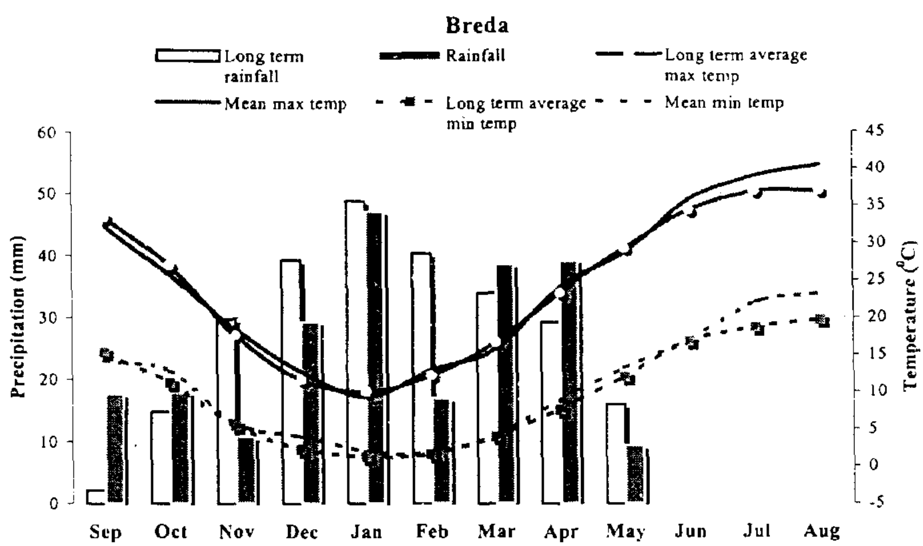
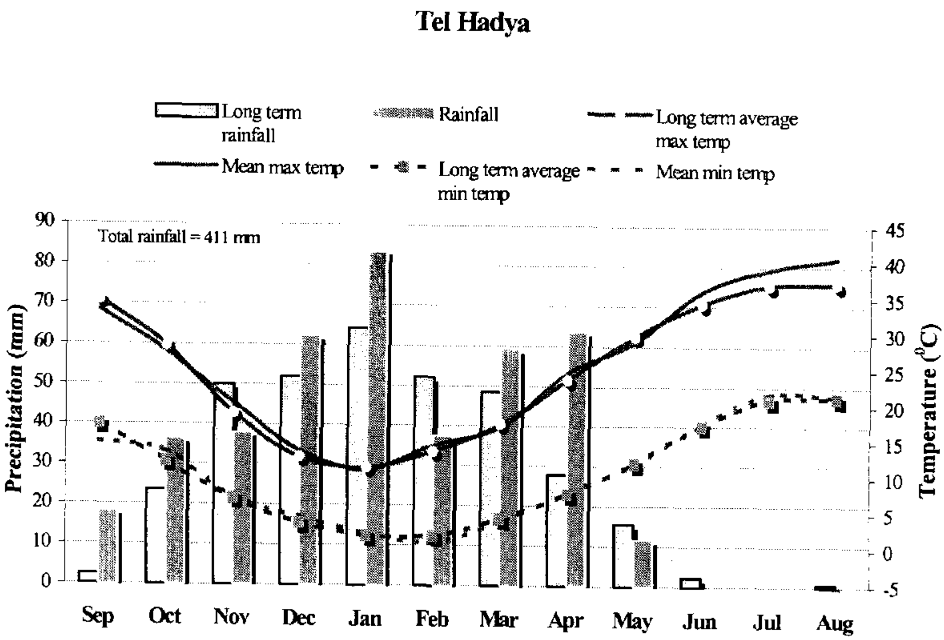


Fig. 1.1. Weather conditions at Bouider and Breda during 1997-98.



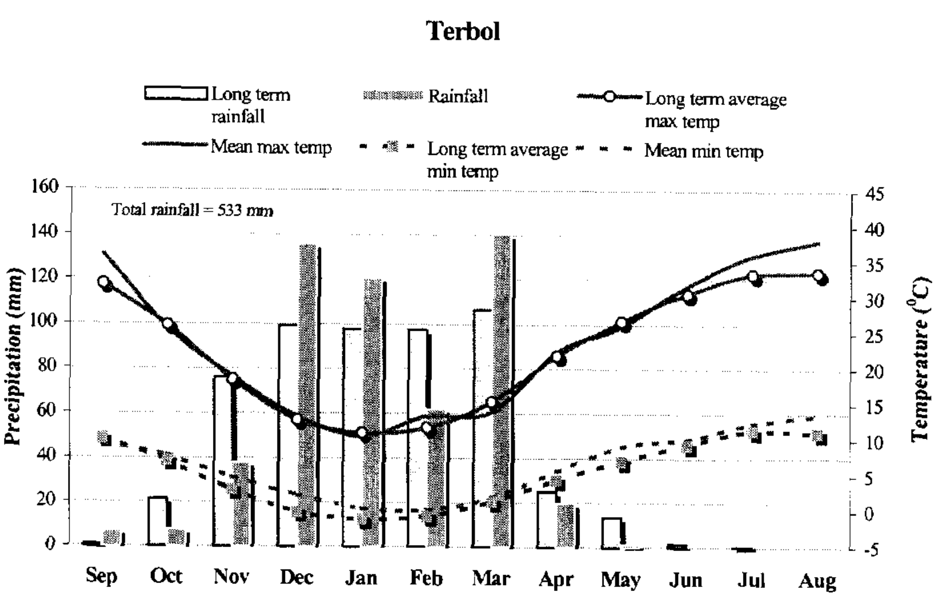


Fig. 1.2. Weather conditions at Tel Hadya and Terbol during 1997-98.

2. BARLEY IMPROVEMENT

2.1. Introduction

The long term objective of the barley improvement project at ICARDA is a sustainable increase in barley productivity by adapting the crop to the different farming systems and uses in developing countries. Special emphasis is given to those areas where the crop is grown by resource-poor farmers, thus contributing to alleviation of poverty.

The specific objectives of the barley project are:

- to collaborate with national programs in germplasm development;
- to strengthen national barley breeding programs;
- to develop a conceptual framework to improve efficiency of breeding in different environments with emphasis on low-input, stressful environments.

These objectives are pursued with strategies which have evolved over the last 20 years and which differ according to the changing research capacity of the cooperating national programs. Initially the main emphasis was on the centralized development of varieties; gradually the program has given increased emphasis to the development of breeding methodologies.

To target the poor, the breeding philosophy of the project, which evolved during the last twelve years, is now based on exploiting specific adaptation through direct selection in the target environments using locally adapted germplasm and sustainable levels of external inputs.

The two major implications of this philosophy are that (1) many varieties will be generated by national programs, each adapted to specific conditions, and (2) the superior performance of the varieties developed for low-input and less-favored lands will not depend on agronomic practices that require large amount of inputs. A breeding program based on this philosophy will not endanger biodiversity, and is environmentally benign.

The project continued to emphasize decentralized breeding to maximize the advantages of specific adaptation. The term decentralization has been used often to describe two fundamentally different processes, namely decentralized selection and decentralized testing and deserves clarification.

Decentralized selection is a term first used by Simmonds[1] and defined as selection in the target environment(s). Decentralized selection has been also called *in-situ* or *on-site* selection. In the case of self-pollinated crops it consists in selection of early segregating populations (such as F_2) in a number of locations representing the target environment(s) (climate, soil, farming system and management) the breeding program aims to serve. Decentralized selection becomes selection for specific adaptation when the selection criterion is the performance in specific environments rather than the mean performance across environments.

Decentralized selection is different from decentralized testing, which is a common feature of breeding programs and takes place, usually in the form of multilocation trials and on-farm trials, after a number of cycles of selection in one or few environments (usually with high levels of inputs).

The barley project at ICARDA maintains a large crossing program to generate genetic variation, but selection (decentralized selection) is carried out by the breeders in the National Programs. At this moment, decentralization of barley breeding is fully implemented in North Africa, in Iraq and in Ethiopia, and it is gradually being implemented in the Mediterranean highlands

[1] Simmonds, N.W. 1984. Principles of crop improvement. Longman, London and New York, pp. 408.

in the framework of the ICARDA/Iran Project and in collaboration with the Krasnodar Lukyanenko Research Institute, and in other countries.

Identification of sources of resistance to pests and diseases follows the same concepts. For example, the identification of sources of resistance to the major barley diseases in North Africa (scald, powdery mildew and net blotch) is entirely conducted in Tunisia and Morocco, while the screening for resistance to barley stem gall midge (*Mayetiola hordei*) is conducted in Morocco. The Latin-America project follows the same principle by screening segregating populations for disease resistance in the target countries.

The future challenge of the project is to implement the concept of decentralized selection in all the major barley growing areas of the world. For this purpose the target areas of the project can be divided in the following six geographic regions:

Central Asia and Russia
Far East
North Africa
West Asia
Horn of Africa and Yemen
Central and Latin America

The total barley area in the six regions exceeds 47 million hectares. In these regions barley is grown for animal feed, human food and malt, and in many different types of environment. However, most barley is grown in marginal environments, often on the fringes of deserts and steppes or at high elevations in the tropics, and receives modest or no inputs.

The project is becoming more and more a source of genetic variability and less and less a producer of fixed lines. Therefore, its major impact will be the sustainability of NARS breeding programs rather than the release of varieties by direct introductions.

The project deals with a wide range of germplasm, from spring to winter and from the wild progenitor, *Hordeum spontaneum* to landraces and modern cultivars.

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

2.2. Headquarters Activities

2.2.1. The crossing program

Despite its global nature, to maximize specific adaptation the barley project develops new germplasm starting with geographically targeted crosses. The crosses made by the project in 1998 are given in Table 2.1.

Crosses with landraces and with *H. spontaneum* are not listed separately as most of the crosses for Syria, Jordan and northern Iraq have a landrace and/or *H. spontaneum* as one parent. Most of the crosses done in 1998 to transfer, incorporate or combine resistance to diseases, pest and BYDV and to incorporate the hull-less gene were included among those targeted for specific countries, except for the group of 56 crosses for Russian Wheat Aphid resistance. The crosses for Central and Latin America are made in Mexico.

In the past we made mostly single crosses. Recently we increased the use of back-crosses and 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 frequency of recombination.

Table 2.1. Number and type of crosses done in 1998 in the barley project compared with 1997.

Country/Objective	1997	1998
Algeria	98	84
Egypt	88	88
Iraq (irrigated areas)	41	74
Libya	62	105
Morocco	171	129
Tunisia	211	128
Cyprus		54
Syria, Jordan and north Iraq	306	272
Vietnam	24	
China		35
Far East	102	79
Ethiopia		94
Eritrea/Tigray/Yemen	9	86
Russian Wheat Aphids		56
Earliness		79
CAC, Turkey, Countinental Highlands	856	840
Disease and pest resistance	129	
Tunisia and Powdery Mildew	23	
Recurrent selection	25	
Malting quality	45	
Total	2190	2203

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

2.2.2. The yield trials

The most commonly used breeding method both at the headquarters and in the decentralized programs, is the bulk-pedigree, which has been described, in the 1997 Annual Report.

As the barley breeding program becomes more and more decentralized, the yield trials conducted at the headquarters are more and more specific in testing breeding material targeted for areas with Mediterranean climate with cool winters, i.e. Syria, Jordan, Iraq, part of Turkey and of Iran. Within these areas barley is grown in two major types of environments. The first type, which is nearly 75% of the 3 million hectares of barley grown in Syria and Iraq, receives usually 250 mm of annual rainfall or less between November and the end of April, has cold winters with as many as 60 days with minimum temperatures below 0°C and absolute minimum temperatures of -15°C, a probability of nearly 60% of grain yields of 1.5 t/ha or less, and a probability of only 14% of grain yields of 3 t/ha or more[2]. The second type receives more than 250 mm of annual rainfall between October and May, has cold winters with 35-40 days with temperatures below 0°C and absolute minimum temperatures of -10°C, a probability of 25% of grain yields of 1.5 t/ha or less, and a probability of nearly 45% of grain yields of 3 t/ha or more.

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

All yield trials are designed as α-lattices: randomization and analysis are performed using ALPHANAL (AFRC Statistics, Edinburgh). In Syria the yield trials are conducted without addition of fertilizer (Breda and Bouider) or with modest amount (30 kg/ha) of nitrogen (Tel Hadya).

In 1998 there has been a 33% reduction in the total number of lines under testing which is now a quarter of the number tested in 1993 (Table 2.2).

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[2] Ceccarelli, S. et al., 1999 Decentralized breeding for marginal environments (in press)

Table 2.2. The number of breeding lines in the Yield Trials conducted at the headquarters from 1993 to 1998.

Year	Initial	Preliminary	Advanced	Total
1993	2268	702	224	3194
1994	1408	564	114	2086
1995	1532	392	132	2056
1996	858	329	137	1324
1997	858	249	89	1196
1998	478	241	79	798

The 1998 data were affected by unusually late rainfall and high temperatures during grain filling. Grain yields in Tel Hadya were lower than in 1997, with a reduction ranging from 19% (Advanced Yield Trials) to 38% (Preliminary Yield Trials). In Breda, the yield reduction was modest (from 8% to 18%) and the preliminary yield trials yielded on average 19% more than in 1997.

2.2.2.1. Initial Yield Trials

The initial yield trials in 1998 were planted in two locations (Tel Hadya with 411 mm rainfall, 72 mm more than the long term average) and Breda (with 229 mm rainfall, 36 mm less than the long term average). They were considerably reduced in size and included 478 new breeding lines and twelve checks.

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

Average grain yield was 981 kg/ha in Breda and 3026 kg/ha in Tel Hadya. The drought intensity index (Fischer and Maurer, 1978)[3], expressed on a scale from 0=absence of stress to 1=maximum stress, was 0.676, (very similar to 1997 when it was 0.656). In Tables 2.3 and 2.4 we show the ten best lines in Tel Hadya and in Breda, respectively.

The best check in Tel Hadya was Alanda-01 (a new promising six-row barley), with nearly 3.7 t/ha (compared with 3 t/ha of both Arta and Rihane-03 (Rhn-03)): 77 lines yielded as much as, or more than Alanda-01 and the top yielding lines produced more than 4.5 t/ha. The majority of the highest yielding lines were six-row, resistant to lodging (except one) and (with some exceptions) very susceptible to drought (shown by their low yields in Breda). The yield advantage of the best line in Tel Hadya over the best check was about 53% (Table 2.3).

In Breda 13 lines out-yielded the best check (Arta), while several lines (220) yielded less than Tadmor and Rihane-03, which were the two lowest yielding checks. The top ten yielding lines were all two-rows, mostly crosses between landraces and/or *H. spontaneum* and crosses between landraces and modern cultivars. All the highest yielding entries in Breda were different from the highest yielding entries in Tel Hadya (the correlation coefficient was negative, $r = -.232$, and significant ($P<0.01$).

With exception of two entries (193 and 149), most of the highest yielding lines in Breda were susceptible to lodging when tested in Tel Hadya. The correlation coefficient between lodging resistance and grain yield was positive and significant in Tel Hadya ($r = 0.488$), but negative and significant in Breda ($r = -0.478$).

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3 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 2.3. The ten best lines in the Initial Yield Trials in Tel Hadya. Heading date and lodging resistance were scored in Tel Hadya. Grain yield is in kg/ha.

				Breda		Tel Hadya	
Entry[a]	Row Type	Heading	Lodging[a]	Plant height	Grain Yield	Plant height	Grain Yield
431	6	120.0	1.0	37.0	1276	83.0	4627
472	6	121.0	1.0	29.0	807	71.0	4626
341	6	120.0	0.9	44.0	248	84.0	4401
393	6	122.0	1.0	48.0	1282	86.0	4355
83	2	124.0	4.8	35.0	1270	73.0	4345
106	2	122.0	1.0	31.0	890	65.0	4332
467	6	122.0	1.2	49.0	296	86.0	4299
429	6	116.0	1.0	47.0	1455	76.0	4290
359	6	122.0	1.0	44.0	699	71.0	4283
277	2	125.0	1.2	58.0	594	72.0	4267
Best checks[b]							
Alanda-01	6	130.0	0.9	49.0	1447	66.0	3664
Arta	2	128.0	3.9	43.0	1467	59.0	3027
Mean		129.0	3.0	43.0	981	75.0	3026
s.e.		0.2	0.1	0.3	15	0.4	27
Max		140.0	9.2	61.0	1613	107.0	4627
Min		114.0	0.5	23.0	94	54.0	1435

[a] (1= no lodging, 9 = maximum lodging)
[b] in Tel Hadya and Breda, in the order

Entry Names
432 =Rihane-03/3/Deir Alla 106/Strain 205//Rihane-03
472 =Precoce/Radical
341 =Lignee527/Rihane-03//Rihane-03
393 =As//Mari/Aths*2/3/Mari/Aths*2-02
83 =Tadmor//Kv/Mazurka/3/Arta
106 =Eagle/4/WI2291/3/CI 03309/Attiki//Hja33
467 =Arizona 5908/Aths//Lignee640/4/WI2291/3/Api/CM67//L2966-69
429 =Rihane-03/3/Mr25-84/Att//Mari/Aths*3-02
359 =Eldorado/4/Arizona5908/Aths//Lignee640/3/Lignee640/Lignee527
277 =Triumph/Moroc 9-75

Table 2.4. The ten best lines in the Initial Yield Trials in Breda. Heading date and lodging resistance were scored in Tel Hadya. Grain yield is in kg/ha.

				Breda		Tel Hadya	
Entry	Row Type	Heading	Lodging[a]	Plant height	Grain Yield	Plant height	Grain Yield
130	2	133.0	7.1	34.0	1613.0	83.0	3401
172	2	123.0	6.9	60.0	1590.0	71.0	2960
159	2	130.0	3.0	47.0	1527.0	84.0	3894
248	2	129.0	6.0	46.0	1520.0	86.0	3085
193	2	123.0	1.2	51.0	1514.0	73.0	3158
485	2	130.0	5.1	45.0	1499.0	65.0	2535
173	2	131.0	8.9	39.0	1493.0	86.0	3296
144	2	129.0	4.8	47.0	1493.0	76.0	2587
139	2	136.0	5.9	35.0	1485.0	71.0	3444
149	2	128.0	0.9	46.0	1477.0	72.0	3524
Best checks[b]							
Alanda-01	6	130.0	0.9	49.0	1447.0	66.0	3664
Arta	2	128.0	3.9	43.0	1467.0	59.0	3027
Mean		129.0	3.0	43.0	981.0	75.0	3026
s.e.		0.2	0.1	0.3	15.0	0.4	27
Max		140.0	9.2	61.0	1613.0	107.0	4627
Min		114.0	0.5	23.0	94.0	54.0	1435

[a] (1= no lodging, 9 = maximum lodging)
[b] in Tel Hadya and Breda, in the order

Entry	Name
130	=SLB 23-52/Arta
172	=Tadmor//Roho/Mazurka/3/Zanbaka
159	=Tadmor/3/ChiCm/An57//Albert/4/Arta
248	=SLB 21-81//SLB 39-60/H.spont.41-1
193	=Moroc 9-75/Arabi Aswad/3/Arta//Moroc 9-75/Arabi Aswad
485	=SLB 5-96
173	=SLB 34-07/Arta//Tadmor
144	=SLB 04-30/SLB 05-96
139	=Moroc 9-75/Arabi Aswad//H.spont.41-4/3/Arta
149	= 7028/2759/3/69-82//Ds/Apro/4/H272//WI2198/ID601810 /5/SLB 05-96

The landrace line SLB 05-96 (entry 485, and a parent of lines 144 and 149) is one of the lines which performed well in the trials of the Mashreq and Maghreb project in Syria.

2.2.2.2. Preliminary Yield Trials

The preliminary yield trials comprised 241 breeding lines in the second year of testing and eleven checks. The average grain yield at Tel Hadya (2641 kg/ha) was higher than in Breda (1125 kg/ha), but the difference was smaller than usual. The drought intensity index was 0.574, in between those of 1997 (0.778) and 1996 (0.278).

There was a large variability for important traits such as plant height (which ranged from 28 to 66 cm in Breda, and from 47 to 107 cm in Tel Hadya) and grain yield (which ranged from 320 and 1800 kg/ha in Breda, and from 1454 and 4016 kg/ha in Tel Hadya). The best check in Tel Hadya was Alanda-01 with 3600 kg/ha, followed by Arabi Abiad (3190 kg/ha) and Rihane-03 (3040 kg/ha). In Breda the best check was Arta with 1800 kg/ha followed by SLB 05-96 (1460) and Zanbaka (1305).

The check with the highest average yield in 1997 and 1998 was Arabi Abiad both in Breda (1787 kg/ha) and in Tel Hadya (4031 kg/ha): 11 lines had an average grain yield higher than A. Abiad in Breda, and the number raised to 22 when the grain yields were expressed in standard units. Of these we only show seven lines which out-yielded Arabi Abiad using either the original or the standardized yields (Table 2.5) and which out yielded A. Abiad by between 4 and 14%. Of these, four were selections from landraces and from the same collection site of Arta (SLB 39-037, SLB 39-029, SLB 39-006, and SLB 39-055) and three were SSD lines derived from crosses between SLB 05-96 and Arta or *H.*

spontaneum. Only one had a grain yield slightly higher than A. Abiad at Tel Hadya.

Table 2.5. Lines in the Preliminary Yield Trials out-yielding Arabi Abiad in Breda (BR) both in 1997 and in 1998. The average heading date was scored in Tel Hadya (TH).

			Grain Yield					
Entry	RT	AVDH	BR97	TH97	BR98	TH98	AVBR	AVTH
18	2	129	2529	5170	1554	3072	2042	4121
16	2	131	2705	3441	1364	2405	2035	2923
72	2	127	2211	3563	1667	2965	1939	3264
5	2	129	1850	4521	1773	3395	1812	3958
20	2	129	2591	4944	1242	2738	1917	3841
78	2	129	1826	3648	1774	3288	1800	3468
117	2	128	2282	3201	1419	2510	1851	2856
Best check[a]								
A. Abiad	2	130	2387	4872	1187	3190	1787	4031
Mean		128	1415	4006	1125	2641	1270	3324
s.e.		33	30	60	21	33	21	42
Max		137	2705	5894	1801	4016	2042	4679
Min		66	356	2069	320	1454	196	1799

[a] both in Tel Hadya and Breda

Entry	NAME
18 =	SLB 39-037
16 =	SLB 39-029
72 =	SLB 05-96/Arta
5 =	SLB 39-006
20 =	SLB 39-055
78 =	SLB 05-96/Arta
117=	SLB 05-96/H. spontaneum 41-1

In Tel Hadya 42 lines out yielded Arabi Abiad either considering the original or the standardized data. Of these the seven lines which also out yielded Arabi Abiad both in 1997 and in 1998 are shown in Table 2.6. These were all six-rows except one, with a yield advantage over Arabi Abiad of between 10 and 16%. As noted earlier, the grain yield at Breda of the top yielding lines at Tel Hadya was lower than A. Abiad.

Table 2.6. Lines in the Preliminary Yield Trials out-yielding A. Abiad in Tel Hadya both in 1997 and in 1998. The average heading date was score in Tel Hadya (TH).

Entry	RT	AVDH	BR97	TH97	BR98	TH98	AVBR	AVTH
201	6	128	1036	5519	1180	3840	1108	4679
61	6	132	1885	4951	905	3954	1395	4452
202	6	127	994	5586	1155	3545	1075	4565
221	6	125	686	5282	1058	3715	872	4498
62	6	130	1882	4567	801	4016	1341	4292
213	6	127	356	5319	494	3566	425	4443
241	2	126	1141	5153	320	3632	731	4392
Best check[a]								
A. Abiad	2	130	2387	4872	1187	3190	1787	4031
Mean		128	1415	4006	1125	2641	1270	3324
s.e.		33	30	60	21	33	21	42
Max		137	2705	5894	1801	4016	2042	4679
Min		66	356	2069	320	1454	196	1799

[a]Entry	NAME
201=	Avt/Attiki//Aths/3/Giza 121/Pue
61 =	Rihane-03/Lignee 527//Eldorado
202=	Avt/Attiki//Aths/3/Giza 121/Pue
221=	Arar/Rihane-03
62 =	Jaidor/Asse//NK1272/3/Arar/Lignee 527
213=	Aths/Lignee 686//Orge 905/Cr.289-53-2
241=	Moroc 9-75//ER/Apm

As noted earlier, lodging susceptibility was consistently negatively correlated with grain yield at Tel Hadya, while it was positively correlated (not always significantly) with grain yield at Breda (Table 2.7). This is likely to be due to negative correlation between days to heading and lodging resistance, which indicates that early genotypes are more susceptible to lodging.

In this data set the correlation between heading and yield was not very strong even when significant. Also, the correlation between the grain yield in 1997 and 1998 was much stronger in Tel Hadya than in Breda. The correlation between Breda and Tel Hadya were never significant.

Table 2.7. Correlation coefficients[a] between lodging resistance (LDG), days to heading (DH), grain yield (GY) in Breda (BR) and Tel Hadya (TH), and average grain yield in two years in the preliminary yield trials.

	DH97	DH98	GYBR97	GYBR98	GYTH97	GYTH98	AVGYBR	AVGYTH
LDG	-0.37	-0.28	0.065	0.411	-0.582	-0.452	0.247	-0.582
DH97		0.541	0.281	-0.02	-0.06	0.106	0.173	0.03
DH98			0.238	0.145	0.014	0.192	0.178	0.176
GYBR97				0.321	-0.111	0.06	0.878	-0.05
GYBR98					-0.07	-0.05	0.735	-0.07
GYTH97						0.663	-0.114	0.955
GYTH98							0.016	0.855
AVGYBR								-0.07

[a]Values greater than 0.138 and 0.181 are significant at $P<0.05$ and $P<0.01$, respectively.

2.2.2.3. Advanced Yield Trials

The advanced yield trials comprised 89 breeding lines in the third year of testing and eleven checks. They were evaluated at Tel Hadya, Breda and Bouider in Syria, and Terbol and Kfardane in Lebanon, with average grain yields of 3298, 877, 6877, 4964 and 725 kg/ha, respectively. The same lines were tested in 1996 and 1997 in Breda and Tel Hadya.

The correlation coefficients (Table 2.8) between the grain yield of the 89 breeding lines in the two highest yielding locations (Tel Hadya and Terbol) are always large (greater than 0.6) and positive, while those between the low yielding locations (Breda, Bouider and Kfardane) are non-significant (except between Breda and Bouider in 1998). This confirms that high yielding environments tend to be more similar than low yielding environments, thus justifying different breeding strategies. The correlation coefficients between low and high yielding locations were either non-significant, or negative and significant. The most notable exception is Kfardane, which is positively and significantly correlated with both Tel Hadya and Terbol, even though the determination coefficients never exceed 12%.

The entries with the highest mean yield in the highest (Tel Hadya and Terbol) and the lowest (Breda and Bouider) yielding locations are shown in Tables 2.9 and 2.10.

All the highest yielding lines in Tel Hadya and Terbol (Table 2.9) were six-row, and many derived from crosses with Rihane-03, which was the best check in the highest yielding locations. These lines had a lodging resistance comparable to Rihane-03 and a range of maturity of nearly two weeks. The yield advantage over Rihane-03 of the best lines was between 5 and 11%. In general these lines did not perform well in low yielding conditions. In fact none out-yielded the best check in low yielding conditions (Arta).

In the low yielding locations only few lines yielded as much as or more than Arta, with a maximum yield advantage of 13%. These were either selections from landraces (entries 1, 2 and 3), or derived from crosses with landraces (entry 30) or with *H. spontaneum* (entries 4 and 23). Of particular interest is entry nr 4 as several lines derived from crosses between *H. spontaneum* and Tadmor appear often amongst the best performing material under harsh conditions. As observed in other trials, the best performing breeding material under stress did not have a good yield under favorable conditions and they tend to be more lodging susceptible than lines adapted to high yielding conditions. In this trial there was at least one exception as the landrace-line SLB 32-39 yielded as much as Rihane-03 in Tel Hadya and Terbol, about 9% more than Arta in Breda and Bouider, and had a good lodging resistance. However, it performed very poorly in Kfardane.

Table 2.8 Phenotypic correlation coefficients[a] between grain yield in Tel Hadya (TH), Breda (BR), Bouider (BO), Terbol (TR) and Kfardane (KF) in 1996, 1997 and 1998 on 89 barley breeding lines.

	TH96	BR97	TH97	BR98	TH98	BO98	TR98	KF98
BR96	0.02	0.109	-0.06	0.095	0.123	0.071	0.067	0.012
TH96		-0.372	0.7	-0.339	0.624	-0.654	0.759	0.352
BR97			-0.234	0.188	-0.306	0.245	-0.328	-0.151
TH97				-0.186	0.687	-0.417	0.738	0.352
BR98					-0.1	0.637	-0.278	-0.136
TH98						-0.339	0.692	0.312
BO98							-0.553	-0.192
TR98								0.239

[a] Values grater than 0.205 and 0.267 are significant at $P<0.05$ and $P<0.01$, respectively.

Table 2.9. Advanced Yield Trials: average grain yield (kg/ha) in the highest (HYS) and lowest (LYS) yielding locations of the best lines in the highest yielding locations with their row type (RT) days to heading (DH) and lodging resistance (LDG) in Tel Hadya and their rank in Kfardane (KFR).

Entry[a]	RT	LDG	DH	HYS	LYS	KFR
59	6	1.1	124	5344	1240	1
60	6	1.0	125	5263	1131	3
68	6	1.1	120	5250	1170	52
73	6	1.0	113	5248	996	2
48	6	2.0	124	5129	1222	49
78	6	1.5	124	5097	1313	32
75	6	1.0	124	5080	1144	56
69	6	1.0	123	5065	1013	76
50	6	1.0	121	5055	1371	16
43	6	1.0	124	5021	1117	71
Best checks						
Rihane-03	6	1.0	126	4794	1180	18
Arta	2	2.2	121	3983	1562	33
Mean		2.2	122.1	4135	1304	
s.e.		0.19	0.4	86	20	
Min		0.88	108.3	2246	816	
Max		6.53	128.5	5344	1768	

[a]Entry Names

59= Lignee 640/Lignee 527//Lignee 527/Rihane-03

60= Rihane-03/3/Lignee 527/Chaaran-01//Lignee 640/Badia

68= Arar/Rihane-03

73= Arizona 5908/Aths//Lignee 640/3/Lignee 527/Arar

48= Martin/Arar

78= Rihane-03/JLB 70-59

75= Lignee 527/NK1272//JLB 70-63

69= U.Sask.1766/Api//Cel/3/Weeah/4/Arar

50= JLB 70-63/Rihane-03

43= Lignee 640/Lignee 527//Aths/Lignee 686

Table 2.10. Advanced Yield Trials: average grain yield (kg/ha) in the highest (HYS) and lowest (LYS) yielding locations of the best lines in the lowest yielding locations with their row type (RT) days to heading (DH) and lodging resistance (LDG) in Tel Hadya and their rank in Kfardane (KFR).

Entry	RT	LDG	DH	HYS	LYS	KFR
4	2	6.5	124	2940	1768	20
2	2	1.5	125	4743	1700	86
1	2	0.9	123	4251	1686	62
3	2	5.9	127	2434	1608	88
30	2	3.2	121	4088	1597	54
23	2	5.0	120	2675	1572	85
Best checks						
Rihane-03	6	1.0	126	4794	1180	18
Arta	2	2.2	121	3983	1562	33
Mean		2.2	122.1	4135	1304	
s.e.		0.19	0.4	86	20	
Min		0.88	108.3	2246	816	
Max		6.53	128.5	5344	1768	

[a]Entry names
4 = H.spont.41-3/Tadmor
2 = SLB 32-39
1 = SLB 31-24
3 = SLB 34-40
30= Harmal//Harmal-02/Arabi Abiad*2
23= SLB 12-59//SLB 45-40/H.spont.41-5

(S. Ceccarelli, S. Grando)

2.2.2.4. Residual Maximum Likelihood (REML)

In our continuous effort to improve the efficiency of various aspects of the breeding program, and following a training course given by Dr. I. DeLacy of the University of Queensland in Brisbane (Australia), we have began using a method of analysis known as 'Residual Maximum Likelihood' or REML, introduced by Patterson and Thompson[4] in 1971. This is considered as a fully efficient analysis, which models the different levels of variation using variance components. Some of the advantages of REML are its ability to deal with incomplete data sets, as often are those of breeding trials, the possibility to chose the most appropriate model in each type of trial, and the generation of adjusted means across environments known as BLUP's (best linear unbiased predictors). The BLUP's are means weighted by the heritability at each location.

2.2.3. Cold tolerance

The methodology for assessing cold tolerance in freezing chambers was shortened from the traditional 12-14 days to 7 days.

The modified screening method was found to be reliable because the agreement with the previous one was very high and good results have been obtained in a considerably shorter period of time without loosing accuracy and precision. The major change is that the critical below zero temperature must be increased by 1-2°C. For example, for the differentiation of the susceptible material such as Harmal and Rihane-03, the screening temperature should be

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4 Patterson, H.D. and Thompson, R., 1971. Recovery of inter-block information when block sizes are unequal. Bometrika, 58: 545-554.

between -9 and -10°C, for moderately resistant material such as Arabi Aswad, Tadmor, Tokak, Walfajr, and Zarjou, it should be between -10 and -11°C, and for the group of the most resistant varieties, such as Radical, Dictoo, NE 93 747, it should be between -12 and -13°C for 24 hours.

The modified technique allowed the classification of the breeding material in susceptible, moderate, and resistant. A large number of resistant germplasm was identified. Among these, there were three hulless barley lines, which possess a level of cold tolerance similar to best checks (Table 2.11).

Table 2.11 Characteristics of cold tolerant hulless barley lines.

Name	Cold tolerance[a]		CD	GH	GV
	ICARDA	Krasnodar			
Rihane-03	5.2	0	3	3	1
Tokak	60.3	20.6	2	5	2
Radical	100.0	100.0	1	4	4
		Hulless barley			
Hymalaya	100.0	100.0	1	4	4
H-1	100.0	100.0	1	4	3
ICB-101354	100.0	90.2	1	5	4
Viringa	8.3	0.0	3	2	2
LSD 0.05	9.8	9.6			

[a] percent of surviving plants
[b] Cold damage in the field (1 = no damage, 5 = severe damage)
[c] Growth habit (1 = erect, 5 = prostrate)
[d] Growth vigor (1 = high, 5 = low)

Hymalaya is a six-row line with long smooth awns. N.I.Vavilov, in his article about the origin of barley smooth-awned landraces, noted that due to negative correlation and pleiotropic effect, he failed to produce artificially such forms, and he was rather skeptical about the possibility to find hulless barley with smooth awns. The data of table 2.11 show that this is indeed possible.

Furthermore, it has been possible to combine cold tolerance with the increased protein content, typical of hulless barley.

Another hulless barley line (H-1), selected in Krasnodar after testing ICARDA material for cold tolerance under controlled environments, and for disease and lodging resistance in high soil fertility conditions has an increased level of winter hardiness and a complex of positive agronomic traits. It is a six-row type with long rough awns. The lines were included into the 1998-crossing program and the hybrid material generated will be used to study the genetic relationship of the traits.

The third line (ICB 101354) is a two-row with long smooth awns and has improved grain quality characteristics. Even though some agronomic characteristics of these three lines are still not satisfactory, they represent valuable breeding material for further work. All these lines were included into the WBCB-CH-CW-99 nursery and were sent to many collaborators in the highlands and to CAC (Central Asia and Caucasus) countries.

The breeding efforts to improve cold tolerance, conducted in collaboration with NARS, were targeted to find an acceptable compromise between the desirable traits of spring types (earliness, good early growth vigor, long straw, drought tolerance) and the cold tolerance of winter barley. We followed two avenues: a) developing winter barley with good early growth vigor and resistance to drought; b) improving the cold tolerance of spring barley, planted in autumn.

This trend is becoming more evident after the merging the two separate projects on spring and winter barley with the goal to use more effectively the available resources. In different nurseries many lines were identified with high level of cold tolerance: If/A//Barsoy/Ri, VA 92-42-46 (IFBYT-98), 308/80M1 (IWBYT-98), Wysor, Radical/Birgit, Dundy, K-253, NE 89747, K-247/Vavilon, K-88M1 (IWBCB-98) and others. Among them there are early lines and genotypes with very good initial growth vigor.

The second approach has resulted in developing new germplasm, similar to the spring types but with increased cold tolerance. In all three sets of international spring barley yield trials (ISBYT-MRA-98, ISBYT-LRA-C-98, ISBYT-LRA-M-98) there were lines with the improved cold tolerance. Especially valuable material has been found in the ISBYT-MRA-98, where the more cold tolerant lines proved to be the highest yielding (Table 2.12).

Table 2.12. Performance of barley lines in the international yield trial for moderate rainfall

Name	GH[a]	GV[b]	CD[c]	LD[d]	Yield, kg/ha
A.Aswad check	4	3	2	5	3694
WI 2291 (improved check)	1	1	2-3	5	4194
Assala-04 (improved check)	4	2	3-4	2	4520
Aths/Lignee686//Hml-02/Arabi Abiad	5	2-3	1	1	5016
5604/1025//Arabi Abiad/3/Hml-02/4/WI2198/Lignee 131	3	1	1	1	4864
WI2291/Bgs//WI2291/Roho	2	2	1	2	4660
LSD 0.05					360

[a] (1 = erect, 5 = prostrate)
[b] (1 = high, 5 = low)
[c] (1 = no damage, 5 = severe damage)
[d] (1 = low, 5 = severe)

From the results of the season a very important conclusion has been reached about the importance of morphological ideotype in increasing of the effectiveness of the field selection. First, a complex of morpho- and physiological traits, typical for the released varieties, should be considered as an optimal model for this purpose. The attempts were undertaken to find out lines phenotypically close to the well adapted released varieties Arta, Rihane-03, Tokak, Zarjou, but improved in some important characters.

To exploit more effectively growth vigor, we can either increase cold tolerance of the spring types, or we can select material with the good growth vigor among the cold tolerant germplasm. Both directions proved to be fruitful. There are lines similar in growth habit to Arta and Rihane-03, but with improved cold tolerance and yielding capacity. A new line Pamir 9, a result of transgressive segregation after crossing two landraces (the Ethiopian line ICB 101351 and the released variety Arta), is phenotypically very close to Arta. The last season it performed well in Turkey and Russia due to increased cold tolerance. This year Pamir 9, with good resistance to lodging and to leaf diseases, has showed high productivity and was identified as a candidate for multiplication and more thorough testing in different locations.

A six rowed line (LB.KanMehterzai/K-273), is very similar in phenotypic architecture to Rihane-03, has a high rate of initial growth, and is early, resistant to lodging and cold tolerant. Taking into account the high yield potential of the widely spread Rihane-03 and the advantage of six-rowed type especially in some areas of Iran, this kind of germplasm is promising (Table 2.13).

We identified a six-rowed cold tolerant line (K-253/Dayton) with smooth awns, performing similarly to Rihane-03, which has long rough awns causing problems during harvesting, threshing and utilization of the straw as animal feed.

A two-rowed line, Scio//YEA422.1/YEA455.25, targeted for Turkey has a plant architecture typical of the widely spread variety Tokak. It proved very successful thanks to high resistance to leaf diseases, stiff straw, resistance to grain shattering, and good productivity.

Table 2.13. Growth habit (GH), growth vigor (GV), Cold damage (CD), lodging resistance (LD) and grain yield of promising lines.

Name	GH[a]	GV[b]	CD[c]	LD[d]	Yield[e]
Arta	2-3	1	2-3	5	100
Pamir-9	3	2	1	1	117
Rihane-03	2-3	1-2	3	1	100
LB.KanMehterzai/K-273	4	2	0-1	1	112
K-253/Dayton (smooth awns)	4	3	2-3	1	97
Tokak	4	3	2	4	100
Scio//YEA422.1/YEA455.25	3	1	0-1	1	160
Alanda-01	3	3	2-3	1	100
Zarjou	4	3	2	1	82
K-273/Morex	4	3	0-1	1	102
Radical/Zarjou	4	2	1	1	93
K-273/Steptoe	4	3	1	1	101

[a] 1 = erect, 5 = prostrate;
[b] 1 = high, 5 = low;
[c] 1 = no damage, 5 = severe damage;
[d] 1 = low, 5 = severe;
[e] percent of the nearest check

Winter barley types with lax big size heads, targeted for Iran, will benefit from the new germplasm, selected on the complex of desirable traits, including very early ripening with high initial growth vigor to compete with weeds and in this way to decrease the need for pesticides. Although none of them could outyield Alanda-01, some have a good balance of agronomic characters and cold tolerance.

Now, the urgent task is to test these promising lines in the targeted environments. Their seeds were delivered to collaborators in the highlands and to CAC countries.

(V. Shevtsov)

2.2.3.1. Head breakage and grain shattering.

This season a very intense selection pressure was applied for resistance to head and stem breakage and to grain shattering. These traits have economic importance, because many farmers in marginal areas do not own combines, and harvesting is seldom done timely. Thus the crop is vulnerable to winds and high temperature which can cause considerable losses. Just before harvesting at Tel Hadya, the majority of winter barley lines looked very uniform and promised yield levels around 4-5 t/ha. However, two days of strong and hot wind changed the situation considerably. While the best line still had a grain yield of 7 t/ha, about 20% of lines yielded 5-6 t/ha, 40% about 3 t/ha and 40% less than 3 t/ha. Even accounting for losses due to lodging (20 - 40%), additional severe losses were due to seed shattering. In some crosses, the difference in yield between sister lines reached 200-300%. For example, in the cross Radical/Precoce, out of 15 sister lines, two yielded 6.2–6.5 kg/plot, six produced 5-6 kg/plot, four lines produced 4-5 kg/plot, two lines produced 3-4 kg/plot, and one line produced 2.6 kg. The difference between crosses was more drastic, ranging from 0.5 kg to 7.7 kg. The six-rows were more affected by head and stem breakage than two-rows. All ICARDA winter barley nurseries for 1999 were prepared using the information on grain shattering.

(V. Shevtsov)

2.2.3.2. Depth of the crown node

The depth of the underground crown node is a trait very closely related to winter hardiness. Every centimeter of soil gives 1-3°C protection against frost in the crown node. To study this character, 460 barley entries from advanced nurseries and crossing block were planted in the field at the fixed depth of 8 cm. The measurements started at tillering, when it is easy to measure the underground internode length. We found that it is indeed possible to measure the depth of the crown node also at stem elongation, and even after maturity, if dry plants are handled carefully.

There is a large genetic variation for this trait, which varies from 2.2 cm to 7.1 cm. The majority of the lines tested formed the tillering node at the depth of 3.0 cm. Some genotypes such as Dictoo, ICB 101302, mutant 26M8, Rostov-55, have a very deep crown node, from 5.5 to 6.8 cm. The American lines NE 93760, NE 93 747, Dictoo (from the Uniform Winter Hardiness Barley Nursery), and the Russian variety Rostov-55 combine very deep crown nodes with high level of cold resistance. This makes them extremely valuable for the improvement of winter hardiness in barley (Table 2.14).

Table 2.14. Cold tolerance (CT), depth of crown node, (DCN), tiller number (*TLN*) and leaf length (*LL*) of barley lines with deep crown nodes.

Name	CT[a]	DCN	TLN	LL
Rihane-03 (check)	5.2	3.2	2.8	25.5
Tokak (check)	40.2	3.6	5.6	21.0
Radical (check)	80.6	3.7	3.8	19.5
Kearney	100.0	5.1	2.0	21.5
Dictoo	100.0	6.1	2.0	17.5
NE 93 760	100.0	6.7	1.6	17.2
NE 93 747	100.0	6.2	2.2	18.3
Rostov-55	75.4	6.1	2.4	14.5
ICB 101 302	60.2	5.8	6.0	22.3
LSD 0.05	8.7	0.4		

[a] frost tolerance in percentage of survival plants after freezing in chambers.
[b] in cm
[c] leaf length (cm) at the beginning of the stem elongation stage.

Many of these lines are six-rowed winter type, and need a long period of vernalization. They possess low tillering capacity and very poor initial growth vigor. But some of them, such as Baluchistan/Cougar, combine a deep tillering node with traits responsible for the adaptation and productivity. The two-rowed line, ICB 101 302, possesses good cold tolerance and large grain size. Even some spring barley lines from advanced trials, targeted for zones with warm climate, form the crown node deeper than 4 cm (Table 2.15).

Table 2.15. Cold tolerance (CT), depth of crown node, (DCN), tiller number (TLN), leaf length (LL) and row type (RT)of barley lines with deep crown nodes.

Name	CT*	DCN	TLN	LL**	RT
Rihane-03 - check	5.0	3.2	2.8	25.5	6.0
Tokak - check	40.0	3.6	5.6	21.0	2.0
Radical - check	81.0	3.7	3.8	19.5	6.0
SLB 31-24	65.0	4.4	5.8	30.0	2.0
SLB 32-39	56.0	5.2	5.8	26.0	2.0
H.spont.41-3/Tadmor	20.0	5.8	3.6	29.0	2.0
H.spont.41-3/SLB39-39	10.0	5.3	4.0	22.5	2.0
Arar/H.spont.19-15/Arta	20.0	5.0	3.4	31.0	2.0
Arar/H.spont.19-5/Harmal	45.0	5.2	3.8	27.5	2.0
Anadolu86//Arar/A.Aswad	50.0	4.1	5.4	34.5	2.0
CI 07117-/Deir Alla//Badia	70.0	4.1	5.6	29.0	6.0
LSD 0.05	8.7	0.4			

* cold tolerance in percentage of survival plants after freezing in chambers

** leaf length at the beginning of the stem elongation stage

These results indicate that the trait is independent from other agronomic traits, and that it is possible to find good combinations of deep crown node and other agronomic characters, when data of lines with crown depth of 4-5 cm are analyzed. The correlation coefficient between the depth of crown node and the early growth vigor recorded as leaf length before the stem elongation was r=0.07, while

2.2.4.1.2. Farmers' Characteristics

It was considered that one of the most important factors that may affect a farmer's selection criteria is the extent to which crop sales contribute to farm income (Table 2.16). Two farmers in Ibbin and Ebla, the two wettest locations, rely solely on crop sales while the majority of farmers obtain income from both crop and livestock production, as well as from off-farm activities. Although the percentages change from one site to the other, more than half of the farmers rely on three different sources of income.

Table 2.16. Main Source of income in % in each location (ranked by mean rainfall)

Location	Rainfall (mm)		Crop Sales	Livestock	Off-Farm
	Mean	97-98	(%)	Sales (%)	Income (%)
Ibbin	350	418	100	0	0
Ebla	350	368	100	0	0
Sauran	300	329	75	0	25
Tel Brak	290	298	50	30	20
Jurn El Aswad	285	202	95	0	5
Bari Sharki	270	316	50	20	30
Al Bab	260	269	29	1	70
Melabiye	253	167	60	20	20
Baylonan	250	200	60	30	10

The area planted with barley varies considerably between farmers, ranging from a maximum of 110.5 ha to a minimum of 1.5 ha (Table 2.17). The area allocated to barley is not a function of farm size, as can be seen from the percentage areas presented in Table 2.18. The percentage area planted to barley depends on both rainfall and the availability of water (see % area irrigated in Table 2.17), which permits greater crop diversification in drier areas. Farmers in higher rainfall areas (e.g., Sauran) or with access to irrigation (e.g., Melabiye, Tel Brak and Jurn El Aswad) allocate a greater area to wheat and other crops.

Table 2.17. Allocation of cropped area to different crops (hectares)

Location	Total (ha)	Barley (ha)	Wheat (ha)	Legumes (ha)	Trees (ha)	Other (ha)	Fallow (ha)	Irrigated Area (ha)
Baylonan	150.5	110.5	40.0	0.0	0.0	0.0	0.0	0.0
Tel Brak	360.0	103.0	122.0	0.0	0.0	35.0	100.0	157.0
Ebla	86.0	30.0	20.0	19.0	1.0	16.0	0.0	0.0
Bari Sharki	44.0	12.0	2.5	8.0	8.0	1.5	12.0	4.0
Melabiye	34.0	10.0	12.0	0.0	0.0	9.0	3.0	21.0
Jurn El Aswad	39.5	6.5	20.0	2.5	1.5	5.0	4.0	15.0
Sauran	10.0	6.0	0.5	1.0	2.5	0	0	0.0
Ibbin	169.0	5.0	43.0	40.0	1.0	40.0	0.0	40.0
Al Bab	12.0	1.5	7.0	3.0	0.5	0.0	0.0	0.0

Table 2.18. Allocation of cropped area to different crops (% of total cropped area), ranked by % area in barley.

Location	Total Area (ha)	% of total area Barley	Wheat	Legumes	Trees	Others	Fallow	Irrigated
Baylonan	150.5	73.4	26.6	0.0	0.0	0.0	0.0	0.0
Sauran	10.0	60.0	5.0	10.0	25.0	0.0	0.0	0.0
Ebla	86.0	34.9	23.3	22.1	1.2	18.6	0.0	0.0
Melabiye	34.0	29.4	35.3	0.0	0.0	26.5	8.8	61.8
Tel Brak	360.0	28.6	33.9	0.0	0.0	9.7	27.8	43.6
Bari Sharki	44.0	27.3	5.7	18.2	18.2	3.4	27.3	9.1
Jurn El Aswad	39.5	16.5	50.6	6.3	3.8	12.7	10.1	38.0
Al Bab	12.0	12.5	58.3	25.0	4.2	0.0	0.0	0.0
Ibbin	169.0	3.0	25.4	23.7	0.6	23.7	0.0	23.7

Based on the information on farm size, area planted to barley and sources of income, the nine participating farmers are grouped in a 2 x 2 matrix shown in Table 2.19. The nine farmers are almost evenly allocated between the four categories. It should be noted that the farmer in Tel Brak, classified as "large-scale, on farm use, also owns a chicken farm, and barley is used to feed not only sheep but also chickens.

Table 2.19.Matrix of selection sites classified by farm size and crop use.

	Purpose of growing barley	
Barley area	Commercial (for sale)	On-farm use (livestock)
Large	Ebla, Sauran	Tel Brak, Baylonan
Small	Jurn El Aswad, Ibbin, AlBab	Melabiye, Bari Sharki

2.2.4.1.3. Analysis of farmers preferences

The analysis of the quantitative scores made during selections is presented under Component 4. In this section, we present the results of the analysis of the qualitative assessment of the breeding material tested in 1997/98.

All the characters were translated literally into English, coded (from A1 through N50), sorted into categories such as head, stem, color, height, etc. and tabulated accordingly. The descriptors were also adopted from farmers' comments and translated. These are presented in a summarized form in Table 2.20, according to three different values, i.e., positive, negative and neutral. Descriptors that were mentioned by the farmers as a reason for raising the score were classified as "positive", while those descriptors that lowered the score by farmers were classified as "negative". Any description that was mentioned by farmers, but had no apparent positive or negative affect on scoring, was listed as "neutral".

Table 2.20. Summary of the list of characters and farmers' descriptors used in evaluating lines

Characters	Positive descriptors (+)	Negative descriptors (-)	Neutral descriptors (N)
A: Height	Excellent, Good, Suitable for combine harvest, Homogeneous	Short, Unsuitable, Non acceptable, Stunted, Heterogeneous	Medium
B: Grain	Excellent, Good, Full, Bigger, Heavy, Soft, Thin crust, Homogeneous-sized	Small, Weak, Thin, Little, Tough, Thick crust, Heterogeneous-sized	Medium softness, Medium weight
C: Straw	Good, Better, Soft	Inedible for sheep, Little, Tough	Medium
D: Head	Full, Unbent, Unbroken, Heavy, Good number of grains per head, Mature	Bent, Incomplete, Bad, Empty, Broken, Shattering, Weak neck	Medium
E: Color	Desirable, (Black/White) Heterogeneous	Undesirable (Black/White), Weak, Rejected, Homogeneous	
F: Row	Desirable two	Rejected six, Undesirable six	
G: Stem	Good, Thick, Strong	Thin, Weak, Bad	Medium
H: Tillering	Good, Excellent, High	Little, Below average, Weak	Medium
I: Maturity	Early, Homogeneous	Late, Early but attracts birds, Heterogeneous	Medium
J: Lodging	No	High, Expected	Medium
K: Productivity	High, Good, Profitable	Low	Medium
L: Adaptation	Tolerant to drought/ environmental conditions/ Suitable to dry region	Intolerant to drought, Needs more rain, unsuitable for this region	
M: Susceptibility	Unaffected by frost, Disease resistant	Affected by low temperature/natural factor	Affected by frost to some extent
N: General View	Good (Thick) vegetation, Good growth, Nice looking crop, Desirable for sheep	Very weak growth, Below average, Unacceptable for feed, Unsuitable for selling Stunted, Bad	Medium vegetation

Thus, the descriptors in Table 2.20 represent farmers' preferences. In some cases aspects of different characters are inter-related. For instance, for row characters, six rows is included as a negative descriptor, because farmers rejected lines with six rows or remarked that six row barley lines were undesirable, for the reason that the grain and straw of the six row barley is considered to be less soft than those of two row barley. Softness of straw (palatability) is a major consideration of farmers when evaluating barley as a feed.

In addition to the farmers' individual preferences, market preferences also have a bearing as they reflect demand and, therefore, are an indirect indicator of preferences. In the case of seed color, for example, market prices reflect differences in preferences between regions. In Hama province, where white seed is preferred, white seed is sold at a higher price than black seed. The situation is reversed in Raqqa and Hassake areas; the farmer from Melabiye told us that the market price for black seed was about twice that for white seed.

Farmers also have preference for different types of barley depending on end-use. For instance, the farmer in Tel Brak, who has a chicken production enterprise in addition to sheep, distinguishes between different types of barley for different uses: the black-seeded barley is used for sheep feed, as he believes that sheep prefer (eat more) of the black seeded barley and also that it is more nutritious, while the white-seeded barley is used for chicken feed.

Table 2.21 indicates how the positive descriptors actually mentioned by the nine host farmers during selection compare with their "ideal" descriptors of barley. Although the descriptions are not always exactly the same, most of the characteristics referred to are quite similar. It can be concluded that the farmers are, in general, consistent with their own stated ideal preferences when making selections in the field. Furthermore, there is evidence that the farmers' individual circumstances and their production objectives affect their preferences. In particular, characteristics associated with straw and feed quality are mentioned by most of the farmers who are producing barley for their livestock, and not at all by those who produce barley solely for sale.

For the plots (lines) with the top fifteen scores at each selection site, the frequency distribution of the barley characteristics was computed. The results for Tel Hadya (a relatively favorable site), Breda (a less favorable site) and in the farmers fields are shown in Tables 2.22, 2.23 and 2.24, respectively. In interpreting these tables, it is important to distinguish between the use of a characteristic as a criterion for selection by farmers, and the importance of that criterion in determining the top 15 selected lines. The percentage of farmers mentioning a certain characteristic gives an indication of the frequency in which that characteristic is used as a criterion for selection by farmers. The percentage of times that a characteristic was mentioned indicates how important it was in contributing to the selection by farmers of the top 15 lines at any given site.

To identify the most preferred characteristics, an index was computed as the average of the % of farmers who mentioned it" and the % of times a character was mentioned". All the characters mentioned by the farmers are displayed in descending order according to the value of the index. The total sample number ranged from 104 (farmers field) to 134 (Breda). The maximum potential sample number was 135 (15 lines x nine farmers each) but some samples had to be discarded due to insufficient information in some of the answers.

Table 2.21. Ideal and Actual Descriptors in farmer's Field

Location / Purpose	Zone	Positive descriptors in his field	Ideal descriptors for Barley	Reasons
Ibbin Crop sales	2	- Good productivity - (ditto) - No lodging under irrigation - (ditto) - Heavy grain weight - N/A - N/A - High market price	- Frost resistance - More tillering - No lodging - Suitable height - N/A - Early maturity - Disease resistance - N/A	- Better production - Better production - Suitable for combine harvesting and better yield - Suitable for combine harvesting - N/A - Unaffected by heat and can be harvested early - Better yield - N/A
Ebla Crop sales	2	- High tillering - Good grain size - Heavy grain weight - Good length of heads - Early maturity	- Tall - Drought tolerant - Positive response to chemical fertilizer - Disease resistant - Non shattering of grain - White seeds	- Suitable for combine harvesting - Low precipitation - Better yield - ditto - ditto - High demand in the market

Tel Brak Crop sales Livestock sales (+chicken)	3	- Good grain size - Black seeds - Good tillers	- Good grain size - Heavy grain - Homogeneous grain size - N/A - Homogeneous grain color - Softness of grain - Good size of heads - Good tillers	- Better yield - Better production - Better market price - ditto - ditto - Better feed quality - ditto - ditto
Jurn El Aswad Crop Sales	3	- Drought tolerance - Good productivity	- Drought tolerance - Good heads - Suitable height - High tillering - Frost resistance - N/A	- Better production - ditto - Suitable for combine harvesting - More production - Better yield
Baylonan Crop sales Livestock sales	2	- Good grain size - Drought tolerance - Desirable color (Abrash) - Desirable for feeding - Homogeneous height - Early maturity - Heavy grain - Good amount of straw	- Good grain size - Drought tolerance - Black Grain - Soft grain - Soft straw - Good height - N/A - N/A - N/A - High productivity	- Better production - Low precipitation in spring - Desired in the market - Good feed quality - ditto - Suitable for combine harvesting - Better production

Al Bab Crop sales Livestock sales	2	- High productivity - Desirable color (Abrash) - Suitable height	- High productivity - Abrash - Medium height - No lodging - High tillering	- Better production - Desirable as feed - Tolerant of lodging - Better production - ditto
Melabiye Crop sales Livestock sales	3	- No lodging - Drought tolerance - Good yield	- Strong and thick stem - Drought tolerance - Good yield - Tall heads - Big grain - Good height	- Tolerant of lodging - Low rainfall - More economic return - More grains - Better production - Suitable for combine harvesting
Bari Sharki Crop sales Livestock sales	3	- Suitable height - Early maturity - Acceptable productivity - Desirable white seeds	- Good height - Early maturity - Thick heads - White seeds - Two row variety	- Suitable for combine harvesting - Shortage of rain - More production - Higher market price - Good for feed due to the softness of grain/ straw
Sauran Crop Sales Livestock sales	2	- White seeds - Softness of straw - Good tillering - Tall heads - Good height	- Desirable white seeds - Softness of straw - More tillers - Tall heads - Good height	- Better market price - Good feed quality - More yield - Ditto - Suitable for combine harvesting

Note: Livestock means sheep in this table unless specified otherwise.

In Tel Hadya (Table 2.22), head characteristics and height were the most common criteria used by farmers (100% and 89% of farmers respectively) and were cited most frequently in selection (69% and 59% of selections respectively). These are followed by tillering, maturity grain characteristics and lodging, all used as criteria by two-thirds of the farmers. Only three farmers considered grain color, and then only in 5% of selections, and only one farmer cited straw characteristics. Characteristics related to stems and adaptation were not mentioned at all. In Tel Hadya, a favorable site, with sufficient rainfall and deep soil, negative descriptors, such as "intolerant to drought", "needs more rain" and "unsuitable for this region" are not in evidence. Similarly, negative stem traits such as "thin" and "weak" were not recorded. Thus, under favorable conditions, farmers' selections appeared to be based primarily on characteristics related to productivity (head, tillering, grain) and height (favoring combine harvesting).

It should be noted in Table 2.22 (and in subsequent tables) that no single criterion is used for every selection. For instance although all nine farmers used head characteristics as a criterion, it was actually cited as a reason for selection in only 69% of the selections, implying that in some cases other criteria took precedence over head characteristics in determining the selection of a particular line.

Table 2.22. Farmers preferences during selection in Tel Hadya

Character	Times mentioned	total # of samples	Times mentioned (%)[a]	# of Farmers	% of Farmers	Index[b]
D: Head	92	133	0.69	9	1.00	0.85
A: Height	70	133	0.53	8	0.89	0.71
A1: Excellent, (Very) Good, Suitable, Tall, etc	70	133	0.53	8	0.89	0.71
A2: Medium	0	133	0.00	0	0.00	0.00
A3: Short	0	133	0.00	0	0.00	0.00
H: Tiller	48	133	0.36	6	0.67	0.51
I: Maturity	37	133	0.28	6	0.67	0.47
B: Grain	23	133	0.17	6	0.67	0.42
J: Lodging	16	133	0.12	6	0.67	0.39
N: General View	7	133	0.05	3	0.33	0.19
E: Color	7	133	0.05	3	0.33	0.19
E1: Color (Black)	5	133	0.04	2	0.22	0.13
E2: Color (White)	0	133	0.00	0	0.00	0.00
E3: Color (Abrash; mixed)	2	133	0.02	1	0.11	0.06
K: Productivity	15	133	0.11	1	0.11	0.11
C: Straw	2	133	0.02	1	0.11	0.06
M: Susceptibility	2	133	0.02	1	0.11	0.06
F: Row	1	133	0.01	1	0.11	0.06
F1: 2 rows	1	133	0.01	1	0.11	0.06
F2: 6 rows	0	133	0.00	0	0.00	0.00
G: Stem	0	133	0.00	0	0.00	0.00
L: Adaptation	0	133	0.00	0	0.00	0.00

[a] times mentioned (%) = times mentioned/ total # of samples
[b] index = (% times mentioned + % of farmers)/2

In Breda (Table 2.23), again head characteristics and height (tall plants) were the most common criteria used by farmers (eight out of nine farmers) and most cited as a reasons for selection of lines. As in Tel Hadya, tillering, maturity and grain were also important characteristics. Color was used as a criterion by four farmers (split equally: two preferring black and two preferring white grain) and influenced 25% of selections. One noticeable difference to the results for Tel Hadya is the lack of mention of lodging. It should be noted in a low rainfall site such as Breda, lodging does not occur and, thus, would not figure in farmers' considerations. Lodging only becomes an issue under higher rainfall conditions such as at Tel Hadya.

In the farmer's fields (Table 2.24), only eight characteristics out of fourteen were mentioned. Of these, height and head characteristics were again the most common criteria, used by seven out of nine farmers, and cited in 91% and 82% of selections respectively. Tillering was also important, used by six farmers and mentioned in 56% of the selections, followed by grain characteristics, used as a criterion by four farmers and mentioned in 35% of selections. Lodging, maturity, "general view" and color were of minor importance (both in terms of number of farmers and number of times mentioned).

Table 2.23. Farmers preferences during selection in Breda

Character	Times mentioned	total # of samples	times mentioned (%)[a]	# of Farmers	% of Farmers	Index[b]
D: Head	102	134	0.76	8	0.89	0.83
A: Height	91	134	0.68	8	0.89	0.78
A1: Excellent, (Very) Good, Suitable, Tall, etc	83	134	0.62	7	0.78	0.70
A2: Medium	7	134	0.05	4	0.44	0.25
A3: Short	1	134	0.01	1	0.11	0.06
H: Tiller	65	134	0.49	6	0.67	0.58
E: Color	34	134	0.25	4	0.44	0.35
E1: Color (Black)	15	134	0.11	2	0.22	0.17
E2: Color (White)	19	134	0.14	2	0.22	0.18
E3: Color (Grey)	0	134	0.00	0	0.00	0.00
I: Maturity	7	134	0.05	4	0.44	0.25
B: Grain	18	134	0.13	3	0.33	0.23
N: General View	20	134	0.15	2	0.22	0.19
K: Productivity	15	134	0.11	1	0.11	0.11
F: Row	14	134	0.10	1	0.11	0.11
F1: 2 rows	14	134	0.10	1	0.11	0.11
F2: 6 rows	0	134	0.00	0	0.00	0.00
G: Stem	4	134	0.03	1	0.11	0.07
C: Straw	2	134	0.01	1	0.11	0.06
M: Susceptibility	1	134	0.01	1	0.11	0.06
J: Lodging	0	134	0.00	0	0.00	0.00
L: Adaptation	0	134	0.00	0	0.00	0.00

[a] times mentioned (%) = times mentioned/ total # of samples
[b] index = (% times mentioned + % of farmers)/2

Table 2.24. Farmers preferences during selection in the farmers fields

Characteristics	times *mentioned*	Total # of *samples*	times mentioned(%)[a]	# of Farmers	% of Farmers	Index[b]
A: Height	95	104	0.91	7	0.78	0.85
A1: Excellent, (Very) Good, Suitable, Tall, etc	94	104	0.90	7	0.78	0.84
A2: Medium	1	104	0.01	1	0.11	0.06
A3: Short	0	104	0.00	0	0.00	0.00
D: Head	85	104	0.82	7	0.78	0.80
H: Tiller	58	104	0.56	6	0.67	0.61
B: Grain	36	104	0.35	4	0.44	0.40
J: Lodging	16	104	0.15	2	0.22	0.19
N: General View	9	104	0.09	2	0.22	0.15
I: Maturity	3	104	0.03	1	0.11	0.07
E: Color	2	104	0.02	1	0.11	0.07
E1: Color (Black)	0	104	0.00	0	0.00	0.00
E2: Color (White)	2	104	0.02	1	0.11	0.07
E3: Color (Grey)	0	104	0.00	0	0.00	0.00
C: Straw	0	104	0.00	0	0.00	0.00
F: Row	0	104	0.00	0	0.00	0.00
F1: 2 rows	0	104	0.00	0	0.00	0.00
F2: 6 rows	0	104	0.00	0	0.00	0.00
G: Stem	0	104	0.00	0	0.00	0.00
K: Productivity	0	104	0.00	0	0.00	0.00
L: Adaptation	0	104	0.00	0	0.00	0.00
M: Susceptibility	0	104	0.00	0	0.00	0.00

[a] times mentioned (%) = times mentioned/ total # of samples
[b] index = (% times mentioned + % of farmers)/2

Viewing the results for the three sites together, it is clear that head characteristics (full heads, number of grains per head, heavy heads), height (important for ease of combine harvesting) and tillering are the three main criteria used by farmers in selection. Although some criteria are important to individual farmers, such as color, row (2- vs. 6-row), and straw characteristics, it should be noted that even for these individuals these factors were not cited frequently in selection. Thus, preferences for color, row-type and soft straw do not have a major influence on selection. Table 2.25 summarizes farmers' preferences in the two research stations (Tel Hadya and Breda) and in the farmers' fields, according to the computed index, which is a combination of the frequency with which a characteristic is used by farmers as a criterion and its importance in determining selection.

From Table 2.25, it is obvious that long heads and tall plants are the characteristics more frequently used as selection criterion, and those more frequently quoted by farmers regardless of the location in which the selection took place. While the preference for tall plants in dry areas (Breda and most farmers' fields) was not surprising, it was interesting to find the tall plants (provided they don't lodge) are desirable also in a wet environment such as Tel Hadya.

Tillering was consistently the third characteristic most frequently used as selection criterion, reflecting the desirability of a good biomass production early in the season as related, presumably with a higher amount of dry matter available for grazing in the case of failure of grain production. Good tillering ability, and hence high biomass before anthesis, are known to be related to higher grain yield. Furthermore, good tillering ability allows a greater flexibility in source-sink relationships at different levels of stresses. It interesting that the farmers attach a high importance to such a trait regardless of the environmental conditions of the selection site.

While the three most important characteristics are the same in the farmers' fields and in the two research stations, the importance of the other characteristics varies with the environment in which the selection takes place. For example, early maturity, large grains and lodging resistance rank immediately after long heads, tall plant and high tillering in Tel Hadya, but lodging resistance is never used as selection criterion, or quoted, in Breda, while early maturity is used as selection criterion, or quoted, very seldom in farmers' fields.

Even though productivity was seldom used and quoted, farmers do use and quote all the most important yield components such as spike length, which also reflects a larger number of grains, tillering, which reflects a larger number of spikes per unit area, and eventually grain size.

Table 2.25. Farmers preferences in research stations (TH = Tel Hadya; BR = Breda) and farmers fields (FF).

Rank	Characteristics	Index FF	Index BR	Index TH	Total Index	Average Index
1	D: Head	0.800	0.825	0.846	2.471	0.824
2	A: Height	0.850	0.784	0.708	2.342	0.781
	A1: Excellent, (Very) Good, Suitable, Tall, etc	0.840	0.699	0.708	2.246	0.749
	A2: Medium	0.060	0.248	0.000	0.308	0.103
	A3: Short	0.000	0.059	0.000	0.059	0.020
3	H: Tiller	0.610	0.576	0.514	1.700	0.567
4	B: Grain	0.400	0.234	0.420	1.054	0.351
5	I: Maturity	0.070	0.248	0.472	0.791	0.264
6	J: Lodging	0.190	0.000	0.393	0.583	0.195
7	E: Color	0.010	0.349	0.193	0.552	0.184
	E1: Color (Black)	0.000	0.167	0.130	0.297	0.099
	E2: Color (White)	0.070	0.182	0.000	0.252	0.084
	E3: Color (Grey)	0.000	0.000	0.063	0.063	0.021
8	N: General View	0.150	0.186	0.193	0.529	0.176
9	K: Productivity	0.000	0.112	0.112	0.223	0.074
10	F: Row	0.000	0.108	0.059	0.167	0.056
	F1: 2 rows	0.000	0.108	0.059	0.167	0.056
	F2: 6 rows	0.000	0.000	0.000	0.000	0.000
11	C: Straw	0.000	0.063	0.063	0.126	0.042
12	M: Susceptibility	0.000	0.059	0.063	0.122	0.041
13	G: Stem	0.000	0.070	0.000	0.070	0.023
14	L: Adaptation	0.000	0.000	0.000	0.000	0.000

2.2.4.2. Participatory Breeding

As indicated in the 1997 report, the lines selected during the cropping season 1997/98 were classified based on a) who selected them, and b) where they were selected. For each of the nine farmers, this resulted in the following four groups of lines:

a. selected by each farmer in his own field
b. selected by each farmer in Tel Hadya
c. selected by each farmer in Breda
d. selected by the breeder in each of the farmer's fields

These four groups were specific for each of the nine sites, although a number of lines were in common among a various number of sites. In addition to these four groups of lines, other two groups of lines were those:

e. selected by the breeder in Tel Hadya
f. selected by the breeder in Breda

The last two groups (e and f) were independent from the nine farmer's sites and were therefore common to all trials.

