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GERMPLASM PROGRAM

CEREALS

Annual Report for 1995

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

This report was written and compiled by program scientists and represents a working document of ICARDA. Its primary objective is to communicate the season's research results quickly to fellow scientists, particularly those within West Asia and North Africa, with whom ICARDA has close collaboration. Owing to the tight production deadlines, editing of the report was kept to a minimum.

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About ICARDA

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), which 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 mission of the CGIAR is to contribute, through its research, to promoting sustainable agriculture for food security to alleviate poverty and hunger 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.

In the context of the challenges posed by the physical, social and economic environments, ICARDA's mission is to improve the welfare of people in the dry areas of the developing world by increasing the production and nutritional quality of food while preserving and enhancing the resource base. ICARDA meets this challenge through research, training, and dissemination of information in partnership with the national agricultural research and development systems.

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 Asia and North Africa region for production enhancement 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.

Much of ICARDA's research is carried out on a 948-hectare farm at its headquarters at Tel Hadya, about 35 km southwest of Aleppo. ICARDA also manages other sites where it tests material under a variety of agroecological conditions in Syria and Lebanon. However, the full scope of ICARDA's activities can be appreciated only when account is taken of the cooperative research carried out with many countries in West Asia and North Africa and elsewhere in the world.

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.

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1. INTRODUCTION

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

To fulfill the global mandate for the improvement of barley, ICARDA has posted a barley breeder in CIMMYT-Mexico to address the needs of barley improvement for Latin America. CIMMYT has placed a durum breeder and a spring bread wheat breeder at ICARDA with a regional responsibility for West Asia and North Africa (WANA). In the case of chickpea, ICRISAT has posted a chickpea breeder at ICARDA to address the needs of the crop in WANA.

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

This objective is being pursued through methodologies emphasizing specific adaptation through decentralized breeding, use of biotechnology, use of inputs compatible with the preservation and improvement of the resource base, and maintenance and enhancement of agricultural biodiversity.

The base for most of our research work is at the Tel Hadya, where ICARDA's headquarters are located and where

additional environments are created by different planting dates. However, an increasing amount of work is done in other sites in Syria (Breda, Bouider and Jindiress) 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 wheat, durum, lentil, chickpea and forage legumes adapted to cold environments. The research sites and facilities of other national programs 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 season are shown in Figures 1.1 for two typically dry sites (Bouider and Breda) and in Figure 1.2 for two wet sites (Tel Hadya and Terbol). The long-term average rainfall at these sites is 236, 267, 323, 548 mm, respectively. In all the four locations the total seasonal precipitation in the 1994-95 cropping season was less than the long term average (203, 244, 313 and 531 mm, respectively). In both Bouider and Breda there was a wet and relatively warm beginning of the winter: the winter continued warm and dry in Bouider and cold and dry in Breda. Late rains accompanied by colder than normal Spring temperatures caused a slightly longer growing season. In Tel Hadya and Terbol there was a very wet start of the season, followed by drier than usual winter and spring. The late rains in Tel Hadya partly alleviated the effects of the drought, while the cropping season ended in Terbol with an increasing moisture deficit.

There were a large number of interesting developments in all the projects and it is not possible to even summarize them in this introduction. There was a critical examination of decentralization with the conclusion that the time has come to include the farmers in a participatory fashion during the development of the major technological output of the

Program, i.e., new varieties. During 1995 this approach has been implemented successfully in our collaborative barley project in Ethiopia. There was also, as a general trend, a continuation of the efforts towards more and more precise targeting of the germplasm, including new efforts towards quality aspects in relation to human consumption. The widespread use of landraces and wild relatives continued to be one of the major characteristics of the breeding programs. A large amount of resources continued to be invested in the identification and use of sources of resistance to biotic stresses, as part of the overall commitment of the Program to sustainable development. Eventually, and this is perhaps the area which saw the largest expansion in 1995, molecular techniques started to be applied in virtually every crop the Program is dealing with, with the exception of the forage legumes.

More than 50 scientists from 25 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.

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 1994-95 season, although work done in earlier years is also reported when considered important.

The training and network activities and the publications of the Program are also listed.

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 sincere appreciation.

S. Ceccarelli

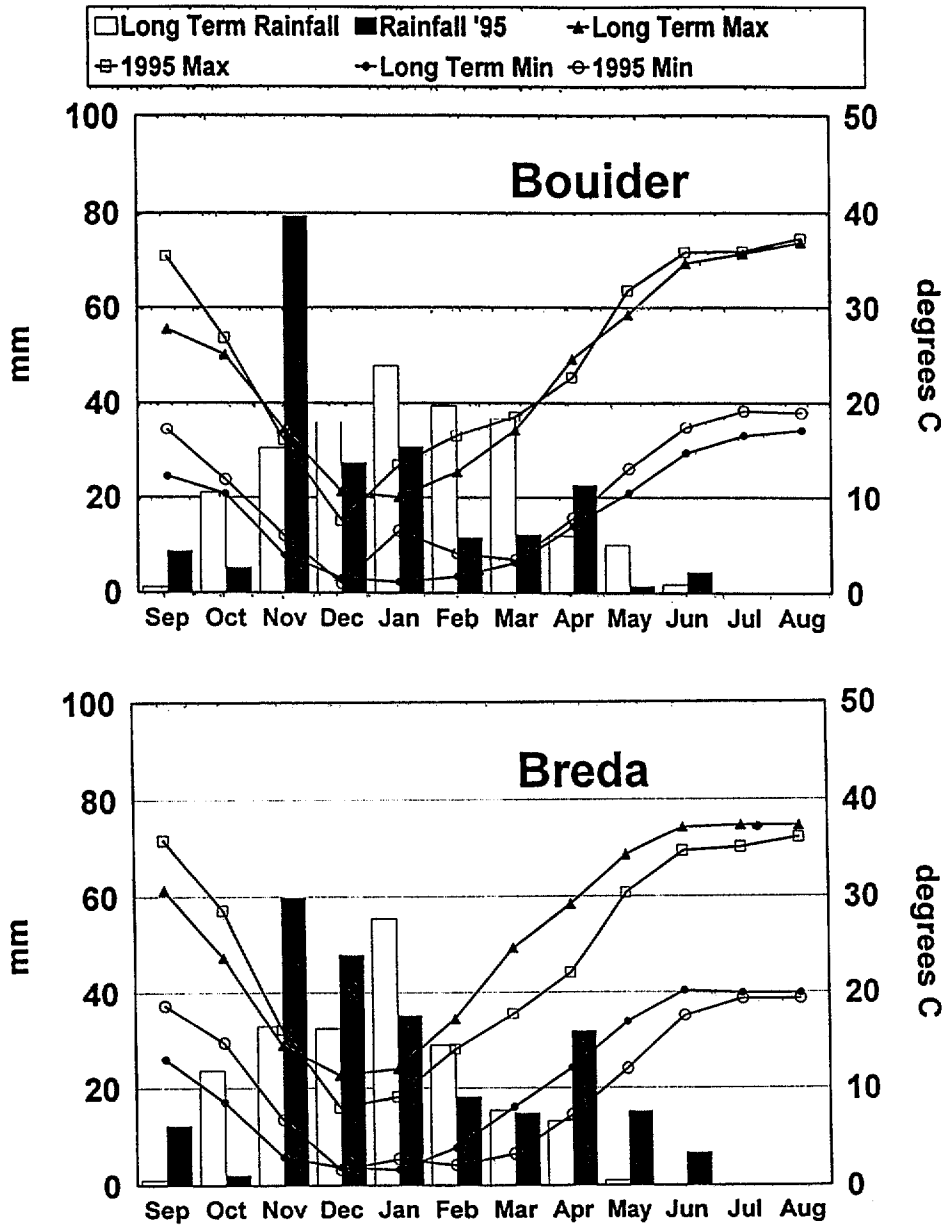

Fig. 1.1. Weather conditions at Bouider and Breda during 1994-95.

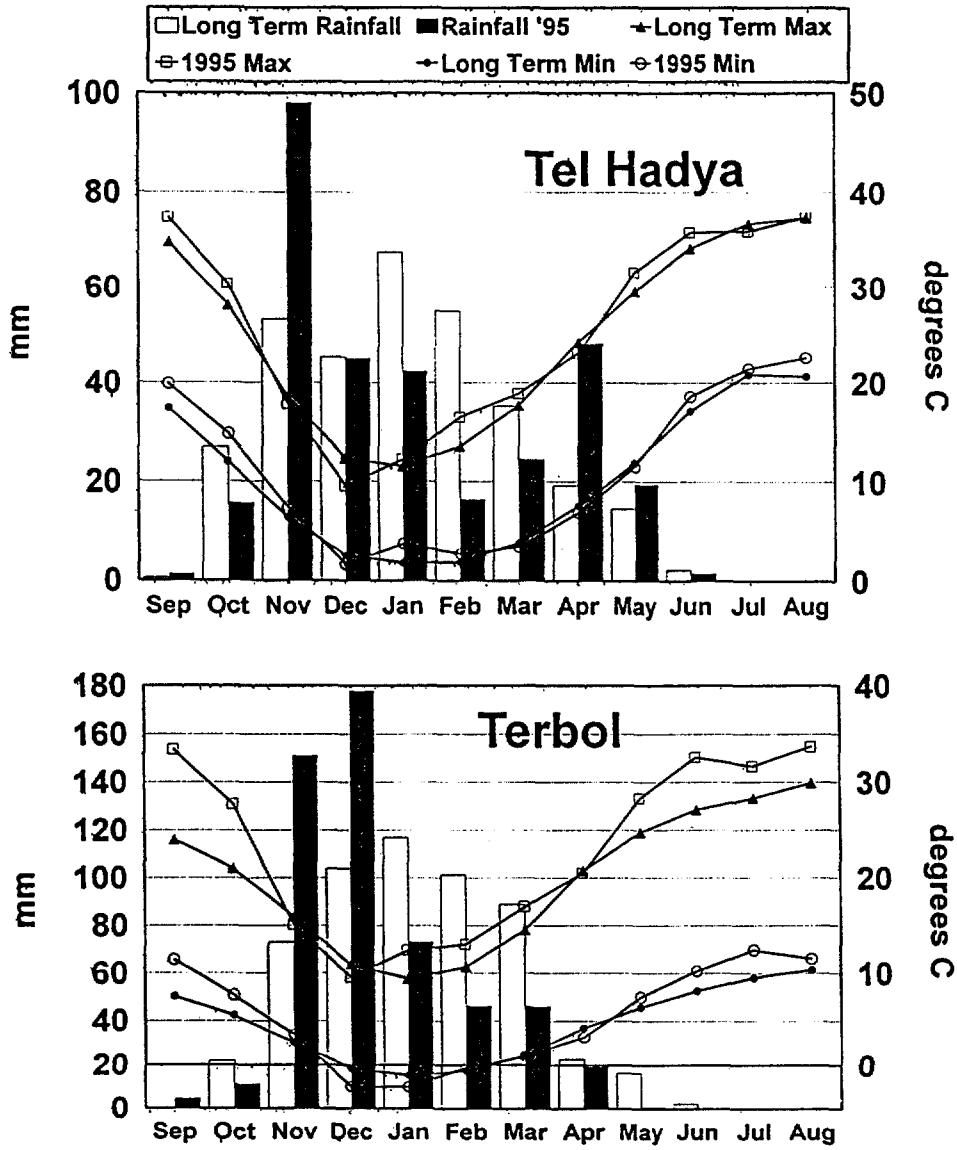

Fig. 1.2. Weather conditions at Tel Hadya and Terbol during 1994-95.

2. BARLEY IMPROVEMENT

Introduction

Barley, one the ICARDA's mandated crops, is grown on approximately 17 million hectares in least developed countries, where it is used as human food, as animal feed, and for malt.

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

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

Barley improvement at ICARDA is organized in three projects: a) spring barley, b) winter and facultative barley, and c) Latin America regional program. The first two project are based in Aleppo, the third is a collaborative ICARDA/CIMMYT project and it is based in Mexico.

2.1. Spring Barley Breeding: an Overview

The main objectives of the spring barley project are 1) to collaborate with national programs in germplasm development, 2) to strengthen national barley breeding programs, and 3) to develop a conceptual framework to improve efficiency of breeding in different environments with emphasis on low-input, stressful environments. The breeding philosophy of the project, which evolved during the last ten years, is based on (1) exploiting specific adaptation through direct selection in the target environments, and (2) using locally adapted germplasm. 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 these varieties will not depend on improved

agronomic practices. Therefore, a breeding program based on this philosophy will not endanger biodiversity, and is environmentally friendly.

The implementation of this philosophy is mainly based on decentralization of the breeding work (Fig. 2.1.1.) which is fully implemented in North Africa, in Iraq and in Ethiopia, and it is gradually being implemented in other countries.

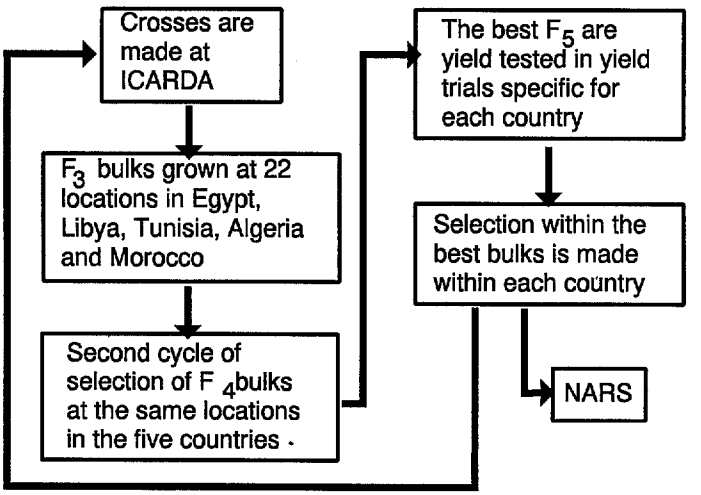

Fig.2.1.1. Decentralization of spring barley breeding: the example of North African countries.

In the type of decentralization implemented in North Africa, national program scientists identify suitable parents, and crosses are made at ICARDA which then distributes early segregating populations, usually in the F_3 generation when sufficient seed is available. Selection between and within populations is made in the target environments within each country, and eventually the best lines are used in further cycles of crosses. Breeding for resistance to diseases and pests is also conducted in a decentralized mode. Table 2.1.1 shows some examples of sources of resistance to diseases and pests identified by Tunisian and Moroccan scientists and used in the crossing program at ICARDA targeted for North Africa.

During 1995 the project started the process of decentralization towards countries in the Far East by distributing barley lines specifically selected from the barley international nurseries in India, Korea, Vietnam and Thailand, by making specific crosses for VietNam, and by sending a special nursery to Nepal.

Table 2.1.1. Examples of sources of resistance to diseases and pests identified by national program scientists and used in the crossing program for North Africa.

Disease/pest	Name	Country	Year[a]
RWA	RWA.M46	Morocco	1995
BYDV	PI 002325/Maf102//Cossack	Morocco	1995
Net Blotch	F2CC33MS/CI7555	Morocco	1994
	M83-194Ras*32	Morocco	1994
Powdery mildew	Hor1657	Tunisia	1994
	Rupee (CI4355)	Morocco	1994
	ISO10R	Tunisia	1994

[a] Year of introduction in the crossing program

Many other special purpose nurseries were distributed in 1995 (Table 2.1.2), including nurseries with material selected by the participants to a cereal traveling workshop held in Syria in April 1995.

Table 2.1.2. Special nurseries distributed during 1995.

Country	Number of lines	Origin/Purpose
Nepal	36	International nurseries
India, Thailand, Vietnam, Korea	65	International nurseries
Morocco	447	Selections in Syria
Tunisia	558	Selections in Syria
Algeria	100	Selections in Syria
Egypt	50	Selections in Syria
Libya	139	Selections in Syria
Iraq	301	Heat, salinity, dual purpose
Iraq (Mosul)	29	Drought, lodging res.
Abu Dhabi	320	Heat, salinity
Japan	200	Chlorophyll a/b ratio
Cyprus	205	Earliness
Australia	150	Res. to *Fusarium graminearum*
Australia	135	Adaptation nursery

Studying the relationship between population structure and yield stability in stress environments is an important component of the development of a conceptual framework to improve efficiency of breeding in low-input

stressful environments. This component has been implemented by (1) the evaluation of three mixtures from 1987 to 1989 (Annual Report for 1989, pg. 31-32), (2) the evaluation of nine mixtures from 1991 to 1995 (reported at pg. 24), and (3) the evaluation of the role of heterozygosity and heterogeneity in collaboration with the University of Hohenheim (reported at pg. 26).

In collaboration with BioSS (Biomathematics & Statistics Scotland) we have explored the usefulness of 2 x 2 tables, a technique known to industrial statisticians for decades but neglected in biological research, in the analysis of Genotype x Environment Interaction.

The potential of C^{13} discrimination ($C^{13}\Delta$) was assessed in eight crosses between lines differing in $C^{13}\Delta$ and evaluated in the framework of a project supported by USAID (the results are reported in the physiology section), and in 50 lines of the cross WI2291/Tadmor (pg 17).

Eventually the results of the two projects initiated in 1994 to use molecular markers to assist in the transfer of powdery mildew resistance from WI2291 to Tadmor, and to characterize barley lines with different degrees of adaptation to stress environments will be reported in the biotechnology section.

During 1995 scientists in Egypt and Iraq were trained on the use of spreadsheet for handling pedigrees and data in a breeding program, five junior scientists from Libya, Yemen, Tunisia, Ethiopia and Syria were trained in the residential training course, and two scientists from Vietnam and Egypt visited the project. A traveling workshop was held in April and was attended by barley breeders of seven countries (Libya, Algeria, Egypt, Morocco, Tunisia, Syria and Turkey).

(S. Ceccarelli)

2.1.2. Main Developments in Barley Breeding

2.1.2.1. Release and Adoption of New Varieties

A number of new barley varieties have been released by NARS, which were not reported in previous Annual Reports. In 1994, Canada released a barley variety (KASOTA) widely adapted to Alberta. The variety originated from a cross

(Celaya//Mezquite/Godiva/3/Trompillo) made in Mexico and was selected from an F_2 population for its stiff straw, semi-dwarf height, and resistance to scald and septoria. Cyprus released two varieties in 1994 (Mial Milia and Achera) and three in 1995 (Lefkonoiko, Sanokrithi-79 and Lysi). Egypt released Giza 126 (in 1993). The new line was selected from a segregating population sent from ICARDA. Two varieties were registered in Italy in 1992, Salus and the naked variety Digersano.

2.1.2.2. Computerization of Pedigree Management and Transfer to NARS

The process of computerization of the handling pedigrees and data through the combined use of QPRO, ALPHANAL and AGROBASE has been completed. Only the field book preparation is still done in the conventional way. Field data recording has been considerably automated and almost 30,000 data were collected with palm tops. National programs are gradually being trained to use these facilities.

2.1.2.3. Beyond decentralization: Farmers' participation

Past research conducted at ICARDA and elsewhere has indicated that varieties which perform well in optimum growing conditions in general perform poorly in stressful and low-input conditions. In the case of barley we have concluded that breeding for specific rather than broad adaptation is more efficient if the resource-poor farmers living in stressful environments were to benefit from the advances of modern plant breeding. To exploit specific adaptation fully we concluded, as described earlier, that we had to decentralize breeding activities by devolving the selection work to NARS.

During 1995 we recognized that decentralization to national programs will not necessarily respond to the needs of resource-poor farmers if it is only a decentralization from ICARDA's research stations to NARS' research stations. Moreover, decentralization to NARS will continue to ignore the potential benefits of indigenous

knowledge existing in farmers' communities. Therefore, we concluded that to exploit the potential gains from specific adaptation, selection needs to be practiced by farmers under their own conditions in what it may be considered as an extreme type of decentralization.

2.1.2.4. Earlier screening for disease resistance

Breeding for disease resistance was considerably strengthen during 1995 by (1) a much earlier screening of parents and of breeding material, and (2) a rapid exchange of data between breeders and pathologist made possible by the developments described under 2.1.2.1. Further details are given in the pathology section.

2.1.2.5. Reduction of the size of the breeding program

One of the expected consequences of decentralization is that the breeding program at the headquarters can be gradually reduced. This is because decentralization of activities implies a decentralization of resources to support the evaluation of the larger number of nurseries grown in other countries. Consequently, the program at the headquarters becomes more and more oriented towards strategic issues, and to environments similar to northern Syria. During 1995 a further reduction of the size of the breeding program at the headquarters has been achieved in four ways:

1. The number of segregating populations visually evaluated at Breda, under drought stress, was increased, and in 1995 all the F_2, F_3, and F_4 were tested in Breda.
2. It was agreed that crosses specifically designed for Syria will be tested in two additional locations (Raqqa and Hassakeh) in collaboration with the Syrian national program starting in 1995/96.
3. A large number of early segregating populations is now evaluated at Terbol (Lebanon) for resistance to lodging and disease, and at Kfardane (Lebanon) for drought tolerance.
4. Screening for disease resistance at earlier stages than in the past (initial yield trials and early

bulks increased for yield testing).

As a result of activities 1, 3 and 4, implemented during the past cropping season, the total number of plots in yield trials was reduced from 8680 in 1995 to 5744 in 1996 with a reduction of 34%, and the number of plots in increase for yield trials from 4150 to 3270 with a reduction of 21%. This, together with a reduction in the total number of segregating populations, brought about an overall reduction of the size of the program of nearly 30%.

2.1.2.5. More Emphasis on Targeted Crosses

Although the total number of crosses was substantially reduced from more than 1500 in 1993 to 800 in 1995, there has been an increased emphasis on targeting crosses for specific countries (Table 2.1.3). The number of crosses targeted to specific countries depends on the resources of the national program, the number of crosses made in the national breeding program, the availability of suitable parents, the diversity of environments in the country, and the need of new germplasm.

Table 2.1.3. Targeting crosses to exploit specific adaptation in barley.

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

(S Ceccarelli and S. Grando)

2.1.3. Progresses in Stress Tolerance

The dry areas of Syria, with low and erratic rainfall,

cold winters and both intermittent and terminal drought, continue to be used as a model to test the efficiency of breeding strategies for stress environments. The underlying hypothesis is that the methodologies and strategies developed in this process may be applied in other types of stress environments, whereas the breeding material is likely to be adapted mostly to the specific type of stress environment it was bred for.

Table 2.1.4. Barley lines which outyielded Arabi Aswad in each of three cropping seasons (1993, 1994 and 1995) in Breda and in 1995 in Bouider (BY = average biological yield in Breda and Bouider 1995, YD = average grain yield in Breda 1993, Breda 1994, Breda 1994 and Bouider 1995, YP = average grain yield in Tel Hadya 1993, 1994 and 1995 and Terbol 1995, PHDR = plant height under drought, DH = average days to heading, GV = average growth vigor: 1 = good 5 = poor, GH = average growth habit: 1=erect 5 = prostrate) in the Advanced Yield Trials.

Entries[a]	BY	YD	YP	PHDR	DH	GV	GH
97	2940	1424	3978	32.0	127	2.2	2.7
38	3081	1421	4554	28.8	128	2.9	3.4
52	2949	1401	4194	29.9	128	2.8	2.1
3	3276	1399	4051	32.2	124	1.8	3.4
15	2444	1394	4025	28.7	131	2.8	4.0
55	2660	1376	4149	30.8	126	2.0	2.0
68	2837	1371	4175	29.4	128	2.5	2.2
1	2836	1369	4492	30.3	127	2.8	3.3
48	2785	1363	3923	33.8	128	3.0	2.9
20	2880	1352	3707	34.2	126	2.7	2.8
Checks							
Arabi Abiad	3199	1183	3748	33.5	130	3.1	3.3
Arabi Aswad	2621	1094	3636	29.2	130	2.9	2.9
Arta	2531	1353	4094	24.0	128	2.3	2.9
Zanbaka	2856	1041	3286	32.7	129	2.4	3.8
Rihane-03	3748	992	4616	29.0	133	2.9	2.8

[a]Entries' Name (row type)
97: Pld10342//Cr.115/Por/3/Bahtim9/4/Ds/Apro/5/WI2291/6/ Th.Unk.23 (2)
38: SLB 45-58/Arta (2)
52: SLB 39-60/WI2291(2)
3: Api/CM67//Harma-03/4/Cq/Cm//Apm/3/RM1508/5/Attiki/6/ Aths/7/Mari/Aths*2//Attiki (6)
15: SLB 45-90/Arta (2)
55: SLB 52-74/Harmal-02 (2)
68: WI2197/CI 13520//Arta (2)
1: Rihane-03/3/Mari/Aths*2//M-Att-73-337-1(6)
48: SLB 45-95/3/ChiCm/An57//Albert (2)
20: SLB 45-93//H.Spont.41-1/Tadmor (2)

In the advanced yield trials evaluated at Breda, 70 of the 133 lines tested outyielded the landrace grown in the area (Arabi Aswad) both in 1994 and in 1995. If the mean across locations is used, the number of lines outyielding Arabi Aswad increases to 113, indicating once again that high mean performance across locations and years does not only identify lines with consistency of performance. Among the 108 lines which were tested for three cropping seasons, 38 outyielded Arabi Aswad in Breda each year and in 1995 in Bouider. Of these, the 10 lines shown in Table 2.1.4 had similar or higher yield and were significantly taller than Arta, which was the best check.

Table 2.1.5. Barley lines which outyielded Arabi Aswad in each of two cropping seasons (1994 and 1995) in Breda (BY = biological yield in Breda 1995, YD = average grain yield in Breda in 1994 and in 1995, YP = average grain yield in Tel Hadya in 1994 and in 1995, PHDR = plant height under drought, GH = average growth habit: 1 = erect 5 = prostrate, DH = average days to heading) in the Preliminary Yield Trials.

Entries[a]	BY	YD	YP	PHDR	GH	DH
281	2810	1333	2597	40.2	2.9	104
188	2875	1264	2573	41.1	3.0	99
168	2312	1236	2816	42.4	3.1	100
176	2976	1231	2882	42.2	3.4	101
174	2627	1177	3049	43.7	3.5	95
300	3034	1168	2497	41.5	2.6	103
159	3037	1127	2370	42.7	3.0	96
Checks						
Arabi Abiad	2510	959	3388	31.2	3.2	104
Arabi Aswad	2313	935	2669	38.5	3.6	106
Arta	2354	1224	3724	26.8	3.1	103
Zanbaka	2301	877	2305	37.9	3.8	105
Rihane-03	2922	1024	3767	36.0	3.0	108

[a]Entries' Name (row type)
281: SLB 22-25 (2)
188: WI2291/Tadmor (2)
168: SLB 45-90/Harmal-02 (2)
176: SLB 22-35//WI2291/WI2269 (2)
174: Tadmor/Harmal (2)
300: SLB 22-74 (2)
159: WI2291/WI2269//SLB 45-95 (2)

The phenology of these lines was similar to the landraces or earlier, had a slightly better early growth vigor and had an intermediate to prostrate growth habit. Two lines (38 and 3) also had a total biological yield comparable to A. Abiad. Among the lines outyielding consistently A.

Aswad under stress conditions, there was a high frequency of lines derived from crosses with landraces (SLB, Tadmor, Arta), but also lines derived from two parents (WI 2291 from Australia and Mari/Aths*2 from Cyprus) known for their good performance under drought. Also, as already noted in previous Annual Reports, among the best lines there was a predominance of two-rowed barleys.

Among the 400 lines tested for the second cropping season in the preliminary yield trials (Table 2.1.5), 150 outyielded A.Aswad at Breda both in 1994 and in 1995. Of these, 16 lines (75% of which were landraces or crosses with landraces) were also taller than A. Aswad in both cropping seasons and had a yield advantage (as average of the two years) ranging from 13 to 43%. Three of the best lines were either pure-line selections from site 22 or crosses with lines selected from the same collection site. Table 2.1.5 shows the means of six characters for the best eight lines. With one exception, the lines had a higher total biological yield than the landraces and of Arta and Zanbaka, and although the grain yield was not much higher than Arta (the best check), there was a marked improvement in plant height under drought. Eventually there was a tendency for most of the best lines to be slightly earlier than the landraces, and of Arta and Zanbaka.

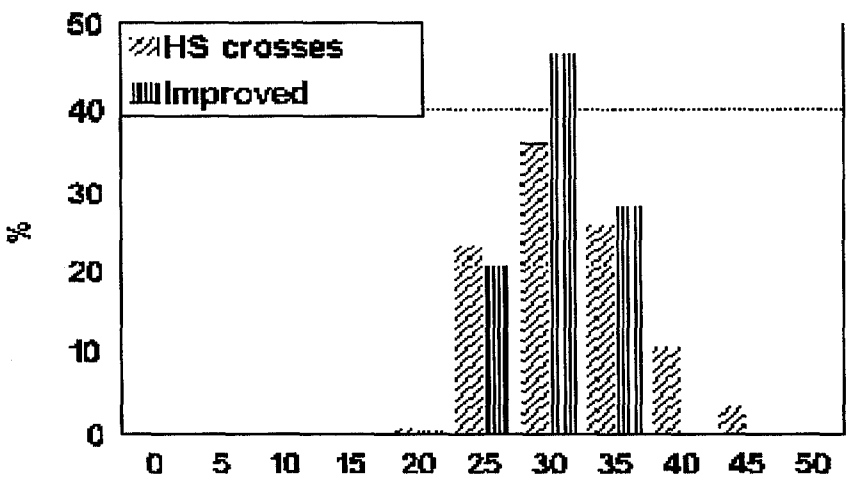

Fig. 2.1.2. Plant height in Breda of lines derived from crosses with *H. spontaneum* (HS crosses) and of lines unrelated to either *H. spontaneum* or to landraces (improved).

In the initial yield trials, 1533 lines were yield tested for the first year. In Breda, the growing conditions were harsh: total rainfall was 244 mm, but effective rainfall was less since planting was done after the first rain, and almost 20 mm felt when the crop was already mature. Average grain yield was 700 kg/ha (ranging from 70 to 1250 kg/ha), average plant height was 23.5 cm (ranging from 13 to 44 cm), and the average harvest index was 0.27 (ranging from as little as 0.03 to 0.41). The check with the highest grain yield was Arta followed by A. Abiad and A. Aswad. The performance of Arta has little practical relevance because farmers will never adopt such a short cultivar in dry areas. There were 191 lines outyielding Arta, 252 outyielding A. Abiad, and as many as 1105 (more that 70%) outyielding A. Aswad.

Table 2.1.6. The ten tallest barley lines in the initial yield trials in 1995 in Breda (PH = plant height, GY = grain yield, BY = total biological yield, THGY = grain yield in Tel Hadya, DH = days to heading) in the Initial Yield Trials.

Entries[a]	PH	GY	BY	THGY	DH
4328	44	554	2632	2908	83
4323	44	675	3236	1515	91
3005	43	607	2867	2207	88
3033	42	647	3055	1952	93
2372	42	639	2719	2180	91
3081	40	614	3416	2765	94
3004	39	747	3021	1840	95
3070	38	659	3041	3904	97
3013	38	887	3192	2872	91
3001	38	639	2577	1815	93
Checks					
Arabi Abiad	24	876	2811	4540	97
Arabi Aswad	24	608	2472	3222	98
Arta	18	901	2604	4781	94
Zanbaka	26	602	2299	2944	97
Rihane-03	23	564	3062	5284	100

[a]Entries' Name (row type)
4328: H.Spont.20-4/Arar 28//WI2291/Bgs (2)
4323: SLB 45-40/H.spont.41-1 (2)
3005: Zanbaka/H.spont.41-2 (2)
3033: Moroc 9-75/Arabi Aswad//H.spont.41-3 (2)
2372: Zanbaka/H.spont.41-2 (2)
3081: WI2291//Apm/PI000046/4/WI2291/3/CI03309/Attiki/ /Hja33 (2)
3004: SLB 45-90/H.spont.41-2 (2)
3070: ER/Apm//Lignee131/4/Antares//12201/Attiki/3/RM1508 /Por7/WI2269 (2)
3013: Moroc 9-75//H.spont.41-5/Tadmor (2)
3001: SLB 45-90/H.spont.41-2 (2)

A number of lines showed an outstanding plant height

despite the severe stress. 347 lines (23% of the total) were taller than Zanbaka, the tallest check. A high frequency of tall lines was derived from crosses with *H. spontaneum* (Fig 2.1.2).

Of the 150 lines derived from crosses with *H. spontaneum*, 101 (67%) were taller than Zanbaka, and 60% were included among the 5% tallest lines. The actual plant height of the ten tallest lines in the initial trials in Breda is shown in Table 2.1.6: eight out of ten have *H. spontaneum* in their pedigree and they are all two-rowed.

Table 2.1.7. Barley lines which outyielded Arabi Aswad in 1995 in Breda (BY = Total biological yield, GY = grain yield, THGY = grain yield in Tel Hadya, PH = plant height, DH = days to heading) in the Initial Yield Trials.

Entries[a]	BY	GY	THGY	PH	DH
2213	4504	1202	5210	27.7	91
2238	3055	1147	3578	27.2	94
1369	2967	1128	4859	28.4	96
4139	3643	1087	3437	29.2	97
2314	3593	1084	4671	27.4	93
4375	4007	1077	2577	34.6	97
4310	3408	1074	4043	27.6	96
4153	3082	1066	3132	27.6	98
2247	3256	1043	3532	27.8	96
4058	3159	1030	2889	28.7	99
Checks					
Arabi Abiad	2811	876	4540	24.2	97
Arabi Aswad	2472	608	3222	24.4	98
Arta	2604	901	4781	18.4	94
Zanbaka	2299	602	2944	26.0	97
Rihane-03	3062	564	5284	23.1	100

[a]Entries' Name
2213: Emir/Sbt//CM67/3/F8-HB-854-23/121//148-221/4/CI 08887/CI05761/5/ER/Apm/3/Arr/Esp//Alger/Ceres.362~
2238: Roho/Arabi Abiad//Belle/Maf102/3/Arta
1369: Mr25-84/Attiki/3/Arizona 5908/Aths//Lignee 640
4139: SLB 29-53
2314: Harmal-02/ArabiAbiad*2/4/Soufara-02/3/RM1508/Por// WI2269
4375: H.spont.41-1/Tadmor
4310: SLB 66-71
4153: SLB 29-70
2247: Tadmor//Kv/Mazurka/3/Roho/Arabi Abiad//Belle /Maf102
4058: SLB 28-53

None of them had a clear advantage in grain yield over the landraces or the lines selected from them, and their yield levels in Tel Hadya also were low. This can be caused by some seed shattering associated with a semi-fragile

rachis. Rachis brittleness is far from being simply inherited and it takes several cycles of selection to restore a completely solid rachis after a cross with *H. spontaneum*. The tall lines derived from *H. spontaneum* were earlier than Arta (the earliest check) with the exception of line 3004.

When selection was made for both grain yield and plant height, none of the tallest lines was included in the selected group (Table 2.1.7). Although the lines shown in Table 2.1.7 have a much higher total biological yield and grain yield that the best check, their advantage in plant height was reduced. The only exception is the H.spont.41-1/Tadmor (line 4375).

Table 2.1.8. Grain yield and plant height (mean and range) in Breda of the best 5% of the lines in the Initial, Preliminary and Advanced yield trials in percent of Arabi Aswad, the predominant landrace in the dry areas of Syria (GY = grain yield, PH = plant height).

	Initial	Preliminary	Advanced
Nr. of lines	1533	400	133
GY best 5%±s.e.	1058 ± 7.6	1011 ± 23.8	1047 ± 21.0
range	1252-985	1362-925	1163-996
range % of A. Aswad	206-162	203-138	171-146
PH best 5%±s.e.	22.9 ± 0.4	24.9 ± 1.2	26.0 ± 1.1
range	34.6-15.2	34.9-15.8	28.4-21.7
range % of A. Aswad	142-62	127-57	114-87
GY A.Aswad	608	671	681
PH A.Aswad	24.4	27.6	24.9

Table 2.1.8 summarizes what we believe is evidence of a continuous progress towards drought tolerance of the barley germplasm, measured both as grain yield and plant height. For the three levels of yield testing (were the initial yield trials contain the newest germplasm and the advanced yield trials the oldest), the table gives the actual grain yield and plant height (mean and range), and also the range in % of Arabi Aswad, the predominant landraces in the target environment. From the oldest to the newest breeding material there was an increase in the yield advantage of the best line over the local landrace in grain yield (from 71% in the advanced to 106% in the initial yield trials) and in plant height (from 14% in the

advanced to 42% in the initial yield trials).

(S. Ceccarelli and S. Grando)

2.1.3.1. Combining Drought Tolerance and Disease Resistance

WI2291 and Tadmor have repeatedly outyielded the local landrace Arabi Aswad in small plots trials as well as in the large plot testing conducted by the Mashreq project. Tadmor has been used frequently as a parent, and it appears often in the pedigree of the lines performing well under drought stress (see pg. 10-14). Both lines are very susceptible to one major disease and resistant to another, WI2291 being resistant to powdery mildew and susceptible to scald, while Tadmor is resistant to scald and susceptible to powdery mildew. A cross between the two cultivars has been advanced by Single Seed Descent, and 264 random F_7 lines have been field tested for the first time in 1995 at Tel Hadya in an unreplicated nursery together with the two parents. The original objective of the cross was to transfer powdery mildew resistance from WI2291 into Tadmor and scald resistance from Tadmor into WI2291. Since the original cross was made, this material has been the subject of both physiological and molecular studies.