For those five locations where we conducted group selection (see Annual Report 1997), an additional group was made with the lines selected by the majority of the farmers in that group.

With the selected lines, and avoiding duplications within the same trials, we prepared a specific trial for each of the nine locations. The layout was improved compared with 1997 by adding systematic checks to the selected entries. In one farmer's site (Al Bab), where the farmer has introduced a forage legume in the rotation (common vetch, *Vicia sativa*), the trial was planted twice, once after barley and once after vetch. The code for the trial after vetch is 10.

All the nine trials were also planted in Tel Hadya and Breda, two of ICARDA's research stations.

The total number of entries, which were tested, was 1083: the details of each trial are shown in Table 2.26.

Table 2.26. Composition of the 1997/98 trials

Location (code)	Nr. of lines	Nr. of checks	Layout	Check
Ibbin (01)	134	14	37 x 4	Rihane-03
Ebla (02)	141	11	38 x 4	Rihane-03
Tel Brak (03)	115	17	33 x 4	Tadmor
Jurn El-Aswad (04)	136	12	37 x 4	Tadmor
Baylonan (05)	136	12	37 x 4	Zanbaka
Al Bab (06 and 10)	129	15	36 x 4	Sara
Melabya (07)	148	12	40 x 4	Zanbaka
Bari Sharki (08)	140	12	38 x 4	Zanbaka
Sauran (09)	140	16	39 x 4	Arta

In total 96 entries were common in all trials, either because they belonged to groups e. and f., or because they were selected by all the farmers, or because they were selected by the breeder in all locations.

Each farmer was given a field book where he recorded the rainfall (measured through a rain gauge) and their selections. The field book was organized in such a way that for each entry it indicated the plot number in 1997 and in 1998. Therefore the farmers had the possibility of consulting the 1997 field book and the notes taken on those entries which were selected.

During 1998 we performed the same four types of selection as we did in 1997, namely:

a) Decentralized-participatory selection (individual selection by each participating (host) farmer on his own field;

b) Centralized-participatory selection (individual selection by each participating farmer in Breda and

Tel Hadya, two research stations representing a stress and a favorable environment, respectively);

c) Decentralized-non participatory selection (individual selection by the senior barley breeder of DASR (Directorate of Agricultural and Scientific Research) of the Ministry of Agriculture and Agrarian Reform in Syria in seven of the nine farmers' fields. In Ibbin (01) selection was not possible because the crop was damaged by a hail storm and in Bari Sharki the crop was harvested before the breeder could do the selection;

d) Centralized-non participatory selection (individual selection by the senior barley breeder of DASR in Breda and Tel Hadya;

e) A different type of decentralized-participatory selection consisting of group selection by neighbors farmers in six of the nine villages, namely Ebla (Jurn El-Aswad, Baylonan, Al Bab, Bari Sharki and Sauran). In each of the five villages a group of farmers (eight in four villages and nine in one), including the host farmer, did a one-time visual selection with a score from 0 (discarded) to 4 (best) with the assistance of a researcher who helped in recording both quantitative and qualitative data. At the end of the selection process, each farmer was asked to identify the best 15 entries and to rank them from best to worse (the best was given the rank of 15, the second best the rank of 14, and so on). The average score and the average ranking of each line were then combined in a preference index which gave the same weight to the average score and the average rank by dividing the first by 4 and the second by 15 then by averaging them. Therefore, the maximum index of preference would be 1, and the minimum 0.

The following characters were recorded by the scientists in each farmer field on a sample of 2.4 m^2 from each plot: grain yield, total biological yield, harvest index, plant height, kernel weight and straw characteristics. Other traits recorded only in the research stations were: growth habit (1 erect 5 prostrate) at Tel Hadya, growth vigor (1 good 5 poor) at Tel Hadya, cold damage (1=none 5 maximum) at Tel Hadya, lodging resistance (1 resistant 9 susceptible) at Tel Hadya, number of tillers per m2 at Tel Hadya and Breda, agronomic score in Breda (1 best 5 poorest) and days to heading (as number of days from emergence to heading) at Tel Hadya.

The physical characteristics of the straw were analyzed with a SMS Texture Analyzer as described in the 1997 Report.

The data were subjected to different types of analysis. Firstly, the entries were classified according to the six groups (from a to f) listed at pg. 28, and analyzed with an ANOVA for groups of unequal size. The means of the six groups were then used to analyze the effect of the selection environment and of who did the selection. The effect of the selection environment (experiment station vs. farmer field) was measured, for each trait by contrast:

(Mean of BS and FS) - (Mean of BF and FF)

where BS and FS are the breeder and the farmer selections on station, while BF and FF are the breeder and the farmer selections in a given farmer field. This contrast was analyzed for both Tel Hadya and Breda, each compared with every farmers' field and for every character. The effect of who did the selection (breeder vs. farmer) was measured by the contrast:

(Mean of BS and BF) - (Mean of FS and FS)

This contract was analyzed for each trait and for Tel Hadya, Breda and the nine farmers' fields. The interaction between the effects a) and b), indicating effectiveness of farmer selection vs. breeder selection differs between experiment station and farmers' fields, was measured by the contrast:

(Mean of FF and BS) - (Mean of BF and FS).

This contrast was analyzed for Tel Hadya, Breda and for each farmer's field. Secondly, the entries were classified according to the six selection criteria used in 1998 and the mean of the different traits in the resulting groups were compared with the population mean using a t-test for groups of unequal size.

As found in the previous year, there were large differences in average grain yield (from about 400 kg/ha in Melabya to more than 3 t/ha in Tel Hadya), biological yield (from less than 2 t/ha in Tel Brak and Melabya to more than 8 t/ha in Tel Hadya), harvest index (from 0.4 and more in Ebla, Sauran, Breda and Tel Hadya, to 0.25 in Melabya), plant height (from just more than 20 cm in Melabya to more than 80 cm in Ebla) and in kernel weight (from less than 30 g in Baylonan and Bari Sharky to more than 40 g in Tel Hadya and Sauran) (Table 2.27).

This was partly due to the different levels of inputs and partly to the large differences in total rainfall, which ranged from less than 200 mm in Melabya to more than 400 mm in Tel Hadya. The coefficients of correlation (Table 2.28) between total rainfall and grain yield, total biological yield, harvest index, plant height and kernel weight were all highly significant ($P<0.01$), indicating that slightly more than 70% ($R^2=0.71$) of the variation in grain yield and almost 60% ($R^2=0.58$) of the variation in total biological yield were associated with the variation in total rainfall. There was a close association between plant height and grain yield ($r=0.91$), plant height and total biological yield ($r=0.91$) and between harvest index and kernel weight ($r=0.82$).

Table 2.27. Rainfall (recorded by farmers through rain-gauges), average grain yield (kg/ha), total biological yield (kg/ha), harvest index, plant height (cm) and kernel weight (g) in nine farmers' fields and in two research stations (Breda and Tel Hadya). The data are based on the 96 entries common to all trials.

Location (code)		Rain	Grain Yield	Biol. Yield	Harvest Index	Plant Height	Kernel weight
Ebla (02)	Mean	368	2849	7163	0.40	86.1	35.5
	s.e.		58	146	0.005	1.4	0.35
Tel Brak (03)	Mean	298	676	1647	0.39	40.3	34.3
	s.e.		30	46	0.009	0.9	0.32
Jurn El-Aswad	Mean	202	773	2707	0.27	28.9	32.4
(04)	s.e.		43	107	0.007	0.8	0.35
Baylonan (05)	Mean	200	825	3065	0.27	37.1	29.5
	s.e.		31	74	0.007	0.8	0.32
Al Bab (06BB)	Mean	269	1134	4110	0.27	42.7	30.8
	s.e.		48	136	0.005	0.8	0.33
Al Bab (06BV)	Mean	269	2567	7605	0.33	53.6	34.3
	s.e.		92	199	0.01	1.1	0.33
Melabya (07)	Mean	167	427	1717	0.25	22.9	31.2
	s.e.		20	55	0.008	0.5	0.43
Bari Sharki (08)	Mean	316	1794	6173	0.29	62.6	28.1
	s.e.		54	137	0.005	1.1	0.35
Sauran (09)	Mean	329	2159	5027	0.43	51.1	42.2
	s.e.		65	130	0.006	1.0	0.40
Breda (BR)	Mean	229	936	2414	0.40	36.2	35.0
	s.e.		15	32	0.005	0.8	0.30
Tel Hadya (TH)	Mean	411	3155	8125	0.40	76.0	42.3
	s.e.		41	101	0.005	1.1	0.38

[a] At Ibbin the crop was damaged by a hail storm and was not harvested

[b] At Al Bab the trial was planted both after barley (BB) and after common vetch (BV)

Table 2.28. Simple correlation coefficients between total rainfall and grain yield, total biological yield, harvest index, plant height and kernel weight (means of 96 barley entries in 8 farmers fields and two research stations).

Characters	Rainfall	Grain Yield	Biol. Yield	Harvest Index	Plant Height
Grain Yield	0.843**	1.000			
Biol. Yield	0.761**	0.964**	1.000		
Harvest Index	0.691*	0.546	0.331	1.000	
Plant Height	0.906**	0.909**	0.876**	0.534	1.000
Kernel weight	0.628*	0.604*	0.400	0.821***	0.421

*P<0.05; **P<0.01; ***P<0.001.

The phenotypic correlation coefficients between grain yield measured in the eight farmers and the two research stations were generally low (Table 2.29), and even when significant they indicated a maximum of 20% of variation in one location (Sauran) explained by the variation in another location (Tel Hadya). The highest positive correlation coefficients were between the highest yielding sites (Ebla, Bari Sharky, Tel Hadya, and Sauran), indicating a certain degree of coincidence in the performance of the barley entries in these locations. However, there was no relationship between the yield at Ebla and the yield at Sauran. In Al Bab, the grain yield in the trial planted after vetch was positively correlated with the yields at Bari Sharky and Tel Hadya, while the grain yield of the trial planted after barley was correlated with the grain yield at Jurn El-Aswad and weakly correlated with the grain yield at Tel Hadya. The correlation coefficients between low yielding locations were generally lower than correlation coefficient between high yielding locations. This trend, already observed last year, indicates that low yielding sites differ more among themselves than high yielding sites.

Table 2.29. Phenotypic correlation coefficients between grain yield of 96 barley entries in nine farmers' fields and in two research stations (Breda and Tel Hadya).

	02	03	04	05	06BB	06BV	07	08	09	TH	BR
02	1.000										
03	0.095	1.000									
04	-0.047	-0.012	1.000								
05	0.084	0.015	0.161	1.000							
06BB	0.087	0.192	0.309**	0.105	1.000						
06BV	-0.086	-0.094	-0.053	0.019	0.118	1.000					
07	-0.045	0.066	0.094	0.032	0.033	-0.090	1.000				
08	0.306**	-0.283**	-0.105	0.037	0.090	0.287**	-0.074	1.000			
09	-0.031	-0.230*	0.135	0.112	0.086	0.201	0.048	0.244*	1.000		
TH	0.316**	-0.215*	0.010	0.090	0.235*	0.298**	-0.088	0.391**	0.446**	1.000	
BR	-0.001	0.216	0.100	0.373**	0.037	0.158	0.234*	-0.185	0.116	0.141	1.000

*P<0.05; **P<0.01; ***P<0.001

The percent of lines selected in common by the breeder and/or the farmers in different locations varied between a minimum of 8.7% and 10.9% (Table 2.30) between the selections done by the breeder in Tel Hadya and those done by the farmers in Breda, and a maximum of over 60% between the selections done by farmers and breeder in farmers fields (62.6%) and between the selections done by the farmers and breeder in Breda (64.3%). The percent of lines selected by the breeder in Tel Hadya (centralized-non participatory breeding) which were in common with those selected by farmers in their fields (decentralized-participatory breeding) were slightly less than 20%.

Table 2.30. Percent of entries selected in common in various combinations of selectors and selection environments.

Selected by[a]	Nr. selected	Percent also selected by				
		F- BR	F - TH	B - FF	B - BR	B - TH
F -FF	341	23.5	31.4	62.6	36.4	19.4
F -BR	238	-	32.8	47.6	64.3	10.9
F -TH	400	19.5	-	34.5	36.3	40.0
B -FF	353	22.7	34.6	-	25.2	38.5
B -BR	414	37.0	35.0	32.9	-	19.3
B -TH	300	8.7	53.3	36.0	26.3	-

[a] F = Farmer, B = Breeder, FF = farmer field, BR = Breda, TH = Tel Hadya

2.2.4.2.1. Effect of the selection environment

A summary of the effect of the selection done in 1997 by the breeder and the farmers in Tel Hadya, Breda and the farmers' fields on grain yield and total biological yield in 1998 is given in Table 2.31. In the case of grain yield, the number of differences in favor of the breeder's selections is nearly the same as the number of differences in favor of the farmers' selections. The effectiveness of the breeder seems to be as good as, or better than the farmer on station, while the farmers seem to be slightly more effective in farmers fields. In the case of total biological yield, farmers' selections were higher yielding more often than breeder's selections no matter where the 1997 selections were made.

Table 2.31. Number of significant differences in grain yield and total biological yield observed in 1998 between the selections done by the breeder's and farmers' in 1997.

	Selection in 1997 done at:					
Location in	Tel Hadya		Breda		Farmer Fields	
1998	Breeder	Farmer	Breeder	Farmer	Breeder	Farmer
Yield						
Tel Hadya	3	0	5	1	3	4
Breda	1	3	1	2	3	4
Farmer Field	1	2	2	2	1	1
Total	5	5	8	5	7	9
Biological Yield						
Tel Hadya	2	2	0	2	1	1
Breda	0	1	2	3	0	2
Farmer Field	0	2	0	3	0	2
Total	2	5	2	8	1	5

2.2.4.2.2. Effect of rotation on selection preferences

An interesting aspect of the influence of the selection environment on the type of germplasm selected by the breeder and the farmers is represented by the two different rotations under which the trial was planted in Al Bab. The two trials were identical, since in 1997 selection was made in the barley-barley rotation, and were adjacent to each other, being planted on both sides of the border between a barley field and a vetch field to minimize differences not attributable to the rotation.

The rotation affected the preference for one of the two opposite expression of the same trait (Table 2.32). For example, the farmer's selections were significantly taller than the population mean in the trial planted after barley, but significantly shorter in the trial planted after vetch. Also the farmer's selections in the trial planted after barley did not show any difference in lodging resistance compared with the population mean, while the selections made in the trial planted after vetch were significantly more lodging resistant than the population mean.

Table 2.32. Plant height (cm) and reaction to lodging (1=resistant; 9= susceptible) of lines selected in the same location under two different rotations (barley-barley and barley vetch).

	Plant height		Reaction to Lodging	
	Barley-barley	Barley-vetch	Barley-barley	Barley-vetch
Selections	48.1***	50.3*	2.6	1.2**
Pop. Mean	43.2	54.6	2.4	2.4

*P<0.05; **P<0.01; ***P<0.01

The effect of rotation on selection preferences was also analyzed with the similarity analysis by calculating the dice coefficients between the selections done by the host farmer, the group of farmers, and the breeder in the farmer's field (in both trials) as well as in Breda and Tel Hadya.

The dendogram of the similarity coefficients (Fig.2.1) shows two distinct clusters; the first includes the selections made by the host farmer, by the farmers' group and by the breeder in the trial planted after vetch (BV) and those made by the host farmer and by the breeder in Tel Hadya. The second includes the selections made by the host farmer, by the farmers' group and by the breeder in the trial planted after barley (BB) and those made by the host farmer and by the breeder in Breda. The trial planted in Al Bab after vetch had an average grain yield of 1134 kg/ha, not very different from the average grain yield of Breda (936 kg/ha), while the trial planted after vetch had an average grain yield (2567 kg/ha) of the same order of magnitude of Tel Hadya (3155 kg/ha). Therefore, the effect of the rotation was to cause a genotype x environment interaction similar to what we observed often in comparing trials planted at Breda and Tel Hadya.

The effect of the rotation on the farmer preferences is further shown in Table 2.33 where we show the 5% most preferred lines by the farmers under the two rotations using the index of preference described earlier.
The 5% most preferred lines in the barley-barley trial were all different from the 5% most preferred in the barley-vetch trial. Of the most preferred lines in the barley-barley trial, only one was selected by the farmer in Tel Hadya, and none were selected by the breeder at Tel Hadya. By contrast, out of the six most preferred lines in the barley-vetch trial, four were selected by the farmer in Tel Hadya, and four were selected by the breeder at Tel Hadya.

The most preferred lines in barley-barley trials had a low index of preference in the barley-vetch trial (from 0.05 to 0.54); the line with 0.54 as index of preference ranked seventh in barley-vetch trial, and was the line with the best combination of preferences in the two trials. Similarly the most preferred lines in the barley-vetch trial had had indexes of preference ranging from 0.09 to 0.26 in the barley-barley trials.

These results illustrate an additional important advantage of participatory breeding programs which consists in the possibility of rapidly adapting the breeding material to the changes in agronomic practices and farming systems of the target environments. Selection under different rotations and agronomic practices is very difficult and very expensive to be incorporated in centralized breeding program. Decentralized plant breeding allows doing it at no additional cost provided innovative farmers are included among the participants or are added to provide this additional advantage.

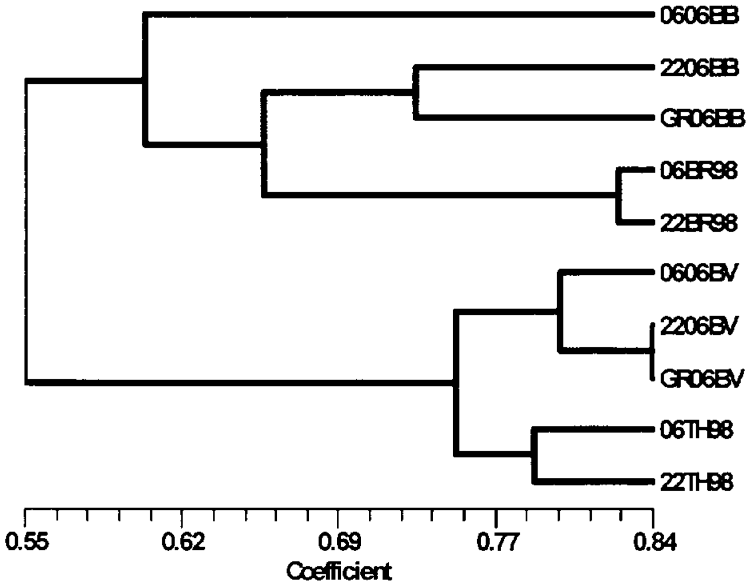

Figure 2.1. Dendogram of the host farmer in Al Bab (06), of the farmers' group (GR) and of the breeder (22) based on cluster analysis of their selections in the farmers' field (06), both in the trial planted after barley (BB) and in the trial planted after vetch (BV), in Tel Hadya (TH) and in Breda (BR).

Table 2.34. Actual selection criteria used by farmers and breeder: number of significant differences between the mean of the selected lines and the population mean (t-test for groups of unequal size).

		Farmers' selection			Breeder's selection		
Trait[a]	Expression	his own	TH	BR	Farmers	TH	BR
Growth habit	Erect	1	2	0	0	2	0
	Prostrate	1	0	1	2	0	0
Growth vigor	Poor	0	3	0	0	0	0
	Good	2	0	3	1	0	1
Cold tolerance	Resistant	2	0	2	2	0	0
	Susceptible	0	2	0	0	0	0
Heading	Earlier	2	0	2	1	0	0
	Later	1	1	0	1	9	0
Lodging	Resistant	1	9	0	1	8	0
	Susceptible	2	0	3	1	0	0
Tillering in TH	Higher	2	0	1	1	0	0
	Lower	0	1	0	0	0	0
Tillering in BR	Higher	0	0	0	1	0	0
	Lower	0	0	0	0	0	1
Kernel size[b]	Larger	0	6	2	1	7	2
	Smaller	1	0	2	0	0	0
Height[b]	Taller	5	0	6	5	0	4
	Shorter	1	4	1	0	4	0
GY FF	Higher	4	0	0	4	1	0
	Lower	0	1	0	0	0	0
GY BR	Higher	2	0	5	2	0	5
	Lower	0	0	0	0	4	0
GY	Higher	1	5	0	0	9	0
	Lower	3	0	2	1	0	0
BY FF	Higher	1	0	1	3	3	0
	Lower	0	1	0	0	0	0
BY BR	Higher	2	0	3	1	0	2
	Lower	0	0	0	0	2	0
BY	Higher	0	0	0	0	1	0
	Lower	0	0	0	0	0	0

[a]GY = grain yield; BY = total biological yield; BR = Breda; FF = Farmer Fields
[b] measured at the selection site.

Breeder and farmers had a similar ability in identifying lines out yielding significantly the population mean in farmer's fields and in Breda. However, in Tel Hadya the breeder's selections always out yielded significantly the population mean, while in the case of the farmers this happens only in 5 out of 9 cases. It must be pointed out that the real issue in participatory plant breeding is whether the farmers' selection in **their own fields** is reliable and not whether they are able to select efficiently in an environment such as an experiment station located in a high rainfall area which is not familiar to most of them.

Of interest are some of the correlated responses to selection for grain yield. For example, farmers' selection in farmers' fields and in Breda resulted in a decreased grain yield at Tel Hadya in three and two cases, respectively. Also the selection of the breeder in Breda caused a decrease in grain yield at Tel Hadya in four cases.

The environment of selection affected the preference for one of the two opposite expression of the same characters. In the case of lodging (Table 2.35), the selections made in farmers' fields (by the breeder and the farmer) were more lodging resistant (like those made in Tel Hadya) than the population mean when the field was in a high rainfall area, but were more lodging susceptible (like those made in Breda) than the population mean when the field was in a low rainfall area.

Similarly in the case of plant height (Table 2.36) the breeder, and less consistently the farmer, selected for shorter plants in Tel Hadya, but for taller plants in dry sites such as Breda, Al Bab and Melabya.

Table 2.35. Resistant or susceptible to lodging? Reaction to lodging (1 = resistant, 9 = susceptible) in the trials planted at Ibbin and Melabya of barley lines selected by the breeder and the farmer at Tel Hadya, Breda and the farmer's field compared with the population mean with a t-test for samples of unequal size.

	Selected at			Selected at		
Selected by	Tel Hadya	Ibbin	Breda	Tel Hadya	Melabya	Breda
Farmer	1.2*	1.4*	3.5*	1.6**	5.3***	5.3***
Breeder	1.0*	-	2.1	1.0**	5.6***	2.5
Pop. Mean	2.4			2.6		

Table 2.36. Tall or short? Plant height (cm) in the trials planted at Al Bab (after barley) and in Bylounan of barley lines selected by the breeder and the farmer at Tel Hadya, Breda and the farmer's field compared with the population mean with a t-test for samples of unequal size.

	Selected at			Selected at		
Selected by	Tel Hadya	Al Bab	Breda	Tel Hadya	Bylounan	Breda
Farmer	71.1*	42.9*	48.1***	79.0	45.1***	43.0**
Breeder	71.8*	40.7	46.5*	74.0**	42.8*	37.9
Pop. Mean	77.5	37.7	43.3	80.3	39.6	36.6

2.2.4.2.4. Effect of decentralized-participatory selection on diversity

One of the hypotheses to be tested with this project is related to biodiversity. Because of the emphasis on specific adaptation, it is expected that, starting from the same gene pool, centralized-non participatory breeding will ultimately result in fewer and less diverse lines than decentralized-participatory breeding.

To test this hypothesis, we compared the frequency of different types of germplasm after two cycles of contrasting types of selection, namely decentralized-participatory and centralized-non participatory. The composition of the initial population of 208 entries is shown in the first column of Table 2.37 with regards to germplasm types such as row type (two vs. six-row), modern or landraces, fixed or segregating and seed color.

Table 2.37. Number (and percent of the original population) of different types of germplasm after two cycles of decentralized-participatory selection and centralized-participatory selection (in two different research stations) done in an initial population of 208 barley entries.

	Initial population	Decentralized Participatory	Centralized-non Participatory (TH)	Centralized-non Participatory (BR)
Total	208 (1.00)	52 (0.25)	17 (0.08)	26 (0.13)
2 row	158 (0.76)	42 (0.81)	12 (0.71)	26 (1.00)
6 row	50 (0.24)	10 (0.09)	5 (0.29)	0 (0.00)
Modern	100 (0.48)	23 (0.44)	17 (1.00)	10 (0.38)
Landraces	108 (0.52)	29 (0.56)	0 (0.00)	16 (0.62)
Fixed	100 (0.48)	27 (0.52)	10 (0.59)	17 (0.65)
Heterogeneous	108 (0.52)	25 (0.48)	7 (0.41)	9 (0.35)
White	161 (0.77)	38 (0.73)	17 (1.00)	16 (0.62)
Segregating	19 (0.09)	5 (0.10)	0 (0.00)	0 (0.00)
Black	28 (0.14)	9 (0.17)	0 (0.00)	10 (0.38)

The total number of entries left after two cycles of decentralized-participatory selection was double the number of entries left after two cycles of centralized-non participatory selection in Breda and three times higher than the number of entries left after two cycles of centralized-non participatory selection in Tel Hadya.

The reduction in the total number of entries does not give a full picture of the decrease in diversity associated with centralized selection. In fact, both in Tel Hadya and in Breda, some type of germplasm disappeared after two cycles of selection. This was the case of landraces and black-seeded types in Tel Hadya, and of the six- row types in Breda.

The same phenomenon, i.e. the disappearance of some germplasm types, does occur also in decentralized-participatory selection, but different germplasm types disappear in different locations.

For example, two cycles of decentralized-participatory selection led to the disappearance of six-row types in all the sites except Ibbin and Ebla, but to an increase of the frequency of the six-row types in wet sites which went from 24% in the original population to 50% in Ibbin and 56% in Ebla. Figure 2.2 shows the example of Ibbin and Bylounan)

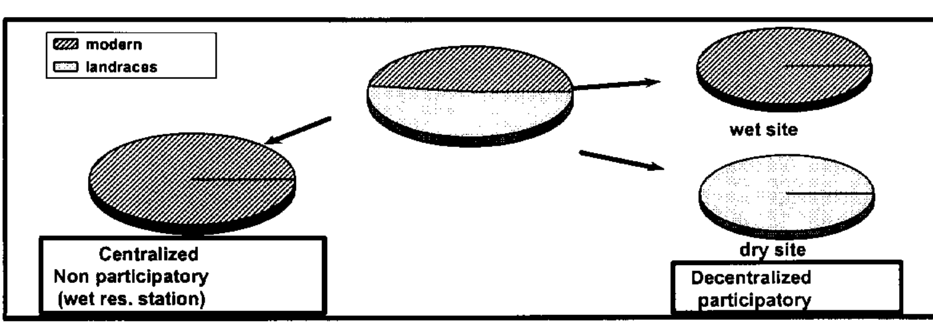

Figure 2.2. Change in the frequency of two- and six row-types after two cycles of centralized-non participatory selection in Tel Hadya (wet research station) and two cycles of decentralized-participatory selection in Ibbin (wet) and Bylounan (dry).

Figure 2.3 shows the case of Ebla, where two cycles of decentralized-participatory selection led to the disappearance of landraces, like in the centralized-participatory selection in the wet research station, while in Melabya two cycles of decentralized-participatory selection led to the disappearance of modern germplasm.

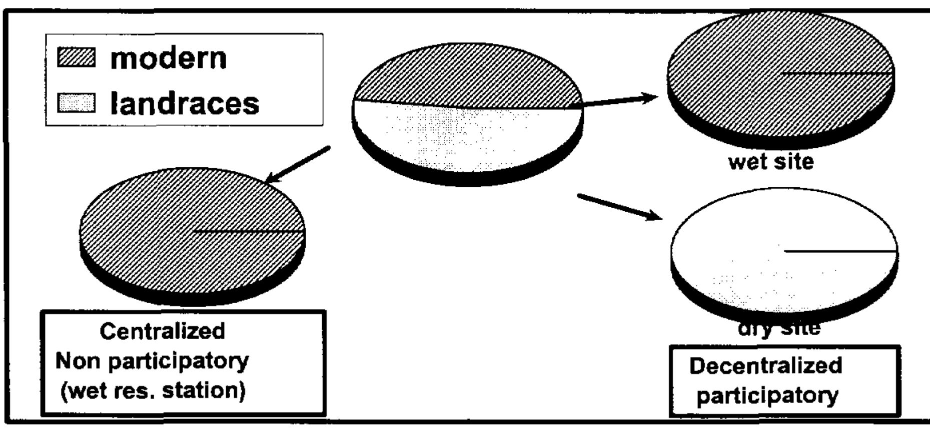

Figure 2.3. Change in the frequency of modern and landraces after two cycles of centralized-non participatory selection in Tel Hadya (wet research station) and two cycles of decentralized-participatory selection in Ebla (wet) and Melabya (dry).

The frequency of landraces, which changed in opposite directions depending on whether centralized-non participatory selection was conducted in Tel Hadya or in Breda, also changed in opposite directions in decentralized-participatory selection depending on whether the location was dry or wet.

Decentralized-participatory selection had the same effect of centralized-non participatory selection in the wet research station on the black seeded types leading to their disappearance (Fig. 2.4 shows the example of Ebla).

This also happened in Sauran and Bari Sharki, where farmers notoriously favor white seeded types. However, in dry sites the frequency of black-seeded types increased almost two-fold in two cycle of selection, as in Jurn El-Aswad (shown in Fig. 2.4). In one extreme case (Bylounan), the population of entries resulting from two cycles of decentralized-participatory selection was only made by black-seeded entries and by entries segregating for seed color in equal proportions.

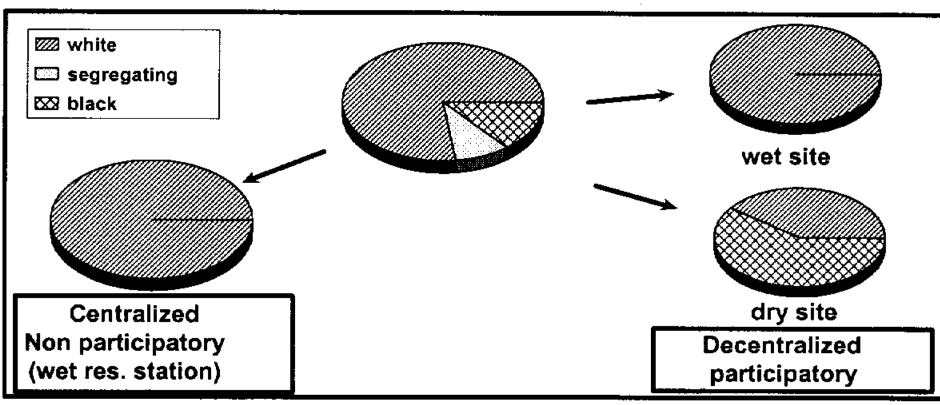

Figure 2.4. Change in the frequency of black-seeded and white seeded entries and of entries segregating for seed color after two cycles of centralized-non participatory selection in Tel Hadya (wet research station) and two cycles of decentralized-participatory selection in Ebla (wet) and Jurn El-Aswad (dry).

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

2.2.5. Molecular Breeding

2.2.5.1. Linkage map in recombinant inbred lines of Arta x *H. spontaneum*

The wild progenitor of barley can contribute useful gene for several characters like disease resistance, earliness, biomass, grain yield, grain protein, tolerance to salinity and drought. In particular *H. spontaneum* is expected to have a potential as donor of adaptive traits to stress conditions, as suggested by its distribution in the driest areas of the region. These considerations have encouraged the use of *H. spontaneum* in the barley project at ICARDA, since 1985.

In 1987 at Bouider, with only 176 mm rainfall, most of the breeding material failed to even reach heading. However, few *H. spontaneum* lines were able to maintain open stomata, and thus to carry some photosynthetic activity at a leaf water potential of -2.63 Mpa when the local variety (Arabi Aswad) had completely closed stomata at a leaf water potential of -2.45 Mpa. These lines combined earliness with acceptable level of cold resistance, and they were able to maintain good plant height under drought conditions. Despite the very dry conditions they were also able to extrude the last internode outside the flag leaf. The best lines were used in the same season to make the first few crosses and 1987 became the year when *H. spontaneum* assumed an important role in breeding activities for dry areas.

One of the most useful traits of *H. spontaneum* in relation to stress tolerance is the plant height under drought. This is important because one of the most evident effects of drought is a reduction in plant height. In those environments where not only grain but also straw has a value to the farmers, plant height is an important trait as it is related to biological yield. Also in dry years the crop is too short to be harvested by combine and farmers either leave it for grazing or harvest it by hand at much higher cost.

Introgression of genes for plant height under drought from *H. spontaneum* into cultivated barley has been a long and difficult process despite crosses between the two are easy to make and fully fertile. This is because *H. spontaneum* has a number of undesirable traits such as brittle rachis, low kernel weight and rough awns. One additional difficulty was that the improvement of plant height under drought often causes a reduction in tillering, and hence in both grain and straw yield.

It is evident that to fully exploit the potentiality of crosses between cultivated barley and *H. spontaneum* a large number of recombinant lines derived from each cross had to be evaluated. In addition the identification of molecular markers closely linked to QTLs of agronomic interest or to negative traits will allow the use of marker assisted selection and thus increase the efficiency in the use of H. spontaneum.

We developed a population of 494 F_7 random inbred lines (RILs) derived by single seed descent from the cross Arta/*H. spontaneum* 41-1. Arta, a pure line selected from the Syrian landrace Arabi Abiad, is well adapted to Syrian conditions, high yielding, but becomes very short under dry conditions. *H. spontaneum* 41-1, a pure line selected for its adaptation to severe drought stress conditions, combines earliness with acceptable cold tolerance, and it is able to maintain a good plant height under drought.

At least six characters are expected to segregate from this cross: rachis brittleness, awn roughness, peduncle extrusion, plant height, tillering, and kernel size. The 494 lines, the two parents, and four checks, were planted at Breda and Tel Hadya for two cropping seasons (1996/97 and 1997/98). An alpha-lattice (10 x 50) design with two replications was used. Plots were eight rows at 0.20 m, 2.5 m long in 1996/97 and four rows at 0.20 m, 2.5 m long in

1997/98. The characters scored or measured in the two seasons were: growth habit, early growth vigor, cold damage, days from emergence to awns appearance, plant height, number of fertile tillers per m^2, grain and biological yield, thousand kernel weight, grain protein content, and grain (-glucan content. The entries were also classified for rachis brittleness.

The main objective of this cross was to develop lines combining the grain yield and tillering ability of Arta with the plant height and the adaptation to severe drought stress conditions of *H. spontaneum* 41-1.

Thirty-six entries were promoted to preliminary yield trial. Eleven lines (Table 2.38) were particularly interesting, combining improved plant height under drought, and high tillering ability typical of Syrian landraces, with higher grain and biological yields than Arta.

Only two lines had a 1000 kernel weight equal or over 30 g. No line was identified with seed size similar to Arta. These lines are already included in the crossing program for 1999.

A subset of two hundred and twenty lines of the total of 500 lines was selected for the mapping effort. First results are presented for a subset of 92 lines (Table 2.39). Genetic mapping was carried out using Amplified Fragment Length Polymorphic (AFLP) markers and microsatellite-based markers. AFLPs usually provide high numbers of polymorphic, although mostly dominant makers. Microsatellite-based markers are usually codominantly inherited PCR markers and are useful because they map to identical linkage groups in different genetic backgrounds. Therefore, they are useful to anchor linkage groups developed by dominant markers (here AFLPs) to chromosomes. For eighty-four markers (11 microsatellite markers, 73 AFLP markers) segregation analysis has been performed on the F_5 derived F_7 recombinant inbred lines so far. Using a stringent LOD of 4.0 and an excluding threshold for linkage

Table 2.38. Grain yield, biological yield, plant height, number of tillers per m^2, and thousand kernel weight of eleven lines derived from the *cross* Arta/*H. spontaneum* 41-1, compared with the two parents. Breda 1997/98 and 1998/99.

Entry	Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Plant height (cm)	Tillers per m^2	1000 kernel weight (g)
115	1943	6133	52	393	29.8
340	1578	5748	43	374	28.2
351	1574	5402	52	397	24.1
243	1565	5476	51	362	26.7
274	1550	5192	46	414	28.6
336	1550	5653	51	449	29.0
76	1549	4999	50	368	27.8
281	1533	6083	54	461	27.9
143	1525	5311	54	383	30.1
295	1514	5088	45	408	25.7
377	1510	5860	52	387	32.4
Arta	1186	4312	29	348	37.2
H. spontaneum	976	4379	52	296	25.6

Table 2.39. Linkage map developed in recombinant inbred lines of Arta x *H. spontaneum* 41-1.

Chromososme 1

Markers		
63	P71M885	23.4 cM
66	P71M888	23.0 cM
33	P81M836	20.6 cM
65	P71M887	25.4 cM
4	P71M824	5.0 cM
22	P71M425	15.9 cM
82	HVM41	0.6 cM
83	HVM42	12.2 cM
61	P71M883	6.4 cM
6	P71M826	8.1 cM
2	P71M423	---------
		140.6 cM

Chromosome 2a

Markers		
77	HVBKASI1	4.9 cM
78	HVBKASI2	8.9 cM
32	P81M835	11.7 cM
58	P71M8411	1.7 cM
57	P71M8410	-------
		27.3

Chromosome 2b

39	P82M834	8.2 cM
75	HVCSG1	3.6 cM
76	HVCSG2	11.8 cM
36	P71M341	-----
		23.6 cM

Chromosome 4a

Markers		
52	P71M845	32.6 cM
11	P71M8211	7.4 cM
10	P71M8210	34.8 cM
46	P81M8311	9.0 cM
42	P82M837	10.0 cM
27	P71M4210	24.9 cM
72	P71M8814	9.6 cM
74	HVM62	7.0 cM
73	HVM61	-------
		35.3 cM

Chromosome 4b

80	HVM401	4.3 cM
81	HVM402	-------
		4.3 cM

Unassigned Linkage Groups

Link 1

54	P71M847	13.8 cM
19	P71M422	19.4 cM
67	P71M889	5.0 cM
5	P71M825	20.2 cM
2	P71M822	---------
		58.4 cM

Link 2

35	P81M838	7.3 cM
12	P71M8212	2.3 cM
21	P71M424	4.4 cM
51	P7	29.6 cM
24	P71M427	14.6 cM
28	P81M831	21.0 cM
64	P71M886	6.8 cM
53	P71M846	----------
		86.1 cM

Link 3

15	P71M8215	0.0
16	P71M8216	6.8
14	P71M8214	3.9
48	P71M841	
49	P71M842	8.4
59	P71M881	16.7
55	P71M848	3.9 cM
56	P71M849	14.7
8	P71M828	
		56.4

Link 4

41	P82M836	16.1 cM
1	P71M821	23.6 cM
69	P71M8811	----------
		39.7

Link 5

40	P82M835	21.1 cM
25	P71M428	18.1 cM
43	P82M838	--------
		39.2

Link 6

37	P82M832	10.2
71	P71M8813	11.3
26	P71M429	----
		21.5 cM

relationships of 0.25, 62 markers were grouped into 11 linkage groups using MAPMAKER 3.0 software.

The microsatellite-based markers identified linkage groups belonging to chromosome 1, 2a, 2b, 4a, and 4b. Another six linkage groups (link 1-6) have not yet been anchored. (At a LOD score of 3.0 76 markers are linked in linkage groups).

The recombinant inbred lines of the cross were developed by single seed descent. Interesting to note is the extent of segregation distortion in the recombinant inbred lines as analyzed by the inheritance of the alleles of the molecular markers (with qGene software 2.18). Of the 62 markers arranged in linkage groups, 14 showed distorted segregation (22.5%) (Table 2.40). Only a few of them are extremely distorted as might originate from linkage to lethal genes, self-incompatibility genes or other fertility reducing genes. Distorted markers are not confined to a particular linkage group; they are more or less randomly distributed throughout the genome. Although, the extent of the distortion is relatively high, it is somehow expected for a wide cross. Distorted segregation of markers might influence their accurate positioning in the linkage map, they do, however, only limit to minor extent the marker trait linkages, especially if the trait also shows non random distribution.

In Table 2.41 difference between the crossover rate in different lines of the mapping populations and summarized for each individual linkage group are depicted. Interesting to note is the lowest overall rate of recombination in chromosome 4a. In many linkage maps chromosome 4 in barley poses problems concerning the extent of recombination. These analyses might help to identify lines with a suitable amount of recombination of the introgressed genes form *H. spontaneum*.

The number of the traits analyzed in the RIL population at ICARDA's research stations Tel Hadya and

Breda in 1996, 97 and 98, and the units of their measurements are listed in table 2.42. Because of the limited number of lines genotyped so far, simple regression analyses was used to identify possible marker-trait linkages.

Table 2.40. Segregation distortion in RILs of the cross Arta * *H. spontaneum* 41-1.

Marker	N	X^2	P	AA	Aa	Linkage group
33P81M836	92	5.26	0.0218	35	57	Chrom1
65P71M887	91	20.31	0.0000	24	67	Chrom1
4P71M824	66	6.06	0.0138	23	43	Chrom1
52P71M845	88	4.54	0.0331	54	34	Chrom4a
27P71M4210	91	5.81	0.0159	34	57	Chrom4a
80HVM40a	91	3.96	0.0466	55	36	Chrom4b
19P71M422	91	3.96	0.0466	55	36	Link1
5P71M825	66	15.51	0.0001	49	17	Link1
2P71M822	89	5.94	0.0148	56	33	Link1
25P71M428	76	10.31	0.0013	52	24	Link4
43P71M348	83	7.53	0.0061	54	29	Link4
35P81M838	91	3.96	0.0466	55	36	Link6
12P71M8212	88	4.54	0.0331	54	34	Link6
24P71M427	75	9.72	0.0018	24	51	Link6

Table 2.41. Crossovers per 100 cM in selected lines of the RIL population

Chrom/Line	1	2	3	4	5	6	7	8	cont. Overall
Chrom1	2.83	1.80	1.59	0.84	2.83	2.12	1.59	1.41	1.32
Chrom2a	0.00	0.00	0.00	3.67	3.67	0.00	3.67	0.00	1.57
Chrom2b	4.23	8.46	0.00	0.00	0.00	0.00	0.00	0.00	1.57
Chrom4a	0.87	2.38	2.73	0.79	0.00	2.21	2.21	2.21	1.21
Chrom4b	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.78
Link1	1.70	2.18	0.00	1.70	2.15	0.00	0.00	0.00	1.36
Link2	0.00	0.00	1.77	0.00	0.00	0.00	0.00	1.77	1.51
Link3	2.51	2.51	0.00	2.51	0.00	2.51	5.02	0.00	1.25
Link4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.54	1.27
Link5	4.64	0.00	0.00	0.00	4.64	0.00	0.00	0.00	1.52
Link6	1.56	0.00	0.00	0.00	0.00	1.16	3.48	1.16	1.35
Overall	1.72	1.57	1.13	0.90	1.21	1.25	1.70	1.25	1.350

Table 2.42. Traits evaluated in RILs of Arta x *H. spontaneum* 41-1.

Trait	Description	Units	*TH96	TH97	TH98	**BR96*	BR97	BR98
GH	Growth habit	Scale (1- 4)	Y	Y	Y	Y	Y	N
SCS96	Reaction to scald	Scale (1-9)	Y	N	N	N	N	N
RS	Rachis	Brittle/tough	N	N	N	N	Y	Y
CD	cold damage	Scale (1-4)	N	Y	Y	N	N	N
CO			N	Y	N	N	N	N
GV	Growth vigor	Scale (0-4)	Y	Y	Y	N	N	Y
DH	Days to heading	Days	Y	Y	N	N	Y	N
TN	Tiller number m^2	No.	N	Y	N	N	Y	Y
PH	Plant height	Cm	N	Y	N	N	Y	Y
BY	Biological yield	Kg ha^{-1}	N	Y	Y	N	Y	Y
GY	Grain yield	Kg ha^{-1}	N	Y	Y	N	Y	Y
KW	1000 kernel weight	G	N	Y	Y	N	Y	Y
PR	Protein content	%	N	Y	N	N	Y	N
AS	Ash content	%	N	N	N	N	N	Y
GLUC	Glucose content	%	N	N	N	N	Y	N

*TH = ICARDA's research station Tel Hadya, 320 mm rainfall

*BR = ICARDA's research station Breda, 280 mm rainfall

Table 2.43. Identified Marker-Trait linkages in the RILs of Arta x *H. spontaneum* by simple regression analyses (trait = dependent variable, Marker 41-1 = independent variable, N = number of progenies analyzed).

	Marker	Chrom.	N	Source	F-value	R^2
GHTH96	14P71M8214	Link2	80	Arta	31.39	0.287
	48P71M841	Link2	90	Arta	34.56	0.282
	49P71M842	Link2	92	Arta	32.97	0.268
	5 more markers	on link2				
GHTH97	48P71M841	Link2	90	Arta	21.43	0.196
	49P71M842	Link2	92	Arta	17.41	0.162
	42P71M347	Chrom4a	85	Arta	12.93	0.135
	5 more markers	on link2				
GHTH98	14P71M8214	Link2	80	Arta	23.64	0.233
	48P71M841	Link2	90	Arta	23.81	0.213
	4 more markers	on link2				
GVTH97	56P71M849	Link2	88	Arta	12.25	0.125
DHBR97	65P71M887	Chrom1	91	Arta	17.24	0.162
	4 more markers	on chrom1				
DHTH97	33P81M836	Chrom1	92	Arta	10.60	0.105
	65P71M887	Chrom1	91	Arta	16.07	0.153
	4P71M824	Chrom1	66	Arta	10.66	0.143
	22P71M425	Chrom1	91	Arta	10.04	0.101
RachisBR97	**52P71M845**	Chrom4a	87	H.spont.	30.30	0.263
RachisBR98	**52P71M845**	Chrom4a	88	H.spont.	23.17	0.212
PHTH97	81HVM40b	Chrom4b	91	H.spont.	10.58	0.106
	14P71M8214	Link2	80	H.spont.	10.54	0.119
	48P71M841	Link2	90	H.spont.	12.85	0.127
PHBR98	46P81M8311	Chrom4a	91	H.spont.	9.31	0.095
PHBR97	63P71M885	Chrom1	91	H.spont	7.40	0.076
	25P71M8215	Link4	92	H.spont.	5.66	0.059
	16P71M8216	Link2	92	H.spont	3.94	0.042
CDTH97	54P71M847	Link1	92	H.spont.	13.73	0.132
	35P81M838	Link6	91	H.spont	16.52	0.157
	12P71M8212	Link6	88	H.spont	19.43	0.184
	51P71M844	Link6	90	H.spont	14.60	0.142
BYTH97	**52P71M845**	Chrom4a	88	Arta	34.81	0.288
BYTH98	**52P71M845**	Chrom4a	88	Arta	20.97	0.196
GYTH97	**52P71M845**	Chrom4a	88	Arta	62.33	0.420
GYTH98	**52P71M845**	Chrom4a	88	Arta	43.98	0.338
KWTH97	4P71M824	Chrom1	66	H.spont.	11.52	0.153
KWBR97	69P71M8811	Link3		Arta	11.47	0.116
KWTH98	1P71M121	Link3	90	Arta	12.70	0.126
KWBR98	77HVBKASIa	Chrom2a	92	Arta	13.44	0.130
	2 more markers ‹	on chrom2				
TNBR97	28P81M831	Link6	92	H.spont.	11.72	0.115
PRTH97	28P81M831	Link6	92	H.spont.	10.29	0.103
COTH97	32P81M835	Chrom2a	91	Arta	14.60	0.141
GLUCBR97	35P81M838	Link6	89	H.spont.	11.37	0.116

*No markers exceeded the threshold (F=10.00) for trait PRBR97, GVTH96, DHTH96, SCH96, TNTH97, BYBR97, GYBR97 GVTH98, GVBR98, ASBR98, TLBR98, BYBR98, GYBR98, BYBRAV, GYBRAV, PHBRAV

The major objectives of the present work was to see weather markers could be identified for the trait brittle rachis from *H. spontaneum* 41-1 and for the trait plant height under drought again introgressed from *H. spontaneum* 41-1. As for brittle rachis the evaluation in Breda 1997 and 1998 showed in both cases linkage to the same AFLP marker 52P71M845 on chromosome 4a. If brittle rachis is treated as a qualitative marker, it will, at a LOD score of 3.0, form a linkage group with marker 52. As marker 52 is located at the distal end of the linkage group with a fair distance to the next marker, the position of marker 52 on chromosome 4a is not yet secured. However, with an R^2 of 0.263 and 0.212 for 1997 and 1998 respectively one major QTL can be expected as indicated by the present analyses. Other markers with smaller effects are located on chromosome 1 (33P81M836 R^2=0.082) chromosome 2b (39P71M344, R^2=0.079), and linkage group 2 (15P71M8215 R^2=0.065).

For the trait plant height under drought stress, linkages with major effects were found for the trait only in Tel Hadya (81HVM40b on chromosome 4b, 14P71M8214 on link2, 48P71M841 on link2 with R^2 = 0.106, 0.119 and 0.127 respectively). For Breda 1997, three markers (63P71M885 on chromosome 1, 25P71M8215 linkage group 4, 16P71M8216 linkage group 2 with R^2= 0.076, 0.059 and 0.042 respectively) and for Breda 1998 one marker (46P81M8311 on chromosome 4a with R^2 = 0.095) with smaller effects was identified. The absolute values for the trait measured were 79.89 and 105.00 cm for Arta and *H. spontaneum* 41-1 respectively in Tel Hadya 1997 and 29.43 cm and 51.9 cm on average for both years in Breda. A range of 31.9 and 64.5 for Breda and 83.5 and 115.1 cm for Tel Hadya 97 were recorded for the analyzed lines. The analysis for the trait plant height under drought stress indicates that no major QTL for this trait will be expected even using a complete linkage map. Different genes seem to be responsible for that trait in Tel Hadya and in Breda.

Most interesting is the marker identified for biological and grain yield for Tel Hadya in 1997 and 1998. AFLP marker 52P71M845 on chromosome 4a showed for the biological yield an R^2 of 0.288 in 1997, an R^2 of 0.196 in 1998, an R^2 of 0.42 for grain yield in 1997, and an R^2 of 0.338 for grain yield in 1998. In all cases, the responsible chromosome segment originates from Arta. For grain yield an average difference of 976 kg/ha (for *H. spontaneum* 41-1) and 1185.87 kg/ha for Arta was recorded for Breda whereas 3156.84 (*H. spontaneum* 41-1) and 4665.19 kg/ha (Arta) were recorded in Tel Hadya. However, due to the brittle rachis the range was from 632 and 4504 kg for the analyzed lines in Tel Hadya and 573 and 1665.5 kg in Breda, respectively. The huge effect of the marker trait association might therefore characterize more the brittle rachis trait rather than the yield, as the chromosomal region is identified by the same marker linked with the brittle rachis trait.

Other interesting traits for which markers were identified and which might be used for a marker assisted selection program were: several markers linked with the growth habit of Arta in linkage group 2, markers for days to heading from Arta on chromosome 1, (125-127 days versus 116-120 days for *H. spontaneum* 41-1), markers against cold damage introduced by *H. spontaneum* 41-1 on linkage groups 1 and 6.

(M. Baum, S. Grando)

2.2.5.2. Evaluating barley crosses for segregation distortion

The development of superior genotypes involves the transfer of genes controlling desired traits into new varieties. Tadmor and Sel160, both lines are very susceptible to one major disease and resistance to another, Sel160 being resistant to powdery mildew (Pm) and susceptible to scald (Sc), while Tadmor is resistant to (Sc) and susceptible to (Pm). Knowledge of the location of such genes in donor plants can accelerate the breeding process.

A cross between the two cultivars has been advanced to homozygosity by producing doubled haploid lines. The major objective of the cross was to develop lines with Pm resistance from Sel160 and scald resistance from Tadmor. The cross was subjected to molecular markers analysis to see weather marker for the resistance traits as well as markers for other traits could be developed. Studying markers spaced evenly throughout the genome, and correlating specific marker with measured changes in a trait, makes it possible to identify regions of the genome that contribute to the trait.

Screening of the parents has been performed for 248 RFLPs markers, 97 RAPDs markers, 147 microsatellite markers, and 13 AFLPs markers table (2.44).

Table 2.44. Analysis of the RFLP, RAPD, SSR, and AFLP marker polymorphism generated in parental lines (Tadmor, Sel160).

Marker Type	No. of assay units	No. of polymorphic bands	Polymorphic bands (%)	Monomorphic bands Or not amplified
RFLPs	248 (58 probes, 5 enzymes)	141	56.8%	107
RAPDs	97 (primers)	48	49.5%	49
SSRs	147 (primer pairs)	41	27.9%	106
AFLPs	13 (primer combinations)	87	66.9%	0
TOTAL	505	317		262

Fifty-one doubled haploid lines (DHL) of the cross Tadmor /Sel160, were used to mapping the polymorphic fragments. Segregation analysis was so far performed for 139 molecular markers (5 RFLPs, 9 RAPDs, 38 SSRs, 87 AFLPs), and 2 morphological markers (powdery mildew, natural infection in plastic house, and seed color) (Table 2.45). DH data were compared with data of fifty-one F_2 derived F_3 (F_2:F_3) plants from the same cross.

Table 2.45. Analysis of the RFLP, RAPD, SSR, AFLP, morphological characters for doubled haploid lines in the barley cross (Tadmor/Sel160).

Marker Type	No. of assay units	No. of polymorphic Bands
	5	5
RAPDs	6	9
SSRs	41	38
AFLPs	13	87
Morphological	2	2
	67	141

Segregation ratios were calculated for each cross by X^2 test. In the doubled haploid population, seed color (black or white) segregated normally in a 1:1 ratio while the other morphological trait (powdery mildew resistance) showed a skewed segregation towards the Sel160 allele, (Table 2.46).

The proportion of loci deviating from the monogenic segregation ratios in the doubled haploid lines of the cross Tadmor/Sel160 is significant higher (39%) than for the F_2 progeny from the same cross (11%).

Tadmor is the more recalcitrant genotype in green plantlet production in the DH protocol. Therefore, a higher number of gametes having Sel160 alleles in microspores should lead to successful green plantlet regeneration. However, interesting will be to map out these segments of higher tissue culture response in the cross.

Table 2.46. Number of tested molecular and morphological markers in a doubled haploid population and its segregation distortion.

Marker	No. of fragments	No. of distorted markers	Distortion (%)
RFLPs	5	3	60
RAPD	9	6	66
SSR	38	16	42
AFLP	87	29	33
Morphological	2	1	50
Total	141	55	39

Linkage mapping was done using MAPMAKER software using a LOD score of 4.0 and a maximum recombination fraction of 0.5. Linkage groups were assigned to chromosomes based on known locations for RFLP and SSR markers. The results revealed that 118 markers were assigned to 7 chromosomes while 23 markers remained unassigned (Table 2.47). Powdery mildew resistance was linked with markers WMS 6 and AF7 on chromosome 4, with less than 20 cM distance.

Table 2.47. Linked markers to the barley cross (Tadmor/Sel160) chromosomes at minimum LOD 4.0, and maximum distance 50.

Chromosome	Assigned Markers	Anchors markers
Chrom 1	39	6
Chrom 2	15	8
Chrom 3	21	2
Chrom 4	21	13
Chrom 5	2	2
Chrom 6	11	3
Chrom 7	9	4
Total	118	38

(H. Sayed, M. Baum)

2.2.5.3. Variability within Syrian landraces revealed by microsatellites

Barley is one of the most important and reliable crops grown by farmers in West Asia, who utilize both the grain and the straw as animal feed. The Near East is recognized as a center of genetic diversity, and one of the three nuclear centers of agricultural origin. This area corresponds geographically to a region, which extends from Palestine through Syria, southern Turkey into Iraq and western Iran.

Barley's importance as a crop is largely associated with the yield stability of landraces under the extremes of temperature and drought, which predominate in the region. Growing landraces or selected mixtures of a number of genetically different pure lines may provide a solution to cope with environmental variability over time. Landraces are populations of genetically different individuals, varying in physiological potential, and differently adapted to various environmental conditions of growth.

Sustainable improvements of yield stability should probably be based on population buffering as achievable with mixtures of genotypes representing different, but equally successful, combinations of traits, as occurs in landraces. This is one of the reasons why analytical breeding has been largely unsuccessful in stressful environments.

ICARDA maintains a large collection of about 6000 pure lines derived from Syrian and Jordanian barley landraces. However, very little is known on the actual population structure of landraces, on the amount of genetic heterogeneity they possess, and which are the traits for which maximum heterogeneity exists. All these information are essential to understand the degree of complexity that is needed in the mixtures to maximize both yield and yield stability.

In collaboration with the Scottish Crop Research Institute microsatellite markers were used to assess the genetic diversity of landrace material from part of the Fertile Crescent. The genetic material consist of a total of 500 lines, of which 480 derived from landraces collected in five sites in each of five geographic regions. These represent the South, the Center-West, the NorthEast, and the Central Steppe of Syria, which are the main barley growing areas of the country, and the North of Jordan. In addition 20 varieties representing the most modern germplasm developed in Europe were include to be used as a reference material particularly in relation to diseases.

In order to evaluate the genetic diversity, at the DNA level, in the entries collected from the different areas, 21 microsatellite primers were used. A total of 245 alleles were detected. Levels of polymorphism detected varied according to the primers and to the sites of collection. NorthEast had the highest number of alleles, 132 alleles were detected by 21 primers, though only 92 alleles were detected in South-Jordan which possessed the smallest value of genetic diversity comparing with the other areas.

The level of genetic diversity in Central-West Asia was higher than South-Jordan but less than South-Syria, Central-Syria and North-Jordan, which have a very similar value of genetic diversity.

The number of alleles detected in a collection derived from one region give an idea about the richness of the genetic reservoir in this region. Accordingly, the Northeast possesses the biggest genetic reservoir between the region studied.

The comparison of genetic diversity between the wild species *H. spontaneum*, landraces, and the cultivated barley demonstrated that *H. spontaneum* had the highest level of genetic variability where 16 microsatellite primers detected 210 different alleles though the same primers detected 172 and 111 alleles in landraces, and the cultivated barley respectively. This also indicates that H. spontaneum is more related to the landraces than to the cultivated barley.

These informations, accompanied with those based on morphological and physiological characters will be very helpful in the development of new landraces and the construction of new mixture of genotypes to meet the most difficult constraints.

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

2.2.6. Stress Physiology

2.2.6.1. Relationships between early vigor, grain yield, leaf structure and stable isotope composition in field grown barley.

Fast growth and early development can improve water use efficiency and transpiration efficiency of barley grown in Mediterranean conditions.

In 1998, in collaboration with the University of Barcelona (Spain) we examined the use of several simple traits based on the structure and stable isotope composition of seedling leaves to assess differences in early vigor, phenology and grain yield, and also the interaction with low temperatures.

The materials were the 260 RIL from the cross Tadmor/WI2291 described earlier and grown in Tel Hadya and Breda. Total chlorophyll content on an area basis (SPAD) and specific leaf dry weight (SLDW) were measured in recently fully expanded leaves of seedlings. The stable isotope composition of carbon and nitrogen ((^{13}C and (^{15}N, respectively) were analyzed in the same leaves on a subset of 75 genotypes. Number of days from planting to heading and grain yield was recorded at both Tel Hadya and Breda.

There was a wide range of variation across the population of RIL (Table 2.48). The grain yield at each location was positively correlated ($P<0.01$) with the chlorophyll content (SPAD) at Tel Hadya but not with SLDW. Days to heading was negatively correlated with SPAD values while early vigor was negatively correlated with SLDW and the total leaf area of the seedlings. No relationships were found between (^{13}C of seedlings and early vigor except when only the genotypes most resistant to low temperatures were considered. This subset of genotypes showed negative relationship between (^{13}C and either total leaf area or total dry weight. In addition (^{13}N was negatively correlated with SPAD only within the high-SPAD genotypes.

Chlorophyll content per area of barley seedling can be used for fast evaluation of tolerance to low temperatures and its effect on final yield. The use of structural traits of seedlings as alternatives to the expensive (^{13}C is constrained by the effect of low temperatures, and therefore (^{13}C can be used as an indicator of the leaf area, total dry mass and rapid growth of seedlings only in those genotypes which are less affected by low temperatures (high-SPAD genotypes). Increased transpiration efficiency (high (^{13}C) may be inherently linked to reduced early growth. Thus, selecting for early vigor and low SLDW may be preferable than selecting for transpiration efficiency.

Table 2.48. Mean, standard deviation, minimum and maximum of physiological, developmental and agronomic data in random inbred lines derived from the cross Tadmor/WI2291.

Traits	Lines	Mean	St. deviation	Min.	Max.
SPAD	260	34.0	2.2	27.6	40.6
Leaf area (cm^2 $seedling^{-1}$)	260	23.3	5.8	11.1	45.4
SLDW (g DM m^{-2})	260	49.4	8.2	28.1	103.3
Dry mass (g $seedling^{-1}$)	260	0.15	0.03	0.07	0.31
$\Delta^{13}C$ seedling (%)	75	-29.4	0.4	-30.6	-28.7
$\Delta^{15}N$ seedling (%)	75	-2.2	0.7	-3.9	-0.4
Heading (TH)	260	124.1	2.6	117.5	131.5
Grain yield (TH)	260	407.5	46.2	251.7	556.1
Protein % (TH)	260	8.9	0.9	6.8	11.1
Heading (BR)	260	131.1	3.6	122.0	139.7
Grain yield (BR)	260	120.4	37.2	44.7	236.2
Protein % (BR)	260	9.6	1.3	6.7	13.4

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

2.2.7. Pathology

Barley production is highly affected by biotic stresses that are highly variable. Diseases often overtake newly developed pure line cultivars before they even reach large areas of production. Hence rapid changes of varieties is an important control measure to avoid epidemics. The use of landrace cultivars and wild relatives offers broader resistance type. The exploitation of landrace population will further improve the longevity of varietal cultivation particularly in low input agriculture that prevails in many barley growing areas in the world.

The most important barley diseases targeted by the breeding program in Aleppo are scald, powdery mildew, net blotch, leaf rust, covered smut, loose smut, barley stripe, and root rots. Barley nurseries are screened for disease resistance at Tel Hadya under controlled and field conditions, selected lines are further evaluated by collaborators under field conditions in hot spot areas.

Identified resistant entries are advanced for further selection. Fixed resistant lines are further tested for yield performance and/or incorporated in the crossing program.

The screening at Tel Hadya is planned initially for single disease, and then for combination of diseases. The germplasm tested at Aleppo during the previous season is shown in Table 2.49. Sets of selected germplasm are also tested under natural conditions by collaborators in the NARS. The screening under field condition at Tel Hadya is complemented by artificial inoculation using local Syrian isolates for each particular disease. Information on virulence of isolates, methods of inoculation, and evaluation are detailed later (see IPM section). Information for the evaluation of specific diseases conducted by NARS will appear in the NARS annual reports.

Table 2.49. Barley germplasm (number of entries) screened for disease resistance at two sites in Syria (Tel Hadya and Lattakia) and one site in Lebanon (Terbol) in 1997-98

	Diseases & number of entries screened					
Sites	Total	Scald	P.mildew	C.Smut	L.Smut	B.Stripe
Tel Hadya	11053	9723	328	334	359	309
Lattakia	1903		1903			
Terbol	680	680				

2.2.7.1. Evaluation of Barley Nurseries for Disease Resistance.

2.2.7.1.1 Resistance to Scald.

Scald represents an important disease in several countries. All the barley germplasm is systematically screened (at a given stage of its development) for resistance to scald at Tel Hadya using a mixture of local isolates for artificial inoculation. A total of 8339 barley lines/families were tested for resistance to scald in 1997/98. Figure 2.5 shows the frequency distribution of the reaction of barley lines within each breeding nursery. Winter barley material (WBON & FBON) showed higher level of resistance. The BI99IN nursery comprises 7330 entries and about 39% of them showed adequate level of resistance to scald. Material in the initial yield trials (BIT98) showed the highest level of susceptibility. It is important to emphasize that the resistance level found in the Syrian landraces (SCRI98) is of the intermediate type and this material can be classified as tolerant (Fig 2.5). The test of WBON (150 lines) and FBON (150 lines) nurseries show an equal number of resistant and susceptible lines with a low number of lines showing an intermediate reaction type. In the HBON97 nursery the resistance level to scald was relatively low, however all the 'Viringa's' crosses showed an outstanding resistance.

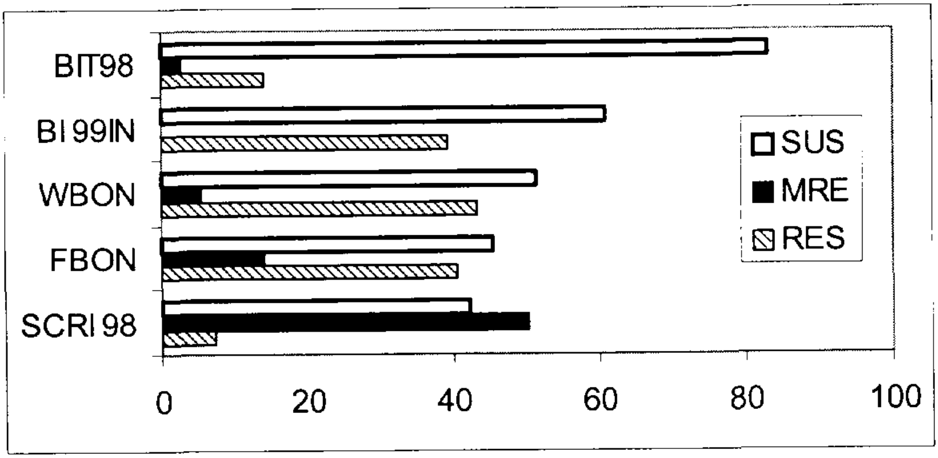

Figure 2.5. Frequency distribution of the reaction to scald of 8339 barley lines in 5 nurseries.

2.2.7.1.2 Resistance to Loose smut and Barley stripe.

Loose smut and barley stripe are seed transmitted diseases that are very common in most developing countries, particularly with farmers that use their own seed and do not or can not apply seed treatment. Resistant/tolerant germplasm offers the best alternative. The breeding program has focused on these diseases in its varietal development program. All the parental lines (PARE) and promising lines are systematically tested for their resistance to the seed borne diseases. Figure 2.6 shows the frequency distribution of different levels of resistance in the PARE nursery. Over 70% of the entries showed good resistance level: 77.9% and 75.5% of the lines showed high resistance to loose smut and barley stripe respectively, most importantly is that 62% of the lines were resistant to both diseases.

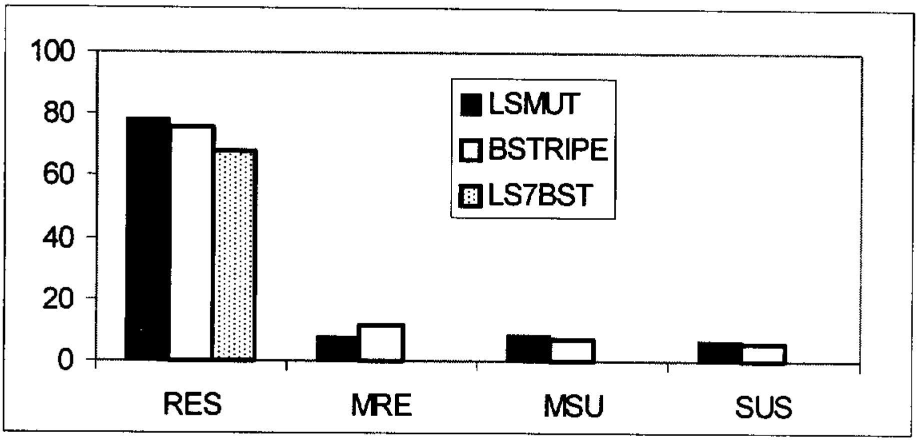

Figure 2.6 Frequency distribution of the reaction to powdery mildew and barley stripe diseases of 272 barley lines.

Generally six-row barleys show better resistance to loose smut than two-row barley. Resistance to barley stripe is being investigated in several crosses. Figure 2.7 shows the distribution of the reaction type of parental lines and

F_2 generation under artificial inoculation with a mixture of *Helminthosporium gramineum* isolates. The tendency of transgressive segregation was observed in the F_2 population of one cross between two susceptible parents: (P1 = JLB 06-36) and (P2 = Arta) as compared to the normal segregation between a resistant parent (P3 = SLB 39-05) and a susceptible parent (P2 = Arta). Further testing is being conducted for detailed genetic analysis and possible identification of selected families for further use as source of resistance to barley stripe of three lines and their F_2's.

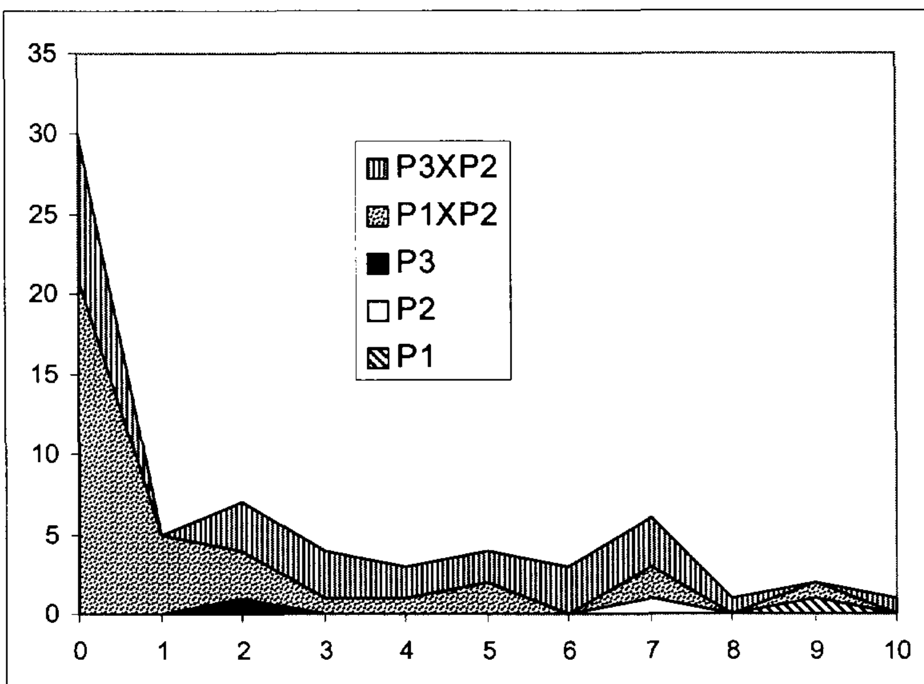

Figure 2.7. Frequency distribution of the reaction to barley stripe disease

2.2.7.1.3 Resistance to scald and powdery mildew

As in the case of seed borne diseases, scald and powdery mildew are very important in developing countries, particularly in North Africa were barley occupies nearly 4.5 million hectares and the cultivars currently grown are relatively susceptible to both diseases. Rihane-03 is the most cultivated variety in North Africa and it has become very susceptible to powdery mildew, scald and net blotch. Fungicides are commonly applied in Tunisia to protect it against these diseases. A combined resistance to powdery mildew and scald is being investigated and breeding lines is being identified among several breeding nurseries. Table 2.50 shows a number of genotypes that have good level of resistance to powdery mildew and scald. Their disease resistance will be further tested in hot spots in a number of countries.

Table 2.50. Barley lines resistant to scald and powdery mildew

Lines	Name
IFYT98-5	Wieselburger/Ahor 1303-61//Sls
IFYT98-12	Jf/A//Barsoy/Ri
IFYT98-20	CWB117-77-9-7//Alpha/Durra
IFYT98-21	VA 92-42-46
IFYT98-22	CWB117-77-9-7/3/Roho//Alger/Ceres 362-1-1
IFYT98-24	CWB117-77-9-7//Alpha/Durra
IWYT98-1	Alpha/Durra//Antares/Ky63-1294
IWYT98-3	Robur/Miraj 1
IWYT98-7	A109-SA-706-79//4341N/Ot/3/Roho//Alger/Ceres 362-1-1
IWYT98-8	Pirate//Alger/Ceres 362-1-1
IWYT98-9	308/80M1
IWYT98-12	Kc/Mullers Heydla//Alpha/Durra
IWYT98-19	Radical/Monolit
WBYT97L-10	ICB 105959/Ranniy
FBYT97L-22	CWB117-77-9-7/3/Roho//Alger/Ceres 362-1-1
FBYT97L-13	CWB117-77-9-7/3/Roho//Alger/Ceres 362-1-1
FBYT97L-16	Jf/A//Barsoy/Ri
FBYT97L-17	Roho//Alger/Ceres 362-1-1/3/CWB117-77-9-7
FBYT97L-37	Kc/Mullers Heydla//Sls
IWFBCB-39	ICB-103351/Arta
IWFBCB-51	YEA389.3/YEA475.4
IWFBCB-52	VA 93-42-23
IWFBCB-53	Kc/Mullers Heydla//Sls
IWFBCB-61	Robur/WA2196-68
IWFBCB-79	Kc/Mullers Heydla//Alpha/Durra
IWFBCB-99	Productiv/3/Roho//Alger/Ceres 362-1-1
IWFBCB-100	Alpha/Durra//Antares/Ky63-1294
IWFBCB-111	ICB-105959/Ranniy
IWFBCB-112	VA 92-44-275
IWFBCB-113	Lokus/Bda
IWFBCB-127	K-253
IWFBCB-158	Russia-1
IWFBCB-182	VA 92-42-46
IWFBCB-186	NE 90721

2.2.7.1.4 Resistance to scald, powdery mildew, and covered smut

As covered smut continues to be a problem in different regions, breeding material is also tested for resistance to this disease. Resistant lines were also tested for resistance to other foliar diseases. Table 2.51 shows a set of lines that combine resistance to covered smut, scald, and powdery mildew.

Table 2.51. Barley lines resistant to powdery mildew, scald and covered smut.

Lines	Name
IFYT98-2	CWB117-77-9-7/Grivita
IFYT98-7	Productiv/3/Roho//Alger/Ceres 362-1-1
IFYT98-6	Robur/Lokus
IFYT98-15	MV-46/Masurka//Slr
IFYT98-18	Roho//Alger/Ceres 362-1-1/3/Tipper
IWFBCB98-27	Bkf/Magnelone 1604//Alouette
IWFBCB98-49	Alger/Cerese 362-1-1
IWFBCB98-55	Wieselburger/Ahor 1303-61/3/Arr/Esp//Alger/Ceres 362-1-1
IWFBCB98-67	Plaisant/Novator
IWFBCB98-156	YEA168.4/YEA605.5//Lignee 131/Arabi Abiad
IWFBCB98-161	Tipper/ICB-102854
IWFBCB98-193	Roho//Alger/Ceres 362-1-1/3/Tipper
IWFBCB98-195	Roho//Alger/Ceres 362-1-1/3/Tipper
IWFBCB98-196	Alpha/Durra//Slb
IWYT98-4	Sonate/Grivita
IWYT98-15	Dt/Robur
FBYT97L-5	Productiv/3/Roho//Alger/Ceres 362-1-1
FBYT97L-10	Lokus/Salmas
FBYT97L-17	Roho//Alger/Ceres 362-1-1/3/Tipper
FBYT97L-20	Roho//Alger/Ceres 362-1-1/3/Tipper

2.2.7.1.5. Combined resistance to scald, powdery mildew, barley stripe, loose and covered smut.

The ultimate objective in breeding for genetic resistance to biotic stresses is to develop varieties that are resistant to as many diseases as possible. Among the material tested for this purpose, seven fixed progenies were identified. Table 2.52 shows the pedigree of the lines that were identified as resistant to five of the most common barley diseases which are scald, powdery mildew, barley stripe, covered smut, and loose smut.

Table 2.52. Barley lines resistant to powdery mildew, covered and loose smut.

Lines	Name
WBYT97-21	Alpha/Durra//Antares/Ky63-1294
WBYT97-14	VA 92-44-275
WBYT97-15	Roho//Alger/Ceres 362-1-1/3/Alpha/Durra
WBYT97-12	VA 93-42-21
WBYT97-4	Robur//Deir Alla 106/Cel
FBYT97-14	Antares/Ky63-1294/3/Roho//Alger/Ceres 362-1-1
FBYT97-19	Tipper/ICB 102854

(A. Yahyaoui)

2.2.7.2. Prospects for breeding for disease resistance in barley.

Adequate resistant material has been developed by ICARDA and could be readily exploited by NARS. This is particularly true for the material that has been generated through the decentralized breeding adopted by the barley project. The diseases present in the region are highly variable and shifts in virulence are common, hence emphasis should be given on developing broad base resistant material. Also tolerance level to multiple diseases should be improved. To tackle these aspects, more screening should be done in hot spots to generate information both on sources of resistance and on predominant virulence types of a given pathogen.

Our aims in breeding for disease resistance will be 1) identify and monitor resistance genes, 2) develop with NARS a gene deployment strategy, 3) pyramid resistance factors for broad base resistance and encourage the use of tolerant type of resistance when possible, 4) develop and adopt marker assisted selection and new biotechnology tools to monitor resistance genes in barley germplasm and virulence genes in some pathogens, and 5) at the farm-level initiate an integrated disease management approach that can strengthen farmer participation in crop improvement by implementing cost effective disease control measures.

(A.Yahyaoui, H.Toubia Rahme)

2.2.8. Entomology

2.2.8.1. Russian wheat aphid (RWA)

Russian wheat aphid, *Diuraphis noxia* (Mordvilko), causes serious damage to barley in North Africa and Ethiopia, mostly in dry years. The aphid injects a toxin into the plant that destroys the chloroplast membrane, causing longitudinal chlorotic streaks to develop. Host plant resistance has been the most practical and economical means of controlling this pest.

2.2.8.1.1. Screening for resistance

Tel Hadya

A total of 300 lines of winter barley were screened in the field at Tel Hadya for resistance to RWA. The entries were planted in hill plots, 10 seeds/hill using alpha-lattice design with 2 reps. One susceptible check for each crop species was used every 10 entries. This field experiment was infested at tillering stage with about 10 aphids per plant. The evaluation was done three times at three weeks intervals using DuToit scale from 1-6, where1= small isolated chlorotic spots on the leaves and 6 = severe white/yellow streaks and tightly rolled leaves. In the greenhouse, 252 barley land races from Ethiopia were screened for resistance to RWA. The experimental design used was a RCBD with 4 reps. At one leaf stage, plants were infested. The method of infestation and evaluation were similar to those of the filed test.

The results showed that out of the 300 winter barley lines tested in the field, 5 were moderately resistant to RWA; these lines had a score of 3 in the DuToit scale. These promising lines will be tested in 1999 under artificial infestation in the greenhouse for confirmation.

Seventeen Ethiopian land races showed a moderate level of resistance to RWA. The damage scores of these lines ranged from 3 to 3.25. Seven out of the 17 Ethiopian land races have been reported to be resistant to RWA in Ethiopia. These land races are 1639-2, 1671-6, 1725-7, 3293-15, 3296-13, 3369-3 and 3379-10. These resistant land races will be used in the breeding program to develop RWA-resistant varieties for Ethiopia.

(M. El Bouhssini, S. Ceccarelli, S. Grando, V. Shevstov, A. Kemal, M. Demissie).

Morocco

A nursery comprised of 31 sources of resistance was sent to **North** Africa for evaluation to the prevailing RWA biotypes. However, the only country where the test was conducted successfully was in Morocco under field and growth chamber conditions. The field test was carried out at Annoceur experiment station, which is a hot spot for RWA. The entries were seeded in rows of 1 m long, as a RCBD design with 4 reps. The material was planted in February and evaluated in May. In the growth chamber test, entries were seeded in greenhouse flats as a RCBD design with 4 reps at a rate of 5 grains/entry. When plants were at the two-leaf stage, they were infested with RWA at a rate of 5 nymphs/plant. Evaluations for resistance were made three times at a week interval starting from the first week after the infestation. The same method of evaluation using Du Toit scale was used.

The results showed that 21 lines had very high level of resistance (<3 in the Du Toit scale). These sources of resistance will be used in the barley-breeding program to develop resistant varieties to RWA in North Africa. This differential reactions between RWA in Morocco (only 21 lines resistant out of 31) and Syria indicates the existence of biotypic variation between North Africa and West Asia.

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

2.2.8.1.2. Development of barley lines resistant to RWA

Twenty-three F_2 populations carrying resistance to RWA were evaluated for resistance to this pest under artificial infestation in the field. Seeds of each population were spaced planted in 30 m long rows. At tillering stage, about

10 aphids were used to infest every individual plant. Three weeks later, and as symptoms developed, susceptible plants were rouged out from the field. A total of 3914 resistant plants from all the populations were individually harvested (Table 2.53). This season, progeny rows from each plant will be evaluated for RWA resistance and also for agronomic characters, in comparison to North African checks, which were included in the test.

Table 2.53. Nr. of plants resistant (R) and susceptible (S) to RWA in 23 F_2 between lines adapted to North Africa and sources of resistance.

Entry	Name	Res	Susc.	Total
1	Saida/RWA.M56	57	610	667
2	Saida/RWA.M54	0	568	568
3	Bda/RWA.M46	196	359	555
4	Bda/RWA.M56	213	469	682
5	Bda/RWA.M55	149	406	555
6	Bda/RWA.M54	146	402	548
7	Lignee 527/Aths//RWA.M55	221	406	627
8	Lignee 527/Aths//RWA.M54	32	450	482
9	Lignee 527/Aths//RWA.M53	197	323	520
10	Lignee 527/Aths//RWA.M47	90	13	103
11	Lignee 527/Aths//RWA.M46	220	398	618
12	Rhn-08/Arar//RWA.M46	435	181	616
13	Rhn-08/Arar//RWA.M55	111	402	513
14	Rhn-08/Arar//RWA.M54	99	279	378
15	Rhn-08/Arar//RWA.M47	224	275	499
16	Apm/11012-2//Np CI	434	427	861
17	Apm/11012-2//Np CI	184	334	518
18	RWA.M56/Ballan	41	350	391
19	RWA.M55/3/Alanda//Lignee 527/Arar	105	385	490
20	RWA.M46/3/Alanda//Lignee 527/Arar	305	191	496
21	RWA.M53/Ballan	230	256	486
22	RWA.M54/Ballan	43	181	224
23	RWA.M54/3/Alanda//Lignee 527/Arar	182	350	532
	Total	3914	8015	11929

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

2.2.8.2. Barley stem gall midge

The barley stem gall midge (BSGM), *Mayetiola hordei* Keiffer, is a destructive pest of barley across the Mediterranean region. In Morocco, this insect causes up to 35% yield losses in barley grain yield each year.

Two ICARDA barley nurseries, SEGMAG98 (347 lines) and BI99IN (5274 lines), were sent to Morocco to be screened in the greenhouse at INRA (Institut National de la Recherche Agronomique), Settat, for resistance to the BSGM. The SEGMAG98 was screened in totality, but only 1950 lines of the BI99IN were evaluated. The remaining lines will be screened in the 1999 season. Seeds were sown in rows (ca. 30 seeds per row) in a standard greenhouse flat (54 x 36 x 8 cm) containing a mixture of soil, vermiculite and peat. Flats containing plants at the one leaf-stage were placed under a cheese cloth tent along with infested plants containing mature pupae of BSGM. When adults emerged, females were allowed to lay eggs on the seedlings for two days. Plant reactions to larval feeding were determined 20 days after egg hatch. Susceptible and resistant plants were separated on the basis of symptoms. Susceptible plants were stunted and dark green, whereas resistant plants were not stunted and retained their light green color.

No antibiosis was recorded in any of these lines. However, few lines exhibited tolerance to the feeding of BSGM. These lines will be retested in 1999 season for confirmation.

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

2.2.9. Virology

2.2.9.1. Evaluation of Best Performing Barley Genotypes from Previous Seasons

Re-evaluation of barley lines from previous seasons identified some entries which are highly tolerant to BYDV as their yield was not seriously affected by virus infection e.g. entries 2BIT-96-267, 2BIT-96-289, 1BIT-97-398 and 2BIT-97-176. Results obtained on the best performing entries are summarized in Tables 2.54 and 2.55.

Table 2.54. Best performing spring barley lines for their reaction to BYDV infection after artificial inoculation with the virus, on the basis of symptoms disease index, grain yield and yield loss (%), during the 1997/98 growing season.

Entry[a]	D.I. (0-9)	Gr. wt. (g/m)	Yield loss (%)
2096-96	4.5	332.5	7.7
2096-190	4.5	398.2	1.7
2096-195	4.5	268.1	13.3
2096-267	4.0	369.6	6.8
2096-393	4.0	295.6	34.1
1097-398	2.0	356.1	6.4
1097-420	3.5	325.0	3.8
1097-428	3.5	337.8	17.8
2097-92	4.0	321.4	11.6
Abee (Susceptible)	6.0	155.8	51.1
JLB 37-057 (Susceptible)	8.0	145.9	47.6

Entry	Name
2096	Sutter*2/Numar//PI 386540
2190	BF891M-599//Giza 121/Pue
2195	Api/CM67/3/Emir/Nackta//Mgh6355/4/H251/3/Api/CM67//Ore/7/CN100/DC23//Fun*3/3/Tra/4/10925-1/5/Bco.Mr/As/6/Seed Source 72-Sal
2267	Lignee 527/Chaaran-01//Lignee 640/Badia/3/Giza 121/Pue
2393	CI 01021/4/CM67/U.Sask.1800//Pro/CM67/3/DL70/5/Gizeh 134/Apm//Aths
1398	Sutter//Sutter*2/Numar
1420	Gustoe/NK1272
1428	Gustoe//Lignee 527/NK1272
2092	Jaidor/Asse//NK1272/3/Rabat013

Table 2.55. Re-evaluation of best performing winter barley lines for their reaction to BYDV infection after artificial inoculation with the virus, on the basis of symptoms disease index, grain yield and yield loss (%), during the 1997/98 growing season.

Entry	D.I. (0-9)	Gr.wt. (g/m)	Yield loss (%)
IWBON-96-88	2	338.1	26.1
IFBYT-97-17	2	284.0	10.5
IWBYT-97-6	3	344.4	7.2
IWBYT-97-17	2	352.5	0.0
IWBYT-97-18	2	361.7	0.0
Sutter (Res. Check)	3	338.5	6.2
Wysor (Res. Check)	3	411.3	2.7
(HBON-97-11) (Susc. check)	9	50.4	86.1

2.2.9.2. Evaluation of Nurseries for their Reaction to BYDV Infection

Evaluation of 1925 lines of barley nurseries in 30 cm short rows, on the basis of symptoms produced indicated that, overall, 215 lines (11.1%) were tolerant to infection (Table 2.56). The best performing lines will be evaluated next season on the basis of yield loss due to infection in addition to symptom severity.

When 94 spring barley and 64 winter barley, which were tested in the previous season in 30 cm short rows, were evaluated for their reaction to BYDV in 1-m long rows during the 1997/98 growing season, some lines showed high tolerance to BYDV infection. Results of the best performing lines are presented in Table 2.57.

(K.M. Makkouk, W. Ghulam)

Table 2.56. Evaluation of barley germplasm in 30 cm rows for tolerance to BYDV infection after artificial inoculation with the virus during the 1997/1998 growing season.

Nursery	Number of lines tested	Number (percent) of tolerant lines
Spring barley		
Initial Yield trials	490	71 (14.5%)
Syrian Landraces	500	65 (13.0%)
Advanced Yield trials	90	14 (15.6%)
Preliminary Yield trials	252	12 (4.8%)
Winter barley		
	200	26 (13.0%)
Crossing Block		
Observ. Nursery (Facultative)	150	19 (12.7%)
Observ. Nursery (Winter)	150	16 (10.7%)
HBON	45	7 (15.6%)
IFBYT	24	8 (33.3%)
IWBYT	24	5 (20.8%)

Table 2.57. Best barley lines for tolerance to BYDV.

Trial	Entry	D.I. (0-9)	Gr.wt. (g/m)
Initial Yield Trial	1013	3.0	173.9
	1381	3.0	378.3
	1410	2.0	203.6
	1420	2.0	225.7
	2183	3.0	289.7
	2397	3.0	177.0
Advanced Yield Trial	27	3.0	209.5
Intern. Winter Trials	2	3.0	245.2
	6	3.0	251.7
	9	3.0	160.6
	17	3.0	339.7
	18	2.5	301.2
	24	2.0	388.6

(K.M. Makkouk, W. Ghulam)

2.2.10. Grain and Straw Quality

Grain quality

The breeding material is routinely tested for grain quality characteristics, mainly thousand kernel weight and protein content. A limited number of lines are also tested for (-glucan content.

Kernel weight represents an important selection criterion because farmers in several countries rank it very high, while protein and (-glucan content are important both in relation to human and animal nutrition, and to malt production.

An example of the range in 1000 kernel weight, protein and (-glucan content is given in Table 2.58 for some of the trials were these traits were measured. Drought stress causes a decrease in kernel size and an increase in protein content, while has no effect on the content of (-glucan. However, the reduction in kernel weight usually observed in dry sites, varies with the genotype (Table 2.59). The genotypes with the largest kernels are more often 2-row and with white seed, even though it is possible to find some 6-row and some black seeded types with a kernel weight comparable with the best 2-row white seeded.

Table 2.58. Mean and range (in parenthesis) of 1000 kernel weight (1000 KW), protein content (%) and β-glucan content in Tel Hadya (TH), Breda (BR) and Bouider (BO) of the barley breeding lines in the advanced and preliminary yield trials.

		Advanced (90 lines)		Preliminary(252lines)	
Trait	Location	mean	range	mean	Range
1000 KW	TH	40.1	30.4-51.2	38.7	27.3-51.7
	BR	34.4	26.2-46.0	33.0	22.7-45.2
	BO	27.8	21.5-36.2	-	-
Protein	TH	9.7	7.9-11.9	9.7	7.4-12.9
	BR	10.8	8.5-14.9	12.4	9.8-17.1
	BO	16.0	16.0-21.0	-	-
β-Glucan	TH	4.3	3.4-5.6	-	-
	BR	4.2	3.1-5.0	-	-
	BO	4.5	3.3-5.5	-	-

Table 2.59. Barley lines with the largest average 1000 kernel weight across 11 locations and with the largest 1000 kernel weight in the more stressful farmers fields.

Entry	Name	RT	col	Tel Hadya	Breda	Farmer field
1	ER/Apm//Lignee 131/4/Antares//12201/Attiki/3/RM1508/Por//WI2269	2	White	53.8	44.0	44.7
2	WI2291//Apm/PI 000046/3/Hml-02	2	White	51.4	40.8	48.5
3	Carina/4/Clipper/Volla/3/Arr/Esp//Alger/Ceres 362-1-1	2	White	50.2	39.5	45.8
4	Mo.B1337/WI2291//Moroc 9-75	2	White	48.9	39.2	42.3
5	ER/Apm//Sls	2	White	48.6	40.0	38.3
6	Roho//Alger/Ceres362-1-1/3/WI2198/Lignee 131	2	White	47.2	34.6	46.0
7	SLB 34-07/Arta	2	White	47.0	38.9	50.5
8	ER/Apm//Lignee 131/3/Lignee 131/Arabi Abiad	2	White	46.3	37.0	51.6
9	ArabiAbiad/WI2291//Tadmor/4/H.spont.93-4/3/Roho//Alger/ Ceres 362-1-1	2	White	46.3	37.6	45.8
10	Leb71/CBB37//Leb71/CBB29/3/Lignee 527/Chn-01	2	White	46.2	36.0	35.0
11	Arta	2	White	46.2	38.1	48.8
12	ChiCm/An57//Albert/3/Alger/Ceres 362-1-1	2	White	46.2	34.2	46.0
13	H.spont.93-4/3/Roho//Alger/Ceres 362-1-1/4/WI2269/Arta	2	White	46.2	37.2	47.5
14	Carina/Sls	2	White	46.1	41.2	42.9
15	Moroc 9-75/4/Roho//Alger/Ceres 362-1-1/3/Kantara	2	White	45.9	38.6	39.1
16	Roho//Alger/Ceres 362-1-1/3/Kantara/4/Tipper	2	White	45.8	39.3	48.5
17	LOCAL 5 (A.Abiad Saraqeb)	2	White	45.7	38.6	40.0
18	Moroc 9-75/Arabi Aswad	2	Black	45.4	35.6	48.3
19	Moroc 9-75//WI2291/WI2269	2	White	45.2	33.8	40.2
20	SLB 45-58/Arta	2	Black	45.1	37.5	42.2
21	SLB 34-65/Arar	2	White	45.0	34.8	36.2
22	Tadmor//ER/Apm	2	Black	44.3	37.8	52.0
23	EB921/Lignee 1335	2	White	44.3	36.4	37.4
24	Aw Black/Aths/5/M69-77/Shi-r-Kci No.87/4/Pro/TolI//Cer*2/TolI/3/5106	6	White	43.8	34.8	39.4
25	WI2737/4/Alger/Ceres//Sls/3/ER/Apm	2	White	43.7	37.6	34.8
26	H.spont.93-4/3/Roho//Alger/Ceres 362-1-1/4/SLB 15-05	2	White	43.3	37.6	45.0
27	ER/Apm/3/Arr/Esp//Alger/Ceres 362-1-1	2	White	43.2	36.4	47.2
28	Moroc 9-75/Arabi Aswad//H.spont.41-4	2	White	43.0	36.2	39.2
29	Arabi Abiad/WI2291//Tadmor/3/Hml/SLB 45-34	2	White	42.0	32.6	38.5
30	WI2291/Tadmor	2	White	40.4	38.1	46.8
31	H.spont.41-1/SLB 39-39//SLB 15-05	2	White	38.4	36.3	37.5

2.2.10.1. Cooking time

In 1998 we started investigating a new aspect of grain quality, namely the cooking time together with traits, such as kernel hardness, measured as CUT test with an SMS Texture Analyzer, which are possibly associated with it. Figure 2.8 shows the range of cooking times of 23 barley lines before and after pearling.

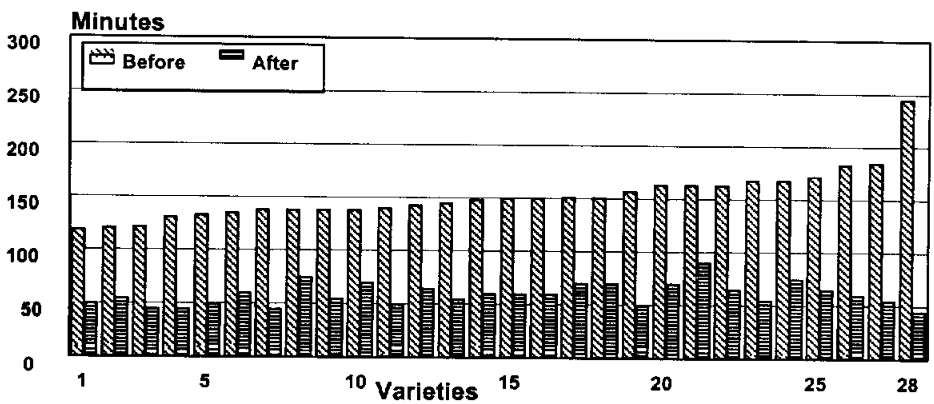

Figure 2.8. Cooking time (minutes) of 23 barley genotypes before and after pearling.

The average cooking time without pearling was 2 hours and 30 minutes, and varied from a minimum of 2 hours in varieties such as Harmal and Sara, to 3 hours in Arta and 4 hours in Lignee 527/Arar/3/Lignee 527/Sawsan//Bc. Pearling reduced the average cooking time to 1 hour, but a considerable variation in cooking time still existed between varieties, as it ranged from 45 minutes (Arabi Aswad and Lignee 527/Arar/3/Lignee 527/Sawsan//Bc, the one with the longest cooking time before pearling) to 90 minutes (WI2291/Tadmor). There was no relationship between the cooking time before and after pearling (r = 0.08) and between cooking time and several seed characteristics (Table 2.60).

Table 2.60. Simple correlation coefficients between seed hardness, seed plumpness, seed size (TKW) cooking time (CT) before (BP) and after pearling (AP), Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), Digestible Organic Matter (DOM) and protein content (those in italics are significant at 5% level, those in bold are significant at 1% level).

	Hardness	Plump	TKW(g)	CTBP(min)	CTAP(min)	NDF(%)	ADF(%)	DOMD(%)	Protein(%)
Plump.	-0.081	1.000							
TKW (g)	0.096	**0.636**	1.000						
CTBP (min)	-0.022	-0.174	-0.393	1.000					
CTAP (min)	0.237	-0.253	-0.317	0.081	1.000				
NDF 9%)	0.091	-0.294	-0.300	**0.529**	0.142	1.000			
ADF (%)	0.373	*-0.421*	-0.343	0.331	0.089	0.325	1.000		
DOMD (%)	-0.330	*0.423*	*0.484*	-0.116	-0.056	-0.272	**-0.635**	1.000	
Protein (%)	0.111	-0.298	-0.252	0.188	-0.031	-0.078	*0.464*	-0.231	1.000
Husk (%)	0.320	-0.153	0.037	0.243	-0.068	*0.433*	0.407	-0.243	0.032

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

Straw quality

Most of the work on straw quality is done within the framework of the participatory breeding project in Syria. The objective is to test whether the lines selected differ from those rejected in parameters associated with straw softness. We used the SMS Texture Analyzer to perform the CRUSH test on ten separate stems (the methodology described in the 1997 Annual Report). Three measurements were calculated from the Texture Analyzer curves: straw diameter, the force used to crush and the shearing energy.

Table 2.61 shows that 2 row barley have softer straw than 6 row barleys, no matter which parameter is used, and that based on two out of three parameters, black barleys have softer straw that white barleys.

Table 2.61. Mechanical characteristics of different types of barley sampled in Breda.

Types	Diameter (mm)	Force (g)	Shearing energy (g mm)
2 row (n=	2.06	1759	3719
6 row (n=	2.25	1882	4306
Sign. of diff.	**	**	**
Black seeded	1.92	1894	3775
White seeded	2.14	1990	4346
Sign. of diff.	**	n.s.	**

(F. El-Haramein)

2.3. The Near East and West Asia

The germplasm development for the Near East is largely a product of the head quarters activities. Therefore in this section we will mainly report progress in breeding for continental areas with very cold winters, as well as specific collaborative activities with the National

Programs of the countries of the Near East. Many of these activities are also part of the Mashreq and Maghreb project, and more details can be found in the reports of that project.

2.3.1. Jordan

During 1998 we continued our collaboration with Jordan both through the University of Jordan (UOJ) in Amman and the National Center for Agricultural Research and Technology Transfer (NCARTT). In five locations (Mowaggar, Khanasri, Ramtha, Rabba and Ghweer), representing a wide range of environmental conditions and of soil types, we tested a new adaptation nursery with 80 entries and an adaptation trial with 20 lines.

The adaptation trial included the ten lines tested in 1997 and the ten most promising lines selected from the 1997 nursery. The ten lines tested in 1997 were evaluated again because in 1997 the performance of the lines was affected by an exceptionally late frost.

The five locations represented very distinct environments (Table 2.62) with Mowaggar and Rabba representing the two extremes. Rabba is included in these trials to provide an estimate of yield potential, even though it is not located in a typical barley growing area.

Table 2.62. Heading date, plant height (cm), spike length (cm), grain yield (g/plot), total biological yield (g/plot) and harvest index in five locations in Jordan.

Trait	Mowaggar	Khanasri	Ramtha	Ghweer	Rabba
Heading	-	-	-	105.0	-
Height	28.8	55.8	77.1	72.9	90.3
Spike length	3.9	5.3	6.3	-	7.3
Grain Yield	16.0	48.9	64.9	192.6	373.5
Biol. Yield	71.4	278.5	1128.3	618.1	699.3
Harvest Index	0.2	0.17	0.09	0.32	0.33

The increasing stress conditions from Rabba to Mowaggar are reflected particularly in the grain yield, the total biological yield, the plant height and the spike length.

The best breeding lines based on the average standardized grain yield across locations (Table 2.63) were all two rows and were all selections from Syrian landraces, or derived from crosses involving Syrian landraces. This confirms that the breeding material targeted for Syria is well adapted also for the rainfed areas of Jordan.

The entries which ranked first and second in 1998 (both obtained from the cross WI2291/Tadmor by Single Seed Descent to produce a mapping population) ranked third and fourth among the 84 lines tested in 1997 for the mean standardized grain yield across four locations (the same used in 1998 minus Mowaggar). This indicates that although 1997 was a very distinct cropping season because of the late frost, some genotypes were top yielders in both seasons.

The entries listed in Table 2.63 performed well in all locations. Some others were among the top five only in some specific locations including some of the driest ones (Table 2.64). Of particular interest in Table 2.64 are the first two entries because these were also the two top yielding entries across the four locations in which this material was tested in 1997.

The best entry in the new nursery distributed in 1998 was Arta

Table 2.63. Grain yield (g/plot) in five locations in Jordan of the entries with the highest standardized average grain yield across locations in a special yield trial for Jordan.

Entry	RT	Mowaggar	Khanasri	Ramtha	Ghweer	Rabba
17	2	23.0	65.0	79.0	285.0	649.0
20	2	19.0	60.0	91.0	234.0	426.0
4	2	34.0	62.0	85.0	183.0	393.0
9	2	16.0	73.0	94.0	158.0	403.0
10	2	30.0	72.0	70.0	165.0	375.0
16	2	25.0	88.0	26.0	230.0	276.0
8	2	34.0	60.0	68.0	161.0	283.0
1	2	26.0	27.0	73.0	184.0	459.0
Mean		16.0	48.9	64.9	192.6	373.5
s.e.		2.43	4.08	4.53	8.99	22.91
Min		0.0	25.6	26.1	105.3	239.6
Max		34.4	87.8	93.9	285.4	648.7

Entry Names
17= WI 2291/Tadmor
20= WI2291/Tadmor
4 = SLB 05-96
9 = Moroc 9-75/Arabi Aswad
10= Zanbaka//Harmal-02/Lignee 131
16= Tadmor/SLB 39-10
8 = Moroc 9-75//H.Spont.41-1/Tadmor
1 = Arta

Table 2.64. Names of entries which were among the top five in specific locations in Jordan (MO = Mowaggar, GW = Ghweer, RB = Rabba, RA = Ramtha).

TOP5 in	Entry	NAME
MO	12	Salmas/Arabi Aswad
GW	13	WI 2291/Tadmor
GW	18	Zanbaka/5/Pitayo/Cam//Avt/RM1508/3/Pon/4/Mona/Ben//Cam
RB	2	SLB 39-10
RB	3	SLB 39-60
RA	5	Sara
RA	19	WI2197/CI 13520//SLB 39-60

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

2.3.2 Lebanon

There was an expansion of both the selection and the testing activities of barley germplasm and finished lines in the last few years in Lebanon.

Since 1997 we have started distributing F_2 bulks which are planted in Terbol and Kfardane for selection of germplasm specifically adapted to wet and dry environments in Lebanon.

Several varieties were tested in a number of Locations (Table 2.65). The released 6-row barley Rihane-03 continued to be superior to most of the tested 6-row lines and across most of the locations. Pamir 35 was a good 2-row type who significantly out yielded the released variety Litani in 3 locations across Beqaa

Table 2.65. Grain yield (tons/ha) of barley genotypes in the Farm and Station Verification trials across 8 locations.

Genotype	Farm Verification Trials						Station Verification Trials	
	North Beqaa				West Beqaa	North Lebanon		
	Al-Kaser	Jabboule	Shaat	Houch Snaaid	Sawiri	Akkar	Tel-Amara	Kfardane
6 Row Barley								
Rihane-03	3.3	1.1	2.8	2.6	5.0	3.6	3.8	2.6
Assi	2.9	0.6	1.7	2.6	4.1	NP	3.1	1.8
Acsad 176	3.5	NP	2.3	2.2	NP	NP	3.7	1.8
Chams	3.3	1.0	2.0	2.4	4.2	NP	3.9	1.4
Saida	2.5	0.9	1.8	2.4	4.4	NP	3.7	2.2
Kerny	3.2	NP	1.5	2.1	4.4	2.8	3.3	1.6
UNDP 1028	NP	1.4	3.7	NP	NP	NP	NP	NP
Ibaa	3.3	NP	NP	2.0	NP	NP	4.3	1.6
2 Row Barley								
LitaniNP	3.8	0.9	1.7	2.6	3.8	NP	3.4	1.3
Pamir 35NP	3.2	0,8	1.8	2.6	4.4*	NP	4.1*	1.8*
Baladi	2.8	0.8	2.0	2.3	NP	NP	3.7	1.0
Faiz	3.3	0.8	1.7	2.1	NP	3.4	3.8	2.0*
Zanbaka	2.1	1.1	1.5	1.8	3.6	NP	1.9	ND
Tadmor	1.6	0.8	1.9	NP	NP	NP	3.8	NP
Arta	2.8	0.8	1.5	NP	NP	NP	3.7	NP
UNDP 1376	NP	1.3	2.3	NP	NP	NP	NP	NP
UNDP 1380	NP	1.3	2.0	NP	NP	NP	NP	NP
UNDP 1420	NP	1.0	2.1	NP	NP	NP	NP	NP
LSD (0.05)	0.64	0.22	0.40	0.46	0.60	0.95	0.66	0.48
CV%	22%	22%	21%	20%	14%	29%	18%	30%

*Significantly better yielding than the check (©) at the 5% level. Np = Not planted in that location. ND= Not determined.

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

2.3.3 Turkey

In 1997-98, the Central Research Institute of Field Crops (Ankara, Turkey) tested 11 different winter barley nurseries at Haymana and Kazan. On the experimental station in Haymana the segregating populations (393 F_4 and 415 F_5) and the Preliminary Barley Yield Trial (2156 entries) were tested for cold tolerance, disease resistance, yield performance and general adaptation. In the segregating material there were no drastic differences for cold damage as a consequence of heavy selection pressure during the last two seasons. In the Preliminary Barley Yield Trial (PBYT) the material was classified in three categories: very susceptible, medium and very resistant to different combinations of winter stresses. One part of the nursery was planted at the optimum date, while the other part was planted 15 days later due to long period of rainy weather. The material planted later had a very poor establishment and was more susceptible to cold. Rihane-03 and Arta had an index of survival of 20-30% and of 60-80% in the early planting, and of 0-5% and 10-20% in the late planting, respectively. Out of the 2156 lines, 20% were very susceptible, 35% were very tolerant and 45% were intermediate. In total, 211 lines were selected from this nursery to continue their evaluation in the next season.

At Kazan the following material was tested: 886 F_2, 643 F_3, 190 lines from the crossing block, 300 lines from the observation nurseries, 50 hulless lines, 46 forage barley lines, and 48 lines from the international yield trials. The main stresses were cold, drought in autumn, variation of temperature in winter, the competition with weeds in spring, and a severe attack by the click beetle larva (*Zabrus* spp.). Rihane-03 was killed by frost, Salmas (Sls) had a survival of 20-30%. A thick carpet of weeds covered the experimental field with a predominance of *Hypericum perforatum* and *Fumaria officinalis*. Some genotypes and populations were able to compete successfully with the weeds due to their growth habit. They depressed weedy plants while the neighboring plots were suffering greatly. Our efforts to arrange artificially such kind of experiments with deliberate sowing of weedy plant seeds were unsuccessful due to dormancy and difficulties in equal distribution of small sized seeds and in establishment of uniform crop stands. The identification of lines (about 6% of all tested material) with excellent agronomic parameters give a good opportunity to develop germplasm suitable for farmers management, i.e. no herbicides and chemicals against diseases and vermin's. Usually the ability to compete with weeds is associated with a prostrate habit and with fast initial growth vigor. In fact the majority of the identified lines possesses the prostrate plant habit, but not all of them had a good growth vigor and earliness (Table 2.66).

There are some other reasons for the good competing ability of these genotypes, including the allelopathic effect, and the research program from ICARDA/IRAN Project, which includes the screening of barley varieties for allelopathic properties against problematic weeds, will clarify this issue.

Some promising lines from various nurseries have been recommended by Turkish breeders for use in the crossing program. Unfortunately, because of a severe hail storm just before harvesting, yield data were not available. Therefore, the testing of the new germplasm will be repeated in the next season.

The efforts of the Turkish barley improvement program in the previous years have resulted in the development of the two-rowed winter barley varieties Anadolu-86, Obruk-86, Bulbul-89, Tarm-92, Yesevi-93, Orza-96, which were released, and of the promising cultivar Ankarpa-1.

Table 2.67. Number of lines selected from a special nurseries for the dry areas of Iraq comprising 126 entries (111 two row and 15 six row).

	Rasheedya (315 mm)		Tel Faris (166 mm)	
	Two row	Six row	Two row	Six row
Selected	27	7	20	2

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

2.3.5 Iran

The main objectives of the Iranian breeding program on barley improvement were: a) to develop new varieties with better yield and quality for different dryland regions of the country; b) to investigate the biotic (diseases and insects) and abiotic (environmental) stresses depressing the productivity of barley; and incorporate genes for resistance into the new germplasm. There is a network of institutions and experimental stations to realize the objectives.

Agricultural Research Center Maragheh

Growing conditions of the year were slightly better than the previous two seasons. Total rainfall (347 mm) was close to the long-term average. Moisture deficit in October affected stand establishment in most of the fields. The main stress was a combination of drought and heat during May and June. A cold winter and a hot spring characterized the season. Therefore, yields were in the range 1.5 - 2.5 t/ha. In the uniform regional yield trial (URBYT) two lines yielded better than the check Sahand: YEA 932/YEA 557.6 (2.7 t/ha) and ICB 111838 (2.7 t/ha). In the advanced yield trials three lines, Cum-50/1146 with 3.3 t/ha, 4847/YEA606.5 with 3.2 t/ha, and YEA 1819/YEA195.4//Grivita with 2.92 t/ha, performed better than Sahand.

Sararood

This season rainfall was much above average (616 mm). The winter was not severe but transition from cold to warm was abrupt. In general, due to the relatively mild winter and the high rate of precipitation in spring and summer, facultative and spring types yielded well. In this station 469 segregating populations, 225 lines in yield trials, and 502 in observation nurseries were tested. The yield levels were higher than that of wheat. In the on-farm testing the entry Chicm/AN57//Albert performed very well. It is resistant to most barley diseases in the region and has an acceptable tolerance to cold and a good kernel size. During 4 years testing the following promising lines have been identified: Xemus, Roho/Mazurka//ICB-102874, and YEA 762.2/YEA 605. All three lines are resistant to scald, net blotch, and powdery mildew. Among the new material some lines considerably outyielded the check Sahand: CWB 117-77-9-7/ICB...(6.23 t/ha), K-615-1/K-616-...(6.23 t/ha), Wiesel Burger/Aho (8.33 t/ha), Arr/Esp//Alger/Ceres (8.33 t/ha).

Gamloo

Although this season's rainfall was much higher than last year's, the crop suffered from prolonged cold that started early in the season. The terminal drought-heat combination limited growth and yield. Barley performed better than wheat. A total of 1209 entries were evaluated in different nurseries, but only a few of them yielded better than the check Sahand. In an on-farm trial near the station a line Boyer//J-126/Gem 14 yielded 2.15 t/ha and Yesevi-93 yielded 2.00 t/ha.

Hayderloo (Oroumieh)

The season was characterized by a lower rainfall (223 mm), coupled with high temperatures during May and June. This resulted in decreasing of yields, ranging from 0.5 t/ha to 1.4 t/ha. Barley performed better than wheat. In URBYT some lines considerably outyielded the check Sahand: Th/Tokak (120 %), ICB 1118777 (120 %), and ICB 111838 (121 %).

Qaidar (Zanjan)

The rainfall was above average (397 mm). However, a terminal drought-heat complex affected productivity of wheat and barley with yields around 1 t/ha. A lot of lines performed better than the local check: YEA 762.2/YEA 605.5 (1.74 t/ha, 122 %), Thibaul/3/Lignee 131//4341...(1.54 t/ha, 119 %), Tokak//Lignee 1246/GZK/3/...1.25 t/ha, 141 %), Roho//Alger/Ceres, 362-1/3/SA...(1.39 t/ha, 156 %), Alpha/Durra//CWB 117-9-7 (1.98 t/ha, 120 %).

Shirvan

The rainfall was low in December and June, while spring was hot, and the weather was relatively favorable in the other months. Some entries performed well and outyielded the best check: Tarm-92 (3.1 t/ha), Yesevi-93 (3.4 t/ha), Meteor/Star (3.5 t/ha), ICB-100945/Donor (3.4 t/ha), YEA 168.4/YEA 605.5//Maragheh (3.4 t/ha), Steptoe/Lignee 640//Alpha/Durra (3.6 t/ha). In total, 557 lines were selected for the further testing.

Gachsaran (warm areas)

The very high rainfall recorded this season (855 mm) was concentrated in the period November-March. High temperature in March (>31 C) and in May (>41 C) marked the end of the season. The material tested this season included segregating populations (238 entries), observation nurseries (299 entries), and yield trials (163 lines). The main yield limiting factors were diseases, especially net blotch and scald. Many of the entries outyielded the check Izeh but were susceptible to diseases. The most tolerant lines includes Dram/Emir//ER/Apm with 4.96t/ha, WI2198/Emir/3/Arr/Esp... with 5.16 t/ha, and JLB 70-20/Sen 'S' with 5.11 t/ha.

At four sites four entries and a local check were tested for their ability to produce green matter plus grain (dual-purpose barley). At Gachsaran, a wet site, the variety Izeh produced 11 t/ha of green forage plus 3.2 t/ha of grain). Other entries performed on the same level. At the drier sites, the green forage and grain yields decreased considerably due to cutting. It was confirmed that dual-purpose barley may be grown more effectively in areas with reliable rainfall.

Kohdasht

The rainfall was adequate. High temperature was recorded in May and June. This site, contrary to the others in the warm areas is characterized by relatively cold winter with an absolute minimum of -19°C in January. This explains the good performance of ICARDA germplasm, despite its tendency for lateness. 230 lines significantly outyielded the check. Among these the best were: Bal.16/API//DeirAlla106/3/As... with 5.75 t/ha, Atem/WI2291//Hml with 5.75 t/ha, ER/Apm//Cerise/3/Lignee 131... with 5.72 t/ha, Triumph/Moroc 9-75 with 6.48 t/ha, and Roho//Alger/Ceres with 5.32 t/ha. All these lines have a good resistance to scald.

Gonbad (Gorgan)

The rainfall was high (412 mm) with a good start and a food distribution within the season. Winter was warm and spring rather hot. In the yield trials a large number of entries out-yielded the check Turkman: Moroc 97-5/Hml-02 (8.08 t/ha), Lignee 527/NK 1272 (5.59 t/ha), ER/Apm/6/Pid0342//CR 115/PRO (5.37 t/ha), WI2291//WI2269/ER/Apm (5.01 t/ha).

Moghan

The season was very dry with only 138 mm of rainfall. Drought was coupled with high temperature in spring and as yield was around 1 t/ha with few exceptions. The best lines were: Hml-02/5/CQ/CM/Apm/3/12410/4/... (2.16 t/ha) and Roho//Alger/Ceres (2.03 t/ha).

(V. Shevtsov, M. Tahir)

2.4. North Africa

2.4.1. Decentralized Barley Breeding Program

There are nearly 4.5 million hectares of barley grown in North Africa, which includes Morocco, Algeria, Tunisia, Libya and Mauritania. Barley improvement activities are conducted almost entirely in a decentralized mode in Morocco, Algeria, Tunisia, and Libya. Egypt has been included in the decentralized breeding program for North Africa.

During 1997/98 three types of nurseries were distributed to the five countries (Table 2.68):

1. Segregating populations. For the first time they have been divided in two groups, SEGEL98, containing mostly early germplasm, planted in Libya, Egypt and

in one location in southern Morocco, and SEGMAG98 which was planted in Tunisia and Morocco;

2. Special nursery for North Africa, NURMAG98;
3. Yield trials for Libya, Egypt, Morocco, and Tunisia.

Table 2.68. Number of entries evaluated in special nurseries for North Africa during 1997/98 (number of locations planted in parenthesis).

Country	Segregating populations(*)	Nursery	Yield trials
Egypt	134 (5)	271 (5)	56 (4)
Libya	134 (3)	271 (3)	60 (4)
Tunisia	328 (6)	271 (4)	90 (4)
Morocco	134 (1)+328 (3)	271 (5)	90 (8)

* There were 134 entries in SEGEL98 and 328 in SEGMAG98. One set of SEGEL98 was also planted in Morocco.

Segregating populations (SEGMAG98 and SEGEL98)

In Morocco selection in SEGMAG98 was done in three locations: Merchouch (401 mm rainfall), Annoceur (542 mm), and Jemaa Shaim (368 mm). On the basis of agronomic performance and resistance to major diseases seventy-five entries were selected at Merchouch, thirty-three at Annoceur, and twenty-nine at Jemaa Shaim. In total 126 entries were selected in Morocco. No entry was selected in all three locations; eleven entries were selected in two locations (six at Merchouch and Annoceur, four at Merchouch and Jemaa Shaim, one at Annoceur and Jemaa Shaim).

Name and pedigree of the best entries selected in Morocco are reported in Table 2.69.

In Tunisia selection was done at three locations out of the six planted: Beja (603 mm rainfall), Tadjerouine and Mograne. One hundred and twenty-four entries were selected in total. One entry (N. 119) was selected in all three locations. The best entries selected in Tunisia are reported in Table 2.70.

Table 2.69. Best entries selected in Morocco from SEGMAG98.

Entry	Cross	Pedigree
3	Lignee 527//Gloria'S'/Copal'S'	ICB93-0152-0AP
14	Alanda-01//Gerbel/Hma/3/Alanda//Lignee 527/Arar	ICB95-0005-0AP
18	Alanda-01//Gerbel/Hma/4/Apm/11012-2//NpCI 00593/3/IFB974	ICB95-0009-0AP
51	Chn-01/CC89//Arial/3/Lignee 640/Bgs//Cel/4/Bda	ICB95-0041-0AP
115	Alanda//Lignee 527/Arar/6/Man/4/Bal.16/Pro//Apm/DwII-1Y/3/Api/CM67/5/N-Acc4000-123-80	ICB95-0268-0AP
119	Alanda/Zafraa//Alanda/Hamra	ICB95-0272-0AP
122	Alanda/Zafraa/5/Alanda-01/4/WI2291/3/Api/CM67//L2966-69	ICB95-0274-0AP
316	QB813-2//Rebelle/CYDBA89#49	ICB95-0697-0AP
334	QB813-2/Shyri-3	ICB95-0714-0AP
342	QB813-2//Alanda/Hamra	ICB95-0721-0AP
346	Rhn/Lignee 527	ICB92-0776-19AP-0AP

Table 2.70. Best entries selected in Tunisia from SEGMAG98.

Entry	Cross	Pedigree
14	Alanda-01//Gerbel/Hma/3/Alanda//Lignee 527/Arar	ICB95-0005-0AP
33	Chn-01/CC89//Arial/3/Lignee 640/Bgs//Cel/4/Rhn-08/Arar	ICB95-0024-0AP
119	Alanda/Zafraa//Alanda/Hamra	ICB95-0272-0AP
131	Lignee 527/Aths//Alanda/Hamra	ICB95-0283-0AP
146	Aths/Lignee 686/4/Avt/Attiki//Aths/3/Giza 121/Pue	ICB95-0297-0AP
305	Alanda//Lignee 527/Arar/3/Rhn/Lignee 527	ICB95-0772-0AP

Fifty-two entries were in common in the selections of the two countries. A total of 198 entries were promoted to further testing in NURMAG99. Selection in SEGEL98 was done at Jemaa Shaim in Morocco, at Sofit (265 mm rainfall) and Azizia (110 mm) in Libya, and at Rafah in Egypt. Twenty-eight entries were selected in Morocco, fifty-eight in

Libya, and sixteen in Egypt. Only one entry was selected in all three countries, twenty-three were selected in two. A total of seventy-five entries were promoted to next year testing.

Special nursery for North Africa (NURMAG98)

The nursery comprised 271 entries (256 new lines and 15 checks). Nineteen entries were selected in Egypt, four (Table 2.71) for two consecutive seasons.

Seventy-five lines were selected in Libya, forty-seven in Morocco, and eighty-five in Tunisia. There was no entry selected in all four countries, ten were selected in three countries, forty-three in two countries. Based on the lines selected from the nursery in each country, four different yield trials were prepared.

Table 2.71. Entries selected in Egypt for two seasons from NURMAG98

Entry	Cross	Pedigree
15	Ssn/Bda//Arar/3/Gloria'S/Copal'S	ICB94-0079-0AP-0AP
47	Hma-02//11012-2/CM67/3/Aths	ICB94-0002-0AP-0AP
84	CYDBA89#49/3/Ssn/Bda//Arar	ICB94-0170-0AP-0AP
142	80-5013/5/Cr.115/Pro//Bc/3/Api/ CM67/4/Giza120/6/BF891M-582	ICB94-0883-0AP-0AP

Barley yield trials for North Africa

In Libya only the trial planted at Sofit (265 mm rainfall) was harvested.

Table 2.72 shows biological yield, grain yield, and plant height of the best lines and three checks.

Table 2.72. Biological yield (kg ha^{-1}), grain yield (kg ha^{-1}), and plant height (cm) of promising barley lines and three checks. Sofit, Libya (265 mm rainfall), 1997-98.

Line[a]	Biological yield	Grain yield	Plant height
1	3517	1188	66
9	3629	1284	70
28	5313	1380	76
36	4055	1188	58
49	3731	1225	69
Athenais	2956	1187	67
California Mariout	3163	893	64
Mari/Aths*2	2689	1004	61
LSD 0.05	1331	423	14

[a] Names

1 9Cr.279-07/Roho/3/Deir Alla 106//7028/2759
9 Giza 124/Algerian Selection DZ 21-56
28 Egypt 89013-32//WI2197/Mazurka
36 Saida//Gloria'S'/Copal'S'
49 Rhn/Lignee 527/3/Arar//Hr/Nopal

Athenais (Aths) produced 1187 kg ha^{-1}, and was the best check for grain yield. California Mariout, the most common barley variety in Libya, produced 893 kg ha^{-1} of grain and 3163 kg ha^{-1}.of total biomass. Entry 28, derived from a cross with an Egyptian landrace, was the top yielding line for both grain and biomass.

2.4.2. New varieties and promising lines

One barley line M126/CM67//As/Pro/3/Alanda has been recommended for release in Tunisia. In Libya three hulless lines, ICNBF8-589, ICNBF8-614, and ICNBF8-617 have been selected and recommended for further testing in farmers fields.

2.4.3. Drought in barley and water use efficiency in wheat network

The network is implemented through the Nile Valley and Red Sea Regional Program in collaboration with the National Programs of Egypt, Ethiopia and Yemen.

During 1997/98 one Regional Drought Tolerant Barley Screening Nursery (RDTBSN) and one Regional Drought Tolerant Barley Yield Trial (RDTBYT) were grown in Egypt and Yemen.

The screening nursery comprised 67 genotypes (38 selected from the RDTBSN of the previous year, 27 received from Ethiopia, and two checks). The nursery was assembled in Egypt and dispatched to Yemen and Ethiopia. Giza 125 and Giza 126 were used as checks.

In Egypt the nursery was planted in seven locations, four in the North West Coast and two in North Sinai, under rainfed conditions, and in Nubaria station under sprinkler irrigation. The season was very dry and in two sites in the North West Coast the trial did not reach maturity. The data recorded were plant height, spike length, biological yield, and grain yield. The average grain yield of the nursery was 0.6, 0.5, 0.4 and 2.8 tha-1 in El-Kasr, Ras El-Hekma, El-Goura, and Rafah respectively. Twenty-four entries performed better the Giza 125 and Giza 126 and were promoted to the Regional Drought Tolerance Barley Yield Trial 1999.

The Regional Drought Tolerance Barley Yield Trial comprised thirteen barley genotypes, selected from the Screening Nursery in 1997, and three checks (Giza 126, Gahrany, and Arafat). The trial was grown at four locations, three in the North West Coast (El-Mathani, El-Kasr, and Ras El-Hekma), and one in North Sinai (Rafah). The experimental design was a randomized complete block design with three replications, plot size was 4.2 m^2 (6 rows 0.20 m apart, 3.5 m long).

Seven barley genotypes were selected under the severe drought stress conditions in the North West Coast of Egypt. Table 2.73 shows the performances of the selected entries compared to Giza 126.

The selected entries will be tested in on-farm verification trials during 1998-99 season.

Table 2.73. Biological yield (kg ha^{-1}), grain yield (kg ha^{-1}), and plant height (cm) of barley lines selected from the RDTBYT in Egypt. Average of four locations, 1997-98.

Line[a]	Biological yield	Grain yield	Plant height
2	3610	992	59.2
4	3223	939	59.0
6	3173	893	57.6
7	3005	852	57.4
8	2866	877	66.3
11	3183	940	59.0
12	3526	915	59.3
Giza 126	3352	955	56.7
LSD 0.05	922	224	7.6

[a] Names

2 Th. Unknown 80
4 Mari/Aths *2//Avt/Attiki/4/2762/Bc//11012-2/Tery/3/10L/2621-2y-Bante 025
6 Mari/Aths *2/4/Deir Alla 106/Cel/3/Bco.Mr/Mzq//Apm/5106
7 Lignee 527/Bahtim/DL71/3/Api/CM67//Mzq/4/Lignee 527/Chaaran-01//Lignee 640/Badia
8 California Mariout
11 Athenais
12 CI010221/4/CM67/U Sask 1800//Pro/CM67/3/DL70/5/Nacha 2

(S. Grando)

2.4.4. Farmer participation in Morocco and Tunisia.

2.4.4.1. Morocco

Barley, through the multiple uses as feed and food, remains the most widely grown annual crop in Morocco with an average annual acreage of 2.3 millions hectares which represent 46% of the total cereal acreage. Its low production and average yield can be attributed to the predominance of its cultivation in the dry areas (70% of the barley acreage), generally on shallow or sloppy soils and most often in succession of wheat. Additionally, barley is considered as a risk aversion crop by the farmers and seldom benefits from inputs (fertilizers, pesticides, etc.). Only 1-2% of the barley acreage is sown with certified seeds in comparison with 17 and 35% respectively for durum wheat and bread wheat. Though the efforts of the National Agricultural Research Institute (INRA) have led to the release of more than 15 new varieties with an average grain yield gain of 30-50% over the local populations the barley area sown to newly released cultivars is estimated at 20% while those of durum wheat and bread wheat are respectively 80 and 100%. The survey conducted by Saade et al. (1993) reported that the high cost of certified seed, low straw production and poor grain quality especially for livestock feeding are among the constraints explaining the low adoption rates of barley varieties.

Under the prevailing conditions of barley cultivation at the farm level, the development of adapted varieties and low cost agricultural packages are the major elements of the INRA research approach to increase the productivity of this sector. The barley breeding strategy is based on the multi-location selection and evaluation of the genetic material at the experiment stations and on the introduction of shared germplasm developed with ICARDA. In this strategy, farmers' role was limited to variety testing and evaluation in on-farm trials in the form of verification, diagnostic, and evaluation trials. One common characteristic to all previous on-farm trials is their use of formally registered barley varieties. Consequently, farmers were at best asked to provide their appreciation of introduced varieties.

The present trials differ from past on-farm trials in several ways. First, they introduce lines into farmers' fields instead of registered varieties. This implies that there is still room for farmers' effective contribution in the variety development process. Second, farmers are approached directly by the breeder without intermediaries. This can only set up the stage for continuous dialogue and mutual learning between barley producers and barley breeders.

Therefore, this project has added a new dimension to the barley breeding strategy that capitalizes on the participation of farmers to the efforts of selection and evaluation of the genetic material as key elements to increase the efficiency of the barley breeding, to enhance specific adaptation and to speed up the adoption rate of the jointly developed varieties.

The present project aims at developing an appropriate approach for implementing the participatory barley breeding. The specific objectives are:

- To determine farmers' barley ideotype attributes based on surveys and on the selection within a set of diverse genetic material.
- To determine at what stage the farmer and the breeder should be involved (segregating populations, observation lines, and yield trials).
- To prospect possible contributions of women in the selection and evaluation processes.
- To ascertain the relevance of individual vs. group selection.

- To investigate new ways of enhancing barley productivity at the community level.

2.4.4.1.1. Activities programmed and executed

During the 1997-98 season, a trial with 72 advanced lines selected by farmers during 1996-97 season and seven checks was planted at seven farmer fields and at the two experiment stations Merchouch and Jemaa Shaim. The farmer fields are located at Merchouch, Zhiliga, Smaala and Oued Zem in the semi-arid zone, at Beni Khloug and Jemaa Shaim in the arid zone and at Tanant in the Mountain areas. The trial is conducted in three blocks with 30 varieties each, the experimental lines were non replicated and the checks are replicated twice or three times. The checks were the most widely grown local populations in the Maghreb countries (Merzaga 077 for Morocco, Martin for Tunisia and Tichedret for Algeria), and the best available newly released cultivars (Manal, Rihane-03, Aglou and Arig 8). The experimental unit consisted of 6 rows plots 2.5 meters long with 0.3 m as row spacing.

The trial at Tanant was discarded since it was highly infested by a weed that could not be controlled by the available herbicides and the two trials programmed for Tiznit and Maaziz were planted at the experiment stations for comparison. Consequently, the results are available for six farmer sites and two experiment stations. At each of these sites, the collaborating farmer and 2 to 5 neighbors participated in the evaluation of the lines at late tillering and at physiological maturity. Reasons for selecting or rejecting some lines were recorded during the selection process. The national barley breeder performed also the selection both at farmer fields and at the experiment stations. Disease reactions and plant height were recorded and grain and straw yields were measured on the four central rows. The farmer selections were recorded using a 0-1 scale (0=discarded and 1=selected).

Grain and straw yields of the experimental lines were transformed as percents of the checks located in the same block. Correlation coefficients were calculated for grain and straw yields between farmer sites and for grain yields between experiment stations and farmer sites. The efficiency of selection both by farmers and breeder were assessed through the number of common selected lines with the high grain or straw yields (12% more than the check average).

Two field days were organized at Oued Zem with the collaboration of the participating farmers, local extension and several INRA scientists. The main objective of the activity was to expose as many farmers as possible to this new experimentation and explore the ways of going beyond individual farmers to the communities they live in. In conjunction with the second field day, focused interviews were conducted with 11 barley producers.

2.4.4.1.2. Climatic conditions and performance

The climatic conditions were characterized by abundant rains received in the period October to mid-February followed by a period of severe drought; less than 1/5 of the total rainfall was received from jointing to maturity stages as shown in the cases of Merchouch and Jemaa Shaim (Table 2.74).

Table 2.74. Monthly rainfall (mm) at Jemaa Shaim and Merchouch experiment stations during 1997-98 season.

Month	Jemaa Shaim	Merchouch
September	0.0	11.0
October	41.0	49.5
November	52.0	86.0
December	75.0	97.5
January	80.0	35.5
February	99.0	62.0
March	26.0	9.0
April	10.0	20.5
May	3.0	2.5
June	0.0	27.0
Total rainfall	386.0	400.5
Long term average	320.0	425.0

This drought was worsened by the hot winds that occurred during the month of April. These adverse climatic conditions did not allow severe epidemics of major pests. However, moderate to high infections of leaf rust and net blotch was recorded in some farmer sites and allowed effective screening for resistance.

The grain yields obtained in the trials were low while the straw yields were good in most of the trials Table 2.75) and this can be explained by the rainfall distribution. With the exception of the very dry site at Beni Khloug, grain yields were similar in the other sites, but straw yields were different among these sites. Large differences between lines for grain and straw yields are shown by the ranges both at farmer fields and at the experiment stations. The lines with winter growth habit consistently gave the lowest grain and straw yields.

The coefficients of variation were acceptable, except for the Beni Khloug where the inherent soil heterogeneity led to a high coefficient of variation of 36%. The lowest coefficients of variation were obtained at the experiment stations.

Table 2.75. Averages, maximum and minimum grain and straw yields at farmer sites and at the experiment stations season.

Sites	Grain yield			Straw yield		
	Average	Maximum	Minimum	Average	Maximum	Minimum
Farmer fields						
Merchouch	1878	3400	400	5950	9067	1600
Zhiliga	2415	3633	1267	6214	11067	3667
Oued Zem	1956	3733	400	4225	7667	1867
Smaala	2022	4667	267	4992	9067	1267
Beni Khloug	770	1740	67	2177	4013	173
Jemaa Shaim	2011	4111	1017	6827	11944	4167
Exp.Stations						
Jemaa Shaim	2038	2778	556	-	-	-
Merchouch	2790	3611	944	-	-	-

These results show the importance of the choice of the farmer's field where the breeding material will be evaluated in order to obtain an acceptable precision of the trials.

2.4.4.1.3. Farmer selections

During the tillering stage, only 3 lines, all winter types, were not selected by any of the six farmers that participated in the visual selection at four sites, and only 30% of the 90 tested lines were selected by at least four farmers (Table 2.76). At maturity, 9 lines were not selected by any of the 15 farmers, and only one line was selected by all farmers. Thirty percent of the lines were selected by at least 7 farmers. At Oued Zem, all the six participating farmers discarded 39 lines and 31 lines were selected by at least 3 farmers. These findings have two major implications. The first is the necessity to avoid winter types for these environments. The second is the importance of involving as many farmers as possible in the selection process at each site. Selection by many farmers at any given site can be instrumental in providing an opportunity to capture collective preferences and concerns and in increasing the selection efficiency.

Table 2.76. Cumulative visual selections of barley lines by farmers at farmer's sites.

Cumulative selection	Selection at tillering stage (6 farmers)	Selection at maturity (15 farmers)	Selection at maturity at Oued Zem(6 farmers)
0	3	9	39
1	19	11	13
2	19	11	7
3	22	13	7
4	13	10	11
5	9	4	4
6	4	5	9
7	1	5	
8		7	
9		3	
10		5	
11		5	
12		1	
13		0	
14		0	
15		1	

Table 2.77 shows the number of selected lines by the farmers, the breeder and on the basis of grain and straw yields. The data show that:

- Generally, the farmers tend to select more lines at tillering than at maturity. At tillering, farmers seem to give a chance to more lines in the hope that these varieties will catch up later on in their growth cycle.
- With the exception of three farmers, all farmers tend to select more lines than the breeder does. This implies the necessity to advice the farmers to apply low to moderate selection intensities and this can be achieved by asking the farmers to pick up the 20 or 30 best lines.

- Among the lines visually selected by farmers, one-fifth to one-half are checks, mainly Merzaga 077, Arig 8 and Laannoceur.
- Generally, the selections made by the farmers included 50% of the lines selected by the breeder except for two farmers that selected fewer lines.
- With the exception of three farmers, 30 to 60% of the lines visually selected by the farmers were in common with the selections made on the basis of grain or straw yields. Generally, more lines are selected on the basis of straw yields. These results show the importance given to straw and grain yields and the fact that farmers base their visual selection on other plant characteristics such as plant height and grain filling.

Table 2.77. Number of lines selected by farmers, breeder and on the basis of grain and straw yields in different locations.

	Total selected	In common with the breeder (22-5)*	In common with grain yield (21-7)	In common with straw yield (29-9)	In common with grain and straw (17-6)
Oued Zem					
Farmer 1	26 (8)	15	12	17	11
Farmer 2	38 (12)	18	6	11	5
Farmer 3	35 (9)	19	16	21	14
Farmer 4	27 (8)	15	15	18	13
Farmer 5	24 (7)	15	14	15	11
Farmer 6	16 (8)	9	9	10	9
Breeder	22 (5)	22	13	15	10
Smaala					
Farmer 1	34 (6)	14	14	20	9
Farmer 2	17 (5)	9	11	11	9
Farmer 3	8 (4)	3	7	6	5
Breeder	22 (5)	22	15	13	10
Zhiliga					
Farmer 1	22 (5)	9	10	11	8
Farmer 2	19 (4)	13	11	13	10
Farmer 3	42 (12)	17	11	18	10
Breeder	23 (2)	23	10	11	8
Merchouch					
Farmer 1	35 (6)	11	15	17	13
Breeder	18 (3)	18	8	7	5
Jemaa Shaim					
Farmer 1	49 (9)	14	10	12	8
Farmer 2	26 (9)	8	10	9	8
Farmer 3	45 (11)	10	13	15	10
Breeder	15 (5)	15	5	6	4
Sidi Boumahdi					
Farmer 1	39 (7)	5	8	12	6
Farmer 2	75 (13)	17	20	22	11
Farmer 3	44 (10)	16	18	15	8
Farmer 4	23 (10)	12	9	10	5
Breeder	18 (5)	18	7	5	3

()= Number of occurrence of checks
(Y-X)*= (Total Selected- Number of occurrence of checks)

• The results showed that local varieties are still preferred by the majority of farmers at both tillering and maturity. As indicated in Table 2.78, Merzaga 077 and Arig 8 had the highest frequency of selection in farmers' fields and on the basis of straw and grain yields.

Table 2.78. Frequencies of selection of checks by farmers, breeder and on the basis of grain and straw yields during 1997-98 season.

Checks	Farmers		Breeder at F sites (6)	Breeder at S sites (2)	Grain yield (6)	Straw yield (6)	Grain and straw (6)
	Early (7)	Late (13)					
Manal	28.5	15.4	11.1	33.3	22.2	22.2	11.1
Rihane-03	42.8	64.1	50.0	16.7	33.3	38.9	16.6
Tichedret	19.0	43.6	11.1	0.0	22.2	22.2	16.6
Martin	50.0	64.4	8.3	0.0	25.0	33.3	8.3
Aglou	28.6	15.4	8.3	25.0	41.7	50.0	41.7
Arig 8	71.4	65.4	33.3	25.0	58.3	66.6	50.0
Merzaga	61.9	69.2	50.0	16.7	55.5	61.1	55.5

F= Farmer S= Experiment Stations

• This finding strongly suggests to consider local varieties as key parents in the crosses made for Moroccan farmers. In fact, the Moroccan local variety Merzaga 077 received the highest selection score (80%) across five farmer sites and was selected at least once by all the participating farmers (Table 2.79). The two-row variety Aglou was the least selected check. More importantly, only a few lines were selected more frequently than the local varieties Merzaga 077 and Arig 8 (Table 2.80). Interestingly, the checks Merzaga 077, Arig 8, and Laannoceur were the most commonly selected lines.

Table 2.79. Frequency of selection of checks by farmers at the six farmers sites.

	Rep	Frequency all farmers	Merchouch 1 farmer	Zhiliga 1 farmer	Oued Zem 6 farmers	Smaala 1 farmer	J.Shaim 2 farmers	B.Khloug 2 farmers
Manal	3	26.0	100.0	11.1	0.0	0.0	22.2	58.3
Rihane-03	3	66.0	33.3	33.3	55.5	22.2	88.9	75.0
Tichedret	3	36.0	0.0	22.2	50.0	0.0	33.3	33.3
Martin	2	60.0	50.0	33.3	75.0	33.3	50.0	87.5
Aglou	2	20.0	50.0	16.7	0.0	16.7	33.3	37.5
Arig 8	2	67.5	50.0	66.7	66.7	66.7	66.7	75.0
Merzaga	3	80.0	33.3	55.5	88.9	66.7	66.7	50.0

Table 2.80. Number of lines chosen by visual selection more often than the checks.