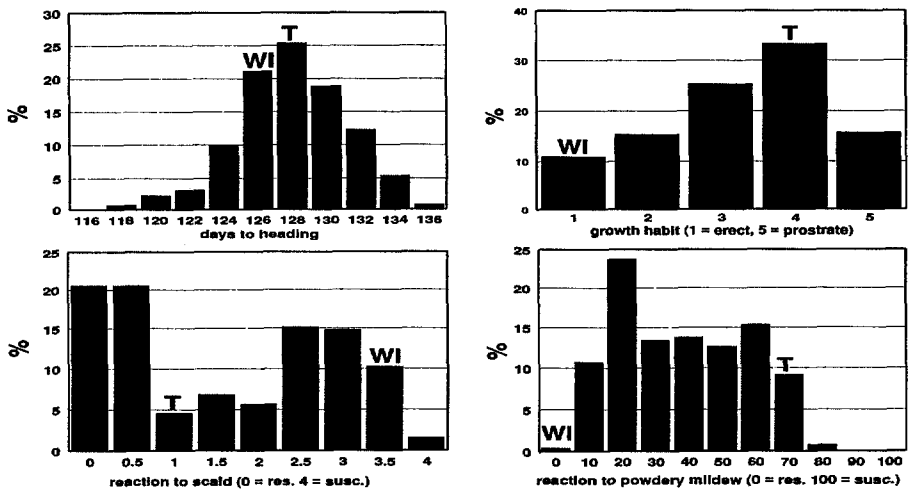

Fig. 2.1.3. Segregation for days to heading, growth habit, reaction to powdery mildew and scald in 264 random F_7 lines from a cross between WI2291 and Tadmor.

Fig. 2.1.3 shows the segregation of days to heading,

growth habit and reaction to scald and powdery mildew in the 264 random inbred families. Although the two parents have a very similar phenology, there was a range of heading times in the progenies of the cross from 118 to 136 days after emergence, indicating transgressive segregation, whereas the segregation for growth habit suggests dominance for the prostrate habit. As expected there was a wide range of reactions to both powdery mildew and scald, from absence of symptoms to high susceptibility. A large number of lines (about 50%) had a high level of resistance to scald while those with a level of resistance to powdery mildew similar to WI2291 were very few. However, three lines had a level of resistance to both diseases that was equivalent or better than the resistant parent (Table 2.1.8). One of the lines has black seed like Tadmor, one has white seed like WI2291, while the third segregates for seed color and will be put through two cycles of Single Seed Descent.

Table 2.1.8. Growth habit (1 = erect, 5 = prostrate), days to heading (from emergence) and seed color of lines combining the resistance to powdery mildew (PM) of WI2291 with the resistance to scald (SC) of Tadmor.

Lines[a]	Reaction to:		Growth habit	Days to heading	Seed color
	SC	PM			
5922	0.3	5.0	3.5	125	White
5688	0.3	4.0	4	132	Black
5701	0.5	5.0	3	126	Black/white
Tadmor	1.3	69.0	4	128	Black
WI 2291	3.5	5.5	1	126	White

[a] The lines are F_7 obtained by Single Seed Descent from the cross between WI2291 and Tadmor.

(S Ceccarelli)

2.1.4. Relationship between Leaf Structure and Carbon Isotope Discrimination

Abiotic stresses such a drought are actually increasing water use efficiency (WUE) of crops. However, the increase in WUE is caused by a stomatal limitation on photosynthetic rates, as indicated by the decrease in carbon isotope discrimination (Δ) of the photosynthates, which in turn affects negatively the yield.

Genotypes of barley and wheat showing constitutively

lower stomatal conductance (and therefore lower Δ and higher WUE values) frequently are less productive than those exhibiting higher stomatal conductance, even under unfavorable conditions.

The possibility of a lower Δ (and therefore higher WUE) being attained by increasing the internal photosynthetic activity, without any concomitant decrease in stomatal conductance, needs to be tested. This could confer higher productivity to those plants showing higher Δ values. Within a given species differences in the intrinsic photosynthetic capacity may be attained by differences in the amount of photosynthetic machinery per unit leaf area. Parameters such as the specific leaf weight (SLDW, dry weight per unit leaf area) or the total chlorophyll content per unit leaf area may became good indicators of the strength of the photosynthetic apparatus.

A negative correlation between SLDW and Δ has been reported in peanuts, and recently in comparisons of barley with wheat. However it is still to be confirmed whether this relationship exists within a given cereal species.

The objective of this study was to evaluate the variation in leaf structure and Δ in the 259 F_6-lines derived from the cross Tadmor/WI 2231 described at page 16. Although the parents were selected on the basis of other characters, they showed a large difference in total chlorophyll and nitrogen content of leaves (Fig. 2.1.4). Plants were grown in Tel Hadya with little or no drought stress. Field measurements and sampling were performed in the penultimate leaf around 2 weeks before anthesis during early April, 1995. Total chlorophyll content was measured in the field using a portable chlorophyll meter (SPAD, Minolta). The leaves used in the SPAD measurements were also used to calculated leaf area and SLDW. Δ was measured with a mass spectrometer on the leaf samples of a subset of 48 lines (plus the parents) selected for a wide range of SLDW and SPAD. The same leaf samples were used to measure total nitrogen content.

The set of lines showed a wide range of values for the different parameters related with the leaf structure. Thus, SPAD ranged from 31.9 to 50.7, SLDW from 28.9 g m^{-2} to 53.3 g m^{-2}, and nitrogen content from 1.11 g m^{-2} to 2.29 g m^{-2}. SPAD values seem to be a valuable tool, providing a single but proper indication of the amount of

photosynthetic machinery displayed behind the leaf surface. As a parameter based on the total chlorophyll content per unit leaf area, SPAD values were significantly ($p < 0.001$) and positively correlated with SLDW ($r = 0.30$, d.f. 259), and particularly with the total nitrogen content per unit leaf area ($r = 0.76$, d.f. 48) (Fig. 2.1.4).

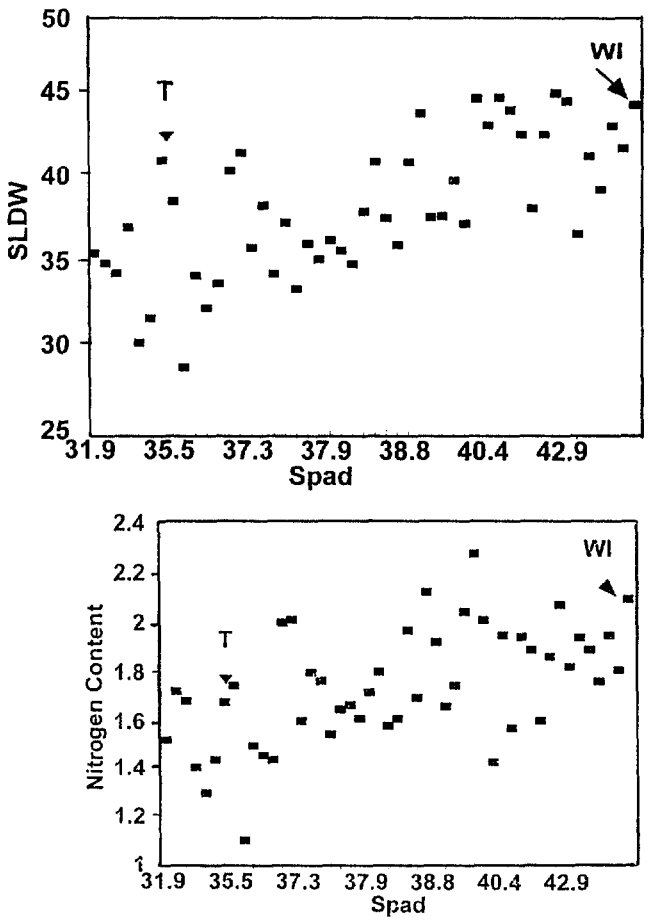

Fig. 2.1.4. Relationships between SPAD (a measure of chlorophyll content) and Specific Leaf Dry Weight and Nitrogen Content in F_6-lines Tadmor/WI 2231

Discrimination values ranged between 18.94% and 21.19%, with a mean value across lines of 19.93%. The high values of Δ for all the lines indicates that they grew without water constrains. Significant ($p < 0.01$, d.f.= 48) and negative correlations existed between Δ and both SLDW ($r = -0.56$) or SPAD ($r = -0.53$) measurements (Fig. 2.1.5), which suggest that lines with higher amount of

photosynthetic machinery per unit leaf area have lower Δ and therefore higher WUE. Total nitrogen content was also negatively correlated ($p < 0.01$) with Δ, although the correlation was weak.

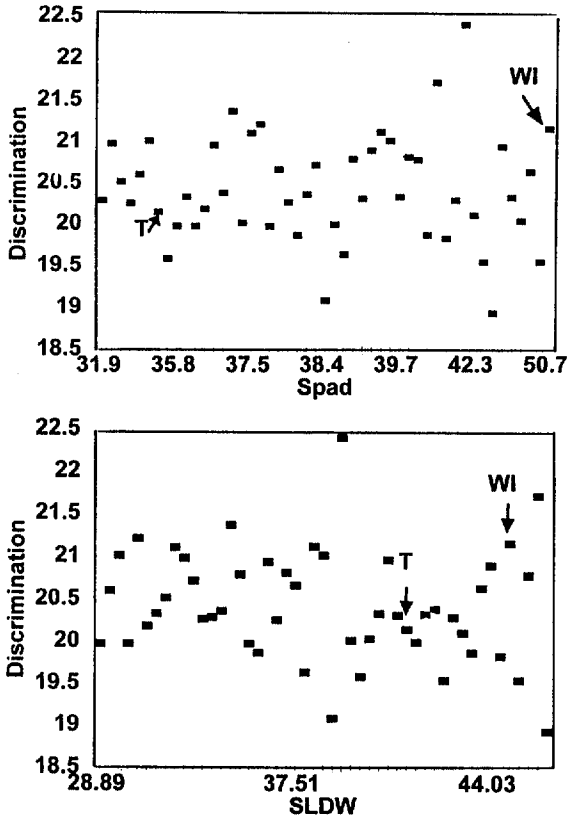

Fig. 2.1.5. Relationships between carbon isotope discrimination and SPAD (a measure of chlorophyll content) and Specific Leaf Dry Weight in F_6-lines Tadmor/WI 2231.

The relationship between Δ of the dry matter of the penultimate leaf and grain yield was also studied. There was a weak, although significant, negative correlation between Δ and grain yield ($r = -0.30$, $p < 0.01$). This would agree with a tendency to higher yield in those lines possessing higher WUE. In addition, there was no correlation for the overall set of 261 genotypes used in this study between leaf area and SLDW. Therefore selection for a higher SLDW will not decrease leaf area.

(J. Araus)

2.1.5. Progresses in yield potential

Advances in yield potential in the breeding material were assessed by comparison with Rihane-03, a cultivar released in six countries (Lebanon, Morocco, Tunisia, Algeria, Iraq and Spain), and also successful in Syria were a farmer reported a yield of 7 t/ha in 1995. The yield potential of breeding lines was also assessed by comparison with Arta, a cultivar released in 1994 in Syria and rapidly spreading among farmers.

Table 2.1.9. Grain yield in Tel Hadya in 1994 and in 1995, and average of the two years of the highest yielding lines in the Preliminary Yield Trials.

Entries[a]	1994	1995	Mean
60	4138	4874	4506
103	4264	4320	4292
80	4172	4371	4272
81	4003	4367	4185
184	4230	4139	4184
84	4105	4252	4179
82	4313	4041	4177
71	4232	3988	4110
41	4058	4143	4101
355	4117	3969	4043
110	4022	4008	4015
Checks			
Arabi Abiad	3435	3341	3388
Arabi Aswad	2704	2634	2669
Arta	3966	3482	3724
Zanbaka	2457	2154	2305
Rihane-03	3624	3910	3767

[a]Entries' Name (row type)
60 : Rihane-03/3/Roho//Alger/Ceres 362-1-1 (6)
103: Roho//Alger/Ceres 362-1-/3/Mo.B1337/WI2291 (2)
80 : Arizona5908/Aths//Lignee640/5/Aths/4/Pro/TolI/ /Cer*2/TolI/3/5106 (6)
81 : Arizona5908/Aths//Lignee640/5/Aths/4/Pro/TolI/ /Cer*2/TolI/3/5106 (6)
184: Arta//WI2291/WI2269 (2)
84 : M126/CM67//As/Pro/3/Arizona 5908/Aths//Lignee 640(6)
82 : Arizona5908/Aths//Lignee640/5/Aths/4/Pro/TolI/ /Cer*2/TolI/3/5106 (6)
71 : Arizona 5908/Aths//Lignee 640/3/Emir//Esp/Sv.Mari (6)
41 : Rihane-03/3/Harma-02//11012-2/CM67 (6)
355: SLB 24-24 (2)
110: Mo.B1337/WI2291/5/Emir/Sbt//CM67/3/F8-HB-854-23/121/ /148-221/4/CI 08887/CI 05761 (2)

In the advanced yield trials, none of the 133 lines

outyielded consistently Rihane-03 and Arta in the three years of yield testing, although few had a higher average yield across years. In the preliminary yield trials, eleven of the 400 lines in the second year of testing, outyielded both Rihane-03 and Arta which yielded about 3.7 t/ha as average of two years (Table 2.1.9).

The results of the initial yield trials are summarized in Table 2.1.10.

Table 2.1.10. Grain yield and days to heading in Tel Hadya (THGY and DHTH), grain yield, total biological yield and plant height in Breda (GYBR, BYBR and PHBR) in 1995 of some the highest yielding lines in the Initial Yield Trials in Tel Hadya.

Entries[a]	THGY	BRGY	BYBR	PHBR	DHTH
2059	5812	748	2301	29	96
1368	5722	841	1982	19	100
2040	5626	611	2488	24	98
4249	5455	1002	2810	20	97
1288	5327	404	2184	18	99
1357	5296	512	2618	17	97
4298	5268	846	2549	16	101
4359	5029	767	2714	29	99
4245	4979	932	2892	20	97
4263	4951	697	2361	19	97
4257	4923	998	3090	22	94
4217	4904	742	3013	18	100
4251	4834	921	2638	21	95
3201	4827	737	2254	19	98
4181	4794	1052	3385	15	100
4258	4791	1032	3521	23	100
Checks					
Arabi Abiad	4540	876	2811	24	97
Arabi Aswad	3222	608	2472	24	98
Arta	4781	901	2604	18	94
Zanbaka	2944	602	2299	26	97
Rihane-03	5284	564	3062	23	100

[a]Entries' Name (row type)
2059: Arupo (2)
1368: Arizona5908/Aths//Lignee640/3/Lignee640/ Lignee527 (6)
2040: Cr.115/Pro//Bc/3/Api/CM67/4/Giza120 /5/Satter2/Numar(6)
4249: SLB 39-24 (2)
1288: Lignee 527/Arar/3/Lignee 527/Sawsan//Bc (6)
1357: M126/CM67//As/Pro/3/Lignee 527/Arar (6)
4298: SLB 66-58 (2)
4359: Moroc 9-75/A. Aswad (2)
4245: SLB 39-10 (2)
4263: SLB 39-73 (2)
4257: SLB 39-42 (2)
4217: SLB 30-69 (2)
4251: SLB 39-26 (2)
3201: SLB 25-20 (2)
4181: SLB 30-28 (2)
4258: SLB 39-55 (2)

Only the first 6 lines in Table 2.1.10 had a similar or higher yield potential than Rihane-03, and other 73 had a similar or higher yield potential than Arta which was the second best check. Of these we only show some lines to indicate that many lines from the same collection site of Arta (SLB 39) had a high yield in Tel Hadya, and that landraces and materials derived from them do not necessarily have a low yield potential. The table shows that the grain yield in Breda of the lines performing better in Tel Hadya is generally low: those combining good grain yield in both locations (such as lines 4249, 4181 and 4258) were very short in Breda.

(S. Ceccarelli and S. Grando)

2.1.6. Stability and Population Structure

Improved stability and decreased disease severity are common features of mixtures relative to their component in monocolture. A recent review[1] has shown that although their yield advantage is generally small, mixture are a viable strategy for sustainable productivity in subsistence agriculture.

2.1.6.1. Mixtures

Landraces are still widely used in subsistence agriculture where maximize stability of performance is more important than maximize yield *per se*. Diversity within a landrace is a buffer mechanism against environmental fluctuations and is considered a mechanism to enhance stability.

Pure line selection within Syrian barley landraces has produced lines (Arta, Tadmor, Zanbaka) with superior performances, but the long term objective is to use the best genotypes selected within landraces to constitute mixtures. The use of mixtures rather than homogeneous varieties has been suggested by several authors as a means to promote yield stability.

To evaluate the role of heterogeneity in stabilizing

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[1]Smithson, J.B. and Lenne, J.L. Varietal mixtures: a viable strategy for sustainable productivity in subsistence agriculture (in press).

yield in stress environments, we conducted a trial for five cropping seasons in 3 to 6 locations per year (total of 26 environments). Two groups of mixtures were included in the trial, one black seeded and one white seeded. For each group the mixtures were constituted with lines extracted from the same population. We started with 72 lines extracted from a black seeded population and 75 from a white seeded population. The lines went through three consecutive cycles of selection for grain yield under stress conditions, at each cycle promoting the best lines to the following year testing. With the lines we constitute mixtures at different level of heterogeneity. The black seeded group had mixtures of 72, 34, 17, and 5 components, the white seeded had mixtures with 75, 34, 15, and 5 components. In the mixtures with the highest levels of heterogeneity, all lines available for each population were included. The mixtures at second highest level (34 lines, in both groups) were constituted with the lines selected for one cycle. In the mixtures with 17 and 15 components the lines selected for two cycles were used, while the mixtures with the lowest number of components contained the lines selected for three cycles. The experiment included 10 pure lines (best 5 black seeded and best 5 white seeded), and six checks.

The trial was evaluated from 1990-91 to 1994-95 in 26 environments. Mean yields ranged from 36 to 4385 kg/ha. Black seeded material tends to have lower average grain yield, lower response, and higher frequency of positive intercept than white seeded material. In both groups the mixtures with five components had an advantage over the more complex mixtures. In the black seeded group (Table 2.1.11), the mixture of five lines did not have a clear advantage over the components. In particular SLB 5-96 had a high average yield (1880 kg/ha), combined with a relatively good response (b=0.97) and a positive intercept (a=91.5).

In the white seeded group (Table 2.1.12) the mixture of five components had an advantage over the single lines, combining a high average grain yield (1978 kg/ha), with a good response (b=1.04) and positive intercept (a=48.1). The only other line with a positive intercept (SLB 9-98) had a very low average grain yield (1588 kg/ha) and low response (b=0.81).

These results confirms what was already reported in

1992, with only 11 environments, and indicate the possibility that the two Syrian landraces possess different buffering mechanisms.

Table 2.1.11. Average grain yield (kg/ha), regression coefficient (b) and intercept (a) of four black seeded mixtures, five lines, and three checks.

Material	Average yield	b	a
MIXB 72	1747	0.89	102.9
MIXB 34	1773	0.97	-8.9
MIXB 17	1786	0.98	-12.1
MIXB 5	1841	0.95	92.5
SLB 5-96	1880	0.97	91.5
SLB 5-07	1868	1.00	24.1
SLB 5-86	1696	0.85	135.7
SLB 5-31	1946	1.06	-9.2
SLB 5-30	1723	0.87	118.6
Arabi Aswad	1636	0.85	66.3
Tadmor	1696	0.88	67.4
Zanbaka	1678	0.86	89.5

Table 2.1.12. Average grain yield (kg/ha), regression coefficient (b) and intercept (a) of four white seeded mixtures, five lines, and three checks.

Material	Average yield	b	a
MIXW 75	1941	1.12	-117.5
MIXW 34	1910	1.13	-167.5
MIXW 15	1869	1.07	-109.2
MIXW_5	1966	1.04	48.1
SLB 9-63	1978	1.12	-85.8
SLB 9-71	1985	1.13	-104.7
SLB 9-76	2053	1.21	-180.1
SLB 9-09	2021	1.11	-26.4
SLB 9-98	1588	0.81	102.7
Arabi Abiad	1887	1.12	-176.3
Arta	2087	1.17	-66.1
Harmal	1931	1.09	-82.0

(S. Grando)

2.1.6.2. Influence of Heterogeneity and Heterozygosity on Yield under Drought Stress Conditions

Intergenotypic diversity (heterogeneity) and intragenotypic diversity (heterozygosity) are two possible buffer mechanisms against unpredictable environmental conditions where distribution and amount of rainfall have a large variability, such as those where barley is grown.

To evaluate the influence of heterogeneity we compared doubled haploid lines (DHL) in mixtures with the same DHL in pure stand, whereas to evaluate the influence of heterozygosity we compared F_2 populations with mixtures of DHL lines. The material consisted of six DHL (indicated as LR1 to LR3 and EL1 to EL3) derived from adapted landraces (gene pool "landraces", or LR) and from double crosses between adapted and non-adapted material (gene pool "experimental lines", or EL). Two crosses each were made within the EL-gene pool (EL1 x EL2, EL1 x EL3) and between the pools (LR1 x EL2, LR2 x EL1). Eight DHL's and the F_2-generation were produced from each cross. The six parental lines, four F_2 populations, four DHL-mixtures and thirty-two DHL in pure stand were tested in Tel Hadya (moderate drought stress) and Breda (severe drought stress).

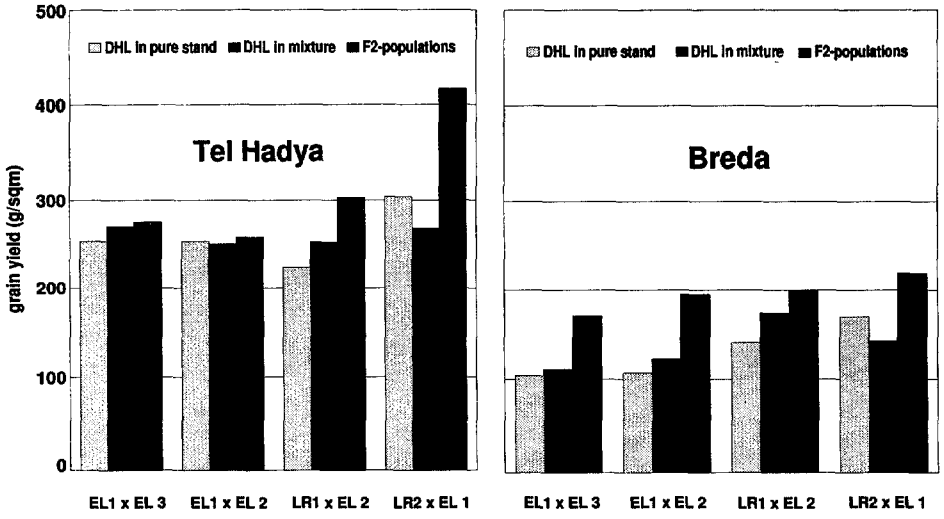

Fig. 2.1.6. Effect of heterogeneity and heterozygosity on grain yield in moderately stressed (Tel Hadya) and severely stressed conditions (Breda).

In the case of the EL x EL populations, heterozygosity led to a slight increase of grain yield in Tel Hadya and to a dramatic (60.5%) increase in Breda (Fig. 2.1.6).

The comparison between DHL-mixtures and their components' mean indicated a yield increase due to heterogeneity of 3% in Tel Hadya and 13% in Breda. In the case of the LR x EL-group, the effect of heterozygosity was independent of the environment. However the importance of heterozygosity differed between populations (20% and 47% increase, respectively).

Also the influence of heterogeneity differed between LR x EL populations. While the DHL-mixture of population "LR1 x EL2" outyielded the component DHL in pure stand, the reverse was true for the mixture and pure stands of population LR2 X EL1. This effect was more pronounced in Breda than in Tel Hadya.

In general, heterozygosity had a stronger influence on grain yield than heterogeneity. Both factors were largely dependent on the genetic background and the environment. Heterozygosity generally had a positive effect on grain yield. In contrast, the effect of heterogeneity was either positive or negative. Therefore, increasing the level of heterozygosity appears to be an avenue to increase yield under drought stress. However, the exploitation through hybrids of the yield advantage associated with heterozygosity is not feasibile for a crop such as barley for which seed is usually produced on the farm. Selection for cross-pollination and production of synthetic varieties would be a better way to exploit the higher vigor associated with heterozygosity.

(C.H.P. Einfeldt, S. Ceccarelli, A. Gland-Zwerger and H.H. Geiger)

2.1.7. Successes and Failures in International Testing

A number of countries continue to receive the barley germplasm developed by the project through the traditional system of international nurseries. These include unreplicated nurseries with a number of entries which varies from year to year, and replicated yield trials with 19 test entries, four ICARDA checks and one national

check. Because of the time needed to receive the data back and to process them, we are reporting the main results of the replicated yield trials grown by NARS in 36 locations and 14 countries during the cropping season 1993/94. The rainfall, the grand mean of the trial, the yield of the national check, the top yielding line and its yield, are given in table 2.1.12 for each location were one or more trials were grown.

There was a large variation in yield among locations, from less than 0.5 t/ha, in Sariab and Tando Jam, in Pakistan, to more than 7 t/ha in Tolentino, Italy and Karaji and Torogh, Iran.

In most of the locations one or more lines outyielded or yielded as well as the national check. Only in five locations (Birjand in Iran, Faisalabad and Tando Jam in Pakistan, Bossares in Spain, and in Thailand) the national check ranked first. In a number of locations the superiority of ICARDA lines over the national check was only marginal (such as Terbol in Lebanon, Torogh in Iran and Bassares in Spain), in others (such as Ramtha in Jordan, Islamabad in Pakistan, Sakha and Nubaria in Egypt) it was very large.

Some of the lines showed a high yield potential with peak yields in favorable or irrigated environments of 7 to 11 t/ha. One point of interest is that, even among this relatively small number of lines, there are differences in specific adaptation, i.e. different lines were the top yielders in different locations. However few lines outyielded the national checks in a number of contrasting locations (such as BYLC94-5 in five locations, and BYLW94-19 and BYM94-4 in four locations).

To summarize the results of such a large number of trials we calculated the following two ratios:

(1) yield of the national check/mean yield of the trial

(2) yield of the top line/yield of the national check

The first ratio gives a measure of the general level of adaptation of the lines to that particular location, as low values of the ratio indicate that the material is, in general, well adapted to the location, and viceversa.

The second ratio gives an indication of failures, when it falls below 1, and of successes, when it is substantially higher than 1. The frequency distributions of the two ratios, calculated using the data of table 2.1.12 (a total of 70 trials) are shown in Fig. 2.1.7.

Table 2.1.12. The highest yielding barley lines distributed with the Regional Yield Trials 1993/94 in different countries (names of the lines are given in Table 2.1.13).

Country	Location	Rainfall	Mean	Nat. Check	Line	Yield
Cyprus	Dromolaxia	381	4539	4460	BYM94-6	5795
	"	"	"	"	BYM94-23	5773
	Athalassa	271	4534	4561	BYLW94-19	5504
	"	"	"	"	BYLW94-23	5455
Iran	Karaj	275[a]	7557	8000	BYM94-20	9067
	Moghan	241[a]	5931	6144	BYM94-2	6822
	Gachsaran	131	1418	1609	BYM94-18	2274
	Khorram	498	5611	4102	BYM94-20	6972
	"	"	"	"	BYM94-4	6593
	Yazd	37[a]	4954	5167	BYLW94-21	6233
	Birjand	112[a]	2609	3888	BYLW94-1	3642[b]
	Torogh	155[a]	9992	11198	BYLC94-5	11720
	Zabol	42[a]	3101	3513	BYLC94-14	4389
	"	"	"	"	BYLC94-5	3903
Jordan	Al-Ghoweir	381	1230	1303	BYLW94-7	1868
	"	"	"	"	BYLW94-9	1653
	Ramtha	201	654	399	BYLW94-3	996
	"	"	"	"	BYLW94-9	967
Pakistan	Sariab	140[a]	175	301	BYLC94-16	345
	Sarkand	n.a.[a]	1770	1911	BYLC94-8	2378
	Seri N.	160	860	994	BYLC94-5	1178
	Islamabad	202		3200	BYLC94-5	6000
	"	"		2600	BYM94-21	4350
	Faisalabad	40[a]	2009	2111	BYM94-9	2972
	Faisalabad[c]	n.a.[a]	1878	2500	BYM94-11	2361[b]
	Tando Jam	177[a]	343	556	BYLW94-13	500[b]
	Bahawalpur	23[a]	1966	1500	BYLW94-19	2967
	"	"	"	"	BYLW94-16	2883
Afghan.	Baghlan	n.a.	1743	1520	BYLW94-1	3131
	"	"	"	"	BYLW94-3	2850
	"	"	"	"	BYLW94-19	2661
S. Arabia	Riyad	100[a]	3646	4300	BYM94-8	4828
	Dirab	20[a]	2510	3026	BYM94-5	3221
	Gassim	68[a]	4624	4998	BYM94-14	5653

[a] irrigated
[b] national check ranked first
[c] different station

Table 2.1.12. cont'd

Country	Location	Rainfall	Mean	Nat. Check	Line	Yield
Qatar	Rawdat	22[a]	5554	6427	BYM94-14	7000
Lebanon	Terbol	475	5361	5789	BYM94-4	6078
	"	"	4992	5522	BYLC94-23	5656
	Kfardan	n.a.	3713	3633	BYM94-14	4522
	"	"	3282	3444	BYLW94-6	4189
	"	"	3282	3444	BYLW94-9	4044
	"	"	3490	3600	BYLC94-9	4422
	Tel Amara	475	2613	2258	BYM94-1	4014
	"	"	2613	2258	BYM94-19	3371
Egypt	Gemmeiza	n.a.[a]	4191	4189	BYM94-19	5911
	"	"	"	"	BYM94-18	5767
	"	"	"	"	BYM94-17	5267
	Sakha	n.a.[a]	3253	2722	BYM94-17	4044
	"	"	"	"	BYM94-20	3967
	Nubaria	n.a.[a]	1539	870	BYLW94-18	3053
	"	"	"	"	BYLW94-21	2387
	Raffah	100	1216	1187	BYLW94-23	1917
	"	"	"	"	BYLW94-18	1711
Greece	Agios	329	4691	3785	BYM94-7	6092
	"	"	4600	4790	BYLW94-1	6041
	"	"	"	"	BYLW94-14	5436
	"	"	4838	4338	BYLC94-11	5897
	"	"	"	"	BYLC94-20	5590
Portugal	Elvas	242	2947	3069	BYM94-4	4575
	"	"	1504	996	BYLC94-19	2090
	"	"	"	"	BYLC94-4	1965
Spain	Bossares	416	557	852	BYM94-21	840[c]
	"	"	524	599	BYLW94-10	784
	"	"	"	"	BYLW94-19	736
	Granada	177	3348	2440	BYLC94-5	5317
	"	"	"	"	BYLC94-3	4847
	"	"	"	"	BYLC94-20	4644
Italy	Tolentino	574	7078	6687	BYM94-23	8387
	"	"	"	"	BYM94-14	8297
Thailand	Boon Rawd	n.a.[a]	612	1333	BYM94-17	857[b]
	"	"	597	1373	BYLW94-16	1043[b]

[a] irrigated
[b] national check ranked first

Table 2.1.13. Names of the entries listed in Table 2.1.12.

Entry	Names
BYLC94-3	Pld10342//Cr.115/Por/3/Bahtim
BYLC94-4	Rihane-07/IFB974
BYLC94-5	ER/Apm/3/Arr/Esp//Alger/Ceres,362-1-1
BYLC94-8	CI 08887/CI 05761//Harmal-02
BYLC94-9	Aths/Lignee 686
BYLC94-11	Pedrong
BYLC94-14	Orge 905/Cr.289-53-2
BYLC94-16	Arabi Abiad/Moroc 9-75
BYLC94-19	WI2291/Roho//Arabi Aswad
BYLC94-20	Lignee 1242/3/Arr/Esp//Alger/Ceres,362-1-1
BYLC94-23	Lignee 640/Lignee 686
BYLW94-19	WI2291/Bgs//Harmal-02
BYLW94-1	Rihane-03
BYLW94-9	Harmal'S'/Kantara
BYLW94-3	Mari/Aths*2//Attiki
BYLW94-16	Baca'S'/3/AC253//CI 08887/CI 05761
BYLW94-23	Aths/Lignee 686
BYLW94-21	Arar/4/Lth/3/Nopal//Pro/11012-2
BYLW94-18	Moroc 9-75
BYLW94-10	Lignee 1242/Harmal-02
BYLW94-7	Arar//Deir Alla 106/Cel
BYLW94-14	Arar/PI386540
BYLW94-13	Mari/Aths*2//Attiki
BYLW94-6	Harmal
BYM94-1	Assala-04
BYM94-2	Lignee 527/NK1272
BYM94-4	Vg/Julia//Zy/3/CM67/Apro//Sv.02109/Mari
BYM94-5	Lignee 527/NK1272
BYM94-6	ER/Apm
BYM94-7	Rihane-05//As46/Aths*2
BYM94-8	Rihane-03/3/Deir Alla 106//Mzq/DL71
BYM94-9	WI2197/Cam/3/OP/Zy//Alger/Union,385-2-2
BYM94-11	N-Acc4000-301-80/IFB974
BYM94-14	Arizona 5908/Aths//Lignee640
BYM94-17	Robur/Hor728//F3 Bulk Hip/3/Harma-02//M480/Gva
BYM94-18	WI2291
BYM94-19	Hd/Aths//Pyo/DL70/3/Apm/5106/4/Mona/Ben//Cam
BYM94-20	Dram/Emir//ER/Apm
BYM94-21	Rihane/Lignee 527
BYM94-23	Vg/Julia//Zy/3/CM67/Apro//Sv.02109/Mari

There was a very small number of cases were the yield of the national check was much higher than the mean of the trials. Most of the trial means are between ± 20% of the yield of the national check, indicating that the majority of the breeding lines in the trials are well adaptaded to the range of conditions represented by this set of locations.

In 49 trials the yield advantage of the best line over the national check was 20% or more, but in 6 trials (two in Pakistan, two in Thailand, one in Spain and one in Iran) even the best line yielded less than the national check.

In general, most of the national programs had superior germplasm made available to them. The most significant failures were Thailand and some areas of Pakistan. This justifies the move towards special nurseries for the Far East described earlier.

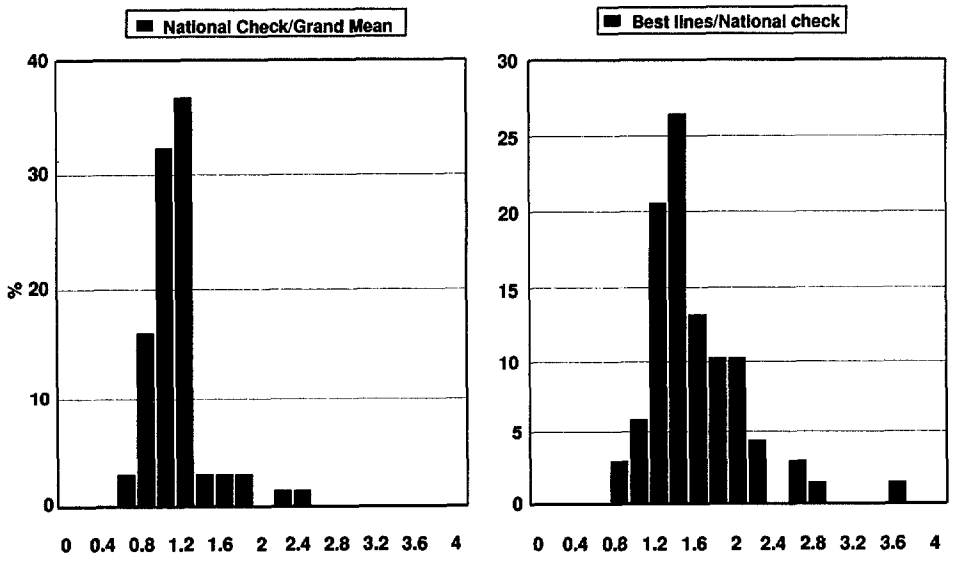

Fig. 2.1.7. Ratio (on the X axis) between the yield of the national check and the mean yield of the trial (top) and between the yield of the top line and the yield of the national check (bottom). The data are based on 36 locations in 14 countries).

(S. Ceccarelli and S. Grando)

2.1.8. Boron Toxicity Tolerance

2.1.8.1. Seedling Test

Screening for B-toxicity tolerance was conducted under a plastic house in soil mixed evenly with boric acid at the rate of 50 mg B/kg soil (giving a hot water extract of around 12 ppm B). Foliar B-toxicity symptom scores were taken 4 to 6 weeks after sowing.

2.1.8.2. Syrian Landrace Selections

One hundred and forty-one pureline selections from Syrian landraces were screened. The selections originated from two collection sites, one of which gave black-seeded lines (site 21) while the other gave white-seeded lines (site 24). There were significant differences in B-toxicity symptom scores between the selections. The two populatios had the same mean scores, but the black-seeded populations had a slightly wider variation. The best four selections with symptom scores comparable to the moderately tolerant check, Galleon, were black-seeded. None of the selection was as sensitive as the sensitive check, Pirate.

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

2.1.8.3. Yield Test

Out of the 50 Iraqi barley accessions screened last season, 15 accessions with lower B-toxicity symptoms scores than Galleon, the moderately tolerant barley check, and low shoot B concentrations were grown in pots up to maturity under a plastic house. There were two treatments: control (0.5 ppm hot water extractable B) and +B (50 mg B/kg soil, giving a hot water extract of 11.4 ppm B).