	Merzaga	Arig 8	Martin	Laannoceur	Tichedret	Manal	Aglou
Experimental lines	3	3	4	10	25	39	45
Checks	2	3	4	4	10	11	16
Total	5	6	8	14	35	50	61

- At Oued Zem, one-third of the 24 lines selected by at least four farmers were the checks, mainly Merzaga 077 and Arig 8. At this site, the two-row variety Aglou and the check Manal were not selected by any of the farmers (Table 2.72).

- Table 2.81 shows that the higher the number of farmers involved in the selection, the more likely it for the highest yielding lines to be selected. There was a high selection intensity on the basis of grain yield at experimental stations, with 48 lines over 90 included all the lines visually selected at farmers' sites. However, the breeding program cannot handle this kind of selection without the involvement of the farmers. Visual selection can be as efficient as yield testing at the experimental stations with the advantage of selecting for targeted environments and responding to farmers needs. Such an approach will help speeding the process of developing new barley cultivars and their use by farmers. Assuring farmers' actual participation in the selection will contribute to making the conventional transfer of technology unnecessary.

Table 2.81. cumulative number of selected lines by farmers at Oued Zem during 1997- 98 season.

	Total lines	Occurrence of checks	Common with breeder
Not selected	39	5	39
Selected by one farmer	13	0	2
Selected by two farmers	7	2	3
Selected by three farmers	7	2	1
Selected by four farmers	13	3	6
Selected by five farmers	4	3	3
Selected by all farmers	9	5	7

The criteria used by farmers during visual selection are shown in Tables 2.82 and 2.83. At the tillering stage, all farmers expressed the importance of tillering ability, early vigor, erect types and large leaves as possible indicators of good forage and straw productions and the suitability for grazing (Table 2.82). Many of the farmers were interested in dual-purpose barley varieties combining good forage and grain production. Dark green leaves, tolerance to drought and resistance to diseases were cited as selection traits only few times. Most of the farmers believe that the development of foliar diseases depends only on the favorable climatic conditions and this project has shown to them the differences in reactions between genotypes.

At maturity, farmers use a large number of selection criteria. Across sites most of the farmers preferred lines with good grain filling, long spikes, and tall plants with good tillering ability (Table 2.84). They also expressed their visual appreciation of grain and straw yields and indicated the best 2 to 3 best lines within the trial. All the farmers selected at least once the landrace Merzaga 077 except at Merchouch where it was severely lodged. Few farmers based their selection on tolerance to drought or heat, and on resistance to foliar diseases. The straw and grain qualities were also seldom cited as selection criteria. These findings show the importance of considering the straw productivity in the barley breeding program and the grain filling under drought and heat stresses. The breeder learned from the farmers to consider grain filling as an important selection criteria under drought. Consequently, all the parental material from Montpellier that in the past represented the elite germplasm in the barley breeding program, should be used carefully in the crossing program. These parents have good general appearance and good disease tolerance but they are highly affected by drought and heat during grain filling. The landraces were among the few lines that filled well their grains under the late drought.

Table 2.82. Common selected lines between group of farmers and the grain and straw yield.

	Total number of selected lines	Common with visual selection at all sites	Common with visual selection at Oued Zem	Common with best yielding lines at farmer fields	Common with best yielding lines at experiment stations
Visual selection at tillering (>3 farmers	27	15	13	15	27
Visual selection at maturity (>6 farmers	32	-	26	22	29
Visual selection at Oued Zem (>3 farmers	31	31	-	20	30

Table 2.83. Selection criteria used by farmers at tillering stage at different sites.

Criteria	*Beni Khloug*	*Jemaa Shaim*	*Smaala*	*Oued Zem*
Large leaves	8	2	-	3
Dark green leaves	1	1	-	4
Erect plant	7	0	-	4
Tillering ability	19	3	9	14
Forage type	2	1	-	10
Lodging resistance	23	1	-	-
Disease resistance	2	3	-	2
Drought resistance	1	3	-	-
Earliness	3	3	3	7
Overall score	6	7	4	5

Table 2.84. Selection criteria used by farmers at different sites (OZ= Oued Zem, SM = Smaala, BK = Beni Khloug, ZH = Zhiliga, JS = Jemaa Shaim, ME = Merchouch) at the physiological maturity stage during 1997-98 season.

Characteristics	OZ						SM	BK		ZH		JS		ME	Total
	F1	F2	F3	F4	F5	F6	F1	F1	F2	F1	F2	F1	F2	F1	
Overall score	3	-	10	2	2	-	1	2	7	-	1	3	21	5	57
Grain yield	6	3	1	-	1	-	2	6	1	9	10	-	-	1	40
Straw yield	3	1	3	8	6	5	3	-	1	-	3	2	1	9	45
Grain & Straw yields	2	3	-	2	-	1	2	5	4	-	2	2	17	3	43
Excellent #1	-	-	2	-	4	1	2	1	-	2	-	-	2	-	14
Earliness	-	1	-	-	1	-	2	-	-	2	-	-	-	-	6
Lateness	-	-	-	-	-	-	1	-	3	-	-	-	1	2	7
Tallness	9	-	17	3	10	-	2	-	-	2	3	1	2	-	49
Tillering capacity	-	1	-	-	13	6	5	-	-	-	4	-	1	1	31
Plant density	-	-	-	5	5	-	-	-	-	2	-	-	1	-	13
Homogeneous stand	-	-	-	-	-	-	-	-	-	1	2	-	-	-	3
Resistance to disease	-	-	-	-	-	1	-	-	-	2	1	1	-	2	7
Tolerance to drought	10	-	-	-	1	-	2	1	12	1	5	-	-	5	37
Tolerance to cold	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Tolerance to heat	-	-	-	-	-	-	-	-	-	-	-	2	-	-	2
Grain filling	13	5	22	9	3	-	3	3	4	-	8	-	2	1	73
Spike length	-	3	-	9	7	6	1	-	5	-	4	14	6	10	65
Two rows types	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Culm appearance	-	-	-	-	-	-	-	-	-	1	-	8	-	-	9
Straw color	-	1	-	-	-	-	-	-	-	-	1	-	-	-	2
Grazing ability	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Straw quality	-	-	-	-	-	-	-	-	-	-	1	2	2	-	5
Food quality	-	-	-	-	-	-	-	-	-	-	-	-	3	-	3
Like Local	1	1	1	2	2	1	1	-	1	2	3	3	1	2	21

Breeder selections

With few exceptions, the breeder selected fewer lines than the farmers and applied selection intensities lower than 30% as done in the conventional breeding (Table 2.85). The selected lines included fewer checks as compared to farmers; the breeder seldom selected the landraces (Merzaga 077, Martin and Tichedret), usually preferred by farmers. This behavior can be explained with the importance given by the breeder to disease resistance, which leads to discard the landraces that are highly susceptible to netblotch. Additionally, breeders often select for a multitude of ideotypes to cover diverse environments, while the farmers do not usually depart from the ideotype represented by the local population. In most of the sites, the breeder was as efficient as most of the farmers in visually selecting for grain and straw yields.

Table 2.85 shows that among the 32 lines visually selected by the breeder in at least 3 sites, 30 were in common with the selections made by at least 6 farmers over all sites, 28 lines were in common with the selection made by at least half of the farmers at Oued Zem and 22 were also selected on the basis of the average grain yield at farmer's sites.

These findings show the importance of conducting trials at as many diverse environments as possible and of involving as many farmers as possible in the evaluation of genetic material.

Table 2.85. Lines selected by the breeder and in common with the selection done by farmers and on the basis of grain yields at farmer fields and experiment stations.

	Number of common selected lines	Total lines selected by each group
Total lines selected by the breeder in at least 3 farmer sites	32	32
Common with visual selection made by farmers at Oued Zem	28	31
Common with visual selection by farmers at all sites	30	32
Common with grain yield selections at the farmer fields	22	22
Common with grain yield selections at experiment stations	32	48

2.4.4.1.4. Relevance of the evaluation site

The breeding efforts aim at satisfying the needs of farmers in the major growing areas. Breeders cover the diversity of environments by using multi-location testing. But, very often, the experiment stations do not cover all the major growing areas of a given crop. The selection and evaluation of breeding material in other sites (farmer's fields) has two major advantages:

- Providing additional sites in target environments;
- Selecting lines under the farming systems that represent the real growing conditions of barley, which are often characterized by low inputs, in contrast to the selection under high inputs at the experiment stations.

These conclusions are supported by the results shown in Table 2.86 that showed no significant correlation between grain yields at the experiment stations and grain yields at farmer's fields with the exception at Merchouch region.

Table 2.86. Correlation coefficients between grain yield at farmer sites and experiment stations during 1997-98 season.

Sites	Jemaa Shaim		Merchouch	
	r	Probability	R	Probability
Merchouch	-0.102	0.3384	0.313	0.0026
Zhiliga	-0.186	0.0791	0.145	0.1721
Oued Zem	0.029	0.7827	-0.142	0.1805
Smaala	-0.036	0.7344	0.164	0.1230
Beni Khloug	0.152	0.1511	-0.083	0.4348
Jemaa Shaim	0.123	0.2467	0.101	0.3413
Merchouch station	1.000	0.0000	-0.063	0.5555

Tables 2.87 and 2.88 showed that only few lines are commonly selected by the breeder and on the basis of grain yields at the experiment stations and farmer fields at Jemaa Shaim and Merchouch.

Table 2.87. Common selections made visually by the breeder at the farmer fields and at the experiment stations at Jemaa Shaim and Merchouch.

Site	Merchouch station (20)	Jemaa Shaim (15)
Merchouch farmer field (18)	7	3
Jemaa Shaim farmer field (19)	3	12

Table 2.88. Common selections made on the basis of grain yields at the farmer fields and the experiment stations at Jemaa Shaim and Merchouch.

Site	Merchouch station (38)	Jemaa Shaim (26)
Merchouch farmer field (26)	18	9
Jemaa Shaim farmer field (16)	8	8

Few significant correlation coefficients were found between grain yields in different farmer's sites except for Oued Zem and Smaala that are correlated among them and with Zhiliga (Table 2.89). The similarities between these later three sites can be explained by the fact that they are within a distance of 45 Km. In the case of straw yield, more correlation coefficients were found to be significant among sites and particularly with Jemaa Shaim and Oued Zem (Table 2.90).

Table 2.89. Correlation coefficients between grain yields at farmer sites during 1997-98.

	Merchouch	Zhiliga	Oued Zem	Smaala	Beni Khloug	Jemaa Shaim
Merchouch	1.000	0.169	0.004	0.115	0.292	0.175
	(0.0)	(0.1100)	(0.9650)	(0.2790)	(0.0052)	(0.0978)
Zhiliga		1.000	0.294	0.296	0.144	0.109
		(0.0)	(0.0049)	(0.0047)	(0.1729)	(0.3037)
Oued Zem			1.000	0.243	0.067	0.125
			(0.0)	(0.0212)	(0.5291)	(0.2390)
Smaala				1.000	-0.041	0.135
				(0.0)	(0.7007)	(0.2058)
Beni Khloug					1.000	0.192
					(0.0)	(0.0691)

( ) Associated probability

Table 2.90. Correlation coefficients between straw yields at farmer sites during 1997-98.

	Merchouch	Zhiliga	Oued Zem L	Smaala	Beni Khloug	Jemaa Shaim
Merchouch	1.000	0.174	0.314	0.069	0.354	0.409
	(0.0)	(0.1013)	(0.0026)	(0.5185)	(0.0006)	(0.0001)
Zhiliga		1.000	0.500	0.351	-0.124	0.337
		(0.0)	(0.0001)	(0.0007)	(0.2421)	(0.0011)
Oued Zem			1.000	0.303	0.178	0.413
			(0.0)	(0.0037)	(0.0926)	(0.0001)
Smaala				1.000	0.026	0.228
				(0.0)	(0.8026)	(0.0304)
Beni Khloug					1.000	0.367
					(0.0)	(0.0004)

( ) Associated probability

These findings stress the importance of extending the selection and evaluation of breeding material in as many contrasting environments as possible, and the need to apply less inputs at the experiment stations in order to simulate the prevailing farmer practices for barley. Indeed, the ranking of lines at experimental stations generally benefiting from optimal conditions and high inputs is different from that at farmers' sites. This means that the selection at farmers' sites is the most appropriate way to search for and develop barley varieties that are adapted to farmer physical and socioeconomic environments.

2.4.4.1.5. Conclusions

The results obtained this season confirmed the importance of integrating a farmer participatory approach in barley breeding in Morocco. Such approach will focus on:

- Using the landraces as parental material in the crossing program and avoiding as much as possible the two row varieties and the winter types unless they are the only sources of some important attributes.
- Initiating the selections in farmer fields and by farmers at generations later than F3 to avoid the segregation for major traits (height, heading, etc.). It is suggested to advance the segregating populations as bulks in farmer fields and start the family selection as F4-F5.
- Evaluating breeding lines in as many contrasting and typical environments as possible.

The visual selection will be conducted by as many farmers as possible to take into account the diversity of farmer's concerns and to avoid the large selection intensities used by individual farmers. The breeder role will be to do the crosses, advancing in bulk the segregating populations and in the choice of experimental sites to ensure the quality of trials.

The implementation of such strategy requires a good choice of the collaborating farmers, the development of close links with them and their communities through the discussion of the objectives and the possible outcomes from the participatory approach. Farmers trusted by their communities as good providers of seeds can play this role. The links with these farmers will be reinforced with the release of the first varieties developed by this approach that avoid the complications and the high prices of certified seed. However, this will require developing an efficient system for producing seed of good quality at the community level.

(A. Amri, F. Nassif)

2.4.4.2. Tunisia

The program realized in 1998 covered a range of activities that directly involved farmers in the project area. The specific objectives for this crop season were to:

- Establish on-farm, permanent testing sites;
- Initiate farmer-to-farmer exchange of information;
- Involve students in on-farm research projects and social studies;
- Strengthen the farmer-researcher communication

The farmer participatory project conducted in Tunisia for the past two year attracted farmers to select barley germplasm and to express their views on priority settings for research. During the last cropping season, all the contacts with the farming communities were formalized through the regional extension service within the project area. This allowed the researchers and the extension agents to work directly with farmers, and hence develop better relationships between the partners.

In the project area three farms are considered as permanent testing site for barley research in the region.

In Kef Governorat, Mr. Amor Mouelhi, farmer at Tejerouine, who is an old collaborator, agreed to actively participate in conducting barley experiments on his farm. Mr. Mouelhi grows about 600 ha of cereals annually, 50% of which is 6-row barley. He uses barley almost exclusively for feed. This farm represents the semi arid region, characterized by low rainfall, cold winter, and early spring drought. Farmers in this region prefer high biomass yield for straw production, and yield stability. The yields in this zone vary from zero to 6 t/ha.

In Kasserine Governorat, Mr. and Mrs. El Khalil, farmers at Foussana, have been partners since the onset of the project and have both agreed to collaborate with researchers in conducting experiments on their farm. This farm represents the small size farm. They grow about 8 ha of barley, 4 ha of wheat, and 6 ha of range and cactus. Barley is used for food and feed, and straw is also very valuable. The farm is located in the semi-arid region, characterized by very cold winter, early sorocco (hot winds), very hot summer, and low rainfall. In this region barley is the most adapted crop, and the only reliable cereal, even though yields are relatively low. Yield in this area fluctuates from 0.3 t/ha to 2.5 t/ha; the record yields did not exceed 4.0 t/ha. Barley landraces cover about 80% of the area.

In Zaghouan Gouvernorat, Mr. Ben Rjeb, farmer at Fahs, was selected as a new collaborator in addition to the farmer in Mograne. He grows 400 ha of cereals (wheat and barley) annually, almost exclusively for seed. He grows the local varieties that are accepted by farmers and not readily available in the seed market. This farmer could very well be a focal point for seed multiplication within his area. This farm is also in the semi-arid region but with mild winters and relatively higher rainfall than the other two sites.

These farmers collaborators have participated for the past two cropping seasons (in the case of Foussana and Tejerouine), and for the last season (in the case of Fahs) in the establishment of the trials, from planting to harvest. Their farming procedures (such as planting dates, fertilizer and chemical uses) were always respected. They have monitored the crop development and have organized tours of the plots for their neighbors.

2.4.4.2.1. Farmer to Farmer Exchange of Information

The collaborating farmers were encouraged to show the experiments to neighbors and to host field days. In this contest farmers, particularly at Tejerouine and Foussana, reported several visits by individuals. Neighboring farmers have offered to participate and asked for experiments to be initiated on their farms.

Organized visits by extension agents took place. Groups of farmers were invited for field days on barley varietal adaptation and on-farm seed multiplication. Throughout the season at least two field days were organized at each site. A group of 5 to 10 farmers per site participated in selection. Results of selection are discussed later in this report.

The on-farm experiments at Tejerouine, Mograne, and Fahs were visited by a group of 10 Egyptian farmers (Marsa Matrouh Project). The visitors were impressed by the active participation of their colleagues and they also liked 6-row barley and large biomass production that favors straw production. The integration of barley-sheep in a fallow-cereal rotation system impressed the visitors the most.

2.4.4.2.2. Students' involvement in on-farm research

At our teaching institutions (ESA-Kef, ESA-Mograne), undergraduate students are encouraged to participate in on-farm research. Breeding and pathology classes have used field experiments for laboratory practicals. Students evaluated disease reactions, studied phenological traits, and have been exposed to the concept of genetic variability within the barley crop as well as the importance of G x E interactions and specific adaptation.

In the rural areas students are well accepted by farmers, particularly when some of them are from within the farming community where we conduct our experiments. Students benefited from farmer's traditional knowledge. Actually those particularly impressed were students coming from urban areas. In collaboration with farmers, and in consultation with social scientists, the students developed a questionnaire, which was adopted as basic information for our breeding work on varietal development. Students summarized the information discussed later in this report, and recorded the selections done by farmers. Two students accompanied each farmer during his field visit for selection.

2.4.4.2.3. Farmer-Researcher Communication

The project allowed us to conduct off-station research experiments and to better understand the farmers rationale in varietal choices. It is common that farmers do not readily accept new varieties, and at times they even reject them. The involvement of farmers in the selection process will definitely resolve the acceptance problems. Eventually barley cultivars (pure lines, mixtures, landraces) that are accepted by farmers will be readily disseminated within each agroecological zone. With farmer participation, breeders can address selection for specific adaptation and specific farmer's requests (quality, phenology, etc.). Researchers will be able to maintain the genetic variability (cherished indirectly by farmers) and hence yield stability in low input agriculture.

2.4.4.2.4. Results

2.4.4.2.4.1. Barley Cultivation

The project area covers part of the semi-arid region in North western and Central Tunisia where barley is the most adapted cereal crop. A small and steady increase in barley production in this region will have a large impact on the farming community that cannot afford crop failures. The questionnaire realized by students from ESA-Kef shows that barley is cultivated under a wide array of farming conditions. The land holding is highly variable within each region (Figure 2.9). At Tejerouine most of the farms range in size from between 100 to 200 ha, whereas at Zaghouan 40% of the farmers interviewed were from farms over 400 ha and about 60% fall in the range of 100 to 200 ha. At Foussana we observed the two extremes, with 60% of the farm which can be considered as large farms, and 40% falling in the small farm range with farms of 5-25 ha.

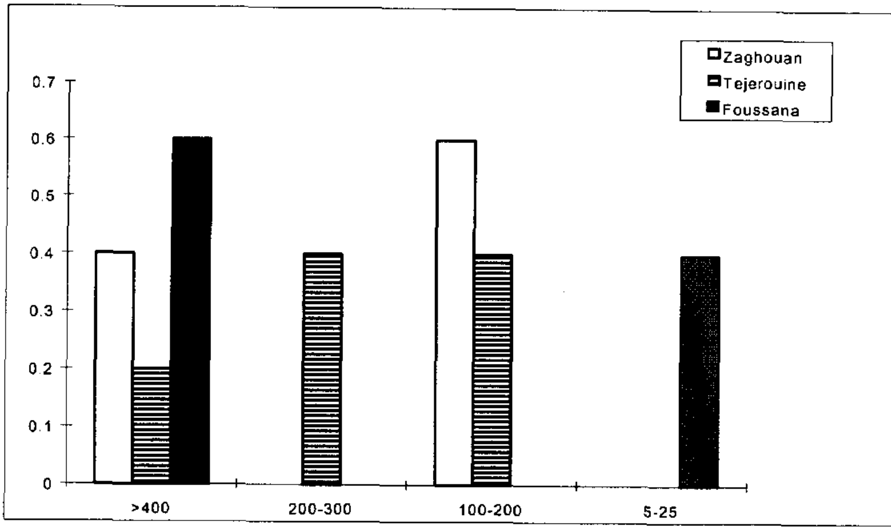

Figure 2.9. Frequency distribution of cultivated area (ha) at three locations.

At the three sites, most farmers grow annually 5-25 ha of barley (Figure 2.10). A large number of farmers at Foussana (40%) grow 50-100 ha of barley. Barley varieties grown on small areas (<50ha) are usually local cultivars.

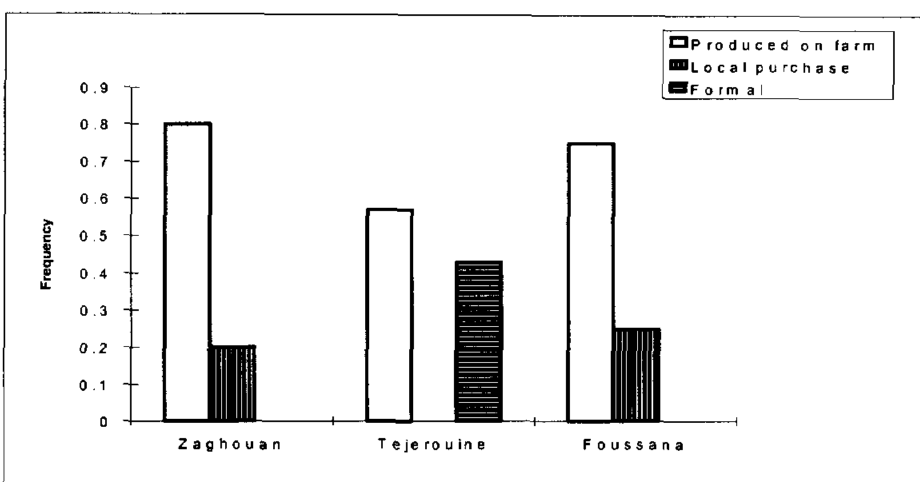

Figure 2.10. Frequency distribution of area (ha) sown to barley

The barley seed (Figure 2.11) at Foussana and Zaghouan is exclusively produced on farm (50-80%) or locally purchased (20-25%). The Tejerouine farming community either produces its own seed (55%) or purchases it from a seed organization (45%). Even though these figures refer to the farmers interviewed, they do show a trend for local barley seed production.

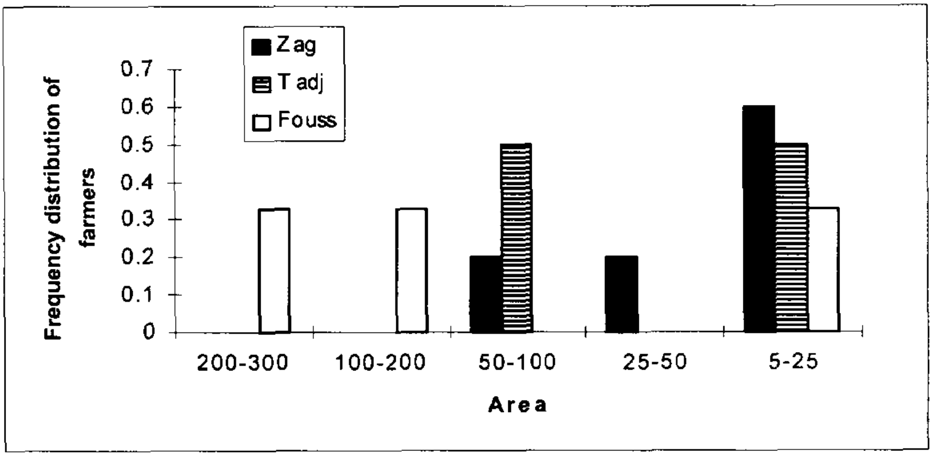

Figure 2.11. Frequency distribution of three types of seed source at the locations.

Barley use within this area is representative of the use of barley in the semi-arid regions of Tunisia. Barley is used as grain for feed and food, for straw, for grazing, and often it is also used for silage, particularly during good years that favor biomass production and when farmers expect high national production and hence lower prices.

Most of the barley cultivated in the semi-arid region, represented by the three testing sites, is used for grain. At Foussana, straw production is as important as grain production. At Tejerouine there is a balanced use of barley for straw, grazing, and silage. At Zaghouan grazing and straw are a more common use of barley than silage.

2.4.4.2.4.2. Selection

A set of barley nurseries was established at the farm level. Segregating populations (SEGMAG), special nurseries for North Africa (NURMAG), and yield trials were installed at each site. A special nursery (TUNMOR) that includes selected lines from Tunisia and Morocco was planned to be used for the selection experiment with farmers, but due to a late arrival of the seed, it was planted late and was not considered for selection. In Tunisia, a yield trial was then used for the experiment. The host farmer, at Foussana (husband and wife) did participate in selection from the late-planted nurseries.

The varieties in the trial (Elite I) used for selection by the farmers at the three sites, are described in Table 2.91.

The varieties Rihane-03 and Martin were used as checks. Most of the varieties were tolerant to scald (Sc) and powdery mildew (Pm). Maturity (Mat), expressed as number of days from planting to harvest, is shown in Table 2.91 together with some morphological observations. Varieties followed by "*" or "**" were selected by breeders, while those followed by FM were selected by farmers. In both cases, selection was done at heading stage and prior to maturity. As shown in Table 2.91, breeders selected 16 varieties (1, 2, 5, 6, 7, 10, 11, 15, 17, 19, 20, 21, 22, 23, and 25), farmers selected 6 varieties (3, 4, 7, 12, 18, and 22). Two (7, 22) varieties were selected by both.

Table 2.91. Description of the barley lines in Elite I.

Pedigree	Origin	Disease Tol.	Mat.	Observation
1. Landrace cultivar	Central TN	SC. PM	90	Hd type **
2. 25005/KBR//X/248	MT	PM	91	Tall, gd head *
3. Mut.Martin(Sc) Sel.For Scald	MT	SC.Pm	97	Tall, FM
4. Landrace x Rihane-03	TN 87	Pm	96	Tall FM
5. Super RSP (Gen.male sterile pop.)	MT	Sc, Pm	96	Gd Spike *
6. Gloria'S'/Copal'S'	ICARDA	SC, PM	95	Short, Gd Spike *
7 MD/2BR//KBY3/SMAI	MT	PM	94	Gd spike ** FM
8. Landrace x Rihane-03	TN 87	SC,Pm	96	
9. Landrace cultivar	Central TN	Pm	104	Tall
10. Mut. Martin (Nb) Sel. For N.Blotch	MT	Sc, PM	105	Gd.spike **
11. Landrace x Martin	TN 87	Pm,	100	Tall *
12. Landrace x Rihane-03	TN 87	SC,PM	99	FM
13. UC 780 42/SMAI	MT	PM	104	
14. Landrace x Rihane-03	TN 87	PM		Tall, Gd foliage
15. Landrace x Martin	TN 87	PM	97	Gd spike **
16. Gloria'S'/Copal'S'	ICARDA	SC, PM	112	Tall *
17. USB//13914/CM/3/SMAI/4/KBY/5/ST/F//C/3/B	MT	Pm	117	*
18. Landrace x Martin	TN 87	Pm	112	FM
19. Land race x Martin	TN 87	Pm	96	*
20. ST/FLD//G/3/B/4/KBY/5/SB401	MT	Pm	95	Tall **
21. UNKNOWN	TBON 82	Pm	97	Gd foliage *
22. RSP-MIX	MT	SC,PM	115	Tall * FM
23. Rihane-03	Check	Sc, Pm	111	*
24. Martin	Check	Sc, Pm	116	Tall, straw
25. RSP-Rpt.10 (Gen.male sterile pop. net blotch)	MT	Sc, PM	97	*

Table 2.92 shows the selection criteria used by farmers at the different sites and for different varieties that are cultivated by most of them. Rihane-03 is usually selected for its yield, Martin for adaptation, and the landraces for combined adaptation, yield and quality, particularly at Foussana where barley is used for feed and food.

Table 2.92. Criteria used by most farmers for growing barley variety at different sites.

Site and selection criteria	Common grown varieties								
	Martin			Rihane-03			Landrace		
	Adapt	Yield	Qlty	Adapt	Yield	Qlty.	Adapt	Yield	Qlty
Zaghouan	+				+		+		
Tejerouine	+		+		+				
Foussana							+	+	+

Adapt = Adaptation, Qlty = Quality

The farmers participating in the project (Tables 2.93, 2.94, 2.95), including two women, have different farm sizes, grow different varieties, and have different seed sources. The varieties selected, listed by number, are shown in Table 2.93 (Kef), Table 2.94 (Zaghouan) and Table 2.95 (Foussana). Variety numbers 1-25 were in the first replication, 26-50 in the second, and 51-75 in the third. Each farmer made selections in one, two, or three replications as shown by the numbers of entries selected. For each variety, the overall number of selection and the number of selection per location, are shown in Figure 2.12. The most frequently selected varieties and the checks were 1, 3, 4, 8, 12, 21, 22, 23, and 24. Varieties 8 and 12, both derived from crosses landrace x Rihane-03, were the most selected at all sites.

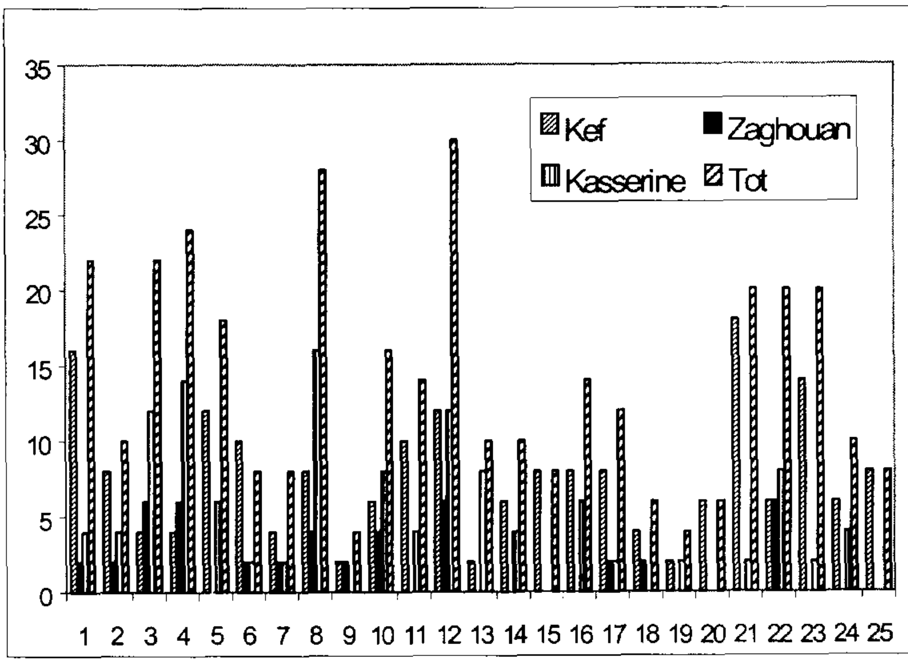

Figure 2.12. Frequency of selection of 25 varieties in the yield trial Elite 1 by farmers at three locations in Tunisia.

Table 2.93. List of participating farmer at Kef Gouvernorat: Survey and selection data

Farmer	Delegation	Farm Size(ha)	Major varieties and Reasons for choice	Seed Source	Uses	Selected Lines
Abdellah Ben Zarroug	Cité Bourguiba	200 ha	Rihane-03, Martin Available on market Grain Yield	Produced on farm	Grain, straw, grazing, silage	-R1: 1,2,3,12,21,23 -R2: 28,29,34,46,49,50 -R3: 51,54,59,63,68,69,72
Abdellah Ben Zarroug	Cité Bourguiba	200 ha	Rihane-03, Martin Grain Yield	Produced on farm	Grain straw, grazing, silage	-R1:6,8,14,24,25,34,37,38 -R2:48,51,52,54,58, -R3 63, 67
Mouldi Mohamed Ben Khmis	Garn El Halfaya	161 ha	Rihane-03 Available on market	Pproduced on farm Seed Org. (Office Cereales)	Grain straw	-R1:12,17,21,23,1,2,8,10 - R2:29,34,39,41,33,43,46,49,50
Rahaim Ben Amor Abdellah Maâoui	Garn El Halfaya	180 ha	Martin high yield, good adaptation	- Auto-produced Seed Org (Office Cereales)	Grain straw, grazing, silage	-49,47,46,43,41,39,34,33,32 -54,56,57,63,68,72 -39,36,27,17,15,6 -56,63,73,84,95
Mouilli Amor	Tejrouin	600 ha	Rihane-03 Grain yield, Good tillering	Seed Org (Office Cereales)	Grain, Straw, silage	-R1:12,17,21,23 - R2:26,28,29,40,39,44,47,50,5 1 -R1: 4,6,9,10,15,27,32,35, -R2: 48,51,52,54,58,60

Table 2.94. List of participating farmer at Zaghouan Gouvernorat: survey and selection data

Farmer	Delegation	Farm size (ha)	Major Varieties and Reasons for choice	Seed Source	Uses	Selected Lines
Ezzedine Ben Ghalba	Zaghouan	100 ha	Local, Rihane-03 Yield, adaptation	Self-produced Local seed dealer	Grain, straw	33,26,44,34
Ulfet Bouchoucha (Woman Farmer)	Bir M'cherga	400 ha	Martin Stress tolerant (salt, clay soil)	Self-produced	Grain, grazing	12,51,52,68,71
Habib Ben Chaâbane	Mograne	120 ha	Rihane-03, local (Arbi)	Self-produced	Grain, silage	26,28,31
Mohamed Ben Dhiaf	Oued El Khadra	150 ha	Rihane-03 by chance	Self-produced	Straw, grazing	4,3,12,10,17
Rejeb Rahaiem Ben Rejeb	Fahs	400 ha	Adaptation	Self-produced	Grain	4,3,9,8,18

Table 2.95. List of participating farmer at Kasserine Gouvernorat: survey and selection data

Farmer	Delegation (District)	Farm Size (ha)	Major Varieties and Reasons for choice	Seed Source	Uses	Selected Lines
Mokrani Abed El Majid	Thala	700 ha	Local Cultivar: tolerance to drought and cold, straw production	Self-produced Local seed dealer	Grain, straw, grazing, silage	R1: 8,10,3,4 R2: 28,31,33,44,45 R3: 69,66,57,56
Abderaouf Mokrani	Thala	400 ha	Martin, Rihane-03 : Yield, Local well adapted	Self-produced	Grain, grazing food	R1: 4,8,14,22 R2: 33,45,44 R3: 70,72
Brahim El Khelil	Foussana	19 ha	Local cultivar and Martin: Grain yield, straw	Self-produced	Grain, food and feed, straw, grazing	R1: 1,4,8,10,22,11 R2: 28,31,33,36,42,45,49 R3: 57,68,70,67,63,54
Mhadhbia El Khelil (Woman-Farmer)	Foussana	19 ha	Local cultivar and Tishedrett: Quality, straw	Self-production	Grain, feed, food, straw, grazing	R1:22,12,7,5,6,14,3 R2:45,34,33,32,29,28 R3:71,56,62,69,53,58

The lines in the Elite I yield trial were tested for grain yield over the past five years at different sites in the semi-arid regions of Tunisia (Table 2.96). Four lines were selected and multiplied for eventual registration. Among the four selected lines (Table 2.97), three were those selected by farmers (1,8,12) during the last cropping season (Table 2.98, Figure 2.13). The yield performance of these lines at Kef, Tejerouine, and Foussana is in most cases better than that of Rihane-03. As shown in Table 2.91, the selected lines originated from crosses involving landrace cultivars.

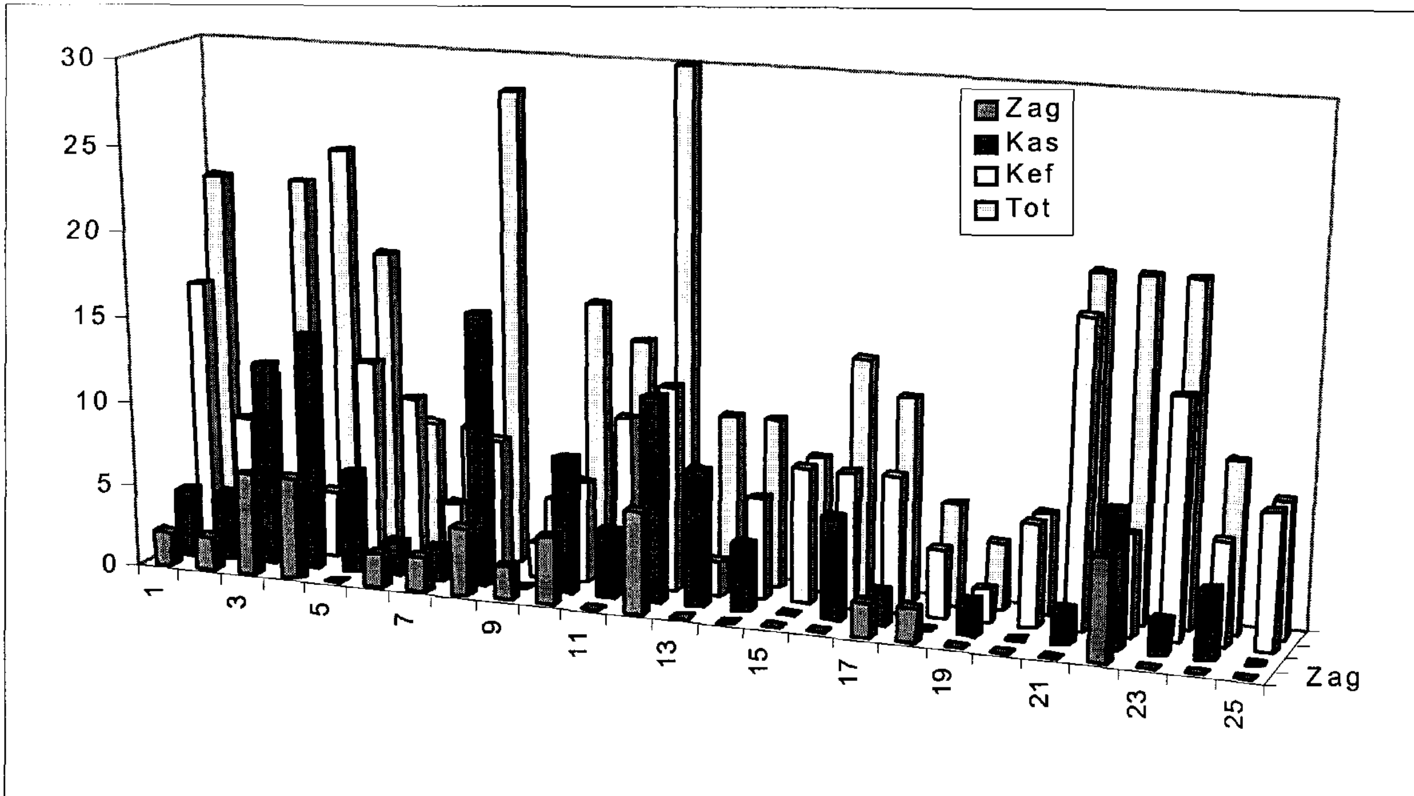

Figure 2.13. Frequency distribution of most selected varieties at each selection site.

Table 2.96. Rank of lines in the Elite 1 trial in three locations (Kef = Le Kef, Tej = Tejerouine, Fou = Foussana) in different years

Entry.Nr	Kef98	Kef96	Kef95	Kef94	Kef93	Tej98	Tej96	Tej95	Fou98	Fou96	Fou94
E.1-01	2	1	1	13	21	2	23	6	21	6	11
E.1-02	7	7	11	19	18	7	25	11	20	24	6
E.1-03	19	14	17	3	12	16	16	13	1	12	19
E.1-04	16	16	13	7	4	6	18	12	4	9	17
E.1-05	9	23	22	22	13	14	14	5	9	4	14
E.1-06	5	22	16	20	5	8	22	3	23	17	10
E.1-07	1	19	14	17	6	19	15	14	11	25	9
E.1-08	20	9	24	1	16	5	4	18	2	8	13
E.1-09	24	17	12	9	19	22	17	19	5	16	1
E.1-10	6	20	20	16	24	23	1	7	12	2	25
E.1-11	11	10	19	6	20	15	3	2	15	3	21
E.1-12	10	11	5	5	7	4	5	22	16	10	7
E.1-13	18	6	18	18	23	21	6	8	6	14	19
E.1-14	21	13	6	11	1	18	20	4	3	7	5
E.1-15	12	4	8	2	10	25	11	16	24	23	3
E.1-16	14	18	9	14	9	9	21	2	7	20	8
E.1-17	22	25	21	21	15	24	24	10	18	22	20
E.1-18	15	12	10	23	17	17	9	24	19	11	16
E.1-19	8	8	7	4	2	11	13	9	14	21	2
E.1-20	4	21	23	25	11	10	12	15	2	18	22
E.1-21	17	15	3	15	3	3	10	23	8	15	4
E.1-22	13	24	15	12	8	12	8	1	17	19	18
E.1-23	3	2	4	7	22	1	7	25	13	5	12
E.1-24	25	5	25	9	14	20	2	20	10	1	13
E.1-25	23	3	2	24	25	13	19	17	25	13	24

Table 2.97. Grain yield of four selected lines from the Elite 1 trial in El Kef (KEF), Tejerouine (TEJ) and Foussana (FOU).

Entry N.	KEF98	KEF96	KEF95	KEF94	TEJ98	TEJ96	TEJ95	FOU98	FOU96	FOU94
1	5.4	6.5	10.1	1.9	1.9	4.3	4.0	1.9	2.8	1.5
8	4.9	6.0	3.5	2.4	1.3	5.6	3.1	1.9	2.6	1.5
11	4.8	5.8	3.5	2.1	1.3	5.7	3.2	1.1	2.9	1.4
12	4.7	5.8	6.7	2.1	1.3	5.7	3.1	1.9	2.6	1.6
Rihane-03	3.7	6.6	7.4	2.1	0.9	5.5	2.1	2.0	3.0	1.5

(Yahyaoui (ESA Kef), A.Rezgui (ESA.Mograne))

2.5. East Africa and Yemen

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

2.5.1. Ethiopia

New areas of collaboration were discussed during 1998 with the Ethiopian barley breeders, namely

1. Evaluation in farmers' fields and with the participation of farmers of the accessions of Ethiopian barley landraces available at the Biodiversity Institute and never evaluated before. The project will be the first step to implement one component of the barley improvement strategy based on a continuous flow of germplasm from the Biodiversity Institute into the breeding program. Outputs from this projects include identification of superior landrace populations specifically adapted to the newly defined agroecological zones, understanding of farmers' preferences, and characterization of the germplasm available at the Biodiversity Institute

2. Development of barley germplasm for Tigray based on the use of local landraces as well as of landraces from Eritrea and Yemen. The project is based on the assumption that barley landraces of the three areas, all affected by drought stress, can be mutually beneficial when used in a program of recombination and selection in the target environment. The project will consist in distributing to the three countries segregating populations derived from crosses between the landraces of the three countries, grow them in farmers' fields and allow farmers to identify the superior populations, and multiply and distribute those populations through the informal seed systems.
3. Identification of genes for resistance to the major barley diseases within local landraces and use of these genes in the barley breeding program. Disease resistance is an important component in barley improvement under Ethiopian conditions. Scald and net blotch are some of the most devastating diseases in barley growing areas particularly at high altitude for scald, and during the rainy seasons for net blotch. The heterogeneity in landrace cultivars for adaptation and other phenological traits should be exploited for disease tolerance. Low level of resistance to foliar diseases is often associated with landrace cultivars. Accumulating this type of resistance in a population using different approaches would improve the productivity of the populations under high biotic stresses. The project will pursue the development of broad base resistance in a population by a) pyramiding resistance factors (particularly those of dominant effects) by direct intercrossing of populations and testing the segregating populations at farmers fields, and b) participating with farmers in doing negative selection (simply eliminating very susceptible plants) and allowing breeders and farmers to select (bulk)

their desired types. The project will also initiate the use of genetic male sterility as a bridge for recombination between populations or selected genotypes. The procedure would be as working on cross-pollinated crops thus handling the population as a whole using alternate cycles of recombination and selection.

During 1998 we also contributed to the development of a new national barley strategy which is essentially based on specific adaptation to seven different agroecological zones and will address both food and malting barley.

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

2.5.2. Eritrea

During 1998, in collaboration with Eritrean scientists, we revised the five-year barley breeding program developed in 1997 and we updated the research program for a MSc student conducting his thesis on "Genetic structure of barley landraces adapted to dryland agriculture" in Aleppo under the joint supervision of the ICARDA barley breeders and of the Royal Agricultural and Veterinary University of Copenhagen (KVL).

During 1998 we also started the evaluation of the barley landraces collected in September-October 1997. The collection consisted of 37 accessions representing 10 different landraces (Table 2.98). In each of 37 collection sites, 50 spikes were collected and about 1 kg of bulk seed.

In January 1998 half of the collection was planted in the research station of Halale, but it was severely damaged by locusts. The remnant seed was planted again in July and characterized for a number of traits. In Table 2.98 we only show the variation between population, which was large for all traits. Of particular interest is the large variation in phenology (more than three weeks difference in heading and maturity between the early Kulih,Kontsebe and Yeha, and the late Atena. With few exceptions, Eritrean landraces are characterized by very large seeds, probably a consequence of the visual selection practiced by farmers for this character.

Those lines for which enough seed is available will be tested in farmer's fields during the next cropping season.

(Yoel Tewelde Mesghenna)

2.5.3. Yemen

The major development in Yemen was the preparation of a special project on "Village-based participatory breeding in the terraced mountain slopes of Yemen". The project will develop and implement a novel breeding approach for crop improvement in Yemen. The null hypothesis to be tested is that a new breeding paradigm based on decentralized participatory selection for specific adaptation is not different from conventional, on station non-participatory plant breeding. The indicators that will be used are 1) the divergence of the selected material in the two approaches, 2) the increased demand and use by participating farmers of new germplasm, 3) the amount of biodiversity, 4) the skills of the farmers in manipulating biodiversity, 5) the use of PPB by the national program, and 6) the cost-effectiveness.

In this project ICARDA will collaborate with the Agricultural Research and Extension Authority (AREA) and with the farmer communities of three villages in the Kuhlan-Affar district in the Hajja province of Yemen.

The project will compare the efficiency of the selection done by farmers and by breeders, both in farmers' fields and in research stations, using both exotic and local germplasm of barley and lentil. In the farmers' fields the project will operate at village level, i.e. the experimental unit will not be the individual farm but the entire village. Three villages with related cropping patterns will be involved and the individual farmers operating the selection will be chosen by the farmer community. The AREA breeders of the two crops included in the project will also conduct the selection in the three villages. The same genetic material planted in the three villages will also be planted in the research station at Al-Erra were the breeders usually conduct selection in the first stages of the breeding programs of barley and lentil.

Farmers will also conduct selection in the research station at the appropriate stage of crop development. During selection (both in the villages and in the research station) the selection criteria of both the farmers and the breeders will be recorded by the sociologists and anthropologists, and compared with objective measures of traits, including the yield and the quality of the grain and (when appropriate) of the straw. The genetic material selected during the first year by the breeder and by the farmers, both in the villages and in the research station will be tested during the second year both in the village in which was selected and in the research station responsible for that crop. The details of the second year activities, the issue of the seed multiplication of the entries selected by farmers, as well as the distribution of seed to non-participating farmers will be decided in consultation with the farmers' communities based on the acquired knowledge of seed exchange mechanisms and will depend on the outcome of the first year activities. Also, the project will look at opportunities to interact with the newly established 'Seed and Agricultural Services" project.

(A. Lutf, S. Ceccarelli)

Table 2.98. Characteristics of Eritrean barley landraces

Landrace	n	Early Vigor	Days to heading	Days to maturity	Grain filling duration	Plant height	Kernel /spike	1000 kw	Yield (g/plot)	Seed color[a]
Abat	173	3.82	62.4	103.1	40.7	89.2	23.9	54.1	148.0	W/B
Abederay	41	3.49	62.6	106.7	44.1	87.8	25.0	55.4	150.0	W
Atena	37	4.30	95.9	127.4	31.5	85.6	26.8	42.9	21.3	W/B
Atsa	47	3.81	66.5	107.6	41.0	85.8	24.9	56.7	146.0	W
Demhay	82	3.45	72.8	108.5	35.8	94.7	25.8	43.9	107.0	W/P
Kontsebe /Seraye	32	3.16	63.3	103.5	40.2	75.3	25.3	53.8	111.0	W
Kontsebe	49	3.04	63.2	102.9	39.7	82.5	25.6	55.7	124.0	W
Kulih	165	3.19	62.6	102.5	39.9	85.6	25.3	53.9	126.0	W/B
Qunto/ Gunaza	73	3.34	81.6	120.1	38.5	87.2	-	-	-	W/B
Quonto	23	3.74	73.7	113.1	39.4	87.4	-	41.5	165.0	W
Tselimo	79	3.28	79.0	113.3	34.3	91.5	25.7	54.3	100.0	B/W
Yeha	141	3.33	64.5	103.8	39.3	85.1	25.9	55.8	114.0	W/B

[a] W=white, B=black, P=purple (the first letter indicates the predominant color

2.6. Central Asia and Caucasus

During the First Coordination Meeting ICARDA/Central Asia in September 1997 some sets of winter and spring barley nurseries have been delivered to the participants and the results of their testing have been obtained from Uzbekistan, Kirgyzstan, and Kazakhstan. This is the first information about the region, and it is very important to undertake the attempt on agro-climatic characterization of the environments and to make the first analysis of what kind of germplasm is needed.

2.6.1. Uzbekistan

The main research establishment for barley breeding in the dry areas of Uzbekistan is the Uzbeck Research Institute of Grain in Galla Aral. The history of the institute started from 1913 after establishing the Zarafshan Research Station in Katta-Kurgan. On the base of the station the Middle Asian Research Station was founded, and in 1957 the Uzbeck Research Institute of Grain was set up. The Institute has 15 laboratories, dealing with cereal and legume crops breeding, development of advanced technologies in dry environments, grain quality evaluation and other issues, related to the grain production and processing. The breeders have succeeded in developing the following varieties of winter barley: Oykar, Zafar, Honakoh, Movlono (six row), and Unumly arpa, Nutans 799, Bolgoly, Gulnoz (two row). The assessment of the new varieties and the preliminary multiplication of the best are carried out in Djizzakh, Samarkand, Navoi, and Kashkadarya testing stations. For seed production and dissemination among private and leaseholder agro-firms there are five experimental farms, belonging to the Institute and located in different zones of the country. They produce annually about 12-15 000 tones of elite seeds of different crops, mainly winter wheat.

The Uzbeck agriculture, which in the past was concentrated on cotton production, thus suffering all the disadvantages of monoculture, is currently trying to resolve the urgent task to reach food independence by increasing wheat production. About a million hectares under irrigation and 400000 ha in rainfed conditions are planned to be sown with the most adapted varieties. Barley now occupies about 100000 ha under irrigation and 200000 ha in rainfed conditions, and there is a tendency to increase the last one. The Institute in Galla-Aral is responsible for grain production in dry areas mostly in rainfed environments, where the average annual precipitation is 300-350 mm and less. Breeding activities for rainfed conditions have been carried out on barley since 1925 and the varieties mentioned above have been obtained. It was shown that well developed root system and long coleoptile are needed to meet the requirements of the local climate. The main yield limiting factors are drought and heat, cold in the foothill areas and low soil fertility (humus or organic matter content is 1.2%). Among the diseases, the most important are netblotch and smut. Sunny bug is the most important insect.

Many promising lines have been developed with the use of barley germplasm from Krasnodar (Russia). As an example, line K-100 with stiff straw and very dense six-row heads, is a parental line of the new released two-rowed variety Lalimikor. This is an evident example of transgressive segregation, a genetic phenomenon very often observed in crosses between geographically and morphologically distant parents. In irrigated conditions they still grow the Krasnodar variety Cyclon, released 15 years ago, although there are many new varieties, suitable for cultivation in more favorable conditions. Among the collection of the advanced varieties and lines from Krasnodar, the winter barley variety Michailo and the spring barley K-101 and Rubicon were the best. The fact that spring barleys varieties can survive during winter suggests that the environmental conditions in the Galla-Aral area are intermediate between Breda and Tel-Hadya. This is especially true in the case of drought, heat and low soil fertility. In spite of the intensive cultivation of winter type cereal crops, there is the expectation that the most suitable varieties for the rainfed environments of the region would be spring or facultative types. Therefore, the plans of the further cooperation include the wide testing of ICARDA spring barley nurseries in the driest areas of the country.

In agreement with the national system of quarantine service, all incoming material must be tested in the quarantine nursery of Uzbeck Research Institute of Plant Industry. The academician N.I.Vavilov established the Institute in 1924. Now it is one of the largest research centers in Central Asia. The collection of the Institute contains 52000 samples of 120 different crops. This gene pool is of great potential value and will be widely used as a base to increase food production for the future generations. The main objectives of the Institute are collection of genetic resources of agricultural plants, quarantine service, description, storage, evaluation and distribution of materials to breeding centers, and introduction of new, non-traditional crops. The quarantine services control annually 2-3000 introduced accessions and after 2-3 years evaluation send the more suitable material (about 15 % of the initial volume) to breeders. More than 200 released varieties of cereals, legume, vegetable crops and fruit trees have been developed with the use of their material. At present about 50 varieties are widely grown in the country.

ICARDA winter/facultative barley observation nurseries were planted in 1 m^2 plots. The performance of varieties such as Tokak, Radical, Salmas was very close to that observed at ICARDA headquarters. From previous year's nurseries, 47 lines were identified, which out yielded the check variety Zafar by between 5 and 38%. The collaboration for 1999 season will include testing of the new material from different nurseries.

2.6.2. Kirgyzstan

The Kirgyz Research Institute of Agriculture is a leading scientific center for barley breeding. The released varieties are mainly locally developed.

The volume of the breeding nurseries consists in 42 winter and 32 spring barley lines in advanced trials, 83 lines in preliminary trials, and 270 lines in the check nursery. All is done in 3-5 replications, with checks every 4 plots. Last year during the first Coordination Meeting at ICARDA, some barley nurseries available at that time were handed over to the collaborators in order to start studying what kind of germplasm is more suitable to Kyrgyzstan. From IWFBCB-96 13 varieties have been selected for testing in yield trials and use in hybridization. In the 4th FBON-97 lines Mv-46/Mazurka, Alpha/Durra// Steptoe, Alpha/Durra//Nacta and Janus/Dundy proved to be promising. The last line, developed in Krasnodar, after evaluation at ICARDA, turned out to be neutral to photoperiod, and rather drought tolerant.

Promising material was found in the spring barley nursery ISBCB-97, from which 15 entries have been identified as source of desirable traits. In addition, entry 59 (Alger/Ceres), the early entry 143 (Kv//Alger/Ceres…), and the naked line BF 89M1 (entry 29 from Naked BON-97) were included in the crossing program as a demonstration of their suitability and high breeding value. These results are encouraging and suggest that further progress is possible by establishing a regular exchange of targeted material.

The efforts of the previous years have resulted in developing the two-rowed spring barley variety Taalay, recommended for rainfed areas of Central Asian Region due to its high drought tolerance, good growth vigor and resistance to major diseases. Jointly with Odessa Research Institute of Genetics and Plant Breeding, the new winter barley variety Ardak (Honor) was bred for irrigated conditions. The experimental farm of the Institute has 200 ha for the elite seed production of barley varieties.

2.6.3. Kazakhstan

This is the largest country in the region with huge territories and a great potential for cereal crop cultivation. The transition to market economy was accompanied by drastic changes in all sectors of agriculture with an acreage reduction for many crops. In 1990, there were 19 million ha under wheat and 7 million ha under barley. Now there are only 11 and 4 million ha of wheat and barley, respectively. The main reason for this decrease is the collapse of the administrative-command system of the former Soviet Union and the breakage of the previous links, regulating the exchange of grain products and industrial goods produced by other republics.

In this large country there are many Institutions and experimental stations dealing with research in agricultural production. For the barley improvement program contacts have been established with the Kazakh Research Institute of Grain (Shortandy, North Kazakhstan, the Kazakh Research Institute of Agriculture (Almaty area, South Kazakhstan), and the Krasniy Vodopad State Breeding Station (South Kazakhstan).

The Kazakh Research Institute of Agriculture, named by A. I. Baraev, is the leading center of Northern Kazakstan, where the main areas of spring barley are found, (about 3.5 million ha.). It is a flat steppe, covered with wild cereal grasses. Soils are chestnut and black with organic matter content of 2.8-3.5%. The average rainfall is 250-300 mm.

Local breeders have succeeded in developing varieties such as Tseliniy 30, Tseliniy 213, Tseliniy 93, Solontsoviy (salt tolerant) and Complexniy.

This season, entries from 10 different spring barley nurseries received from ICARDA were tested in 2 row plots 2.5 m long as a first step in the preliminary screening of the most suitable germplasm. In the early date of planting (May 8) some spring barley lines started heading in June 10, while the local varieties headed 15-20 days later. At the same time, there were 99 (25.4%) genotypes of winter type, which did not head in either dates of planting (May 8 and May 28). This fact justifies the preliminary screening of the new coming material in the small sized plots.

Among the 389 lines tested for the first time, there were many 97 (24.9%) late lines with high growth vigor, good tillering capacity, and drought tolerance especially in the first period of the vegetation. They received good or excellent agronomic scores. The local breeders recognized that ICARDA material carries a lot of successful combinations of trait useful to the national barley breeding program. Some lines have already been selected as candidates for hybridization to exploit transgressive segregation. When germplasm exchange will reach the continuity of other countries, the results will further improve.

The Kazakh Research Institute of Agriculture is responsible for cereal and legume breeding in the Southern areas of the country. The spring barley improvement program of the Institute covers forage and malting barley. The common volume is 20000 plots annually. In the yield trials they have 40 lines of malting barley and 50 lines of forage barley. All is done in three replications with a check variety every two plots. In other nurseries the check is planted every 4 plots.

The following locally developed varieties were released: Azyak, Sever-1, Saule, and Bota, which performed better than the old variety Baysheshek susceptible to lodging. The new spring barley variety Arna, released in 11 areas of Kazakhstan and neighboring countries, has become the most popular variety in the Region due to its excellent malting qualities.

This season was very atypical for the area. Instead of the average 300-400 mm, the amount of precipitation reached 650 mm. Favorable weather conditions favored a good grain size development (1000-kernel weight 40-50g). The spring barley lines Api/CM67//… and Moroc 9-75//WI2291/… had very attractive agronomic characteristics with 1000-kernel weight of 58.8 and 57.6 g, respectively.

In the ISBCB 1996-97 a group of early lines was identified, which headed 10-15 days earlier than the check variety Arna. For the improvement of grain quality, lines with large kernels can be useful. Among them the two-rowed lines Wum 143 (57.2g), Lignee 1242/Hml-02 (55.6g), ER/Apm//AC 253 (56.6g), WI21298//Er/Apm (57.2g) and the six-rowed lines Hma-03//M25/Attiki (52.0g), NK 1272/Moroc 9-75 (54.2g), Aths/Lignee 686 (52.8g), Rhn-03/Bda (50.0g), Aths/Rihane-03 (51.2g).

The area of Almaty was very mild in 1997/98, and even cold susceptible varieties like Salmas, had a survival rate of 70%. In general, the performance of Winter and Facultative Barley Observation Nurseries, Forage Barley Observation Nursery and Hulless Barley Observation Nursery was similar to Tel Hadya with the only difference in the dates of heading and maturity. Promising results have been obtained in IWBYT-98. The testing site Almalybak, near Almaty, turned out to be very similar to Tel-Hadya in crop establishment. The consistency of yield data was very high. Two six rowed lines, Baluchistan/Coungbar and 308/80M1, performed well and ranked among the best at Tel Hadya and Almaty. They possess increased cold tolerance and good plant architecture. Their testing will be continued on Krasniy Vodopad State Breeding Station.

The breeding station of Krasniy Vodopad was established in 1911. The station is responsible for research in the southern part of Kazakhstan. The winter barley varieties Bereke 54, Yuznokazakstan 45 and the spring barley Baysheshek have been bred and released for rainfed conditions.

Concerning the seed supply system in CAC countries, it is necessary to know that practically all cereal breeders breed for phenotypically stable varieties to meet the demands of farmers and seed producers. This is because farmers are interested only in pure varieties and because there is a very strict double control of elite standards. The representatives of the State Seed Control Committee visit frequently the elite producing farms and they can discard the whole fields or many tons of seeds if the standards are not met. Now there is a program of the double-haploid production through pollen culture of the most promising lines or nearly released varieties. In this way the high uniformity of both morphological and biochemical characters is expected to be reached very rapidly.

(V. Shevtsov)

2.7 Central and Latin America

Breeding for high yield potential and multiple disease resistance are the main objectives of the Central and Latin America Project. Barley germplasm developed by the Project has been widely accepted by NARS in Latin America and around the world. This year three new barley varieties have been released by NARS: Capuchona, a forage variety released in Mexico, and S500, and V06 in Yunnan, China. With the new varieties released in 1998, 18 countries have released 41 varieties derived from germplasm bred during the last 14 years by the joint ICARDA/CIMMYT Project.

2.7.1 Yield trials (CIANO Experiment Station)

During the 1997-98 winter, 1344 advanced barley lines were yield tested under irrigation at CIANO Experiment Station. Experimental lines were classified in four different groups: six and two-rowed, hull-less and early maturing barley (Table 2.99).

The yield trials were damaged by a windy rain damaged immediately after irrigation was applied. Plants that had reached anthesis were more prone to lodging. Severe lodging resulted in lower grain yield, as demonstrated by comparing the check Cabuya (7.3 t/ha) in lodged trials, with agronomy trials conducted by Dr. Ken Sayre using identical fertilization, sowing method (three-row beds) but sown in a different area and on a different date. In these trials lodging did not occur and Cabuya yielded 9.2 t/ha.

Four two-rowed lines and one six-rowed lines yielded 8 t/ha or higher (Table 2.99), while yield of early maturing and hull-less barley lines had relatively lower yields.

During the summer, the best high yielding lines were sown at El Batan Experiment Station for seed increase and Toluca Experiment Station for disease (scald) screening.

Table 2.99. Grain yield and leaf rust scores at CIANO Experiment Station during winter 1997-98 and BYD resistance at Toluca Experiment Station during the summer of 1998, for top ten advanced lines of two-and six-rowed barley.

Genotypes	Yield T/ha	Leaf rust	BYVD biotypes
TWO-ROWED			
ARUPO/K8755//MORA/3/ATAH92	8.2	60S	PAV-MAV
CANELA/AZAFRAN	8.2	TR	PAV-MAV
ANTARTICA/CANELA//AZAFRAN	8.0	100S	
ALPHA/DURRA//CORACLE/3/ALELI/4/MPYTI96.1Y/LAUREL//OLMO…	8.0	TR	PAV-MAV-RPV
TRIUMPH-/TYRA//ARUPO*2/ABN/3/CANELA	7.8	TR	PAV-MAV
MOLA/ALELI//MORA/3/CANELA	7.8	TR	
ATAH92/CANELA/4/ALPHA-BAR/DURRA//CORACLE/3/ALELI	7.7	80S	
CANELA/3/HEGE GS679.82/SHYRI//LAUREL/4/CERISE/SHYRI//ALELI	7.6	TR	
ASAHI 5/2*ALELI	7.6	TR	
SHYRI/ALELI	7.6	TR	PAV-MAV
SIX-ROWED			
GLORIA/COME//LIGNEE640/3/S.P/4/SLLO/5/SEN/6/CARDO/7/…	8.1	TR	
TOCTE/TOCTE//BERROS	7.7	TR	MAV
DC/SEN/3/AGAVE/YANALA//TUMBO/4/CEN/2*CALI92·	7.5	TR	PAV-MAV-RPV
DC/SEN/3/AGAVE/YANALA//TUMBO/4/CEN/2*CALI92	7.3	TR	PAV-MAV-RPV
GLORIA/COME//LIGNEE640/3/S.P/4/SLLO/5/SEN/6/CARDO/7/…	7.2	TR	
ABETO//GLORIA/COME/3/SEN/4/CEN/2*CALI92/5/LBIRAN/…	7.2	TR	
GLORIA/COPAL//BEN.4D/3/S.P/5/CEN/3/LBIRAN/UNA8271…	7.2	TR	PAV-MAV
LINAZA/JAZMIN/5/CEN/3/LBIRAN/UNA8271//GLORIA/COME/4/…	7.1	TR	
CEN-/3/LBIRAN/UNA8271//GLORIA/COME/4/SEN/5/TOCTE/6/…	7.1	TR	MAV
PUEBLA/CARDO//TOCTE	7.0	TR	

Due to unusually heavy rains, the seed from nurseries sown at El Batan was affected by sprouting. Good quality seed is required for international shipments and for that reason the nurseries will be sown again at Mexicali in northwest Mexico during the winter season.

Table 2.100 shows the results of grain protein analyses made in two different laboratories on 32 hull-less and hulled barley genotypes. High protein values were found in both the hull-less cultivar Petunia (16.5-18.8) and Gob96DH (15.9-18.1). Protein levels such as those of Petunia could enhance farmers' adoption of hull-less barley in areas where it is not cultivated. High protein barley is desirable in markets where barley is used as food and feed. The head scab resistant cultivar GobDH96 (not shown in Table 2.100) resulted from a project where scab resistance was transferred to a malting type. In this case high protein levels are a disadvantage because they are not acceptable to the malting industry.

Table 2.100. High and low grain protein of hull-less and hulled barley cultivars. Two laboratories tested grain samples harvested in the Yaqui Valley during 1997-98.

Genotype	CIMMY	Cajeme Union
Hull-less		
Escoba/3/Mola/Shyri/		
/Arupo*2/Jet/4/Aleli	12.8	14.6
Falcon	11.7	13.3
Petunia 2	13.6	15.5
Petunia 1	12.8	14.6
Petunia 1	16.5	18.8
Malting types		
Franklin/Azafran	11.1	13.9
Leo/Aleli//Azafran	11.1	13.9
B1//Mari//Coho/3/Gada/4/		
6*Grit/5/Aleli	11.1	13.9
ICARO	11.2	12.8
Leo/Aleli//Azafran	11.2	12.8

2.7.2. Summer nurseries (Toluca)

2.7.2.1. Barley yellow dwarf screening

During the summer of 1998, the 114 highest yielding advanced lines were screened for barley yellow dwarf using artificial inoculation with reared aphids in the greenhouse. Three virus biotypes (PAV, MAV and RPV) were inoculated independently in adjacent plots at Toluca Experiment Station. Each entry consisted of four plots, one of each was kept virus-free using several insecticide applications during the growing season. Yellowing, dwarfing and tillering were evaluated at the optimum growth stage and scores were compared to the check.

Twenty-six barley lines were found to have field tolerance (defined as low symptoms expression in the field) to PAV, MAV and RPV biotypes. Sixteen lines were tolerant to a combination of two biotypes and 22 were tolerant to only one biotype. Seed of genotypes showing field tolerance was further tested in the greenhouse using monoclonal antibodies (ELISA) to determine the virus titer in seedlings.

BYDV screening was done for four consecutive years. Last year's results showed that out of 64 BYDV field tolerant genotypes, only three lines (Tinctoria, Guayaba and Gramacote) had low ELISA titers for PAV and MAV and high titers for RPV. These lines were tolerant to the same biotypes in the field and are considered to be resistant (resistance is low symptoms expression plus low virus titers as determined by ELISA). Tolerance provides a good level of protection to the barley crop from damage by BYDV in farmers' field.

BYDV tolerant lines were sent to Colombia, Ecuador and Tunisia, where the disease is a serious problem. At Sta. Catalina Experiment Station in Ecuador, a few entries were tolerant to BYDV with good adaptation to the station's acid soils. Selected lines were sown at the Chuquipata Experiment Station in southern Ecuador for seed increase.

During the past four growing cycles, BYD tolerant lines were crossed with barley lines resistant to other diseases, with the aim of introducing an adequate level of BYDV resistance into hull-less and hulled germplasm.

(H. Vivar, M. Henry)

2.7.2.2. Head scab screening (Toluca)

Field and greenhouse screening for *Fusarium graminearum* resistance was done in collaboration with Dr. Lucy Gilchrist.

Head scab (HS) in wheat and barley is a problem in the Southern Cone (Brazil and Uruguay), the Andean region (Ecuador and Colombia) and Mexico. The disease has become very important in the American continent. Since 1993, the large losses caused by the disease in small grains exceed the damage caused by any other disease recorded in the USA.

Breeding activities have expanded to match regional needs and those of China. Three areas of research were identified in breeding for HS:

a. development of two- and six-rowed HS resistant hull-less cultivars;
b. transfer of HS resistance genes from non-malting to malting quality two-rowed lines for NARs in the Southern Cone;
c. mapping HS resistant genes using molecular markers in doubled haploid lines derived from the cross Gobernadora/Azafran. The work is conducted in close cooperation with Dr. Pat Hayes (Oregon State University).

a. Development of HS resistant hull-less lines

Resistance to head scab is present in the two-rowed gene pool and only occasionally found in a six-rowed background. Only one six-rowed resistant source (Chevron) is known so far. For this reason development of HS resistant six-rowed barley has proved to be more difficult.

In the summer of 1998, 32 six-rowed, hull-less F_3 and F_4 lines from crosses having Chevron as a parent were field screened for HS resistance (Types I and II) at the Toluca Experiment Station. Only nine lines were identified to be resistant to HS. These lines will be increased during the winter cycle at the CIANO Experiment Station under fusarium-free conditions and will be tested as F_5 and F_6 in 1999.

In addition, one advanced six-rowed hull-less line from the cross Chamico/Tocte//Congona was found to be HS resistant. Before the screening test, the line had been selected during the last two years for its excellent grain site, when sown at the Toluca Experiment Station, characterized for its high precipitation, conducive to fusarium epidemics. Since both Tocte and Congona are HS susceptible, the implication is that the other parent (Chamico) provided the resistance. Evidence gathered this summer during grain selection in crosses involving susceptible cultivars with Chamico seems to confirm this hypothesis. Nonetheless, further and careful screening is needed to confirm Chamico's resistance.

With the development of six-rowed, HS resistant hull-less barley, the aim is to increase the yield potential of naked barley. In general, six-rowed cultivars tend to produce more grain than two-rowed barley. Petunia, a six-rowed hull-less barley, has produced 8.3 t/ha under irrigation, compared to 7.3 t/ha by the best two-rowed line, Atahualpa/Canela. However, despite its high yield, Petunia will not be acceptable in fusarium-prone areas.

Breeding for HS resistance in two-rowed hull-less barley is more advanced than in six-rowed barley. The aim is to cross different sources of resistance among themselves to upgrade the level of HS resistance. Several F_3 lines, having three different HS resistant sources (Tocte/Gobernadora//Humai/3/Atahualpa/Aleli) out of five parents involved in the cross, were screened for their HS resistance. It is too early to know whether the level of resistance found in those lines will be superior to that observed in their parents.

Grain harvested from inoculated plots was compared to grain harvested from plots kept fusarium-free by several fungicide applications during the growing season. After grading the grain, only the best 30 lines were sent for toxin evaluation to the USDA laboratory in Peoria, IL, USA.

b. Transfer of HS resistance genes

The Latin American Barley Network (RECLA) at a meeting in Chile suggested continuing the transfer of resistance genes from the variety Gobernadora into germplasm with good malting quality. This work was planned in three steps. The first was the development of doubled haploid lines from the cross Gobernadora/Azafran(=Shyri/Gloria//Copal/3/Shyri/Grit). The lines were extensively field screened for HS resistance in Mexico, China and USA. Furthermore, phenotypic data collected served for mapping the HS resistance (Types I, II and III) with molecular markers. The second step was to cross resistant doubled haploids (96 and 24) with three malting cultivars from U.S.A., Uruguay and Brazil. A new doubled haploid set was produced in cooperation with Oregon State University and evaluated in the greenhouse for HS resistance (Types I and II) at El Batan during the summer of 1998. The third step consisted in crossing between HS resistant doubled haploids obtained from step 2 and both Aquario, a malting variety from Chile, and Logan from the USA. These crosses will be made next year at CIANO Experiment Station. The single seed descent method will be used for rapid generation advance.

The close linkage between HS resistance and a morphological marker (lateral florets) mentioned in a previous report was confirmed by molecular markers. Both genes are located in the centromeric region of chromosome 2. Indirect selection for head scab in breeding two-rowed barley (will not work in six-rowed barley) using a morphological trait shows big promise for NARS that cannot afford expensive fusarium and toxin testing. Selection among segregating populations for plants lacking lateral florets was implemented two years ago, apparently with great success, as judged by the excellent grain quality of the Toluca harvest, where 1200 mm of rain was measured for the five months (June-October) that the crop remained in the ground during 1998.

2.7.3 NARS cooperation

In Patzcuaro, in the Mexican state of Michoacan, Rebeca Gonzalez of INIFAP (National research organization) identified and is increasing seed of a barley line with excellent HS resistance. The line Arupo/K8755//Mora is being tested for a second year and is showing good adaptation to the area. The same line was reported producing 11 t/ha yield in Chile.

A farmer near Toluca planted the new Mexican variety Capuchona in a 5-ha field. Sheep and cattle starting grazing 40 days after planting, on strips set off using an electric fence that was easy to move every day. Early grazing allowed a second planting of the variety, regardless of the short growing season that in the past has permitted only one crop per year. Capuchona is the first forage barley variety released in Mexico, and is rapidly expanding to other Mexican states such as Chihuahua and Aguas Calientes.

Hull-less barley was sown in the Mexican state of Jalisco, where there is increased interest for this novel crop as hog feed. A short visit to Jalisco showed that several lines are well adapted to the region. During November three hull-less barleys will be planted in the Yaqui Valley for demonstration to hog producers in Sonora, who are looking to adopt a new crop that might require less irrigation than wheat.

In the Nariño Department in southern Colombia, two hull-less barley lines are in the final stage of testing for adaptation. Farmers growing peas on 9000 ha in the region are looking into hull-less barley as a new crop for rotation with the legume according to Luis Campuzano from CORPOICA (Colombia's NARS). Luis was part of a group that visited Ecuador during the summer to observe large scale hull-less barley cultivation.

(H. Vivar)

2.8. Aknowledgements

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

OPEC Funds for International Development
The Government of Italy
The Government of the Netherlands
The Government of Denmark
Der Bundesminister für Wirtschaftliche Zusammenarbeit (BMZ)
The International Development Research Centre (IDRC)
The United States Agency for International Development (USAID)
The System Wide Program on Participatory Research and Gender Analysis (SWP PRGA)

The financial support of these donors is gratefully acknowledged.

3. DURUM WHEAT IMPROVEMENT

3.1. Durum Breeding

In 1997/98 season, the CIMMYT/ICARDA durum program for the Mediterranean dryland region emphasized on upgrading and broadening the genetic base for abiotic stress tolerance (drought, cold, heat, and terminal stress). As for the biotic stress resistance, leaf rust and Hessian fly were given high priority; and for quality traits, gluten strength and yellow pigment. Further, the development of genetic stocks of resistance to multiple abiotic and biotic stresses was also given high priority in the program.

3.1.1. Widening the Genetic Base

To broaden the genetic base of durum, crosses were made with landraces from the Mediterranean region, in order to enhance adaptation to Mediterranean drylands, improve resistance to boron toxicity and root rots; and improve grain quality and yield potential.

The durum x wild relatives hybridization program continues also in the 1997/98 to show promising results for resistance to biotic and abiotic stresses, particularly to drought and heat stress, leaf rust, and Hessian fly. In the 1998 season, the selection percentage made from crosses/ populations derived from durum x wild relatives was as follows: *T. dicoccoides* (49%), *A. kotschii* (7.9%), *T. monococum*/urartu(11%), *A. peregrinacylindros* (27%), *A. vavilovii* (5.9%), *T. carthlicum* (4%), *A. biuncialis* (1%), *T. ovata* (1%), *T. compactum* (1%), *A. umbellulata* (0.2%), and *A. columnaris* (1%).

3.1.2. Biotic Stress Resistance

Genetic stocks from different countries of WANA were used in the crossing program to upgrade the resistance in the drought and cold resistant genotypes. The most common landraces from Algeria, Morocco, Tunisia, Syria, and Turkey are used as a parents to generate mapping populations for basic genetic and physiological studies.

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

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

In the case of the resistance to sawfly, required in the Continental Dry Areas of WANA, the genotypes which were identified last season with a high level of resistance (Awalbit, Rufom, Awalbit-6, Omsnima, Bicre, Marrout, D-2/Bit, IC19939-MAR-Landrace, IC16143-MAR-landrace, Rufom-4) were used in the breeding program.

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

Disease	Year	Average	Min.	Max.
Yellow rust (ACI)*	1994	4.1	0.2	44.0
	1995	3.7	0.2	55.0
	1996	8.9	1.5	32.0
	1997	7.5	0.1	34.0
	1998	8.4	0.0	44.0
Common bunt (%)	1994	25.6	1.4	66.2
	1995	45.3	23.1	97.5
	1996	20.5	0.0	65.1
	1997	19.5	0.0	60.7
	1998	39.3	0.0	95.6

* ACI = Average Coefficient of Infection.

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Table 3.2. Reaction of advanced durum lines to Leaf rust and *Septoria tritici*.

Disease Reaction		Average (ACI)	Min.	Max.
Leaf rust (ACI)*	1993/94	25.2	1.5	48.3
	1994/95	20.1	0.4	55.7
	1995/96	23.2	0.7	43.7
	1996/97	18.9	0.3	38.9
	1997/98	18.8	0.0	59.0
*Septoria tritici***	1993/94	3.7	2.0	6.5
	1994/95	3.4	1.5	8.5
	1995/96	7.3	3.0	8.0
	1996/97	7.0	3.0	8.2

* ACI = Average Coefficient of Infection.
** Septoria rating is on 1-9 scale (1=very resistant, 9=very susceptible).

As for the resistance to Hessian fly in the Temperate Dry Areas of WANA, the genetic resistance recently incorporated to durum, by using the resistance gene H5 to produce Telset lines, are now used extensively in the breeding program to incorprate this resistance to drought tolerant advanced genotypes.

Combining resistance to leaf rust been made, while for *Septoria tritici* the resistance is still lacking (Table 3.2). These sources of resistance are shown in Table 3.3. *Septoria tritici* usually is not a major constraint in the dry areas, however it is important in the high-rainfall areas of the temperate areas of the Ibero-Atlas region.

(M.M. Nachit, M. Azrak, A. Asbati, A. Yahyaoui)

3.1.2.1. Evaluation of durum wheat germplasm resistance to root and foot rot disease complex (*Fusarium culmorum* and *Cochliobolus sativus*)

Root and foot rot of durum caused by *Fusarium culmorum* and *Cochliobolus sativus* have been shown to be a serious problem in the Mediterranean temperate dry areas, especially in dry years. All cultivars and available germplasm of durum are in general susceptible to this disease complex. Since 1992, an evaluation programme of regional and world wheat germplasm has been conducted using both field and laboratory techniques to identify sources of tolerance to root and foot rot in durum wheat in cooperation with the national program in Morocco. Field results of dry seasons are encouraging since many sources of tolerance were identified. Among 1130 durum accessions tested, 140 entries showed moderate to good tolerance of the disease complex. However, only 28 were agronomically acceptable. Similar results were obtained from seedling evaluation under laboratory conditions.

(M.M. Nachit, M. Nasrallah, M. Mergoum)

Tabble 3.3. Sources of resistance to different diseases.

ADYT98	***SEPTORIA (less than 5 on a 1-9 scale)***	
614	Shwa/Stk//Bit/3/Kyp/4/Chah88	ICD92-0020-MABL-2AP-0TR-4AP-0AP
909	DF9-71/3/VZ466//61-130/414-44/4/Ergene	TE01061-23A-1A-1A-0A-0AP
1103	Chl/T.dic.-Sy20121//ICD77-185/3/CD20626	ICI86-W-0089-2AP-1AP-0AP
1209	Krf/T.monIC2165//Chah88	ICD92-0723-W-0AP-2AP-0TR-3AP-2AP-0AP
	COMMON BUNT (less than 8%)	
110	Mrb5/Mgr-4	ICD91-0828-AB-13AP-0AP-2AP-0AP
113	NN90E4-6(MOR)/Mrb3	ICD91-0310-AB-11AP-0AP-2AP-0AP
204	Ombit-1	ICD92-1006-CABL-0AP-8AP-0TR
321	Mrb3/Albit-1	ICD91-0394-C-0AP-1AP-0AP-4AP-0TR-3AP-0AP
413	Otb-5	ICD91-0811-AB-4AP-0AP-2AP-0AP
424	Albit-9	ICD84-0322-ABL-5AP-TR-AP-6AP-TR-2AP-0TR
804	Zna-4	ICD88-1233-ABL-8AP-0AP-6AP-0AP
	YELLOW RUST (ACI=0)	
108	Omgenil-3	ICD91-0400-AB-17AP-0AP-4AP-0AP
118	Mna-1/Rfm-7	ICD91-1251-AB-8AP-0AP-11AP-0AP
121	Mrb3/Mna-1	ICD91-0760-AB-14AP-0AP-4AP-0AP
212	Rec.S.P.(M.E)	R.S.P(M.E)-93-4AP-0AP-1AP-0TR
219	Lahn//Gs/Stk/3/Gil-3	ICD92-0091-CABL-0AP-21AP-0TR-14AP-0AP
310	Terbol97-4	ICD92-0150-CABL-8AP-0AP-1AP-0TR-5AP-0AP
417	Zna-7	ICD88-1233-ABL-8AP-0AP-4AP-0AP
521	LLOYD/Kia//Chl	ICD91-0109-MABL-0AP-3AP-0AP-4AP-0TR
621	20123 (Mor)/Mrb5//Stj4	ICD92-0534-MABL-6AP-0TR-14AP-0AP
	LEAF RUST (ACI less than 2)	
121	Mrb3/Mna-1	ICD91-0760-AB-14AP-0AP-4AP-0AP
212	Rec.S.P.(M.E)	R.S.P(M.E)-93-4AP-0AP-1AP-0TR
221	Bcr//Fg/Snipe/3/GdoVZ578/Swan//Dra2	ICD92-0175-CABL-0AP-5AP-0TR-2AP-0AP
314	Bcr/3/Chl//Gta/Stk/4/Bcr/Lks4	ICD92-0150-CABL-11AP-0AP-8AP-0TR-1AP-0AP
406	Bcrch-1	ICD87-0459-0TR-ABL-9AP-0TR-4AP-0AP
503	Bcr/Lks4	ICD87-0108-ABL-15AP-0TR-3AP-0AP
518	Altar84/Stn//Lahn	ICD92-MABL-0237-5AP-0AP-4AP-0TR
609	Ossl-1/Gdfl	ICD92-0940-CABL-0AP-5AP-0TR
615	Ch5/20048 Traikia(Mor)//Stj3	ICD92-0509-MABL-2AP-0TR-6AP-0AP
705	20048 Traikia(Mor)/Mrb5//Stj3	ICD92-0511-MABL-0AP-16AP-0TR-9AP-0AP
806	Otb-2	ICD91-0811-AB-3AP-0AP-4AP-0AP

3.1.2.2. Introgression of Hessian fly resistance into durum wheat in Morocco

Hessian fly (*Mayetiola destructor*, Say) is a perennial scourge of cereal production in the Mediterranean region, particularly in North Africa. In Morocco, it accounts for considerable yield losses of wheat (*Triticum spp.*), especially in the semi-arid southwestern coastal provinces. Yield losses are estimated at 36% on average in Morocco but Hessian fly infestation may result in total crop failure. Genetic resistance to Hessian fly has not been found in durum wheat although thousands of durum accessions were screened. Since 1988, crosses with resistant bread wheat and other related species have resulted in the introgression of Hessian fly resistance into durum. Resistant durum wheat lines originating from single crosses are being proposed for release in Morocco.

Genetic resistance has proven to be the most efficient means of control of this pest. Ten named genes for resistance have been identified to be effective in bread wheat in Morocco. The mechanism of resistance in these wheat genes is antibiosis. Genes located on the A genome were transferred from bread to durum wheat. Moreover, new sources of resistance were identified in wild relatives. These sources can be transferred into durum wheat.

In collaboration with the Moroccan durum breeding program and USA, durum resistance to insects pests in Morocco was studied. The mechanism of resistance in these wheat genes is antibiosis. The first durum line resistant to Hessian fly has been identified. To diversify sources of resistance for Hessian fly, wild relatives of wheat, such as *Aegilops ovata* (UM), *Ae. Quarrosa* (D), and *Ae. Triuncialis* (UC) were studied. Since few sources of resistance to Hessian fly in durum are available, we transferred the H5 gene located on the A genome from bread wheat to durum.

When 347 accession of *Aegilops* species were screened in the greenhouse for resistance to Hessian fly, several accessions of *Ae. Geniculata* Roth, *Ae. triuncialis* L., *Ae. neglecta* Req.ex Bertol., *Ae. ventricosa* Tausch, *Ae. cylindrica* Host and *Ae. markgrafii* (Greuter) Hammer showed a resistant reaction. All expressed antibiosis as the mechanism of resistance against first instar Hessian fly larvae. These *Aegilops* sources of resistance could be exploited for transferring Hessian fly resistance to wheat.

(M.M. Nachit, N. Nasrellah and A. Amri, S. Lhaloui, M. El-Bouhssini, J. Ryan, M. Abdel Monem, J.P. Shroyer)

3.1.3. Grain Quality

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

Table 3.4 shows the traits of the grain quality for the Advanced Durum Yield Trials for Continental Areas (ADYT) of 1997/98. The highest values for protein content and sedimentation test (SDS) were achieved under Breda and Tel Hadya Late Planting conditions and the lowest under Tel Hadya Rainfed conditions (330 mm). Breda (270 mm) and Late Planting rainfed conditions have also showed relatively high values for grain quality traits. The largest range for quality traits was also found in this season at Tel Hadya. Therefore, the rainfed conditions are best to use in the future as selection site for grain quality. The best genotypes with improved grain quality traits are shown in Table 3.5. For gluten strength test, methods based on biochemical analysis have been developed and are now used as a routine tool. Poly-acrylamide gel electrophoresis methods are used for gliadins (A-PAGE) and for glutenins (SDS-PAGE) analyses. The glutenins with low molecular weight (LMW) are two types: the subunit type 1 (LMW1) is usually associated with poor gluten strength and the subunit type 2 (LMW2) with strong gluten strength.

Within the collaboration with University of Cordoba/ Spain, testing for grain quality under dry (Tel Hadya Rainfed, 330 mm) and wet (Tel Hadya Irrigated: 30 mmm + 100 mm: 50 mm at tillering stage and 50 mm at anthesis) conditions shows the following results: the quality traits tested in 151 recominant inbred lines of Korifla/T. dicoccoides//Korifla are Sulfate dodecyl Sedimentation test (SDS), Protein Content (PRT), Thousand Kernel Weight (TKW), Vitreousness of 100 Kernel Count (VKC), Yellow Pigment (YPGT), Ash Content (Ash). Tests were analyzed using NIRS equipment and for protein content, SDS, and yellow pigment chemical analyses were made.

The highest protein content mean (%) was achieved in the dryland environment (17.1%) and the lowest in supplementary irrigated (15.47%). For the Sulfate Dodecyl Sedimentation test (SDS), the highest sedimentation mean value was 43.95 ml in dryland.

For the thousand kernel weight, the highest means was achieved in the supplementary irrigated environment. Yellow pigment trait shows also an interesting large range especially in the dryland environment (from 3.7 to 11.1 ppm) with a mean of 7.9 ppm.

Table 3.4. Minimum, maximum, and mean of some quality traits for ADYT in Mediterranean severe (Breda) and moderate (Tel Hadya Rainfed) dry conditions, 1997/98.

Rainfed-Tel Hadya

	PRT %	SDS ml	SDSI	SDSN	VKC%	YPGT ppm	TKW gr	Ash%
Mean	12.47	20.07	1.61	2.52	87.59	5.83	36.07	1.67
Std	0.99	6.26	0.47	0.89	7.66	1.23	4.28	0.07
Max	16.48	39.00	3.07	5.76	98.50	8.53	46.50	1.88
Min	10.37	7.00	0.61	0.80	45.00	2.62	21.40	1.48

Breda

	PRT %	SDS ml	SDSI	SDSN	VKC%	YPGT ppm	TKW gr	Ash%
Mean	15.70	36.68	2.34	5.78	99.14	5.52	32.78	1.71
Std	0.98	3.53	0.17	0.85	0.90	1.18	3.31	0.06
Max	18.24	45.73	2.77	8.34	100.00	8.40	41.90	1.96
Min	13.34	27.68	1.77	3.77	94.00	2.15	24.65	1.51

Late planting
Tel Hadya

	PRT %	SDS ml	SDSI	SDSN	VKC%	YPGT ppm	TKW gr	Ash%
Mean	16.86	39.53	2.34	6.68	97.19	6.50	31.17	2.00
Std	0.74	3.50	0.16	0.81	1.72	1.06	2.87	0.08
Max	18.56	50.81	2.86	9.38	100.00	9.34	39.15	2.22
Min	15.34	28.53	1.82	4.46	85.00	3.56	24.15	1.80

Protein Content (PRT), Sulfate dodecyl Sedimentation test (SDS), SDSI and SDSN indices, Thousand Kernel Weight (TKW), Vitreousness of 100 Kernel Count (VKC), Yellow Pigment (YPGT), Ash Content (Ash).

Table 3.5. Pooled means for durum genotypes with the best grain quality, ADYT 1997/98, according to 1)SDSN, 2)Pigment, 3)TKW.

No.	Entry	PRT %	SDS ml	SDSI	SDSN	VKC%	YPGT ppm	TKW gr	Ash %
108	Omgenil-3	16.0	39	2.4	6.3	97.7	5.5	30.9	1.8
110	Mrb5/Mgr-4	16.4	37	2.3	6.2	97.8	7.2	32.2	1.9
112	Gdfl/Gro 1	15.5	35	2.3	5.6	97.7	5.4	36.3	1.8
117	Otb4	16.3	39	2.4	6.3	97.2	6.6	40.0	1.8
309	Wdz-2/Stj-2	14.9	38	2.6	5.8	94.5	6.0	33.6	1.8
317	Rec.S.P.(M.E)	16.0	35	2.2	5.7	96.8	5.7	34.0	1.8
318	Rec.S.P.(M.E)	16.7	34	2.0	5.8	96.7	6.5	31.3	1.8
415	Shihani/Brch	15.4	34	2.2	5.4	96.8	6.7	30.4	1.8
708	D 681/PT-D13 Tess 83//Cr/Albe/3/Gil4	15.5	37	2.4	5.8	96.5	4.8	32.1	1.8
715	LLOYD/Kia//Chl	16.6	39	2.4	6.5	96.0	6.8	25.6	1.9

Protein Content (PRT), Sulfate dodecyl Sedimentation test (SDS), SDSI and SDSN indices, Thousand Kernel Weight (TKW), Vitreousness of 100 Kernel Count (VKC), Yellow Pigment (YPGT), Ash Content (Ash).

The ash content was also measured, the lowest mean value was achieved in the supplementary irrigation about 1.74% and the highest about 1.81% in the dryland environment.The results of this work shows the possibility of the introgression of additional sources/ genes for protein content to durum from T. dicoccoides.

The correlation coefficients (Table 3.6) among subunits of gliadins and glutenins show two major groups, the low molecular weight group 1 (LMWgs1) and group 2 (LMWgs2). The LMWgs1 group comprises LMW1, Gamma-a (relative mobility = 44), Omega-b (relative mobility = 39), Alpha-a (relative mobility = 85. Whereas the group LMWgs2 comprises LMW2; Gamma gliadin 45; and Alpha gliadin 6 (relative mobility = 83). LMWgs1, Gamma-a; Alpha-a; and Omega-b are originated from *T. dicoccoides*. As for the LMWgs2 group, all subunits are originated from durum cultivar Korifla. All these subunits were found be associated with gluten strength, represented by SDS. The LMWgs1 group was associated negatively with gluten strength, whereas the LMWgs2 group positively.

The SDS values in all environments associated positively with the presence of LMW2, gamma 45, and Alpha-6; and negatively with the presence of LMW1, Gamma-a, Omega-b, and Alpha-a. These results show that three new subunits (Alpha6, Alpha-a, and Omega-b) are significantly associated with gluten strength with a positive effect of Alpha-6 and negative one with Alpha-a and Omega-b. As for protein content, in both dryland and supplementary conditions, a positive effect with the presence of Omega-a (introgressed to durum from T.dicoccoides) on protein content was detected. However, no association between this subunit (Omega-a) and protein content was found in dryland. This might be explained by the fact that protein content was relatively higher in this environment (17.6%).

Table 3.6. Kendall Tau-b correlation coefficient among polymorphic gliadins and glutenins subunits.

Subunit	Omega-a	Omega-28	Omega-b	Gamma-a	Gamma-45	Alpha-6	Alpha-a	LMW1	LMW2
Omega-a	1.0								
Omega-28	0.366	1.0							
Omega-b	0.112	0.114	1.0						
Gamma-a	0.097	0.114	0.947a	1.0					
Gamma-45	-0.127	-0.14	-0.921a	-0.948a	1.0				
Alpha-6	-0.12	-0.127	-0.987a	-0.934a	0.907c	1.0			
Alpha-a	0.12	0.127	0.987a	0.934a	-0.907c	-1	1.0		
LMW1	0.105	0.127	0.934a	0.987a	-0.961a	-0.921a	0.921a	1.0	
LMW2	-0.12	-0.153	-0.934a	-0.961a	0.987a	0.92a	-0.92a	-0.974a	1.0

The a and c = significance level at 99.9 and 95% respectively.

Further, Omega-a showed negative association with kernel weight. However several recombinants with subunit Omega-a combining high values for protein content with acceptable kernel weight values (approaching those of the durum cultivar Korifla) were identified.

The introgression of subunits from *T. dicoccoides* did not show any contribution to the improvement of gluten strength. The combination of the processing quality from durum with the nutritional protein quality from *T. dicoccoides* would help the durum breeding programs to develop cultivars with both traits. The results of recombining gluten strength, high protein content, and kernel weight are promising and provide undoubtedly the basis to improve durum quality.

(M.M. Nachit, I. Elouafi, A. El Saleh, A. Martin, L. M. Martin)

3.1.3.2. Use of *Triticum dococcoides* to Improve Grain Quality in Durum Wheat

Wild emmer has a higher grain protein content than cultivated durum wheat (*Triticum turgidum* L. subsp. *durum* Desf.) Husn.) From crosses between durum x *Triticum turgidum subsp. dicoccoides*, recombinant lines were identified with high protein content, high grain yield, and other desirable traits. The F_6 lines from crosses between durum (Haurani Nawawi, Stork) and *T. dicoccoides* JS were studied, The recombinant lines were grown in two environments. The quality traits measured were grain protein content (%), carotene content (ppm), sedimentation (mL), 1,000 kernel weight (gr), vitreousness (%), and grain yield per plant (g). Significant differences for environmental means were observed for most traits. The recombinant lines showed higher protein content than durum x durum lines; similar results were detected for vitreousness and sedimentation. The results demonstrate that *T. dicoccoides* could be a good source to improve durum grain quality.

(M.M. Nachit, S.H. Maali, M. Duwayri)

3.1.3.3. Use of PCR-analysis in Durum Wheat to Screen for Quality Parameters

In collaboration with the University of Tuscia, specific primers for the PCR amplification of low molecular weight glutenins and gliadins, and high molecular weight glutenins were carried out. The amplified fragments for LMW glutenins varied and allowed classification of lines into the group carrying LMW-1 and LMW-2 genes. Amplified fragments for gliadins allowed the differentiation of genotypes with Υ-gliadin 42 and Υ-gliadin 45. No polymorphism was found for HMW glutenins. The advanced durum yield trials were analyzed; 244 lines amplified for the LMW-2 genes, and only 23 for LMW-1. Two hundred and sixty three lines from the same trial were analyzed for gamma gliadins. Two hundred and thirty five showed an amplified fragment indication a Υ-gliadin 45 type, and 28 a Υ-gliadin 42 type. Putative recombinants were identified. Comparison with SDS-PAGE must be carried out to confirm recombination.

As for Polymorphism for the High Molecular Weight (HMW) Glutenin subunits present in the Syrian durum wheat landrace Haurani. Variability for High Molecular Weight (HMW) glutenin subunits in the Syrian durum wheat landrace Haurani, originated from Hauran plateau, Southern Syria, was investigated using sodium dodecyl-sulphate-polyacrylamide *gel electrophoresis* (SDS-PAGE). Haurani is spread in the entire Middle East region with an excellent adaptability to different dryland conditions. A survey of several populations collected from different locations in Syria was conducted in terms of HMW glutenin subunits composition. Multiple allelic forms at the Glu-A1 and Glu-B1 loci located on the long arms of chromosomes 1A and 1B have been reported. The HMW glutenin subunits frequencies were also studied. Large variation for HMW glutenin subunits was detected.

(M.M. Nachit, A. El Saleh, A. Impiglia, E. Iacono, M. Pagnota, R. D'Ovidio, E. Porceddu')

3.1.3.4. Recent Applications of Near-infrared Spectroscopy to Evaluate Durum Grain Quality

NIRS can be successfully used to analyze several important quality parameters in durum germplasm. There are no significant differences in accuracy using whole durum grain or ground durum for the determination of protein content and SDS sedimentation volume. The whole grain technique requires only 20-25 g of grain, which allows early generation materials to be tested for protein content and SDS sedimentation without any grinding. Subsequently, the same samples can be planted. For yellow pigment content, more accurate results were obtained with ground durum wheat. Ground grain calibration can be used with as little as 2-5 g. The data suggest that use of a NIRS scanning monochromator with a visible wavelength range would improve the results of yellow pigment prediction. Finally, NIRS greatly improve the efficiency of screening durum wheat germplasm for quality. The reduction in the time required to analyze durum germplasm enables testing of about 250 samples per day for the three important parameters described. Using traditional wet chemical methods, testing of the same number of samples for the same parameters would required 16 working days.

(F. Jaby El Haramein, A. El Saleh, M.M. Nachit)

3.1.4. Abiotic stress resistance

In 1997/98 season at Breda, the highest yielding lines were those which combined cold with drought resistance. Several lines were identified which out-yielded Haurani under dryland by almost one ton per hectare (Table 3.7). These results show the continuous progress made during the last decade to improve productivity in dryland.

Table 3.7. Performance (kg/ha) of Durum at Breda during the last 12 years, compared with the check Haurani.

Season	Rainfall (mm)	ADYT Entries Mean	ADYT Entries Max.	Haurani
1985/86	218	1224	1697	1014
1986/87	245	1127	2500	1066
1987/88	408	3608	4372	3066
1988/89	186	758	1237	503
1989/90	179	494	1420	695
1990/91	181	930	1248	846
1991/92	270	1324	1936	1150
1992/93	284	2447	3166	2385
1993/94	291	1860	2610	1848
1994/95	244	1345	2269	992
1995/96	332	2231	3497	1849
1996/97	280	1504	2259	1490
1997/98	229	1540	2521	1431
Mean	257	1569	2368	1411

The traits most associated with performance under the dryland conditions of 1997/98 were the score for agronomic performance, it explained up to 60.1% of the total variability of grain yield at Breda station. The scores for cold resistance, early growth vigor, and leaf rolling indices were also important in 1997/98 season.

(M.M. Nachit, M. Azrak, A. Asbati, H. Hazzam)

3.1.4.1. Breeding for drought resistance: Associations of RFLP-Markers with Grain Yield and Morpho-Physiological Traits under Dryland Conditions

To identify drought tolerant durum germplasm, the empirical selection approach is employed. Germplasm evaluation for drought tolerance require large number of testing sites and seasons. Empirical selection approaches to genetically improve grain yield in drylands have been effective but they are time-consuming and require the employement of large amount of resources. However, the analytical selection approach using the morpho-physiological traits have been slowly adopted for selection in the segregating generations in some dryland breeding programs. The employed trait for dryland selection needs to be simple and rapid to use and less expensive than the field and design techniques used in the empirical selection approach.

Understanding the drought tolerance basis of the morpho-physiological traits offers the potential to select germplasm based on key-traits linked with grain yield in dryland. Morpho-physiological traits can be used as indirect selection criteria for grain yield in dryland, however, their effectiveness depends on their correlations with grain yield under drought and the degree to which each trait is genetically controlled. Usually, a dryland crop deploys a complex set of interacting to grow and survive under moisture-stress. Therefore it is of interest to know the efficiency with which water is used by a crop in the dry area (mol CO_2 fixed per mol H_2O transpired).

The Carbon Isotopic Discrimination (CID) was found as an useful tool to screen for variation in water use efficiency. Further, Restriction Fragments Length Polymorphism (RFLP) markers could serve to identify traits that are difficult to identify phenotypically.

At the drought screening station of ICARDA and for the Durum Core Collection studies, the results show the followings. The relationships between grain yield, yield components, carbon isotope discrimination, and ash content in the flag leaf were positively correlated among each other. Whereas Ash content in the kernel (ACK) was negatively with all traits and canopy temperature did not show any significant relationship with the other traits. The association of CID with grain yield was similar to that of number of fertile tillers and number of spike kernels with grain yield. Further, it is also of interest to notice that the positive and significant correlation between the CID and ash content in the flag leaf. However, the association between grain yield and ACK was relatively low compared with that of grain yield and CID. The results of this study that ash content in flag leaf support the use of CID as trait to select for improved dryland yield and enhanced water-use efficiency.

Table 3.8 shows the analysis of variance for the regression of CID with grain yield under the conditions of the Mediterranean continental dryland. The F-ratio of the mean square of the regression to the mean square of the residual was found to be highly significant. The multiple correlation was estimated at 0.526 and the squared multiple correlation at 0.277; i.e. almost one-third of the total variability of grain yield under dryland was explained by the carbon isotope discrimination. The inclusion of ash content in flag leaf increased the squared multiple correlation only to 0.297, whereas when all traits were included it reached 0.663, explaining together almost two-third of the total variability of grain yield.

Table 3.8. Analysis of Variance for Regression of Carbon Isotope Discrimination (CID) with Grain Yield (GY) in Durum, Breda station.

Source	Df	Mean-Square	F-ratio	P
Regression	1	4158608.417	52.787	0.000
Residual	138	78781.214		

N: 140; multiple R: 0.526; squared multiple R: 0.277.

Table 3.9 shows the effect of presence and absence of some RFLP markers on grain yield and CID under the Mediterranean continental dryland. Only significant differences between the two population means are presented. The presence or absence of several RFLP markers in a genotype were associated with improved values grain yields and CID. Positive difference indicates RFLP marker presence is desirable, whereas negative difference indicates RFLP marker absence is desirable for improved grain yield and CID expression. Similarly, trait expression with positive difference was associated with presence, and negative difference with absence.

RFLP markers (CDO1090/2B, KSUG48/8A; BCD1434/25C; BCD1434/25J; BCD348/27O) associated with both grain yield and CID. Grain yield showed stronger associations with RFLP markers than did CID. Earlier studies under similar conditions (Nachit et al., 1993) showed significant relationship between some molecular markers and leaf water potential, canopy temperature, chlorophyll fluorescence inhibition, and proline content. Screening with traits associated with drought tolerance or water-use efficiency is complex, time consuming, expensive, and difficult to use in a practical breeding program. It is also of interest to note that molecular markers could be associated directly with grain yield in dryland.

Indirect selection for molecular markers, using PCR-primers may have an advantage over direct selection. When the correlation between a DNA marker and a desired trait is greater than the heritability of the desired trait, molecular marker-facilitated selection may be advantageous. The results are encouraging and suggest the use of molecular markers to improve productivity and drought tolerance in association with physiological traits such as CID in the Mediterranean dryland.

(M.M. Nachit, I. Elouafi, A. Asbati, M. Azrak, H. Hazzam)

Table 3.9. Associations of Grain Yield and Carbon Isotope Discrimination with RFLP-Markers

RFLP-marker	Number of Genotype with		Trait mean		Difference	t-Test
Trait	Marker Present	Marker Absent	Marker Present	Marker Absent		
CDO1090/2B						
Grain yield	132	8	2602.90	2210.37	392.53	4.284***
CID	132	8	15.33	14.91	0.42	2.848**
CDO1090/2D						
Grain yield	103	37	2530.58	2719.365	-188.8	2.553*
CID	103	37	15.27	15.39	-0.13	2.064*
KSUG48/8A						
Grain yield	100	40	2508.31	2760.86	-252.55	3.329***
CID	100	40	15.26	15.43	-0.17	2.693**
MWG634/10O						
Grain yield	109	31	2633.78	2393.016	240.77	2.864**
CID	109	31	15.35	15.163	0.18	1.992*
CDO1312/20F						
Grain yield	46	94	2419.89	2659.053	-239.16	3.044**
CID	46	94	15.16	15.379	-0.22	3.060**
BCD1434/25C						
Grain yield	6	134	1930.50	2609.575	-679.07	4.304***
CID	6	134	14.71	15.333	-0.62	2.490*
BCD1434/25D						
Grain yield	12	128	2304.17	2606.375	-302.21	2.010*
CID	12	128	15.06	15.329	-0.26	2.584**
BCD1434/25J						
Grain yield	10	130	2159.90	2612.823	-452.92	3.677***
CID	10	130	14.87	15.340	-0.47	2.412*
BCD348/27O						
Grain yield	29	111	2376.47	2633.77	-257.30	3.336***
CID	29	111	15.122	15.35	-0.23	2.743**
CDO412/31C						
Grain yield	80	60	2484.37	2708.60	-224.22	3.179**
CID	80	60	15.24	15.40	-0.16	2.595**

*, **, ***: Significant at 0.05, 0.01, and 0.001 probability level

3.1.4.2. Effects of water deficit on photosynthetic rate and osmotic adjustment in tetraploid wheats

In Collaboration with INRA-Montpellier/ France and the University of Barcelona/ Spain, the effects of water deficit on photosynthetic rate and osmotic adjustment in tetraploid wheats were studied. Osmotic adjustment, accumulation of soluble saccharides, and photosynthetic gas exchange were studied in five durum wheat (*Triticum turgidum* L. var. durum) and one wild emmer wheat (*Triticum turgidum* L. var. *dicoccoides*) cultivars of contrasting drought tolerance and yield stability. Soil water contents (SWC) were 100, 31, 20, and 12% of maximum capillary capacity. Under mild water stress (SWC 31 to 20%), osmotic adjustment capacity and high accumulation of saccharides were found in cv. Cham 1, a high yielding and drought tolerant cultivar, and in var. dicoccoides, while lowest values were noted in the durum wheat landraces Oued-Zenati and Jennah-Khetifa. Under more severe water stress (SWC 12%), the cv. Cham 1 maintained higher net photosynthetic rate (P_N) than other genotypes. The observed changes in the ratio intercellular/ambient CO_2 concentration (c_i/c_a) indicated that under mild and severe water stress, the decrease in PN was mainly due to stomatal and non-stomatal factors, respectively.

On the use of Tetraploid Wheats to Improve Drought Tolerance in Durum, *triticum turgidum* subspp. *dicoccoides*, *dicoccon*, *polonicum*, and *carthlicum*, represent a promising source of disease resistance, high protein content, and drought resistance. *Triticum dococcon* shows many interesting agronomical characters, such as biomass production, number of tillers and spikes per plant, number and deepness of roots, and maintenance of high relative water content (RWC) under water stress. *Triticum polonicum* has a long peduncle, long awns, good spike fertility, high 1,000 kernel weight, and a good superficial rooting pattern. *Triticum carthlicum* generally has good tillering ability and good spike fertility. *Triticum dicoccoides* has good tillering capacity. The osmotic adjustment capacity of *T. dicoccoides*, the genetics of RWC, and quality traits were studied. The capacity for maintaining high RWC, or increasing leaf osmotic potential (LOP) when leaf water potential (LWP) is decreasing, were also studied. RWC, LOP, and LWP were assessed in five durum genotypes (Cham 1, Jennah Khetifa, Korifla, Oued Zentani, and Kabir 1) and *T. dicoccoides* 600-808. Results show that the durum cv Cham 1 and *T. dicoccoides* 600-808 maintain their RWC under stress, while Kabir 1, Korifla, Oued Zenati, and Jennah Khetifa rapidly decrease RWC with increasing LWP and Ln(LOP). Leaf RWCs for *T. polonicum*, *T. dicoccoides*, and *T. carthlicum* were higher than for *T. durum* and *T. dicoccon*. Accessions (*T. polonicum*, *T. dicoccon*, and *T. carthlicum*) with the highest RWC were crossed with Cham 1 (drought tolerant durum), and their F_2 populations were assessed. Similarly, T. dicoccoides were crossed with the durum variety Korifla and assessed for RWC. The distribution of RWC in the four populations suggested a polygenic determinism for this trait. Broad- and narrow - sense heritabilities were determined. The high mean value of the F_2 over the mean of the parents suggested overdominance effects and transgressive inheritance. A divergent selection was initiated for the crosses of *T. polonicum*, *T. dicoccon*, and *T. carthlicum* to determine narrow-sense heritability and response to selection, and to validate the possible use of this trait in breeding progras. In the *T. polonicum* x *T. durum* F_2 population, RWC showed significant correlation with the harvest index (r=0.66**). One single cycle of divergent selection appears to increase the average RWC value. Realized heritabilities for RWC showed the highest value for the *T. polonicum* cross and the lowest value for *T. carthlicum*. Although backcrossing has decreased, the transgressive positive effects of RWC, approximately 10%of the BC_1 plants maintained higher values than the *T. dicoccoides* parent, and 75% higher values than Korifla. The effect of using *T. polocicum*, *T. dicoccon*, and *T. carthlicum* on durum quality was evaluated. Protein content was higher in all tested interspecific lines than in the durum check (Omrabi 5), and some lines also showed higher grain yield and 1,000 kernel weight than the check. Evaluation of AB tetraplid wheats for drought-tolerance-releated traits indicates that many accessions are potentially useful for the improvement of drought tolerance in durum.

Cocerning the development of molecular markers, DNA sequences of durum dehydrin genes pTd27e, pTd16, pTd25a, and pTd38 were characterized and compared with the sequences of dehydrin and RAB genes of other cereal crops. Structure, conformation, and physiological role of durum dehydrin proteins were detailed. Correlations between the expression of dehydrins genes and drought tolerance were studied in three tolerant and one susceptible durum genotypes.

(M.M. Nachit, P. Monneveux, D. Rekika, A. AlHakimi, J.L. Araus, M. Labhilili, & P. Joudrier)

3.1.4.3. Studies on Drought Tolerance in Durum, yield stability, and Genotype-Environment Interaction

In Collaboration with the Algerian durum program and INRA-Montpelleier/ France, hydric status, energetic status (chlorphyll fluorescence), and osmoregulation (proline an soluble sugars) were studied. The analysis of yield stability showed three major varietal groups: wide adaptoition, intermediate adaption, and narrow adaption. Varieties Bidi 17, GG Rkhem, Cloire de Montgolfier, Montpellier, and Oued Zenati had low yield and low response to favorable conditions. Mexicali, Vitron, Waha, and ZB/Flg showed high yield and linear response to favorable conditions. Capeiti, INRAT 69, Polonicum, and Sahel showed satble yield. Yield was found to be negatively correlated with the sensitivity index to environment constraints (ISCE). Vitron was identified for favorable areas, Bidi 17 for unfavorable areas, and Polonicum, INRAT 69, and Capeti for moderate water-stress areas. Stress physiological traits, water status, energetic status, and osmoregulation countribute to varietal adaptation. The use of countrasting models was proposed (1) Hedba 3 (low values for proline and fluorescence) and Stork (high values for proline and flurescence); (2) Hedba 3 (low value for proline) and Waha (high value for proline); (3) Bidi 17 (high values for proline and psi, low yield) and Waha (high value for proline, low value for psi, high yield); (4) Polonicum (low values for proline and psi, low yield) and Stork (high values for proline and psi, high yield). Results showed a consistent relationship between groups in terms of physiological traits and expressed yield stability. Chlorophyll flourescenece was found to have transgressive inheritance. The other physiological parameters have intermediate heritability. Analytical and synthetic approaches were proposed to identify drought-resistant varieties.

A national trials was conducted at 14 sites for three years for 13 durum wheat cultivars grown in Algeria. Newly developed varieties, such as Mexicali 75, Hoggar and Zenati Bouteille/Fg exhibited good levels of adaptability to favorable and intermediate zones. Chougran, Inrat 69, Capeiti and Sahel were adapted to moderate drought, and a group of local cultivars performed well under severe water deficit (Bidi 17, Gemgoum Rkhem, Rahouia, Oued Zenati and Montpellier). Waha performed well over a relatively wide range of environments. Water-deficit physiological traits such as florescence, water potential (Ψf), and accumulation of free proline seemed to be involved in the drought tolerance mechanism. These results indicated the possibility of selecting genotypes of specific zones, by using these physiological traits.

(M.M. Nachit, Benbelkacem, L. Brinis, & P.Monneveux)

3.1.4.4. Boron-toxicity Tolerance in Durum Wheat

Boron (B) toxicity occurs mainly in arid and semi-arid regions, especially in alkaline sils. It has been observed in the semi-arid areas of many countries in West Asia and North Africa (WANA). Selecting or breeding crop cultivars with high tolerance or resistance to B toxicity is the only effective approach to increasing yield on soils high in B. In view of the importance of durum wheat in WANA, especially in semi-arid areas, work to identify B toxicity tolerant tolerant durum wheats was initiated at the International Center for Agricultural Research in the Dry Areas (ICARDA) in 1993. Experiments were in a plastic house under controlled temperatures and natural sunlight. Boric acid was added to create soil media with different B levels. Durum wheat had foliar B toxicity symptoms similar to bread wheat. When subjected to high soil B levels, grain soil B levels, grain yield was reduced, and heading delayed. There was significant variation in response to high soil B level among durum wheat genotypes. Screening of seedlings detected some germplasm accessions with high levels of B toxicity tolerance.

(S.K. Yau, M.M. Nachit, J. J. Rayan & J. Valkoun)

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

Under continental drylands, several lines derived from crosses between drought resistance x drought resistance and drought resistance x landraces have shown grain yield superiority over the checks. The highest yielding test entries out-yielded the best checks by more than one and half ton/ha (Table 3.10). The largest contribution (%) to grain yield variability was made leaf rolling, agronomic score, and date to heading, 38.9%, 24.4%, and 5.1%, respectively. There is no doubt that earliness continues to play a major role in durum yields in areas with heat and drought stress.

The durum crosses with the dryland improved germplasm and *T. dicoccoides* are showing the best performance under drought conditions (Table 3.11). The main contribution (%) to grain yield variability were agronomic score (39.3%), date to maturing (6.1%, and resistance to wheat stem sawfly.

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

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

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

Table 3.10. Grain Yield (kg/ha) of durum genotypes under dryland, Tel Hadya, ADYT, 1997/98.

Entry number	Cross/ Name	Grain yield (Kg/ha)
201	Fadda-98	6243
821	Altar84/Stn//Lahn	6170
823	Altar84/Stn//Lahn	6120
904	Awl2/Bit	5930
1013	Ruff/Fg//Turk 1/3/Stj6	5873
312	Bcr/3/Chl//Gta/Stk/4/Bcr/Lks4	5827
123	Gidara-2	5792
313	Bcr/3/Chl//Gta/Stk/4/Bcr/Lks4	5700
1105	Sebah	5693
819	Otb-1	5681
905	Quadalete//Erp/Mal/3/Unk	5622
810	Syrian-2	5601
221	Bicrederaa-1	5548
519	Aghrass-1	5540
208	Terbol97-1	5538
204	Ombit-1	5495
919	Ruff/Fg//Turk 1/3/Gil3	5495
Checks		
2	Omrabi5	4623
7	Haurani	2953
11	Korifla	3654
16	Waha	3600
	Grand mean	4489
	LSD (5%)	1028
	CV(%)	7.3

Table 3.11. Grain Yield (kg/ha) of durum genotypes for Continental Dryland, Breda, ADYT, 1997/98.

Entry number	Cross/ Name	Grain yield (Kg/ha)
921	Ruff/Fg//Turk 1/3/Gil4	2521
1014	Rutucha-1	2376
604	Lahn//Gs/Stk/3/Gil-3	2363
818	Bcrch-1	2242
910	Albit-9	2232
821	Altar84/Stn//Lahn	2165
609	Ossl-1/Gdfl	2164
906	Bcr//Memo/Goo	2149
905	Quadalete//Erp/Mal/3/Unk	2126
1120	Rutucha-1	2079
1021	G-1273/4/DF21-75//61-130/Uvy/3/128-13	2019
904	Awl2/Bit	1984
1020	Ruff/Fg//Turk 1/3/Brach	1979
403	Lahn/Hcn	1944
1103	Chl/T.dic.-Sy 20121//ICD 77-185/3/CD 20626	1942
823	Aghrass-1	1934
617	20123 (Mor)/Mrb5//Stj4	1924
Checks		
102	Omrabi-5	1291
107	Haurani	1431
111	Korifla	1595
116	Waha	1565
	Grand mean	1540
	LSD	425.9
	CV%	8.8

3.1.5. Conclusion

Broading genetic base for durum is achieved through introgression og genes from wild relatives. Improved drought research tools were identified. Use of molecular markers in the breeding was initiated. Improved durum germplasm has been generated with the adaptation required for the main target agro-ecological zones. Gene pools for resistance to the constraints encountered in each zone of

WANA region were developed with improved resistance to biotic and abiotic stresses and for grain quality.

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

3.2. Pathology

3.2.1. General Overview

Durum wheat is cultivated under widely variable climatic conditions in the WANA region and is the most sustainable crop in the Mediterranean basin. Varietal monoculture is common among many farming communities, even large farm operations get use to manage and commercialize a given variety and often don't accept to change it. The variety Karim occupies about 50 to 80% of the wheat area in Morocco and Tunisia respectively. Cham 3 is the most cultivated in Syria, and Gerek79 in Turkey. These varieties and others probably fit the demand of the market for quality and that of the farmer for their productivity. Unfortunately they also fit pre-requisites of disease epidemic development. Karim ,Cham 3, and others have become very susceptible to septoria, yellow rust, and leaf rust. During favorable years yield loss due to diseases can reach up to 40%. The improvement of disease resistance of the commonly cultivated varieties or the newly developed germplasm is very important in order to sustain an adequate production level. The identification of sources of resistance to the prevalent durum wheat diseases is an important objective of the regional CIMMYT/ICARDA durum wheat project.

At ICARDA all the potential durum wheat germplasm is screened for resistance to the predominant diseases in WANA such as yellow rust, leaf and stem rust, septoria, and common bunt. Breeding nurseries are initially screened at ICARDA (Tel Hedya) then within the region in collaboration with NARS. Over 900 entries were screened in 1998, 130 fixed lines were tested for specific disease resistance and about 800were tested for multiple disease resistance (Table 3.12) at ICARDA (Tel Hedya) then within the region in collaboration with NARS. Over 900 entries were screened in 1998, 130 fixed lines were tested for specific disease resistance and about 800 were tested for multiple disease resistance (Table 3.12). Data pertaining to the evaluation of the nurseries within the region will be reported by NARS collaborators in the national annual report. Diseases also formed an important component in the WANADDIN project and reports of the disease networks will complement the information presented here. Thus only the results of the screening conducted at ICARDA are discussed in this report. Information pertaining to the diseases tested (isolates used, virulence types etc...) is reported in the IPM section. The nurseries tested (number of entries) and the diseases used for artificial inoculation are shown in the following table.

Table 3.12. Durum wheat germplasm (number of entries) screened for resistance to rust, septoria and common bunt under artificial inoculation (Field & Plastic house)

Breeding Nursery screened	Total Nb. Entries	Wheat Diseases used for screening *				
		Y.rust	L.rust	S.rust	Sept.	C.bunt
DYR (Yellow rust)	40	+				
DLR (Leaf rust)	35		+			
DSR (Stem rust)	35			+		
DWST (Septoria)	20				+	
DOUMA (SYR.Nur)	54	+			+	+
DKL (Key Loc.Nur)	200	+	+	+	+	+
DPD (Prel.Yd Trial)	400	+	+	+	+	+
DACB (Aleppo CB)	80	+	+	+	+	+
DRTB	17	+	+	+	+	+
FFVT (farmer Trial)	48	+	+	+	+	+
Total	929	839	780	780	819	799

* Syrian local isolates were used for artificial inoculation

3.2.2. Evaluation of Durum Wheat Nurseries for Disease Resistance

3.2.2.1. Resistance to Rust, Septoria, and Common Bunt

Special nurseries for specific disease (325 lines) were evaluated under field conditions (Tel Hedya,Terbol, Roumania) and in the plastic house. The diseases considered were stripe rust, leaf and stem rust, septoria leaf blotch, and common bunt.

Resistance to stripe rust (YR) was relatively good for all the nurseries tested. The number of entries showing good resistance to stripe rust was over 57% for DACB (crossing block) and DPD (preliminary yield trials), and exceeded 40% in DYR and DKL nurseries (figures, 3.1,3.3). DOUMA breeding material showed lower level of resistance to stripe rust as well as to common bunt (fig.3.2).

Large number of fixed durum lines showed good resistance against Syrian isolates (65.8% in DLR) but a lower resistance level (20% in DLR+) was recorded in Romanian (fig.3.1). The breeding nurseries (DACB, DKL, DPD, FFVT) also showed a low resistance level to leaf rust (fig.3.1). In the yield trials (DPD) only 40 entries out of 400 showed a good resistance level. The frequency of resistant material (27%) tested as farmer field verification trials (FFVT) is quite adequate considering the high infection level recorded among the screened material.

The durum wheat germplasm screened in 1998 showed a relatively low resistance level to septoria, stem rust (fig.3.1& 3.3) and common bunt (fig.3.2). A relatively large number of lines showed intermediate type of resistance to stem rust (45.7% in DSR) and to septoria (40% in DST) (fig 3.1). This type of resistance is considered as tolerant and can be very useful in the improvement of resistance to septoria in durum wheat. Sources of resistance to stem rust should be improved in the Aleppo Crossing Block nursery (DACB).

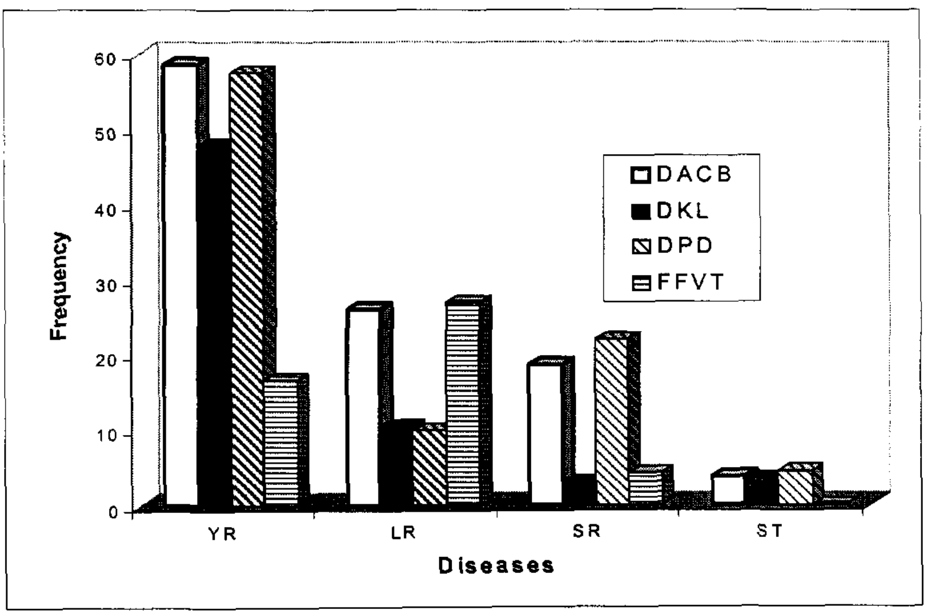

Figure 3.1. Frequency distribution of resistance to rusts and septoria in four durum wheat nurseries

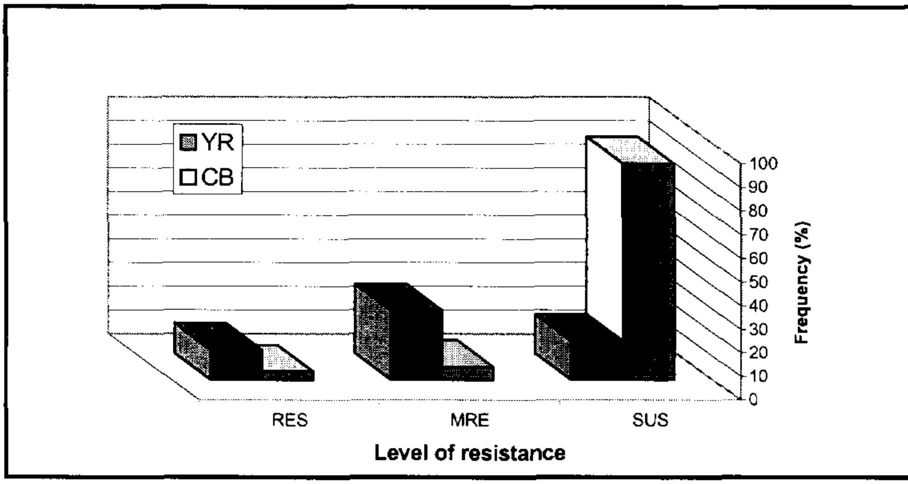

Figure 3.2. Frequency distribution of resistance to yellow rust and common bunt in DOUMA nursery

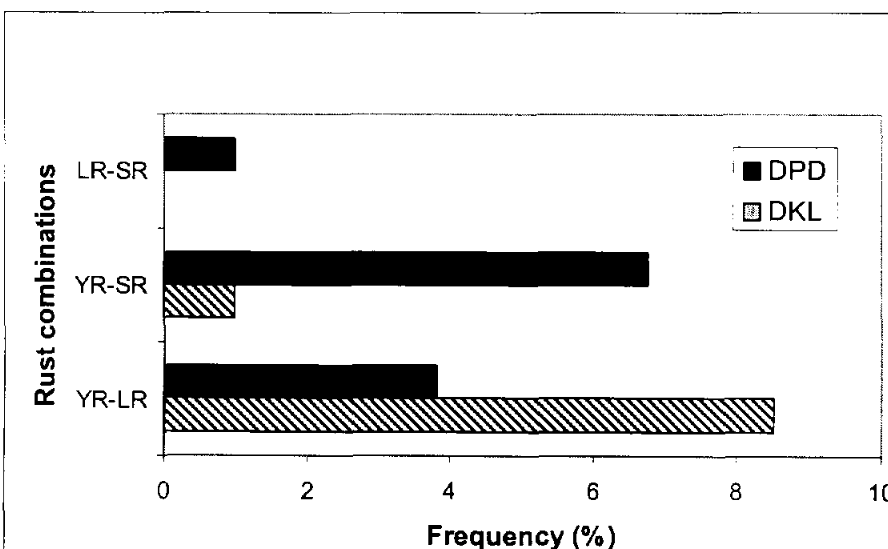

Figure 3.3. Frequency distribution of resistant lines to combinations of rusts in two durum nurseries

3.2.2.2. Screening for Multiple Disease Resistance.

Durum wheat is grown under a wide range of climatic conditions that are conducive to the development of a wide array of fungal pathogens. In the WANA region quit often at least two of the rusts will appear simultaneously. It is common to observe good development of stripe rust and leaf rust in Syria, leaf rust and stem rust in Egypt. The rusts are also associated with other diseases such as septoria leaf blotch and tan spot. Resistance to septoria and leaf rust is essential for durum wheat targeted to North Africa. The nurseries tested for multiple disease resistance (table 3.12) showed a good level of resistance to yellow rust (fig.3.2), however, the proportion of resistant lines to septoria among all the nurseries did not exceed 5%. Durum wheat lines in the DPD and DKL nurseries showed good to combinations of two rusts (fig.3.3). In the DPD nursery 27 entries showed good resistance to both stripe and stem rust, 15 entries were resistant to stripe and leaf rust, and only 4 entries showed resistance to leaf and stem rust. In the DKL nursery 17 entries showed resistance to stripe and leaf rust, 2 entries were resistant to stripe and stem rust but none of the lines tested shoed resistance to both stem and leaf rust.

Among all the genotypes tested (Table 3.1) only 4 entries (0.43%) showed resistance to the three rusts (Table 3.13). Resistance to septoria and rust was identified from different nurseries. Tables 3.14, 3.15,and 3.16 show the genotypes that are resistant to septoria and stripe rust, septoria and leaf rust, and septoria and stem rust respectively.

Table 3.13. List of Resistant Durum Wheat lines to Stripe rust, Leaf rust, and Stem rust

Nursery	Ent	Name	Pedigree
DACB98	27	Hel/3/Bit/Corm//Shwa/4/T.mon1450/5/Mtl6	ICD92-0721-WABL-0AP-3AP-0TR
	39	Ossl1/Gdfl	ICD92-0940-CABL-0AP-5AP-0TR
DPD98	175	Hel/3/Bit/Corm//Shwa/4/T.mon 1450/5/Mtl-6	ICD92-0721-W-0AP-3AP-0TR
	217	Stj3/3/Gdfl/T.dicdsSY20013//Bcr	ICD94-1010-W-0AP-21AP-0AP

Table 3.14. List of Durum Wheat Lines Resistant to Septoria an stripe rust

Nursery	Ent	Name	Pedigree
DACB98	55	Unk/5/PI178043/3/61-130/Lds//Gla/4/Vls//Ge553	YA06128-0A-1A-0AP
DKL98	151	DF9-71/3/VZ466//61-130/414-44/4/Ergene	TE01061-23A-1A-1A-0A-0AP
	84	HFN94N MOR NO 21/Mrb5	ICD94-0172-T-0AP-24AP-0AP
	138	BD272/C Jucci//Stj1/3/Mnal	ICD93-0257-T-0TR-12AP-6AP-0AP
DPD98	141	BD272/C Jucci//Stj1/3/Mnal	ICD93-0257-T-0TR-12AP-10AP-0AP
	241	Krf/T.monIC 2165//Chah88	ICD92-0723-W-0AP-2AP-0TR-3AP-3AP-0AP
	314	Ruff/Fg//Turk1/3/Gil3	ICD92-0081-H-2AP-0AP-14AP-0AP
	329	Ruff/Fg//Turk1/3/Stj6	ICD92-0087-H-3AP-0AP-18AP-0AP

Table 3.15. Reistant line to Septoria and Leaf rust

Nursery	Ent	Name	Pedigree
DKL98	98	Shwa/Stk//Bit/3/Kyp/4/Chah88	ICD92-0020-MABL-2AP-0TR-4AP-0AP

Table 3.16. Durum Wheat Line Resistant to Septoria and Stem rust

Nursery	Ent	Name	Pedigree
DACB98	61	SD-19539 (USA)//Awl2/Bit/3/Gil4	ICD92-0507-T-0AP-9AP-0TR-2AP-0AP

3.2.3. Prospects for Breeding for Disease Resistance in Durum Wheat

Durum wheat cultivation under wide range of agroclimatic conditions and diversified farming systems necessitate special control measures for fungal pathogens that are inherent to such conditions. Disease resistance is essential for durum wheat cultivation in order to ensure stable yields under for low input environments and potential yields for high input environments. Future emphasis on breeding for disease resistance for the regional CIMMYT/ICARDA durum wheat program will target the following areas; 1) consolidate studies on diseases development and screening for resistance undertaken by sub-networks within WANADDIN project, 2) target resistance to prevalent diseases within agroecological zones, 3) identify effective resistance genes and with NARS attempt to develop a gene deployment strategy. 4)develop and adopt marker assisted selection and new biotechnology tools to monitor resistance genes in bread wheat germplasm and virulence genes in some pathogens, and 5) at the farm- level initiate an integrated disease management approach that can reinforce the collaboration with the IPM project in its attempts to develop cost-effective disease management control measures

(A.Yahyaoui, H.Toubia-rahme, M.Naimi)

3.3. Virology

When 84 durum wheat lines, which have been tested in the previous season in 30 cm short rows, were evaluated for their reaction to BYDV in 1-m long rows during the 1997/98 growing season, some lines showed high tolerance to BYDV infection. Results of the best performing lines are presented in Tables 3.17., 3.18., 3.19.

Table 3.17. Re-evaluation of best performing Durum wheat lines for their reaction to BYDV infection after artificial inoculation with the virus, on the basis of symptoms disease index (D.I.), grain *yield and yield loss* (%), during the 1997/98 growing season.

Entry	D.I. (0-9)	Gr. wt. (g/m)	Yield loss (%)
Om rabi3/4Mrb SH/3/Rabi//GS/Cr	5.5	207	37.2
Waha	6.5	226	45.3
Ouassel-1/4/Gdoz	6.0	243	27.2
512/Cit//Ruff/Fg/3/Pin/Gre//Tob			
Mrb9/Haucan	5.0	206	39.7
Hau/T.dic.-Sy 20017//Cham1/3Cham 1	5.0	202	40.5
Aus1/5/Cando/4/By*2/Tac//11217655/3/ TIME//ZB/W*2	5.5	211	47.2
Kia/Vic//Brachoua	5.0	202	42.7
Lahn/Haucan	5.0	223	23.0
Cannizzara	5.0	209	41.6
Monroe	5.0	194	30.3
Chl/Brachoua	5.0	303	10.1
AW12/Bit	5.0	239	45.0
Brach/T.dicds20017//Haucan	5.0	239	29.4
Mrb5/Omguer-4	5.5	235	34.3
Gdovz512/Cit/Ruff/Fg/3/DWL5023	5.5	271	24.9
Cys's'/Sincape9Yel's'/Cfns-Fg's'	5.5	173	65.5
Dack'S'-Kiwi'S'	7.5	119	69.0
(Hau)27)/DCC-Susc.	8.0	154	45.2

Table 3.18. Performance of selected Durum wheat lines provided by the breeders at ICARDA and planted in 1 m rows showing tolerance to BYDV infection after re-evaluation, during the 1997/98 growing season.

Entry	D.I. (0-9)	Gr.wt. (g/m)
Gedifla/Guerou 1	5.0	147
Stk/4/Jo/3/Jo/Cr//Cit71/5/Mrb3	5.0	124
Stk/4/Jo/3/Jo/Cr//Cit71/5/Mrb3	5.0	168
Bicre/3/Chl//Gta/Stk/4/Bicre/Loukos 4	5.0	164
Stj4/3/Khb1//BD2014/Rabi	5.5	146
Shihani/Brach	5.0	124
GdoVZ	5.0	153
512/Cit//Ruff/Fg/3/Ente/Mario//Cando		
LLOYD/Kia//Chl	5.0	136
Chen/Altar84//Genil-4	5.0	182
Arthur 71/Bicre//Mrb3	4.0	163
Mrb5/Omguer-3	4.0	131
Kob/Lds//6783/3/Berk/7/Cr/Gs//Apul/3 /DF17-72/4/PI/Gd/5/AA/6..	3.0	141
Ruff/Fg//Turk 1/3/Omguer-1	5.0	125
Kunduru	4.5	164
Moundros-2	5.0	154
Waha	4.0	146
Sicilia lutri	4.5	147
Cannizzara	5.0	140
Mrb5	5.5	141
Po	4.0	194
Deraa	4.0	156
Kabir-1	4.0	148
Karasu	5.0	152
Quadelete	5.0	167
Heider	5.0	124
Aric 31708.70/3/Bo//C.de Chile/Br/4/Cit/Gta	5.0	153
Omruf-2	4.0	101
Barba de lobo	4.0	110
Simeto	4.5	136
Cakmak	5.0	108
Sert.165.a	5.5	146
Rugby	5.0	131
Monroe	5.0	170
Mrb5	5.0	106
Outrob-6	4.0	166
Mrb11//Snipe/Magh/3/Rfm-7	5.0	129
Chl/T.dic.-Sy 20121//ICD77-185/3/CD20626	5.0	159
Otb2	5.0	100
Brch/T.dicds20017//Hcn	4.5	163

Table 3.19. Evaluation of wheat germplasm in short 30 cm rows for tolerance to BYDV infection after artificial inoculation with the virus during the 1997/1998 growing season.

Cereal nursery	Number of Lines tested	Lines with tolerance to infection
Durum Wheat DKL- 1998	200	2, 6, 10, 17, 23, 29, 37, 55, 61, 67, 81, 83, 95, 98, 119, 145, 153, 157, 158, 160, 161, 163, 174, 176, 178, 182, 183, 186, 191, 198, 199

(K.M. Makkouk, W. Ghulam)

3.4. Entomology

3.4.1. Russian wheat aphid (RWA)

Russian wheat aphid, *Diuraphis noxia* (Mordvilko), causes serious damage to wheat in North Africa, mostly in dry years. The aphid injects a toxin into the plant that destroys the chloroplast membrane, causing longitudinal chlorotic streaks to develop. Host plant resistance has been the most practical and economical means of controlling this pest.

A total of 269 durum wheat lines were screened in the field at Tel Hadya for resistance to RWA. The entries were planted in hill plots, 10 seeds/ hill using alpha lattice design with 2 reps. One susceptible check for each crop species was used every 10 entries. This field experiment was infested at tillering stage with about 10 nymphs per plant. The evaluation was done three times at three weeks intervals using DuToit scale from 1-6, where1= small isolated chlorotic spots on the leaves and 6 = severe white/yellow streaks and tightly rolled leaves. The promising lines selected from the field go through two stages screening in the greenhouse, initial and advanced. In the initial screening, the material is evaluated in just one rep. The promising lines from this initial screening go through an advanced evaluation (4 reps). The method of infestation and evaluation is similar to that of the field, except that seeds are planted in regular greenhouse flats and individual plants are infested at one leaf stage with 10 RWA aphids.

Table 3.20 summarizes the selected accessions that showed an intermediate level of resistance, score 3 in the Du Toit scale from 1-6. It is interesting to note among the resistant material, the durum wheat line PDYT97 1614, which is derived from a cross with *Ae. columnaris*. These new sources of resistance are in use in the durum-breeding program to develop RWA resistant varieties in North Africa. Several other sources of resistance have been identified in the initial screening tests as promising to RWA, and will be tested in advanced screening for confirmation this season.

Table 3.20. Sources of resistance to RWA, field and plastic house test at Tel Hadya, 1998.

Source/number	Species/Pedigree
DGR97 467	*T. monococcum* IC 500134
DGR97 468	*T. monococcum* IC 500236
DGR97 472	*T. monococcum* IC 500240
DGR97 473	*T. monococcum* IC 500241
DGR97 477	*T. monococcum* 44
DGR97 479	*T. monococcum* 46
DGR97 502	*T. araraticum* 500338
PDYT97 1614	Hcn/Ae.columnaris 400020//Mtl-1/3/Mla-3
AEGCO97 18	*Ae. Ovata*
AEGCO97 63	*Ae. Ovata*
AEGCO97 73	*A. kotschyi* IC 400063

(M. El Bouhssini, M. Nachit, A. Joubi)

3.4.2. Hessian fly

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

3.4.2.1. Screening for resistance in Morocco

This test included 100 accessions of wild relatives, and several hundred durum wheat lines. The test was carried out in the greenhouse at INRA, Settat. Entries were seeded in standard greenhouse flats, containing a mixture of soil and peat, at a rate of one row per entry and 25 seeds per row. In each flat, we included Nasma and Saada as susceptible and resistant checks respectively. At one leaf stage, flats were covered with cheesecloth and about 100 females were released in each flat. The evaluation was made three weeks later. Susceptible plants were stunted and dark green, where as resistant plants retained their light green color and were not stunted. Resistance was also confirmed by the presence of dead first instar larvae at the base of the stems.