The performance of the most B-toxicity tolerant accessions is presented in Table 2.1.14. All the lines in the table had lower B-toxicity symptom scores and shoot B concentrations than Galleon at the seedling stage. Unlike Galleon, they showed an increase in grain yield under the +B treatment. The best accession had a 27 % yield increase, higher than that of the very tolerant check, Sahara 3763, though Sahara 3763 had less symptoms and lower shoot B concentration. Results of the study

confirmed the expectation that good sources of tolerance to B toxicity can be found in Iraqi landraces.

(S.K.Yau, J. Ryan, J. Valkoun)

Table 2.1.14. Performance of the most B-toxicity tolerant Iraqi accessions (in terms of least reduction in grain yield when grown in soil to which 50 mg B/kg soil [+B] was added, as compared to the control [-B]).

Accession number	B toxicity symptom score[1] at +B	Shoot B conc. (ppm)	Grain yield at -B (g/pot)	Grain yield at +B (g/pot)[2]
ICB 109419	2.75	319	8.1	10.3(127)
ICB 108477	0.75	103	7.7	8.9(115)
ICB 109415	1.25	132	10.1	11.5(115)
ICB 121426	1.75	225	8.1	9.0(113)
ICB 109420	1.75	306	9.8	11.0(111)
Moderately tolerant check:				
Galleon	4.50	468	11.7	7.3(65)
Very tolerant check:				
Sahara 3763	0.10	66	10.0	11.0(109)
Mean (n=28)	1.91	346	9.3	8.3(90)
LSD (P=0.05)	1.408		2.35	2.27

[1] 0-9 scale: 0 = no symptom, 9 = severe symptom. Scores taken at seedling stage.
[2] yield under +B expressed as a percentage of -B yield

2.1.8.4. Differential Responses to Different Levels of Soil Boron

A pot experiment with three replicates was conducted under plastic house conditions to compare the responses of Harmal, which is moderately sensitive to B toxicity based on severity of foliar toxicity symptoms when grown in soils to which 50 mg B/kg soil was added, with that of Galleon, a moderately tolerant Australian cultivar. There were four soil B levels created by adding 0, 12.5, 25 and 50 mg B/kg soil, which gave hot water extractable B levels of 0.5, 3.1, 5.8 and 10.2 ppm, and they were designated as B0, B3, B6 and B10, respectively.

Shoot growth at heading for both Galleon and Harmal was decreased only at B10, though B-toxicity symptoms appearred at B3, B6 and B10. Unlike Galleon, shoot dry weight of Harmal was significantly higher at B3 than at B0, despite the shoot B concentration of Harmal at B3 was significantly higher than that at B0 (Table 2.1.15). Root

growth of Harmal at B3 was similar to that at B0. Galleon's root dry weight was significantly lower than the control at B10, but that of Harmal was significantly reduced even at B6. Thus there is no indication that Harmal has a higher requirement of B for optimal growth, or is more tolerant to B toxicity than Galleon. Results suggest that at mild B toxicity, Harmal is able to grow faster than normal to compensate for the leaf damage caused by toxicity.

(S.K. Yau and J. Ryan)

Table 2.1.15. Boron-toxicity symptom scores (at tillering), and shoot and root dry weights and B concentrations (at heading) for Galleon and Harmal barley at four different soil B levels.

Genotype	B levels (ppm)	Toxicity symptom score[1]	Dry wt. (g/pot)		B conc.	
			Shoot	Root	Shoot	Root
Galleon	B0		0.0	13.5	4.1	1113
	B3	2.5***[2]	12.9ns	4.0ns	83*	24**
	B6	4.2***	12.8ns	3.9ns	197***	39***
	B10	3.7***	9.3***	2.8***	557***	60***
Harmal	B0		0.0	11.7	3.4	1315
	B3	3.8***	13.9*	3.7ns	92*	28***
	B6	5.8***	11.2ns	2.7**	232***	39***
	B10	5.5***	8.1**	1.6***	599***	57***
SE (means)		0.18	0.65	0.19	22.9	1.9

[1] 0 to 9 score based on % of leaf affected: 0 = no symptom
[2] *, **, *** significanly different from B0 at P<0.05, 0.01, and 0.001, respectively.

2.1.8.5. Zinc Deficiency Tolerance: between and within Crop Differences

Zinc (Zn) deficiency is a wide-spread micronutrient problem in West Asia. In response to the encouraging observation of last season's preliminary work on Zn deficiency, an experiment was conducted to study differences in tolerance of Zn deficiency tolerance between and within barley, durum and bread wheat. Seven cultivars/lines from each species were grown in pots under a plastic house in a randomized complete block design with two replicates. Soil from a Tel Hadya field known to be low in Zn was used. There were two treatments: control

(0.7 ppm Zn), and plus zinc (5 mg Zn/kg soil, added as $ZnSO_4.7H_2O$, giving 1.7 ppm Zn in soil). Three harvests were conducted: at tillering, booting and maturity.

Zinc application increased the shoot and root Zn concentrations, but had no effects on all other characters measured: seedling emergency, dry weight of shoot and root, tiller number, days to heading, head number, plant height, grain yield, and harvest index. There were significant differences between genotypes for all these characters, but there was no genotype by Zn interaction. Transient Zn deficiency symptom was observed in some of the durum and bread wheat entries, but not in any of the seven barley genotypes: Zanbaka, Arta, Rihane 03, Harmal, ER/Apm, Tadmor and Tokak. Apparently the soil used in this study was not Zn-deficient enough to affect cereal growth. Results suggested that barley may be more tolerant to Zn deficiency than durum and bread wheat.

(S.K. Yau, J. Ryan, S. Ceccarelli)

2.1.8.6. Boron By Zinc Interaction

Addition of B caused a reduction in grain and straw yield for Mexipak bread wheat, but not for Harmal barley. However, no significant effects were detected with Zn application. (see section 3.5.3 for details).

2.1.9. Barley Biotechnology

2.1.9.1. The Barley Marker Project

The objective of our collaborative research project with the University of Weihenstephan, Munich is to establish and use the non-radioactive protocols for the RFLP-analysis in ICARDA's mandated crops. With this technology we aim to tag genes of agronomic importance and to use them for marker assisted selection.

2.1.9.2. Molecular Marker Analysis

Ninty-four lines of the 264 random inbred lines of the

cross Tadmor x WI2291 described earlier (pg.17) are being used in the inital phase to cover the barley genome of this cross with well placed markers. If complete coverage of the genome is obtained, linkage between agronomical traits and molecular markers can be established.So far, segregation analysis has been performed for 31 molecular markers (29 RFLPs, 2 RAPD-markers). The mapping is being carried out in Munich with radioactive labelled RFLP-markers and at ICARDA with non-radioactive labelled RFLP markers (Fig.2.1.8). The data for molecular marker analysis is combined to lead to a working linkage map (see Figure 2.1.9). The positions in the linkage map are obtained from the cross Igri x Franka which was mapped in Munich in 1991. We assume the same positions for the markers in the Tadmor x WI2291 cross, if no translocation, inversion or duplication have occured in the genomes. Besides the located markers, the following markers have been subjected to segregations analysis but the markers have not yet been located within the linkage groups: MWG3 (7H), MWG569 (5H), MWG649a, b, c, (1H or 7H), MWG920 (5H), CDO482 (3H) pTAG 163 (2H), OPJ19 (1H or 7H). The already established linkage relationships within the cross are shown in Table 2.1.16.

Table 2.1.16. Linkage relationships between markers in the mapping population of Tadmor x WI2291 with their recombination ratios (theta), probabilities (LOD) and their distance in centiMorgans (cM).

Locus 1	Locus 2	Theta	LOD	cM
MWG503	OPU7	0.10	14.64	11.03
MWG514A	MWG514b	0.01	21.45	1.32
MWG533	MWG569	0.29	2.80	43.85
MWG533	MWG850	0.25	4.09	34.66
MWG539A	MWG832	0.15	11.12	17.69
MWG539A	MWG836	0.14	11.42	16.56
MWG539B	MWG584	0.18	9.00	22.47
MWG569	MWG850	0.20	7.75	25.88
MWG602	MWG891	0.13	10.75	14.65
MWG832	MWG836	0.25	5.23	34.66
MWG896	MWG920	0.18	5.45	22.16
MWG949	MWG950	0.01	25.30	1.11

The segregation of the markers showed a near 1:1 segregation for 77% of the markers analyzed Table 2.1.17. Markers in linkage group 1,3 and 5 showed a segregation distortion. The number of heterozygote alleles which can

be seen in hybridizations with codominant inherited RFLP-markers does not exceed 3%.

Table 2.1.17. χ^2-square analysis of markers segregating in the recombinant inbred lines.

Marker	n	Segregation	X2	P
MWG502	94	41:53	1.28	0.26
MWG503	93	44:49	0.16	0.69
MWG542a	79	36:43	0.44	0.51
MWG541b	79	37:42	0.20	0.65
MWG522	72	50:22	10.11*	0.00
MWG533	94	54:40	1.78	0.18
MWG539a	94	54:40	1.78	0.18
MWG539b	94	63:31	10.22*	0.00
MWG569	94	39:55	2.38	0.12
MWG571	94	45:49	0.08	0.78
MWG584	94	59:35	5.67*	0.02
MWG602	94	50:44	1.78	0.18
MWG682	94	50:44	1.78	0.18
MWG832	92	46:46	0.00	1.00
MWG836	94	49:45	0.08	0.78
MWG837	94	68:26	17.88*	0.00
MWG850	58	27:31	0.14	0.71
MWG891	79	50:29	6.76 *	0.01
MWG896	93	87:6	68.80*	0.00
MWG912	94	57:37	3.84	0.05
MWG916	72	38:34	0.12	0.73
MWG920	56	49:7	30.00*	0.00
MWG949	92	46:46	0.00	1.00
MWG950	94	45:49	0.08	0.78
MWG2033	94	40:54	1.78	0.18
CDO482	82	41:41	0.00	1.00
MWG3	82	40:42	0.00	1.00
pTAG163	88	49:39	0.92	0.34
OPJ19	54	29:25	0.16	0.69
OPU7	92	47:45	0.00	1.00

*skewed segregation

During the season 1993/94 and 94/95 the lines had been seed increased in unreplicated double rows at Tel Hadya. Several qualitative and quantitative traits were evaluated. Statistical association of traits with molecular markers had been tested by t-test (Table 2.1.18).

Table 2.1.18. Associations between traits and molecular markers as revealed by t-test probabilities in recombinant inbred lines of Tadmor x Wi2291.(Difference = differnce for the trait between Tadmor and Wi2291, significants = P=95%, chromosome = chromosome location of the marker).

Trait chromosome	Difference	Signif.	p r o b e
growth habit 95	-0.29 sp	0.041	MWG5146H
growth habit 95	+0.03 sp	0.045	MWG5335H
growth habit	-0.16 sp	0.036	MWG5146H
plant height 94	-4.43 cm	0.002	MWG5225H
plant height 95	+2.99 cm	0.016	MWG5713H
awns	+0.65	0.036	MWG5335H
SPAD	-1.10	0.039	MWG5335H
SPAD	-1.01	0.028	MWG8822H
SLDW	+1.74g/m2	0.015	MWG8327H
SLDW	+1.65 g/m2	0.021	MWG8367H
SPAD/SLDW	-0.038 g/m2	0.042	MWG8367H
Scald lab 95/2	-0.70sp	0.016	MWG5695H
scald lab 95/1	-0.53sp	0.023	MWG5695H
scald lab 95/1	-0.60 sp	0.014	MWG9753H
scald lab 95/1	+0.64 sp	0.021	OPJ19?
scald lab 95	-0.49sp	0.032	MWG9753H
scald field 95	-0.091sp	0.011	MWG9753H
scald field 95	-0.72sp	0.040	MWG6025H
lodging 95/2	+0.44sp	0.034	MWG5713H
lodging 95/2	-0.48sp	0.049	MWG8505H
lodging 95/1	+0.59sp	0.008	MWG8804H
lodging 95	+0.36sp	0.019	MWG4404H
lodging 95	+0.37sp	0.046	OPJ19?
leaf roll 95	-0.18sp	0.039	MWG6025H
leaf roll 95	-0.18sp	0.035	MWG8804H
ground cover 95	+0.31sp	0.020	MWG9492H
ground cover 95	+0.31sp	0.018	MWG9502H
ground cover	+0.29sp	0.005	MWG9492H
ground cover	+0.28sp	0.007	MWG9502H
vigor	+0-37sp	0.008	MWG9492H
vigor	+0.41sp	0.003	MWG9502H
powdery mildew95	+17.24%	0.003	MWG9753H
powdery mildew	+9.29%	0.032	MWG9753H
days to heading	+1.70d	0.049	MWG9753H

An association had been established for *Powdery mildew* and *Rynchosporium secalis* on the same chromosome with marker MWG975. Associations can be apparent or real.

To establish a genetic linkage, segregation analysis between the molecular markers and the agronomocal traits have to be performed using computer software MAPMAKER/QTL which can be performed as soon as complete genome coverage is obtained.

(A. Sabbagh, V. Mohler, H. Sayed, S. Ceccarelli, S. Grando, H.L. Araus, G. Backes, A. Jahoor, G. Fischbeck and M. Baum)

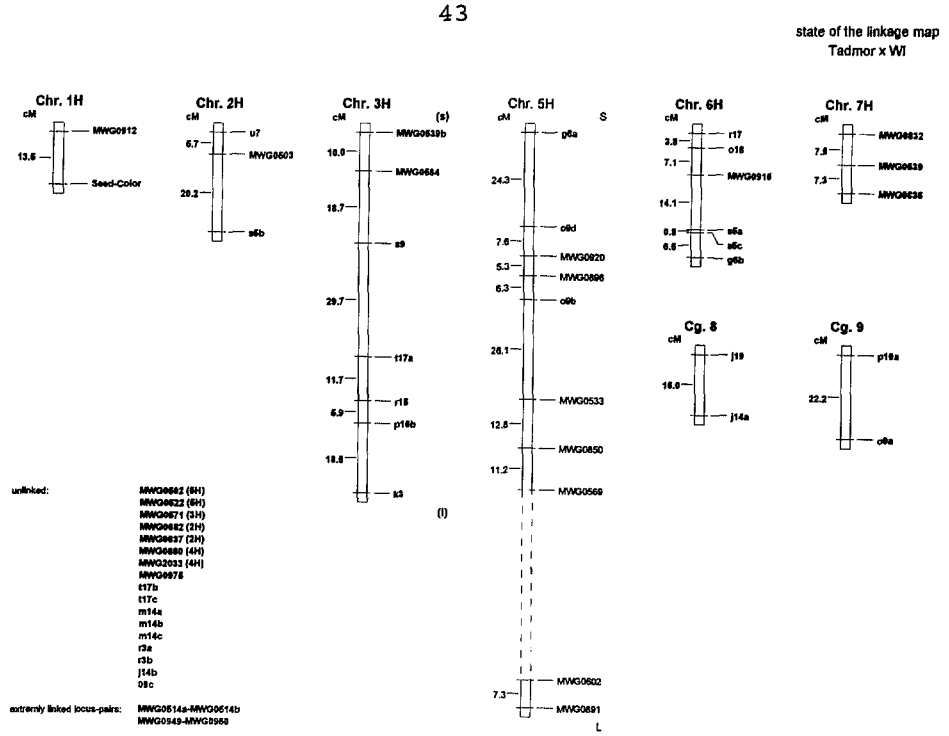

Fig. 2.1.8. Segregation of probe pTAG163 in the F_7 recombinant inbred lines of Tadmor WI2291. The allele indicated by the arrow is segregating for presence and absence of an allele located on chromosome 7H.

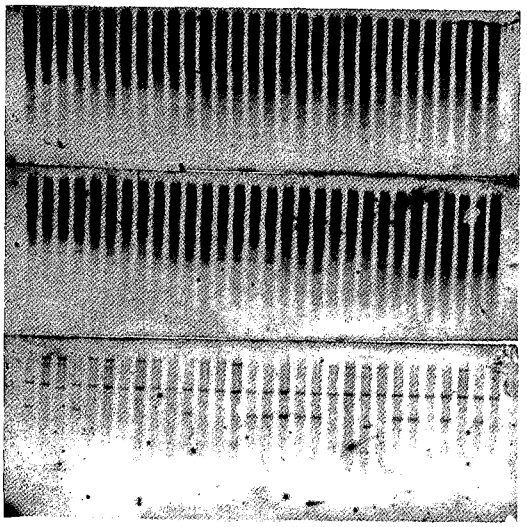

Figure 2.1.9. Preliminary linkage map for the cross Tadmor x Wi2291. For the markers indicated on the map, segregation analysis on 94 recombinat inbred lines had been performed.

2.1.9.3. Screening for Powdery Mildew Resistance

Individual lines of the three North African landraces Martin, Saida and Tichedrett have been screened for powdery mildew resistance using 12 European isolates and their reaction compared to known resistance genes of a differential set. None of the 13 lines tested for each landrace expressed any resistance against those isolates.

(S. Tawkaz, A. Jahoor and M. Baum)

2.1.9.4. Bulk Segregant Analysis for Powdery Mildew Resistance in Barley

In order to develop easy to use PCR markers for the Powdery mildew resistance gene(s) available in the population Tadmor x WI2291, we have conducted bulk segregant analysis. So far, around 200 ten base pair primers (Operon) have been tested on DNA bulks resistant or susceptible for Powdery mildew (see Fig. 2.1.10a and b). Ten resistant and ten susceptibel lines had been selected based on the field infection with Powdery mildew and their DNA had been combined to bulks. So far, two markers were identified which show an additional fragment in the resistant bulk awhich is absent in the susceptibel bulk. It should be possible to identify with this procedure markers linked to the resistance. Marker OPU7 was found to be located in linkage group 2, marker OPJ19 could so far not belocated into a linkage group. More markers will be tested to identify useful markers for the Powdery mildey resistance.

A. Sabbagh and M. Baum

Fig.2.1.10a. Bulk segregant analysis for Powdery mildew resistance in Tadmor Wi2291 recombinant inbred lines. From left to right: Lane 1 susceptible bulk and lane 2 resistant bulk with Primer OPJ12, lane 3,5,7,9,11,13 susceptible, lanes 4,6,8,10,12,14, resistant bulks. Lane 15 susceptible, lane 16 resistant bulk with primer OPJ19.

Fig.2.1.10b. Segregation of OPJ19 in recombinant inbred population (F7) of Tadmor and Wi2291. From right to left: lane 1 = recombinant line No.1, lane 2 = recombinant line No.2

2.1.10. The IAR-ICARDA/NVRSRP collaborative project on barley improvement in Ethiopia.

Barley cultivation and use in Ethiopia is unique in many ways. In no other country the crop is grown in environments so diverse in terms of altitude, rainfall, soils and farming systems. In addition to abiotic stresses, like drought, excess of water, low soil pH and poor soil fertility, there is often a heavy competition with weeds. Barley is affected by a range of diseases and pests. Occurrence of pests and diseases is influenced by climatic conditions and farming systems and differs therefore strongly among barley growing regions and years. Nearly all barley grain is used for human consumption. A variety of dishes and beverages are prepared from barley. In the higher altitudes no other crops than barley can be grown and entire communities depend on it for their subsistence. In lower altitudes with adequate rainfall, barley is grown in rotation with other cereals and with legumes. Barley can be harvested earlier than other cereals and ensures the farmer a supply of food, when grain stocks are dwindling. Because of its drought resistance, barley is the only crop that can be grown in the low rainfall areas in the north of the country and

during the small rainy season in the central highlands.

The variety of growing conditions and uses of the grain has resulted in a large variability of the indigenous barley germplasm. The unique features of Ethiopian barley have been realized since a long time and Ethiopian germplasm has played a prominent part in breeding programs worldwide, especially to improve resistance against diseases and viruses.

The fast population growth in Ethiopia requires a substantial increase of the production of food. So far attempts to introduce new production techniques and improved germplasm have only been successful for the more accessible areas in zones with a relatively high production potential. For most of the barley growing areas farmers still rely on their traditional cultivars, which are grown without or little external inputs. Research on barley is carried by different teams within the Institute of Agricultural Research, but research stations are located in areas that only represent a small part of the barley growing environments. The only way to address all barley growing areas is by moving research from these stations. However, on-farm research is costly, especially in a country like Ethiopia where some of the major barley growing areas are very difficult to reach. The inception of on-farm barley research in Ethiopia has been helped by a special project, financed by the Netherlands Government. The project, started in 1993, concentrates on those barley growing areas that received less attention in the past. Because of the large variability in growing conditions, the work relies largely on local germplasm. Socio-economic studies play an important role in directing barley improvement efforts by describing farming systems in terms of requirements for the barley cultivars and usage of the grain.

2.1.10.1. On-farm test of major barley landraces

These trials were among the most important on-farm activities of the 1994 season. Their objective was to test 'major' barley cultivars from different regions in Ethiopia over contrasting environments.

The lines under testing were divided in two sets: one with early material and the other with later maturing

germplasm. A single source of seed of each andraces was bought from farmers. The lines were placed in either set based on their expected behavior. Next to the local cultivars some improved lines were tested: HB-120 and Beka (a malting barley) in the early set; HB-42, HB-120, Beka, Ardu 12-60B and 3336-20 (the latter two being pure line selections from Arsi landraces) in the late set. The lines were compared to a local check, either the cultivar grown by the farmer on whose land the experiment was planted, or the predominant cultivar in the region. The trials were planted on farmers' fields both without and with fertilizer (41 kg N, 46 kg P_2O_5/ha) as an RCB design with three replications, with the fertilized trial planted next to the unfertilized one. Plot size was 3 m^2 (6 rows of 2.5 m with a row distance of 0.2 m) of which 2 m^2 was harvested. Soil preparation was first done by the farmer using the local plow ('Maresha'), drawn by two oxen. After this a finer seed bed was made using hoes and other hand-held implements. Seed was sown by hand in rows made by a rake. Apart from yield data, records were taken on disease development and other characteristics. Neighboring farmers were invited to evaluate the lines under testing, which led to interesting discussions on barley cultivation and rotation patterns. In different sites farmers were interested in new germplasm and in inputs like fertilizer, herbicides and pesticides. Often farmers were complaining about price and availability of fertilizer.

A highly significant effect of the fertilizer application was found in most locations, showing the poor fertility of barley growing areas (Tables 2.1.19 and 2.1.20).

Table 2.1.19. On-Farm Cultivar Trial - Early Set 1994, grain yield (kg /ha) in 16 locations with and without fertilizer. Average yield (Avg), highest yielding entry (and entry number) of the 12 test entries, yield of the check. Least Significant Difference between cultivars at 5% probability (LSD) from ANOV per location and per fertilizer treatment. Summary of the Analysis of Variance per location combined over fertilizer treatments: P-values for fertilizer effect (P-f), for cultivar effect (P-c) and for their interaction (P-fc).

	Unfertilized					Fertilized					Combined		
	Avg	Highest		Check	LSD	Avg	Highest		Check	LSD	P-f	P-c	P-fc
Tigray													
Aynalem	812	1305	(2)	1705	319	1699	2340	(8)	2957	786	0.00	0.00	0.29
Astbi	1517	2030	(7)	1995	598	2395	2997	(6)	2568	ns	0.00	0.01	0.80
Ganta Afeshun	595	1067	(7)	972	ns	3533	4713	(6)	4697	1376	0.00	0.00	0.08
Korem	1818	2553	(7)	2507	963	4183	6313	(6)	6045	2218	0.00	0.00	0.21
Wello													
Kabbe	585	782	(3)	758	ns	875	1206	(6)	870	ns	0.06	0.43	0.80
Kutaber	1232	1774	(10)	1794	ns	1762	2336	(10)	2623	835	0.35	0.00	0.80
Kone Abo	233	357	(1)	138	ns	972	1280	(12)	576	480	0.00	0.00	0.03
Chira Wuha	346	550	(12)	187	ns	611	1039	(8)	530	ns	0.20	0.16	0.80
Gojam & Gonder													
Adet	1387	2015	(7)	1830	ns	2430	2792	(12)	1803	639	0.00	0.03	0.09
Farta	1120	1686	(12)	1634	461	1674	2606	(12)	2677	565	0.01	0.00	0.34
Injibara	160	255	(4)	326	116	332	586	(5)	577	99	0.00	0.00	0.00
Shewa													
Holetta	2198	2644	(7)	2346	ns	3560	4480	(9)	3270	ns	0.00	0.19	0.31
Degem	801	1663	(1)	1256	514	1406	2546	(1)	1602	437	0.00	0.00	0.80
Bale													
Sinana	1903	3207	(10)	3240	892	1872	2660	(2)	2772	909	0.80	0.00	0.40
Gasera	2186	3337	(7)	3603	820	2558	3393	(9)	2443	1115	0.33	0.00	0.03
Wellega													
Shambu	3322	4978	(4)	2444	ns	4032	5244	(12)	3756	1338	0.27	0.00	0.12

Table 2.1.20. On-Farm Cultivar Trial - Late Set 1994, grain yield (kg /ha) in 12 locations with and without fertilizer. Average yield (Avg), highest yielding entry (and entry number) of the 14 test entries, yield of the check. Least Significant Difference between cultivars at 5% probability (LSD) from ANOVA per location and per fertilizer treatment. Summary of the Analysis of Variance per location combined over fertilizer treatments: P-values for fertilizer effect (P-f), for cultivar effect (P-c) and for their interaction (P-fc).

	Unfertilized					Fertilized					Combined		
Location	Avg	Highest		Check	LSD	Avg	Highest		Check	LSD	P-f	P-c	P-fc
west Shewa													
Holetta	1592	2237	(12)	2241	576	3329	4483	(14)	3662	683	0.00	0.00	0.00
Menagesha	2486	3222	(12)	3046	ns	2226	3041	(14)	1875	950	0.80	0.05	0.21
Rob-Gebeya	320	778	(1)	352	184	1079	1493	(11)	1065	432	0.00	0.00	0.01
Altufa	3315	3940	(14)	4643	989	5038	6971	(12)	4288	ns	0.03	0.34	0.00
north Shewa													
Angolola	467	910	(12)	607	337	1097	1675	(13)	1241	ns	0.00	0.02	0.14
Faji	701	1133	(12)	740	490	1405	2077	(5)	1218	ns	0.01	0.25	0.07
south Region													
Hosaina	947	1943	(3)	1000	385	3360	4067	(7)	3512	685	0.00	0.00	0.06
south Gondar													
Gayint	1440	1727	(6)	1301	ns	2027	2767	(6)	2359	ns	0.01	0.05	0.17
Bale													
Dinsho	1567	2280	(7)	1568	491	2784	3357	(7)	2175	ns	0.80	0.00	0.80
Gassera	1381	2352	(10)	2472	824	1557	2378	(3)	2970	866	0.02	0.00	0.80
Borena													
Bore	1187	1722	(14)	1222	726	3174	4277	(6)	3500	ns	0.00	0.01	0.80

Significant yield differences among cultivars were present in a number of locations, but the local check was rarely out-yielded by any of the other entries. A significant fertilizer treatment x cultivar effect was only found in a few sites. This indicates that the response of unselected Ethiopian landraces to a moderate level of fertilization is similar to that of improved cultivars.

Because of the lack of interaction in most locations the performance of the different cultivars per location is presented averaged over fertilizer treatments (Tables 2.1.21 and 2.1.22). Only few sites showed a correlation in the performance of the different entries, showing the wide variability of growing conditions. Although local checks were generally performing well, some landraces performed well outside their region of origin. This was also shown in earlier selection work where lines extracted from Arsi landraces performed outstandingly in the central highlands. The tested material represented only a very small faction of the Ethiopian germplasm. Ethiopian farmers differentiate among groups of landraces by names that reflect the production system (Belg barley, Belga barley), the end-use of the grain (Senef Kolo), or a clearly distinguishable characteristic (white barley, black barley, naked barley). Within these landrace groups a wide variability is present. Our future efforts will concentrate on identifying superior sources within these groups through on-farm testing in the areas of origin. Afterwards these lines can be tested in different areas with a similar ecology.

2.1.10.2. Yield losses caused by diseases on farmers' fields

Studies on losses due to scald and net blotch have been carried out over the years at Holetta Research Center. Abiotic stress factors influence disease development and the effect of diseases on yield. Moreover,t is well possible that the highly heterogenous Ethiopian landraces provide a natural buffer to disease development and compensate for losses. Crop loss studies in a experiment station are therefore of limited value, especially if highly susceptible lines are used.

Table 2.1.21. On-Farm Cultivar Trial - Early Set 1994. Grain yield (t/ha) of 13 cultivars in 16 locations averaged over with and without fertilizer.

			Tigray				Wello				Gojam			Shewa		Bale		Well	
No	Name	Origin	Ayn	Ast	Gan	Kor	Kab	Kut	Kon	Chi	Ade	Far	Inj	Hol	Deg	Sin	Gas	Sha	Mean
1	Semereta	w-Shewa	0.8	1.5	1.3	2.9	0.7	1.1	0.8	0.5	1.5	1.3	0.1	2.8	2.1	1.7	1.5	4.0	1.5
2	Tebel	s-Gonder	1.7	1.5	2.2	3.2	0.6	1.4	0.5	0.6	2.1	1.1	0.3	2.8	0.9	2.5	2.3	3.6	1.7
3	Belga	n-Gonder	1.4	2.1	1.8	2.7	0.9	1.3	0.6	0.5	1.8	0.9	0.4	2.4	1.0	1.5	2.2	3.2	1.5
4	Shasho/Kinchiko	Bale	1.6	2.1	2.4	3.7	0.7	1.7	0.7	0.5	2.0	1.5	0.4	2.4	1.0	1.9	2.7	4.6	1.9
5	Aruso$-$Bale	Bale	1.5	2.2	2.5	2.5	0.8	1.3	0.5	0.6	2.0	1.2	0.4	2.8	0.9	2.5	2.8	3.3	1.7
6	Demoyie	n-Shewa	1.5	2.2	2.8	4.1	0.9	1.4	0.7	0.4	1.7	1.5	0.1	2.9	0.8	1.3	2.4	3.7	1.8
7	Somie	e-Gojam	1.4	2.2	2.4	4.1	0.6	1.9	0.8	0.7	2.4	1.4	0.4	3.2	1.1	2.5	3.3	4.5	2.1
8	Ehilzer	s_Wello	1.6	2.0	1.7	2.5	0.7	1.7	0.7	0.7	1.6	1.1	0.3	2.6	0.7	1.2	2.5	4.2	1.6
9	Kessele	Bale	1.1	2.4	2.4	2.9	0.9	1.2	0.7	0.4	2.1	1.5	0.2	3.4	1.1	1.7	2.5	4.2	1.8
10	HB-120	-	1.1	2.1	2.4	2.4	0.7	2.1	0.3	1.8	0.8	1.5	0.2	2.8	1.0	2.7	2.6	2.5	1.6
11	Beka	-	0.4	1.2	1.4	1.9	0.5	1.3	0.2	0.2	1.8	1.7	0.2	2.9	0.9	2.1	2.1	2.2	1.3
12	Aybo gebs	s-Wello	0.9	2.0	1.3	3.1	0.7	1.7	0.7	0.5	2.2	2.1	0.1	3.5	1.8	0.9	1.7	4.0	1.7
13	Local check	-	2.3	2.3	2.8	4.3	0.8	2.2	0.4	0.4	1.8	2.2	0.5	2.8	1.4	3.0	3.0	3.1	2.1
	Average		1.3	2.0	2.1	3.1	0.7	1.6	0.6	0.5	1.9	1.5	0.3	2.9	1.1	2.0	2.4	3.6	1.7

Table 2.1.22. On-Farm Cultivar Trial - Late Set 1994. Grain yield (t/ha) of 15 cultivars in 11 locations averaged over with and without fertilizer.

			west Shewa				northShewa		s-Region	s-Gondar	Bale		Borena	
No	Name	Origin	Hol	Men	Rob	Alt	Ang	Faj	Hos	Gay	Din	Gas	Bore	Mean
1	Baleme	w_Shewa	2.2	2.7	1.0	4.4	0.9	1.2	2.2	1.5	2.1	0.9	2.3	2.0
2	Magie	n-Shewa	2.0	1.9	0.7	3.8	0.9	0.9	2.5	1.8	2.2	1.0	1.3	1.7
3	Semereta	w-Shewa	2.4	2.2	0.8	4.0	0.8	1.1	2.8	1.8	2.4	2.3	2.4	2.1
4	Awra gebs	n-Gonder	1.9	2.4	0.6	3.8	0.9	1.1	2.4	1.5	2.1	0.7	1.2	1.7
5	Muga	Arsi	2.2	2.3	0.6	4.1	0.8	1.3	2.1	1.6	2.1	0.9	2.0	1.8
6	HB 42		2.9	2.7	0.7	4.2	0.7	1.0	2.1	2.2	2.5	1.8	3.0	2.1
7	Ardu 12-60B		2.2	1.9	0.5	4.2	0.8	0.7	2.5	2.0	2.8	1.3	2.6	2.0
8	HB 120		2.6	2.0	0.7	3.5	0.9	1.2	1.8	1.6	1.7	1.8	2.0	1.8
9	Beka		2.8	2.0	0.6	4.0	0.6	0.8	1.5	1.8	1.8	1.3	2.6	1.8
10	3336-20		2.3	2.4	0.6	4.2	0.4	1.0	1.8	1.7	2.4	2.3	2.5	2.0
11	Senef kole	w-Shewa	2.8	2.9	0.9	4.6	0.5	1.0	2.6	1.5	1.9	1.6	1.7	2.0
12	Luyita	e-Gojam	2.6	3.0	0.8	4.9	0.9	1.2	2.8	1.7	2.0	2.0	2.5	2.2
13	Dimbulo	e-Gojam	2.2	1.7	0.5	4.0	1.2	1.2	1.9	1.8	2.1	0.7	1.7	1.7
14	Mirtzer	Arsi	3.2	2.8	0.7	4.7	0.7	1.1	2.2	1.7	2.3	1.9	2.7	2.2
15	Local check		3.0	2.5	0.7	4.5	0.9	1.0	2.3	1.8	1.9	2.7	2.4	2.1
	Average		2.5	2.4	0.7	4.2	0.8	1.0	2.2	1.7	2.2	1.6	2.2	2.0

Table 2.1.23. Effect of fungicide spray on yield and yield components in demonstration trials, comparing local with improved farmer's practices.

	Heads / m				Thousand kernel weight				Yield (gram) / m^2			
	local		improved		local		improved		local		improved	
Location	uns	spr	uns	spr	uns	spr	uns	spr	uns	spr	uns	spr
Welmela	205	216	171	222	38.5	44.8 *	50.0	51.0	165	186	201	315
Rob g. (1)	204	258	106	150	47.8	49.8	50.3	53.3 +	122	160	137	219 +
Rob g. (2)	122	180	139	164	42.0	40.8 +	53.7	54.3	143	194	254	273
Rob g. (3)	134	189	213	180 *	37.7	44.3 **	53.3	57.0 *	258	334	360	382
Degem (1)	211	197	168	214	47.7	50.2 +	49.2	51.0	178	173	225	289
Degem (2)	72	65	150	144	46.7	43.0 *	53.8	52.8	107	114	301	300
Degem (3)	174	102 +	143	133	33.2	39.0	48.7	50.7	51	52	186	213
Average	161	172	156	173	41.9	44.6	51.3	52.9	146	173	238	284

\+ Significant difference within location and farming practice at P= 0.1
* Significant difference within location and farming practice at P= 0.05
** Significant difference within location and farming practice at P= 0.01

During the 1994 season an attempt was made to quantify losses on farmers' fields, using demonstration trials in seven different sites. Demonstration trials are established by the Extension Division to compare improved cultivation practices with traditional ones. The improved practice consisted of an improved cultivar (HB-42), fertilizer and weed control. Plots of 10 x 10 m in each practice were protected against leaf diseases by repeated fungicide sprays (Sportak and Tilt). Yield and yield components were measured on three quadrats of 1 m^2 per treatment. The sprays resulted in a significant increase of yield (18% for local, 19% for improved practices), kernel weight (6% for local, 3% for improved) and number of heads/m^2 (7% for local, 11% for improved) averaged over locations (Table 2.1.23). There was no difference between the effect of the spray on plots under improved farming practices and on those with traditional practices and the local cultivar. The experimental error was too high to detect but large differences in the individual locations. Kernel weight was significantly increased by the fungicide spray on the local cultivar in three locations, but significantly decreased in two other locations. The rather large effect of the fungicide spray on the number of heads / m^2, could be an indication that leaf diseases can affect the development of the plant in an early stage.

H. Gebre, B. Bekele and J. van Leur

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2.2. WINTER AND FACULTATIVE BARLEY

Winter and facultative (WF) barleys are cultivated all over the world for a variety of uses and under a wide range of environments. In the major parts of the developing countries, WF barley is grown in the continental environments of WANA (highland) and Central Asia, due to its better adaptation and high yield under low rainfall and harsh environmental conditions. It plays a vital role in the cereal (barley & wheat)-livestock-pastoral system of farming by providing food to the small resource poor farmers and feed to their animals. The diversity of environments encompasses with it a host of complex and recurring problems which reduce the productivity of barley. To ensure a sustainable and stable barley production in optimum manner without damaging the resource base, the objectives of the WF barley improvement project are:

a) resistance to environmental stresses such as drought, cold, heat and mineral deficiencies or toxicities;
b) resistance to diseases (scald, powdery mildew, leaf stripe, and smut);
c) increase grain, forage and straw yield and quality;
d) enhance the technical competence of NARS scientists.

To achieve these objectives a decentralized approach in close collaboration with NARS has been followed.

2.2.1. Expansion of the Genetic Base and Germplasm Enhancement

756 new accessions, mainly originating from NARS of WANA were evaluated for a number of agronomic traits and 507 lines/varieties were selected for further evaluation and use in germplasm development.