Table 3.21 shows the reaction of the wild species collection to Hessian fly in Morocco. Forty-eight accessions showed a good level of resistance. The highest number of resistant accessions was observed for Ae. ovata; 68% of the accessions tested were either homogeneous or heterogeneous for resistance. Moreover, 43% of these selected accessions were homogeneous for resistance.

Table 3.21. Reaction of an ICARDA collection of wild relatives of wheat (*Aegilops* and *Triticum*) species for resistance to Hessian fly in Morocco

Species	Number of accessions tested	Number of resistant accessions
Ae. Biuncialis	2	2 (H)
Ae. Cylindrica	2	2 (R)
Ae. Caudata	2	1 (R)
Ae. Ventricosa	6	5 (R)
Ae. Ovata	47	32 (14R, 18H)
Ae. Triaristata	2	2 (H)
Ae. Speltoides	4	1 (H)
Ae. Squarrosa	1	1 (R)
Ae. Umbellulata	2	1 (H)
Ae. Geniculata	2	1 (R)

Ae. ventricosa also showed a high number of resistant accessions to Hessian fly. Five out of the 6 accessions tested were homozygous resistant.

These resistant accessions in the wild relatives will diversify the sources of resistance available to Hessian fly in Morocco.

Table 3.22 summarizes the reaction of the durum wheat Hessian fly nursery. Ten breeding lines showed a homozygous resistance reaction. Setal-3 and 4 are already in yield trials in Morocco. These lines will be the first durum wheat lines carrying Hessian fly resistance to be released in Morocco.

Table 3.22. Selected durum wheat lines resistant to Hessian fly in Morocco, greenhouse test, Settat, Morocco, 1998.

Entry	% resistant plants
Telset-2	58.3
Telset -3	100.0
Telset -4	100.0
Telset -5	82.4
HFN94N MOR 30	7.1
HFN94N MOR 47	100.0
Bezaiz-SHL	100.0
F4 38 J.S.	79.0
F4 49 J.S.	92.3
F4 20 J.S.	100.0
F4 37 J.S.	100.0
F4 15 J.S.	30.0
Telset cross	100.0
Cit/Saada//Sarif	100.0
Nasma (Susceptible check)	0.0
Saada (Resistant check)	100.0

(S. Lhaloui (INRA, Morocco), M. El Bouhssini, N. Nsarellah (INRA, Morocco), M. Nachit, A. Amri (INRA, Morocco))

4. SPRING BREAD WHEAT IMPROVEMENT

4.1. Spring Bread Wheat Breeding

4.1.1. Introduction

This project is a joint collaborative effort between CIMMYT and ICARDA. It emphasizes research on spring bread wheat for the dry areas of WANA, while CIMMYT-Mexico concentrates in developing germplasm and technologies for the more optimum environments (the irrigated and high rainfall areas) of the region. Improvement of winter and facultative bread wheat, grown in the high elevation and lowland areas with cold winters is handled through the joint TURKEY/CIMMYT/ICARDA program based in Ankara-Turkey.

In 1997/98 season important changes took place in the program. Dr. G. Ortiz Ferrara who has led the program for the past 14 years has been transferred to a new post in Nepal and has been replaced by Dr. Osman S. Abdalla. The program has also gone through budget and personnel reduction. In this process two of the long time assistants in program were retired. All these changes have prompted reconsideration of some of the on-going activities as well as the focus of the program.

In this report the importance of bread wheat in West Asia and North Africa (WANA) is discussed and some of the results of spring bread wheat breeding, pathology, virology and biotechnology research are presented. Changes in the program methodology are highlighted and future research thrusts are outlined.

(Osman S. Abdalla)

4.1.2. Importance of Bread Wheat

Nearly one-third of the area planted to bread wheat in developing countries is located in marginal environments characterized by frequent drought stress during the growing season. Although marginal environments are widely distributed across the developing world, most of these areas are concentrated in West Asia and North Africa (WANA). In WANA, bread wheat is the principal food source for the majority of the population, which on average consumes more than 185 kg/capita/year, the highest per capita consumption in the world. This crop provides over half the calories consumed by people in WANA region and in some countries half of the protein of the daily diet. However, total wheat production and productivity in WANA is generally low and many countries in the region are substantial net importers of bread wheat. This trend is expected to continue on the rise if current rates of demand are maintained.

Thus bread wheat is a strategic crop in WANA region and has an important role in the diet and the economy of the region. The main goal of this project is to enhance food security through achieving sustainable improvement in spring bread wheat productivity, yield stability and end-use quality in the rainfed, low-rainfall areas, of West Asia and North Africa (WANA) region. In achieving this goal, through close partnership with NARS in WANA, the project aims at supporting resource-poor farmers in the region and protecting the environment.

4.1.3. Breeding Methodology

The breeding methodology followed in the program continue to emphasize the following:

I) Targeted crossing program

II) Decentralization of selective research activities to NARS (e.g. Hessian fly research to INRA-Morocco).

III) Multilocation testing: to expose the germplasm to the prevailing biotic and abiotic stresses in the region.

Starting with 1998 summer nurseries, all basic material and segregating populations the SBW program for WANA, has been restructured and reorganized in a way that would clearly reflect germplasm adaptation and targeted environment. Summer 98 nurseries and segregating populations were classified into Low Rainfall (LR) or Moderate Rainfall (MR). Eventually the germplasm classification will reflect adaptation to (a) WANA Continental LR and MR Areas (e.g. *West Asia*: T. Hadya-Syria) where drought tolerance, cold tolerance, yellow rust resistance and sawfly resistance is needed and (b) WANA Sub-continental / Sub-Oceanic LR and MR Areas (e.g. *North Africa:* Settat-Morocco) where drought tolerance, terminal heat stress tolerance, Septoria resistance, and Hessian fly resistance is needed.

The crossing program of 1998 reflected the new emphasis in the program where research on dry areas of WANA is prioritized. (Table 4.1) shows that 52% of the crosses made were targeted to Mediterranean Continental areas and 48% were directed to Sub-continental dry areas.

Table 4.1. Frequency Distribution of Dryland Crosses, CIMMYT/ICARDA, 1998

A) Mediterranean Continental Areas (CA)	No. of Crosses	% CA	% Total DL* Crosses
Drought + Cold Tolerance	97	69%	
Drought + Yellow Rust Resistance	43	31%	
Sub-total	140	100%	52%
A) Mediterranean Subcontinental Areas (SC)	**No. of Crosses**	**% SC**	**% Total DL* Crosses**
Drought+Rusts & Septoria Resistance	60	47%	
Drought+Hessian Fly Resistance	68	53%	
Sub-total	128	100%	48%

4.1.4. International Nurseries

To achieve its goal the spring bread wheat improvement program provides NARS in WANA with germplasm that combines high yield potential with resistance or tolerance to the biotic and abiotic stresses prevalent in the Mediterranean (continental and subcontinental) drylands. The continental areas set is meant for non-irrigated Mediterranean continental drylands (annual rainfall 250-400 mm) with fluctuating rainfall pattern and cold winters where cold damage can occur around tillering and anthesis. Germplasm targeted to such areas combine drought tolerance, cold tolerance and high yield potential. The major biotic stresses in such areas include yellow rust, common bunt and wheat stem sawfly.

The subcontinental areas set is meant for Mediterranean temperate drylands (annual rainfall 250-500 mm) with fluctuating rainfall pattern and mild winters. Germplasm targeted to such areas combine drought and heat tolerance with high yield potential. The major biotic stresses in those areas include leaf rust, septoria blotch, tan spot, barley yellow dwarf virus (BYDV) and Hessian fly.

4.1.5. Experimental Design

The use of an efficient experimental design greatly enhances the precision of estimating differences between test cultivars and hence enhances the efficiency of identifying superior cultivars. In 1997/98 season the experimental design for spring bread wheat (SBW) yield trials at ICARDA main stations has been changed, for the first time, from Randomized Complete Design (RCBD) to incomplete block design utilizing Alpha-Lattice Design (ALD). Analysis of semi-arid advance yield trials (AWYT-SA) at the dryland site of Breda showed 25% reduction in average SE of the differences between pairs of test lines and the alpha-lattice design resulted in relative efficiency of 2.06 over RCBD. The trials were conducted utilizing alpha-lattice design with 24 entries and 2 replications. The observed efficiency factor of 2.06 meant that the same precision could be obtained if RCBD with twice the number of plots (i.e. 4 replications) was used. Thus the use of alpha-lattice design has resulted in grater efficiency than the traditional RCBD and at the same time it represented a great saving in resources.

Similarly, SBW International Yield Trials (RWYT-MR and RWYT-LR) for 1998/99 season were distributed, for the first time, utilizing alpha-lattice design instead of the usual RCBD. To deal with the highly variable experimental and environmental conditions in WANA the search for and utilization of efficient experimental designs will continue in the future. In addition efforts will be made to identify the proper experimental plot size to use.

4.1.6. Results of Advance Yield Trials

In 1997/98 season a total of 5 trials each of Advance Wheat Yield Trial-Favorable Areas (AWYT-FA) and Advance Wheat

Yield Trial-Semi-Arid Areas (AWYT-SA) were conducted at ICARDA main research stations at Tel-Hadya, Breda and Terbol. The objective of these trials was to identify superior lines candidates for Regional Wheat Observation Nursery (WON) that was distributed to NARS in WANA region. The test stations represent a gradient in moisture and temperature stresses. Breda represents continental areas with sever drought and cold stress, Tel-Hadya is moderately dry and cold, while Terbol represents moderate/high rainfall and cool temperature. Table 4.2 lists some of the top yielding lines in AWYT-FA and AWYT-SA and shows their grain yield performance relative to the checks (Chame-4 and Cham-6).

(O. Abdalla, M. Assad Mousa, A. Yaljarouka)

Table 4. 2. High Yielding Lines from Advance Wheat Yield Trials (AWYT), Tel-Hadya, Breda and Terbol 1997/98.

Nursery/Entry	Name / Pedigree	MYLD (kg/ha)	Yld % Cham-4
AWYT-FA:			
117	SHUHA'S'//TJB368.251/BUC"S"	4163	110
302	SERI82/VEHYK	4261	122
303	TEVEE'S'//BOL'S'/PVN'S'	4571	131
311	CHAM4/4/CNO/MFD//MON'S'/3/GOV/AZ//MUS'S'	3928	112
522	CHIL/2*SATR	4852	122
523	CHIL/2*SATR	4632	116
		MYLD (kg/ha)	Yld % Cham-6
AWYT-SA:			
406	PIK/OPATA	3957	108
422	LIRA/SHA5	4171	114
515	KAUZ/STAR	4280	112
516	KAUZ//KAUZ/STAR	4330	114
517	STAR//KAUZ/STAR	4191	110

FA= Favorable Areas, SA = Semi-Arid, MYLD = Mean Yield across Tel-Hadya, Breda and Terbol.

4.1.7. Abiotic Stress-Cold Tolerance and Heat Stress Screening

Many biotic and abiotic stresses limit wheat production in WANA. Temperature extremes (cold and heat) are among the major abiotic stresses that reduce wheat productivity. In WANA, typically wheat is sown in the fall, where its early growth and development occur during the coolest months and grain ripening occurs during the warmest months. Severe cold stress is common in the continental areas of WANA where cold damage can occur around tillering and anthesis leading to great yield losses. To improve yield in farmers' fields in environments prone to cold stress, the joint CIMMYT/ICARDA wheat program for WANA Region is actively involved in activities aimed at developing and enhancing genetic diversity for cold stress in adapted wheat germplasm.

At Tel-Hadya, ICARDA main research station, planting dates of segregating populations and advanced lines are shifted in a way that would expose the germplasm to temperature extremes during the critical stages of plant development. Early planting, in the 1st week of October, utilizing supplementary irrigation and high fertility is routinely used to facilitate better selection for cold tolerance. Traits that are scored during selection include cold damage and frost resistance, in addition to yield. Depth of tillering node was found to be a good indicator for cold tolerance and it is measured in elite germplasm (Table 4.3). Cold tolerance of genotypes selected in this procedure is further confirmed in multi-site trials conducted at cold stress prone locations. This methodology has been proven to be effective and known cold tolerant lines such as "BOCRO" and "SHUHA" have been identified using this approach. Table 4.4 lists outstanding lines identified as cold tolerant in 1997/98 season.

Table 4.3. Evaluation of Elite Bread Wheat Cultivars for Frost Resistance and Cold Tolerance

CULTIVAR	Depth of Tillering Node	Cold Damage	Frost Resistance	Cold Tolerance
	(cm)	(1-5)*	(5-100%)	(L,M,H)
VENAC	2.6	2	70	MH
CHAM-4	3.6	2	70	HM
KABY	4.0	2	75	HM
BLOYKA	3.3	2	75	HM
CHAM-6	4.0	1	85	H
BOCRO-4	4.3	1	85	H
TRACHA-1	3.2	1	90	H
BOCRO-1	4.0	1	90	H
BOCRO-3	3.9	1	100	H
PICUS	4.1	1	100	H

*Cold Damage: 1-Low, 5-Very High; Frost Resistance:5%very Low, 100% Very High, Cod Tolerance: L-Low, M-Medium, H-High.

Table 4.4. List of Outstanding Cold Tolerant Lines, Tel-Hadya Early Planting, 1997/98.

Nursery	Name / Pedigree
AWYT-FA:	
117	SHUHA'S'//TJB368.251/BUC"S"
303	TEVEE'S'//BOL'S'/PVN'S'
306	RSK/5/21931/3/CH53/AN//GB56/4/AN64/6/BOW'S'*2/PRL'S'
307	RSK/5/21931/3/CH53/AN//GB56/4/AN64/6/BOW'S'*2/PRL'S'
AWYT-SA:	
114	TUI//CMH76-252/PVN'S'
308	KAUZ'S'//BOW'S'/CM64798.7H.3H
PWYT:	
117	KAUZ'S"/CHORIZO
306	CHIL//TSI/SNB'S'
417	RMN F12-71/SKA//CA8055/3/MAYON
520	SHUHA'S'/3/RMN F12-71/SKA//CA8055
1506	NESSER/3/TX62A4793-7/CD809//VEE'S'

AWYT= Advance Wheat Yield Trial; FA= Favorable Areas; SA= Semi-Arid; PWYT= Preliminary Wheat Yield Trials.

Similarly, late planting (2nd/3rd. week of March) and summer planting (June/July) are used to expose the germplasm to heat stress at grain-filling stage and during the whole growth cycle, respectively. Heat stress during heading and grain-filling period is common in WANA, particularly in North Africa, while heat stress during the whole cycle is predominant in the Nile Valley and Red Sea countries (Egypt, Sudan and Yemen). In addition to heat stress screening, summer planting helps in identifying lines that have vernaliztion requirement. In Table 4.5 outstanding lines from families that exhibited good heat tolerance in summer planting at Tel-Hadya are listed.

(O. Abdalla, V. Shevtsov, M.A. Mousa, A. Yaljarouka)

Table 4.5. List of Outstanding Heat Tolerant Lines, F6 Summer 1997/98

Name / Pedigree	SELECTION HISTORY	F6 SUMMER 98
VEE#7/KAUZ'S'	ICW94-0029-0AP-0L-6AP-1AP-5AP	23
CHIL/VEHYK	ICW94-0052-0AP-0L-1AP-1AP-7AP	42
KAUZ'S'//MON'S'/CROW'S'	ICW94-0061-0AP-0L-1AP-1AP-3AP	76
NAC/VEE'S'//CARP	ICW94-0173-0AP-0L-2AP-1AP-4AP	308
TRACHA//NS732/HER	ICW94-0262-0AP-0L-2AP-1AP-7AP	366
SUDAN#3/KAUZ'S'	ICW94-0383-0AP-0L-5AP-1AP-7AP	546
FLORKWA/KAUZ'S'	ICW94-0392-0AP-0L-3AP-1AP-2AP	559
SIBIA/MILAN	CMSS93Y00048S-0AP-6AP-1AP-3AP	1273
KAUZ/ATTILA	CMSS93Y00066S-0AP-4AP-2AP-6AP	1305
ATTILA/IRENA	CMSS93Y00090S-0AP-1AP-1AP-4AP	1398
ATTILA//VEE#5/DOBUC'S'	CMSS93Y00095S-0AP-4AP-3AP-8AP	1408

4.1.8. Yield Stability and Adaptation of Spring Bread Wheat in the Mediterranean Dryland

The international nurseries play an important role in germplasm dissemination as well as generation of information about germplasm adaptation from multilocation international testing. Such information is critical in planning future crosses and eventually determines up-coming germplasm. It generally takes about two years to compile data from multilocation international testing. In such activity NARS collaboration can not be under estimated.

Here we briefly present results of 1996/97 multilocation international yield trials testing with special emphasis on yield stability and germplasm adaptation.

The mean yield of the 3 top-yielding cultivars, expressed as a percentage of the local check yield, in each test site of 1996/97 Regional Bread Wheat Yield Trial for Favorable Areas (RWYT-FA) and Semi-arid Areas (RWYT-SA) is shown in Figure 4.1 and Figure 4.2, respectively. Local check performance is indicative of site-specific adaptation. The range of observed yields in RWTY-FA was from 2757 kg/ha (Beja, Tunisia) to 7630 kg/ha (Jalalabad, Afghanistan) and for RWYT-SA was from 424 kg/ha (Qala Azad, Afghanistan) to 4604 kg/ha (Terbol, Lebanon). In both yield trials, the 3 top-yielding cultivars derived from CIMMYT/ICARDA germplasm yielded more than the locally adapted checks across most test sites (Figs 4.1 and 4.2). In general, these results indicate that the spring bread wheat improvement program has been successful in providing NARS in WANA with high-yielding germplasm, adapted to their own environments and with potential for release as new varieties to enhance wheat production.

In Figures 4.3, the yield response of line #20 in RWYT-FA is regressed over site mean yield across the 19 test sites of the Regional Bread Wheat Yield Trial for Favorable Areas. At most test sites, the yield of line #20 was higher than the site mean yield. These results shows that line #20 (Seri 82//Vee's'/Snb's') combines high yield and yield stability and as a consequence wide adaptation. Similarly, the performance of line # 7(Chil's'//Vee's'/Tsi) across all 19 test sites of RWYT-SA exhibited its high yield and yield stability (Figure 4.4). Thus in addition to germplasm that exhibit high yield and specific adaptation, many lines in the germplasm provided by CIMMYT/ICARDA program express wide adaptation as well.

(O. Abdalla, M. Assad Mousa, A. Yaljarouka, WANA NARS)

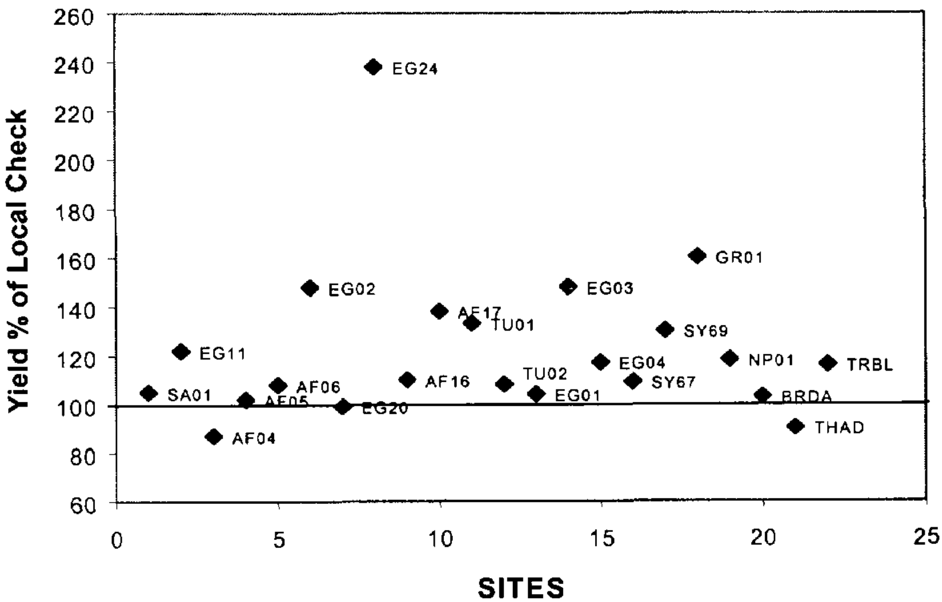

Figure 4.1. Performance of Top 3 Cultivars at Each Location Relative to the Local Check, RWYT-FA, 1996/97.

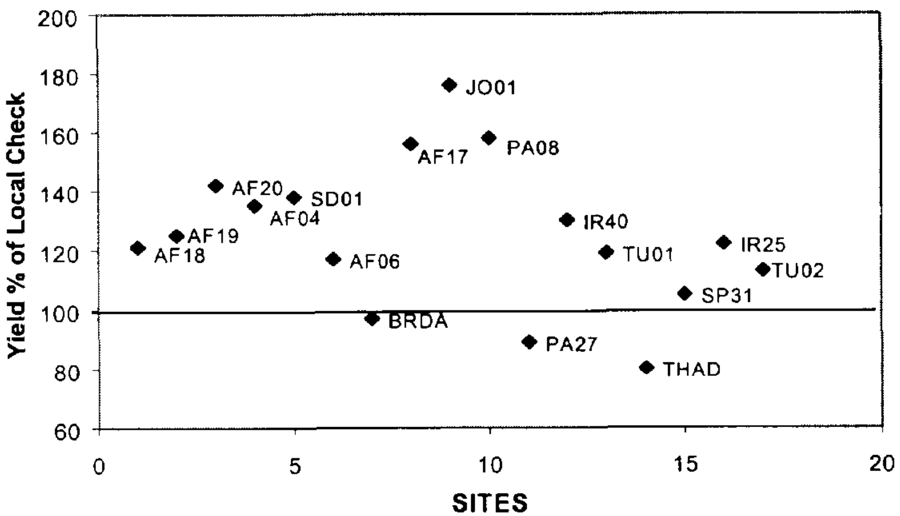

Figure 4.2. Performance of Top 3 Cultivars at Each Location Relative to the Local Check, RWYT-SA, 1996/97.

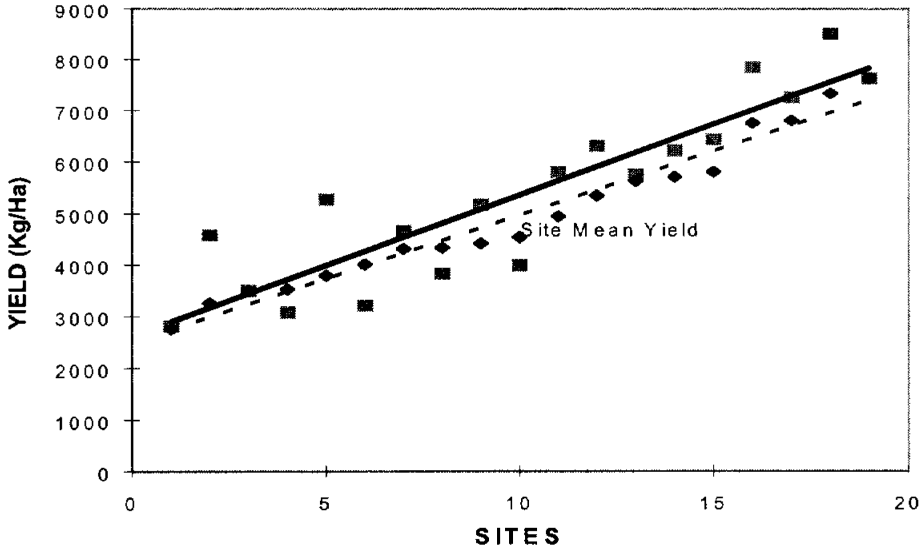

Figure 4.3. Yield Of Advance Line #20 across 19 Locations in the RWYT-FA, 1996/97.

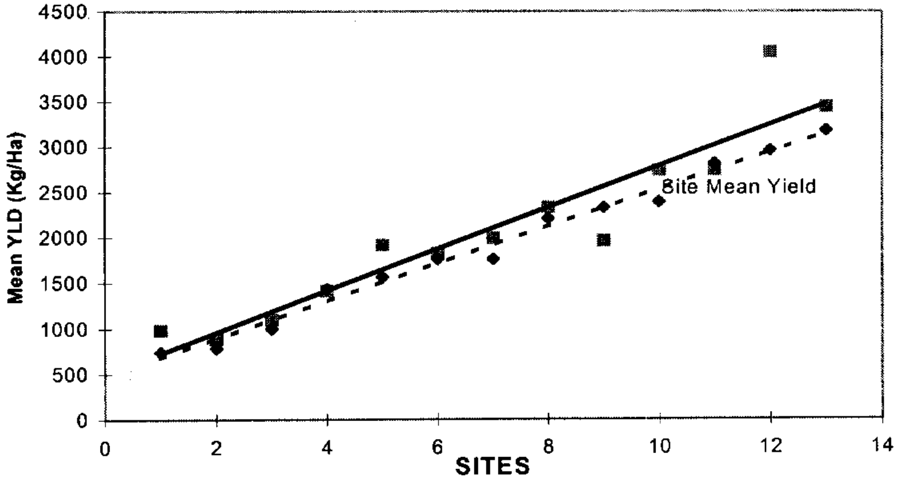

Figure 4.4. Yield of Advance Line # 7 across Dryland Sites in the RWYT-Semi-arid, 1996/97.

4.1.9. Interaction with NARS

4.1.9.1. On-Farm Verification Trials - Syria

Collaborative research with the Syrian national program aims at identifying new bread wheat cultivars with better yield, yield stability, quality, disease resistance and tolerance to abiotic stresses than the best improved varieties currently under cultivation. On-going research activities are directed towards the main areas of wheat cultivation in Syria, namely:

(I) Irrigated or supplementary irrigation areas

(ii) Areas with >350 mm rainfall (Zone "A") and

(iii) Areas with 250 - 350 mm rainfall (Zone "B").

Results of on-farm verification yield trials in Syria showed that the improved line "Bloyka", derived from CIMMYT/ICARDA germplasm, is promising in Zone "A". Its combined yield performs across all test sites showed 7% yield advantage over the improved check "Cham 4" (Table 4.6). In addition, "BLOYKA" exhibited high yield stability outyielding "Cham 4", the main and widely cultivated variety in the zone, in 8 out of the 10 test sites (Figure 4.5).

(A. Shehada, O. Abdalla, H. Hamzeh, M. Michael, M. Assad Mousa, A. Yaljarouka)

Table 4.6. Yield of "BLOYKA" Relative to "CHAM-4", Farm Verification, Zone "A", Syria, 1997/98.

CULTIVAR	MEAN* GRAIN YIELD (Kg/ha)	YIELD % CHAM-4
BLOYKA	5385	107
CHAM-4	5043	100
LSD 5%	233	
CV %	8.8	

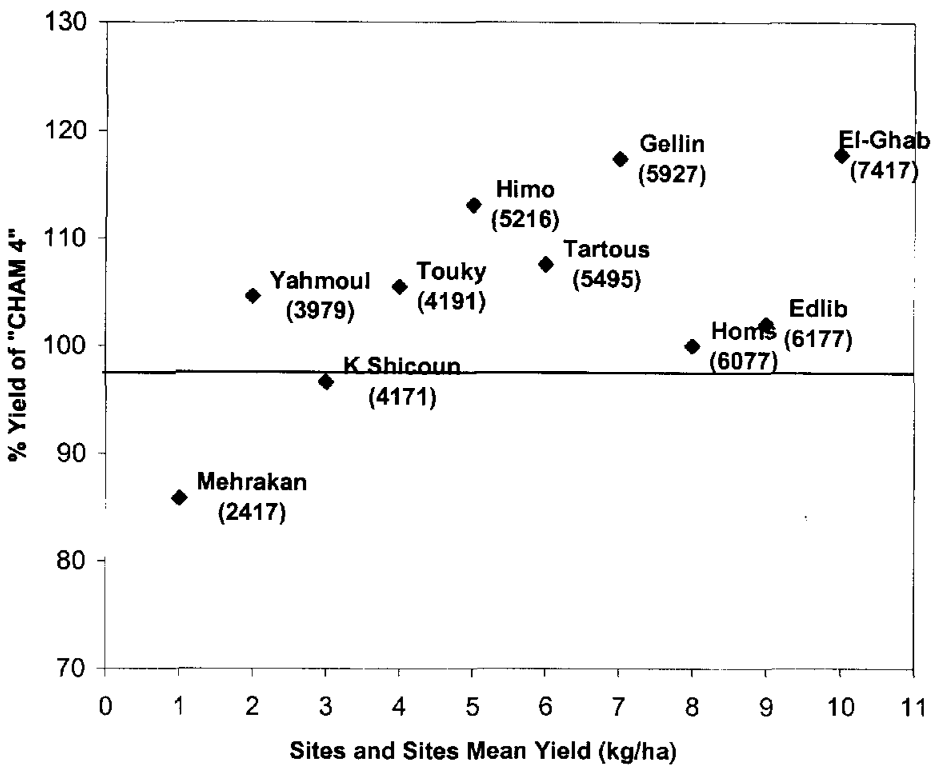

Figure 4.5. Yield Performance of "BLOYKA" Relative to "CHAM-4" - On Farm Trial, Zone A, Syria, 1997/98.

4.1.9.2. On-Farm Verification Trials - Lebanon

Within the frame work of the on-going collaboration between CIMMYT/ICARDA wheat program and the Lebanese Agricultural Research Institute (LARI), new promising bread wheat lines were evaluated on Farmers' fields at 8 locations across Lebanon in 1997/98 season. In general, the results obtained indicate that tested bread wheat genotypes performed well in Central and West Beqaa and in North Lebanon.

"Memof 22" significantly outyielded the check "Nesser" across 4 locations (Table 4.7) and exhibited reasonably high yield under the drier conditions of North Beqaa. However, the good performance of "Memof 22" in low rainfall conditions of North Beqaa needs to be confirmed next season.

In the coastal locations, "Memof 22", "Bocro-1" and "Shuha-1" were superior. "Towpe" was better than "Memof 22" in terms of resistance to yellow rust and outyielded "Nesser" in 3 locations (Table 4.7). Average grain yield for "Towpe" ranged between 1.8 t/ha under low rainfall conditions and 9.3 t/ha under high rainfall environments. "Towpe" is the most preferred cultivar by farmers and it is currently under consideration for release in Lebanon.

(H. Machlab, O. Abdalla, N. Rbeiz, A. Yaljarouka)

Table 4.7. Bread Wheat Grain Yield* on-Farm and Station Verification Trials in Lebanon

	FARM VERIFICATION TRIALS						Station Verification	
Genotype	North Beqaa Houch Snaid	Jabboule	Central Beqaa Barelias	West Beqaa Jeb Jannin	South Lebanon Ansarieh	North Lebanon Akkar	Tel-Amara	Kfardan
Nesser	1.8+/-0.5	NP	7.7+/-0.7	3.8+/-0.7	NP	4.2+/-0.7	3.9+/-0.6	0.9+/-0.4
Memof 22	2.5+/-0.5*	1.3+/-0.2	9.2+/-1.0*	3.8+/-0.7	2.4+/-0.6	5.2+/-0.7*	4.5+/-0.9	2.2+/-0.4*
Towpe	1.8+/-0.4	NP	9.3+/-1.2*	4.4+/-1.3	NP	4.1+/-1.1	4.0+/-0.4	1.6+/-0.2*
Bocro-1	2.2+/-0.7*	1.3+/-0.2	8.3+/-0.4	3.8+/-1.2	2.5+/-0.7	5.4+/-0.5*	4.1+/-1.2	1.2+/-0.6
Shuha-1	2.1+/-0.3	NP	8.0+/-0.7	2.9+/-1.0	NP	6.2+/-0.5*	3.8+/-0.5	1.8+/-0.6*
LSD (0.05)	0.43	0.21	0.87	0.93	0.59	0.74	0.70	0.43
CV %	26 %	18%	10.6%	26%	28%	15.6%	24%	32%

Yield* = t/ha +/- St. Dev. ; * Significantly outyielded Nesser at 5% level; NP = Not planted

(Dr. Hassan Machlab, Project Coordinator, Winter Rainfed Crops Project, LARI, Tel-Amara, Lebanon)

4.1.9.3. Nile Valley and Red Sea Regional Program (NVRSRP)

4.1.9.3.1.Thermo-Tolerance Wheat Network

Promising materials were tested in yield trials in 10 environments in Egypt, Sudan, and Yemen. Seven genotypes gave mean yields greater than the mean yield of the checks (Condor, Debeira, El-Neilain, Giza 164, and Giza 165) across all environments. The genotypes were Condor's' x Baladi, Pfau, Pfau/Vee #5, Attila, Sids 1, Ures 81/Geln 81 and Yemen.

The results on morpho-physiological character studies indicated that grain yield under heat stress is highly associated with high biomass production, canopy temperature depression, number of heads per unit area, kernel weight, and slightly late maturity.

(A. Elahmadi, A. Abdel Shafi, O. Ibrahim, A. Sailan, N. Hadad, O. Abdalla)

4.1.9.3.2. Drought and Water-Use Efficiency Network

Promising lines were tested in a regional yield trial across locations. Seven genotypes proved to be tolerant to moisture stress. Their grain yield ranged from 6 to 6.8 t/ha in Egypt, 2.2 to 2.6 t/ha in Sudan, and 2.4 to 2.8 t/ha in Yemen. These genotypes are:Jup/Zp//Coc/3/Pin/4/Gen, Pfau/Vee no.9//Ures, Vee's'/Bon's', Giza 164, Attila, Yemen and El-Neilain.

(M.G. Mosaad, A. Elahmadi, A. Abdel Shafi, Z. Ali, A. Haider, N. Hadad, O. Abdalla)

4.1.9.4. Agricultural Technology Utilization and Transfer (ATUT) Project

This is a tripartite project involving FCI-ARC, Egypt, ARS-USDA, Beltsville-MD and CIMMYT/ICARDA joint wheat improvement program. The role of CIMMYT/ICARDA SBW program in collaboration with the Pathology and Biotechnology units at ICARDA is to produce Recombinant Inbred Lines (RIL) with and without stripe rust resistance from crosses involving long spike wheat from Egypt. Doubled haploid techniques are used in developing the RIL. The FCI-ARC, Egypt is expected to conduct field evaluation of the derived material while ARS-USDA is expected to develop micro-satellite markers for the major traits (yellow rust resistance, heat tolerance and high tillering capacity) of the derived populations. Sources of yellow rust resistance were identified and crosses involving high tillering yellow rust resistant source and susceptible long spike wheat were made. Currently development of doubled haploids is under way and progress is reported under biotechnology section of this report.

4.1.9.5. In-service training and visiting scientist and Consultation with NARS

Training and consultation with NARS activities conducted during 1997/98 included the following:

- At ICARDA hands-on training on breeding techniques and selection was conducted for two individual trainees from Egypt and Syria. The duration of the training was 6 weeks.
- Logistical support and orientation was provided to In-service trainees from WANA Region (Sudan, Egypt and Tunisia) who attended 1998 Wheat Improvement Training in Mexico.

- One M.Sc. student, from Sudan, was attended to and assisted in conducting his thesis research in the summer of 1998. His research aims at evaluating progress made in breeding SBW for heat stress.
- A number of visitors to ICARDA were attended to, interacted with and assisted in selecting SBW germplasm relevant to their areas.
- Germplasm selection and evaluation was jointly carried out with the national programs of Sudan, Morocco and Iran.
- Participation in national research planning meetings of Egypt and Syria as well as Regional research coordination and planning meetings of North Africa Regional Program and the Nile Valley and Red Sea Regional Program.

4.2. Pathology

Bread wheat production in the WANA region is highly variable and generally much below the ever increasing demand. Major efforts have been made in increasing total production and productivity of wheat in WANA; nonetheless at the farm level average yields are low due to several production constraints. Among other factors that affect the productivity of bread wheat in WANA, diseases remain the most important constraint. Foliar diseases in particular can be very severe and hence not only reduce the biological yield but also incur other expenses, such as use of fungicides, that are associated with control measures.

The most common wheat diseases in WANA region are the rusts, septoria leaf blotch, and common bunt. CIMMYT/ICARDA regional wheat improvement program has always focused on the development of genetic resistance as its main strategy for disease control. In 1998, over 1200 bread wheat lines were tested at ICARDA (Tel Hedya) for their reaction to prevailing diseases. A total of 325 lines were tested for resistance to a specific disease and 891 lines were tested for resistance to multiple diseases (Table 4.8). Information on disease isolates used and their respective virulence on Known resistant genes are discussed in the IPM report.

Table 4.8. Bread wheat germplasm (number of entries) screened for resistance to rust, septoria and common bunt under artificial inoculation (Field & Plastic house)

Breeding Nursery screened	Total No. Entries	Wheat Diseases used for screening *				
		Y.rust	L.rust	S.rust	Sept.	C.bunt
WYR (Yellow rust)	50	+				
WLR (Leaf rust)	50		+			
WSR (Stem rust)	45			+		
WST (Septoria)	40				+	
WKL (Common Bunt)	140					+
WPD (Prel.Yd Trial)	470	+	+	+	+	+
WAC (Aleppo CB)	97	+	+	+	+	+
WKL (Key Loc.Nur)	270	+	+	+	+	+
DOUMA (SYR.Nur)	54	+	+	+	+	+
Total	1216	941	941	936	931	1031

* Syrian local isolates were used for artificial inoculation

4.2.1. Evaluation of Bread Wheat Nurseries for Disease Resistance

4.2.1.1. Resistance to Rusts, Septoria Leaf Blotch, and Common Bunt

The bread wheat germplasm tested showed a good level of resistance particularly to leaf and stripe rust. Resistance to stem rust and septoria leaf blotch and common bunt was relatively very low (Figures 4.6 & 4.7).

Figure 4.6 shows the frequency distribution of resistance level within special bread wheat nurseries. Selected lines from these nurseries will be recommended for use in breeding programs as sources of resistance. In the special leaf and stripe rust nurseries (WLR & WYR) about 50% of the entries showed good resistance. The number of resistant lines within the stem rust (WSR) and the septoria (WST) nurseries did not exceed 20%. Over 90% of the lines tested were susceptible to common bunt (WKL-B) (Figure 4.6). With regard to septoria about 20% of the lines showed an intermediate type of resistance. This kind of resistance is considered as tolerant and could be exploited by the breeding programs. Complete resistance to bunt is very low among the material tested, however the intermediate type of resistance should be also maintained and used to develop tolerance within breeding material (Fig.4.6).

Figure 4.7 shows the level of resistance (in %) to rusts and septoria leaf blotch among breeding nurseries such as: key location (WKL), preliminary yield trials (WPD), and Aleppo Crossing block (WAC. WAC showed the highest number of resistant lines to leaf rust and septoria (Fig.4.7). WPD contained the highest frequency (60%) of yellow rust resistant lines. Selected lines from WPD could be recommended in areas where yellow rust is predominant. Better sources of resistance to septoria and stem rust need to be incorporated in such nurseries as WPD and WAC.

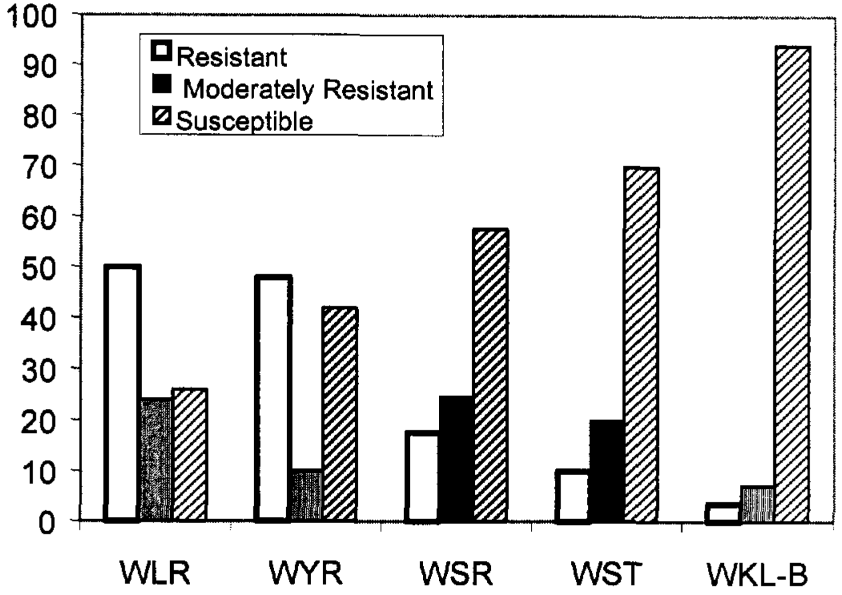

Figure 4.6. Frequency Distribution of Disease Reaction in 325 Bread Wheat Lines.

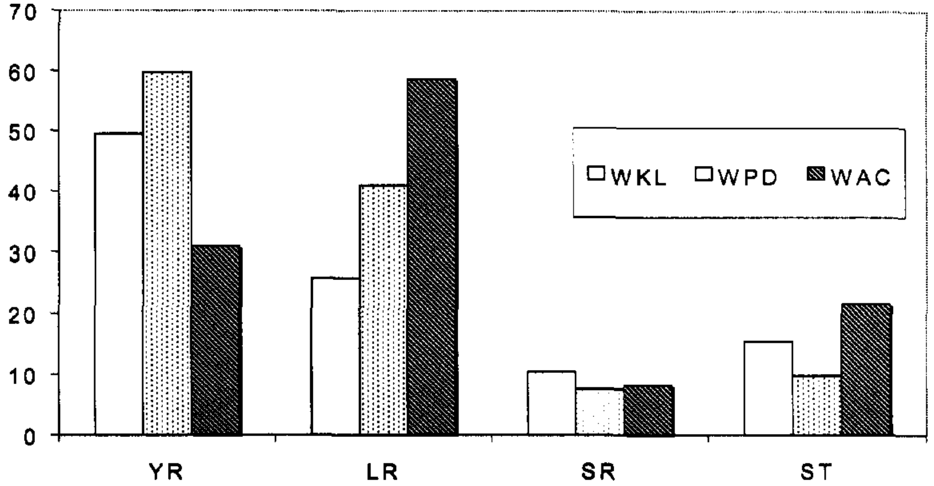

Figure 4.7. Frequency Distribution of Resistant Bread Wheat Lines to Rusts and Septoria tritici in Selected Nurseries.

4.2.1.2. Resistance to Disease Combinations

Under field conditions more often diseases infection can be due to combinations of different pathogens. Hence, germplasm within the advanced breeding nurseries was tested for combinations of rust diseases and rusts and septoria. About 840 entries within the WKL, WPD, and WAC nurseries were tested.

Figure 4.8 shows the relative distribution (in %) of resistant lines to combination of diseases. The highest level of resistant lines (121 genotypes-25.7%) combining both stripe and leaf rust resistance was observed in WPD nursery. In WAC nursery 18.5% of the entries combined resistance to both leaf and stem rusts, 16.5% combined stripe and leaf rust resistance and 10.3% combined stripe and stem rust resistance. Fewer lines showed combined resistance to septoria and rust diseases (Fig.4.9).

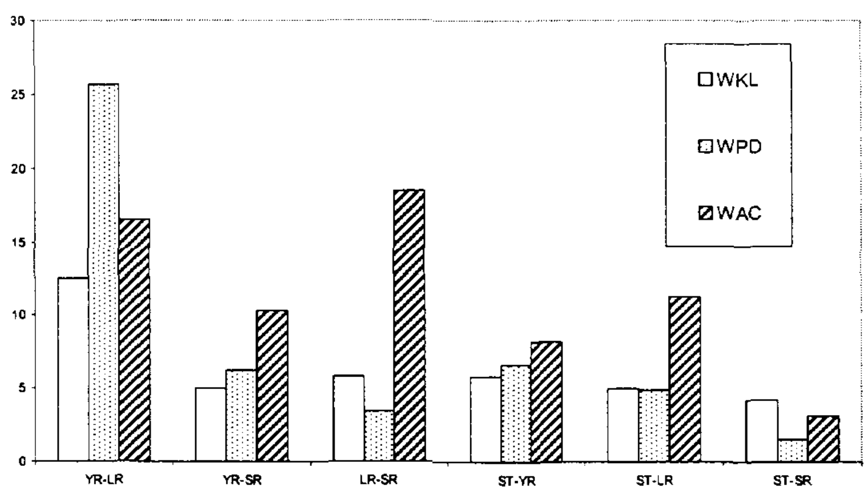

Figure 4.8. Frequency Distribution of Resistant Bread Wheat Lines to a Combination of Diseases in Selected Nurseries

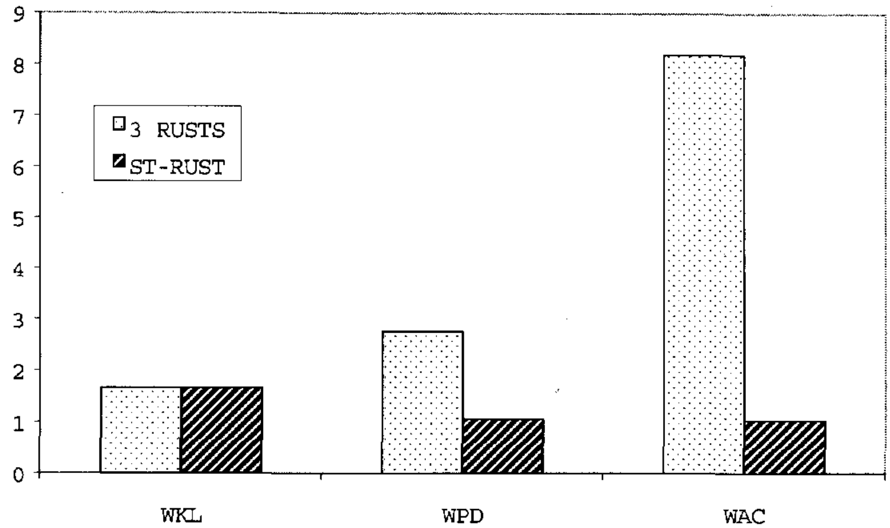

Figure 4.9. Frequency Distribution of Resistant Bread Wheat Lines to Multiple Diseases in Selected Nurseries.

A number of valuable genotypes (Table 4.9) exhibited good resistance to all three rusts. Lines that showed good resistance to septoria, stripe rust and leaf rust are listed in table 4.10. Lines resistant to septoria, leaf rust and stem rust are listed in table 4.11, and those resistant to septoria, stripe rust and stem rust are shown in table 4.12. The genotypes that combine resistance to septoria and to the three rusts are listed in Table 4.13. These genotypes confer a good resistance level for the predominant diseases in WANA region and therefore they will be utilized extensively in the crossing program.

Table 4.9. Resistant Bread Wheat Lines with combined resistance to Stripe, Leaf, and Stem Rust.

Nursery	ENT	Name	Pedigree
WKL98			
	4	PRL'S'/PEW'S'//V763-153	ICW93-0332-1AP-0L-9AP-0L-0AP
	21	ANZA/KATYA A-1//BORO'S'	ICW92-0504-1AP-0L-0BR-0AP
	41	TRACHA'S'//CMH76-252/PVN'S'	ICW93-0065-8AP-0L-1AP-0L-0AP
	59	BOCRO-2	CM 69599-4AP-2AP-2AP-0AP
	101	TINAMOU	CM 81812-12Y-06PZ-4Y-1M-0Y-5M-0Y-3SJ-0Y
WPD98			
	93	HUDHUD-1	ICW92-0609-1AP-1AP-1AP-0AP
	97	HUDHUD-10	ICW92-0609-1AP-4AP-4AP-0AP
	121	CHIL'S'/MILLAWA	ICW93-0112-1AP-0L-4PH-0AP-0AP
	164	BACANORA 86/4/FCT/3/GOV/AZ//MUS	ICW93-0273-1AP-0L-4AP-0L-1AP-0AP
	197	CHORIZO/3/NAC//F76/ALD'S'	ICW93-0570-1AP-0L-7AP-0L-2AP-0AP
	257	TEVEE'S'/SHUHA'S'	ICW92-0598-3AP-0L-3AP-0L-1AP-0AP
	259	TEVEE'S'/SHUHA'S'	ICW92-0598-11AP-0L-6AP-0L-1AP-0A
	261	TEVEE'S'/SHUHA'S'	ICW92-0598-11AP-0L-6AP-0L-2AP-0A
	277	TRACHA'S'//CMH76-252/PVN'S'	ICW93-0065-6AP-0L-1AP-0L-1AP-0AP
	322	TEVEE'S'//BOL'S'/PVN'S'	ICW91-0233-0TS-6AP-1AP-3AP-3AP-0
	325	TEVEE'S'//BOL'S'/PVN'S'	ICW91-0233-0TS-6AP-1AP-1AP-2AP-0
	326	TEVEE'S'//BOL'S'/PVN'S'	ICW91-0233-0TS-6AP-1AP-2AP-1AP-0
	327	TEVEE'S'//BOL'S'/PVN'S'	ICW91-0233-0TS-6AP-1AP-2AP-2AP-0
	406	KAUZ'S'/3/Tx62A4793-7/CD809//VEE'S'	ICW91-0310-0Br-8AP-3AP-0L-0BR-1A
WAC98			
	35	F//68.44/NAT/3/CUC'S'/4/ALGERIA.M 28	ICW89-0293-2AP-0AP-2AP-0TS-0AP
	36	SAKER/5/RBS/ANZA/3/KVZ/HYS//YMH/TOB/4/BOW'	ICW88-0209-3AP-0L-5AP-0L-0AP
	39	TEVEE'S'//BOBWHITE #1	ICW89-0273-4AP-0L-1AP-0AP-2AP-0TS-0AP
	40	MAYA'S'/SAP'S'	CM59008-6AP-1AP-4AP-2AP-2AP-0AP
	58	GV/Ald'S'/5/Ald'S'/4/BB/G11//CNO67/7C/3/KVZ/TI	ICW87-0092-0AP-2AP-0L-2AP-0L-0AP
	62	FLORKWA-2	ICW84-0074-09AP-300L-1AP-300L-8AP-0L
	83	HYS//DRC*2/7C	SWM 72394-4H-1H-1P-S
	90	CC//CAL/SE/3/K3L/BB/4/NS732/HER	466-91 HBW9-2

Table 4.10. Bread Wheat Lines with combined resistance to Septoria, Stripe, and Leaf Rust

Nursery	Ent	Name	Pedigree
WKL98			
	51	TEVEE'S'//BOL'S'/PVN'S'	ICW91-0233-0TS-6AP-1AP-2AP-0AP
	101	TINAMOU	CM 81812-12Y-06PZ-4Y-1M-0Y-5M-0Y-3SJ-0Y
WPD98			
	135	BOCRO'S'/BAU'S'	ICW91-0682-4AP-0AP-1AP-1AP-0AP
	3	ZIDANE 89/3/PEG'S'//HD2206/HORK'S'	ICW93-0020-3AP-0L-4AP-0AP
	16	KAVZ'S'/CHORIZO	ICW93-0122-7AP-0L-1AP-0AP
	18	KAVZ'S'/CHORIZO	ICW93-0122-7AP-0L-5AP-0AP
	52	CHIL'S'//TSI/SNB'S'	ICW92-0600-1AP-2AP-2AP-0AP
	54	CHIL'S'//TSI/SNB'S'	ICW92-0600-1AP-3AP-3AP-0AP
	93	HUDHUD-1	ICW92-0609-1AP-1AP-1AP-0AP
	97	HUDHUD-10	ICW92-0609-1AP-4AP-4AP-0AP
	139	CHIL'S'/CV.BURGAS 2	ICW93-0108-1AP-0L-2AP-0L-4AP-0AP
	323	TEVEE'S'//BOL'S'/PVN'S'	ICW91-0233-0TS-6AP-1AP-3AP-4AP-0
	324	TEVEE'S'//BOL'S'/PVN'S'	ICW91-0233-0TS-6AP-1AP-1AP-1AP-0
	325	TEVEE'S'//BOL'S'/PVN'S'	ICW91-0233-0TS-6AP-1AP-1AP-2AP-0
	326	TEVEE'S'//BOL'S'/PVN'S'	ICW91-0233-0TS-6AP-1AP-2AP-1AP-0
	378	STAR'S'/LIZ	ICW92-0751-0AP-1AP-0L-3AP-0L-1AP
	379	STAR'S'/LIZ	ICW92-0751-0AP-1AP-0L-3AP-0L-2AP
	386	NS732/HER/4/VEE'S'/3/R37/GH1121//KAL/BB	ICW91-0279-1AP-0TS-5AP-0L-0BR-2A
	387	NS732/HER/4/VEE'S'/3/R37/GH1121//KAL/BB	ICW91-0279-2AP-0TS-1AP-0L-0BR-1A
	406	KAUZ'S'/3/TX62A4793-7/CD809//VEE'S'	ICW91-0310-0Br-8AP-3AP-0L-0BR-1A
	429	CHIL/2*STAR	CM 112793-0TOPY-7M-020Y-010M-2Y-
WAC98			
	68	HENNE/PGO	CM 103540-0AP-0L-6AP-0TS-0AP
	76	KACINO	
	83	HYS//DRC*2/7C	SWM 72394-4H-1H-1P-S

Table 4.11. Bread Wheat Lines with combined resistance to Septoria, Leaf and Stem Rusts

Nursery	Ent	Name	Pedigree
WKL98			
	93	CATBIRD	CM 91045-5Y-0M-0Y-4M-7Y-0B-1M-0Y-2M-010Y
	94	TOW/SARA//BAU	CM 91961-M-0Y-0M-0Y-2M-0Y-2SJ-010Y-0M-2S
	95	TOW/SARA//BAU	CM 91961-M-0Y-0M-0Y-2M-0Y-2SJ-010Y-0M-3S
	101	TINAMOU	CM 81812-12Y-06PZ-4Y-1M-0Y-5M-0Y-3SJ-0Y
	102	CATBIRD	CM 91045-5Y-0M-0Y-4M-4Y-1M-0Y-4SJ-0Y
	103	CATBIRD	CM 91045-5Y-0M-0Y-4M-7Y-0B-0FC-2PZ-0Y
	104	CATBIRD	CM 91045-5Y-0M-0Y-4M-7Y-0B-0FC-4PZ-0Y
	105	CATBIRD	CM 91045-5Y-0M-0Y-4M-9Y-3M-0Y-4SJ-0Y
WPD98			
	93	HUDHUD-1	ICW92-0609-1AP-1AP-1AP-0AP
	97	HUDHUD-10	ICW92-0609-1AP-4AP-4AP-0AP
	325	TEVEE'S'//BOL'S'/PVN'S'	ICW91-0233-0TS-6AP-1AP-1AP-2AP-0
	326	TEVEE'S'//BOL'S'/PVN'S'	ICW91-0233-0TS-6AP-1AP-2AP-1AP-0
	406	KAUZ'S'/3/TX62A4793-7/CD809//VEE'S'	ICW91-0310-0Br-8AP-3AP-0L-0BR-1A
WAC98			
	51	BOBWHITE#1/FENGKANG 15	ICW88-0061-8AP-0L-3AP-0L-1AP-0AP
	83	HYS//DRC*2/7C	SWM 72394-4H-1H-1P-S

Table 4.12. Bread Wheat Lines with combined resistance to Septoria Stripe, and Stem Rusts.

Nursery	Ent	Name	Pedigree
WKL98			
	82	GOV/AZ//MUS/3/DODO/4/BOW	CM 79515-044Y-1M-02Y-07M-3Y-3B-0Y-0PZ-2M
	83	GOV/AZ//MUS/3/DODO/4/BOW	CM 79515-044Y-1M-02Y-07M-3Y-3B-0Y-0PZ-2P
	101	TINAMOU	CM 81812-12Y-06PZ-4Y-1M-0Y-5M-0Y-3SJ-0Y
WPD98			
	93	HUDHUD-1	ICW92-0609-1AP-1AP-1AP-0AP
	95	HUDHUD-7	ICW92-0609-1AP-3AP-1AP-0AP
	96	HUDHUD-8	ICW92-0609-1AP-4AP-3AP-0AP
	97	HUDHUD-10	ICW92-0609-1AP-4AP-4AP-0AP
	325	TEVEE'S'//BOL'S'/PVN'S'	ICW91-0233-0TS-6AP-1AP-1AP-2AP-0
	326	TEVEE'S'//BOL'S'/PVN'S'	ICW91-0233-0TS-6AP-1AP-2AP-1AP-0
	406	KAUZ'S'/3/TX62A4793-7/CD809//VEE'S'	ICW91-0310-0Br-8AP-3AP-0L-0BR-1A
WAC98			
	83	HYS//DRC*2/7C	SWM 72394-4H-1H-1P-S

Table 4.13. Bread Wheat Lines with combined resistance to Septoria, Stripe, Leaf and Stem Rusts.

Nursery	Ent	Name	Pedigree
WKL98			
	101	TINAMOU	CM 81812-12Y-06PZ-4Y-1M-0Y-5M-0Y-3SJ-0Y
	93	HUDHUD-1	ICW92-0609-1AP-1AP-1AP-0AP
	97	HUDHUD-10	ICW92-0609-1AP-4AP-4AP-0AP
WPD98			
	325	TEVEE'S'//BOL'S'/PVN'S'	ICW91-0233-0TS-6AP-1AP-1AP-2AP-0
	326	TEVEE'S'//BOL'S'/PVN'S'	ICW91-0233-0TS-6AP-1AP-2AP-1AP-0
	406	KAUZ'S'/3/TX62A4793-7/CD809//VEE'S'	ICW91-0310-0Br-8AP-3AP-0L-0BR-1A
WAC98			
	83	HYS//DRC*2/7C	SWM 72394-4H-1H-1P-S

4.2.2. Prospects for Breeding for Disease Resistance in Bread Wheat

Development of resistant germplasm should be targeted to specific agro-ecological zones within WANA where given biotic stresses are predominant such as septoria and leaf rust in North Africa, leaf, stripe and stem rusts in the Nile Valley region, and stripe rust in West Asia. Currently, at CIMMYT/ICARDA program, the level of resistance within the spring bread wheat germplasm is good for diseases such as leaf rust and stripe rust but it is not adequate for septoria, stem rust and multiple disease combinations.

To achieve the objectives of disease resistance breeding the following activities are expected to continue or will be initiated in the future:

1) Target prevalent diseases within the different agro-ecological zones in WANA,
2) Evaluate germplasm, in collaboration with NARS, for specific diseases at hotspots representative of a given agro-ecological zone,
3) Study the effectiveness of known resistance genes for incorporation in specific crosses,
4) Develop and adopt marker-assisted selection and new biotechnology tools to monitor and recombine resistance genes,
5) Initiate an integrated disease management approach, at the farm- level, to reinforce the collaboration with farmers and attempt to develop cost-effective and environmentally safe disease management control measures.

(Amor Yahyaoui, H. Toubia Rahme, O. Abdalla, M. Al Naimi, I.Maaz)

4.3. Virology

4.3.1. Evaluation of Best Performing Bread Wheat Genotypes from Previous Seasons

Re-evaluation of bread wheat lines from previous seasons identified some entries, which are highly tolerant to BYDV, as their yield was not seriously affected by virus infection. Out of 44 bread wheat genotypes evaluated, many lines were highly tolerant to BYDV infection e.g. WKL-96-30, WCB-96-9, PS-97-7, PS-97-61, Sel-Str-96-2, Sel-Str-96-18, WW-97-76 and Can-93-21. (Tables 4.14).

Table 4.14. *Re-evaluation of best performing spring bread wheat lines for their reaction to BYDV infection after artificial inoculation with the virus, on the basis of symptoms disease index (D.I.), grain yield and yield loss (%), during the 1997/98 growing season.*

Entry	D.I.(0-9)	Gr. wt.(g/m)	Yield loss(%)
WKL-96-4	4.0	208	29.9
WKL-96-30	4.5	240	17.9
WKL-96-109	4.5	188	34.5
WKL-96-110	4.0	211	36.3
WCB-96-9	4.0	242	23.0
WCB-96-26	4.0	206	45.1
WCB-96-75	4.5	198	44.1
WKL-97-6	5.5	240	35.2
WKL-97-9	5.5	220	25.8
WKL-97-17	5.5	247	29.2
WKL-97-28	4.5	203	42.5
WKL-97-61	5.0	172	48.6
WKL-97-84	4.5	244	39.3
PS-97-7	4.5	208	18.8
PS-97-19	4.5	226	16.0
PS-97-27	4.5	193	30.3
PS-97-31	6.5	196	35.0
PS-97-34	4.0	197	20.7
PS-97-61	4.5	202	13.4
Maringa	4.0	193	18.3
82Hari-776	4.5	212	24.5
12^{th}-IBW-459 (Susc. Check)	8.8	121	54.0

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

A total of 1020 wheat lines were evaluated in 30 cm short rows based on the symptoms produced following BYDV inoculation. Results obtained suggested that 134 lines (13.1%) were tolerant to infection (Table 4.15).

When 84 bread wheat lines, which have been tested in the previous season in 30-cm short rows, were evaluated for their reaction to BYDV in 1-m long rows during the 1997/98 growing season, some lines showed high tolerance to BYDV infection. Results of the best performing lines are presented in Table 4.16.

(K.M. Makkouk, W. Ghulam)

Table 4.15. Evaluation of wheat germplasm in short 30 cm rows for tolerance to BYDV infection after artificial inoculation with the virus during the 1997/1998 growing season.

Cereal nursery	Number of Lines tested	Lines with tolerance to infection
Bread Wheat		
WKL- 1998	240	2, 4, 13, 18, 21, 28, 30, 31, 50, 57, 63, 73, 110, 115, 119, 144, 165, 177, 178, 179, 183, 185, 193, 203, 206, 211, 212, 217, 224, 228, 231, 234
WON-FA-1998	148	37, 51, 55, 78, 79, 81, 85, 97, 98, 99, 103, 106, 111, 112, 123, 130, 138, 140, 144, 146
WON-SA-1998	182	1, 8, 10, 15, 20, 32, 41, 47, 62, 63, 76, 77, 81, 137, 157, 165, 176, 180

Table 4.16. Performance of selected spring and winter bread wheat lines provided by the breeders at ICARDA and planted in 1 m rows showing tolerance to BYDV infection after re-evaluation, during the 1997/98 growing season.

Entry	D.I. (0-9)	Gr.wt. (g/m)
Spring Wheat		
WKL-97-3	4.0	196
WKL-97-6	4.0	181
WKL-97-41	5.0	163
WKL-97-68	5.0	138
WKL-97-94	6.0	132
WKL-97-97	4.5	148
WKL-97-130	5.0	168
WKL-97-151	5.0	152
WKL-97-169	4.0	155
WKL-97-177	5.0	141
WKL-97-178	5.0	152
WKL-97-186	4.0	141
PS-97-7	4.5	124
PS-97-19	3.5	126
PS-97-29	4.0	134
PS-97-31	4.0	143
PS-97-34	5.0	106
PS-97-54	4.0	115
PS-97-61	3.0	139
PS-97-63	4.0	118
PS-97-67	5.0	134

4.4. Entomology

4.4.1. Identification of Resistance Sources to Hessian Fly in Spring Bread Wheat

Hessian Fly (HF) is a serious insect pest on wheat in North Africa (Morocco, Algeria and Tunisia) and Southern Europe (Spain and Portugal). Among the biotic constraints, Hessian fly (HF) damage is considered to be the most important constraint limiting the productivity of wheat in North Africa. In Morocco, bread wheat yield losses due to Hessian fly have been estimated at 36%. However, if high infestations occur in the early stages of the crop development, studies have shown that damage caused by Hessian fly can result in total loss of the crop.

For long-term crop protection, breeding genetic resistance in adapted cultivars has been identified as the most practical and economic control method for Hessian fly. Through the collaborative research between the National Institute of Agricultural Research (INRA, Morocco), and CIMMYT/ICARDA spring bread wheat program, some progress has been made with host plant resistance to control the damage of this insect. Screening bread wheat germplasm at Hessian fly "hot spots" in Morocco has identified several sources of resistance. Table 4.17 lists bread wheat lines that combine Hessian fly resistance and drought tolerance identified in Jemma Sahim, HF hot spot, during 1997/98 season.

4.4.2. Broadening the Genetic Base of Hessian Fly Resistance in Spring Bread Wheat

The genetic interaction between wheat and Hessian fly is highly specific and consistent with a gene-for-gene relationship. Because of this highly specific interaction system between the host and the insect, often virulent biotypes evolve when few resistance genes are deployed on vast acreage for several years. The evolution of biotypes is a selection phenomenon that is challenging breeders and entomologists to continually find new sources of resistance and to properly combine and deploy the existing genes to increase their durability.

Recently, the collaborative research on Hessian fly between INRA (Morocco) and CIMMYT/ICARDA durum wheat program has developed resistant lines through the introgression of H5 gene from bread wheat to durum wheat. Since H5 is major resistance gene in most HF resistant bread wheat cultivars in Morocco, this will greatly increase the vulnerability of both durum and bread wheat to new biotypes of Hessian fly. To avoid such a problem, CIMMYT/ICARDA spring bread wheat program has started combining different resistance genes to broaden the genetic base of resistance. Special emphasis is being made to incorporate resistance genes located on the D-genome since durum wheat lacks the D-genome. Table 4.18 list sources of HF resistance currently utilized in the program and indicates the resistance genes involved. It should be noted that some of the HF resistant lines combine as well resistance to Russian Wheat Aphid (RWA) or Wheat Stem Sawfly (WSSF). Currently there is an attempt to utilize multiple insect pest resistance in crossing program (Table 4.18).

Table 4.17. Drought Tolerant & Hessian Fly Resistant Bread Wheat Lines -Morocco, 1998

WON-SA 1997/98	Line
Plot No.	
22	NS732/HER//KAUZ'S'
84	CHAM-6/SHUHA'S'
88	CHAM-6/TRACHA'S'
98	CHAM-6/KAUZ'S'
166	TEVEE'S'/KAUZ'S'
RWYT-SA 1997/98	
Entry No.	
5	DOVIN-1
17	NS723/HER//KAUZ's'
22	CC//CAL/SE/3/KAL/BB/4/NS723/HER

Table 4.18 Sources of Resistance to Hessian Fly, Russian Wheat Aphid and Wheat Stem Saw Fly

Line	Origin	Gene	Pest Resistance
JOUDA/SAADA	INRA-MOROCCO	H5	HF + RWA
JOUDA/KS811261-5	INRA-MOROCCO	H13	HF
NASMA*2/261-9	INRA-MOROCCO	H13	HF
POTAM*2/KS811261-8	INRA-MOROCCO	H13	HF + WSSF
NASMA*2/14-2	INRA-MOROCCO	H22	HF + RWA
SAIS*3/14-2	INRA-MOROCCO	H22	HF

HF= Hessian Fly; RWA= Russian Wheat Aphid; WSSF= Wheat Stem Saw Fly

4.5. Biotechnology

4.5.1. Development of Mapping Populations by the Doubled Haploid Techniques in Spring Bread Wheat

Bread wheat lines with heat tolerance and resistance to yellow rust are needed for Egyptian farming conditions. To analyze the inheritance of these most important traits, crosses introducing yellow rust resistance into lines with the long spike character were developed and subsequently subjected to doubled haploid production.

The crosses Giza 164 x Wyr 96 #2 and Sids 6 x Wyr-96 #2 were performed under controlled environmental conditions in a plastic-house. Wyr96 being a source of Yellow rust resistance, Giza 164 being heat tolerant line and Sids 6 possessing the long spike character. One plant each of the respective parent was crossed with one plant of the corresponding parent. For the cross Sids 6 x Wyr-96 #2, a total of 9 F1 plants and for Giza 164 x Wyr-96 #2, a total of 14 F1 plants were embryo-rescued after the initial cross to speed up population development. The F1 plants were then planted in pots and grown as donor plants for anther culture under controlled environmental conditions. Of the 14 F1 plants used for anther culture for the cross Giza 164 x Wyr-96 #2, 9977 calli developed, and they gave rise to 500 green plantlets. Of the 9 F1 plants used for anther culture for the cross Sids 6 x Wyr-96, 4483 calli developed, and they gave rise to 200 green plantlets. Since doubling rate of 80% after colchicine treatment is common, a number of 150 fertile DH lines are expected. This number will be sufficient for QTL analysis.

(S. Tawkaz, M. Baum, O. Abdalla)

5. FACULTATIVE AND WINTER BREAD WHEAT

Introduction

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

The 1997-1998 season was characterized by high rainfall in most of the CWANA region, and a closer collaboration with ICARDA partners in the improvement of winter and facultative bread wheat.

As in the previous season, the major component of the breeding work is conducted in Turkey, while research at ICARDA, Syria concentrates on germplasm enhancement through crossing with adapted winter, facultative and spring bread wheat, and on the evaluation of the facultative and winter wheat germplasm for response to different diseases and insect pests. Special studies are also conducted to support the breeding work. A particular emphasis is placed on collaboration with Iran where rainfed winter wheat covers wide areas, and is subject to drought and diseases.

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

(H. Ketata)

5.1. Growing Conditions

Climatic conditions in Turkey were marked by a relatively mild winter and favorable rainfall, in most of the country, including the Central Anatolian Plateau. Lodging was frequently observed, particularly in eastern Turkey (Diyarbakir) and in the Eskisehir region. Yellow rust was important throughout the country, but sunn pest was not a major problem. In Syria, the season was characterized by mild winter, high rainfall, and hot weather in late spring and throughout the summer (Table 5.1). The temperature pattern was similar at all 4 sites, but winter was colder and longer at Konya and Maragheh, and much milder and shorter at Tel Hadya; the Sarghaya site is more representative of the North African highlands, with milder winter than in the Central Anatolian Plateau but higher risk of spring frost. Crop development at Tel Hadya was good in the irrigated field (with 20 mm irrigation, applied mid May 1998), but suffered from terminal heat/drought in the rainfed field, with yield averages around 5.0 t/ha and 4.3 t/ha in the irrigated and rainfed fields, respectively.

Yellow rust developed well in all nurseries at Tel Hadya, as a result of rainy weather and timely sprinkler irrigation. Leaf rust was also observed at Tel Hadya on late-maturing susceptible types, including those of the crossing-block and the preliminary yield trials.

In Iran, the growing conditions of the rainfed winter wheat areas were generally above average. However, differences in climatic conditions did exist among regions. A major heat wave swept the whole country towards flowering time. This checked the development of diseases but also affected yields in certain areas. In the Maragheh region, rainfall was above normal (347 mm), but October was dry, which affected stand establishment, and winter was cold with 125 days with below-freezing temperatures.

Table 5.1. Meteorological data for four testing sites, 1997-1998 season.

	Konya, Turkey			Sarghaya, Syria			Tel Hadya, Syria			Maragheh, Iran		
	Max *	Min	Rnf	Max	Min	Rnf	Max	Min	Rnf	Max	Min	Rnf
Sep	30.0	1.2	16			18	37.8	9.4	18			
Oct	27.0	0.4	93	29.0	- 3.0	14	36.4	7.8	36	25.0	0.5	7
Nov	19.4	- 4.2	16	29.0	- 3.5	69	24.8	0.8	38	13.5	- 7.0	48
Dec	14.2	-11.4	23	15.0	- 6.0	130	18.2	-3.3	62	13.0	-15.0	23
Jan	13.8	-11.7	9	12.0	-12.0	144	17.4	-5.8	84	2.5	-18.5	64
Feb	15.6	- 8.8	18	16.0	-12.0	64	20.8	-6.2	38	5.0	-17.6	34
Mar	19.8	-10.4	37	20.0	- 7.0	154	25.9	-1.1	59	14.5	-11.0	96
Apr	30.0	- 2.7	28	37.0	- 5.0	27	34.1	3.7	64	24.5	- 2.0	52
May	27.8	5.2	59	35.0	- 3.0	4	35.5	7.0	12	28.0	1.5	17
Jun	33.0	9.4	17	35.0	0.0	0	41.5	11.9	0	35.0	5.0	6
Jul	38.2	13.0	0				45.5	18.6	0	35.5	9.5	1
Tot			316			624			411			340

* Max and Min: absolute maximum and minimum temperature; Rnf: rainfall in mm

(H. Ketata)

5.2. Germplasm Development and Screening

A total of 1501 crosses were successfully made in 1998, at both Izmir-Turkey(349 singles plus 431 top crosses) and Tel Hadya-Syria (410 singles plus 311 top crosses). Table 5.2 lists the number of entries in different nurseries developed and/or screened in each of Turkey and Syria. The entries are different across the two sites for the F1, F2, and F3 nurseries, as different crosses are made at each of the two sites.

Table 5.2. Number of entries in major nurseries grown in Turkey and Syria, 1998.

Nursery	Turkey	Syria
F1	1447*	890
F2	1024	1075
F3	960(645 plus 315)	315
F4 (bulks from Syria)	459	459
Head rows (HR)	35,500	-
PYT (IRR & RF)	2849 (1984 & 865)	2849 (1984 & 865)
YT (IRR & RF)	420 (220 & 200)	420 (220 & 200)
AYT (IRR & RF)	200 (100 & 100)	200 (100 & 100)

* Of which 472 come from Mexico.

At ICARDA, Tel Hadya, all the germplasm was successfully screened for yellow rust, whose development was guaranteed by artificial inoculation and timely sprinkler irrigation. PYT entries were also screened for common bunt resistance. A natural leaf rust infection allowed additional screening for this disease. Table 5.3 shows the best entries from the crossing block (CB) that combined resistance to yellow rust and leaf rust, and that possessed good cold tolerance, as measured under controlled-temperature conditions at ICARDA, Tel Hadya. Advanced breeding lines of the AYT98 were further evaluated for reaction to BYDV, and to the Russian wheat aphid.

Table 5.3. Some characteristics* of most promising entries in the Crossing Block-98.

Name	Source	YR	LR	CT	Other
163HAMIDIYE//VEE/KOEL	CB-09	R	MR	M	Early
88 ZHONG 257//CNO79/PRL	CB-17	R	MR	MR	High tillering
OK82282//BOW/NKT	CB-28	MR	R	M	
TIRCHMIR1/LCO	CB-46	R	R	M	
KS82W409/SPN	CB-50	MR	R	M	
CH75539	CB-69	R	R	R	Late
CHAM6//1D13.1/MLT	CB-75	R	R	R	Good phenotype
BUL1056.12186	CB-95	MR	R	R	Waxy
F4549-W2-1	CB-99	R	R	MR	
VORONA/HD2402	CB-136	R	R	MR	Short, late
TAST/TRM/3/MLC/4/CWW339.5/SPN	CB-154	R	R	R	Short, late
COLIBRE//09344/AU/3/SDV1	CB-168	R	MR	R	Mid-late
YUMAI15	CB-178	R	MS	MR	Very early
88 ZHONG 257//CNO79/PRL	CB-238	R	R	R	Early
VONA//KS75210/TAM101	CB-240	R	MR	R	
FANDANGO	CB-248	R	R	MR	Late
DARI-16	CB-275	MR	MS	R	Mid-late

* YR: yellow rust, LR: leaf rust, CT: cold tolerance. R=resistant, MR=moderately resistant, MS=moderately susceptible. M=medium.

In Turkey, the high rainfall in most of the country caused a wide-scale disease development. By far, the most frequently observed disease in Turkey was yellow rust, which was noted over Central Anatolia (Ankara, Haymana, Kayseri, etc.), Eastern and Southeastern Anatolia (Erzurum, Elazig, Malatya, Diyarbakir), and in the Transitional Zone (Eskisehir). Root-rot infestation was important in Cumra. At Eskisehir, in addition to yellow rust, the following diseases were observed on suceptible types: leaf rust, powdery mildew, basal glume rot, and tan spot. At Haymana, all the facultative/winter wheat germplasm was screened for the three rusts, despite the moderate hail damage that affected the leaves.

The selection scheme is similar to that described in the previous annual report (1997), with segregating populations evaluated primarily at Konya, Eskisehir, and Ankara in Turkey and at Aleppo-Tel Hadya, Syria; some segregating material was also evaluated by NARS at Maragheh, Iran. Yield performance is primarily evaluated in Turkey. To alleviate the soil problems of Konya, Cumra, and Eskisehir, an attempt was made to include more sites where advanced materials were tested. Again, results accumulated through years point to the usefulness of the Tel Hadya testing for the milder highlands of the region.

Some of the most promising entries from the Preliminary Yield Trials (PYT), Yield Trials (YT), and Advanced Yield Trials (AYT) are included in Tables 5.4 through 5.9.

The results show a clear improvement of germplasm resistance to yellow rust. However, more research is needed to the improve leaf rust resistance, an important disease in some environments of the CAC countries.

Table 5.4. Ten most promising entries from Preliminary Yield Trials under irrigation PYT98(IRR) with high grain yield and other desirable traits*, 1998.

Entry	Name	TKW	YR	CB
6041	WEAVER//1D13.1/MLT	41	MS	S
5139	YMH/HYS//SPN/3/KEA/TOW	35	R	S
5252	TIRCHMIR1/GRK/4/II21031/TPR//CO652363/3/12300//SON/TZP	40	MS	MR
5353	BUC/5/NAPHAL/CI13449/4/SEL14.53/3/LANCER//ATL66/CMN	42	R	MR
5350	BUC/5/NAPHAL/CI13449/4/SEL14.53/3/LANCER//ATL66/CMN	40	MS	S
5766	CHAM4/TAM200//RSK/FKG15	37	R	S
6058	1D13.1/MLT//AGR/NAC	37	MS	MR
5166	AGRI/NAC//ATTILA	38	R	MR
5703	ECVD12/KAUZ//*UNKNOWN*	42	*MS*	*MS*
6657	SDY/OK78047//ATTILA	40	MS	-
	DAGDAS94 (Check)	41	S	MR
	GEREK79 (Check)	32	VS	S

* TKW: 1000-kernel weight (g); YR: yellow rust; CB: common bunt. R: resistant, S: susceptible, MR: moderately resistant, MS: moderately susceptible, VS: highly susceptible.

Table 5.5. Ten most promising entries from Preliminary Yield Trials (rain fed) PYT98(RF) with high grain yield and other desirable traits*, 1998.

Entry	Name	YR	CB
709	88ZHONG25/FDL4//HATUSHA	R	MR
616	ZCL/3/PGFN/CNO67/SON64(ES86-8)/4/SERI/5/UA-2837	MR	S
681	SKAUZ/4/NAI60/HN7/BUC/3/F59.71/GRK	MS	S
624	LOV26//LFN/SDY(ES84-24)/3/SERI/4/SERI	MR	S
546	*ID800994.W/KAUZ*	MR	MS
617	ZCL/3/PGFN/CNO67/SON64(ES86-8)/4/SERI/5/UA-2837	MR	MR
708	88ZHONG25/FDL4//HATUSHA	MR	R
832	NECOMP1/5/BEZ//TOB/8156/4/ON/3/TH*6/KF//LEE*/6/TAST/	MR	R
625	LOV26//LFN/SDY(ES84-24)/3/SERI/4/SERI	MR	R
761	CHAM6//1D13.1/MLT/3/SHI4414/CROW	MR	MR
	DAGDAS94 (Check)	S	MR
	GEREK79 (Check)	VS	S

* YR: yellow rust, CB: common bunt, R: resistant, etc.

Table 5.6. Most promising entries from yield Trials under irrigation YT98(IRR) with high grain yield and other desirable traits*, 1998.

Entry	Name	YLD	%Best check	YR	LR
7079	FDL4/KAUZ	6659	139	S	MS
7030	55.1744/MEX67.1//NO57/3/ATTI	6078	112	MS	R
7141	JI5418/HATUSHA	5708	116	MR	MS
7180	WN156/NSD//MT773/3/F4141W1.1	5455	108	MS	R
7154	SPN/NAC//ATTILA	5929	117	MS	R
7159	TAM200/JI5418	5543	110	MR	MS
7070	F130L1.12/KAUZ	5364	109	MS	MS
7102	F308.02.2/PASA	5243	107	MS	MS
7171	DAGDAS94 (Check)	4779	95	S	S
7189	KINACI97 (Check)	5027	100	S	R

* Mean grain yield (YLD)in kg/ha, based on yield at Konya, Eskisehir, and Edirne. YR: yellow rust; LR: leaf rust.

Table 5.7. Most promising entries from Yield Trials (rain fed) YT98(RF) with high grain yield and other desirable traits*, 1998.

Entry	Name	YLD	BC(%)	YR	LR
7488	PI/MZ//CNO67/3/LFN/4/ANT/5/ATTILA	3281	115	MR	R
7422	1.27.7876/CONDOR/3/AU/CO652337//CA80	3267	120	R	MS
7411	VEE/TSI//GRK/3/NS55.03/C126.15/COFN/	3161	116	R	MS
7387	LFN/VOGAF//LIRA/5/K134(60)/4/TOB/BMA	3545	113	MS	S
7492	PI/MZ//CNO67/3/LFN/4/ANT/5/ATTILA	3449	121	S	R
7372	AGRI/NAC//ATTILA	2906	115	MR	S
7482	DAGDAS94 (Check)	2851	100	S	S
7389	GEREK79 (Check)	2708	86	VS	S

* Mean grain yield (YLD)in kg/ha, based on yield at Konya, Hamidya, Obruk and Cumra (root-rot). Selection also based on performance at Tel Hadya. BC: best check; YR: yellow rust; LR: leaf rust.

Table 5.8. Most promising entries from Advanced Yield Trials under irrigation AYT98(IRR) with high grain yield and other desirable traits*, 1998.

Entry	Name	YLD	BC(%)	YR	LR
9089	ZCL/3/PGFN/CNO67/SON64(ES86-8)/4/	6294	107	MR	S
9014	OK82282//BOW/NKT	6005	99	MR	S
9034	DYRB82.83/842ABVDC.50//KAUZ/3/PLK	6043	105	MR	MS
9116	VORONA/HD2402	5986	102	MS	R
9041	CHAM4/TAM200//FDL483	5755	100	MR	MS
9043	MEX COMP3/4/CA8055/5/777TWWON87	5813	101	MS	MS
9101	OK28822//BOW/NKT/3/F4105W2.1	6103	104	S	MR
9015	KINACI97 (Check)	6050	100	MS	MS
9060	KATYA1 (Check)	6313	100	S	S

* Mean grain yield in kg/ha, based on yield at Konya, Cumra (root-rot), Eskisehir, Beysehir and Edirne. Selection also based on performance at Tel Hadya. BC: best check; YR: yellow rust; LR: leaf rust.

Table 5.9. Most promising entries from Advanced Yield Trials (rain fed) AYT98(RF) with high grain yield and other desirable traits*, 1998.

Entry	Name	YLD	BC(%)	YR	LR
9326	NWT/3/TAST/SPRW//TAW12399.75	4577	113	R	S
9363	LOV26//LFN/SDY(ES84-24)/3/SERI/4/SERI	4205	116	MR	MR
9411	TRK13/KAUZ	4295	111	MR	S
9407	TRK13//TRP1/BOW/4/YMH/TOB//MCD/3/LIRA	4647	120	MS	MR
9307	MNCH//TX71A374.4/TX71A1039.VI/3/74CB4	4622	118	MS	MR
9329	TIRCHMIR1/KRC66//TRK13	4657	115	MS	S
9348	130L1.11//F35.70/MO73/4/YMH/TOB//MCD/	4741	117	R	S
9380	DAGDAS94 (Check)	4027	100	MS	S
9335	GEREK79 (Check)	3709	92	VS	S

* Mean grain yield in kg/ha, based on yield at Eskisehir, Hamidya, Obruk and Erzurum. Selection also based on performance at Tel Hadya. BC: best check; YR: yellow rust; LR: leaf rust.

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5.3. Genetic Stocks

Repeated testing of advanced breeding lines under controlled conditions led to the identification of elite lines with specific attributes. Table 5.10 lists winter/ facultative bread wheat lines with combined resistance to yellow rust and common bunt (Syrian isolates) and with resistance to different pathotypes of common bunt from Iran. All of the identified lines possess good agronomic characteristics.

Table 5.10. Winter bread wheat lines resistant to common bunt and to yellow rust.

Name	Cross	Pedigree
6720.11/MDA38/WRM/3/69.148/YMH/ HYS/4/ASP/BLT	WSY900378A	10H-0P-2YC-0YC
TSI/VEE//1D13.1/MLT/4/HYS/NO//L VII/3/KVZ/HYS	TCI922141	0SE-0YC-1YC-0YC
PVN/CLI/TAM200/3/SHI4414/CROW// CA8055	TCI922565	0SE-0YC-1YC-0YC
130L1.11/TAM200//JI5418	TCI925084	0SE-0YC1YC-0YC
TSI/VEE//2*TRK13	TCI922292	0SE-0YC-1YC-0YC

A number of advanced lines also showed tolerance to BYDV, including *Triticum aestivum-Thinopyron* derived lines. The results need confirmation during 1999. Three entries showed adequate tolerance to Russian wheat aphid at Tel Hadya (Table 5.11), and confirmative testing will be carried out in 1999.

Table 5.11. Winter bread wheat lines tolerant to Russian wheat aphid (RWA), Tel Hadya, 1998.

Entry	Name	Score*
AYT98RF-9361	ZCL/3/PGFN/CNO67/SON64(ES86-8)/4/SERI /5/UA	3
AYT98RF-9389	MEX COMP3/4/TRK13/5/NE887U122	3
AYT98RF-9380	DAGDAS94	3
AYT98RF-9365	GEREK79 (Check)	4
AYT98RF-9360	BOLAL (Check)	4
AYT98IR-9115	KINACI97 (Check)	4

* Score : 1-5 scale with: 1=tolerant, 5=plant completely dead.

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5.4. International Cooperation

5.4.1. Turkey

With the major component of the breeding activities decentralized from Tel Hadya, an emphasis was placed on the collaboration with partners in Turkey, which included the planning and implementation of various joint breeding activities at Konya, Eskisehir and Ankara institutes sites. A special effort was made to test winter wheat germplasm for cold tolerance in collaboration with the Erzurum Research Institute, where facilities are being established for more reliable testing of seedlings in the absence of snow cover. However the facilities have not been completed yet, and testing was conducted in the open fields. Joint work was also conducted with the Diyarbakir Research Institute, with an emphasis on on-farm testing of improved cultivars. Two observation nurseries (WWONIR and WWONSA) were evaluated at Elazig and Malatya. At both testing sites, rainfall was high, which led to a good disease (mainly yellow rust) development and to moderate lodging. At Elazig, 22 improved breeding lines were evaluated along

with 3 checks(2 stocks of the Ashoure land race and one improved check). The land race stocks suffered from high susceptibility to yellow rust and lodging and were significantly outyielded by the improved check and the breeding lines (Table 5.12).
(H. Ketata, L. Tahtacioglu, T. Yildirim, I. Ozberk, F. Ozberk, H. Braun)

Table 5.12. Performance of two advanced breeding lines of facultative/winter wheat, in comparison with the Ashoure land race and commercial cultivars, Elazig, Turkey, 1998.

Name	Source98	Yield	YR	CT	LOD
CHAM4/TAM200/FLD483	AYT-9041	7.9	5MS	2	1
PEHLIVAN (Improved check)		7.7	5MR	1	1
TAST/SPRW/BLL/7/SOTY/4/SUT//LER/.	AYT-9309	7.5	0R	1	1
GEREK79		2.7	100S	1	4
DAGDAS94		5.7	20S	1	3
KIRGIZ95		2.9	100S	1	4
GUN91		4.5	60S	2	2
IKIZCE		5.4	30S	2	2
ASHOURE-1	Farmer1	3.4	90S	1	4
ASHOURE-2	Farmer2	3.1	90S	1	5
LSD(0.05)		0.9			
CV(%)		12.8			

Yield in t/ha; YR: yellow rust; CT: cold tolerance, and LOD: lodging, both measured on a 1-5 scale (1: tolerant, 5: highly susceptible).

5.4.2. International Nurseries

In order to improve the infrastructure for nursery preparation and insure that healthy seed is distributed through the IWWIP, the 3 partners (Turkish NARS, CIMMYT and ICARDA) joined efforts to build a seed unit and a seed health laboratory at Konya. While the seed unit is completed, the seed health laboratory still awaits completion, perhaps in 1999-2000. Seed for the 2nd WWON-IR, 2nd WWON-SA, and 8th FAWWON was harvested from nurseries grown at ICARDA, Tel Hadya, due to concerns regarding the health of seed produced in Turkey; and the 3 nurseries were prepared and sent from ICARDA. The 3rd EYT-IR and 3rd EYT-RF were prepared and distributed from Turkey after seed samples from Turkey had been checked in the Seed Health Lab at ICARDA. Although there was a delay in dispatching seed from ICARDA, all nurseries for CWANA countries reached in time for proper planting, in contrast to destinations outside the CWANA region. The number of nursery sets sent to 45 countries are shown in Table 5.13.

Table 5.13. International facultative/winter wheat nurseries distributed by the IWWIP, August-September 1998.

Nursery	WANA	CAC	Other	World(total)
8th FAWWON	21	16	70	107
2nd WWONIR	22	16	17	55
2nd WWONSA	20	14	15	49
3rd EYTIR	23	15	5	43
3rd EYTRF	21	15	9	45
Total	107	76	116	299

Preliminary results from the 1st Winter Wheat Observation Nursery for Irrigated Conditions -WWONIR (100 entries)and 1st Winter Wheat Observation Nursery for Semi-Arid Conditions-WWONSA (75 entries)indicated the usefulness of these two nurseries for providing NARS with improved, adapted facultative/ winter wheat germplasm. These 2 nurseries, prepared for the first time in 1998, were dispatched to 20 programs in the CWANA region. Results will be compiled and analyzed by mid-1999. Data for the 6th FAWWON were returned from 94 cooperators from within and outside CWANA. Some of the best performing entries are shown in Table 5.14. Data of the 2nd Facultative and Winter Wheat Elite Yield Trial for Irrigated Conditions (2nd EYT-IR) and the 2nd Facultative and Winter Wheat Elite Yield Trial for Rain-fed Conditions (2nd EYT-RF) were received from cooperators in 18 sites of the CWANA region and Mexico.

Table 5.14. Performance* of frequently selected entries from the 6th FAWWON, 1997.

				Rank			
Entry	Name	TS	SEL	YLD	CT	YR	LR
7	LOV6/SMS//TAST/SPRW	S	18	124	62	76	194
21	SULTAN95	S	22	47	50	37	91
22	HN7/OROFEN//BJN8/3/SER	R	17	15	93	122	91
25	LCR/SERI/3/MEX-DW/BACA	S	16	138	165	21	8
31	DMN//SUT/AG(ES86-7)/3/	S	18	19	142	18	6
33	ATAY/GALVEZ87	MR	16	10	121	157	157
41	LOV26//LFN/SDY(ES84-24	S	16	24	141	137	181
52	DYBR1982-83/842ABVD C-	MR	20	42	91	19	104
53	DYBR1982-83/842ABVD C-	S	21	54	110	2	91
55	HATUSHA/TRK13	R	16	57	34	79	139
68	KS82142/SERI	S	16	11	147	63	34
97	RPB868/CHRC///UT1567.	S	17	17	49	72	64
104	CLLF/BEZ//SU/CI13645/3	S	16	152	188	148	64
115	WEI132	S	17	194	177	85	91
127	YUMAI14	S	18	8	137	11	116
129	CH75460	S	16	28	43	9	91
133	CH75584	S	18	97	73	6	124
137	BUL1518.4.38	S	22	56	52	52	45
162	MV19	S	17	71	23	96	59
170	AKN/81-130//KS73H530/.	MR	21	4	51	66	34

* SEL=frequency of selection (the highest frequency in the nursery is 22, out of a total of 200 entries), YLD=grain yield, CT=cold tolerance, YR=yellow rust, LR=leaf rust. Lower values for rank indicate better performance across the sites. TS=tan spot, as assessed by field observation in Kazakhstan, during the travelling workshop, June 1998; S=suscetible, R=resistant, MR=moderately resistant.

Results, summarized in a separate report, indicate that some of the early-developed lines already combined relatively high grain yield and some resistance to yellow rust. This is the case of the line 'AGRI/BJY//VEE' and 'OK82282//BOW/NKT' (entries 9918 and 9920, respectively). However, the level of disease resistance in these 2 nurseries still needs improvement.

(H. Ketata, H. Braun, A. Morgounov, H. Ekiz, A. Bagci, R. Malhotra, M. Jarrah, NARS collaborators).

5.4.3. Iran

The growing conditions in most of the rainfed winter wheat areas of Iran were above average. However, a major heat wave swept the whole country, towards wheat flowering. This stopped the development of diseases but also decreased yields in certain areas. In the Maragheh region, grain yields were in the range of 1-2.5 t/ha. In the Kermanshah region, yields were much higher, primarily because of higher rainfall (616 mm versus 347 mm). Many of the superior lines significantly outyielded Sardari by 20-30%. Selections of the IWWIP cross OK82282//BOW/NKT showed good performance at Maragheh, Kermanshah, and Shirvan. At Qamlo, 70 km south of Sanandaj, yields were low (1-2 t/ha), despite the high rainfall (430 mm), primarily because of long, cold winter and hot spring.

Results of repeated testing of advanced winter wheat materials in the major rainfed wheat areas of Iran led to the identification of the following three lines, which are considered for release by NARS in 1998-1999:

-(1) KVZ/TM71/3/MAYA'S'//BB/INIA/4/SEFID; IW89-1-10838-0MA-0MA-6MA-0MA. This line yields higher than Sardari (108-110%). It is moderately tolerant to yellow rust and to bunt, and possesses good bread making quality.

-(2) SBN//TRM/K253; IW89-1-11302-0MA-0MA-0MA-6MA-0MA. This line has higher (110-120%) grain yield than Sardari, is moderately resistant to yellow rust and to bunt, and possesses good grain quality (white kernels, 11.6% protein, and good hardness).

-(3) SABALAN/1-27-56-4; iw89-110870-0MA-0MA-4MA-0MA. This line is equivalent or superior in yield as compared to Sardari, is resistant to yellow rust, and moderately resistant to dwarf and common bunt. It has red kernels, slightly smaller than Sardari, but with better protein content.

A review of the past 4 years (1994-1997) cereal work was jointly conducted by ICARDA and DARI-Iran researchers, and published in a document titled 'Wheat and Barley Improvement in the Dryland Areas of Ira: Present Status and Future Prospects'. While the review highlighted the important achievements made during this short period, it also pointed to the need for more research and resources (especially human resources) to achieve the goal of sustainable food production in the rainfed cereal growing areas of Iran. In addition, the review emphasized the need for closer collaboration between DARI and SPII, and for farmer participation in the process of technology development.

DARI and ICARDA cereal researchers jointly wrote several publications dealing with cereal breeding for stress environments. These were presented at the 9th International Wheat Genetics Symposium, Saskatoon, Canada.

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

5.4.4. Central Asia and the Caucasus (CAC)

A travelling workshop was organized by ICARDA and CIMMYT through 3 Central Asian Countries (Uzbekistan, Kyrghyzstan and Kazakhstan) during 13-21 June, 1999. Twenty-two wheat scientists from CAC countries, Turkey and Iran, participated in the workshop, along with scientists from ICARDA and CIMMYT, and other invited institutions (World Bank, Washington State University). The participants visited research stations and farmers fields, observed wheat germplasm and commercial cultivars in the 3 visited countries, and discussed the outcome of the workshop at the closing day in Kazakhstan.

As far as this project is concerned, two important facts emerged: (1) the germplasm selected in Central

Anatolia-Turkey is overwhelmingly late in these three countries (e.g. Atay, Dagdas, Sultan; Gerek is mid-late). Facultative or spring-like types (e.g. OK82282//BOW/NKT and SON64//SK/2*ANE/3/SX/4/BEZ/SERI) are much more suitable to the sites visited, i.e. Gallaaral, Tashkent, in Uzbekistan, Bishkek in Kyrghyzstan, and Krasnovodopask, Kurday, and Almaty in Kazakhstan. Although the winter is cold in these areas, the winter duration is short. Facultative types with early maturity, similar to those suitable to Tel Hadya environment, perform extremely well in these Central Asian sites, provided they possess adequate cold tolerance. The two lines mentioned above were among the highest yielding test entries at Tel Hadya in 1996-1998. (2)Yellow rust is important in Azerbaijan (see GP Annual Report for 1996), in Tadjikistan, and of course in Iran and Turkey; and according to participating NARS scientists, it is less frequent in Uzbekistan, Armenia, and Kyrghyzstan, and is not important in Turkmenistan, Georgia and Kazakhstan. During the travelling workshop, no yellow rust was observed except in Kazakhstan, where it was attributed to unusually wet weather. On the other hand, leaf symptoms attributed to tan spot disease were frequently observed in Kyrghyzstan and Kazakhstan. Among the observed materials, the following were resistant to tan spot in Bishkek: PYN/BAU, AGRI/NAC//MLT (both from EYT-1996), LUTESCENS 42, ERYTHROSPERMUM 13, and ADYR (all from Kyrghyzstan); a number of lines in the 6^{th} FAWWON were also found resistant, based on field observations in southern Kazakhstan (Table 5.15). Laboratory analysis by a consultant pathologist revealed the presence of the following pathogens on the diseased wheat plants: *Fusarium culmorum, Pyrenophora tritici-repentis, Fusarium oxysporum, Rhizoctonia* sp., and *Alternaria alternata*. Several other pathogens were also detected but were less prevalent.

The travelling workshop was judged successful by the participants. They appreciated the genetic variability of materials from CIMMYT-ICARDA, expressed the desire to have a regional nursery specific for the CAC, and suggested to hold another travelling workshop in Turkey during 1999. The participants commented that more work and facilities are needed in pathology to monitor disease variation across the region. The seed sector needs improvement that would allow farmers to use the improved, adapted cultivars. Although agronomic research has been conducted in the past, research results have not reached the farmers. It was suggested to compile previous results and draw conclusions as to what can be adopted on-farm, and what further research needs to be conducted. In addition to training of researchers in specific subjects (including English language), equipment and necessary infrastructure need to be provided to research institutes to enable them meet the challenge of improving food production in this transitional phase.

Table 5.15. Selected TCI* wheat breeding lines from the 6th FAWWON, with tolerance to tan spot (TS), 1998.

Entry	Name	TS
22	HN7/OROFEN//BJN8/3/SERI	R
27	HAWK/YACO//SXL/VEE	R
30	KRC/SERI/4/YMH/TOB//MCD/3/LIRA	R
55	HATUSHA/TRK13	R
57	KVZ/HB2009/5/CNN/KHARKOV//KC66/3/SKP35/4/VEE	MR
61	HAWK94/CHAM4	R
65	KVZ/CUT75/3/YMH//61.1523/DRC	R
70	RAN/NE701136//CI13449/CTK/3/SERI	R
71	NEMURA/PRL	R
72	ECVD14/SERI	R
77	C126-15-COFN/N10B-P14//P101(ES85-8)/3/KAUZ	R
78	VORONA/HD2402	R
79	VORONA/HD2402	R
81	VORONA/HD2402	R
20	BEZOSTAYA1 (resistant check)	MR
40	SERI82 (resistant check)	R
80	GEREK79 (resistant check)	MR

* TCI: TURKEY-CIMMYT-ICARDA.
R: resistant, MR: moderately resistant.

(H. Ketata)

6. PATHOLOGY

6.1. General Overview

The cereal pathology program has conducted extensive screening for disease resistance. Breeding nurseries evaluated during 1997-98 for smuts and foliar diseases contained 11053 entries for barley, 1216 for bread wheat, 929 for durum wheat and 250 for facultative winter wheat. The following table shows the diseases studied in 1997-98.

Table 6.1. Wheat and Barley Germplasm Screened for Disease Resistance in 1997-98

	Foliar diseases				Smut
Cereal	Stripe rust	Leaf rust	Stem rust	Septoria	C.Bunt
Bread Wheat	941	887	882	931	1031
Durum Wheat	839	780	780	819	799
F.W.Wheat	250				
	Foliar diseases		Seed transmitted diseases		
Barley	Scald	P.Mildew	B.Stripe	L.Smut	C.Smut
	9723+680	328+1903	309	359	334

The relative performance of this material is discussed in the pathology chapter of each cereal breeding project in the germplasm program.

The material covered in this part of the report pertains to specific studies on host-pathogen interaction and the development of specific germplasm pools for disease resistance, hence, identification of sources of resistance among breeder's material. For each crop species a specific germplasm has been assembled for use in breeding programs as sources of resistance for single as well as multiple disease resistance.

Another important ongoing activity was the study of disease incidence, virulence patterns and shifts of most common diseases through surveys, trap nurseries, and pathogenicity studies under controlled environment.

Special studies pertaining to cereal pathology were carried out through thesis projects or special projects. In 1997-1998 studies on cereal cyst nematodes and root rots have been realized.

Crop loss assessment and the development of an integrated disease management as a control measure are also among the activities being undertaken by the cereal pathology program.

Collaborative projects with NARS in WANA region, and advanced institutions represent an important activity in cereal pathology at ICARDA.

(A.Yahyaoui)

6.2. Cereal Disease Survey in Syria

6.2.1. Foliar Diseases.

A survey was conducted between 3-10 May 1998, one day in Al-Gab, Two days in south Syria and two days in North - East Syria, in farmers fields and research stations at Al-Gab, Jillin, Al-Raqqa, and Himo, to assess the importance of foliar diseases on wheat and collect samples for pathotype identification. The major diseases encountered were yellow rust, leaf rust and septoria leaf blotch. The severity of infection and reaction types were recorded in each surveyed field for yellow and leaf rust on 0-100% scale and disease incidence in case of septoria leaf blotch. The visit included both irrigated and rain-fed cereal crops.

Survey in Al-Ghab region:

The trip started from Khan Sheikhoun near Hama where the first disease incidence was observed. The survey included 20 fields in 9 locations, in addition to the Al-Ghab research station. The majority of the wheat area was planted to durum wheat, mostly the varieties Cham 3 and ACSAD 65. Out of 20 surveyed fields only three were planted to bread wheat. In these 20 fields, yellow rust was observed in all visited fields: severity of infection ranged from 10 MS in the durum wheat cultivar Lahen to 75 S in the durum wheat cultivar Cham 3, and from 50 to 60 S in the durum wheat cultivar ACSAD 65. Severity of infection in bread wheat fields ranged from 60S to 90S in cv. Mexipak at Salh.

Leaf rust was found in all durum wheat fields included in this survey. Severity of infection ranged from 60S in durum wheat cultivar Cham 3 to 85S in ACSAD 65, and from 40S to 90S in bead wheat fields.

Septoria leaf blotch was observed in the 20 surveyed fields of both durum and bread wheat. The disease incidence ranged from 10% in the bread wheat field at Salh to 75% in the durum wheat, cultivar ACSAD 65, at Al-Ghab research station.

Survey in Jillin Region:

The survey included the wheat fields from Damascus to Izzer and from Izzer to Jillin research station. All wheat fields were planted to durum wheat and out of 18 visited fields in 9 locations, 17 fields were under rain-fed condition. Only one field was irrigated at Tafas. Yellow rust was found in all visited fields and severity of infection ranged from 10S near Izzer to 50S at Tafas. Leaf rust was found in all visited fields and severity of infection ranged from 50 to 80S. Septoria leaf blotch was found in four locations and the disease incidence ranged from 5% to 30%.

Survey in Himo region:

Out of 40 surveyed fields (30 durum wheat and 10 bread wheat), yellow rust has been found in all visited fields and severity of infection ranged from 20S in durum wheat at Masskaneh to 50S at Al-Raqqa research station, 20S at Tel-Abiad to 40S at Kamishley. In bread wheat fields, severity of infection ranged from 10MS at Masskaneh to 80S at Al-Raqqa research station and 100S at Himo.

Leaf rust was observed in 30 fields and severity of infection ranged from 10S to50S in durum wheat on the main road from Masskaneh to Al-Raqqa, 50S at Al- Raqqa research station, from 20S to 10S from Al-Raqqa to Tel-Tamer, and 50S at Tel-Abiad. In bread wheat severity of infection ranged from 25S at Masskaneh to 50S at Al-Raqqa, 10S at Tel-Tamer, and 10S at Himo.

Septoria leaf blotch was in 11 fields, five fields between Masskaneh and Al-Raqqa, two fields between Tel-Tamer and Kamishly, and two fields from Tel-Abiad to Aleppo. The disease incidence in these fields ranged from 10% to 30%.

(S.Hakim (University of Aleppo), A.Yahyaoui, M.Naimi)

6.2.2. Root rots of barley in Northern Syria

Surveys were made in May 1998 covering four routes (Hama-Selamiyeh; Aleppo-Al Bab; Al Bab- Raqqa and Raqqa-Hassakeh). A total of 40 barley fields, 20 to 40 km apart, were surveyed. The growth stages of barley ranged from late milk to maturity. However, 60% of the crops were at their maturity stage.

An assessment was made for the incidence and severity of barley root rots. Forty plants with their roots were randomly uprooted from each farm and the subcrown internode (SCI) of each plant was examined for the extent of lesions in the laboratory. The plants were separated into 6 disease categories based on SCI surface covered by lesions:

- 1, no lesion;
- 2, 1 or 2 lesions covering <10%;
- 3, lesions covering 10-25%;
- 4, lesions covering 25-50%;
- 5, lesions covering 50-99%;
- 6, lesions covering 100%.

Disease severity was calculated using the following formula:

Disease severity (%) = $(2N_1 + 5N_2 + 10N_3) \times 100/10 \times$ total number of plants, where

N_1 is the number of plants in categories 2 and 3,

N_2 is the number of plants in category 4, and

N_3 is the number of plants in categories 5 and 6.

The cropping sequences recorded during the survey were as follows:

1) continuous barley, 2) barley-fallow and 3) barley-cumin/forage legume rotations.

The barley-fallow rotation covered 32% of the total fields surveyed. The incidence and severity of root rots varied from field to field but on average the incidence was not very much different in the four routes (Table 6.2). However, the highest severity of root rots were observed in Aleppo- Al Bab, and Al Bab- Raqqa routes. The pathogens associated with infected roots are being under investigation in the laboratory.

Table 6.2. Mean percent incidence and severity of root rots of barley in north Syria, 1997/98 Crop- season

		Incidence		Severity	
Route	No. of fields	Mean	Range	Mean	Range
Hama-Selamiyeh	12	41.5	22-70	8.9	5.0-14.0
Aleppo - Al Bab	11	44.8	43-71	13.3	7.8-15.7
Al Bab - Raqqa	13	48.7	24-75	10.6	5.0-17.5
Raqqa-Hassakeh	4	46.2	23-59	7.8	4.7-10.6

(S. Kamal)

6.3. Virulence studies

6.3.1. Wheat rusts.

Trap nurseries were used to identify the prevailing pathotypes and races for yellow and leaf rust of wheat in Syria. The trap nurseries consisting of differential sets (45 genotypes for yellow rust and 37 for leaf rust) were planted in "hot spots": Tel Hadya, El-Ghab, and Jillin for both diseases, an additional two sites were used for stripe rust: Himo in Syria and Terbol in Lebanon.

Each genotype in the differential nursery was planted in the field in 2 rows, 1m long. The plant were evaluated under natural infection, except at Tel Hadya, where the plants were inoculated twice, at tillering stage, with a mixture of urediospores. The inoculum was collected the previous season from naturally infected fields at different locations of Syria. Severity of infection (0-100%) and reaction type, as designated by Peterson *et al* 1948, were assessed at heading stage. Table 6.3 shows the reaction types of the differential genotypes at the different sites. The stripe rust differentials include new accessions being tested as potential differentials in the WANA region. Known resistant "Yr" genes are shown (Table 6.3).

The field data showed that the virulence to Yr. gene at the adult stage was as follow:

Jillin (6, 7, 9+, 7+, 6+, 8, 2+, 10, 9, 18, 2, A+)
Tel-Hadya (6, 7, 10, SD, SU, 9+, 6+, 7+, 2+, 8, 9, 18, 2, A+)
Al-Ghab (6, 7, 10, SU, 9+, 7+, 6+, 2+, 8, 9, 18, 2, A+)
Himo (6, 7, 10, SU, 9+, 6+, 7+, 2+, 8, 2+, 9, 18, 2, A+)
Terbol (6, 7, SD, SU, 9+, 6+, 7+, 3N, 2+, 8, 15, 10, 9, 18, 2, A+)

Table 6.3. Severity of infection and reaction type of wheat yellow rust differentials in Different locations in Syria and Lebanon in 1998.

No.	Genotype: Differentials (Yr. Gene) Crosses w/Selected '' Yr''genes	Syria El-Ghab (3/5/98)	Jillin (5/5/98)	Himo (10/5/98)	T.Hadya (14/5/98	Lebanon Terbol (5/6/98)
1	Chinese 166 (W;Yr1)	TR	TR	TR	TR	5MR
2	Lee (S; Yr7)	80S	80S	70S	80S	70S
3	Hiene's Kolben (S; Yr6+one)	80S	85S	65S	85S	70S
4	Vilmorin 23 (W;Yr3a,4a+other)	TR	TR	TR	TR	10MR
5	Moro (W; Yr10)	10S	TR	10S	10S	5MR
6	Strubes Dikkopf (W;2-more?)	10R	10R	5R	30MS	50M
7	Suwon 92xOmar (W: 1?)	40S	10R	20S	35MS	30M
8	Clement (W;Yr9+1)	10S	10S	25S	60S	40M
9	Hybrid 46 (W; Yr3b,4b)	TR	TR	TR	TR	TMR
10	Rrichersberg 42 (W; Yr7+one)	10S	20S	20S	65MR-M	15MS
11	Heine's Peko (S;Yr6+one)	10S	35S	40S	65MR-M	25MS
12	Nord Desprez (W;Yr3a+4a)	TR	TR	TR	TR	15M
13	Compare (S;Yr8)	TR	10MS	10MS	10MR	5MR
14	Carstens V (W;?)	TR	TR	TR	TR	5MR
15	Spaldings Prolific (W;?)	TR	TR	TR	TR	TMR
16	Heines VII (W;Yr2+1)	10S	10S	30S	55S	30MS
17	Aroona	-	-	-	95S	-
18	Aroona*5/Yr1	5R	5R	5R	5R	TMR
19	Aroona*6/Yr5	5R	10MS	TR	40M	25MS
20	Aroona*6/Yr8	10S	40S	20S	80MS	70S
21	Aroona*3/Yr15	TR	TR	TR	5R	15MS
22	Aroona*6/Yr17	TR	TR	TR	5R	0
23	Avocet R	50S	40S	5R	5R	0
24	Avocet S	80S	95S	85S	95S	90S
25	Yr5/6* Avocet S	5R	5R	5R	5R	5MR
26	Yr8/6* Avocet S	40S	10S	25S	40MS	50M
27	Yr15/6* Avocet S	5R	10R	TR	TR	TMR
28	M2435	50S	80S	40S	85S	40S
29	Yr 5/6* M2435	TR	TR	TR	TR	10M
30	Yr10/6* M2435	50S	80S	70S	95S	70S
31	Federation	95S	95S	85S	85S	90S
32	Fed. 4/Kavkaz (Yr9)	90S	95S	95S	85S	90S
33	Jupateco R (Yr18)	50S	70S	80S	95S	60S
34	Jupateco S	50S	95S	90S	95S	70S
35	Kalyansona (Yr2)	70S	90S	95S	95S	80S
36	Cranbrook (Yr7)	80S	90S	90S	90S	80S
37	Corella (Yr6+Yr7)	80S	95S	95S	80S	80S
38	Oxley (Yr6+APR)	40S	50S	85S	20M	60M
39	Cook	10R	10MR	10MS	75S	25MS
40	Anza (A+)	50S	70S	90S	90S	70S
41	*Sonalika*	*40S*	*75S*	*90S*	*TR*	*70S*
42	Triticum spelta (Inter, Yr5)	TR	5R	TR	90S	0
43	Gereck 79	70S	40S	70S	5R	50S
44	Cham 1	10R	5R	TR	40S	5MR
45	Seri 82	20S	60S	85S		80S

Table 6.4 shows the reaction types of the differential genotypes under field conditions at El-Ghab and Jillin and following artificial inoculation at Tel Hedya. The virulence to known resistant "Lr" genes observed at different sites in Syria was as follows:

(2b, 2c, 3, 3B, 9, 10, 14b, 25, 26, 29, 30, 32, 33, 34, 36)

The virulence analysis (Table 6.4) shows that the natural population of leaf rust at Jillin was the most virulent in Syria . The virulence to Known "Lr" resistant genes at adult stage was as follows:

Tel-Hadya	(2b, 2c, 3, 3Bg, 10, 14b, 25, 26, 29, 30, 32, 33, 36)
El-Ghab	(2b, 3Bg, 14b, 32, 33, 34, 35, 36, 13)
Jillin	(2b, 1, 2a, 2C, 3, 3ka, 3Bg, 10, 11, 13, 14b, 15, 18, 20, 22a, 25, 30, 32, 33, 34, 36)

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6.3.2. Pathotype identification and virulence analysis of wheat stripe rust

From the field survey a total of 200 diseased leaf samples were collected and brought to the laboratory for pathotype identification. Pathotype identification started mid-May 1998 under controlled conditions in the growth chambe. Urediospores of single pustule from 20 leaf samples were multiplied on the seedlings of the susceptible bread wheat cv. Morocco. Spores from pustules appearing 10 to 14 days after inoculation were collected every 2 days and multiplied on cv. Morocco separately. Seedlings of the differential set as proposed by Johnson *et al* (1972) and additional supplementary cultivars were inoculated by the isolates obtained. Reaction type was assessed on 0-9 scale (Mc Neal *et al.*, 1971), 17 days after inoculation.

Table 6.4. Severity of infection and reaction type of wheat leaf rust differentials in different locations in Syria.

No	Name	T.Hadya (PH) 22/4/98	El-Ghab 3/5/98	Jillin 5/5/98
1	Thatcher, Lr22b	60S	10S	80S
2	TC*6/Centenatrio (RL6003), Lr1	TR	TR	40S
3	TC*6/Webster (RL6016), Lr2a	5R	TR	30S
4	TC*6/Carina (RL6019), Lr2b	10MR	10S	30S
5	TC*6/Loros (RL6047), Lr2c	65S	TR	60S
6	TC*6/Democrat (RL6002), Lr3	55S	TR	50S
7	TC*6/Aniversario (RL6007),	TR	TR	40S
8	Lr3Ka	15S	10S	30S
9	Bage/8*TC (RL6042), Lr3Bg	TR	TR	TR
10	Transfer/6*TC (RL6010), Lr9	25S	TR	60S
11	TC*6/Exchange (RL6004), Lr10	5R	TR	50S
12	Kussar (w976), Lr11	5R	TR	TR
13	Exchange/6*TC (RL6011), Lr12	TR	TR	10S
14	Manituou, Lr13	TR	TR	TR
15	Selkrik/6*TC (RL6013), Lr14a	40MS	20S	60S
16	TC*6/Maria Escobar (RL6006),	TR	TR	40S
17	Lr14b	20R	TR	TR
18	TC*6/Kental483 (RL6052), Lr15	25R	TR	10R
19	TC*6/Exchange (RL6005), Lr16	5MR	TR	20S
20	Klein Lucero/6*TC (RL6008)Lr17	TR	TR	TR
21	TC*7/Africa 43 (RL6009), Lr18	5MR	TR	10S
22	TC*7/Tr (RL6040), Lr19	5R	TR	5R
23	Thew (W203), Lr20	20MR	TR	60S
24	TC*6/RL5406(RL6043), Lr21	40M	TR	5R
25	TC*6/RL5404 (RL6044), Lr22a	TR	TR	TR
26	Lee 310/6*TC (RL6012), Lr23	10MS	TR	10S
27	TC*6/Agent (RL6064), Lr24	40MS	5R	10R
28	Transec (Awned), Lr25	10R	TR	TR
29	TC*6/ST-1-25 (RL6078), Lr26	TR	TR	5R
30	Gatcher (W3201), Lr27+Lr31	10S	TR	5R
31	CS2D-2M, Lr28	5S	TR	40S
32	TC*6/CS7AG#11 (RL6080), Lr29	10S	10S	60S
33	TC*6/Terenzio (RL6049), Lr30	30MS	25S	60S
34	TCLR32 (RL 5497), Lr32	40M	10S	60S
35	TC*6/PI58548 (RL6057), Lr33	10R	10S	10R
36	TC*6/PI58548 (RL6058), Lr34	50S	10S	75S
37	RL5711, Lr35	TR	5MS	5R
	E84018, Lr36			
	WL711, Lr13			

From the diseased leaf samples collected in May 1998 the following observations were recorded:

- virulence to Yr (6, 7, SD, 7+, 8, 2+, A+, 9), were identified at Tel-Hadya,
- virulence to Yr (6, 7, 9+, 6+, 7+, 2+, A+, 9), identified at Izzer and
- virulence to Yr (6, 7, 10, 6+, 7+, 8, 2+, 9, and 2, A+), identified at Himo and Al-Ghab.

(M.S. Hakim (university of Aleppo), A.Yahyaoui, I.Maaz, M.Naimi)

6.3.3. Pathotype identification and virulence analysis of wheat leaf rust:

Leaf rust Seedling test was started in 1997 using 25 selected differential genotypes, then in 1998 we increased the number of differential genotypes to 37 entries to allow better differentiation between isolates. The inoculum used was collected from Tel Hedya the previous year. The virulence analysis (Table 6.5) showed that the inoculum obtained from bread wheat could overcome the following known "Lr" resistant genes.

(2b, 2c, 3, 3Ka, 3Bg, 10, 11, 12, 13, 14b, 16, 17, 18, 20, 21, 22a, 23, 30, 32, 33, 34, 35, 36)

The inoculum obtained from durum wheat can overcome the following known "Lr" resistant genes.

2b, 2c, 3, 3Ka, 3Bg, 9, 10, 11, 12, 13, 14a, 14b, 15, 17, 18, 19, 21, 22a, 23, 24, 32, 33, 34, 35, 36

The " Lr" resistant genes: 1, 2a, 9, 15, 19, 24, 25, 26, 28, 29 were shown to be highly effective under artificial inoculation at Tel -Hadya (Table 6.5). These genes can be considered as a source of resistance. Table 6.5 shows the reaction types of the differential genotypes following inoculation with leaf rust spores originating from bread

Table 6.5. Reaction of Differential genotypes at seedling test of wheat leaf rust, *Puccinia recondita*, at Tel-Hadya 1997,1998

		Source of Inoculum in 1997			1998
No	Name	Bread wh.	Durum wh	Bread Wh	Durum Wh
1	Thatcher, Lr22b	-	-	4	4
2	TC*6/Centenatrio (RL6003), Lr1	0	0	1	1
3	TC*6/Webster (RL6016), Lr2a	; - 1	;	1	1
4	TC*6/Carina (RL6019), Lr2b	3	3	1	2
5	TC*6/Loros (RL6047), Lr2c	4	4	4	3
6	TC*6/Democrat (RL6002), Lr3	3	3	3	4
7	TC*6/Aniversario (RL6007), Lr3Ka	3	3+	3	4
8	Bage/8*TC (RL6042), Lr3Bg	4	3	2	3
9	Transfer/6*TC (RL6010), Lr9	1	1	0	3
10	TC*6/Exchange (RL6004), Lr10	4	4	4	1
11	Kussar (w976), Lr11	3	3	4	4
12	Exchange/6*TC (RL6011), Lr12	-	-	4	4
13	Manituou, Lr13	-	-	4	4
14	Selkrik/6*TC (RL6013), Lr14a	-	-	2	4
15	TC*6/Maria Escobar (RL6006),	-	-	4	4
16	Lr14b	1	1	0	4
17	TC*6/Kental483 (RL6052), Lr15	0	2+	3	2
18	TC*6/Exchange (RL6005), Lr16	3	3	4	3
19	Klein Lucero/6*TC (RL6008)Lr17	3	3+	4	4
20	TC*7/Africa 43 (RL6009), Lr18	0	2	1	4
21	TC*7/Tr (RL6040), Lr19	3	;	2	1
22	Thew (W203), Lr20	3	3	3	4
23	TC*6/RL5406(RL6043), Lr21	-	-	4	3
24	TC*6/RL5404 (RL6044), Lr22a	3	3	4	4
25	Lee 310/6*TC (RL6012), Lr23	0	0	2	4
26	TC*6/Agent (RL6064), Lr240	;	;	0	1
27	*Transec (Awned), Lr25*	1	1	0	1
28	TC*6/ST-1-25 (RL6078), Lr26	-	-	1	4
29	Gatcher (W3201), Lr27+Lr31	1	1	1	2
30	CS2D-2M, Lr28	1	2	1	1
31	TC*6/CS7AG#11 (RL6080), Lr29	4	1	2	1
32	TC*6/Terenzio (RL6049), Lr30	3	3	2	2
33	TCLR32 (RL 5497), Lr32	-	-	4	3
34	TC*6/PI58548 (RL6057), Lr33	-	-	4	4
35	TC*6/PI58548 (RL6058), Lr34	-	-	4	3
36	RL5711, Lr35	-	-	4	4
37	E84018, Lr36	-	-	2	2
	WL711, Lr13				

wheat and from durum wheat. Reaction types 0 & 1 are considered resistant, reaction type 2 intermediate, and reaction types 3 & 4 are susceptible.

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6.4. Development of Germplasm Pools

Germplasm pools have been developed through the screening of breeding material under artificial inoculation at Tel Hedya, and field evaluation at different sites within the WANA region. Selected lines for a single disease are designated for use in crossing programs or to be introduced in the area were the disease is the most prevalent. Germplasm pools referred to as advanced germplasm for disease resistance has a set of lines that confer resistance to multiple diseases. For artificial inoculation only Syrian isolates were used for screening under field conditions. The relative virulence of these isolates is, for some diseases, similar to the common virulence types in WANA. Evaluation for disease resistance, under artificial inoculation, to stripe rust, septoria, scald, barley strip, common bunt, loose and covered smut is conducted under field conditions. Screening for wheat leaf rust, stem rust, and barley powdery mildew is conducted in plastic houses.

6.4.1. Barley Germplasm Pools

In 1998 four germplasm pools were assembled and compared to the most promising lines from ICARDA and DOUMA in the FFVT (Farmer Field Verification trial) nursery. The germplasm pools are as follows:

- ADGB- Advanced Disease Germplasm-Barley, contains 55 entries of high yielding barley lines and includes most cultivated varieties as checks
- PDG-Preliminary Disease Germplasm -Barley contains 255 lines of promising barley families (fixed lines) and includes most cultivated varieties as checks
- SBPMG- Spring Barley Powdery Mildew RESISTANT Germplasm contains 18 entries including three checks
- SBSCG- Spring Barley Scald RESISTANT Germplasm contains 18 entries including three checks
- SBCSG-Spring Barley Covered Smut RESISTANT Germplasm contains 25 entries and includes one check variety

The selected germplasm pools were screened for other diseases and highly susceptible lines were eliminated. Figure 6.1 shows the performance of the four-germplasm pools and the FFVT for resistance to powdery mildew, scald, covered smut, and combination of powdery mildew-scald resistance.

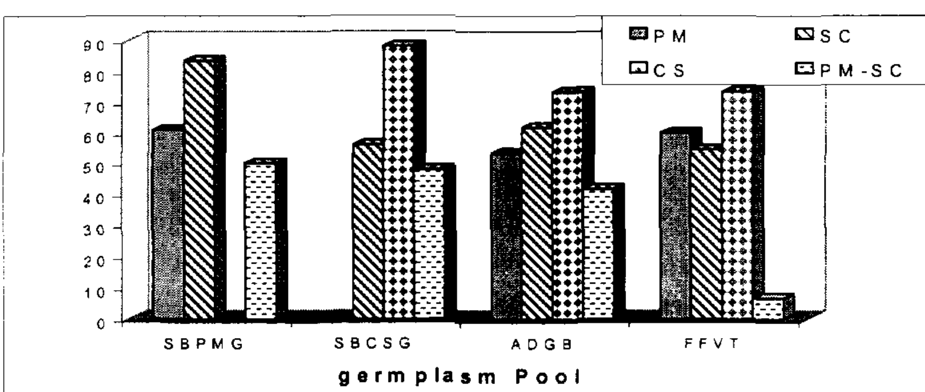

Figure 6.1 Frequency Distribution of Resistance to Four Barley Diseases in Gerplasm Pools and Farmer Verification Trial

Barley lines in the **SBPMGP** in addition to their resistance to powdery mildew also showed good resistance to scald and about 50% of the entries showed resistance to both diseases. Table 6.6 shows the list of lines that combined resistance to powdery mildew and to scald. Most of these lines have a maturity range (134-145 days) that matches that of commonly cultivated varieties in WANA (Rihane=140).

The 18 entries in **SBSCG** were all resistant to scald and to powdery mildew, 30% of the lines have the same maturity as Rihane. Table 6.6 shows the pedigree of these lines.

Resistance to covered smut is highly desirable in the WANA region. In the **SBCSGP** germplasm pool, 22 out of the 25 lines showed complete resistance to covered smut. About 48% of these lines also showed combined resistance to covered smut and scald (Table 6.7). Among ICARDA barley germplasm, the six row types have an adequate level of resistance to covered smut.

Advanced barley lines selected by breeders for yield performance were tested for disease resistance over two to three years and at different sites. Figure 6.1 shows the frequency distribution of resistant lines in the **ADGB** tested against powdery mildew, scald, and covered smut in 1997-98 crop season. The relative resistance level of the lines in this nursery is better than that of the promising lines in the FFVT for the diseases tested under field conditions at Tel Hedya, Lattakia, and Terbol. Over 60% of the lines were resistant to scald, 54.5 % showed resistance to covered smut and about 42% showed resistance to both scald and powdery mildew (Table 6.8). Promising barley lines that are being tested for yield performance are simultaneously studied for resistance to the prevalent diseases in WANA region.

Table 6.6. List of Barley Lines that Combine Resistance to Powdery mildew & scale in SBPMG & SBSCG-Powdery mildew & Scale Germplasm Pools

Nursery	ENT	Name	Pedigree
	2	Arar/Lignee 527	ICB85-0625-1AP-5AP-0AP
	3	Arar/Lignee 527	ICB85-0625-6AP-0AP-17APH-0AP
	7	Austria	ICB121478
	8	CI 07117-9/Deir Alla 106//Badia/3/Arar	ICB82-0114-6AP-0AP
SBPM	9	Carbo	-
GP98	10	Cq/Cm//Apm/3/12410/4/Gizeh 134-2L	-
	13	Eldorado	0
	16	M64-76/Bon//Jo/York/3/M5/Galt//As46/4/Hj34-80/Astrix/5/NK1272	ICB84-0156-0AP
	18	Turkey	-
	1	Ager	-
	2	Apm/11012-2//NP CI 00593/3/IFB 974	ICB84-1485-4AP-0AP-3APH-0AP
	3	Arar/H.Spont.19-12	-
	4	Arar/Lignee 527	ICB85-0625-6AP-0AP-29APH-0AP
	5	Arar/Lignee 527	ICB85-0625-6AP-0AP-30APH-0AP
	6	Arar/Lignee 527	ICB85-0625-6AP-6AP-2AP-2AP-1APH-0TR-0AP -3AP-0TR-0AP
	7	Arr/Esp//Alger/Ceres.362-1-1	LB-2L-9L-6AP-0AP
	8	Begona	-
SBSC	9	CI 07117-9/Deir Alla 106//Badia/3/Arar	ICB82-0114-6AP-0AP
GP98	10	Carbo	-
	11	ChiCm/An57//Albert/3/Alger/Ceres.362-1-1	ICB88-1560-11AP-1APH-1APH-2AP-0TR-0AP
	12	Courlis	-
	13	Cq/Cm//Apm/3/12410/4/Gizeh 134-2L	-
	14	Eldorado	-
	15	Harmal-02/5/Cq/Cm//Apm/3/12410/4/Giza 134-2L	ICB83-0157-10AP-0TR-0AP-7AP-1APH-0AP
	16	Lignee 527/Sawsan//Bc/3/Arar	ICB89-0176-6LAP-4AP-0TR-0AP
	17	M64-76/Bon//Jo/York/3/M5/Galt//As46/4/Hj34-80/Astrix/5/M6/Robur-35-	ICB88-1391-15AP-0AP-1AP-0TR-0AP
	18	Tipper	-

Table 6.7. List of Resistant Barley Lines to Covered smut & Scale In the SBCSG-Germplasm Pool

Nursery	ENT	Name	Pedigree
	1	80-5145//Giza 121/Pue	ICB88-1156-16AP-0AP-6AP-0TR-0AP
	3	Arar/Lignee 527	ICB85-0625-6AP-6AP-2AP-2AP-1APH-0TR-0AP-3AP-0TR-OAP
	5	Arizona 5908/Aths//Lignee 640/4/Arizona 5908/Aths//Asse/3/F208-74	ICB89-0841-4LAP-3AP-0TR-0AP
	7	As46/Aths*2//WI2197/Arabische	ICB88-0293-1AP-0TR-4AP-0AP-11AP-0TR-0AP
	9	As46/Aths*2/5/CI 01021/4/CM67/U.Sask.1800//Pro/CM67/3/DL70	ICB89-0278-1AP-1AP-3AP-0TR-0AP
	11	Chaaran-01/3/Arizona 5908/Aths//Bgs/4/Ager//Api/CM67/3/Cel/WI2269//Ore	ICB89-0799-4AP-1AP-2AP-0TR-0AP
SBCSGP98	13	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-OAP
	15	Deir Alla 106/Cel/S/Cr.115/Pro//Bc/3/Api/CM67/3/Giza 120	ICB83-0211-0AP-3AP-0TR-0AP
	16	M64-76/Ben//Jo/York/3/M5/Galt//As46/4/Hj34-80/Astrix/5/M6/Robur-35-6-3	ICB88-1391-15AP-0AP-1AP-0TR-0AP
	23	UC566/5/M64-76/Bon//Jo/York/3/M5/Galt//As46/4/Hj34-80/Astrix	ICB83-1818-2AP-1AP-5AP-7AP-4AP-0TR-0AP-2AP-0TR-OAP
	24	UC566/5/M64-76/Bon//Jo/York/3/M5/Galt//As46/4/Hj34-80/Astrix	ICB83-1818-2AP-1AP-5AP-7AP-4AP-0TR-0AP-4AP-0TR-OAP
	25	UC566/5/M64-76/Bon//Jo/York/3/M5/Galt//As46/4/Hj34-80/Astrix	ICB83-1818-2AP-1AP-5AP-7AP-4AP-0TR-0AP-5AP-0TR-OAP

Table 6.8. List of Barley Lines Resistance to Powdery Mildew,Covered Smut,and Scald In ADGB & PDG-Advanced and Preliminary Barley Germplasm Pools.

Nursery	ENT	Name	Pedigree
	1	Gloria'S'/Celo'S'//Teran 78	CMB84A-0236-0AP-1AP-0TR-1AP-0TR-0AP
	6	CI 01021/4/CM67/U.Sask.1800//Pro/CM67/3/DL70/5/Gizeh	ICB89-0562-5LAP-2AP-2AP-0AP
	9	Lignee 527/Sawsan//Bc/3/Arar	ICB89-0176-1LAP-6AP-0TR-2AP-0AP
	24	Express	-1
	39	YEA389.3/YEA475.4	YAA348-4A-2A-1A-0AP
	41	Salmas*2/3/Vg/Julia//Zy	ICB85-0373-0AP-1AP-4AP-3AP-0AP
ADGB96	42	Plaisaut	-1
	47	Rapidan	-1
	48	ICB-103351/Arta	ICBH88-0050-1AP-2AP-0AP
	51	Wieselburger/Ahor 1303-61/3/Arr/Esp//Alger/Ceres,362-1-1	ICBH89-0136-0AP-0AP-3AP-0AP
	52	Roho//Alger/Ceres,362-1-1/3/CWB117-77-9-7	ICBH89-0156-0AP-0AP-3AP-0AP
	54	Rihane/Lignee 640//ICB-107766	ICBH88-0088-0AP-18AP-0AP
	13	Tun-Landrace	-1
	28	Eldorado/Anoidium	ICB94-0154-0AP
	29	Manitou/Courlis	ICB94-0193-0AP
	31	Courlis//As46/Aths	ICB94-0201-0AP
	46	Tun-landrace	
	96	Rihane-03/3/5604/1025//Arabi Abiad	ICB89-0145-5AP-1AP-1AP-0TR-0AP-4AP-0AP
	101	Rihane-03/3/5604/1025//Arabi Abiad	ICB89-0145-5AP-1AP-1AP-0TR-0AP-3AP-0AP
PDG99	104	Rihane-03/3/5604/1025//Arabi Abiad	ICB89-0145-5AP-1AP-1AP-0TR-0AP-5AP-0AP
	118	MD ATL/CM5S-3W-B/6/MD ATL/CM-B-4-2-1-B-B/5/Cer/Por//Tb/3/Pro/4/DL75	ICB85-0587-2AP-5AP-0TR-2AP-0TR-0AP-1APH-0AP-12AP-0AP
	189	Api/CM67//Mona/3/DI//Asse/CM65-1W-B/4/Assala-02	ICB85-0225-2AP-3AP-0TR-1AP-0TR-0AP
	194	AV 92-42-52	Belts. 600807/Henry//Sussex/3/2*Barsoy
	196	Tipper/ICB-102854	ICB90-0032-0AP-5AP-0AP-2AP-0AP

The nursery (**PDG**) will be tested over years and against different diseases at different sites. Selected lines for disease resistance will be added to the germplasm pool for exploitation as source of resistance by NARS breeding programs in WANA. Results of 1997-98 screening show that 60% of the lines have good resistance to scald, 57 % were resistant to covered smut and 39% to powdery mildew (Fig.6.2). Lower frequency of resistant lines (18-25%) to combined diseases was also registered. Table 6.9 shows a list of lines that have high resistance to powdery mildew, scald, and covered smut. Crosses with the variety Rihane (Table 6.8) showed good resistance to three diseases and would have good adaptation in WANA region.

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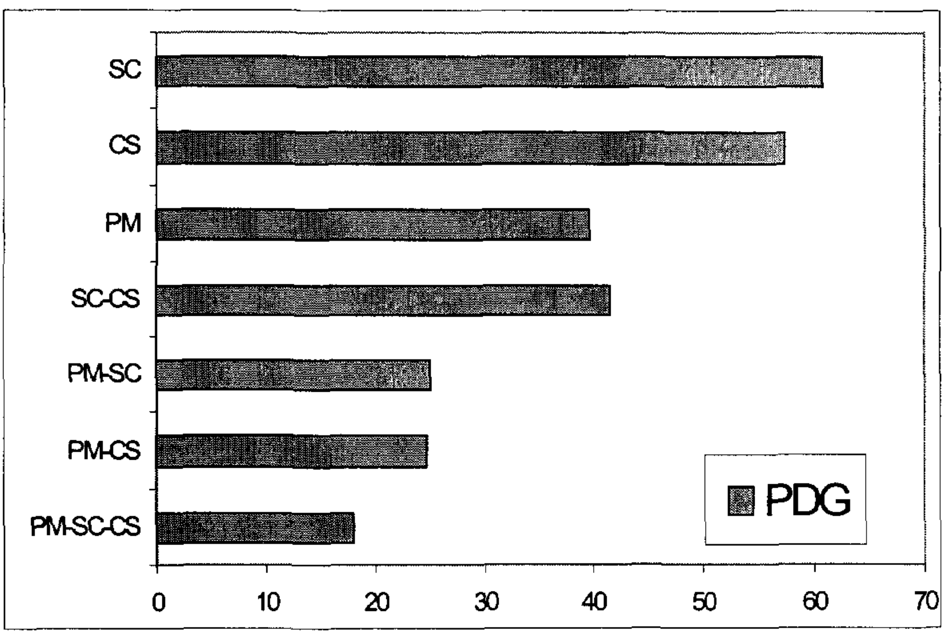

Figure 6.2 Frequency Distribution of Resistant Line to Scald (SC), Powdery mildew (PM), andCoverd smut (CS), and combinations in Preliminary Germplasm Pool (PDG).

Table 6.9. Resistance to scale & cover Smut & Powdery Mildew.

Nursery	ENT	Pedigree
	13	Tunisia
	28	Eldorado/Anoidium ICB94-0154-0AP
	29	Manitou/Courlis ICB94-0193-0AP
	31	Courlis//As46/Aths ICB94-0201-0AP
PDG99	46	TUNISIA
	96	Rihane-03/3/5604/1025//Arabi Abiad ICB89-0145-5AP-1AP-1AP-0TR-0AP-4AP-0AP
	101	Rihane-03/3/5604/1025//Arabi Abiad ICB89-0145-5AP-1AP-1AP-0TR-0AP-3AP-0AP
	104	Rihane-03/3/5604/1025//Arabi Abiad ICB89-0145-5AP-1AP-1AP-0TR-0AP-5AP-0AP
	118	MD ATL/CM5S-3W-B/6/MD ATL/CM-B-4-2-1-B-B/5/Cer/Por//Tb/3/Pro/4/DL75 ICB85-0587-2AP-5AP-0TR-2AP-0TR-0AP-1APH-0AP-12AP-0AP
	189	Api/CM67//Mona/3/DI//Asse/CM65-1W-B/4/Assala-02 ICB85-0225-2AP-3AP-0TR-1AP-0TR-0AP
	194	AV 92-42-52 Belts. 600807/Henry//Sussex/3/2*Barsoy
	198	Tipper/ICB-102854 ICB90-0032-0AP-5AP-0AP-2AP-0AP
	205	Rihane/lignee 640//ICB-107766 ICBH88-0088-0AP-12AP-1AP-0AP
	213	Lignee 131//4341 N/Ortolan ICBHA81-2207-1AP-3AP-0AP
	216	Rapidan
	218	Cyclone
	219	Taman

6.4.2. Wheat Germplasm pools

In 1997-98 four-wheat germplasm pools were made after testing for disease resistance for three consecutive years. They have been dispatched to NARS collaborators for use in 1998-99 crop season. The wheat germplasm pools are as follows:

- WYRGP98- Wheat Yellow Rust Germplasm Pool (Table 6.10)
- WLRGP98-Wheat Leaf Rust Germplasm Pool (Table 6.11)
- WSRGP98-Wheat Stem Rust Germplasm Pool (Table 6.12)
- WSTGP98-Wheat Septoria Germplasm Pool (Table 6.13)

The genotypes of these four germplasm pools are listed in tables 6.10-6.13, the evaluation for each specific disease is shown for three years (1996-1998). Appropriate rating scales are used for each disease. The information for other diseases is shown as coefficient of infection (CI) for the rusts, in percent for common bunt (%), and scale 0-9 for septoria.

The coefficient of infection is determined by attributing a numeric value to the reaction type (i.e. R, MR, MS, and S) then multiplying it by the % of infection (severity). A CI < 5 means that the variety is resistant to rust. All the genotypes were susceptible to common bunt (Tables 6.10-6.13), and some showed lower resistance to septoria (values >5) as shown in tables (6.10, 6.11).