To increase the genetic tolerance to biotic and abiotic stresses 840 new F_1's were produced for the introgression of desirable gene(s) into locally adapted germplasm. The germplasm development activities were carried out at a number locations. In total 7752 segregating populations were

evaluated for drought, cold and disease resistance (Table 2.2.1.).

Table 2.2.1. WF Germplasm Development during 1994-95.

Nursery	Number Total	Number Selected	Testing site
F1	840	715	Tel Hadya
F2	675	610	Breda, Tel Hadya, Turkey
F3	397	385	Tel Hadya, Breda, Turkey, Iran
F4	210	2600	Tel Hadya, Breda
F5	325	3290	Tel Hadya, Breda
M3	6145	1525	Tel Hadya, Breda
Elite	1433	1130	Tel Hadya, Breda
PBSN	835	645	Turkey, Breda, Tel Hadya
WFBYT	24	24	Turkey, Iran, Tel Hadya, Breda, Terbol
FBYT	24	24	-do-
WFBON	150	111	-do-
FBON	150	107	-do-
Hull-less BON	30	25	-do-
WFBCB	210	85+78*	-do-
Exotic Germplasm	211	155+(325)	Tel Hadya

( ) Selected out of GRU evaluation plots
* Selected from other material and added into new CB.

From F_2 and F_3 the selected populations were bulked whereas out of the selected F_4 and F_5 populations single heads (6~18 heads per population) were collected to raise head rows. The number of lines selected out of other nurseries is also given in Table 2.2.1.

2.2.2. Vernalization and Photoperiod

In view of the diverse needs of different NARS, the efforts to characterize the new germplasm on the basis of growth habit (vernalization and photoperiod response) were continued. In total 1055 lines/accessions were classified on

a growth habit gradient of 1 (spring type-no vernalization required) to 5 (pure winter types-with strong vernalization requirement). The check varieties: Tokak, Bulbul, Salmas, and Rihane-03 were scored 4, 5, 3 and 1, respectively, whereas Arabic Abiad was 3 on growth habit scale. Most of the newly developed germplasm and lines of Turkish origin were observed to be of winter type (Table 2.2.2.). On the basis of this evaluation the material was grouped into winter (55%), facultative (35%) and spring (10%) types.

Table 2.2.2. Classification of barley germplasm for growth habit based on vernalization response.

Nursery	Total Entries	Growth Habit				
		1	2	3	4	5
Selected Germplasm (GRU)	484	102	7	28	9	340
WBF6	187	12	4	7	14	150
BOT	78	30	2	2	8	36
Turkish Lines	125	23	1	15	8	78
Elite Lines	60	5	1	11	20	22
Hull-lesS	61	23	0	7	3	28
WBSN	60	8	0	2	0	50
Checks						
Tokak					*	
Bulbul						*
Salmas				*		
Rihane		*				
Arabi Abiad				*		

Special attention was paid to select a few super-early spring type lines which do not carry vernal genes and are day neutral. Some of these lines will be tested for spring planting in Eastern Turkey and Western Iran where winter is too severe and causes major cold/winter kill.

This classification has been very useful in the formulation of international nurseries for each target environment and avoiding sending non adapted germplasm to the NARS. As a result, this strategy has helped NARS in saving their limited resources and at the same time has increased selection efficiency of desirable germplasm.

2.2.2.1. Heat Tolerance

1055 lines/accessions including advanced breeding lines and exotic germplasm from NARS, were planted in early July at Tel Hadya to screen for tolerance to high temperatures. The heat tolerance nursery was irrigated at one week intervals to avoid drought effect. The observations were recorded on a scale of leaf damage of 1 (no damage) to 5 (extensive damage). 296 lines were found to be resistant, 297 moderately resistant, 417 moderately susceptible and 45 susceptible. Interestingly more than 65% of the winter types were found to be resistant or moderately resistant where as many as 65% of the spring types were moderately to highly susceptible. This may be due to their early maturity which during the normal growing avoids exposure to high temperature.

(M. Tahir)

2.2.3. Evaluation for Cold Tolerance

2.2.3.1. Turkey

The WF barley breeding material developed at ICARDA is routinely evaluated at various testing sites in Turkey for cold tolerance and specific adaptation in collaboration with the Turkish national program. In 1994/95, a total of 2372 entries of segregating populations and advanced materials were tested (Table 2.2.3). All materials were tested at Kazan, while some materials were also tested at Haymana, Ulas, Malya, and some other sites. From the 397 segregating populations, 163 populations (or 40%) were selected. In contrast, only 18% of the more advanced materials was selected.

2.2.3.2. Russia

Some of the WF barley materials developed at ICARDA are also evaluated for cold tolerance at Krasnodar, Russia, in collaboration with the Russian scientists.

Table 2.2.3. Evaluation and selection for cold tolerance and specific adaptation in Turkey.

Nursery	No. of entries	Testing sites	No. selected
Seg. Pop.	397	Kazan	163
IWFBCB	149	Kazan	39
PBSN	835	Kazan	105
PBYT	389	Haymana, Kazan, Ulas, Altinova, Konya, Eskirsehir, Ederne, Erzurum, Izmir, Samsum, & Diyarbakir	80
EBL	183	Kazan	32
5th IWFBON	150	Kazan	43
2nd IFBON	150	Kazan	39
Hulless	30	Kazan	0
4th IWFBYT	24	Haymana, Kazan, Ulas & Malya	4
2nd IFBYT	24	Haymana & Ulas	0
BHEAYT	24	Haymana, Kazan, Ulas & Malya	4

Table 2.2.4. Performance of the selected ICARDA winter barley lines at Krasnodar, Russia.

Name/cross	CT	PH (cm)	Disease resistance			Grain yield (kg/ha)
			PM	NB	ES	
Kozir	8[1]	105	6[1]	7[1]	7[1]	8020
Lignee 131	7	110	7	6	5	7380
Roho/Masurka ...	7	110	6	5	7	6910
NY 6005-18/OWB ..	8	95	5	8	5	7460
Dicto-MS/WA...	7	105	7	6	6	7360
Sonya//1658/Emir	7	115	5	3	7	6510
Robur/WA 2196	7	105	3	4	7	6490
Xemus	7	100	7	8	2	7160
Scio/3/CI/72AB...	8	110	3	8	3	6530
ZDM 8265	9	90	1	1	8	4460
Alpha/Dura//Antares	8	110	4	2	7	6820
Vavilon (check)	8	105	6	5	7	7420
LSD(0.05)						420

CT=cold tolerance, PH=plant height, PM=powdery mildew, NB=net blotch, and ES=eye spot.
[1] 1-9 scale, 1=poor, 9=excellent

Table 2.2.4 shows the performance of some cold tolerant lines selected there. The variety 'Kozir' had significantly higher yield than the local check, Vavilon, and had good resistance to powdery mildew, net blotch and eye spot. The Chinese accession 'ZDM 8265' had excellent cold tolerance and

resistance to eye spot, but had poor yield and high susceptibility to powdery mildew and net blotch. Some of the ICARDA developed lines also performed well.

2.2.4. Breeding for Disease Resistance

The barley productivity is greatly influenced by a number of diseases in the continental mediterranean environments. To improve the germplasm for disease resistance, the segregating populations are planted at hot spot locations in WANA for field evaluation under natural conditions. The advanced lines are tested under controlled, artificial epiphytotic conditions. Four nurseries, i.e. Winter Barley Yield Trial (WFBYT), Facultative Barley Yield Trial (FBYT) Winter Barley Observation Nursery (WFBON) and Facultative Barley Observation Nursery, were evaluated against scald, powdery mildew and covered smut. The scale used to select lines/varieties for resistance to these diseases was 0-10% infection for scald, less than 10% infection for powdery mildew and covered smut.

Table 2.2.5. Breeding for disease Resistance.

Nursery	Entries	No. Selected for resistance to			
		Scald (1)	PM (2)	CS (3)	1 + 2 + 3
WFBYT	24	7	15	21	4
FBYT	24	6	15	22	3
WFBON	150	83	110	NA	57
FBON	150	74	103	NA	50

1. scald: 0-10=R, 11-20=MR; 21-30=MS; > 30=S: the average score for the checks Tokak and Rihane-03 was 10.5 and 70%, respectively.
2. powdery mildew (PM): the average score for Tokak & Rihane-03 was 33.5 and 0.4%, respectively.
3. covered smut (CS): the average score for checks Tokak and Rihane-03 was 3.0 & 0.0% respectively.

The number of lines resistant to each disease as well as with multiple disease resistance is given in Table 2.2.5. From these data it is clear that the great majority of lines were resistant to one or the other disease. It is also clear that the number of lines with multiple disease resistance is

much higher in the new germplasm, i.e., observation nurseries as compared to the material developed earlier indicating that strategy to develop WF barley germplasm with multiple disease resistance is effective.

The most advanced lines were also provided to the NARS in the form of yield trials. Six lines with multiple disease resistance identified out of the two yield trials under artificial infection are listed in Table 2.2.6. From the data it is obvious that these six lines are highly resistant to scald, powdery mildew and covered smut as compared to the widely grown winter cultivar Tokak and the spring type Rihane-03, used as checks.

Table 2.2.6. Multiple disease resistant lines.

Lines	Source	Infection score (%)		
		Scald	PM*	CS**
1. ICB102998/3/Alger/Ceres...	WFBYT95-5	5.5	1.0	3.0
2. Lignee131/5/Cq/Cm/Apm...	WFBYT95-8	0.5	1.0	5.0
3. Rihane/Lignee640//ICB107766	WFBYT95-16	1.0	10.0	0.0
4. Yea 389.3/Yea 475.4	WFBYT95-20	0.0	3.0	0.0
5. Salmas*2/3/Vg/Julia//Zy	FBYT95-2	0.0	0.5	0.0
6. Alfa/Durra	FBYT95-19	1.0	0.0	2.0
Checks				
Tokak		10.5	33.5	3.0
Rihane 03		70.0	0.4	0.0

* PM : Powdery Mildew; CS** : Covered Smut.

To increase disease resistance and incorporate tolerant gene(s) in the new germplasm, efforts are made to include locally adapted germplasm from target environment in the hybridization and genetic manipulation activities. All the resistant lines, except Alfa/Durra, had locally adapted germplasm in their parentage.

(O.F. Mamluk and M. Tahir)

2.2.5. Screening for Barley Yellow Dwarf Virus (BYDV)

The incidence of BYDV infection on WF barley has increased during the last few years. Therefore, 92 lines/varieties of barely were evaluated during summer at Terbol where BYDV

occurred in epidemic form, along with three checks (Tokak, Zarjou and Rihane-03). On the basis of infection (%) the lines were classified as follow:

Resistant (<10%);	27 lines
Moderately resistant (10-20%):	27 lines
Moderately susceptible (21-30%):	11 lines
Susceptible (31-50%):	19 lines
Very susceptible >(51-100%):	8 lines

Tokak was classified as resistant and Zarjou and Rihane-03 were classified as moderately resistant.

The selected resistant lines are being employed in the hybridization program to develop new germplasm resistant to BYDV.

2.2.6. Variability and Relationship between Morpho-phenological Traits in Barley under Stress Environments

Association between different traits within and among environments provide useful information how how these could affect the crop response under the testing environments. Cold, drought and high temperature are the major abiotic stresses in the continental Mediterranean areas which adversely affect barley yields. To develop high yielding and resistant material to various biotic and abiotic stresses of WF barley the initial screening of breeding material is conducted at Tel Hadya and Breda. Early generations and advanced lines are sent to the NARS for testing in the target environments. It is always desirable to have information on the relationship between yield and yield components in different environments. The morpho-phenological traits associated with yield under stress can then be used to increase selection efficiency.

Two sets of experiments i.e. Winter Barley Yield Trial (WBYT) and Facultative Barley Yield Trial (FBYT), each with 24 entries were planted at Tel Hadya and Breda in a randomized complete bloc design with three replications and plot size of 4 meter square (8 rows, 2.5 m long with 0.2 m row to row distance). The data were collected for the following traits: Growth Habit (GH) using a visual score of

1 (erect, spring types) to 5 (prostrate winter type), Plant Height (PH), Days to Heading (DH), Days to Maturity (DM), Grain Filling Period, i.e. Number of days from heading to maturity (GFP); and Grain Yield (GY) in kg/ha.

Table 2.2.7. Range, Means, Standard deviations (SD), Standard error (SE) and Coefficient of variation (CV) for winter and facultative barleys at Tel Hadya during 1994-95.

Character		Range	Mean	SD	SE	CV (%)
Grain yield	W	3667-7500	5181.5	729.1	85.9	12.4
(Kg/ha)	F	3667-7233	5504.1	783.8	92.4	13.5
Plant height	W	50-90	70.1**	7.7	0.9	6.3
(cm)	F	60-100	78.4**	9.2	1.1	9.4
Days to heading	W	113-132	122.7**	4.9	0.6	1.4
	F	112-139	122.8**	5.6	0.6	1.9
Days to maturity	W	149-174	159.4**	7.0	0.8	2.6
	F	149-175	160.5**	7.7	0.9	2.3
Grain filling	W	25-49	36.7**	5.8	0.7	11.5
period	F	25-49	37.7**	5.1	0.6	11.2
Growth habit	W	2-5	3.5**	0.7	0.1	9.8
	F	2-4	3.1**	0.7	0.1	12.1

** Means significantly different at the 1% level
W = WBYT
F = FBYT

The range, mean, standard deviation, standard error and coefficient of variation for different traits of winter and facultative barley genotypes are presented in Table 2.2.7. A significant variation was found for all the traits. Genetic variation in plant height, grain filling period, growth habit, days to heading and maturity in the material tested indicate more selection opportunities and hence, suitability of the material for diverse environments in WANA region.

Mean grain yield of five top yielding lines/varieties from winter barley yield trial (WBYT) and facultative barley yield trial (FBYT) at Tel Hadya and Breda is given in Table 2.2.8. Drought and high temperatures were the major stresses during 1994-95. The total precipitation from September to June was 312.9 mm at Tel Hadya as compared with 373 mm during 1993-94 crop season. Total rainfall at Breda was also about 50 mm less as compared to last year. Absolute maximum temperature during the month of May, grain filling period,

went up to 41.8 °C and 41.6 °C at Tel Hadya and Breda, respectively. In spite of the severe drought and high temperatures, high yielding genotypes were identified from winter and facultative material which produced about 6000 kg/ha average yield at Tel Hadya and 3000 to 4000 kg/ha at Breda, which shows adaptation of the material under stress conditions.

Table 2.2.8. Mean grain yield of five top yielding lines/varieties from WBYT and FBYT at Tel Hadya and Breda during 1994-95.

Line/variety	GH	Grain yield (Kg/ha)
Tel Hadya		
1. Roho/Mazurka/ICB-103020	3	6355
2. Rihane-03	2	6344
3. CAB 117-77-9-7/ICB-102893	4	6111
4. ICB-105981/5/Pitayo/Cam/Avt/~	4	6011
5. YEA 932/YEA 557.6	5	5966
Breda		
1.Rihane 03	2	3988
2.Lignee 131/5/Cq/Cm//Apm/3/12410/4/~	3	3788
3.Roho/Mazurka//ICB 103020	3	3722
4.ICB-101719/ICB-105932	3	3277
5.Rihane/Lignee 640//ICB 102854	3	3188

At Breda, most of the high yielding genotypes, however, were with the growth habit of 2-3. Facultative types, therefore, were more productive under these two environments. The genotypes with strong vernal gene(s) were lower yielding than spring and facultative types due to their longer growth period.

2.2.7. Relationship between Morpho-phenological Traits

The magnitude of relationship among different characteristics in winter and facultative types was almost similar (Tables 2.2.9 and 2.2.10). A significant positive correlation was found between plant height and yield at both locations. There was, however, significant negative correlation between grain yield and days to heading and maturity indicating that tall and early lines performed better under semi-arid conditions in northern Syria and that lines with strong vernalization requirement and long growth period can suffer badly due to moisture stress and high temperature during grain filling.

Table 2.2.9. Correlation coefficients between traits in WBYT and FBYT lines at Tel Hadya during 1994-95.

		2	3	4	5	6
1. DH	W	0.575**	0.072	-0.142	0.661**	-0.201
	F	0.749**	0.037	0.094	0.372**	-0.231*
2. DM	W		0.134	0.729**	0.475**	0.057
	F		0.156	0.718**	0.367**	-0.045
3. PH	W			0.102	-0.044	0.361**
	F			0.217	-0.205	0.318**
4. GFP	W				0.021	0.237*
	F				0.187	0.164
5. GH	W					-0.158
	F					-0.033
6. GY	W					-
	F					-

*,** Significant at the 5% and 1% level, respectively.
W = winter barley yield trial (WBYT)
F = facultative barley yield trial (FBYT)
DH days to heading, DM days to maturity, PH plant height, GFP grain filling period, GH growth habit, GY grain yield.

A negative association was found between growth habit and yield at both locations. Careful interpretation needs to be made regarding this trait. The positive and significant association of growth habit under cold stress and the negative significant association of this trait under drought and terminal heat conditions can be attributed to the degree of vernalization requirements of the genotypes. Since the winter was mild at both locations during 1994-95 and drought and high temperatures were the main stresses, the winter types with longer period to heading and maturity suffered the

most. Testing the material under different environments is extremely important to observe the variable response of genotypes under those conditions.

Table 2.2.10. Correlation coefficients between traits in WBYT and FBYT lines at Breda during 1994-95.

		2	3	4	5	6
1. DH	W	0.775**	0.072	-0.142	0.661**	-0.201
	F	0.749**	0.037	0.094	0.372**	-0.231*
2. DM	W		0.134	0.729**	0.475**	0.057
	F		0.156	0.718**	0.367**	-0.045
3. PH	W			0.102	-0.044	0.361**
	F			0.217	-0.205	0.318**
4. GFP	W				0.021	0.237*
	F				0.187	0.164
5. GH	W					-0.158
	F					-0.033
6. GY	W					-
	F					-

*,** Significant at the 5% and 1% level, respectively.
W = winter barley yield trial (WBYT)
F = facultative barley yield trial (FBYT)
DH = days to heading, DM = days to maturity, PH = plant height, GFP = grain filling period, GH = growth habit, GY = grain yield.

Therefore, winter and facultative barley breeding project at ICARDA uses testing sites with different biotic and abiotic stresses prevalent in the region to ensure differentiation for response to stresses among germplasm and develop improved germplasm specifically adapted to those environments. Major sites for screening to cold tolerance are used in Turkey, and Iran; whereas Krasnodar-Russia is used to develop cold tolerant, high yielding germplasm.

2.2.8. Performance of Forage Barley Germplasm

The forage barley germplasm, like the feed barley germplasm, is categorized into spring, facultative and winter types, before evaluation for forage and grain production. In the continental mediterranean environment the predominantly grown cultivars are either winter or facultative types. Two separate experiments with 44 entries each, including the checks, were carried out to evaluate their forage and grain yield production potential at Tel Hadya. The forage yield was taken by clipping before heading. The ratoon crop was also harvested to identify lines which can be used as dual purpose (forage plus grain). Data were recorded on growth habit (1 = spring; 5 = winter type), days to heading and maturity, green forage yield, crude protein (%), acid detergent fiber (%ADF) and Neutral Detergent Fiber (%NDF), total dry biomass, grain yield (unclipped) and the grain yield of the ratoon crop.

a) Facultative Barley

The data of the top 10 forage yielding lines out of the 44 entries along with two check cultivars (Tokak and Arta) are presented in Table 2.2.11. All the top forage yielding lines except two were significantly earlier than the winter type check variety Tokak, whereas only one line was later in maturity as compared to Arta. Though no significant differences in plant height were observed in these lines as compared to Tokak (except line Rihane 3/Rihane 08, which was significantly taller than all the entries) all the lines gave significantly higher forage yield than the check varieties Tokak and Arta. The forage yield ranged from 11,595 kg/ha to 15,840 kg/ha indicating major genetic differences in forage production. Seven out of these 10 lines gave significantly higher grain yield as compared to Tokak. Generally all these high forage producing lines also have high total biomass except one line i.e., ICB 100709/Rihane 03.

In all these high forage producing lines the grain yield from the ratoon crop was very small. In earlier

studies[2] reductions in yield and yield components after grazing and clipping during winter were reported, and it was shown that winter defoliation did not affect grain yield but reduced lodging[3].

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[2]Hadjichristodoulou, A.,, 1991. Dual purpose barley. Rachis 10:13-16.

[3]Kang, Y.K. and Kang, H.S., 1991. Effect of cutting on forage production and grain yield of naked barley cultivars, Korean J. Crop Sci. 36:294-299.

Table 2.2.11. Characteristics of top yielding forage barley lines (facultative types).

Variety / Line	GH	DH	DM	PH (cm)	Forage yield*	CP (%)	Grain yield (kg/ha)	Total dry biomass	ADF (%)	NDF (%)
Rihane 03/Rihane-08	3	120	159	120	15840 (510)	16.2	4814	15150	24.1	49.9
ICB100709/Rihane-03	3	115	155	80	15350 (645)	18.1	3154	8830	24.2	43.8
ICB105932/Marageh	3	120	161	100	13485 (925)	13.6	3486	11566	22.2	42.2
ICB102998/3/Roho//Alger/ Ceres 362	3	120	159	90	12750 (1190)	21.3	4233	13620	24.8	47.5
Salmas	3	117	160	90	12540 (570)	18.2	3735	11080	25.5	55.8
K/Alt/Air/Esp//Alger/ Ceres 362	2	112	156	80	12540 (860)	13.6	5229	12790	23.3	50.4
Dear Ala 106/Cel=ICBH88-0134	2	119	155	95	12510 (470)	14.8	3901	12240	22.9	50.3
Salmas/3/KV//Alger/Ceres 362	3	124	170	90	12138 (770)	17.9	4814	10806	22.7	46.4
Rihane/Lignee 640//ICB102854	4	120	160	95	12138 (990)	14.3	4233	14200	22.3	43.0
CWB 117-77-9-7/ICB102411	3	126	159	90	11595 (570)	17.1	4150	11510	21.7	47.9
Checks										
Tokak (winter type)	4	130	172	90	8388 (1105)	19.6	3154	10240	23.4	52.0
Arta	3	115	151	80	10388 (750)	19.6	2158	10720	25.9	47.1
LSD at 5%		9	11	10	1132 (231)		745	1252	1.33	3.50

(*) = Total Biomass yield of the ratoon crop at maturity.

These conflicting results are due to differences in environment, sowing date and cultural practices. The response of defoliated crop is highly dependent on the stage of the crop at the time of clipping. The crude protein (CP) content (%) ranged from 9.4 to 22.5% in all the 44 tested entries. However in the top forage yielding lines the CP (%) ranged from 13.6 to 21.3% as compared to 19.6% in check cultivars (Table 2.2.11). The CP is highly influenced by soil fertility, stage of the crop at the time of harvest and genotype. A significant genetic variability in ADF an DNDF content, which ranged form 20.8 to 27.7 and 37.6 to 55.8%, respectively was found in the 44 lines. With one exception, nome of the top yielding line had significantly higher ADF or NDF content than the checks. A wide range in these two characters suggest that there is considerable scope to reduce them and to further improve the quality of fodder.

Based on these studies we classified the lines into three groups: grain, fodder or dual purpose types.

From these studies it is obvious that early maturing lines give higher forage yield, when clipped in early spring, as compared to late maturity types. However, their grain yield from the ratoon crop drop drastically at the time of final harvest.

b) Winter Barley

The data on agronomic traits, forage and grain yield of the nine top yielding lines along with three check cultivars (Arta, Tokak and Zarjau) are given in Table 2.2.12. There are major differences in forage production, ADF, NDF, and crude protein content which is in conformity with earlier studies[4]. Majority of the lines included in this trial have relatively higher vernalization requirement and are responsive to long day length. Though significant differences in days to heading were observed, they all matured almost at the same time. In West Asia and North Africa the crop often suffers due to terminal moisture stress and high temperature, which forces the crop to mature rapidly.

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[4]Kang, Y.K. and Kang, H.S., 1991. Effect of cutting on forage production and grain yield of naked barley cultivars, Korean J. Crop Sci. 36:294-299.

Table 2.2.12. Agronomic traits of top forage yielding winter barley lines

Variety / Line	GH	DH	DM	PH (cm)	Forage yield*	CP (%)	Grain yield (kg/ha)	Total dry biomass	ADF (%)	NDF (%)
Roho/Mazurka//ICB 10320	3	131	178	80	16345 (300)	13.5	11160	4690	24.4	45.1
Salmas	3	130	178	65	16110 (240)	19.5	8350	3030	24.4	45.4
Roho/Mazurka//ICB 102411	3	129	178	65	14160 (400)	18.7	7650	3154	25.2	49.3
Arta-Check	2	132	172	75	13955 (265)	11.8	7940	2935	23.0	52.6
BMG-86	3	138	172	75	13425 (235)	10.5	8540	3569	25.0	45.3
K247/2401-10//Vavilon	4	137	178	75	13000 (205)	13.1	8500	2573	25.4	46.5
Kitchen/Muller Heydla//Salmas	4	144	178	80	12995 (685)	13.2	10020	3818	24.2	47.5
K247/2401//Vavilon LF7	3	132	178	80	12960 (280)	10.2	9960	4150	25.1	48.5
Torrent	4	142	180	70	12900 (560)	10.3	10620	3528	25.5	47.3
CWB117-77/ICB 104078	4	137	178	75	11580 (990)	10.9	11610	4565	24.0	50.3
Checks										
Tokak	5	159	180	65	6505 (850)	11.6	10350	3192	25.2	50.8
Zarjou	3	130	178	80	8270 (330)	13.2	8760	3818	25.6	48.8
LSD at 05%	11	NS	12	1245	(85)		1156	731	1.21	2.11

(*) : Figures in parenthesis are total biomass yield of ratoon crop at maturity.
CP : Crude Protein (N x 6.25).

In this experiment the winter types which otherwise would have taken longer time to mature had forced maturity due to moisture and high temperature stress.

From the forage yield results it seems that in the Tel Hadya environment the lines with moderate vernalization perform better than lines with strong vernalization requirements which suffer more in receding available moisture and high temperature. However, the yield data of the ratoon crop shows that facultative types give higher forage yield, and low grain yield from the ratoon crop as compared to lines with strong vernalization requirements.

The correlations between total biomass yield and agronomic characteristics in different groups of barley show that in spring and facultative types grain yield, days to maturity and heading are significantly correlated with total biomass yield. No strong correlations were found between plant height, harvest index and total biomass yield. However, in winter types only grain yield was positively correlated with total biómass, whereas negative correlations were found between days to heading/maturity, and harvest index with total biomass yield (Table 2.2.13).

Table 2.2.13. Correlations between total biomass yield and agronomic characteristics in different types of barley.

	Total biomass		
Traits	Spring	Facultative	Winter
Grain yield	0.57**	0.62**	0.41*
Days to maturity	0.55**	0.57**	-0.47*
Days to heading	0.62**	0.53**	-0.40*
Plant height	0.31	0.28	0.22
Harvest Index	0.22	0.17	-0.42*

*, ** Coefficients significant at P = 0.05 & 0.01, respectively.

In the present studies, highly significant correlations were found between total biomass and days to heading/maturity in spring and facultative types, but in winter types significant negative correlations were found between these traits. From these studies it appears that spring and facultative types can make best use of the available moisture, and that it should be possible to

select lines that are superior for both traits. The winter types under Tel Hadya conditions are not suitable because of their long growing season and because they suffer badly in spring and early summer due to moisture stress coupled with high temperature. However, they seem to provide an important genetic resource to develop superior dual purpose barley varieties.

(M. Tahir and A. Goodchild)

2.2.9. Performance of Disomic-Addition Lines of Barley under Moisture Stress.

Among the winter cereals barley occupies a very unique position due to its drought tolerance and adaptation to environmental stressess. Though a large amount of work has been carried out by a number of scientists on gene analysis for various traits, the information on the role of each barley chromosome in drought tolerance is scanty. Therefore, disomic-Addition lines of barley cv. Betzes in the genetic background of wheat variety Chinese Spring were obtained from Dr. A.K.M. Islam (University of Adelaide, Australia) for their evaluation under moisture stress conditions at ICARDA. Six disomic-addition lines for chromosomes 2H-7H, one ditelosomic-addition line for chromosome 1H along with their parental varieties (Betzes-Barley and Chinese Spring-Wheat) were evaluated at Tel Hadya and Breda.

The overall agronomic performance of both the disomic-addition (2H-7H) and ditelosomic-addition (1H) lines was poor when compared with the parental wheat and barley lines at both locations (Table 2.2.14). Plant height of all the disomic-addition lines was significantly reduced except in ditelosomic-addition-1H and disomic-addition-5H lines as compared to pure Chinese Spring at Breda. However, at Tel Hadya the significant reduction in plant height was only observed in lines with chromosomes -2H and -4H. Spike length was not affected at both the locations. Number of grains/spike was increased in ditelosomic-addition line -1H at both the locations. Though several chromosomes had a positive effect on tillers/plant and number of spikes/plant, significant increase was only observed in linès with -1H chromosome.

Table 2.2.14. Effect of moisture stress on agronomic traits in Disomic Addition lines of barley.

Line/Variety		Breda					Tel Hadya				
		PH(cm)	SpL(cm)	G/Sp	Till/P	Sp/P	PH(cm)	SpL(cm)	G/Sp	Till/P	Sp/P
1. Ditelosom.Add.1H		61.0	6.86	9.66	5.66	5.23	96.66	8.00	11.10	16.43	15.10
2. Disomic Addition.2H		53.2*	6.56	7.86	4.23	4.00	81.80	6.90	9.56	15.10	12.53
3. Disomic Addition-3H		53.90	5.90	7.73	4.96	4.23	85.56	6.76	8.80	14.86	12.43
4. Disomic Addition-4H		52.86	7.63	9.63	3.33	2.76	83.66	8.43	10.33	12.80	10.66
5. Disomic Addition-5H		60.76	7.33	8.00	3.33	3.33	94.00	8.66	10.33	10.00	18.90
6. Disomic Addition-6H		59.76	6.53	8.43	2.13	2.00	92.33	8.53	10.43	10.66	10.33
7. Disomic Addition-7H		54.67	7.56	8.56	4.10	3.86	88.86	7.66	9.66	13.90	13.33
8. Chinese Spring		68.23	6.76	8.90	2.76	2.43	99.46	7.66	10.00	11.76	10.03
9. Betzes (barley)		54.20	9.10	12.53	17.66	10.33	87.10	9.00	13.80	27.33	19.33
10. Arabic Abiad		51.00	5.43	10.90	8.8	3.66	69.88	8.00	12.43	21.56	13.29
Overall Mean		56.96	6.97	9.22	5.70	4.18	87.84	7.98	10.64	15.44	13.59
CV	8.51	11.09	7.54	23.97	33.26	9.27	8.76	4.94	17.41	34.14	
LSD at 0.05		8.32	1.32	1.19	2.34	2.38	13.98	1.28	0.90	4.61	7.96

As expected, each chromosome exerts a different influence on agronomic characteristics. However, under dry environments, chromosome 1H seems to have the most desirable traits such as plant height, spike fertility (determined from grains/spike) and tillering capacity.

2.2.10. Grain Quality

In view of barley's use as human food and animal feed, efforts are continuously made to improve quality characteristics of the new WF barley germplasm. The most important quality parameters in feed barley are the protein content and thousand kernel weight (TKW). Therefore, the most advanced lines (387 lines and varieties) of Winter Barley Yield Trial (WBYT), Facultative Barley Yield Trial (FBYT), Winter Barley Observation Nursery (WBON), Facultative Barley Observation Nursery (FBON) and Hull-less barley Observation Nursery (HBON) grown at Breda and Tel Hadya were evaluated. Since moisture stress adversely affects thousand kernel weight, only the results from Breda are presented in Figures 2.2.1 and 2.2.2

In WBON and WBYT the protein content ranged from 11~19% where as the TKW ranged from 25~50 gm. The check varieties Tokak (winter type) had 15.2% protein and 41 gm TKW. However, 82% of the lines had more than 14% protein and 58% had more than 40 gm TKW. A large number of lines (42%) showed lower TKW is, because most of them were of pure winter types and late in maturity, therefore suffered badly under terminal moisture stress. In case of FBON and FBYT the ranges in protein content and TKW of 13-19% and 35~50 gm, respectively were observed. The check variety Rihane-03 had 13.0% protein and 40.5 gm TKW.

However, contrary to winter barley, the proportion of lines, with thousand kernel weight greater than 40 was 71%; and 96% of the lines had protein content (>14%) higher than the spring type check cultivar, indicating that the facultative barley lines were less affected by terminal drought and high temperature. In hull-less barley the protein content as well as TKW were slightly lower than the hulled barley.

Based on these evaluations 11 lines were identified (Table 2.2.14) having high protein and TKW. Landraces from

the dry cold areas of WANA were in the pedigree of nine of these lines. This shows that the locally adapted germplasm can provide an excellent source of desirable gene(s) to develop new improved barley material for stressed environments.

Table 2.2.14. Winter barley lines with high 100-kernel weight (TKW) and protein under moisture stress situation.

No.	Line/Variety		TKW (gm)	Protein (%)
1.	WBYT-7	Roho/Mazurka//ICB 103020	43.8	14.3
2.	WBYT-19	Rihane/Lignee 640//ICB-107766	45.9	17.2
3.	WBYT-12	**Tokak (Check)**	41.0	16.5
4.	WBYT-4	Alpha/Quina	41.3	16.2
5.	WBYT-7	CWB117-77-9-7/ICB-104073	43.0	16.0
6.	WBON-2	Roho/Mazurka	44.1	13.6
7.	WBON-6	CAB 117-77-9-7/ICB-103020	38.2	14.8
8.	WBON-53	ICB-100081	39.2	14.8
9.	FBON-7	ICB-101719/Rihane-08	45.0	13.8
10.	FBON-77	ICB-103209//Roho/Mazurka	40.4	14.5
11.	FBON-103	ChiCm/An57//Albert/3/ICB105981	39.7	14.0
12.	FBON-130	**Rihane-03 (Check)**	40.5	13.0
13.	FBON-131	ICB-103351/Harmal	41.0	14.6

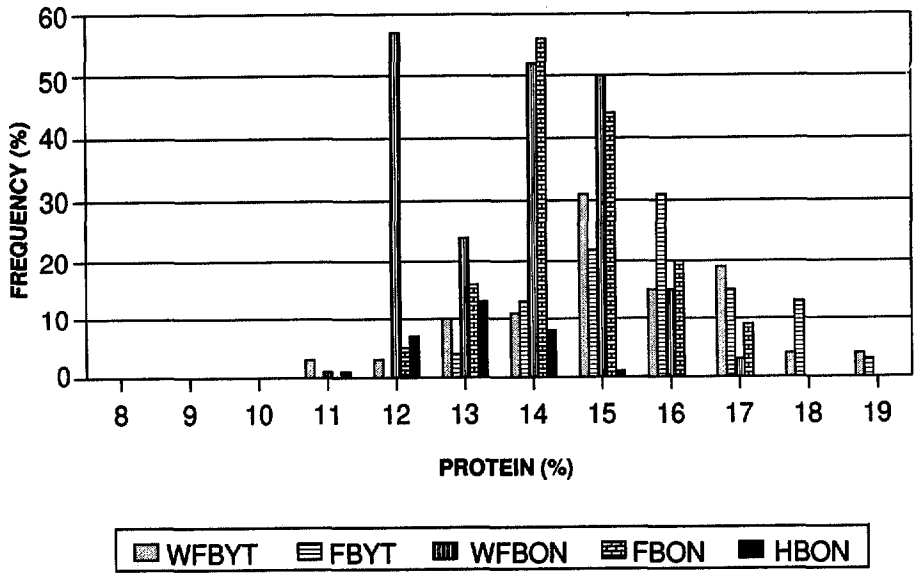

Fig. 2.2.1. Protein distribution in winter barley breeding material, Breda 1994/95

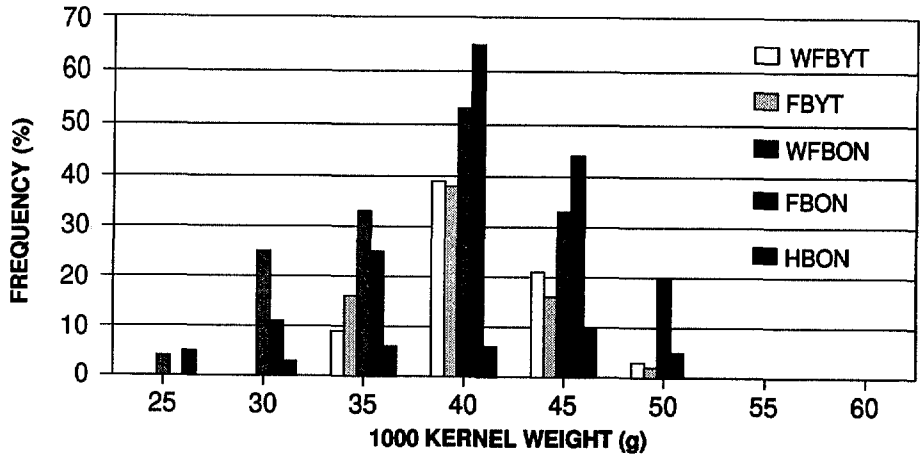

Fig. 2.2.2. Thousand kernel weight distribution in winter barley breeding material, Breda 1994/95.

2.2.11. Barley as Source of Bread

Historically, wheat and barley were used by our ancestors for preparing bread in many countries of the world. A significant portion of the barley production is still used for bread making in Ethiopia, the Andean countries, Nepal and in north Africa, especially the region of the Atlas mountain. The bread made from barley is normally 20 cm in diameter with a thickness of 2 cm. However, in the past barley was also used for making a single layered tannour bread in west Asia until early 1950s. Recently, barley has been discovered to control obesity and lowers cholesterol level if consumed regularly, and this has been attributed to its β-glucan content. Therefore, intensive research is conducted in several laboratories to develop barley varieties suitable for human consumption in different food recipes.

In WANA, one of the largest use of barley as food is bread. Therefore, preliminary studies were carried out to prepare tannour bread from pure barley flour as well as with barley (B) and bread wheat (BW) flour blends of: 25%B:75%BW (58), 50%B:50%BW (57), 75%B:25BW (52), and 100% BW. A panel of 18 judges (chosen among ICARDA's staff) evaluated, shortly before lunch, the bread prepared from the above formulations of flours for taste and palatability on a scale of 1 (poor) to 5 (excellent).

The bread prepared from 25%B:75%BW mixture scored the

highest points (63) followed by 50%B:50%BW, 100%BW, 75%B:25BW and 100% Barley (39). These studies indicate that, to some extent, the deficit of wheat can be met by mixing at least 25% of barley flour in bread preparations. Since barley is the only winter cereal which can be successfully grown in dry areas and in salt affected areas, it can play an important role in overcoming food shortage and can be an excellent ingredient of daily healthy diet, especially for those who have the problem of obesity and high cholesterol.

2.2.12. Boron Toxicity Tolerance

Five entries had symptom scores as low as the tolerant check, Tokak (Table 2.2.15), and no entries had symptoms as severe as the sensitive check, Pirate. The very tolerant checks, Sahara 3763, 3768 and 3769, showed no B-toxicity symptoms. The Turkish cultivar, Bulbul, which was claimed by some Turkish colleagues to be highly sensitive, was found to be moderately tolerant, confirming the result obtained in the 1993 screening.

Table 2.2.15. Entries with the least B-toxicity symptoms in the 1994/95 International Winter and Facultative Barley Observation Nursery.

Ent. No.	Name/cross	Symptoms Score[1]
7	Rihane/Lignee 640//ICAB-107766	0.5
11	Wysor (from USA)	0.5
31	5035/CI8865	0.5
54	BM6-36	0.4
63	YEA168.4/YEA605.5	0.5
Checks:		
	Tokak (Tolerant)	0.5
	Pirate (Very sensitive)	4.5

[1] 0 to 5: 0 = no symptoms, 5 = severe symptoms

(S.K.Yau, M. Tahir)

2.2.12.1 Turkish Barley

Under the ICARDA/Turkey mini-project on B-toxicity research, 121 Turkish advance barley lines were screened. Most of the materials were fairly tolerant. There was

moderate, but significant, variation between entries. Twenty-four entries had less severe symptom scores than Tokak, the most widely grown Turkish cultivar. The least tolerant entries still had significantly less symptoms than the sensitive check, Pirate.

(S.K. Yau, H. Tosun, A. Cildir)

2.2.13. International Testing of Improved Germplasm

One of the objectives of the WF Barley Improvement Program is to supply NARS with improved germplasm which can give stable, high yield. The improved germplasm is usually supplied globally to NARS in the form of international nurseries or international trials.

2.2.13.1. Observation Nurseries

Starting from 1993/94, the International Facultative Barley Observation Nursery (IFBON) was made available to NARS in addition to the International Winter and Facultative Barley Observation Nursery (IWFBON). This further enhances the targeting of materials for specific environments. Both nurseries comprised 150 entries of advanced material developed at ICARDA. Detailed results of both nurseries for 1993/94 are published in the International Nursery Report. Here, the performance of the two nurseries in 1994/95 at Kazan, Turkey, is reported (Table 2.2.16). On the basis of agronomic score and grain yield, 61 and 67 entries were selected from the IFBON and IWFBON, respectively. The 15 top-yielding entries from both nurseries were higher yielding than Tokak or Bulbul, the two widely grown Turkish checks.

Table 2.2.16. Grain yield (kg/ha) of the 10% top-yielding entries of the IFBON and IWFBON at Kazan, Turkey.

Nursery	Yield range	10% top-yielding lines		Checks	
		Mean	Range	Tokak	Bulbul
IFBON	1270-5620	4580	3810-5620	2950	2540
IWFBON	890-5970	4580	4080-5970	2710	3990

2.2.13.2. Yield Trials

In addition to the International Winter and Facultative Barley Yield Trial (IWFBYT), the International Facultative Barley Yield Trial (IFBYT) was assembled starting from 1993/94. This replicated trial also includes 24 entries, which had gone through several cycles of selection at key locations in the highlands of WANA. Both trials provide NARS the most advanced material for their testing and selection.

2.2.13.2.1. 1993/94 IFBYT

Table 2.2.17 shows the five highest yielding lines, which were significantly (P<0.05) higher yielding than the national check, at three of the sites (Sanandaj, Iran; Islamabad, Pakistan; Elvas, Portugal) where the IFBYT was tested in 1993/94.

Table 2.2.17. Entry number and grain yield (kg/ha) of the best lines outyielding significantly (P<0.05) the national check in the 1993/94 IFBYT in different countries.

Site					
Sanandaj (Iran)		Islamabad (Pakistan)		Elvas (Portugal)	
Entry	Yield	Entry	Yield	Entry	Yield
22	7930	10	5360	22	7170
14	7780	19	5200	14	7090
15	7560	3	5110	19	6810
19	7560	17	4510	17	6790
17	7480	14	4490	10	6730
nc[1]	6000		2960		4170

[1] national check

Entry names/crosses:

3 = ICB-101719/ICB-105932
10 = ICB-105981/5/Pitayo/Cam//Avt/RM1508/4/Por//Ds/Apro/3/CM67/Dwg*2
14 = CAB 117-77-9-7/ICB-102893
15 = Rihane/Lignee 640//ICB-102854
17 = ICB-102998/3/Alger Ceres,362-1-1//Emir
19 = ICB-101669//Gaines/Ore'S'
22 = Zarjau/80-5151

Some of the entries, like CAB 117-77-9-7/ICB-102893, ICB-102998/3/Alger Ceres 362-1-1//Emir, and ICB-101669//Gaines/Ore'S', outyielded the respective national checks at all three sites. This suggests that the three sites had a fairly similar environment. In contrast to the good results at Sanandaj, Islamabad and Elvas, none of the lines in the trial yielded significantly more than the national check at Zahle (Lebanon), Fes (Morocco), Valladolid (Spain) and Zaragoza (Spain).

2.2.13.2.2. 1994/95 IWFBYT

The results of the 1994/95 IWFBYT at three highland sites (Haymana and Kazan, near Ankara, Turkey, and Orumieh in Iran) are given in Table 2.2.18. At Haymana, four lines (no. 2, 4, 10 and 23) gave higher yield than Tokak, the most widely grown barley variety on the Anatolian Plateau. Eleven lines were higher yielding than Tokak at Kazan, but only entries 3, 8 and 21 were presented.

Table 2.2.18. Top yielding barley lines and grain yield (kg/ha) in the 1994/95 IWFBYT at three highland sites in WANA.

Entry no.	Variety/cross	Site		
		Haymana	Kazan	Orumieh
2	CWB117-77-9-7/ICB-104073	5820	3870	3100
3	Zarjou/80-5151	5330	5280	4800
4	Alpha/Quina	5930	3730	4920
8	Lignee 131/5/Cq/Cm//Apm/...	5180	5610	3980
10	YEA 17.27/YEA 534 YEA.10	5760	3510	4990
21	Roho/Masurka	4680	4510	4760
23	CWB117-77-9-7/ICB-104073	6010	3280	3810
Checks				
	Tokak	5470	3900	4780
	Bulbul-89	6140	3350	4510
	Local check	5630	4080	4500

Four lines (no. 3, 4, 10 and 21) out-yielded Tokak and the local check at Orumieh. It appears that the three sites are different from each other, as none of the best performing lines was among the top yielding across sites. Selected lines from this trial have been included by NARS in their national trials for further testing.

Results of the trial were also available from two colder highland sites in eastern Turkey: Malya and Ulas. None of the entries yielded more than Tokak or Bulbul. This suggests that despite the rapid progress that has been made over the last few seasons on winter hardiness of the IWFBYT, winter hardiness needs to be further improved for growing breeding material in the eastern Anatolian Plateau.

2.3. LATIN AMERICA REGIONAL PROGRAM

2.3.1. International Trial

During 1994, six barley nurseries (Table 2.3.1) were distributed to national research programs that had previously requested them.

Table 2.3.1. Barley Nurseries distributed from the Latin America Regional Program.

Nursery	No. of sets
International Barley Yield Trial (IBYT)	65
International Barley Observation Nursery (IBON)	81
Early Maturity Barley Screening Nursery (EMBSN)	59
Hull-less Barley Screening Nursery (HBSN)	50
F2 SxS	37
F2 SxW	33

A total of 325 nurseries was distributed to the five continents: Africa (54), Asia (108), Oceania (8), North America (65), and Europe (46).

2.3.2. Germplasm Development

During the 1994 summer planting at El Batan and Toluca Experiment Stations in central Mexico and the 1994-95 winter season at CIANO Experiment Station, barley germplasm was advanced two generations. The winter season at Ciano was characterized by heavy rains that caused severe damage during germination. Yield trials were discarded due to poor stand establishment. Also as a result of the heavy rains, a new disease was observed in the area which caused white soaked blotches on the spikes of susceptible plants. Infected heads were sent to CIMMYT's Plant Pathology Laboratory for identification. The disease was identified as bacterial *Pseudomonas*. It was thus possible to screen for leaf rust and bacterial disease (*P. syringae*) at Ciano, although the latter has not been previously reported in the latin America region.

During the summer cycle in Toluca, *Rynchosporium secalis* spores were produced in the laboratory and used to inoculate a combination of susceptible cultivars sown in

small areas. Once the scald epidemic was well established, the infected plants were pulled, split, and a few tillers placed between the plots throughout the nurseries. The technique provided excellent disease spread. A natural stripe rust epidemic was present in addition to scald, and plants were selected for resistance to both diseases. Precipitation in Toluca during the first 10 months of 1994 was 1012 mm.

At El Batan Experiment Station, 23 yield trials and seed increase plots for International Nurseries were planted in the summer of 1995. Early crop development was good, but heavy rains at the end of season caused severe lodging.

2.3.3. Hull-less Barley

Hull-less barley cultivars are thought to yield less than covered cultivars due to their lack of the lemma and palea, and lower yields have always been mentioned as a major obstacle to their adoption by farmers.

Table 2.3.2. Grain yield of hull-less barley cultivars as compared to the highest yielding covered check Tocte at El Batan Experiment Station, Mexico, 1995 summer cycle.

Yield Cultivar	t/ha	% of covered check
640	7.1	101
334	5.4	98
618	6.4	91
611	6.4	91
643	6.3	90
633	6.3	90
Cerraja	5.2	90
628	6.2	89
659	6.1	87
573	6.6	86
Congona	4.6	84

However, in these trials, several hull-less lines produced yield comparable to that of Tocte, the best covered check, which had an average yield of 7.2 t/ha in 20 experiments. For example, the grain yield of Cerraja was not significantly different from that of Tocte for the second consecutive year of testing. These results confirm that it is possible to develop hull-less lines with yield levels

similar to those of covered types. Naked barleys whose grain yields were not statistically different from that of the best covered check are listed in Table 2.3.2).

2.3.4. Early Maturing Barley

Barley lines bred for grazing as a companion crop with ryegrass or medic (*Medicago polymorpha*) continued to be tested in verification trials in farmers' fields.

Table 2.3.3. Dry matter production of early maturing, hooded barley lines at El Batan Experiment Station, Mexico, 1995 summer cycle.

Cultivar	Height cm	Dry matter t/ha	Days to harvest	Lodging 1-9
EHBBV95-68	90	8.5	582	
EHBBV95-77	100	8.4	584	
EHBBV95-37	85	7.6	582	
EHBBV95-38	85	7.5	582	
EHBBV95-59	90	7.3	582	
EHBBV95-3	100	9.2	642	
EHBBV95-21	95	9.1	646	
EHBBV95-54	105	9.0	648	
EHBBV95-119	105	9.0	649	
EHBBV95-9	95	8.9	646	
EHBBV95-129	110	12.4	704	
EHBBV95-132	115	12.2	709	
EHBBV95-126	120	11.6	709	
EHBBV95-135	110	11.4	706	
EHBBV95-30	110	11.3	704	

Farmers who practice this cereal-based farming system have suggested the need for earlier, taller, hooded genotypes that could be cut for hay or silage. Removing barley plants mechanically early in the season eliminates competition for light, water and nutrients and allows the medic, which are sown at the same time as barley, to grow well. The forage is put in the store for the dry season (January to May), when it is used as animal feed.

During the summer cycle at El Batan, 135 F_5 population were planted in unreplicated plots consisting of two 11-m rows. Plants were selected for resistance to disease and lodging, as well as for total biomass at the milk-dough stage. The 49 liens selected, some of which are shown in Table 2.3.3 were classified into three groups

based on number of days needed to reach growth stage 77 (Zadok's decimal code scale).

The early maturing hooded barley lines will be distributed to Bolivia and Ecuador in South America, as well as northern Mexico, where the University of Nuevo Leon will test their adaptation.

2.3.5. Breeding for Disease Resistance

2.3.5.1. Scab (*Fusarium graminearum*)

In the United States, head scab is a major constraint of barley production in the upper Midwest, where wheat and78xd barley losses worth US$ 1 billion were reported in 1993. The main cause of the losses was the rejection of scabby grain having vomitoxin content exceeding 2 ppm for wheat and 4 ppm for barley.

In cooperation with Oregon State University, a set of 98 double haploid lines were developed with good malting quality. During the 1995 summer cycle, the parents, F_1, and 98 double haploids were screened for scab resistance at Toluca Experiment Station. They were inoculated with *Fusarium gramineaum* cultures obtained from infected barley spikes collected in Mexico. A lattice design with three replications was used.

For field inoculation tweezers were used to insert a cotton plug soaked in a spore suspension (50,000 spore concentration) into a central spiklet. Ten spikes were covered with glassine bags immediately after inoculation. Symptoms scores were recorded 24 days after inoculation; hyphae spreading within the spike were measured by counting the number of infected grains. Table 2.3.4 shows the results as percentage of infected grains over total grain number.

Since there are reports of significant year to year variation in wheat, the results obtained must be seen as preliminary. Lines with low severity scores also had low DON (deoxynivalenol) leaves according to Rasmusson. Vomitoxin levels were not determined in our experiments.

Table 2.3.4. Results of screening barley double haploid lines for *Fusarium graminearum* resistance at Toluca Experiment Station, Mexico, 1995 summer cycle.

Cultivar	Severity
85	12.9
82	13.3
24	13.8
67	14.4
89	14.6
Zhenmai-1	20.9

The progeny showed transgressive segregation against hyphal spread within the spike. The 98 double haploids and parents will be sent to the Shangai Academy of Agriculture Sciences in China for testing under their conditions.

In a second experiment, 36 genotypes were screened for *F. graminearum* and *F. culmorum* using a randomized complete block design with two replications. Most entries had been reported to be scab resistant in previous screening conducted in Japan, China, and USA. Results showed that several lines from our program have good resistance to hyphal spread for both Fusarium species and compare favorably against the best sources of resistance reported elsewhere.

In a third experiment, different spore concentrations (30,000, 40,000, 50,000, 60,000 and 70,000) were tested on eight genotypes using a randomized complete block design with four replications. These cultivars were tested not only for hyphal spread within the spike, but also for initial penetration by the fungus. Results showed that theses two types of scab resistance are operating in barley under the conditions of Toluca, Mexico. For example, the six-row barley cultivar Aliso showed intermediate resistance to hyphal spread but very high susceptibility to initial penetration.

Testing barley for toxin content is expensive because lab analyses cannot be done in Mexico and materials have to be sent elsewhere. Financial assistance has been requested from the US malting industry to be able to complete the information on the resistance in these lines with additional dated on DON levels.

2.3.5.2. Stripe rust (*Puccinia striiformis*)

In cooperation with Colorado State University, several hundred accessions were field screened against stripe rust in Toluca. The disease reaction recorded showed there was no dramatic change in virulence of *P. striifromis* in Mexico for 1995.

2.3.5.3. Scald Resistant Barley to be Tested in Ethiopia

Ethiopia's national program requested a few scald resistant barley genotypes with good malting quality for testing under Ethiopian conditions.

2.3.5.4. Partial Resistance to Leaf Rust in Barley

Results of a survey conducted in Ecuador, where samples of leaf rust on barley were collected, were made available to the Ecuadorian national program by Tel Aviv University in Israel. Results show the presence in Ecuador of *Puccinia hordei* virulences that render all the major genes in the set of differential cultivars ineffective. Breeding for resistance to leaf rust should thus focus on the partial resistance mechanism described by Parlevliet. The variety Shyri is a good example of a commercial variety with partial resistance to leaf rust, as demonstrated by Jose Ochoa, Ecuadorian plant pathologist, who found Shyri produced 3 t/ha under a severe leaf rust epidemic. The line V5, a potential variety that has undergone several years of testing, was also classified by Parlevliet as having partial resistance to leaf rust.

2.3.5.5. Genetic Analysis of Disease Resistance

This work is mostly done in collaboration with OSU where double haploid populations are developed with this purpose. The total number of double haploid populations from Oregon State University has increased since last year. They were field tested in Mexico as part of a work scheme where resistant progenitors provided by our program were evaluated for their reaction to several diseases. The

OSU Biotechnology Laboratory conducted molecular marker (RFLP) analysis.

A summary of the double haploid populations being studied are:

1. Calicuchima "S"/Bowman Derivative

Strip rust analysis is complete. Two resistant genes were identified on chromosomes 4 and 7 that confer resistance to race 24 of *P. striiformis* f.sp. *hordei*. One gene conferring leaf rust resistance was identified on chromosome 1. One gene conferring Barley Yellow Dwarf (BYD) resistance was located on chromosome 3. One gene conferring scald (*Rynchosporium secalis*) resistance was identified on chromosome 3.

2. Shyri/Galena

A second year of testing for stripe rust conducted in Toluca using three planting dates. The resistant/susceptible ratio confirmed the presence of two resistance genes in Shyri. Their exact location has not yet been determined.

A gene responsible for leaf rust resistance was identified in Shryi based on preliminary results from one location (CIANO) during the 1994-95 winter cycle.

Ratios obtained for scald for all three planting dates in one location (Toluca) pointed to two-gene segregation. Both genes are present in Shyri; Galena was found to be susceptible.

The double haploid population was inoculated with three BYD biotypes (MAV, PAV, and RPV). The study is still in progress, but Shyri was found to be resistant to MAV and susceptible to PAV and RPV.

Inoculation with net blotch isolates (*Pyrenophra teres*) failed to produce symptoms in the double haploid population. The inoculation will be repeated at CIANO next winter.

3. Shyri/CBC2

The 100 double haploid populations inoculated with stripe rust, leaf rust, scald, BYD and net blotch confirmed the results mentioned above.

4. Shyri/CI 10587 and 5. Shyri/CI 11958

Both populations were screened for stripe rust reaction. In each population one gene is responsible for stripe rust resistance. No data were collected to establish whether the genes are the same or different.

6. BSR 45/Steptoe

The BSR45 line is a double haploid from population 1 above (Calicuchima "S"/Bowman derivative). It was found to be stripe rust and BYD resistant with good mating quality. The population was screened for stripe rust in Toluca for the second time. Thirteen double haploid lines from this population showed stripe rust resistance in the field. The same genotypes were found to be stripe rust resistant using marker assisted selection.

7. Gobernadora Advanced Line with Good Malting Quality (Shyri/2/Gloria/Copal/3/Shyri/2/Grit)

Collected preliminary information on stripe rust segregation (summer 1995). Screened against *Fusarium graminearum*. The double haploid lines will be selected for leaf rust during the 1995-96 winter cycle at CIANO, and for head scab in China during 1996.

8. BSR 45/Colter

Population screened for its stripe rust reaction. All lines of the population were found to be susceptible.

2.3.6. Barley-medic Rotation

During the 1995 summer cycle in the central Mexican highlands, six more hectares were sown to medic with barley as a companion crop. The early maturing barley was grazed by sheep for several weeks starting 45 days after planting. In September the sheep were removed from grazing, and the medic plants grew and set seed. The barley showed no regrowth.

Another hectare was planted as a demonstration plot using 15 kg of medic seed. This plot and an adjacent

hecter established last year were used for testing herbicide mixtures for broad-and narrow-leaf weed control. Mixtures of Butirac + Pivot, Butirac + Fusilade, Basagran + Pivot, and Bassagran + Fusilade provided incomplete weed control; weeds such as tomatillo were not controlled by any mixtures. Malva was controlled with a combination that included Pivot, and wild oats with Fusilade combinations. Under Mexican conditions the cost of chemical weed control is generally high, making it unacceptable for farmer recommendation.

A four-hectare field under rotation with medics was sown with the maeting barley variety Esneralda. Stand development was good, free of weeds, and produced a harvest of 3.4 t/ha without fertilizer application, as compared to the check sown without medic or fertilizer (1.6 t/ha). A field day was held on 28 September 1995.

(H. Vivar)

3. DURUM WHEAT IMPROVEMENT

Introduction

Durum wheat is an important winter cereal crop in the Mediterranean region. Its products have been historically important in the diet of the Mediterranean populations, and for these reasons it is considered a typical Mediterranean crop. The area in the West Asia and North Africa region covered by durum is now more than 85% of the total area in the developing countries. Morocco, Algeria, Tunisia, Syria, and Turkey are among the major eight durum producing countries. The durum crop in WANA region is grown mainly under dryland conditions. These are characterized by drought, cold, terminal stress (drought and heat), and soil and nutrients problems (alkalinity, boron toxicity and micronutrients deficiency). In addition, almost all diseases, insects, and viruses that attack durum are prevailing and widespread in this region. However, because of the progress made recently in developing productive and stress resistant durum varieties and the favorable world market price, durum grain yield per unit area and the area planted to durum is increasing in most of the countries of the WANA region, particularly in Syria, Turkey, and Morocco.

The durum grain is mainly used for making several food items which are locally produced and consumed, such as Burghul, Couscous, Pasta, and durum bread, and therefore grain quality is an important factor in durum manufacturing industry. The durum manufacturing industry is gaining momentum in the region.

The main objective of the joint ICARDA/CIMMYT durum project is to assist Mediterranean countries to enhance durum production in the dry areas by (1) developing productive and adapted germplasm, resistant to abiotic and biotic stresses with good grain quality; (2) improving breeding methodology; and (3) strengthening national research capabilities through providing training and increasing interaction among NARSs.

Drought, cold, and terminal stress tolerant varieties with enhanced diseases and insects resistance are being released for commercial production in many countries of the WANA region. Cham 3 is the most widely

grown variety in Syria. It has also been released in Jordan (as Petra), in Algeria (as Korifla), in Libya (as Zahra 5), and in Turkey (as Haran-93). Furthermore, Heider, Kabir 1, Omrabi 9, Belikh 2 were also released in Algeria. New durum genotypes with better resistance to abiotic and biotic stresses were recently released. In Syria, Omrabi 3 is released as Cham 5 and in Tunisia as Oumrabii, and in Turkey an Omrabi sister line is released as Aydin 93. Omrabi 5 is proposed for release in Libya, Iraq, Iran; while in Morocco Omrabi 6, Aconchi, and 2777/Javardo are proposed for release.

In 1995 improved durum genotypes were identified with enhanced tolerance to drought, cold, heat, and boron and resistance to Hessian fly, root rot, tan spot, powdery mildew, black point, leaf rust, and septoria tritici. Progress was also made in widening the genetic base of resistance to Hessian fly and to the three rusts through the use of landraces and wild relatives. Furthermore, the utilization of seed storage proteins, gliadin and glutenin, as molecular markers by PCR techniques to screen for grain quality was successfully incorporated as a routine tool in the breeding program. The development of molecular markers probes to test for abiotic stresses is under study.

The SEWANA (Southern Europe and West Asia-North Africa) durum research network was developed in collaboration with the durum scientists of NARSs and advanced institutions working on durum improvement to link and improve the durum research activities in the Mediterranean region. The SEWANA durum network has improved the collaboration among NARS and South European institutions. This collaboration has lead to the development of joint research program among the NARS of the major durum growing countries in WANA, partly funded by the International Fund for Agricultural Development (IFAD). This program is based on decentralizing breeding to NARSs and enhancing joint research among NARS, The program is based on comparative advantage (occurrence of specific environmental constraints, commitment of NARS. availability of funds, research infrastructure, and expertise). The current research activities within the durum network for each agroecological zone are as follows:

1. Mediterranean Continental Areas (MCA)

The work for these areas is conducted in collaboration with NARSs of Syria, Tunisia, and Jordan and its aim is to use the genetic diversity occurring in durum wheat in these areas, represented by landraces and wild relatives, and to improve tolerances to moisture stress, cold, and heat. This work is associated with the ongoing basic research on moisture stress resistance with France and with the use of molecular markers techniques with Italy and USA.

2. Mediterranean Temperate Areas (MTA)

The breeding work for these areas is conducted in collaboration with the NARSs of Morocco and Tunisia to screen and develop durum material combining productivity with resistances to Hessian fly, septoria tritici, leaf rust, root rot, tan spot, powdery mildew, and BYDV.

3. High Altitude Areas (HAA)

The collaborative breeding work for those areas is conducted in collaboration with the NARSs in Turkey, Algeria, Morocco, and Lebanon and it emphasizes cold tolerance.

(M.M. Nachit)

3.1. Breeding and Breeding Methodology Studies

3.1.1. Widening Genetic Base of Durum

3.1.1.1. Use of Landraces in the Crossing Program

Around 375 crosses were made between improved genotypes and Mediterranean landraces to improve and broaden the genetic base for the resistance to biotic and abiotic stresses. The landraces from the Middle East were used in the crossing program to enhance drought tolerance, those from Turkey and Algeria to incorporate cold resistance, those from Morocco-Iberia region to improve resistance to root rot and Hessian fly, and those from Ethiopia to

improve leaf rust resistance.

Selection from similar crosses made in previous years was done under different environments with different abiotic and biotic stresses. Selection was conducted at Tel Hadya and Breda stations during the winter cycle for resistance to drought, terminal stress, yellow rust, and septoria tritici and at Tel Hadya and Terbol stations during the summer cycle for resistance to heat and leaf and stem rusts: as a result a total of 844 promising populations were selected for continental environment, 503 for temperate and 328 for high altitude environments. In 1995, the selection was also linked to the visual agronomic performance of the F_2 and F_5 of these populations in their specific areas in WANA region i.e. continental (El-Kef in Tunisia, Tessaout in Morocco, Moushaqer in Jordan), temperate (Merchouch in Morocco, Beja in Tunisia, Adana in Turkey), and high altitude (Annaceur in Morocco, Terbol in Lebanon, Yabrud in Syria, Haymana and Hamidye in Turkey). In addition, more than 300 promising lines were cut in bulk and advanced to yield test in 1995/96.

(M.M. Nachit, A. Asbati, M. Azrak, N. Rbeiz, A. Saleh)

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

Wild progenitors of durum, such as diploid *T. urartu* and tetraploid wild emmer, *T. dicoccoides*, are limited in their geographical distribution only to the Fertile Crescent and adjacent regions. However, they can be found in very diverse environments within the region; ranging from 100 m bsl to 1700 m asl and from 200 mm to 1000 mm of rainfall, with similar variations in temperature extremes and soil fertility. Consequently, the wild relatives of durum developed different ecotypes which display specific adaptation. Unpredictable fluctuation of climatic conditions from year to year, characteristic for the Near East region, resulted in the development of highly heterogeneous populations composed of many homozygous individuals. This particular population structure provides for extraordinary buffering capacity. Recent results have

revealed population variability for traits of economic importance, such as grain quality and resistance to yellow rust and septoria tritici. Crosses between durum genotypes adapted to dry areas and *T. dicoccoides* were made to improve grain quality, resistance to *Septoria tritici* and yellow rust. More than 200 back-crosses were made to the durum wheat parent to eliminate undesirable genes. In the segregating populations, plants were selected for resistance to drought, heat, yellow rust, leaf, and stem rust. In the advanced populations, crosses with *T. dicoccoides* showed high levels of resistance to tan spot, heat, and cold. Several lines from these crosses are now included in the international trials.

Since both *T. urartu* and *T. dicoccoides* chromosomes are homologous to chromosomes of durum, their genetic diversity has been relatively easily exploited in the durum breeding program. Variation in gluten elasticity and strength is usually attributed to differences between the glutenins. These group of proteins includes high molecular weight (HMW) or A subunits and low molecular weight (LMW) glutenins subunits; this latter group is subdivided into B, C, and D, according to their mobility in sodium dodecyl sulfate (SDS)-PAGE and their relative isoelectric point. In durum, a consistent relationship has been found between the B group of LMW glutenins, coded by genes at the complex *Glu-B1* locus, *Glu-B3* and *Glu-B4* and gluten quality. Two main types of LMW glutenin subunits, designated as LMW-1 and LMW-2, have been detected in the durum, which are related to poor and good gluten viscoelasticity, respectively.

The analysis of storage protein of *T. dicoccoides* has shown that this species is highly variable for HMW glutenin subunits encoded by the *Glu-A1* and *Glu-B1* loci and for the B-group LMW glutenins of subunits. The electrophoretic analyses have shown that *T. dicoccoides* alleles by the Glu-A1, Glu-B1, and Glu-B3 loci are uncommon among cultivated durum. The effects of A and B subunits of glutenin on gluten properties were evaluated in F6 progenies of durum x *T. dicoccoides*. These progenies have allelic variants at the *Glu-A1*, *Glu-B1*, *Gli-B1*, and *Glu-B3* loci, which are not usually present in durums.

The results showed that the F6 progenies with the best quality contained the *Glu-A1* allele from *T. dicoccoides* and the *Glu-B3* allele (LMW-2) from durum.

(M.M. Nachit, A. Impiglia, A. Saleh, A. Asbati, M. Azrak)

3.1.1.3. Introgression of Genes for Abiotic and Biotic Stresses from Wild Relatives of Durum Wheat

More than 250 crosses were made with wild relatives to introgress novel genes for resistance to cold, Hessian fly and leaf rust. Introgression from *T. dicoccum* and *T. polonicum* produced promising lines under dry and heat conditions, in addition to leaf and stem rust and BYDV resistance (Table 3.1.1). Crosses with *T. polonicum* performed well under terminal stress conditions; and crosses with *T. carthlicum* performed well under cold conditions.

Crosses with *T. monococcum* were made to improve rust resistance, earliness, and early growth vigor. Introgression from *T. monococcum* are important in widening the genetic base for resistance to stem and leaf rust, and to enhance drought tolerance. From these crosses, several lines were advanced and tested in the different durum nurseries.

Table 3.1.1. Percentage of selection for different biotic and biotic stresses in segregating and advanced populations involving crosses with durum wild relatives.

	Winter 1994/95	Summer 1995
Species used	YR, ST, WSSF, C, D	LR, SR, H, BYDV
Aegilops Spp.	38.5%	54.0%
T. monococcum	42.5%	51.7%
T. dicoccoides	45.2%	49.8%
T. dicoccum	41.0%	44.0%
T. carthlicum	62.1%	21.0%
T. polonicum	17.0%	51.4%
T. araraticum	25.5%	20.0%
T. dicoccoides	34.8%	46.6%

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

Furthermore, 177 crosses were made with different A*egilops species* which were earlier selected for yellow rust, Hessian fly, and Russian Wheat Aphids resistance. Several A*egilops*-RCLs are now in the advanced generations and show promising performance under dryland conditions. Crosses with Hessian fly resistant A*egilops* were given high priority during 1994 crossing program. Recombinant lines with *Aegilops* and other wild relatives will be screened for Hessian fly resistance.

(M.M. Nachit, A. Asbati, M. Azrak, Z. Yunis, A. Saleh)

3.1.1.4. Introgression of Genes for Resistance to Hessian Fly from *Aegilops Spp.*

More than 140 *Aegilops* accessions from the ICARDA collection were screened for Hessian fly resistance by staff of INRA, Morocco. Nineteen accessions were found resistant to Hessian fly. Techniques for embryo-rescue was established at ICARDA and used to develop RCLs with recalcitrant A*egilops*. A cut stem method was developed in which spikes from durum and A*egilops* are kept under controlled temperature conditions and media, to extend the crossing period and increase the efficiency of rescuing the A*egilops* x durum hybrid embryos. At ICARDA, more than 200 crosses with different *Aegilops* were made including the 19 resistant to Hessian fly. The hybrids are back-crossed to durums with different desirable traits, particularly, leaf rust and septoria tritici resistance. Similarly, at IAVH2, Morocco, six accessions of *Aegilops ovata*, 3 *Aegilops triuncialis*, and one *T. monococcum* were crossed with several durum genotypes. The embryo-rescue technique was also used and plantlets were obtained. The plants were treated with colchicine and at anthesis back-crossed to durums. The durum x *Ae. ovata* crosses were more successful than those with durum x *Ae. triuncialis*.

(M.M. Nachit, A. Asbati, M. Bouhssini, O. Benlhabib)

3.1.2. Morphophysiology and Molecular Markers Studies

3.1.2.1. Drought

The objective of this activity is to develop an information base for a Durum Core Collection (DCC), which consists of morphophysiological and quality traits and reaction to diseases and insects, as well as molecular and biochemical markers, their chromosome location, and their linkage to loci affecting those traits. Analyses are under progress for stress tolerance traits including C^{13} discrimination (Δ), diseases and insects resistance, gliadin and glutenin components, boron toxicity, and pasta and bread making.

The DCC (144 genotypes/populations from the Mediterranean region) was used in 1994/95 season to study the association among the morphophysiological traits. The preliminary results have shown dryland grain yields to be associated with anthesis (-0.60, p= 0.001), after midday leaf rolling (0.31, p= 0.001), pale canopy color after anthesis(0.60, p= 0.001), fertile tillering ability (0.58, p= 0.001).

Among the different chlorophyll fluorescence parameters (Fv/Fm, Fo, Fm, Fv, t1/2), Fv/Fm - the ratio of variable to maximum chlorophyll fluorescence - is an indicator of photochemical efficiency of PSII. A very weak correlation coefficients was found between grain yield in the dry environments (Breda, and Tel Hadya rainfed) and Fv/Fm, 0.007 and 0.171, respectively; however, a significant correlation was found for the irrigated environment at Tel Hadya ($r = 0.228$, $p = 0.05$). Fo, the fluorescence emission when all reaction centers are open and the photochemical quenching is minimal, was found to be associated significantly and positively with grain yield in all environments (Breda: 0.487, $p = 0.001$; Tel Hadya rainfed: 0.455, $p<0.001$; Tel Hadya irrigated: 0.541, $p<0.001$). Similar results were found for the maximum fluorescence (Fm) (Breda: 0.370, $p<0.001$; Tel Hadya Rainfed: 0.443, $p<0.001$; Tel Hadya irrigated: 0.489, $p<0.001$), and for the variable chlorophyll fluorescence (Fv = Fm - Fo) (Breda: 0.300, $p<0.001$; Tel Hadya rainfed: 0.411, $p<0.001$; Tel Hadya irrigated: 0.464, $p<0.001$). However, a negative but significant correlation coefficients were found between the half-time of the

increase from Fo to Fm (t1/2) and grain yield (Breda: -0.489, $p<0.001$; Tel Hadya Rainfed: -0.407, $p<0.001$; Tel Hadya irrigated: -0.544, $p<0.001$).

The association between the chlorophyll fluorescence parameters (Fo and t1/2) and (Δ) of mature kernels showed for Fo significant positive correlation in all environments (Breda: 0.158, $p<0.05$; Tel Hadya rainfed: 0.499, $p<0.001$; Tel Hadya irrigated: 0.510, $p<0.001$); and for t1/2 significant negative coefficients in all environments (Breda: -0.220, $p<0.01$; Tel Hadya Rainfed: -0.347, $p<0.001$; Tel Hadya irrigated: -0.588, $p<0.001$).

Other correlations were found between grain yields and ash content in the flag leaf (Breda: 0.354, $p<0.001$; Tel Hadya rainfed: 0.277, $p<0.001$; Tel Hadya irrigated: 0.525, $p<0.001$); between grain yield and ash content in mature kernels (Breda: -0.524, $p<0.001$; Tel Hadya Rainfed: -0.423, $p<0.001$; Tel Hadya irrigated: -0.440, $p<0.001$). Also, a significant correlation between grain yields and (Δ) was found (Breda: 0.528, $p<0.001$; Tel Hadya Rainfed: 0.501, $p<0.001$; Tel Hadya irrigated: 0.511, $p<0.001$).

The preliminary results of another study to assess canopy waxiness, and awns contribution to grain yield showed that canopy waxiness was more associated with grain at Breda than at Tel Hadya. The waxy lines were higher yielding than non waxy lines (7.8% more). Similar trend was obtained for lines with awns which yielded 5.3% more than awnless lines.

The results of the morphophysiological studies are very encouraging, and some morphophysiological, such as the chlorophyll fluorescence parameters, ash content, and the behavior of canopy traits along with the yield components in the stressed environments, will be incorporated routinely in the breeding program. Markers correlated with drought resistance will be developed at ICARDA and tested in the mapping populations. Because of the difficulty in creating artificial screening conditions, traits such as Hessian fly, leaf rust, and common bunt are potential candidates for marker-assisted selection.