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Table 6.10. Performance [1] of Selected Bread wheat Lines to Yellow rust (*Puccinia striiformis*) and other Diseases (WYRGP 98):Yellow rust Germplasm Pool

		Screening year and site [2]							Other diseases [3]				
		1996		1997		1998							
Ent.	Cross or Name	TH	TE	TH	TE	TH	TE	DH	LR	SR	ST	PM	CB
1.	Cham4//Vee'S'Sub'S'	5R	10MR	5R	trR	tM	5MR	5R	1	2	6	2	19
2.	F//68.44/Nzt/3/Cuc'S'/4/Algeria.M28	10R	5MR	5R	trR	5M	5MR	10S	1	1	4	0	36
3.	KAUZ'S'/4/Car853/COc//Vee£5'S'/3/Ures	5R	10MR	5MR	5MR	5R	5MR	20MR	1	30	3	0	32
4.	NS732/Her//Ures/Bow'S'	5MR	10MR	5MR	5MR	10MR	10MR	10MR	1	9	4	0	-
5.	NS732/Her//71St2959/Crow'S'	5MR	15MR	5R	5MR	5MR	5MR	20MR	1	12	4	0	24
6.	SUNBIRD	5R	-	5MR	trR	5R	10MR	20MR	-	-	-	0	-
7.	Shi£4414/Crow'S'//Vee'S'/Snb'S'	5R	10MR	5MR	trR	5R	5MR	5R	4	4	4	0	-
8.	Snb'S'//Shi£4414/Crow'S'	5MR	10MR	5R	5MR	10MR	5MR	10R	1	6	4	0	52
9.	Tzpp*2/Ane//Inia/3/Cno/Jar//Kvz/4/...	5MR	15MR	5MR	5MR	tMR	5MR	10R	1	6	5	3	42
10.	Tzpp*2/Ane//Inia/3/Cno/Jar//Kvz/4/...	5R	5MR	5MR	trR	5MR	5MR	20MR	4	16	6	1	28
11.	Vee'S'//Bow'S'/Crow'S'	5MR	10MR	5MR	5MR	5MR	15M	20MR	1	2	5	4	60

1) Performance: % severity and reaction type. 2) Screening year and sites: TH=Tel-Hadya/Syria; TE=Terbol/Lebanon; DH=Dhamar/Yemen.

2) Other diseases: LR=Leaf rust and SR=Stem rust, both as CI; ST=Septoria tritici blotch, PM=Powdery mildew, both on 0-9 scale; CB=Common bunt, % head infection.

Table 6.11. Performance [1] of Selected Resistant Bread wheat Lines to Leaf rust (*Puccinia recondita*) and other Diseases (WLRGP 98):Leaf Rust Germplasm Pool

		Screening year and site [2]						Other diseases [3]				
		1996		1997			1998					
Ent.	Cross or Name	TH	TE	TH	TE	FU	TH	YR	SR	ST	PM	CB
1.	KAUZ'S'/Kauz'S'	5R	trR	5R	5MR	-	trR	9	2	5	0	45
2.	KAVZ'S'//Kea'S'/Tan'S'	5R	10MR	5R	15M	5R	5R	4	2	5	8	14
3.	Mon'S'/Ald'S'//Tow'S'/Pew'S'	5R	5MR	5R	10MR	5R	3R	1	12	6	5	31
4.	NS732/Her//Shi£414/Crow'S'	5R	5MR	5R	5MR	-	3R	2	24	5	0	24
5.	NS732/Her//Shi£4414/Crow'S	5R	trR	5R	5MR	trR	3R	1	4	5	8	12
6.	Opata/Bow//Bau/3/Opata/Bow	5R	15MR	5R	trR	-	5R	4	2	5	0	-
7.	SKH8/4/Rrv/Wwi5/3/Bj'S'//On*2/Bon.	trR	-	5R	5MR	-	trR	6	2	4	-	33
8.	8.Tzpp*2/Ane//Inia/3/Cno/Jar//Kvz/4.	5R	10R	5R	trR	-	trR	2	4	5	3	42
9.	Ures*2/Prl'S'//Tow'S'/Pew'S'	5R	trR	5R	trR	-	trR	16	4	7	0	29

[1] Performance: % severity and reaction type. [2] Screening year and site : TH=Tel-Hadya/Syria; TE=Terbol/Lebanon; FU=Fundulea/Romania.

[3] Other diseases: YR=Yellow rust and SR=Stem rust both as CI, ST=Septoria tritici blotch, and PM=Powdery mildew on 0-9 scale, CB=Common bunt % head infection.

Table 6.12. Performance [1] of Selected Resistant Bread wheat Lines to Stem rust (*Puccinia graminis*) and other *Diseases* (*WSRGP 98*) Stem Rust *Germplasm* Pool

Ent.	Cross or Name	Screening year			Other diseases			
		1996	1997	1998	YR	LR	ST	CB
1.	F//68.44/Nzt/3/Cuc'S'/4/Algeria.M28	10MR	5R	trR	1	0.2	4	35
2.	KAUZ'S'/3/Tx62A4793-7/CD809//Vee'S'	-	5MR	10MR	4	2.0	5	60
3.	KAVZ'S'//Kea'S'/Tan'S'	5MR	5R	15MR	1	4.0	5	14
4.	Opata/Bow//Bau/3/Opata/Bow	10MR	5MR	15MR	4	1.0	5	51
5.	Tsi/Veef5'S'//KAUZ'S'	5MR	5R	10MR	1	1.0	5	35
6.	Veef7/Kauz'S'	5MR	5MR	10MR	16	4.0	5	66

[1] Performance : % Severity and reaction type. [2] Other diseases : YR=Yellow rust and LR=Leaf rust, both as CI; ST=Septoria tritici blotch on 0-9 scale; CB=Common bunt, % head infection.

Table 6.13 Performance [1] of Selected Resistant Bread wheat Lines to Septoria tritici blotch, (*Mycosphaerella graminicola*) and other Diseases (WSTGP 98): Septoria Germplasm Pool

		Screening year and site [2]						Other diseases [3]			
		1996		1997			1998				
Ent.	Cross or Name	TH	LA	TH	LA	TH	LA	YR	LR	SR	CB
1.	Bau'S'/6/Atl66/H567.71//Atl66/5/Pmn5...	2	4	3	5	5	5	2.0	1	6	61
2.	COLOTANA	1	4	2	2	5	2	6.0	-	-	-
3.	IAS58/4/KAL/BB//CJ"S"/3/ALD"S"/5/BOW"S"	1	3	2	3	3	5	0.4	-	-	-
4.	KAUZ'S'//Bow'S'/Nkt'S'	3	4	3	5	5	5	4.0	2	2	39
5.	KAUZ'S'/3/Tx62A4793-7/CD809//Vee'S'	4	4	3	5	5	5	1.0	2	3	-
6.	KAUZ'S'/3/Tx62A4793-7/CD809//Vee'S'	2	4	2	2	4	3	2.0	2	4	-
7.	Psn'S'/Bow'S'//Kauz'S'	1	3	4	4	4	5	3.0	8	9	-
8.	Sn64/Hn4//Rex/3/Edch/Mex/4/Sls'S'/5/Bow'S'	2	2	3	5	4	4	6.0	1	6	50
9.	Snb'S'/Kauz'S'	1	2	2	5	2	3	1.0	6	9	56

[1] Performance : on 0-9 scale [2] Screening year and site : TH=Tel-Hadya and LA=Lattakia/Syria; [3] Other diseases: YR=Yellow rust, LR=Leaf rust, and SR=Stem rust as CI; CB=Common bunt % head infection.

6.5. Nematodes

The seed-gall nematodes are seed-borne pest. Seed-galls fall during harvest on the soil or get mixed with healthy seed. Seed galls in the soil or sown with healthy seed release thousands of larvae in soil. With adequate soil moisture, larvae move towards the plant apex and penetrate flower primordia. Nematodes mature, copulate and produce large number of eggs, developing to Juveniles. Dark nematode galls replace the kernels. The dissemination of nematodes can be by infected seed, from fine straw that harbor nematodes, and from infected soils particularly those under continuous cereal cultivation

Preliminary studies conducted in 1995 over viewed the problem of "Abu Ulaiwi" and the presence of the seed-gall nematodes on barley in North-Eastern Syria (Bellar, 1995). However, in-depth characterization of "Abu Ulaiwi" on barley, quantification of the incidence and severity, and the relation to the seed-gall nematodes were needed.

A comparative study of the seed-gall nematodes affecting wheat and barley in Syria and their impact on cereal production was realized. The preliminary results of this study are discussed thereafter.

6.5.1. Distribution of barley and wheat seed-gall nematodes *Anguina* spp. in farmers fields of wheat and barley in Northern Syria.

6.5.1.1. Field survey of "A. Ulaiwi" and barley seed-gall nematode in Northern Syria.

Studies on head sterility "A. Ulaiwi" during harvest 1996, 1997, 1998 included 120, 72 and 57 samples representing 30, 24, and 18 barley fields respectively in Al-Bab, Qabbasin, Djerablous, and Membij areas. The samples were grouped into three categories (tall, normal, and short plants). Number and percentage of healthy spikes, totally infected spikes and those of partially infected spikes were determined. Sub-samples were taken at random to count healthy seed, sterile spikelets, and nematode galls. Table 6.14 shows the incidence of head sterility and grain losses. The incidence (%) varied from year to year and the highest incidence was observed in 1998.

Table 6.14. Incidence of head sterility and % of grain loss

Year	No. of surveyed fields	No. of infected Fields	% Infection (%Head sterility)	% Grain Losses
1996	30	29	23.5% (9.6-57)	11.4% (2.4-43)
1997	24	23	20.4% (5.9-47)	12.3% (4.2-21)
1998	18	17	24.7% (2.3-42)	13.6% (1.2-30)

The results showed that the head sterility is not correlated with plant height. Head sterility was found in short, normal and tall plants in the following percentages 21.7%, 23.3% and 31% respectively in 1995-96 season. Furthermore the results showed a correlation between head sterility and presence of nematodes. Nematodes were found in 93% of infected spikes. These results were confirmed in the 1996-97 and 1997-98 seasons.

The survey results showed that the spread of barley seed gall nematode in the region of Al-Bab, Qabbasin, Djerablous, and Membij surveyed in 1995-96, 1996-97 and 1997-98 crop seasons was not affected by two years of crop rotations. Barley seed gall nematode was found in 90% of the fields surveyed. The biannual rotations practiced in these areas are as follows: 1) Barley after barley, 2) Barley after legumes, 3) Barley after wheat and 4) Barley after fallow.

The surveyed wheat fields after barley (1996-97 and 1997-98 seasons) were free from infection with barley seed gall nematode (BSGN) in spite of these field were infested with barley seed gall nematode in 1996-97 and 1997-98 seasons. The low infection ratio (<2%) with (BSGN) was observed in 4-year rotation system in one field in El-Eiobiia, 30 Km. north of El-Bab.

The sources of infection of barley seed gall nematode in barley fields surveyed are due to one or more of the following:

- infected seeds (most farmers use local seed)
- Hard straw- standing stubble & straw
- Very fine straw spread during harvest.

In an estimated 30% infection, the nematode were detected as follows:

- 32% in infected seeds
- 28 % in hard straw
- 40% in fine straw

6.5.1.2. Field survey of wheat seed-gall nematode (WSGN) *Anguina tritici* in the major wheat growing areas (farmer's fields) of wheat in Northern of Syria.

Field survey of WSGN during harvest 1997, 1998 included 140 and 110 samples representing durum and bread wheat from farmer's field in Aleppo and Raqqa areas respectively. The samples were evaluated and the number and percentage of healthy and infected seeds were determined.

The survey results showed that the infection in the fields under crop rotation were very low (4%). Continuous of wheat increased the number of infected fields (60%). Actual grain loss in infested fields ranged from 0.2-17% with an average of 4%.

The infection with wheat seed gall nematode in wheat fields was due to infected fields following mono - culture practices and the use of healthy seed mixed with the infected seed with WSGN.

6.5.2. Pathogenicity test and Host range of the wheat and barley seed-gall nematodes *Anguina* spp.

Pathogenicity test and host range determination were initiated in 1996-97 in pots and under field condition on wheat and barley. Cereal crops being tested include bread and durum wheat, wheat wild relatives/progenitors (*Aegilops* and *Triticum* spp.), Triticale, two and six-rows cultivated barley, as well as wild barley (*Hordeum spontaneum*). Following artificial inoculation the preliminary results show that BSGN can infect *Hordeum vulgare* and *H. Spontaneum these two species are considered as* good host plants. WSGN can infect *Triticum aestivum, T. durum,* Triticale , and these species are good plant host. *T. beoticum, T. dicocoides* and *Aegilops were not considered as good plant hosts.*

6.5.3. Reaction of wheat and barley cultivars to seed-gall nematodes.

Experiments were undertaken during 1995-96, 1996-98 1997-98 and growing seasons in pots and under field conditions to investigate the reaction of barley and wheat cultivars to the seed-gall nematode. Inoculation was done directly after sowing with barley seed-gall nematode for barley cultivars and wheat seed-gall nematode for the wheat cultivars. Infection incidence varied significantly between tested barley, durum and bread wheat cultivars (1995-96 and 1996-

97). The results of 1997-98 growing season are under studies.

Results also showed that the reproduction ratio of barley seed-gall nematode is 0.1-3.9 and that of wheat seed-gall nematode 0.6-20. The results of 1997-98 season are under studies.

The screening test for resistance to barley seed-gall nematode were undertaken during 1997-98 growing seasons in pots and under field conditions to investigate the reaction of barley germplasm to seed-gall nematode. Infection incidence varied significantly between tested material (0.0-84%). 5 lines were free from infection and were considered as highly resistant(HR), 10 lines were resistant (R), 8 lines shoed intermediate reaction type (MR), 33 lines were moderately susceptible (MS), and 34 lines were susceptible (S) to the nematode from Al-Bab population. These preliminary results show that it is possible to screen for resistance. The screening experiments will be run during the coming seasons.

(H.Zainab (University of Aleppo), Y. Swedan (DSAR),S.Ceccarelli, A.Yahyaoui, H.Toubia-RahmeZ.Alamar)

6.5.4. Screening for resistance to *Heterodera latipons*

A screening nursery of 90 barley entries was screened in 1998 for resistance to cereal cyst nematode (CCN) *Heterodera latipons* (Boueidar population). The test was carried out in pot experiment. Five seeds were sown in pots. Inoculation was done directly after sowing with 20 eggs and Juveniles/g soil of CCN. The barley variety Arta was used as a check. Plants were uprooted 70 days after emergence. The number of Juveniles and stages were estimated by fixation and staining the root tissue. The final population in root was estimated using a rating scale 0-5 as describedin Table 6.15.

Table 6.15. Evaluation scale for *Heterodera latipons*

Scale	Reaction Type		Number of cyst /plant	
1	HR	Highly resistant	0- 2	Cyst/plant
2	R	Resistant	3-10	Cyst/plant
3	MR	Moderately resistant	11-20	Cyst/plant
4	MS	Moderately susceptible	21-50	Cyst/plant
5	S	Susceptible	More than 50 Cyst/plant	

The infection level of the tested barley genotypes varied from 7-226 female/plant. Results are summarized in the following table 6.16.

Table 6.16. Reaction of Barley lines to CCN infection

No. of tested entries	HR (1)	R (2)	MR (3)	MS (4)	S (5)
86	0	3	14	40	29

These preliminary results show that the screening for resistant is a valid approach to develop resistant/tolerant cultivars as a control for nematodes. Detailed studies are being conducted to further characterize the pathogenic nematodes and develop appropriate control measures

(U.Scholz (University of Bonn), S.Ceccarelli, H.Toubia-Rahme, Z.Alamdar)

6.6. Integrated disease management (IDM)

6.6.1 Effect of varietal mixture on scald development

Cultivar mixture could be used as a control in an integrated disease management approach. Resistance to scald often breaks down and yield losses could be relatively high. High yielding varieties often lose their yield potential under high disease infection. Many researchers have advocated the effectiveness of varietal mixture and in some cases could be the most effective way to maintain adequate yield under disease infection. Three varieties that have a differential reaction to scald were studied for grain yield and straw production under artificial inoculation with scald and protected experiments. The treatments in the experiment are as follows:

- Resistant variety V1 Salmas/A.Aswad
- Tolerant variety V2 Salmas
- Susceptible variety V3 WI2291
- Mixtures & Ratios
  - V4 (1:1:1) = 1 V1 (R) : 1 V2(M) :1 V3(S)
  - V5 (1:1:2) = 1 V1 (R) : 1 V2(M) :2 V3(S)
  - V6 (1:2:1) = 1 V1(R) : 2 V2(M) :1 V3(S)
  - V7 (1:1:2) = 1 V1(R) : 1 V2(M) :2 V3(S)
- Treatment:
  - Inoculated (INO): artificial inoculation with scald under field conditions
  - Protected (TRE): protected with fungicide against scald

Figure 6.3 shows the grain yield of the three varieties (V1,V2,V3) and their mixtures (V4,V5,V6,V7) following artificial inoculation with scald. Yield differences were observed for V2 and V3 for the two scald treatments (i.e. inoculated Vs protected). The susceptible variety (V3) showed higher yield when protected against the scald disease. A yield loss of 930 kg was registered under disease infection (figure 6.3). The susceptible variety contributed to the obtainment of higher yield in the mixture V5 (Table 6.17). The fungicide treatment (TRE-protected) and the artificial inoculation did not have a significant impact on the grain yield of the four mixtures (V4,V5,V6,and V7).

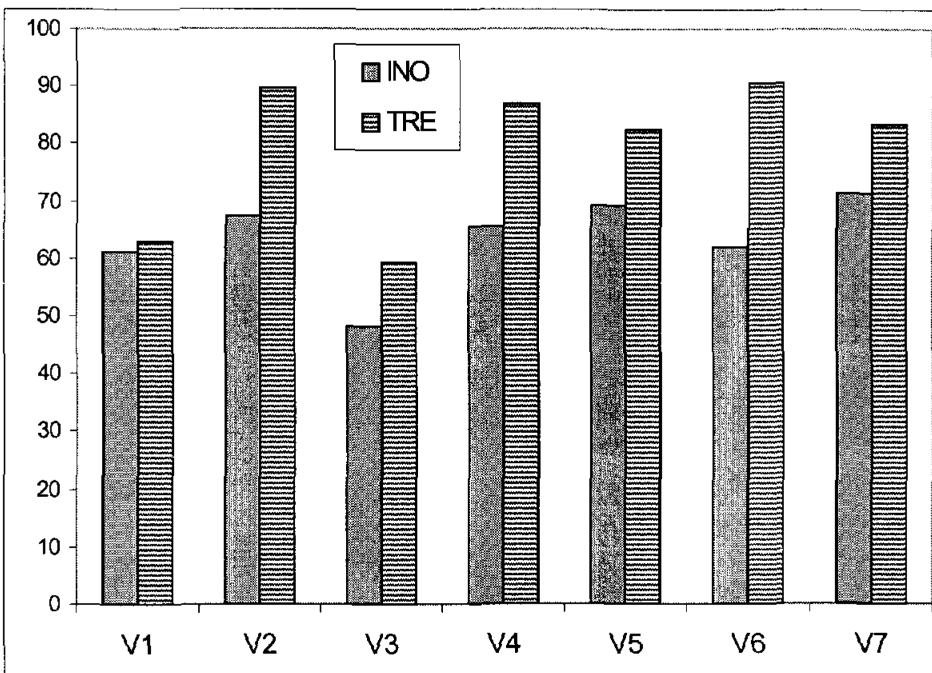

Figure 6.3. Straw Production (t/ha) of three Cultivars and Mixutres Under Two Scald Treatments

The effect of scald disease on straw production was apparent with the tolerant variety (V2) and the mixture where V2 has higher proportion (Figure 6.4). The susceptible variety has the lowest straw yield when inoculated but a similar yield to that of the resistant variety (V1) when protected against scald. The straw yield of the mixtures was higher than that of the individual varieties (Table 6.17).

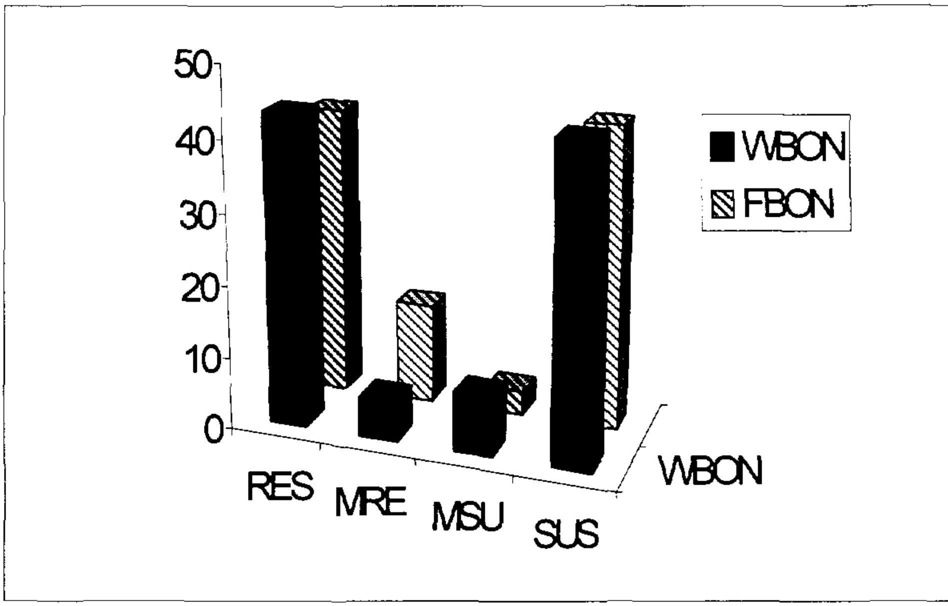

Figure 6.4. Reaction of 300 Barley Lines to Scald (FBON &WBON) to Scald at Tel Hedya 1998

Varietal mixture resulted in higher straw yield and maintained higher yield of the susceptible variety that was and much different from that obtained following fungicide treatment. The gain in grain yield varied from 0.7 % (V1) to 26.2% (V2), that of straw yield Varied from 3.1% (V1) up to 46.3%(V6). Grain yield and straw yields also varied according to the mixture ratios of the tested varieties.

Table 6.17. Variation of Grain and Straw yields under two scald treatments for three barley varieties and their mixtures.

Variety, Disease reaction & Mixture ratio	Grain Yield (qx/ha) & % Gain			Straw Yield (t/ha) & % Gain		
	Inoculated	Treated	Gain Qx/ha- %	Inoculated	Treated	Gain Qx/ha-%
V1 (R)	41.8	4.21	0.30- 0.7	6.11	6.30	0.19- 3.1
V2 (M)	42.3	53.4	11.10-26.2	6.76	8.98	2.22-32.8
V3 (S)	50.0	56.9	6.90-13.8	4.81	5.93	1.12-23.3
V4 (1R:1M:1S)	47.0	50.9	3.90-08.3	65.70	87.00	21.30-32.4
V5 (1R:1M:2S)	52.8	55.0	2.20-04.2	69.40	82.40	13.00-18.7
V6 (1R:2M:1S)	48.7	52.0	3.30-06.8	62.00	90.70	28.70-46.3
V7 (1R:1M:2S)	50.2	50.9	0.70-01.4	71.30	83.30	12.00-16.8

(A.Yahyaoui, H.Toubia-Rahme, Z. Alamdar, & I. Maaz)

6.6.2. Effect of fertilizer application on the severity of powdery mildew on barley in long-term rotation trial

The severity of powdery mildew (*Erysiphe graminis* f. sp. *hordei*) of barley was high, in 1997-98 growing season, due to the lack of rain during the month of February and the beginning of March. The severity of the disease was assessed in the barley-forage legume rotation trial at Tel Hadya, using the Horsfall and Barratt (HB) scale, to see if fertilization had an effect on the severity of powdery mildew. Only one rating was done on whole plot basis and further recordings could not be made due to unfavorable weather condition that stopped further disease development. The disease severity data were analyzed using analysis of variance on the 22 treatment combinations indicated in table 6.18.

Table 6.18. Fertilizer combinations applied in the barley-forage legume rotation in the long term rotation trial, Tel Hedya

	NP			
Previous crop	0:0	0:60	40:60	80:60
Lathyrus sativus	+	+	+	+
Vicia sativa (Grazed)	+	+	+	+
Vicia sativa (Hay)	+	+	+	+
Vicia narbonensis	+	+	+	+
Barley-Barley	+		+	
Barley-Barley	+		+	

[+] Treatment combination in the long-term barley-forage legume rotation.

The preliminary results showed that significant differences ($p<0.05$) were observed among treatments. Plots without fertilizer showed the highest powdery mildew infection followed by plots receiving only by phosphorus fertilization (Fig.6.5). The application of 80:60 kg NP/ha showed the lowest powdery mildew severity. Proper application of NP fertilization is recommended to reduce powdery mildew infection. The result showed that proper fertilization could be used in the overall integrated management of powdery mildew in barley.

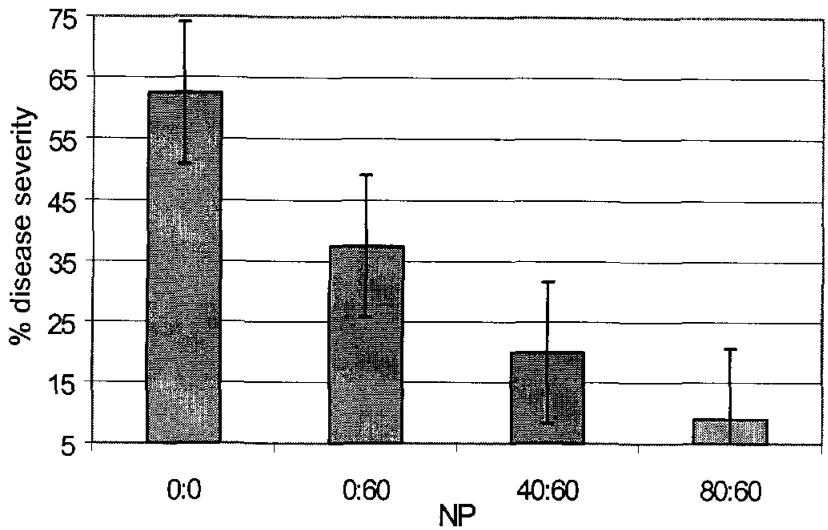

Figure 6.5. Effect of fertilizer application on the severity of powdery mildew of barley, Tel Hadya 1997/98.

NP= Nitrogen and phosphorus; Vertical bars are the standard errors of means. B1+L= Rihane + legumes; B2+L= Salamas + legumes; B3+3= Tokak + legumes; B4+L= Arabia Aswad + legumes; B1= Rihane; B2= Salamas ; B3= Tokak; B4= Arabia Aswad. Vertical bars are standard error of means.

6.6.3. Effect of forage legume mixtures on the severity of barley powdery mildew

The 1997/98 season was partly favorable for natural epidemics of powdery mildew on barley at Tel Hadya. As a result, the effect of barley-legume mixtures on powdery mildew severity on barley was evaluated. Four barley cultivars (cvs. Rihane, Salmas, Tokak and Arabia Aswad) were mixed individually with different forage legumes for biological yield by the Forage Improvement Project. The experiment was replicated three times in randomized block design. Powdery mildew severity was assessed in March 1998 from plots of barley-legume mixtures and barley pure stands. Further assessments were not done due to weather changes that did not favor powdery mildew development. The growth stage of the barley was booting at the time of disease assessment. Percent disease severity was analyzed after transforming (arcsine) the data.

Significant differences ($p<0.05$) were observed among treatments affecting disease severity. In general, higher disease severity was observed in barley pure stands than in barley-legume mixtures (Fig.6.6). Among the individual forage legume species mixed with the susceptible cv. Tokak, severity was lowest when mixed with *Vicia dasycarpa* (Fig.6.6). This preliminary result showed that, farmers not only benefit from high biological yield with barley-forage legume mixtures, but also reduce the impact of powdery mildew in areas where susceptible barley cultivars are grown. Similar evaluations will be done in the 1998/99 cropping season on similar trials. Moreover, it will be interesting to study how barley mixed with forage legume could affect foliar diseases of the latter.

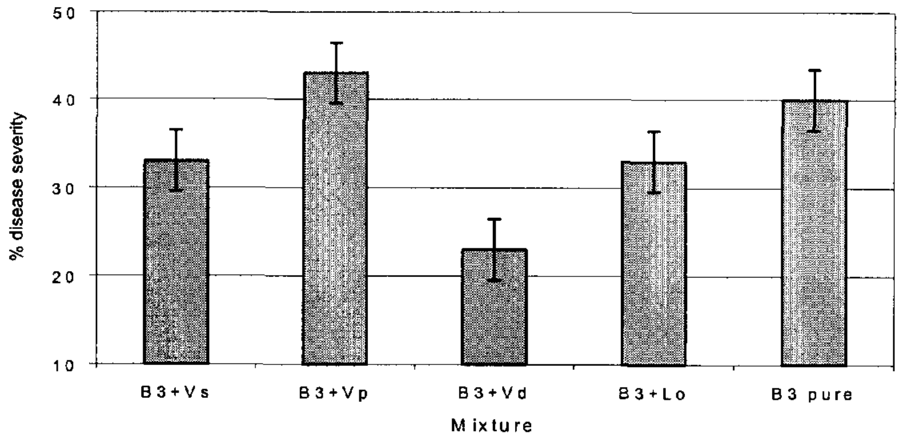

Figure 6.6. Effect of Forage-Legume Mixture with Susceptible Barley Cultivar on the Severity of Powdery mildew.
B3+Vs= Tokak + *Vicia sativa*; B3+Vp= Tokak + *V. palaestinia*; B3+Vd= *V. dasycarpa*; B3+Lo= Tokak + *Lathyrus ochrus*; B3= Tokak pure stand. Vertical bars are the standard errors of means.

(S.Kamal, A.Yahyaoui, & Z.Alamdar)

6.6.4. Root rots in Wheat-based two-course rotation

This trial was established in the1985/86 cropping season at Tel Hadya. The main treatments were: (a) seven cropping sequences (wheat-wheat, wheat-chickpea; wheat-fallow; wheat-medic; wheat-summer crop (water melon); wheat-lentil; and wheat-vetch); (b) four levels of nitrogen (0, 30, 60, and 90 kg N/ha) applied to subplot at planting and tillering stage in wheat phase. The trial was in split plot design where rotation was main plots and fertilizer levels as sub plots in three replications. Disease data were collected from two replications. Each rotation treatment comprised of two phases: one carrying wheat and the other legumes and summer crop (SC) in any given year. Root samples were collected from each plot with their sub-crown internodes and percent root rot severity and incidence were evaluated. Disease severity was calculated following the formula described earlier. Analysis of variance was made on both disease parameters.

No significant differences ($p<0.05$) were observed among treatments or their interactions in affecting both disease parameters. The mean percent root rots incidence ranged from 46% in wheat-watermelon rotated plots to 78% in fallow rotated plots (Table 6.19). The mean percent disease severity ranged from 10% in plots rotated with watermelon to 17% in plots rotated with fallow (Table 6.20). On the other hand, there were not much differences among nitrogen levels in affecting mean percent disease incidence and severity.

Table 6.19. Effect of crop rotation and nitrogen fertilization on mean percent wheat root rots incidence, Tel Hedya, 1997/98

Previous crop	Nitrogen level				
	0:0	0:30	0:60	0:90	Mean
Wheat	62	38	40	52	48
Chickpea	71	50	56	48	56
Fallow	91	80	74	68	78
Medic	39	39	64	70	53
Water melon	55	48	32	50	46
Lentil	38	68	60	55	55
Vetch	54	66	62	49	58
Mean	59	56	55	56	

SE (rotation)3.74 ; fertilizer=1.78; rotation X fertilizer = 5.53
LSD(0.05) rotation = 9.1; fertilizer = 3.7; rotation X fertilizer = 11.6

Table 6.20. Effect of crop rotation and nitrogen fertilization on mean percent wheat root rots severity, Tel Hadya, 1997/98

Previous crop	Nitrogen level				
	0:0	0:30	0:60	0:90	Mean
Wheat	12	8	12	11	11
Chickpea	15	10	13	9	12
Fallow	19	17	15	16	17
Medic	8	8	15	13	11
Water melon	12	9	7	10	9
Lentil	8	14	12	11	11
Vetch	10	13	12	11	11
Mean	12	11.3	12.3	11.6	

SE (rotation)= 3.07; fertilizer=1.07; rotation X fertilizer = 3.94

LSD(0.05) rotation = 7.5; fertilizer = 2.3; rotation X fertilizer = 8.4

(S.Kamal, A.Yahyaoui)

7. VIROLOGY

Evaluation of interspecific hybrids for their resistance to barley yellow dwarf virus (BYDV) was continued during 1996. In addition, a survey for cereal viruses in Yemen was conducted in collaboration with colleagues in National Programs of Nile valley and Red Sea countries. Results of this survey is included in the Legume section as part of a survey on legume and cereal viruses in Yemen (6.3).

7.1. Evaluation of Wheat Wild Relatives

A total of 88 accessions of wheat wild relatives were evaluated for their reaction to BYDV. Because symptoms expression was mild, selection of resistant accessions was based on intensity of plant invasion with the virus as elucidated by the tissue-blot immunoassay. Twenty-five accessions (Table 7.1) were found as relatively resistant and these will be evaluated again during the next growing season. More information on the evaluation of 14 resistant accessions over a five years period are provided in (Table7.2).

(K. Makkouk, W. Ghoulam)

7.2. Regeneration of Wheat x *Thinopyrum* Derived Lines from Immature Embryos

Previous studies indicated that a number of wheat x *Thinopyrum ponticum* derived lines have a high level of BYDV resistance. However, cytological studies indicated that some of these lines have the 42 wheat chromosomes plus two telocentric chromosomes coming from the alien species.

Table 7.1. Reaction of *Aegilops* and *Triticum* species to infection with BYDV, when plants were artificially inoculated with BYDV during the 1997/98 growing season.

Species	Total No. of accessions tested	Average and range of virus conc. Index [a]	No. of accessions selected as resistant
Ae. Biuncialis	6	1.23 (1.06-1.42)	3
Ae. Caudata	2	1.64 (1.42-1.87)	1
Ae. Columnaris	4	1.40 (1.05-1.59)	1
Ae. Crassa	1	0.98	1
Ae. Cylindrica	3	1.05 (1.35-1.71)	2
Ae. Geniculata	1	1.29	1
Ae. Kotschii	1	1.15	1
Ae. Longissima	2	1.56 (1.46-1.67)	1
Ae. Neglecta	1	0.86	1
Ae. Searsii	2	1.35 (1.30-1.40)	1
Ae. Speltoides	5	1.39 (1.10-1.69)	2
Ae. Triuncialis	5	1.37 (0.95-1.83)	3
Ae. Vavilovii	1	1.55	1
Ae. Ventricosa	1	1.78	1
T. monococcum	34	1.07 (0.57-1.62)	12
T. turgidum	13	1.54 (1.13-1.93)	3
T. urartu	6	1.36 (1.15-1.61)	2
	88		37

[a] virus concentration index was based on a 0-4 scale devived from the number of stained phloem bundles by TBIA test.

Table 7.2. *Triticum* and *Aegilops* accession resistant to BYDV-PAV showing low virus concentration index when plants tested (TBIA) during evaluation in the last five planting seasons.

Germplasm	ICARDA Accessi on No.	Geogra-phical Origin	Virus conc. index [a] 1998	1997	1996	1995	1994
T. turgidum	600958	Syria	1.56	0.82	1.00	1.2	
T. turgidum	601028	Syria	1.82	1.13	1.00		
T. turgidum	601049	LBN	1.67	1.18	1.00		
Ae. Searsii	400781	Jordan	1.40	1.50			1.04
Ae. Speltoides	401763	Bulgaria	1.34	1.00		1.0	1.07
Ae. Biuncialis	401816	Bulgaria	1.37	1.40		0.6	1.15
Ae. Coundata	402255	Syria	1.87	1.00		1.0	
Ae. Triuncialis	400451	Turkey	0.95	1.74		0.8	1.22
Ae. Ventricosa	400536	Turkey	1.78	1.80		1.0	
Ae. Cylindrica	401224	Bulgaria	1.35	1.40			1.98
Ae. Neglecta	401805	Bulgaria	0.86	1.50		0.8	1.15
Ae. Biuncialis	401819	Bulgaria	1.17	1.00		0.8	1.47
Ae. Columnaris	402179	Syria	1.59	1.11		1.0	
Ae. Biuncialis	401792	Bulgaria	1.30	1.33			1.68

[a] virus concentration index was based on a 0-4 scale devived from the number of stained phloem bundles by TBIA test.

Regeneration of mature plants from callus tissue obtained from culturing immature embryos of such lines increases the probability of translocating the genomic

Segment conferring BYDV resistance from *T. ponticum* into the 42 wheat chromosomes. Accordingly, immature spikes from 10 BYDV-resistant wheat x *T. ponticum* lines were cultured to produce mature wheat plants. A total of 140 mature plants were obtained (Table 7.3), which produced 3705 seeds. During the next growing season, these seeds will be planted, the emerging plants will be evaluated for BYDV-resistance, and seeds from the best performing plants will be sent at a later stage to Dr. Andre Comeau (Agriculture Canada, *Sainte Foy, Quebec*) *for* cytological study.

Table 7.3. Frequency of plant regeneration from immature embryo-derived callus for a number of wheat x Thinopyrun ponticum derived lines.

Wheat x Thinopyrun ponticum derived lines	No. of immature spikes used	No. of regener-ated green plants	No. of Plants which reached maturity	Total No. of seeds produced and range/plant
OK-1	178	8	6	492 (32-160)
OK-2	85	32	20	324 (2-58)
OK-4	55	10	8	110 (4-24)
OK-7	60	37	35	746 (5-45)
OK-8	111	6	5	165 (5-110)
OK-9	110	20	11	205 (3-60)
OK-10	117	50	37	920 (2-64)
OK-14	85	8	7	234 (12-75)
OK-15	170	7	6	279 (10-75)
OK-16	193	6	5	230 (9-98)
Total	1164	184	140	3705

7.3. Testing for seed-borne Viruses

7.3.1 Cleaning Germplasm in the Gene Bank from Seed-borne Infections

One thousand four hundreds and eighty accessions of barley dry seeds were tested for the presence of barley stripe mosaic virus and 77 accessions were found to be infected with the virus. The virus-free accessions will be stored in the Gene Bank, and accessions with virus-infected seeds will be cleaned later.

7.3.2. International Nurseries.

About 1022 genotypes of barley and wheat were tested for barley stripe mosaic virus during November and 1011 genotypes were found virus-free. In all above cases, only virus-free accessions were dispatched to collaborators.

(K.M. Makkouk, N. Attar)

7.4. Distribution of Elisa Kits

ELISA kits or antisera for any of four cereal viruses available at the Virology Laboratory were sent to collaborators in Alegeria, Australia, China, Egypt, Ethiopia, Iraq, Jordan, Pakistan, Turkey and Yemen.

(K.M. Makkouk, S.G. Kumari)

8. ENTOMOLOGY

8.1. Sunn pest

Sunn pest (*Eurygaster integriceps* Puton) is one of the most damaging pests of wheat and barley in West Asia, where over US $42 million is spent annually for its control. Yield loss from its damage is commonly estimated at 20-30% in barley and 50-90% in wheat. Efforts are being put on developing an integrated pest management (IPM) package to replace the existing chemical control strategy. The IPM components that were studied in 1998 include parasitoids and entomopathogenic fungi.

8.1.1. Entomopathogenic fungi

Exploratory activities to collect entomopathogenic fungi of Sunn pest were conducted in southern Turkey and Southeastern Syria in January 1998. Eight scientists participated in this collection, 1 from ICARDA, 2 from the University of Aleppo, 1 from the University of Cukorova, 2 from Plant Protection Research Institute of Adana and 2 from the University of Vermont.

Adult Sunn pests were collected from the overwintering habitats, which varied depending upon geographic location. If mountains were present, surrounding cereal fields, the insect was found on steep slopes beneath the litter at the bases of bushes. At lower elevations, where mountains were absent, Sunn pests were found under the litter of bushes or at the bases of Eucalyptus and Mediterranean pine trees. Care was taken to collect all dead individuals and pieces of dead individuals.

A total of 1063 Sunn pests were collected; 84 of these were dead on collection. From these, a total of 104 fungal isolates were made. The most common entomopathogenic isolates belonged to the genus *Beauveria*. Also found were representatives of *Paecilomyces* and *Fusarium*. The latter is considered a rather moderate entomopathogen, but cases have been found where the strains are very pathogenic. From these, pure cultures of 45 isolates were prepared. These are now being subcultured and multiplied for pathogenicity trials against Sunn pest at ICARDA in February 1999.

(B. Parker, M. Skinner (University of Vermont), M. El Bouhssini)

8.1.2. Parasitoids

The objective of this study was to test the performance of the parasitoid *Trissolcus grandis* Thom. on cold-stored eggs of the alternate host *Dolycoris baccarum*.

- This study was carried out under laboratory condition (23 °C, 60-70% RH and a photoperiod of 16:8 (L: D) in the biological control laboratory, University of Aleppo. Egg masses of *D. baccarum* were stored at two temperatures regimes (5 and 10°C) for 7 different periods (0, 2, 4, 6, 8, 10, and 12 weeks). Five egg masses were used per each treatment combination. At the end of each storing period, eggs of *D. baccarum* were removed from the incubator and placed in glass tubes (10x1.5 cm). In each of these tubes where a drop of honey was added, one female *T. grandis* was released and kept for 3 days.
- The results showed that the percent parasitism of *T. grandis* on fresh eggs *of D. baccarum* eggs was high (98.6%). This level of parasitism stayed similarly high even on eggs stored for 6 weeks at 5°C and 4 weeks at 10°C. Storing eggs for more than 8 weeks at 5 and 10 °C reduced drastically the % parasitism by *T. grandis* (24-30%). These results show the potential of using stored

eggs of *D. baccarum* in cold temperatures (5 or 10 °C) for up to two months (January and February) to mass rear the parasitoid *T. grandis* early March just before Sunn pest move to cereal fields.

(M. Saloum, A. Babi (University of Aleppo), M. El Bouhssini)

8.2. Hessian fly parasitoids

Hessian fly, *Mayetiola destructor* (say), is the most destructive pest of wheat in North Africa. In Morocco, yield losses due to this pest have been estimated at 32% and 36% for durum wheat and bread wheat respectively. Hessian fly also occurs in West Asia, however, it is not an economical pest. Since the pest originates in this part of the world, natural enemies could be the main factor keeping the pest below the economic threshold.

During the last two seasons we surveyed the importance of parasitoids in the costal areas of Syria where Hessian fly usually occurs. About 1000 infested plants were randomly sampled from Lattakia region around April, when Hessian fly is at the flaxseed stage. The samples were brought to Tel Hadya and stored in a cold room (5°C) for three months, a period necessary to get over the diapausing stage. To allow emergence of the Hessian fly and/or parasitoids, samples were placed in the insect rearing room (22°C and 16 H light).

The results indicate that the level of parasitism is very high. From the two- year samples, no Hessian fly adult emerged; all were just the parasitoid. Specimens of this parasitoid were sent to France and USA, and they were identified as *Homoporus destructor*, Say. This species, which seems to be effective in regulating Hessian fly populations in western Syria, has not been reported in North Africa. More surveys of Hessian fly natural enemies covering the other parts of Syria as well as Lebanon will be conducted. Once the role of this and/or other Hessian fly parasitoids is assessed, efforts will be made to introduce effective and efficient species to North Africa.

(M. El Bouhssini, A. Joubi, A. Babi (University of Aleppo))

9. TRAINING AND VISITS

Training activities in Germplasm Program aim to assist researchers in NARS to develop their competencies in recognizing the problems of cereals and legumes and applying modern techniques to solve these problems. The training in Germplasm Program focused on providing technical training for individual non-degree trainees, conduct and support the research for graduate research students and conduct short-term training courses at ICARDA headquarters and regional, sub-regional and in-country courses. The trainees are taught to design and manage conventional experiments in the various aspects of breeding, hybridization, note taking, disease scoring, selection, analyzing and interpretation of experimental data and preparation of short technical reports; the trainees mainly are familiarized with practical application in the field and in the laboratory as well as some lectures. Round table discussions take place in specialized short-term group training courses. A method for evaluating progress is used to measure the performance of trainees and the impact of their training on agricultural research in their countries.

The following training activities were conducted during 1998.

9.1. Short-Term Courses

9.1.1. Short-Term Courses at ICARDA Headquarters

9.1.1.1. Mechanical Harvesting for Food and Feed Legumes

Food and feed legumes are important crops in WANA region. A legume harvest mechanization short course was organized at Tel Hadya from 24-28 May 1998 jointly conducted by the

Station Operation and Germplasm Program. Ten participants (5 from Syria, 3 from Iran and 2 from Egypt) attended the course. The purpose of the training course was to demonstrate a system of legume production and mechanization that decreases the cost of production. The program included both lectures and practical orientation to harvest machinery. Lectures were on problems of mechanization, breeding, agronomy, and economics of harvest mechanization. The participants evaluated the course as highly successful and useful.

9.1.1.2. DNA Molecular Marker Techniques for Crop Improvement

This course was organized at ICARDA headquarters Tel Hadya (13-24 September 1998), jointly sponsored by ICARDA and International Center for Advanced Mediterranean Agronomic Studies (CIHEAM). Eleven participants from 10 countries attended the course. The lectures covered such topics as the origin and structure of the DNA, gene cloning, DNA marker technologies and statistical analysis of marker data for genetic mapping and biodiversity evaluation. Lectures were given by Prof. Dr. G. Kahl from Frankfurt University and ICARDA biotechnology staff. The course was well received by the trainees and some of the trainees will make use of the demonstrated techniques in their respective national programs.

9.1.2. Regional/Sub-Regional Short-term Training Courses

9.1.2.1. Diagnosis and Control of Diseases of Grain and Pasture Legumes Adapted to Mediterranean Environments

This advanced course was held in Spain from 20-30 April 1998 and sponsored by ICARDA, Center for Legumes in Mediterranean Agriculture (CLIMA) and CIHEAM. Thirty-one participants attended the course (Table 9.1.). The aim of the training course was to increase the knowledge of NARS to identify the diseases of grain and pasture legumes grown in the Mediterranean environments. Drs. K. Makkouk and C. Akem provided input into the course from the ICARDA side.

Table 9.1. Attendance at Diagnosis and Control of Diseases of Grain and Pasture Legumes Adapted to Mediterranean Environments

Country	No. of Participants
Algeria	3
Egypt	2
Morocco	3
Portugal	1
Spain	13
Syria	2
Tunisia	3
Turkey	3
TOTAL	30

9.1.2.2. Computer Application in Breeding Management (AGROBASE)

Germplasm Program and CBSU jointly conducted in-country short-term training course on computer application in breeding management in Cairo, Egypt from 26 February to 03 March 1998. There were 16 participants attended the course. The major emphasis of the course was on designing, and management of breeding trials. The course also covered computer basics, data entry and analysis by AGROBASE. The level of skill achievement was very high.

9.1.2.3. Insect Taxonomy and IPM of Insect Pests

This sort-term course was held in Oman and sponsored by ICARDA and Ministry of Agriculture and Fisheries (S. Oman) from 21 March to 1 April 1998. A total of 21 participants attended the course, (17 participants from S. Oman, 1 from each S. Arabia, Bahrain, Kuwait and UAR). Pre and post-course evaluation showed a big improvement in the entomology knowledge of the participants. All participants were mostly interested in biological control of the insects.

9.1.3. In-Country Short Term Training Courses

9.1.3.1. Introduction to Wilt/Root Rot Diseases

The short-term course was organized by ICARDA and held in Giza, Egypt from 26-31 March 1998. Eight participants attended the course (5 males and 3 females). The program included theoretical, laboratory and field training. Lectures were on wilt root/rot disease, strategies for the identification of resistant sources and integrated management of root/rot diseases. Laboratory and field training focused on the identification, isolation and control of the pathogens.

9.1.3.2. DNA Molecular Marker Techniques for Crop Improvement

A training course on DNA molecular marker techniques was held in Karaj, Iran from 6-19 June 1998. The course was sponsored by ICARDA/Iran project. Ten scientists from Iran participated in this course. Most of the participants had some experience in either breeding or biotechnology. The major aim of the course was to ensure that basic DNA marker technologies could now routinely be used in Iran. Once the basic technology has been established, the Iranian national program can build on this experience and take up new technology. All the trainees expressed their satisfaction with the new knowledge they acquired.

9.2. Individual Training

9.2.1. Individual Non-degree Training

Training in specific areas of techniques in Germplasm Program was provided to 62 researchers from 14 countries (Table 9.2.) who spent periods ranging between 1 week to 3 months in learning different research activities in the program (Table 9.3.). Individual training is most suitable for scientists who have undertaken research for a reasonable period of time, so their training programs were tailored to meet the specific need of NARSs.

Table 9.2. Individual Non-degree Trainees to the Germplasm Program in 1998

Country	No. of Participants
Algeria	1
Bangladesh	3
Egypt	9
Eritrea	1
Ethiopia	1
Iran	6
Iraq	5
Jordan	2
Lebanon	2
Nepal	1
Spain	1
Syria	26
Turkey	3
Yemen	1
TOTAL	62

Table 9.3. Training subjects provided to individual non-degree trainees in the Germplasm Program.

Training Activity	No. of Trainees
Breeding Food Legumes	20
Breeding Legumes for Disease Resistance	2
Breeding Barley	5
Breeding Barley for Disease Resistance	1
Breeding Bread Wheat	2
Breeding Durum Wheat	5
Biotechnology	2
Data Analysis & AGROBASE	3
Entomology in Cereal & Legume	3
Grain Quality	2
IPM in Cereal & Legume	3
Pathology in Cereal & Legume	6
Rhizobium Technology	1
Stress Physiology	2
Viruses in Cereal & Legume	5
TOTAL	62

9.2.2. Graduate Research Training

An important aspects of our training concerns post-graduates. We have in the Germplasm Program a total of 31 students (18 M.Sc. and 13 Ph.D. students). During 1998, a total of ten students (three Ph.D. and seven M.Sc. students) graduated or completed their thesis research, while three new students started their thesis research work at ICARDA (Table 9.4).

Table 9.4. Graduate Research Students at the Germplasm Program during 1998.

	M.Sc. Students		Ph.D. Students	
Country	No.	Graduated in 1998	No.	Graduated in 1998
Algeria	0	0	1	0
Eritrea	1	0	0	0
Germany	0	0	1	1
Iraq	0	0	1	1
Jordan	1	0	0	0
Morocco	0	0	1	0
Netherlands	0	0	1	0
Somalia	1	1	0	0
Sudan	1	0	1	1
Syria	14	6	4	0
Turkey	0	0	2	0
UAE	0	0	1	0
TOTAL	18	7	13	3

9.3. Visitors and Scientific Visits

Visits between the Germplasm Program and NARS are an effective tool for transferring scientific information and research experiences. In 1998, forty-two visitors from Egypt. Algeria, Iran, Iraq, Tunisia, Morocco, Libya, Pakistan, Kazakhstan, Germany, Spain and Turkey visited the Germplasm Program. Most of the visitors were invited for a short periods from one week to one month to had an overviews on breeding activities on the improvement of ICARDA mandate crops, discuss joint projects, selected germplasm, lectures in training courses, discuss graduate student research, or gathered information on Germplasm Program activities and results. In addition, more than 150 farmers and students from Syrian universities visited the program for one day visit.

10. PUBLICATIONS

10.1. Journal Articles

Al Hakimi, A.; Monneveux, P.; Nachit, M.M. 1998. Direct and indirect selection for drought tolerance in alien tetraploid wheat x durum wheat crosses. Euphytica 100: 287-294. [En].

Araus, J.L.; Amaro, T.; Voltas, J.; Nakkoul, H.; Nachit, M.M. 1998. Chlorophyll fluorescence as a selection criterion for grain yield in durum wheat under Mediterranean conditions. Field Crops Research 55: 209-223. [En].

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Morocco. Genetic Resources and Crop Evolution 45: 343-345. [En].

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10.2. Newsletter Articles

Amiri, A.; Mahfoozi, S.; Hosseini, K.; Hosseinipour, M.H.; Mohamedi, M.; Tahir, M. 1998. Zagros: a new bread-wheat cultivar released in Iran. RACHIS 17(1-2): 40-42. [En].

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10.3. Book Chapters and Conference Papers

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11. CEREAL VARIETIES RELEASED BY NATIONAL PROGRAMS

Crop	Country	Year of release	Variety
Barley	Algeria	1987	Harmal
Barley	Algeria	1992	Badia
Barley	Algeria	1993	Rihane-03
Barley	Australia	1989	Yagan
Barley	Australia	1991	High
Barley	Australia	1993	Kaputar
Barley	Australia	1993	Namoi
Barley	Bolivia	1991	Kantuta
Barley	Bolivia	1993	Kolla
Barley	Bolivia	1994	San Lorenzo
Barley	Brazil	1989	Acumai
Barley	Canada	1992	Seebe
Barley	Canada	1993	Falcon
Barley	Canada	1994	Tukwa
Barley	Canada	1995	Kasota
Barley	Chile	1989	Centauro
Barley	Chile	1989	Leo/Inia/Ccu
Barley	China	1988	Zhenmai 1
Barley	China	1989	Api/CM67//B1
Barley	China	1989	CT-16
Barley	China	1989	V-24
Barley	China	1998	S500
Barley	China	1998	V06
Barley	Cyprus	1980	Kantara
Barley	Cyprus	1989	Mari/Aths*2
Barley	Cyprus	1994	Achera
Barley	Cyprus	1994	Mia Milia
Barley	Cyprus	1995	Lefkonoiko
Barley	Cyprus	1995	Lysi
Barley	Cyprus	1995	Sanokrithi-79
Barley	Ecuador	1989	Shyri
Barley	Ecuador	1992	Atahualpa-92
Barley	Ecuador	1992	Calicuchima-92
Barley	Egypt	1993	Giza 125
Barley	Egypt	1993	Giza 126
Barley	Egypt	1993	Giza 127

Crop	Country	Year of release	Variety
Barley	Egypt	1994	Giza 128
Barley	Ethiopia	1973	Beka
Barley	Ethiopia	1975	IAR/H/485
Barley	Ethiopia	1979	Holkr
Barley	Ethiopia	1980	Ardu 12-60B
Barley	Ethiopia	1985	HB-42
Barley	Ethiopia	1986	HB-120
Barley	Ethiopia	1994	Shege
Barley	Ethiopia	1996	Misratch
Barley	Ethiopia	1998	Abay
Barley	Iran	1986	Aras
Barley	Iran	1990	Kavir
Barley	Iran	1990	Star (Makui)
Barley	Iran	1996	Ezeh
Barley	Iran	1997	Ganub
Barley	Iran	1997	Sahand = Tokak
Barley	Iraq	1993	Rihane-03
Barley	Iraq	1994	IPA 265
Barley	Iraq	1994	IPA 7
Barley	Iraq	1994	IPA 9
Barley	Italy	1992	Digersano
Barley	Italy	1992	Salus
Barley	Jordan	1984	Rum
Barley	Kenya	1984	Bima
Barley	Kenya	1993	Ngao
Barley	Lebanon	1989	Rihane-03
Barley	Lebanon	1997	Assy
Barley	Lebanon	1997	ER/Apm
Barley	Libya	1992	Wadi Gattara
Barley	Libya	1992	Wadi Kuf
Barley	Libya	1997	Ariel
Barley	Libya	1997	Borjouj
Barley	Libya	1997	Irawen
Barley	Libya	1997	Maknosa
Barley	Mexico	1986	Mona/Mzq/DL71
Barley	Mexico	1998	Capuchona
Barley	Morocco	1984	Asni

Crop	Country	Year of release	Variety
Barley	Morocco	1984	Tamelalt
Barley	Morocco	1988	Aglou
Barley	Morocco	1988	Armal
Barley	Morocco	1988	Tiddas
Barley	Morocco	1991	Laannaceur
Barley	Morocco	1997	Igrane
Barley	Morocco	1997	Safia
Barley	Nepal	1987	Bonus
Barley	Pakistan	1985	Jau-83
Barley	Pakistan	1987	Frontier 87
Barley	Pakistan	1987	Jau-87
Barley	Pakistan	1993	Jau-93
Barley	Pakistan	1995	AZRI-95
Barley	Pakistan	1996	Sanober-96
Barley	Pakistan	1996	Soorab-96
Barley	Peru	1987	Nana 87
Barley	Peru	1987	Una-87
Barley	Peru	1989	Buenavista
Barley	Peru	1994	Una-94
Barley	Peru	1996	Una-96
Barley	Portugal	1982	Campones
Barley	Portugal	1982	Enxara
Barley	Portugal	1982	Sereia
Barley	Portugal	1983	CE 8302
Barley	Portugal	1990	Ancora
Barley	Qatar	1982	Gulf
Barley	Qatar	1983	Harma
Barley	Qatar	1989	Harma 88
Barley	Saudi Arabia	1985	Gustoe
Barley	Spain	1990	Resana
Barley	Syria	1987	Furat 1113
Barley	Syria	1991	Furat 2
Barley	Syria	1994	Arta
Barley	Tanzania	1991	Kibo
Barley	Thailand	1987	BRB-8
Barley	Thailand	1987	Semang 1
Barley	Thailand	1987	Semang 2

Crop	Country	Year of release	Variety
Barley	Tunisia	1985	Faiz
Barley	Tunisia	1985	Roho
Barley	Tunisia	1987	Rihane-03
Barley	Tunisia	1992	Manel 92
Barley	Turkey	1993	Tarm 92
Barley	Turkey	1993	Yesevi
Barley	Turkey	1995	Orza
Barley	USA	n.a.	Micah
Barley	USA	n.a.	Poco
Barley	Vietnam	1989	Api/CM67//B1
Barley	Yemen	1986	Arafat
Barley	Yemen	1986	Beecher
Bread Wheat	Algeria	1982	HD 1220
Bread Wheat	Algeria	1982	Setif 82
Bread Wheat	Algeria	1989	Zidane 89
Bread Wheat	Algeria	1992	ACSAD 59 = 40DNA
Bread Wheat	Algeria	1992	Alondra = 21AD
Bread Wheat	Algeria	1992	Nesser = Cham 6
Bread Wheat	Algeria	1992	Rhumel = Siete Cerros
Bread Wheat	Algeria	1992	Sidi Okba = Cham 4
Bread Wheat	Algeria	1992	Soummam = DouggaXBJ
Bread Wheat	Algeria	1994	Ain Abid
Bread Wheat	Algeria	1994	Mimouni
Bread Wheat	Egypt	1982	Giza 160
Bread Wheat	Egypt	1988	Giza 162
Bread Wheat	Egypt	1988	Giza 163
Bread Wheat	Egypt	1988	Giza 164
Bread Wheat	Egypt	1988	Sakha 92
Bread Wheat	Egypt	1991	Gammeiza 1
Bread Wheat	Egypt	1991	Giza 165
Bread Wheat	Egypt	1993	Sahel 1
Bread Wheat	Egypt	1994	Benesuef-3
Bread Wheat	Egypt	1994	Giza 166
Bread Wheat	Egypt	1994	Giza 167
Bread Wheat	Egypt	1994	Sids 1
Bread Wheat	Egypt	1994	Sids 2
Bread Wheat	Egypt	1994	Sids 3

Crop	Country	Year of release	Variety
Bread Wheat	Egypt	1995	Sids 4
Bread Wheat	Egypt	1995	Sids 5
Bread Wheat	Egypt	1995	Sids 7
Bread Wheat	Egypt	1995	Sids 8
Bread Wheat	Greece	1983	Arachthos
Bread Wheat	Greece	1983	Louros
Bread Wheat	Greece	1983	Pinios
Bread Wheat	Iran	1986	Azadi
Bread Wheat	Iran	1986	Golestan
Bread Wheat	Iran	1988	Darab
Bread Wheat	Iran	1988	Quds
Bread Wheat	Iran	1988	Sabalan
Bread Wheat	Iran	1990	Falat
Bread Wheat	Iran	1995	Darab 2
Bread Wheat	Iran	1995	Mahdabi
Bread Wheat	Iran	1995	Tajan
Bread Wheat	Iran	1996	Gaher
Bread Wheat	Iran	1996	Nicknejad
Bread Wheat	Iran	1996	Zagross
Bread Wheat	Iran	1997	Alement
Bread Wheat	Iran	1997	Alrand
Bread Wheat	Iran	1997	Atrak
Bread Wheat	Iran	1997	Chamran
Bread Wheat	Iran	1997	Zareen
Bread Wheat	Iran	1998	Azar 2
Bread Wheat	Iraq	1989	Es14
Bread Wheat	Iraq	1994	Abu Ghraib
Bread Wheat	Iraq	1994	Adnanya
Bread Wheat	Iraq	1994	Hamra
Bread Wheat	Iraq	1998	Vee 'S'
Bread Wheat	Italy	1996	Sibilla
Bread Wheat	Jordan	1988	Cham 1
Bread Wheat	Jordan	1988	L88 = Rabba
Bread Wheat	Jordan	1988	Nasma = Jubeiha
Bread Wheat	Jordan	1988	Petra
Bread Wheat	Jordan	1990	Nesser
Bread Wheat	Lebanon	1990	Seri

Crop	Country	Year of release	Variety
Bread Wheat	Lebanon	1991	Nesser = Cham 6
Bread Wheat	Lebanon	1998	Towpe
Bread Wheat	Libya	1985	Germa
Bread Wheat	Libya	1985	Zellaf
Bread Wheat	Morocco	1984	Jouda
Bread Wheat	Morocco	1984	Merchouch
Bread Wheat	Morocco	1989	Kanz
Bread Wheat	Morocco	1989	Saba
Bread Wheat	Morocco	1996	Massira
Bread Wheat	Morocco	1998	Aguilal
Bread Wheat	Morocco	1998	Arrihane
Bread Wheat	Oman	1987	Wadi Quriyat 151
Bread Wheat	Oman	1987	Wadi Quriyat 160
Bread Wheat	Pakistan	1986	Sutlej 86
Bread Wheat	Pakistan	1996	AZRI-96
Bread Wheat	Pakistan	1996	Sariab-96
Bread Wheat	Portugal	1986	LIZ 1
Bread Wheat	Portugal	1986	LIZ 2
Bread Wheat	Qatar	1988	Doha 88
Bread Wheat	Sudan	1982	Debeira
Bread Wheat	Sudan	1987	Wadi El Neel
Bread Wheat	Sudan	1990	Elnielain
Bread Wheat	Sudan	1992	Sasaraib
Bread Wheat	Sudan	1996	Nessr
Bread Wheat	Syria	1984	Bohouth 2
Bread Wheat	Syria	1984	Cham 2
Bread Wheat	Syria	1986	Cham 4
Bread Wheat	Syria	1987	Bohouth 4
Bread Wheat	Syria	1991	Bohouth 6
Bread Wheat	Syria	1991	Cham 6
Bread Wheat	Tunisia	1983	T-DUMA-D6811-INRAT
Bread Wheat	Tunisia	1987	Byrsa
Bread Wheat	Tunisia	1987	Salambo
Bread Wheat	Tunisia	1992	Vaga 92
Bread Wheat	Tunisia	1996	Tebica 96
Bread Wheat	Tunisia	1996	Utique
Bread Wheat	Turkey	1979	Gerek 79

Crop	Country	Year of release	Variety
Bread Wheat	Turkey	1985	Atay 85
Bread Wheat	Turkey	1986	Dogankent-1 (Cham 4)
Bread Wheat	Turkey	1988	Dogu 88
Bread Wheat	Turkey	1988	Genç-88
Bread Wheat	Turkey	1988	Kop
Bread Wheat	Turkey	1989	Es14
Bread Wheat	Turkey	1990	Karasu 90
Bread Wheat	Turkey	1990	Katia 1
Bread Wheat	Turkey	1990	Yuregir
Bread Wheat	Turkey	1991	Gun 91
Bread Wheat	Turkey	1994	Dagdas 94
Bread Wheat	Turkey	1994	Kutluk 94
Bread Wheat	Turkey	1995	Basribey 95
Bread Wheat	Turkey	1995	F//68.44NZT/3/CUC'5'
Bread Wheat	Turkey	1995	Kasifbey 95
Bread Wheat	Turkey	1995	Kirgiz 95
Bread Wheat	Turkey	1995	Sultan 95
Bread Wheat	Turkey	1996	Ikizce 96
Bread Wheat	Turkey	1996	Pehlivan 96
Bread Wheat	Turkey	1997	Kinaci 97
Bread Wheat	Turkey	1997	Palandoken 97
Bread Wheat	Turkey	1997	Suzen 97
Bread Wheat	Turkey	1998	Aytin 98
Bread Wheat	Turkey	1998	Mizrak 98
Bread Wheat	Turkey	1998	Turkmen 98
Bread Wheat	Turkey	1998	Uzunyayla 98
Bread Wheat	Turkey	1998	Yildiz 98
Bread Wheat	UAE	1995	Cham 2
Bread Wheat	UAE	1995	Kirgiz 95
Bread Wheat	UAE	1995	Seyhan 95
Bread Wheat	Yemen	1981	Ahgaf
Bread Wheat	Yemen	1983	Marib 1
Bread Wheat	Yemen	1988	Aziz
Bread Wheat	Yemen	1988	Dhumran
Bread Wheat	Yemen	1988	Mukhtar
Bread Wheat	Yemen	1992	Alswiri
Bread Wheat	Yemen	1995	Radfan

Crop	Country	Year of release	Variety
Bread Wheat	Yemen	1998	Seiyun
Durum Wheat	Algeria	1982	ZB//Fg/Loukos
Durum Wheat	Algeria	1984	Timgad
Durum Wheat	Algeria	1986	Sahl
Durum Wheat	Algeria	1986	Waha
Durum Wheat	Algeria	1992	Om Rabi 6
Durum Wheat	Algeria	1993	Belikh 2
Durum Wheat	Algeria	1993	Heider
Durum Wheat	Algeria	1993	Kabir-1
Durum Wheat	Algeria	1993	Om Rabi 9
Durum Wheat	Cyprus	1982	Mesaoria
Durum Wheat	Cyprus	1984	Karpasia
Durum Wheat	Cyprus	1994	Macedonia
Durum Wheat	Egypt	1979	Sohag 1
Durum Wheat	Egypt	1988	Beni suef
Durum Wheat	Egypt	1988	Sohag 2
Durum Wheat	Egypt	1990	Sohag 3
Durum Wheat	Greece	1982	Selas
Durum Wheat	Greece	1983	Sapfo
Durum Wheat	Greece	1984	Skiti
Durum Wheat	Greece	1985	Samos
Durum Wheat	Greece	1985	Syros
Durum Wheat	Iran	1996	Seimareh = Om Rabi 5
Durum Wheat	Iran	1997	Heider
Durum Wheat	Iran	1997	Korifla
Durum Wheat	Iraq	1994	Waha Iraq
Durum Wheat	Iraq	1997	Korifla
Durum Wheat	Jordan	1988	ACSAD 65 = STK
Durum Wheat	Jordan	1988	Amra = N-432
Durum Wheat	Jordan	1988	Maru = Cham 1
Durum Wheat	Jordan	1988	Petra = KRF
Durum Wheat	Lebanon	1987	Belikh 2
Durum Wheat	Lebanon	1989	Sebou
Durum Wheat	Lebanon	1993	Waha = Cham 1
Durum Wheat	Libya	1985	Baraka
Durum Wheat	Libya	1985	Fazan
Durum Wheat	Libya	1985	Ghuodwa

Crop	Country	Year of release	Variety
Durum Wheat	Libya	1985	Marjawi
Durum Wheat	Libya	1985	Qara
Durum Wheat	Libya	1985	Zorda
Durum Wheat	Libya	1991	Zahra 1
Durum Wheat	Libya	1992	Khiar 92
Durum Wheat	Libya	1993	Zahra 3
Durum Wheat	Libya	1993	Zahra 5 = Korifla
Durum Wheat	Libya	1995	Zahra 9
Durum Wheat	Morocco	1984	Marzak
Durum Wheat	Morocco	1989	Om Rabi 1
Durum Wheat	Morocco	1989	Sebou
Durum Wheat	Morocco	1991	Tensift
Durum Wheat	Morocco	1992	Brachoua
Durum Wheat	Morocco	1992	Om Rabi 5
Durum Wheat	Morocco	1994	Anouar
Durum Wheat	Morocco	1994	Jawhar
Durum Wheat	Morocco	1997	Telset
Durum Wheat	Pakistan	1985	Wadhanak
Durum Wheat	Portugal	1983	Celta
Durum Wheat	Portugal	1983	Timpanas
Durum Wheat	Portugal	1984	Castico
Durum Wheat	Portugal	1985	Helvio
Durum Wheat	Portugal	n.a.	Te 9204
Durum Wheat	Saudi Arabia	1987	Cham 1
Durum Wheat	Spain	1983	Mexa
Durum Wheat	Spain	1985	Nuna
Durum Wheat	Spain	1989	Jabato
Durum Wheat	Spain	1991	Anton
Durum Wheat	Spain	1991	Roqueno
Durum Wheat	Sudan	1996	Cham 1
Durum Wheat	Sudan	1997	Waha
Durum Wheat	Syria	1984	Cham 1
Durum Wheat	Syria	1987	Bohouth 5
Durum Wheat	Syria	1987	Cham 3
Durum Wheat	Syria	1993	Om Rabi 3
Durum Wheat	Syria	1994	Cham 5 = MRB-3
Durum Wheat	Tunisia	1987	Razzak

Crop	Country	Year of release	Variety
Durum Wheat	Tunisia	1993	Khiar
Durum Wheat	Tunisia	1993	Om Rabi 3
Durum Wheat	Turkey	1984	Susf bird
Durum Wheat	Turkey	1985	Balcali
Durum Wheat	Turkey	1988	EGE 88
Durum Wheat	Turkey	1990	Cham 1
Durum Wheat	Turkey	1991	Kiziltan
Durum Wheat	Turkey	1994	Aydin 93
Durum Wheat	Turkey	1997	Haran = Om Rabi 5
Durum Wheat	Turkey	1998	Altin 98
Durum Wheat	Turkey	1998	Ankara 98

12. STAFF LIST

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4. Dr Osman Abdallah	Bread Wheat Breeder (CIMMYT)
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57. Mr Haitham Sayed	Cereal Biotechnologist

***Left the Program in 1998**
****Joined the Program in 1998**

المركز الدولي للبحوث الزراعية في المناطق الجافة
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ICARDA-07/1500/May 2000