(M.M. Nachit, J.L. Araus, A. Asbati, Z. Yunis, M. Azrak, A. Saleh)

3.1.2.2. Development of Molecular Markers for Resistances to Biotic and Abiotic Stresses

In collaboration with Cornell university, primers were constructed for the following clones which will be available for mapping and marker-assisted selection in durum: BCD21, BCD120, BCD450, BCD1426, BCD1434, CDO64, CDO431, BCD249, CDO482, CDO786, CDO795, DGG12. CDO482 is linked with leaf rust and Hessian fly resistance. Most of these are associated with pre-harvest sprouting resistance. The five most important diseases were tested for associations with RFLPs and eleven markers were identified for stem rust, 11 for yellow rust, 2 for septoria tritici, 2 for common bunt, and 1 for leaf rust.

Genotypes that are resistant and susceptible to drought, cold, and heat stresses in the field are tested to determine DNA markers that are associated with resistances to these stresses. Several cDNA or genomic clones are identified that can be specific for one or more abiotic stresses. In durum, six cDNA dehydrin clones were characterized. In addition to these clones, new specific clones for Mediterranean environmental conditions, will be used to screen for the abiotic stress tolerance in durum.

For this purpose, eleven genotypes with contrasting tolerance to the main abiotic stresses were tested. Samples were taken in different growth stages (germination, 3-leaves stage, tillering, and anthesis). The chlorophyll fluorescence inhibition technique was used to quantify the effect of the stress. The expression of dehydrins was also followed by studying mRNA. From the samples collected, cDNA library will be synthesized and clones isolated and characterized. Some of these clones will be used to identify molecular markers related with abiotic stress tolerance.

(M.M. Nachit, O. Mamluk, M. Sorrells, M. Labhilili, M.Baum, A. Asbati, M. Azrak, M. Baalabaki)

3.1.3. Grain Quality

In the Middle East, farmers had indirectly selected for characteristics associated with grain quality, such as kernel size and plumpness, golden amber or red color

according to the grain use, vitreousness, and glume color (white instead of black color). White glume is an indicator for α-45 and LMW 2 and black glume color for α-42 and LMW 1 and therefore associated with the gluten strength. Visual selection for glume color has been used for the last 12 years in the durum breeding program and 90% of the improved genotypes have strong gluten characteristics, carrying α-45 and LMW 2. This shows that markers, either morphological, biochemical or molecular, can be used efficiently in plant breeding. However, the number of morphological markers is very limited in comparison to protein or DNA markers. Therefore, in 1994-95, RFLPs, gliadins, glutenins, and quality traits were analyzed for 148 durum accessions that represent the most important germplasm for the durum improvement in Mediterranean region. Individual gliadin and RFLP bands were analyzed for association with quality traits. The gliadins do not have a functional role in grain quality. They could be considered only as biochemical markers, while the LMW-γ play the major role for pasta quality.

For RFLP bands associated with quality traits, mean difference between those accessions possessing and those missing the indicated band with the probable chromosome location were estimated as follows:

Protein

with RFLPs = CDO405.15c (2) (0.70**), BCD21.37c (5,6) (0.80**),; with gliadins = 78 (-0.98**).

SDSI

with RFLPs = BCD809.24b (chr.3) (-0.38***), CDO669.31e (chr.4) (-0.27**), BCD1355.13f (chr.7) (+0.35***), and WG585.5a (chr.5) (-0.27**); with gliadins= g-42 (-0.23*), g-43 (+0.23*), g-45 (+0.29*).

Vitreousness

with RFLPs = CDO669.31e (chr.4) (+3.6**), BCD1355.13d (chr.7) (-0.90**), CDO718.11d (chr.3) (+3.8**), BCD926.8b (chr.5) (6.8***).

Kernel weight

with RFLPs = BCD1355.13f (chr.7) (-4.2**).

Yellow pigments

BCD809.24b (chr.3) (+0.69**), CDO669.31e (chr.4) (+0.64**), CDO393.27f (chr.1) (0.60**), BCD1095.36h (chr.2) (-0.69**), BCD21.37e (chr.5,6) (-0.85***); gliadins = 76 (-0.68**).

The stars (*, **, ***) indicate significance at the 0.005,

0.01,and 0.001 probability levels, respectively.

Molecular marker techniques for LMW-2 was initiated to test marker-assisted selection for efficiency in the durum breeding program using the Cham 1/Cham 3//Cham 1 backcross F1 population. Oligonucleotide for Polymerase Chain Reaction (PCR) amplification of the appropriate DNA sequence were used to screen the backcross progeny in each generation prior to anthesis. These primers were successfully used in 1993/94 and 1994/95 to screen the advanced durum genotypes for grain storage protein related to quality.

The DNA molecular markers (PCR primers) were sequenced and amplified in collaboration with the University of Tuscia, Italy, for γ gliadins (45 and 42), low molecular weight (LMW-1 and LMW-2), and high molecular weight (HMW) glutenin subunits.

The amplification of γ-gliadin showed the presence of 5 major bands, ranging between 750 and 1000 base pairs (bp). The bands 800, 830, and 970 bp were not polymorphic, while 900 and 950 were polymorphic. Genotypes with 900 bp correspond to γ-42 gliadin genotypes (e.g. Cham 1) and with 950 bp to γ-45 genotypes (Omrabi 5). The amplification of LMW glutenin sequences showed the presence of 3 bands, ranging between 900 and 1200 bp. The two smaller fragments were present in all genotypes. The size of the long fragment differed between genotypes possessing LMW-1 or LMW-2 glutenin subunits. The amplification product of LMW-2 genotypes (Omrabi 5) was about 50 bp longer (larger) than that obtained in LMW-1 genotypes (Cham 1). Further, the primers used for amplification of HMW-glutenins revealed one band only at about 900 bp which was monomorphic for all the genotypes.

The genotypes with the highest gluten strength, such as Omrabi 5, Haurani, and Korifla (Cham 3) showed DNA-glutenin (LMW-2 and γ-45 gliadin). In contrast, the genotypes with weak gluten strength, such as Cham 1, showed DNA-glutenin with LMW-1 and γ-42 gliadin. Thus the use of PCR amplification for the identification of LMW-1 or LMW-2 permits to select lines with good grain quality without environmental effects.

In collaboration with Cornell university the technique will be expanded to screen for other important quality traits such as yellow pigment and vitreousness.

(M.M.Nachit, M. Sorrells, M.Labhilili, M.Baum, A. Asbati, M. Azrak, M. Baalabaki)

3.1.3.1. Development of Populations for QTL Analysis

The mapping populations of Jennah Khetifa/Cham 1, Omrabi 5/*T. dicoccoides* 600545//Omrabi 5, and Korifla/*T. dicoccoides* 600806//Korifla were advanced to F_6. The first cross includes Jennah Khetifa, a landrace with good quality traits, common bunt resistance, but with low yield and high susceptibility to yellow rust, and Cham 1, with high yield potential and resistance to yellow rust, but low grain quality. In the backcross the parents used were Omrabi 5 and a *T. dicoccoides;* Omrabi 5 is drought tolerant with good adaptation to dryland, and *T. Dicoccoides* 600545 is resistant to *septoria tritici* and yellow rust and has good grain quality. The F_6 plants are now under increase and F_7 seed will be available for genomic mapping. Development of the mapping populations Cama di Abbou x Cham1 for the temperate areas, Kunduru x Cham 1 for the high plateaus in the Middle East region, and Selbera X Cham 1 for the Atlas plateaus is in progress.

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

3.1.3.2. Analysis of Gliadins and Glutenins by Protein Electrophoretic Analyzes

Gliadin and glutenin protein was extracted from single seed of Waha (Cham 1), Australian Polar (ICDW 12060) and Korifla (Cham3). Electrophoretic analyses of gliadins by SDS-PAGE (Figure 3.1.1a), show the presence of γ-gliadin 42 in Waha, γ-gliadin 45 in Korifla and a band similar to γ-gliadin 45 in Australian Polar. The ω-gliadin components 33, 35 and 38 were found in Cham 1 and Australian Polar,

while Korifla shows only w-gliadin 35. The electrophoretic analyses of glutenins (Fig.3.1.1b), show the presence of LMW-1 in Waha and Australian Polar and LMW-2 in Korifla. The expression of LMW-1, ω-gliadins 33, 35 38 and the expression of γ-gliadin 45 suggests that Australian Polar is a recombinant line. In order to confirm the recombination we carried out the gliadin analyses using PCR.

3.1.3.3. PCR Amplification of Gliadin Genes

PCR amplifications of γ-gliadin DNA sequences were performed using conditions reported earlier (annual report 1994) with minor modifications. PCR analyses were carried out using specific primers for the coding regions of γ-gliadins. Amplification at the Gli-B1 locus shows 5 fragments, that vary between 750 and 1000 bp (basepairs). Only one fragment with medium mobility (950 or 900bp) reveals polymorphism between Cham 1, Australian Polar and Jennah Khetifa. Cham1 and Australian Polar amplify the medium fragment (900bp) corresponding to γ-gliadin 42, whereas Jennah Khetifa amplifies a band with lower mobility (950bp) that corresponds to γ-gliadin 45.

Protein gel electrophoresis of Cham 1, Australian Polar and Jennah Khetifa shows a different pattern to amplification of gliadins by PCR. Cham 1 and Jennah Khetifa have the protein pattern of γ-gliadin 42 and 45 respectively, whereas the pattern for Australian Polar was similar to Jennah Khetifa.

PCR analysis reveals that the amplified fragment in Cham 1 and Jennah Khetifa corresponds to γ-gliadin 42 and 45 respectivly. For Australian Polar the amplified fragment correspond to γ-gliadin 42. We postulate that Australian Polar has lost the expression of the gene γ-gliadin 42. The band obtained by protein gel electrophoresis does not correspond completly to the pattern of γ-gliadin 42 or 45. Lack of expression could be the result of deletion of part of the gene or a damaged promoter sequence for γ-gliadin 42. This two modifications of γ-gliadin gene can not affect transcription of the other genes, LMW and ω-gliadin genes. The analysis characterizes a durum wheat genotype

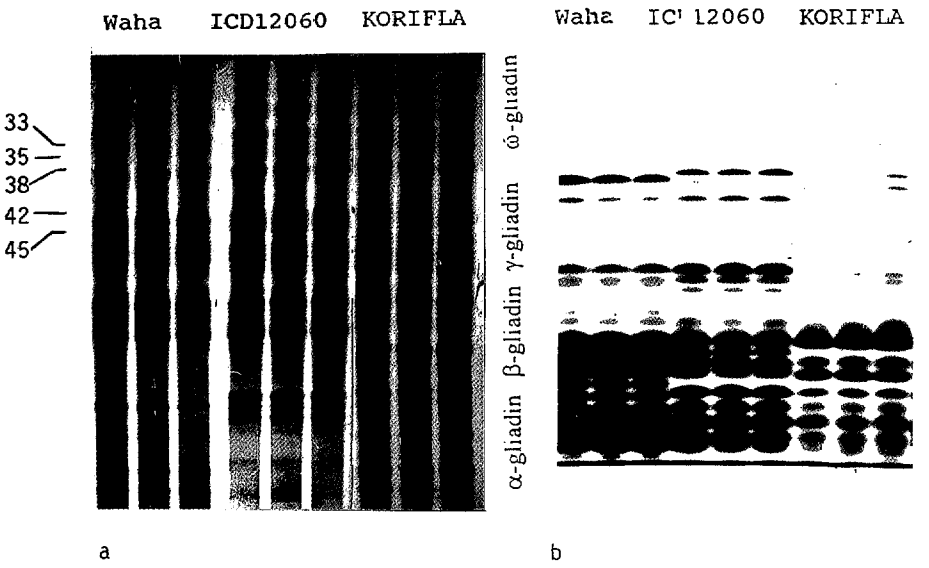

Figure 3.1.1a. Polyacrylamide gel electrophoresis of gliadins (a) and glutenins (b) for Cham 1 (Waha), Australian Polard (ICD 12060) and Cham 3 (Korifla).

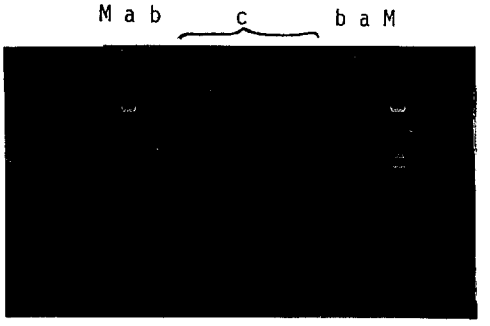

Figure 3.1.1b. PCR amplification of γ-gliadin. (M) DNA marker, (a) Jennah Khetifa, (b) Cham 1 and (c) Australian polar (ICD 12060).

in which a specific γ-gliadin 42 gene is present but not expressed. The gene amplification by PCR has detected the presence of the coding region of the unexpressed -gliadin genes by comparing the amplified fragments of Australian Polar with durum wheat cultivars having typical -gliadin expression. The result demonstrates the potential and power of PCR analysis for rapid detection of the presence of unexpressed genes. Genotypes lacking expression of specific gluten protein components offer the possibility to assess the role of specific components for the gluten structure and the resulting technological properties.

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3.1.3.4. Restriction Fragment Length Polymorphism (RFLP) in durum wheat.

The objective of this collaborative research project with the Universities of Cornell, USA and Tuscia, Italy and ENSA/INRA Montpellier, France is to develop a linkage map for durum wheat. For this purpose we have developed a mapping population of recombinant inbred lines (F_6) of the cross Jennah Khetifa and Cham1 through Single Seed Descent. The RFLP map will be used to analyze quantitative trait loci linked to biotic and abiotic stresses which will help the breeder to increase selection efficiency for these traits.

The parents were screened for polymorphism using the non-radioactive protocol at ICARDA. Barley genomic clones, MWG, wheat genomic clone ATMI and oat cDNA clones, CDO were tested with DNA of the parents Cham 1 and Jenaha Khatifa (Fig. 3.1.2). Twenty-one clones were tested so far of which 13 clones were polymorphic. The polymorphism observed seems to be much higher than that reported for bread wheat. The non-polymorphic clones were all barley genomic clones. Non of the wheat clones tested were non-polymorphic. The revealed polymorphism will be used for segregation analysis in the mapping population.

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

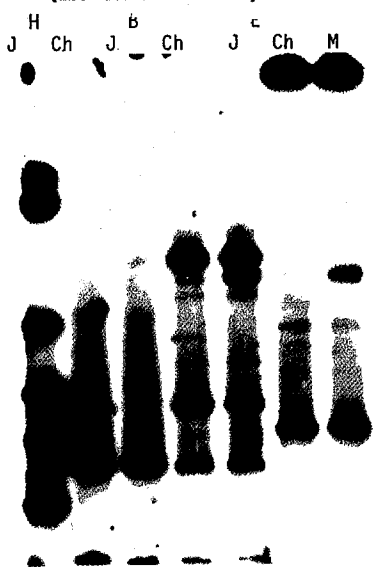

Figure 3.1.2. Restriction fragment length polymorphism (RFLP) of marker ATMI 386 on genomic digests of Jennah Khetifa and Cham 1 with restriction enzymes EcoRI (E), BamH1 (B) and HindIII (H).M= molecular weight marker.

3.1.4. Selection for Multiple Resistance to Abiotic and Biotic Stresses

Improved germplasm with multiple resistance to abiotic stresses (drought, cold, and heat) and to biotic stresses (diseases and insects) is needed to cope with the erratic occurrence of both types of stresses in the WANA region. During the 1994/95 winter season the screening for resistance to drought, heat, cold, diseases, and insects in the Double Gradients Selection Techniques (DGST) was effective (see previous annual reports of Cereal Program at ICARDA). In the 1994 summer season (beginning of July at Tel Hadya, and end of July at Terbol), segregating populations and advanced lines were selected for heat tolerance and vernalization requirement at Tel Hadya, and for leaf and stem rust resistance at Terbol. Results of the screening are included in the specific stresses, mentioned later.

(M.M. Nachit, and M. Azrak, N. Rebeiz)

3.2. Breeding for Mediterranean Continental Environments (MCA)

3.2.1. Testing and Use of Durum Landraces and Wild Relatives

Durum landraces were assessed for traits associated with productivity in the Mediterranean continental environment (MCA) at 3 different environments in Syria, Tel Hadya, Himo, and Mjarja. Preliminary results show that the traits more closely associated with high productivity are early growth vigor and fertile tillering ability. Crosses between improved genotypes and landraces with *T. dicoccoides* from Syria, Jordan, Iraq, and Lebanon were tested at Rabba in Jordan at Tel Hadya, Lattakia, and Breda in Syria and at Terbol in Lebanon. For the segregating populations targeted to the MCA, an average of 30.1% was selected, ranging between 22% for F_6 and 39% for F_7.

3.2.2. Abiotic Stress Tolerance of MCA

The continental areas are affected by drought in combination with cold during vegetative development, and heat during the grain filling period. The segregating populations and advanced lines targeted to these areas were tested at Tel Hadya and Breda. The total seasonal precipitation was 373 and 244 mm, respectively at these two sites. The mean percent of selection ranged from 38% in the F_3 to 61% in the F_6. The selection average was 53% for all segregating populations. Under the dry conditions of Breda, grain yields ranged between 768 and 2385 kg/ha. Several lines outyielded the checks Cham 1 (1733 kg/ha), Haurani (1848 kg/ha), Cham 3 (1889 kg/ha), and Omrabi 5 (1939 kg/ha).

Table 3.1.2. Grain yield (kg/ha) of entries in Advanced Durum Yield Trials (ADYT) at Breda for last 9 years, compared with Haurani.

Season	Rainfall (mm)	Grain yield (kg/ha) ADYT-C Entries Mean	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
Mean	**251**	**1512**	**2245**	**1356**

These results demonstrate the continuous progress is being made in improving drought resistance in durum. A comparison was made between the mean yield of the lines included in the advanced durum yield trials (ADYT), the maximum yielders, and the local landrace (Haurani). Table 3.1.2 shows the grain yields achieved at Breda, over the last 10 seasons. The yields of the best lines under dry conditions at Breda are presented in Table 3.1.3. The best yielding lines represent the new generation of germplasm developed from crosses with local material and selected

under Mediterranean continental dryland conditions for multiple abiotic stress resistance. These results also confirm the possibility of selecting and making genetic progress under dry conditions. The breeding work undertaken under moisture deficit shows the continuous accumulation of drought resistant genes in the new genotypes, such as Zeina and Omlahn that are showing higher performance under severe dry conditions than Omrabi 5 which has outyielded in this season Haurani by 71% and Cham 3 by 57%.

Table 3.1.3. Grain yield of some promising drought tolerant lines for continental dryland conditions at Breda, 1994/95.

Cross/entry	Grain yield		Percent of	
	kg/ha	Haurani	Cham 3	Omrabi 5
Zeina 5	2269	229	201	133
Omlahn	2045	206	181	120
Gemarido	1997	201	177	117
Zeina 6	1997	201	177	117
Blk2/Haucan	1920	193	171	113
Checks				
Haurani	992	100	-	-
Cham 3	1129	114	100	-
Omrabi 5	1699	171	-	100
LSD(0.05)	317			

The morphophysiological traits that were mostly associated with grain yield at Breda were the canopy color ($r = 0.54$, $p<0.01$), fertile tillering ($r = 0.68$, $p<0.01$), spike fertility ($r = 0.55$, $p<0.01$), and peduncle length ($r = 0.50$, $p<0.01$). The fertile tillering ability explained 46.9% and the spike fertility 5.8% of the total variability of grain yield at Breda in 1994/95 season. The continental areas are also affected by cold and terminal stress at the end of the season. Therefore, the segregating populations and the advanced lines were screened under terminal stress. The early planting method of the double selection gradients technique is used to screen for cold. More than 57% of the segregating populations were selected. Grain yield at Terbol showed a range between 1669 and 5336 kg/ha. Among the checks, Omrabi 5 showed the highest yield (4380 kg/ha), followed

by Cham1 (3740 kg/ha), and Haurani (3653 kg/ha). The highest yielding lines were crosses with durum germplasm originated from the continental areas of the WANA region (Table 3.1.4).

Table 3.1.4. Grain yield of the drought tolerant lines under favorable/cold (Terbol) and terminal stress (Tel Hadya) conditions, 1994/95.

	Grain yield(kg/ha)		
Cross/entry	Breda	Terbol	Late Planting
Zeina 5	2269	3028	1000
Omlahn?	2045	3728	1019
Gemarido	1997	3228	742
Zeina 6	1997	3195	1277
Blk2/Haucan	1920	3144	1279
Checks			
Haurani	992	2653	938
Cham 1	1129	2740	925
Omrabi 5	1699	4380	1627
LSD(0.05)	317	929	384

Similarly, the late and summer sowing of the DSG-technique was used to identify material resistant to terminal stress (drought + heat). Table 3.1.4 shows that although improvement in drought tolerance was achieved by producing better yielding genotypes than Omrabi 5, combining multiple stress (drought/cold/heat) resistance in a single genotype (as in the case of Omrabi 5) continues to be a very difficult task. However, genotypes like Zeina and Omlahn show the progress made in developing more productive durums for the dry areas. However, by targeting the breeding activities to specific agroecological areas, the stresses temperature extremes (cold and heat) are given different weights in each area.

3.2.3. Biotic Stresses

3.2.3.1. Disease Resistance

Crosses were made to upgrade resistance to the main diseases encountered in the Mediterranean continental areas (yellow rust, common bunt, and to a less extent

Septoria tritici, leaf rust, stem rust, and BYDV). All crosses had at least one parent resistant to yellow rust. The segregating populations were screened for resistance to yellow rust and wheat stem sawfly in the winter cycle; and to leaf and stem rusts in the summer cycle, in addition to abiotic stresses. More than 30% of all segregating populations of MCA were advanced to the 1995/96 winter cycle, after selection for resistance to the above mentioned stresses. The continental durum material possesses high levels of resistance to yellow rust, however, the level of resistance to common bunt is still low (Table 3.2.1). Durum genotypes carrying resistance to a range of 8 biotypes of common bunt from WANA region and yellow rust, were identified. The genotype Kristal showed the highest level of resistance to all common bunt isolates, except to the Turkish isolate number TR12. However, the genotypes number 2, 3, and 4 (Table 3.2.2 showed low percentage of infection, 0.7, 0.0, and 0.7, respectively. Special effort will be given in the future to improve the common bunt resistance in durum, although most of the seed is chemically treated before planting

Table 3.2.1. Reaction of advanced durum lines to yellow rust and common bunt, ADYT-MCA, 1995.

Disease	Year	Average	Min.	Max.
Yellow rust(ACI)*	1994	4.1	0.2	44.0
	1994		0.2	55.0
Common bunt (%)	1994	25.6	1.4	66.2
	1994	23.1	97.5	

* ACI = Average Coefficient of Infection

Table 3.2.2. Resistant lines to common bunt(CB) and yellow rust (YR)

Entry	CB infection (%)	YR reaction
1 Kristal	1.3	10MR*
2 Lahn//Gs/Stk	7.5	Tr**
3 Cp/GVZ156//Kobak/Amarelo/Hayn..		10.55MR*
4 Plc/Cr//Rabi/Bit/3/Bye/Tc/Gs..	12.2	TMR***
5 96DACB95	5.2	1R

* MR = Moderately resistant, *** Tr = Traces; TMR = Traces to moderately resistant.

Durum gene-pools with resistance to common bunt (*Tilletia foetida* and *T. caries*), *Septoria tritici (Mycosphaerella graminicola)*, yellow rust (*Puccinia striiformis*), leaf rust (*Puccinia recondita*), and stem rust (*Puccinia graminis*), powdery mildew (*Erysiphe graminis*), and BYDV were assembled and distributed to NARSs on request.

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

3.2.3.2. Stem Sawfly

Crosses made for resistance to stem sawfly were subjected to natural infestation by stem sawfly at Breda and Tel Hadya. The pedigrees of the resistant lines show that most of the resistance used in the durum breeding program originates from Haurani (Table 3.2.3). This resistance is not related to solid stem. The resistant lines have hollow stem, a desirable trait for using straw as animal feed. Crosses with solid stem landraces from Morocco were also made.

Table 3.2.3. Some resistant durum genotypes to sawfly with their percentage infection, Saraqueb, 1995.

Cross	Pedigree	Infection (%)
Awal2/Bit	ICB84-0322-ABL-7AP-TR-AP-21AP-OTR	0.27
Ru/Mrb15	ICD84-1257-8AP-OTR	0.55
Awalbit-6	ICB84-0322-ABL-5AP-TR-AP-151AP-OTR	0.63
Mrb11//Snipe/Magh	ICD85-0538-ABL-TR-9AP-OTR	0.83
Bit/Creso	ICD84-34346-2TR-2AP-1AP-OAP	0.83
Marrout	ICD84-52612-7AP-4AP-0AP	0.83
D-2/Bit	ICD84-20796-4AP-6AP-2AP-0AP	1.11
IC19939 (Mor)		1.69
Rufom-4	ICD84-1257-14AP-TR-13AP-0TR	2.22
Heider//Mt/Ho	ICD86-0414-ABL-TR-2AP-TR-10AP-TR	4.12
IC16143 (Mor, Solid stem)		4.44
Haurani		1.75

3.2.4. Grain Quality

The advanced genotypes developed for the Mediterranean Continental Areas (MCA) were analyzed for protein content,

SDS-sedimentation test, yellow pigment, and kernel weight. Table 3.2.4 shows some of the genotypes with high quality both in Breda and Tel Hadya. They were also analyzed for DNA-gliadin (γ-42 and γ-45) and DNA-LMW glutenin (LMW-1 and LMW-2) subunits which are highly related to gluten strength (Table 3.2.5). This test has been conducted for the last two years, and in both seasons the percentage of lines developed for MCA had LMW-2 subunits, clearly reflecting the improvement in quality in the breeding lines for these areas. Haurani, Omrabi 5, and Cham 3 were used as good quality checks (LMW-2 type), while Cham 1 was used as poor quality check (LMW-1 type).

Table 3.2.4. Some durum genotypes with high levels for quality traits, ADYT-MCA, Breda and Tel Hadya, 1994/95.

No.	Genotype	protein	SDS	SDSI	TKW	YP
112	ADYT	17.9	40	2.2	36.5	8.0
217	ADYT	15.7	42	2.6	36.0	6.1
219	ADYT	14.7	40	2.7	43.1	5.9
310	ADYT	13.5	35	2.6	51.3	6.3
407	ADYT	15.7	44	2.8	37.5	7.9
422	ADYT	15.9	40	2.5	44.2	6.6
424	ADYT	14.6	40	2.7	41.8	5.2
508	ADYT	14.9	41	2.7	46.0	5.2
509	ADYT	14.6	43	2.9	42.2	5.5

Table 3.2.5. Frequency (%) of DNA - γ 42/45 gliadins and DNA LMW 1/LMW 2 in the durum advance lines targeted to Mediterranean Continental Areas (MCA), 1993/94 and 1994/95.

	ADYT-MCA	
	1994	1995
DNA Gliadins(%)		
γ 42	-	11.8
γ 45	-	82.2
γ 42/γ 45	-	9.3
DNA Glutenin(%)		
LMW 1	9.2	6.8
LMW 2	90.8	90.7
LMW 1/LMW 2	-	2.5

(M.M. Nachit, M. Labhilili, A. Saleh, M. Baalabki, R.D´Oviedo, E.Porceddu)

3.2.5. Productivity and Yield Stability

The performance of stable yielding durum genotypes combining yield potential with abiotic and biotic stress resistance is shown in Figure 3.1.1, The data are from the RDYT-LR (Continental Areas) conducted at 11 locations in the Mediterranean dry areas in 1993/94. This material was developed for erratic environmental conditions common in WANA region. The durum advanced material showed high performance and stability in the Mediterranean region. The mean for stable productivity of newly developed durum genotypes was 34.1% better than that of Cham 1, the standard check.

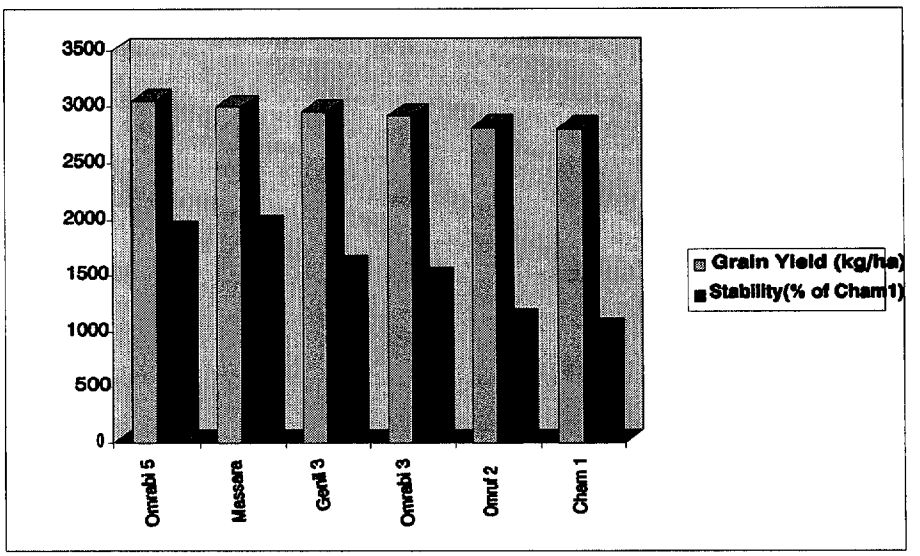

Fig. 3.1. Durum genotypes with stable productivity in the Mediterranean continental areas, RDYT-LR, 1993/94. Relative stability(%) = (MDMYL of Check Entry/MDMYL of Test Entry) x 100. MDMYL = Mean of difference from maximum highest yielder at each location divided by location mean.

3.2.6. On-farm Trials, Large Scale Testing, and Seed Multiplication:

In 1994/95 season 1.5 tons of certified seed of Omrabi 3 (released in 1994 as Cham 5) were given to the Syrian Organization for Seed Multiplication for seed increase, and 50 tons of certified seed were produced for commercial production. About 80.000 tons of Cham 3 (released as Korifla in 1987); and 16 900 tons of Cham 1 released in 1983 were produced and distributed to farmers. Omrabi 3 is a cross between Haurani and Jori C69 which went through the selection strategy developed by the durum breeding program described earlier. Later it was also tested through the international nurseries in the WANA region. Omrabi 3 showed high productivity and yield stability in the MCA. It was included in the Syrian on-farm trials and the large scale testing for 4 years. Omrabi 3 combines high productivity with resistance to drought and cold. It also possesses good quality properties for making burghul and durum bread in Syria. It shows better performance than Haurani, Cham 1 and Cham 3 in stressed and non stressed conditions. Omrabi 3 is also released in Tunisia for El Kef province, and it was selected for further tests in the continental areas of Algeria (interior plains). A sister line of Omrabi 3 was also released in Turkey under the name of Aydin-93 for the continental areas (South-East Anatolia, Diyarbakir). Another sister line, Omrabi 5 was selected and proposed for release in Iran. In Syria, the line Omruf 1 had showed promising results during the last 4 years in onfarm trials and in the large scale test trials. In 1994/95 season, it has outyielded Cham 1 in several sites (Table, 3.2.5).

Table 3.2.5. Yield performance (kg/ha) of Omruf 1 in comparison to Cham 1 in large scale test trials in Syria, 1994/95.

Variety	Grain Yield			
	Afice	K.Khasher	Tartab	Mean
Omruf 1	6382	3677	2901	4320
Cham 1	4836	3473	3008	3772

Several lines also showed promising results in the on-farm trials of Syria and other countries, such as Stojocri, Massara, Omruf, Omsnima, Chanst, and Genil.

(M.M. Nachit, M. Michael, A. Shehade)

3.3. Progress in Mediterranean Temperate Areas (MTA)

3.3.1. Germplasm Testing

For the Mediterranean Temperate Areas (MTA) more than 450 crosses were made, mainly with landraces from Morocco, Tunisia, Libya, Portugal, Jordan and Spain, and with parental material carrying resistance to Hessian fly, root rot, leaf rust, and BYDV. The segregating populations were screened at Tel Hadya and Breda for stem sawfly, drought, and terminal stress during winter, and at Terbol and Kfardan for heat, leaf, and stem rust and BYDV in summer. More than 150 populations were grown in Tunisia (Beja) for septoria tritici resistance, Morocco (Settat) for Hessian fly and root rot screening, and Jordan (Rabba) for terminal stress testing. The Rabba station is used for terminal stress testing, because of its typical weather pattern, in which rainfall stops at the end of February when hot winds from south-east starts to blow. This normally happens when the durum plant is at the booting stage. The average frequency of selection for the segregating populations was 27.3% with a range between 16% for F_2 and 41% for F_8. The selected material was advanced for further tests and selection in 1995/96 season.

3.3.2. Breeding to Tolerance to Abiotic Stress in MTA

The Mediterranean Temperate Dryland is characterized by drought and terminal stress. The mean grain yield under MTA conditions was 1097 kg/ha and the range was between 99 and 1740 kg/ha. The grain yields of the best lines under dry and terminal stress conditions are presented in Table 3.3.1. The best yielding lines represent the new generation of germplasm developed and selected under Mediterranean Temperate Dryland conditions. These lines

also outyield Omrabi 5, the best check under MTA conditions. The results also show that it is possible to combine tolerance with moderate level of yielding ability.

Table 3.3.1. Grain yield of drought and terminal stress tolerant promising lines for Mediterranean Temperate Areas (MTA), Tel Hadya, 1994/95.

	Grain yield (kg/ha)	
Cross/entry	Stress	nonstress
Awalbit?	1740	5310
Qte/Erp//Mal/3/Unk	1719	3918
Chahba88/Mrb11	1707	3410
Chanst	1646	4784
Gdo...	1637	4877
Mrb5/Omguer 3	1622	4043
Checks		
Omrabi 5	1586	4533
Cham 1	1230	4340
Korifla (Cham 3)	1146	3806
LSD(0.05)	356	1333

The morphophysiological traits more closely associated with grain yield under this environmental condition are days to heading ($r = -0.57$, $p<0.001$), and plant height ($r = 0.485$, $p<0.001$).

3.3.3. Biotic Stresses

3.3.3.1. Hessian Fly

Until last year, no resistance to Hessian fly was available in durum wheat, although it existed in bread wheat and other wild relatives. Therefore, a crossing program was established jointly with the durum breeder and entomologist of INRA/Morocco to incorporate genes of resistance to Hessian fly. Several simple crosses and back-crosses were performed with different Hessian fly resistance genes originating from different *Triticum* species. Screening for Hessian fly resistance was made by INRA/Morocco. As result, several resistant lines have been found and one of them is included in the catalogue for release (INRA 1770 = 2777/Javardo). Additionally, other Hessian fly resistant (H5) lines which are more productive and tolerant to drought and heat (SD8036/Omtel-1//Awalbit-

3) are now under increase to be proposed for on-farm yield test in Morocco (Table 3.3.2). However, all these genotypes are originated from the same cross, and therefore have the same resistance background (the gene involved is H5 from the South Dakota 8036 line). Further, a durum accession No.829 was also identified in 1995 as resistant to Hessian fly.

Table 3.3.2. Pedigree and selection history of lines combining resistance to Hessian fly with tolerance to heat and drought DHFN-MA, 1995/95.

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

In the summer planting 1995, 27.3% of the segregating populations with resistance to Hessian fly were also selected resistance to leaf and stem rust to obtain lines with combined resistance to Hessian fly and leaf rust with tolerance to terminal stresses.

Screening of *Aegilops spp*. collected from the areas where Hessian fly is endemic showed that several accessions of *Aegilops Spp*. were resistant. The resistance is possibly due to different genes from those already known.

Reaction of *Aegilops spp*. to Hessian fly is as follows: 25 resistant populations out of 124 *Ae. Ovata* originated from Morocco, Portugal, and Syria were identified; 6 out of 56 *Ae. Triuncialis* from Morocco and Portugal; 2 out of 11 *Ae. Triaristata* from Morocco; 1 out of 4 *Ae. Cylindrica* from Turkey; 2 out of 4 *Ae. ventricosa* from Morocco; and 5 out of 7 *Ae. squarrosa* from unknown origin.

The *Aegilops* populations showing resistance were crossed with durum genotypes adapted to temperate dryland conditions. In 1994/95 more than 350 crosses were made to

upgrade the Hessian fly resistance in durum. Embryo rescue technique was employed. The advanced populations of the Hessian fly crossing program were also subjected to screening for other biotic and abiotic stresses and grain quality tests.

(M.M. Nachit, A. Asbati, M.Azrak, Nsarellah, M. Bouhssini,M. Baum, O. Benlhabib, A. Comeau)

3.3.3.2. Screening for Root Rot Resistance

The testing for root rot tolerance was made by inoculating through spraying the fungal suspension (*Fusarium culmorum* and *Heminthosporium sativum*) on the seeds which were left to dry before sowing. Data were taken on emergence, number of tillers and spikes, and on white heads percentage. The towel paper technique is used to screen for resistance to root rot. From the durum core collection 10 highly resistant populations/cultivars were identified, whereas 18 were moderately resistant, 11 were moderately susceptible, and 86 were susceptible. The resistant ones are Cannizzara from Italy, Kabir-1 and Omlahn 3 from Aleppo, Roqueno from Spain, Ambral from France, Pelissier, Coulter, Macoun, and DT from North America, and Santa Marta 2442 from Portugal. This material will be used extensively in the crossing program along with the population carrying resistance to Hessian fly, in order to improve the performance of durum in the Mediterranean temperate dryland.

(N. Nsarellah, M.M. Nachit, M. Mergoum, A. Asbati, M. Azrak)

3.3.3.3. Leaf Rust and *Septoria Tritici*

Until recently, durum germplasm had low levels of resistance to leaf rust. Most of the sources of leaf rust resistance reported in durums, are ineffective in the Middle East. Therefore, emphasis was placed on broadening the genetic base for leaf rust resistance through the use of resistance genes from diverse sources including wild relatives such as *Triticum monococcum*. Results are encouraging as resistance to leaf rust has started to

build up in the program. The level of resistance of advanced lines show that the average coefficient of infection (ACI) to leaf rust is 25.2 with more than 17.1% of all the advanced lines having an ACI less than 10 (Table 3.3.3).

The resistance to *Septoria tritici* blotch, the most important disease of durum in the Mediterranean region, particularly in the temperate areas, is at acceptable levels (Table 3.3.3). Almost 90% of advanced lines show reactions below 5. The *Septoria tritici* resistant durum material is widely utilized by NARSs, particularly by INRAT, Tunisia. Because of the frequent concurrent occurrence of leaf rust and Septoria tritici attack in the Mediterranean temperate areas, efforts were made to incorporate the resistance of the both diseases to the improved germplasm targeted to this area (Table 3.3.4).

Table 3.3.3. Reaction of advanced durum lines to leaf rust and *septoria tritici* in ADYT-MTA, 1994.

Disease reaction		Average (ACI)	Min.	Max.
Leaf rust (ACI)	1993/94	25.2	1.5	48.3
	1994/95		0.4	55.7
*Septoria tritici**	1993/94	3.7	2.0	6.5
	1994/95		1.5	8.5

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

Table 3.3.4. durum lines combining low level of Average coefficient of infection (ACI) of leaf rust and *Septoria tritici* resistance.

No/Entry	Leaf rust ACI	*Septoria tritici**
613 DAT95	0.7	4.5
822 DAT95	2.1	2.0
906 DAT95	1.0	4.0
188 DL95	1.1	3.0
617 DPT95	1.5	2.0
618 DPT95	1.5	1.5
619 DPT95	1.5	4.0
57 DACB95	2.5	4.5
67 DACB95	3.0	4.5
103 DACB95	4.5	4.5

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

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

After the successful introduction of resistance to *Septoria tritici* in the durum genotypes targeted for the MCA, there was the need to increase the resistance to *Septoria tritici* also in the germplasm targeted to the MTA. This was done by decentralizing the work to the Tunisian durum program of INRAT with provision of resistant durum material and funds to incorporate resistance in the germplasm for the Tunisian favorable areas and similar areas in other Maghreb countries. Sources of resistance to *Septoria tritici* are already identified and crosses were made during spring 1994/95 to high yielding material and to widely grown commercial varieties and promising lines. A Tunisian *Septoria* nursery was assembled and is distributed in the Maghreb region. The lines included in the nursery originated from the ICARDA/CIMMYT joint breeding program, from the ICARDA septoria nursery, and from the INRAT durum breeding program. The development of productive genotypes with good resistance to *Septoria tritici* blotch, good quality, and good adaptation to favorable conditions is the objective of this activity. Because of the extreme drought in 1994/95 crop season in Tunisia, incidence of *Septoria tritici* was low in all sites where the material was planted. However, agronomically well adapted lines and populations were selected and advanced for screening in 1996.

Very little work is done on powdery mildew, blackpoint, and tan spot. Although these diseases are restricted to specific areas, they affect production and grain quality. Within the IFAD durum dryland project, the work on powdery mildew and tan spot will be enhanced in collaboration with NARSs of Morocco/Tunisia and the work on blackpoint with the NARS of Lebanon.

(M.S. Gharbi, A.R. Maamouri M.M. Nachit, A. Asbati, M. Azrak, Y. Zuhair)

3.3.4. Grain Quality

The advanced genotypes Developed for MTA were also analyzed for the quality traits. Table 3.3.5 shows the genotypes with the highest means at Breda and Tel Hadya for quality traits. They were also analyzed for DNA-

gliadin (γ-42 and γ-45) and DNA-LMW glutenin (LMW-1 and LMW-2) subunits. 92.4% of the lines developed for MTA carried the γ-45, but 79.2% carried glutenin LMW-2 subunits. However, in 1994 LMW-2 glutenin subunit, was present only in 69.3% of the test lines (Table 3.3.6). This percentage is below the one found in the lines included in the Mediterranean Continental Areas.

Table 3.3.6. Some durum genotypes with high quality, ADYT-MTA, Breda and Tel Hadya, 1994/95.

No.	Genotype	protein	SDS	SDSI*	TKW	YP
713	ADYT	14.8	41	2.8	49.2	6.3
714	ADYT	14.1	37	2.6	46.4	6.3
724	ADYT	15.1	40	2.6	44.5	7.0
1007	ADYT	14.8	43	2.9	40.2	6.2

*= Sedimentation test / protein content (%)
(ml.)

Table 3.3.7. Frequency (%) of DNA - g 42/45 gliadins and DNA LMW 1/LMW 2 in the durum advance lines targeted to Mediterranean Temperate Areas (MTA), 1993/94 and 1994/95.

	ADYT-MTA	
	1994	1995
DNA Gliadins(%)		
γ 42	-	9.3
γ 45	-	92.5
DNA Glutenin(%)		
LMW 1	30.8	20.8
LMW 2	69.3	79.2

(M.M. Nachit, M. Labhilili, M. Baalabki, R. D´Ovidio, E. Porceddu)

3.3.5. Productivity and Yield Stability

Durum genotypes combining high productivity with yield stability are shown in Figure 3.2. The data from 11 sites in the Middle East and Tunisia were used to determine productivity and yield stability of the genotypes included in the regional yield trial (RDYT-MR). This material is targeted for areas with favorable conditions and

irrigation, where, however abiotic stresses, such as drought and extreme temperatures (cold and heat) do occur. The mean for stable productivity of the best genotypes developed in Aleppo was 30.7% higher than that of Cham 1. The results of the RDYT-MR for favorable areas, similar to the results of RDYT-LR, demonstrate the importance of using local germplasm and selection under the environmental conditions of the target production area.

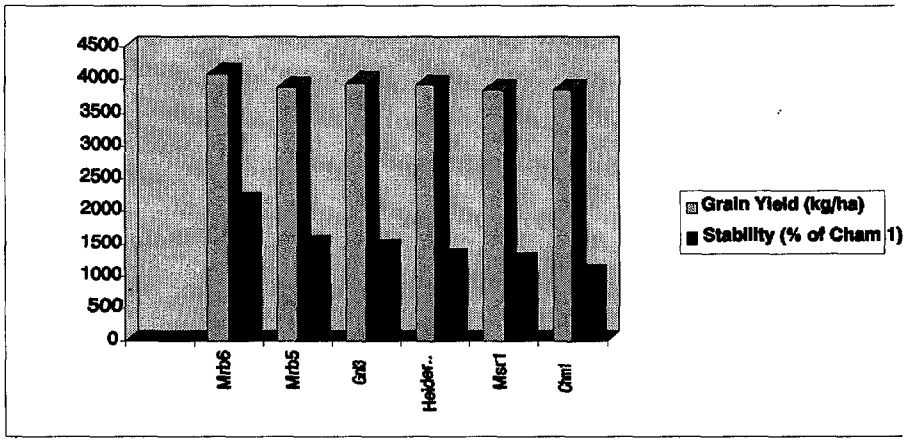

Fig.3.2. Durum genotypes with stable productivity in the Mediterranean favorable areas, RDYT-MR, 1993/94. Relative stability(%) = (MDMYL of check entry/MDMYL of test entry) x 100. MDMYL = mean of difference from maximum highest yielder at each location divided by location mean.

The germplasm developed at Aleppo for the favorable areas of WANA has more resistance to abiotic stresses and to the prevailing diseases and insects of WANA region, particularly to yellow and leaf rust and stem sawfly, than the material developed in Mexico and thus has higher and more stable yield in this region.

(M.M. Nachit, M. Azrak, A. Asbati, Y. Zuhair)

3.3.6. On-farm Trials, Large Scale Testing, and Seed Multiplication

High yielding genotypes for the MTA were produced in collaboration with NARSs. However, the adoption of durum germplasm in some major durum producing countries is still slow, because of the occurrence of Hessian fly in the major durum producing country with temperate dry areas. Hessian fly had hampered the speed of release of drought tolerant genotypes in Morocco. However, within the joint work with INRA morocco, several lines were recently identified with high level of resistance to Hessian fly. In the areas where Hessian fly is not a limiting factor, durum genotypes targeted to MTA were released (Libya, Jordan, Iraq, and Iran). Omrab 3, Omrabi 5, Omlahn 1, and Genil 5 are among the best performing genotypes in these areas. For example, Table 3.3.8 shows the performance of Omrabi 5 in comparison to Waha and the local check in Jordan (Haurani) and in Iraq (Abu Ghraib). These results demonstrate again the productivity of the abiotic stress tolerant durum material, such as Omrabi 5. In Iran, Genil 5 was identified as highly adapted genotype for dry areas.

Table 3.3.8. Mean performance of Omrabi 5 in Jordan and Iraq.

Variety	Yield (kg/ha)	% of Check
Jordan		
Omrabi 5	2409	128
Haurani (Check)	1881	100
Iraq		
Omrabi 5	2025	302
Abu Ghraib (Check)	670	100

3.4. Progress in Mediterranean High Altitude Environment (HAE)

Crosses for high altitude areas were made in 1994/95 mostly with Turkish and Algerian cold resistant durum landraces. Crosses with *T. dicoccoides* and Turkish landraces showed good adaptation and resistance to the constraints encountered in the high altitude areas. The cold screening for segregating populations and advanced lines was made mainly in the high altitude areas: Yabroud

and the simulated conditions of early planting at Tel Hadya in Syria, Terbol and Kfardan in Lebanon, Annaceur in the Atlas mountains of Morocco, and Haymana, Hamidye, Eskisehir, and Erzurum in the Anatolian plateaux of Turkey.

The screening for yellow rust and stem sawfly was done at Tel Hadya and Terbol (winter sowing), for tan spot resistance at Annaceur, for leaf and stem rust resistance at Terbol (summer-sowing), and for boron toxicity at Tel Hadya (green house), and at Hamidye, Eskisehir, and Haymana. The average frequency of selection for the segregating populations was 26.6% with a range between 10% for F_2 and 61% for F_6. The selected material was advanced for further tests and selection in the Syro-Lebanese mountains and Anatolian and Atlas plateaux, and for grain quality in 1995/96.

3.4.1. Yield Testing and Boron Toxicity

Durum lines adapted to high altitude were tested for tolerance to boron toxicity and at the same time tested for grain yield. The most tolerant lines with high yield in Turkey (Haymana), Lebanon (Terbol), Portugal (Elvas), and Syria (Breda) are shown in Table 3.4.1. These results also indicate the importance of using local germplasm. The landraces Kobak and Haurani and *Triticum dicoccoides* were largely represented in the pedigrees of the genotypes tolerant to boron.

Table 3.4.1. Performance of tolerant/susceptible durum genotypes to boron in high altitude areas, RDYT-HAA, 1994/95.

Entry		Mean Grain Yield(kg/ha)			
No.	Name	Haymana	Terbol	Elvas	Breda
2	Omrabi 5	8237	3855	2793	1933
8	Hrn/T.Dic../Chm1	6534	3666	2130	1083
10	Chm1/T.Dic..	6784	3455	1176	1800
20	Wadalmez 6	7207	2722	2454	1500
21	Omrabi 6	8323	4233	2260	2150
16	Cham 1	6812	3144	2170	1500
22	Kunduru	7064	3300	1029	1400
	LSD(0.05)	1387	847	645	713

3.4.2. Productivity and Yield Stability

Many of the lines included in RDYT-HA showed resistance to cold and gave high grain yields in high elevation areas where vernalization requirement is satisfied. Stable or consistentlty productive durum genotypes combining yield potential with cold, yellow rust and common bunt resistance are shown in Figure 3.4.1 based on results from 5 locations.

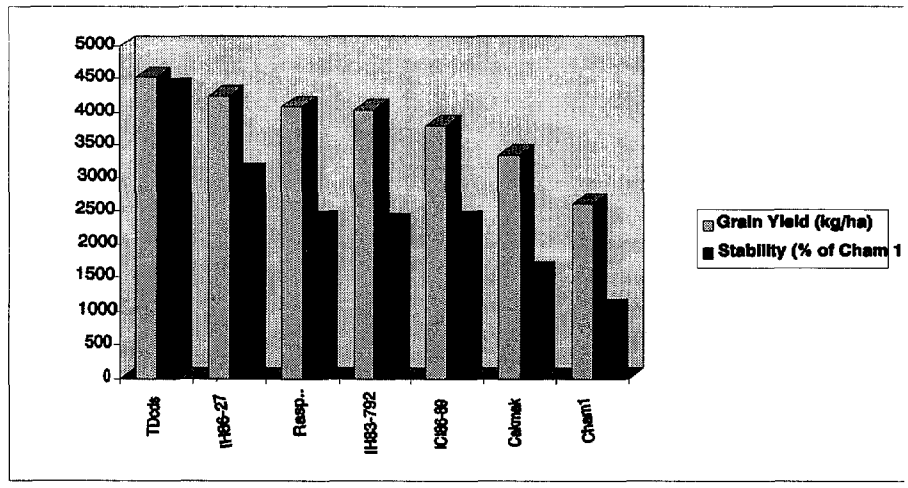

Fig.3.4.1. Durum genotypes with stable productivity in the Mediterranean high altitude areas, RDYT-HAA, 1993/94. Relative stability(%) = (MDMYL of Check Entry/MDMYL of Test Entry) x 100. MDMYL = Mean of Difference from maximum highest yielder at each Location divided by location mean.

The results of this test show, once again, that the promising durum genotypes for high altitude areas derive from crosses with WANA landraces and wild relatives, particularly with *T. dicoccoides*. The stable productivity of genotypes developed for high altitude areas was 187.6% better than that of Cham 1, whereas that of Cakmak, the leading Turkish variety, was 56% better than Cham 1. The results are encouraging and demonstrate the importance of using local germplasm and selection under environmental conditions similar to those of the production area.

3.4.3. On-farm Trials, Large Scale Testing, and Seed Multiplication

For the Atlas mountains, INRA Morocco has identified Omrabi 6 which was proposed for release in these areas. Omrabi 6 and Massara are also promising in the high plateaux of Turkey, Lebanon, and Algeria. Massara (=Mrb3/4/BYE*2/Tc//ZB/W/3/Cit) and Atlal have significantly outyielded most of the varieties tested in a multilocation trials in the areas of Tessala and Zidane in Algeria.

In Lebanon for the high altitude areas (above 1200 m asl and up to 1700 m asl) several genotypes were identified during the last two years to be tested in the onfarm trials (Table 3.4.2). There are two types of environments: dry and favorable. Therefore two types of germplasm were selected for these areas: 1) tolerant to cold and drought, such as Omrabi 17 and Tel Amara 5, and 2) tolerant to cold and responsive to high inputs, such as Lahn and Massara 1. Because of the performance of Lahn in farmers fields in the Bekaa valley, where up to 6 t/ha was achieved, Lahn will not be grown on large scale in farmers fields and tested for Burghul and Kishk at the Burghul and Kebba factories in Zahlé Area. While the Lebanese consumers and market prefer dark red color for the products Burghul and Kebba, most of the Lebanese durum landraces, e.g. Bekai, have dark red grain. Therefore, a specific crossing program was established in Terbol with the Lebanese Agricultural Research Institute (LARI) to incorporate the trait red color in the durum germplasm targeted to the highland of Lebanon and Syria.

Table 3.4.2. Yield performance (t/ha) of some promising lines in Terbol and Kfardan, Lebanon, 1994/95.

Genotype	Grain yield (kg/ha)	
	Terbol	Kfardan
Omrabi 17	4.1	2.6
Massara 1	4.2	2.4
TA 5	4.1	2.4
Omrabi 5	4.0	3.1
Waha (Check)	3.9	2.1

3.5. Micronutrient Studies

3.5.1. Boron Toxicity Tolerance

3.5.1.1. Haurani versus Mexipak

Haurani (durum wheat) and Mexipak (bread wheat) were the two dominant wheat cultivars in Syria. In previous screening for Boron tolerance, Mexipak was found to be Boron (B) sensitive. Since Boron tends to occur in dry areas, it is postulated that Haurani may be more tolerant than Mexipak to Boron, thus explaining why it is more widely grown in drier areas than Mexipak. A pot experiment was conducted under plastic-house conditions to test this hypothesis. Four soil Boron levels were created by mixing 0, 12.5, 25 and 50 mg B/kg soil, giving 0.4, 3.1, 5.8 and 10.0 ppm hot water extractable B (designated as B0, B3, B6 and B10), respectively.

Although Haurani had significantly higher Boron toxicity symptom scores than Mexipak at B3, B6 and B10, and had similar shoot B concentrations as Mexipak (Table 3.5.1), its shoot dry weight at tillering, number of head and grain yield were less affected by high soil B levels than Mexipak. Thus it appeared that Haurani is more tolerant to B toxicity. However, grain yield of Mexipak was significantly higher than that of Haurani at B0, B3 and B6. The yield advantage of Mexipak over Haurani at low soil B levels might have caused farmers to plant Mexipak in higher rainfall areas, while reserving the drier areas for Haurani.

(S.K. Yau, J. Ryan, M. Nachit, M.C. Saxena)

Table 3.5.1. B-toxicity symptom score, shoot dry weight and shoot B concentration at tillering, and head number and grain yield of Haurani durum and Mexipak bread wheat at four soil B levels.

Cv	B level	Symptom score[1]	Shoot B conc. (ppm)	Shoot dry wt. (g/pot)	Head per pot	Grain yield (g/pot)
Haurani						
	0	0.0	13	1.83	4.0	3.46
	3	2.0	106	1.64	3.75	3.23
	6	3.0	344	1.48	3.75	3.95
	10	4.0	913	0.80	3.0	3.56
Mexipak						
	0	0.0	17	1.84	5.0	7.01
	3	1.0	137	1.26	4.0	6.21
	6	1.75	342	1.25	3.0	6.20
	10	2.75	1020	0.60	3.5	3.95
	$lsd_{(0.05)}$	0.41	140.2	0.536	1.00	1.585

[1] 0 - 5 scale: 0 = no symptom, 5 = severe symptoms

3.5.2. Seedling Test

Observation Nursery for High Altitude Areas

Ninety-four advanced durum lines from the 1994-95 Regional Observation Nursery for High Altitude Areas were tested in a plastic house in soils mixed evenly with boric acid (50 mg B/kg soil, giving a hot water extract of around 12 ppm). As in previous years, there was only moderate, though significant, variation between entries in symptom score, and all lines had higher symptom scores than the tolerant bread wheat check, Halberd. Entries 8, 12, 16, 33, 36, 43 and 46 had the least symptom scores of 1.5. The tolerant durum check, Oued Zenati, had a score of 2.0, and the score was 3.5 for the sensitive check, Kunduru.

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

Durum Core Collection

To look for higher tolerance to B toxicity, germplasm accessions were also screened. Screening was carried out at a higher soil B level (100 mg B/ kg soil added), under

which sensitive plants had retarded growth with yellowish to pale green color.

From the Durum Core Collection of 125 entries, which includes many landraces from WANA and southern Europe, the following were selected based on growth: Chahba 88, Siliana, followed by Kishk, Jordan Coll. 86 No. 80, Tensift-1, Jordan, Awali-1, H.O-FAO 25918, Aric 31708.70/3/Bo//C.de Chile/Br /4/Cit /Gta, N. Dakota 86 line No. 10, Wakooma, Entre largo de Montijo No.7621 and Candeal de Grao Escuro No. 7746. These entries had a growth score as good as the Halberd bread wheat. The sensitive check, Kunduru, had the worst growth score.

(S.K. Yau, M. Nachit)

Germplasm Accessions

Screening of 25 durum wheat accessions from each of six WANA countries (Afghanistan, Iran, Iraq, Jordan, Syria and Turkey) was also carried out at high soil B level (100 mg B/kg soil). Many accessions from Afghanistan looked outstanding, but they were later found to be bread wheat. The most tolerant durum accessions were: ICDW 9762, 9833 and 9761 from Afghanistan; 7743 and 9975 from Iran; 6267 and 6268 from Turkey; 11470 from Syria; 20869 from Jordan; and 6145 and 7327 from Iraq. These accessions had a growth score as good as Halberd, and better than the tolerant durum check, Oued Zenati.

(S.K. Yau, J. Valkoun)

3.5.3. Yield Testing

Out of the 134 advanced lines screened last season, 4 lines with low B-toxicity symptoms were grown in pots up to maturity under a plastic house. There were two treatments: control (0.4 ppm hot water extractable B) and +B (50 mg B/kg soil, giving a hot water extract of 10 ppm B). All lines showed a substantial reduction in grain yield under the +B treatment. The two best lines, Kristal and 'Bd 272 /T.dic.Sy 20101 //Cham1 /3/Cham1' suffered a 20% yield decrease, which was lower than that of the durum check, Gezira 17, but higher than that of Halberd.

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

Zinc Deficiency Tolerance

In an experiment comparing seven durum wheat genotypes grown in a low-zinc soil, zinc deficiency symptoms were observed during late February to early Stork, Cham 3, Cham 5 and the unknown sensitive check, but not on Haurani and Cham 1. Symptoms appeared as yellowish patches in the central part on middle-aged leaves, but disappeared after the leaves with symptoms became senescent. The appearance of such transient symptoms in five of the seven durum genotypes but not in the seven barley genotypes tentatively suggests that durum wheat may be more sensitive to zinc deficiency than barley (see section 2.1.7.5).

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

3.6. International Nurseries

3.6.1. Nursery distribution

The 1995/96 regional durum wheat nurseries were restructured. Instead of dividing the observation nurseries and yield trials for 'semi-arid areas' or 'favorable areas', nurseries were targeted to 'temperate areas' or 'continental areas'. The continental areas sets are meant for Mediterranean continental dryland areas with fluctuating rainfall patterns and cool to cold winters where cold damage can occur around tillering and anthesis. The temperate sets are meant for Mediterranean temperate dryland areas with fluctuating rainfall patterns and mild winters. With this new initiative, two separate segregating populations were assembled as well. Thus this was the first time that yield trial, observation nursery and segregating populations were made available specifically for the three agro-ecological zones, namely Mediterranean temperate, continental and high altitude areas (Table 3.3.1). Four new germplasm pools, one each for yellow, stem, and leaf rusts, and Septoria tritici blotch, were also assembled, expanding the number of durum nurseries to 15. A total of 455 sets of nurseries were distributed this year.

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

Table 3.6.1. Regional durum wheat nurseries for 1995-96.

Nursery	Abbre-viation	No. of entries	No. of sets distributed
Mediterranean Continental Areas:			
Segregating Populations	DSP-CA	30	22
Observation Nursery	DON-CA	144	27
Yield Trial	DYT-CA	24	27
Drought & Cold Tolerance Observation Nursery	DCTON	48	24
Mediterranean Temperate Areas:			
Segregating Populations	DSP-TA	41	25
Observation Nursery	DON-TA	120	44
Yield Trial	DYT-TA	24	50
Drought & Heat Tolerance Observation Nursery	DHTON	48	40
Mediterranean High Altitude Areas:			
Segregating Populations	DSP-HAA	60	21
Observation Nursery	DON-HAA	57	17
Yield Trial	DYT-HAA	24	9
Germplasm Pools			
Yellow Rust Resistance	DYRGP	12	39
Leaf Rust Resistance	DLRGP	18	40
Stem Rust Resistance	DSRGP	12	35
Septoria Tritici Blotch Res.	DSTGP	15	35

4. SPRING BREAD WHEAT IMPROVEMENT

4.1. Spring Bread Wheat Breeding

4.1.1. Introduction

During 1995 the spring bread wheat breeding program, a joint CIMMYT/ICARDA project, further emphasized the development of improved germplasm adapted to the variable and unpredictable environments of West Asia and North Africa (WANA), with special attention to rainfed areas, particularly those receiving less than 400 mm annual rainfall.

The long term objectives of the program are: a) stable and sustainable increases of bread wheat production in the rainfed, harsh environments of the region; b) develop and identify spring bread wheat germplasm with high yield and stability, acceptable disease and insect pest resistance and good processing quality in the agroclimatic conditions of WANA; c) develop breeding methodologies and identify bread wheat germplasm for the low-rainfall areas; and d) upgrade the bread wheat research and production capabilities of national programs in the region. This report presents results achieved to meet the specific research objectives set in ICARDA's Medium-Term Plan (1994-98). Activities such as germplasm development, testing, distribution, performance, and adoption, were carried out in close partnership with National Programs of WANA, with advanced institutes, with research programs/scientists of ICARDA and CIMMYT, and they lead to the identification and release of promising cultivars.

We also present our results on the role of photoperiod and vernalization on adaptation, wheat adaptation studies in the region, and on other joint strategic research activities conducted in close collaboration with NARS in WANA.

(G. Ortiz Ferrara)

4.1.2. Germplasm development

Table 4.1.1 shows the average number of crosses made during the last five years (1991-1995) classified by type. About 900 crosses are made yearly to cope with different agroclimatic regions.

Special emphasis is placed in crosses for low-rainfall areas where abiotic stresses are most important. Biotic stresses are important in the moderate to high rainfall areas of WANA where they reduce yields. About 35% of our crossing program is aimed at abiotic stresses, 44% to biotic stresses, 9% to bread making quality, and about 12% involve non-conventional material such as landraces (Table 4.1.1). The landraces used were extracted from collections made in the region. They were evaluated for two to three consecutive years under drought, cold and disease pressure before being used in crosses.

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

Table 4.1.1. Type and average number of crosses made during the last five years (1991-95) in the spring bread wheat crossing program.

Purpose of the cross	Average No. of crosses per year	% of total
Abiotic stress tolerance		35
Terminal drought	140	
Cold	105	
Terminal heat	65	
Biotic stress resistance		44
Yellow rust	107	
Leaf rust	35	
Stem rust	30	
Septoria leaf blotch	92	
Common bunt	41	
Wheat stem sawfly	40	
Hessian fly	30	
Barley yellow dwarf virus	20	
Bread making quality	83	9
Special purpose		12
Selected landraces	105	
Total	893	100

4.1.3. Germplasm Testing

The spring bread wheat breeding project follows the principle that stress tolerant material is difficult to identify unless selection is done under those stresses followed by multilocation testing.

Four environments are used by the project to select for abiotic stress tolerance. They are: a) Breda, (average long term rainfall of 267 mm), used to select under terminal drought and low fertility; b) Tel Hadya early planting (used to screen for cold stress), a simulated environment where the planting date of breeding material is shifted to early October and germplasm is grown under supplementary irrigation; c) Tel Hadya late planting (planting date end of March), which expose the breeding material to terminal heat stress; and d) Terbol, an environment in Lebanon used by the project to screen for cold under optimum moisture and fertility conditions.

Table 4.1.2. Number and percentage of bread wheat lines yielding more than the local and improved checks in different environments in Syria and Lebanon, Advanced bread wheat yield trials 1994-95.

Environment	Checks							
	Mexipak (L)		Cham 4 (I)		Cham 6 (I)		All three checks	
	No.	%	No.	%	No.	%	No.	%
Terminal drought								
-Breda:	80	54	67	46	21	14	16	11
Cold								
-TH-EP:	145	98	34	23	48	32	27	18
Terminal heat								
-TH-LP:	118	80	87	59	34	23	28	19
High input								
-Terbol:	123	84	10	7	59	40	9	6

N = 147; TH-EP = Tel Hadya early planting; TH-LP = Tel Hadya late planting; L = Local; I = Improved.

Seven advanced yield trials, with 21 entries and 3 checks each, were planted during 1994-95 at these four environments. Table 4.1.2 presents the number and percentage of lines yielding more than the local and

improved checks. The data indicates the progress being made by the project to identify germplasm with better drought tolerance than Cham 6, the main bread wheat variety in farmer's fields in the dry areas of Syria. Several promising lines were also identified with higher yields than Cham 4 the leading commercial variety in the high rainfall and irrigated areas of this country. Most of the bread wheat lines tested were superior to the local check Mexipak across the four environments. This variety has already been replaced by new, disease resistant, and high yielding varieties in Syria and other countries in WANA.

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

4.1.4. Germplasm Distribution

Improved bread wheat germplasm was distributed to national programs in West Asia and North Africa with the goal of: 1) providing promising lines for potential release as commercial varieties in those countries, and 2) collecting information on the adaptation of the lines in the region.

Close interaction with key national program staff in WANA has resulted in a number of improved genetic stocks being identified. These stocks are assembled as parental material having desirable traits and are distributed yearly, upon request, to NARS for use in their breeding programs (Table 4.1.3). A total of 1617 breeding lines have been distributed during the last nine years. This activity assists in decentralizing our breeding activities and encourage national programs to take more responsibility for generating new sources of genetic variability.

Table 4.1.3. Number of bread wheat lines with desirable genetic traits distributed to national programs as genetic stocks during the last nine years, 1987-1995.

Genetic traits:	Average No. per year	Total over nine years
High yield and stability:	38	345
Abiotic stress tolerance:		
Terminal drought	24	217
Cold	14	125
Terminal heat	14	130
Biotic stress resistance:		
Yellow rust	15	133
Leaf rust	10	88
Stem rust	6	50
Septoria leaf blotch	12	107
Common bunt	11	100
Wheat stem sawfly	15	131
Hessian fly	5	45
Selected landraces:	8	71
Bread making quality:	8	75
Total		1617

In addition to these gene pools and other improved, semi-finished germplasm, the bread wheat breeding project has also distributed early segregating populations (F_2's and F_3's) to NARS in WANA. This operation started in 1979 with the objectives of a) providing increased genetic variability and b) allowing national programs to select breeding material under their local conditions. Table 4.1.4 lists the number of F_2 and F_3 segregating populations that have been distributed to NARS in WANA, and the number of locations where these crosses have been tested during the last 13 years (1983-1995).

A total of 6835 early segregating populations have been distributed to 449 location-years within the region. The experienced obtained so far is that most NARS have released more varieties from directly introduced, semi-finished material than from early segregating populations. This trend is in agreement with results that have been documented in a recent survey carried out by the economics

program of CIMMYT[5]. Research infrastructure, budget availability, trained manpower, and overall strength of NARS are the main factors accounting for these differences.

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

Table 4.1.4. Early segregating populations distributed to national programs in WANA from 1983 to 1995.

Year	No. of accessions			Total	No.of locations	
	F2	F3			F2	F3
1983	150	-	150	32	-	
1984	150	918	1068	30	6	
1985	150	600	750	15	7	
1986	87	126	213	50	6	
1987	150	425	575	26	6	
1988	128	455	583	26	6	
1989	102	155	257	29	5	
1990	120	848	968	30	6	
1991	116	471	587	30	6	
1992	122	362	484	25	5	
1993	135	350	485	40	5	
1994	130	282	412	30	5	
1995	123	180	303	20	3	
Total	1663	5172	6835	383	66	

4.1.5. Germplasm Performance

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

Grain yield and yield stability are the most important factors to consider in Zone 1. Table 4.1.5 shows the performance of elite bread wheat lines in selected Zone 1 locations of West Asia and North Africa. All the

[5] Byerlee and Moya, 1993

seven lines shown in this Table were significantly higher (P<0.05) than the national check. This is significant considering that the national check is an improved commercial variety grown at each particular location. A considerable number of other lines in the trial also yielded significantly higher than the national check. The yield superiority ranged from 35% (El Kef, Tunisia) to 120% (Irbid, Jordan). All these lines are under extensive testing and multiplication in those countries.

Table 4.1.5. Performance* of bread wheat germplasm in the rainfed (less than 400 mm) and temperate areas of WANA. Regional Yield Trials for Semiarid Areas 1993-94.

Country (Site)	Top Grain Yielding Line	Yield (Kg/ha)	% Over NC	LSD.05 CV (%)	F
West Asia:					
Pakistan	Kvz/7C//Jun	2289	170	571	7
S. Nawrauf	NC	1344		25	
Syria	Lacfen/Chov..	3163	139	811	7
(Izra'a)	NC	2276		23	
Iran	Tevee-1	6338	183	1028	19
(Moghan)	NC	3467		15	
Jordan	Kvz/7C//Jun	2893	220	358	23
(Irbid)	NC	1311		11	
North Africa:					
Algeria	Venac	3833	140	882	10
(Setif)	NC	2747		20	
Morocco	Towpe	4744	151	1127	7
(Tessaout)	NC	3133		22	
Tunisia	Kvz/7C//Jun	2673	135	588	6
(El Kef)	NC	1973		20	

* = Based on its statistical superiority over the national check variety at each location.
F = Number of lines yielding significantly higher (P<0.05) than the national check.
NC = National check.

Yield potential and disease resistance are the most important factors responsible for the adaptation of wheat in Zone 2 (moderate rainfall with moderate to high temperatures). Table 4.1.6 shows grain yield, stability of performance, and yellow rust reaction of four promising

bread wheat lines in selected locations of Zone 2. It is interesting to note not only the yield advantage over the improved and long-term checks, but also the better yellow rust resistance in those lines. Yellow rust has become the most important foliar disease, especially in West Asia. This disease has caused considerable yield losses during the last three years in Iran, Turkey, Lebanon, Syria, Afghanistan, Iraq and Pakistan. Seed of these and other yellow rust resistant lines have been made available to these countries during 1995.

Table 4.1.6. Overall performance for grain yield and stability of promising bread wheat lines in 36 locations of West Asia and North Africa. Regional yield trial-favorable areas (RWYT-FA) 1993-94.

Pedigree	Mean Yield (Kg/ha)	Reg. coef.	Top 5*	Over NC	YR
Bloyka ICW84-0008-013AP-300L-3AP-300L-0AP	5100	1.107ns	10	9	5 MR
Dovin-1 CM84655-02AP-300AP-300L-3AP-300L-0AP	4977	0.991ns	11	6	R
Dovin-2 CM84655-02AP-300AP-300L-3AP-300L-3AP-0L	4977	1.001ns	9	4	R
Kapsw ICW86-0860-300L-300AP-0L-0AP	4960	0.965ns	10	6	R
Cham4 (Improved check)	4888	0.996ns	8	4	10 MS
Mexipak (long-term check)	4677	1.012ns	4	3	100 S

* = Total number of times that each entry ranks fifth or less. Over NC = Number of times that the entry exceeds the national check (LSD test, P=0.05, 1-sided test). ns = Not significantly different from 1.0 at P<0.05. YR = Yellow rust disease reaction at Tel Hadya under artificial inoculation.

Table 4.1.7 shows the agronomic characteristics of bread wheat germplasm that are associated with the highest and lowest record of visual selection in the dry areas of WANA. The lines with the highest average number of visual selection were more disease resistant than the lines with the lowest average selection index. The data confirms the importance of disease resistance in bread wheat germplasm

grown in the dry areas of the region. As expected, the average grain yield of the most frequently selected entries was higher that the lines with the lowest average number of visual selection. The phenology and plant height of both types of lines was the same.

Although this material was unreplicated, grain yield correlated well with the number of times that a line was visually selected. These results indicate the value of visual selection in the international observation nurseries distributed to NARS in the region.

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

Table 4.7. Agronomic characteristics of bread wheat lines with the highest and lowest frequency of visual selection in the dry areas of West Asia and North Africa. Wheat Observation Nursery for Semi Arid Areas 1993-94.

Entry No.	Sum Sel	Grain Yield (Kg/ha)	DHE	DMA	PH	Diseases ACI YR	LR	SR
109	9	4153	114	148	85	1MR	0	1MR
104	8	4078	113	149	81	5MR	0	0
164	8	4180	112	148	79	5MR	30	0
61	7	4184	111	147	88	5MR	5	0
169	7	3689	114	150	85	0	30	5R
41	7	3850	109	147	78	5MR	20	1R
Mean		4022	112	148	83		14	
81	1	3789	110	147	87	40MS	0	40MS
83	1	2921	113	149	85	40MS	70	5S
193	1	3513	115	151	80	60S	10	20S
196	1	3485	110	147	88	60S	60	50S
101	0	3267	112	148	78	60S	10	70S
158	0	3540	114	150	79	15MS	10	5S
Mean		3419	112	149	83		27	
No. of sites	18	14	18	14	18	1	4	1

Sum Sel = No. of times visually selected based on agronomic type. DHE = Days to heading; DMA = Days to maturity; PH = Plant height (cm); ACI = Average coefficient of infection; YR, LR, SR = Yellow, Leaf, and Stem rust respectively.

4.1.6. Release and Adaptation of New Varieties

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

Programs in Syria, Algeria, Sudan, Lebanon, Morocco, Tunisia, Yemen, and Jordan. These activities aim to substitute the local with improved varieties. As a result of the on farm testing a number of bread wheat varieties have been released as a result (ICARDA's Annual Report 1994). Many countries requested and obtained small amounts of newly bred cultivars registered in the region.

Figure 4.1.1 shows the amount of seed multiplied by the Government Organization for Seed Multiplication of Syria (GOSM), of the commercial varieties of bread wheat released in the country since 1983. Assuming a seed rate of 150 kg/ha, this would amount to a coverage of approximately 241,000 ha during 1992-93 crop season, about 200,000 ha during 1993-94, approximately 279,000 ha in 1994-95, and about 436,000 ha in 1995-96 with the improved bread wheat varieties. The actual area covered may be more because many farmers in Syria retain their own seed for the next crop cycle.

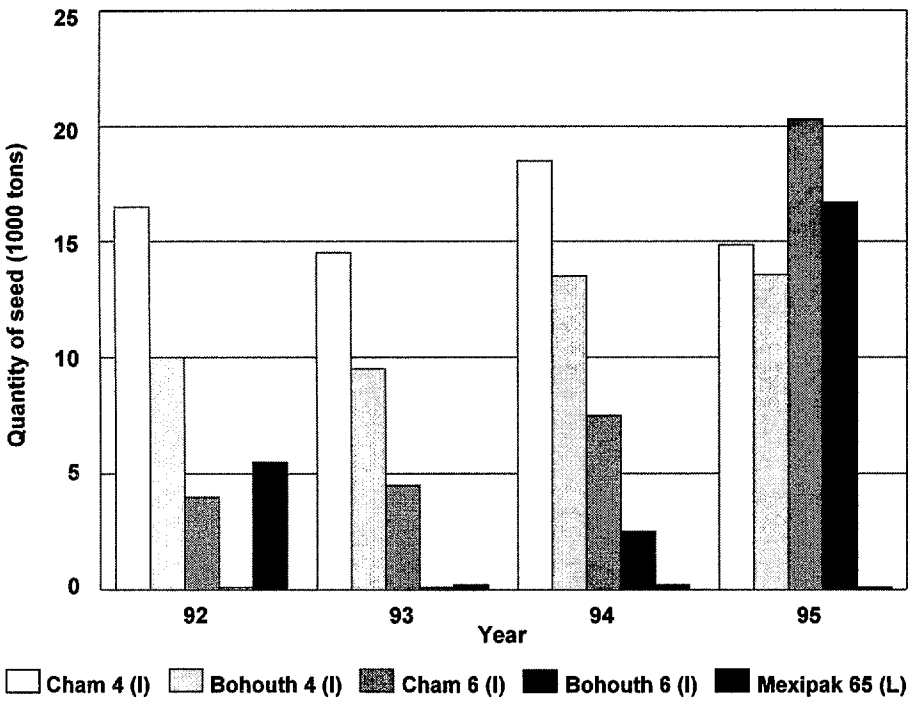

Fig.4.1.1. Seed of improved (1) and local (L) bread wheat varieties produced by the Government Organization for Seed Multiplication (GOSM) of Syria and distributed to farmers during the last 4 years (1992-95).

During the last four years, the improved bread wheat varieties have replaced the local wheat variety Mexipak 65. Cham 4, an improved bread wheat variety released by the Syrian national program in collaboration with the bread wheat project, has become the leading variety grown by farmers (Figure 4.1.1). Cham 6, another bread wheat variety jointly identified and released for farmers in the low rainfall areas of the country, is rapidly increasing in area. The approximate amount of seed multiplied of this variety has increased from 2,250 tons in 1992 to 20,300 tons in 1995, a ten fold increase. Similar trends are occurring in other countries such as Lebanon, Algeria and Jordan, where this variety has also been released for commercial production.

The collaboration with the Syrian national program to identify new bread wheat cultivars with better yield, yield stability, disease resistance and tolerance to abiotic stresses than Cham 4 and other improved varieties has led recently to the identification of two new promising bread wheat lines Ghurab-2 (SWM 11623-9AP-3AP-7AP-2AP-1AP-0AP), and DOUMA 11670 (=Shuha-5, SWM11508-1AP-1AP-5AP-1AP-0AP). They had higher yielding and have better disease resistance than the local check in our joint on-farm verification yield trials, and are currently under large scale testing and multiplication in farmers fields.

Results from farmer verification yield trials in 1994-95 in the rainfed areas of Lebanon show two bread wheat varieties yielding more than the local check variety Balbek. These are: Roomy (Pvn/Cli, CM 52139-2AP-2AP-1AP-4AP-1AP-0AP), and Nesser, also known in Syria as Cham 6 (Tale 4.1.8). On average, these varieties yielded 17 and 15%, respectively more than the local check at two locations in Lebanon (Terbol and Kfardan). Nesser was released three years ago by the Lebanese national program and has now replaced the susceptible low-yielding local varieties in farmers fields. Roomy was released for commercial production in 1995 and it is expected to be widely adopted by farmers due to its better yellow rust resistance and grain quality.

Table 4.1.8. Performance of two bread wheat varieties in on-farm verification trials planted in the rainfed areas of Lebanon during 1994-95.

Variety	Location		Average	% Over Balbek
	Terbol	Kfardan		
Roomy (I)	4375	2525	3450	117
Nesser (I)	4575	2250	3412	115
Baalbek (L)	4025	1900	2962	100

I = Improved; L = Local variety.

Table 4.1.9 presents grain yield and yellow rust disease data of two promising bread wheat lines in demonstration trials in the rainfed areas of Lebanon. Roomy and Ghurab-2 yielded 7 and 2%, respectively more than the improved check Nesser. In order to diversify the spectrum of disease resistance, and in order to provide farmers with more options when they choose new varieties, the Lebanese national program released Roomy in 1995 and has Ghurab-2 under extensive testing in other rainfed areas of the country.

(G. Ortiz Ferrara, A. Shehade, M. Moaheldin, M.A. Antoun, N. Rebeiz, N. Haddad, O.F. Mamlouk, M. Michael, M.A. Moussa and A. Yaljarouka)

Table 4.1.9. Grain yield and yellow rust disease data of promising bread wheat varieties under rainfed conditions in Lebanon. Farmers Demonstration Trials 1994-95.

Cultivar	Grain Yield (kg/ha)			Average (kg/ha)	% Over	
YR	1993	1994	1995			
Nesser						
Roomy	3700	5400	4000	4367	107	R
Ghurab-2	3700	4600	-	415	102	10MR
Nesser	3200	5000	4000	4067	100	30M

YR = Yellow rust reaction under artificial inoculation.

4.1.7. Boron-Toxicity Tolerance

In the screening of 25 germplasm accessions at a high soil

B level, many Afghanistan accessions looked outstanding. The performance of the most tolerant accessions is given in Table 4.1.10. These accessions had a symptom score similar to that of the tolerant checks, Halberd and Greek G61450. The identification of many tolerant wheat accessions from Afghanistan was in agreement with Moody *et al.*[6] who found that within Asia Minor, Afghanistan has the highest frequency of tolerant lines.

(S.K. Yau, J. Valkoun)
(GRU)

Table 4.1.10. Boron-toxicity symptom score, shoot B concentration and dry weight, and regrowth score of five Afghanistan bread wheat accessions grown in soil to which boric acid was mixed at a rate of 50 mg B/kg soil.

Accession no. (ICDW)	Symptom score[1] (0-5)	Shoot B conc. (ppm)	Shoot dry wt. (mg/pl.)	Regrowth score[2] (0-5)
7674	1.0	338	120	4.0
7675	2.25	563	103	1.5
7676	2.25	415	63	2.5
7720	2.25	492	41	1.0
8541	1.75	475	52	2.0
Tolerant checks:				
Halberd	2.5	717	51	0.25
Greek	1.75	495	72	0.25
$lsd_{(0.05)}$	0.771	55.7	1.246	

[1] 0 = no symptom, 5 = severe symptoms
[2] 0 = no regrowth, 5 = good regrowth

4.1.8. Zinc-Deficiency Tolerance

In an experiment comparing seven bread wheat genotypes grown in a low-zinc soil, zinc (Zn) deficiency symptoms were observed during mid-March on Mexipak and Doragge, but not on Cham 2, Cham 4, Cham 6, Ghurub 2 and Warigal, the last of these is a Zn efficient Australian cultivar. Symptoms appeared as yellowish patches in the central part of middle-aged leaves, but disappeared after the leaves

[6]Moody, D.B., A.J. Rathjen, B. Cartwright, J.G. Paull, and J. Lewis. 1988. Genetic diversity and geographical distribution of tolerance to high levels of soil boron. Proc. 7th Int. Wheat Genetics Symp., vol 2, p. 859-865.

with symptoms became senescent. The appearance of such transient symptoms in two of the seven bread wheat genotypes but not in any one of the seven barley genotypes tentatively suggests that bread wheat may be more sensitive to Zn deficiency than barley (see section 2.7).

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

4.1.9. Boron By Zinc Interaction

A pot experiment was conducted under plastic house conditions to test for the interaction effects of B and Zn. There were three factors: two B levels (0 and 50 mg B/kg of soil, giving 0.7 and 10.1 ppm hot water extractable B in soil), two Zn levels (0 and 5 mg Zn/kg of soil, giving 0.7 and 1.6 ppm Zn in soil, designated as Zn0 and +Zn), and two crops (Harmal barley and Mexipak bread wheat). The experiment was in a randomized complete block design with two replicates.

There was a significant crop by B interaction for grain and straw yield, which was reduced by addition of B in the soil for Mexipak bread wheat, but not for Harmal barley. Mexipak yielded more than Harmal at B0. The soil used was not Zn-deficient enough to give any significant yield responses to Zn application. However, when B was not added, addition of Zn caused a large, though non-significant, drop in shoot B concentrations (Table 4.1.11). There was no B-toxicity symptom at B0. But when B was added, Zn addition did not reduce shoot B concentrations or B-toxicity symptoms of the leaves. Graham *et al.*[7] showed that Zn deficiency led to higher B uptake, but at high external B concentration, the protective role of Zn disappeared. Results of this study tended to support their findings. For Zn concentration in the shoot, there was also a significant B by Zn By crop interaction.

(S.K. Yau and J. Ryan)

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[7]Graham, R.D., R.M. Welch, D.L. Grunes, E.E. Cary, and W.A. Norvell. 1987. Effect of zinc deficiency on the accumulation of boron and other mineral nutrients in barley. Soil Sci. Soc. Am. J. 51: 652-657.

Table 4.1.11. Shoot B and Zn concentrations of Harmal barley and Mexipak bread wheat under different B and Zn treatments at 7-leaf stage.

Treatment	B conc. (ppm)		Zn conc. (ppm)	
	Harmal	Mexipak	Harmal	Mexipak
B0, Zn0	58	64	17.5	22.5
B0, +Zn	5	6	22.5	42.5
+B, Zn0	161	169	22.5	35.0
+B, +Zn	178	147	30.0	40.0
$lsd_{(0.05)}$			118.0	8.67

4.2. International Nurseries

4.2.1. Nursery distribution

Regional bread wheat nurseries for 1995/96 assembled by the bread wheat project at ICARDA are given in Table 4.2.1. There were seven nurseries, as the three germplasm pools for sources of resistance to yellow rust, leaf rust and septoria tritici blotch, which had been made available over the last two consecutive years, were discontinued as scheduled. This year there was no major seed shortage. A total of 331 nursery sets were distributed in response to cooperators' requests.

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

Table 4.2.1. Regional spring bread wheat nurseries for 1995-96.

Nursery	Abbre-viation	No. of entries	No. of sets distributed
Regular Nurseries			
Crossing Block	WCB	117	40
Segregating Populations	WSP	121	27
Observation Nurseries:			
- Semi-arid Areas	WON-SA	195	45
- Favorable Areas	WON-FA	185	55
Yield Trials:			
- Semi-arid Areas	WYT-SA	24	50
- Favorable Areas	WYT-FA	24	60
Specific-trait Nurseries			
Heat and Drought Tolerance Observation Nursery	HDTON	50	54

4.3 Strategic Research with Advanced Institutions and NARS

4.3.1. Australia/GRDC/CIMMYT/ICARDA Wheat Adaptation Studies in WANA.

Plant breeders need to evaluate an ongoing supply of new germplasm as potential parents in their breeding programs. International Centers like ICARDA and CIMMYT are valuable sources of germplasm and direct introductions have been released for commercial production in Australia. Characterization of selection environments using reference or probe genotypes would enhance the plant breeders ability to distinguish among genotypes.

Several Australian researchers have conducted adaptation studies using CIMMYT spring and ICARDA winter wheats, respectively. However, there is no local basis for assessing spring and facultative germplasm from the program in Syria. Rather, Australian breeders select germplasm for their region from sets of ICARDA lines produced for a very wide array of production situations. This reflects the diverse nature of the production areas in West Asia and North Africa. A more efficient system of introducing spring/facultative germplasm from the CIMMYT/ICARDA program would be of great benefit to local industry as phenologically this material is similar to Australian germplasm and the range of production climates in certain areas of West Asia closely resembles that of the Australian wheat belt.

In 1994, a GRDC-funded special collaborative project was initiated between the University of Sydney, I.A. Watson Wheat Research Center, Narrabri and the CIMMYT/ICARDA spring bread wheat breeding program to: a) conduct adaptation trials in countries of WANA using named wheat varieties and advanced breeding lines from all Australian wheat breeding programs; b) to use this data to develop a set of Australian indicator varieties for use in trials in Syria from which germplasm for introduction to Australia would be drawn; and c) to allow assessment of the most suitable breeding programs in Australia for introduction to the WANA region. A total of 203 Australian wheat varieties and breeding lines were tested under artificial inoculation for yellow rust at Tel Hadya during 1994. These lines originated from six different breeding stations in the country. Figure 4.3.1 shows the number of

lines within each of five yellow rust disease-reaction classes. Most lines had a high level of susceptibility indicating the lack of resistant genes to the prevalent races of the pathogen at Tel Hadya. About 25% of the lines showed a resistant or moderately resistant reaction. Although it is not known which gene or genes are present in the resistant lines, the program at Aleppo emphasizes the use of this germplasm in the crossing program with the aim of further widening the yellow rust resistance base.

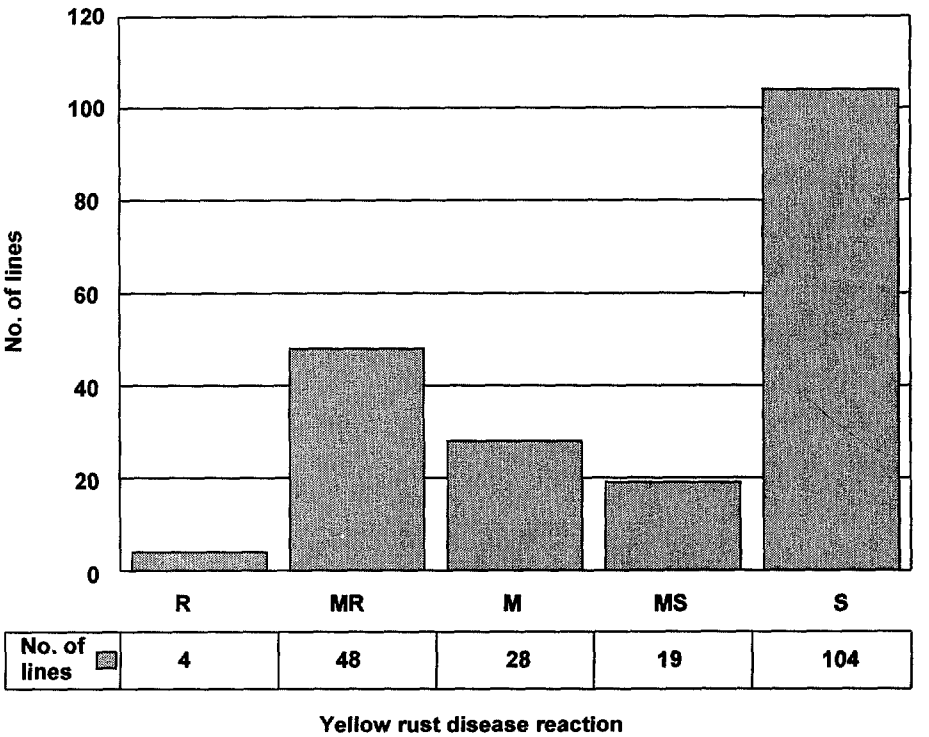

Fig. 4.3.1. Response of Australian breeding bread wheat lines and varieties to yellow rust at Tel Hadya, Syria.

Figure 4.3.2 presents the site mean grain yield of 49 advanced breeding lines in three locations in Syria and Lebanon. Total rainfall received during the season at Breda (BR) was 244 mm with 32 days of below zero temperatures. The trial in Tel Hadya (TH) received 373 mm (313 mm rainfall plus 60 mm as supplementary irrigation) and 23 days of freezing temperatures. Terbol (TR) station received 531 mm rainfall with 48 days of below zero temperatures.

A heavy infection of yellow rust was observed during the season at TH. The grain yield of the top yielding entries at TH and BR, and the disease reaction of the lines at TH are presented in Table 4.3.1. Australian lines such as WW 1006, combining high grain yield and yellow rust resistance, have been crossed extensively in the program. Other lines such as Janz, Lark, 84Z 1282, etc, have selectively been crossed with yellow rust resistant lines.

(G. Ortiz Ferrara, L. O'Brien, S. Sivapalan, O.F. Mamluk, M.A. Moussa, A. Yaljarouka and N. Rbeiz)

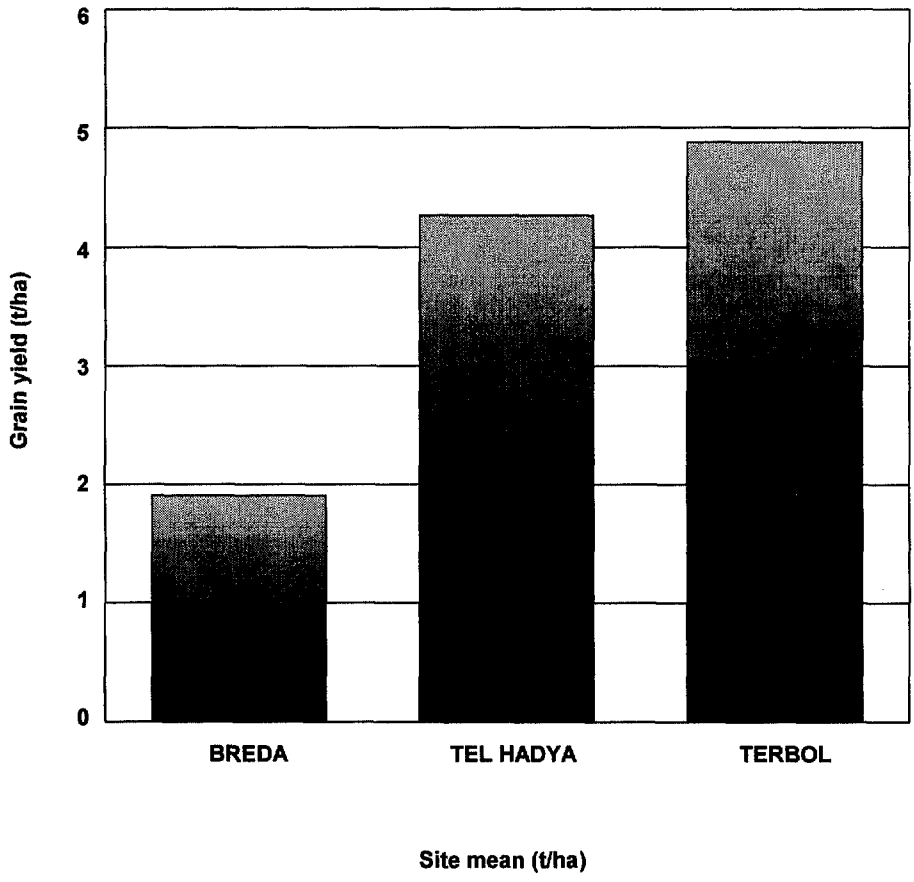

Fig. 4.3.2. Grain yield of 49 bread wheat lines at three experiment stations in Syria and Lebanon.

Table 4.3.1. Grain yield and yellow rust disease reaction of the top performing at Tel Hadya and Breda.

Name and pedigree:	Grain Yield (Kg/ha)	YR(*)
Tel Hadya:		
Kapsw	6583	5 R
Bacanora	6106	10 MR
Florkwa-1	5950	20 R
Shuha-2	5736	5 MR
Janz	5216	30 MS
WW 1006	5016	20 R
Cham 6 (Improved check)	4650	20 MS
Site mean	4266	-
LSD (0.05)	1581	-
CV (%)	18	-
Breda:		
Shuha-2	2470	5 MR
WW 1006	2440	20 R
Fow-1	2251	10 R
Lark	2244	50 S
(Wyuna*(Wr*Hz)*Pf/2/2....	2229	100 S
84Z 1282	2224	80 S
Cham 6 (Improved check)	2104	20 MS
Site mean	1902	-
LSD (0.05)	742	-
CV (%)	19	-

YR(*) = Yellow rust data collected at Tel Hadya only.

4.3.2. Hessian Fly Research in North Africa.

The collaboration between North African countries and the spring bread wheat improvement project on Hessian fly continued during 1995. In close collaboration with senior scientists in Morocco the following areas of research were emphasized: a) screening for Hessian fly resistance in the wild relatives and transfer of effective genes into wheat; b) exchange of germplasm with combined resistance to Hessian fly, Septoria, and rusts; c) laboratory and field screening of bread wheat double haploids with Hessian fly resistance.

Approximately 148 accessions from an ICARDA collection of five different *Aegilops* species were tested by INRA's laboratory in Settat, Morocco during 1995. Of these, about 33 accessions showed a high level of resistance to the main biotypes present in the country.

Crosses have been made trying to incorporate this gene(s) into more adapted backgrounds.

In close partnership with senior Moroccan scientists, and with the support of the biotechnology group at ICARDA, the project evaluated during the last two years a series of double haploids. These double haploids have been tested under field and laboratory conditions, under natural and artificial infestations of Hessian fly. The reaction of six double haploids showed the same number of resistant plants as the resistant check Saada under laboratory conditions (Table 4.3.2). Under field screening, these double haploids also showed similar levels of resistance, and higher grain yields than the resistant and susceptible checks

(M. El Bouhssini, M. Merghoum, M. Jlibene, A. Amri, M.S. Mekni, P. Lashermes, M. Baum, and G. Ortiz Ferrara)

Table 4.3.2. Reaction of six bread wheat double haploids to artificial infestation of Hessian fly under laboratory conditions in Morocco, 1995.

Line	Number of Plants Tested	% Resistant Plants
DHP-1	20	100
DHP-2	14	100
DHP-3	18	100
DHP-4	19	100
DHP-5	18	100
DHP-6	25	100
Nasma (Susceptible Check)	19	0
Saada (Resistant Check)	50	100

4.3.3. Characterization for Photoperiod and Vernalization Response of Local and Improved Bread Wheat Cultivars from the Mediterranean Region.

Forty nine local and improved bread wheat cultivars from the Mediterranean region in West Asia and North Africa were analyzed for their response to photoperiod and vernalization under controlled environment conditions

(Fig.4.3.3.). The techniques and methodologies followed to characterized these cultivars were published[8].

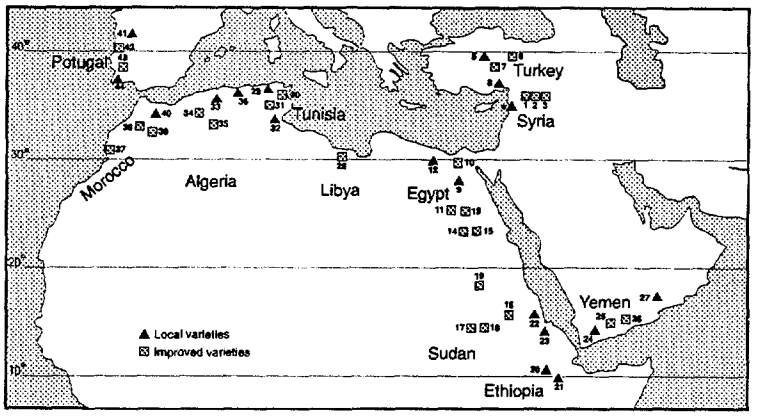

Fig.4.3.3. Countries of origin and approximate area of the 49 bread wheat cultivars of West Asia and North Africa.

Table 4.3.3 shows the days to anthesis of the 49 local and improved bread wheat cultivars used in this study. Differences in response to photoperiod and vernalization and genetic variation independent of vernalization and photoperiod (intrinsic earliness), affecting time to anthesis of wheat were identified. Long photoperiod (h) separated non-vernalized plants into three distinct groups, corresponding to commonly recognized winter, facultative, and spring types. Most old cultivars were sensitive to both vernalization and photoperiod. All the improved genotypes were insensitive to photoperiod. Responses to vernalization were generally small under short photoperiods (10h & 13h) but were not pronounced in long photoperiod (h), particularly in winter and facultative types from northern latitudes. The opposite reaction was found in Spring-type cultivars adapted to low latitude whose response to vernalization was smaller in long photoperiod compared to short photoperiods. The results of this study should help to explain the adaptability of cultivars based on photoperiod and vernalization requirements and their interaction.

(G.Ortiz Ferrara, M.G. Mosaad, V. Mahalakshmi, and S. Rajaram)

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[8] Ortiz Ferrara, G.; Mahalakshmi, V.; and Fischer, R.A., 1995. Photoperiod and vernalization response of wheat under controlled environment and field conditions. Plant Breeding, 114, 505-509, (1995).

Table 4.3.3. Days to anthesis of local and improved wheat varieties adapted in various countries of West Asia and North Africa under vernalized (V) and non-vernalized (0) treatment under long (L) photoperiod (16 h) and short (s) photoperiod (10 h) and the main effect of vernalization ($_{\Delta}V$), main effect of photoperiod ($_{\Delta}P$) and their interaction V x P.

No.	Cultivar	Type	Origin	VL(BVP)	OL	VS	OS	$_{\Delta}V$	$_{\Delta}P$	VxP
Insenstive to V and P										
49	Anza	1	Check	50	49	63	67	-1(-)	13(-)	5
45	Jupateco	1	check	55	61	64	77	6(-)	9(-)	7
48	Siete Cerros	1	Check	49	51	61	67	2(-)	12(-)	4
47	Sonora 64	1	Check	55	52	63	62	3(-)	8(-)	2
10	Shaka 69	1	Egypt	48	46	60	66	-2(-)	12(-)	8
14	Sohag 2	1	Egypt	50	46	57	54	-4(-)	7(-)	1
39	Jouda	1	Morocco	46	50	57	66	4(-)	11(-)	5
28	Bohoth 111	1	LIBYA	45	49	55	57	4(-)	10(-)	-2
38	Merchouch	1	Morocco	47	49	59	59	2(-)	12(-)	-2
37	Saada	1	Morocco	50	46	56	57	-4(-)	6(-)	5
2	Cham 6	1	Syria	45	50	59	69	14(-)	14(-)	5
1	Mexipak 65	1	Syria	50	55	59	71	5(-)	9(-)	7
31	Tanit 80	1	Tunisia	51	54	58	64	3(-)	7(-)	3
11	Giza 160	1	Egypt	43	48	54	78	5(-)	11(-)	19
15	Sohag 3	1	Egypt	54	56	61	80	2(-)	7(-)	17
40	L-22	1	Morocco	49	52	58	71	3(-)	9(-)	10
43	Tejo	1	Portugal	54	53	64	78	-1(-)	10(-)	15
16	Condor	1	Sudan	46	50	57	71	4(-)	11(-)	10
17	Debeira	1	Sudan	55	50	67	80	-5(-)	12(-)	18
18	El-Nilein	1	Sudan	47	50	57	77	3(-)	10(-)	17
24	Sonalika	1	Yemen	45	51	49	67	6(-)	4(-)	12
Sensitive to V and insensitive to P										
34	Zidane 89	1	Algeria	56	76	70	96	20(+)	14(-)	6
35	Zidi Okaba	1	Algeria	47	58	59	71	11(+)	12(-)	1
46	Pitic	1	Check	52	73	62	89	21(+)	10(-)	6
13	Giza 164	1	Egypt	54	71	69	91	17(+)	15(-)	5
42	Centauro	1	Portugal	54	NF	62	NF	>50(+)	8(-)	--
19	Sasarieb	1	Sudan	53	74	64	86	21(+)	11(-)	1
3	Gomam	1	Syria	47	62	60	88	15(+)	13(-)	13
29	Florence Aura	L	Tunisia	41	50	54	83	9(+)	13(-)	20
30	Byrsa	1	Tunisia	51	80	59	101	29(+)	8(-)	13
7	Bolal	1	Turkey	53	NF	60	NF	>50(+)	7(-)	--

Table 4.3.3. **Contd...**

No.	Cultivar	Type	Origin	VL(BVP)		OL	VS	OS	ΔV	ΔP	VxP
25	Aziz	1	Yemen	50	66	54	91	16(+)	4(-)	21	
6	Mokhtar	1	Yemen	52	71	65	81	19(+)	13(-)	-3	
27	L-33	L	Yemen	51	74	63	97	23(+)	12(-)	11	
Insensitive to V and sensitive to p											
9	giza 155	L	Egypt	55	56	76	87	1(-)	21(+)	10	
23	L-17	L	Ethiopia	50	53	68	66	3(-)	18(+)	-5	
22	L-23	L	Ethiopia	46	49	64	70	3(-)	18(+)	3	
8	L-66	L	Turkey	65	61	119	113	-4(-)	54(+)	-2	
Sensitive to V and P											
20	L-1	L	Ethiopia	50	63	76	108	13(+)	26(+)	19	
32	L-56	L	Tunisia	62	77	98	115	15(+)	36(+)	2	
6	Gerek	L	Turkey	49	77	66	103	28(+)	17(+)	9	
33	Mohon Demiaz	L	Algeria	61	102	98	NF	41(+)	37(+)	--	
36	L-10	L	Algeria	63	102	106	NF	39(+)	43(+)	--	
21	L-7	L	Ethiopia	50	78	96	NF	28(+)	46(+)	--	
12	L-18	L	Egypt	72	83	NF	NF	11(+)	--	--	
44	Almansor	L	Portugal	55	75	72	80	20(+)	17(+)	-12	
41	Lodi	L	Portugal	51	NF	68	NF	>50(+)	17(+)	--	
4	L-45	L	Syria	55	100	102	117	45(+)	47(+)	-30	
5	Benzostaya	L	Turkey	56	NF	76	NF	>50(+)	20(+)	--	

LSD for comparing genotypes within each Photoperiod and vernalization+2.40
LSD For comparing a genotype across photoperiod and vernalization= 2.40
l=improved cultivar, L= Cultivar.
+ = sensitive, - + insensitive.
NF = did not flower.

4.3.4. Double Haploid Line Production in Spring Bread Wheat

During 1995 we have initiated screening of spring wheat germplasm to assess its capacity of androgenesis. The F_1 material used (Table 4.3.4a) combines yellow rust resistance with good agronomic performance. In the initial phase of a DH production system, germplasm is screened to identify lines or crosses which have a higher green plant production capacity than others. This will allow to select material suitable for DH production to lead to a production of a high number of DH lines.

The F_1 of 17 spring wheat crosses were analyzed for their green plantlet regeneration capacity under the same experimental conditions (growing conditions of donor plants 15^{0}C, day 10^{0}C night with 16h daylength, 8h night in growth chambers, using the same induction media, BAD1 and two different regeneration media (R9 and PLR) (Table 4.3.4a). The crosses with a high number of induced calli and even more importantly, with a high conversion rate of calli into green plants, yield an acceptable number of green plants per 100 cultured anthers. In general, the conversion of calli into green plantlets is comparable with that of other tissue culture programs, whereas the number of induced calli should be increased.

Regenerated DH lines of F_1s are usually preferred, because populations can be produced which would be suitable for mapping with molecular markers. From a practical point of view DH line production in an F_2 or even F_3 might be advantageous as screening in early generations would allow to select lines expressing e.g. resistance to a disease and would reduce largly the input needed to produce a certain number of resistant DH lines. We, therefore, have compared the potential of F_1 plants and of F_2 derived from them for androgenetic capacity. F_2 lines of the cross WCB77xWCB32 revealed the highest green plant production capacity even though their F_1 plants showed only a very low capacity in the initial screening (Table 4.3.4b, 4.3.4c). This can be explained by the segregation of genes for androgenetic capacity in an F_2 generation. Individual F_2 plants of such a cross will show a much higher regeneration capacity than others. On the other hand the cross WCB95xWCB32, the best cross for DH production in F_1, had also a very good capacity in the F_2

generation.

Table 4.3.4a. Anther culture in spring bread wheat: cross, number of calli per hundred anthers (calli), number of green plants per hundred anthers (green plants) and number of calli converting into green plants (convers.).

Cross	Calli	Green Plants	Convers.	Albinos
WCB95xWCB32	18.8	16.3	86.7	0
APCB41xWCB87	21.9	11.4	51.0	0.2
WCB1xWCB129	16.5	5.5	33.3	0
APCB7xWCB131	8.3	5.0	60.0	0
WCB9xWCB83	9.4	5.0	53.3	0
WCB10xWCB133	11.3	4.4	38.9	1.5
WCB135xWCB32	17.5	3.9	22.2	0.8
WCB26xWCB131	13.9	3.3	38.4	0.4
WCB2xWCB130	5.7	3.2	56.3	0
WCB128xWCB32	26.9	1.9	7.0	0.8
APCB4xWCB130	18.8	1.9	10.0	0.6
APCB16xWCB80	38.8	1.3	3.2	0
WCB77xWCB32	6.7	0.8	12.5	7.5
WCB9xWCB82	8.1	0.6	7.7	0
APCB12xWCB131	23.8	0	0.0	0
APCB30xWCB87	17.5	0	0.0	0
APCB35xWCB87	12.5	0	0.0	0
Average	**15.31**	**4.4**	**0.56**	

Table 4.3.4b. Response of F_2 plants to androgenesis using two temperature regimes (15°C and 18°C) donor plants:cross, number of calli per hundred anthers (calli), number of green plants per hundred anthers (green plants) and number of albinos per hundred anthers (albinos).

	Calli		Green Plants		Albinos	
Cross	15°C	18°C	15°C	18°C	15°C	18°C
WCB77xWCB32	24.1	18.1	10.3	6.4	0.1	0.6
WCB95xWCB32	15.7	14.1	4.5	11.6	0.0	0.0
APCB41xWCB87	5.2	12.1	3.2	8.4	0.5	0.3
WCB26xWCB131	14.4	6.3	7.1	2.5	1.2	0.3
WCBxWCB83	4.4	2.0	0.6	0.0	0.0	0.0
WCB9xWCB82	6.0	n.t.	1.9	n.t.	n.t.	n.t.
Average	12.4	13.9	5.2	7.5	0.3	0.3

Experiments carried out in DH line production at an earlier stage (annual report 1991) used a higher growing temperature for the donor plants (18°C and 23°C) and only one regeneration medium. From those experiments it was concluded that the genotypic interactions with experimental conditions (growing temperature of donor

plants, sucrose or maltose in the induction medium etc.) were high and it was possible to find better specific experimental conditions for a given genotype which were advantagous over the commonly used conditions. However, for a mass production of DH lines for spring bread wheat under ICARDA conditions, growing temperature of donor plants of 18°C and the PLR regeneration medium appear to be the better average conditions.

Table 4.3.4c. Response of F_2 plants to androgenesis using two different temperature regimes (150C and 180C) and using two regeneration media (R9 and PLR), n.T. = not tested.

	% of calli converting into green plants on			
	R9 medium		PLR medium	
Cross	15°C	18°C	15°C	18°C
APCB41xWCB87	70.8	41.5	50	97.6
WCB26xWCB131	35	0	63.2	66.6
WCB95xWCB32	41.9	77.5	18.4	87.2
WCB77xWCB32	52.1	34.9	32.4	35.2
WCB9xWCB83	28.6	0	0	0
WCB9xWCB82	39.8	n.t.	26.1	n.t.
Average	48.3	45.6	35.2	61.8

5. FACULTATIVE AND WINTER WHEAT

Introduction

ICARDA work on facultative wheat is part of a joint effort with CIMMYT on the improvement of facultative and winter wheat. ICARDA pays a special attention to the germplasm enhancement of facultative wheat in highlands of WANA countries including Iran, Turkey, Pakistan, Afghanistan, and the Atlas plateaux of Morocco and Algeria, and more recently, parts of the Central Asian Republics.

Wheat grown in the highlands faces multiple biotic (disease and insect pests) and abiotic (cold, drought, soil mineral deficiencies and toxicities) stresses that depress grain yield in these areas. This is further aggravated by the limited research resources devoted to such areas.

In the 1994/95 season, a severe drought in North Africa caused a drastic reduction of wheat production in that region. In West Asia, yellow rust, favored by mild winter and cool weather in early spring, developed to an alarmingly epidemic level in several countries. This was followed by early heat in late spring which impaired normal grain development and led to a high level of spike sterility in the rainfed wheat areas, decreasing yield by over 50 percent in some farmers' fields.

5.1.1. Generation of Facultative/Winter Wheat Germplasm

In the last two seasons, a limited number of crosses were made at Tel Hadya because of the unavailability of senior staff during the hybridization period, and most of the segregating (F_2 onward) material is tested in Turkey with little attention to its testing in Syria. Several factors favor a concomittent active work in Syria: (a) conditions for hybridization and germplasm testing under more controlled growing and inoculation conditions are secured (b) the winter environment at Tel Hadya and other selected sites within Syria provides enough cold to vernalize the most-requiring winter types and to expose the material to drought and a reasonable level of cold (c) many of the wheat growing areas in WANA have environments that favor

the planting of facultative types, requiring less vernalization and cold resistance than true winter types. To make full use of these comparative advantages, the crossing program is gradually reinforced, putting emphasis on the introgression of desirable genes from the true winter types into a germplasm pool dominated by facultative types. In 1995, about 600 crosses were made at Tel Hadya, using greenhouse and field facilities. The majority (about 80%) of crosses were winter x facultative and facultative x facultative, other crosses were winter x spring and facultative x spring. A limited number of interspecific crosses were also made to introgress cold resistance, adaptation to harsh environments and disease resistance. All hybridizations were single crosses as all F1's of 1994 crosses were planted in Turkey only. The materials generated from these hybridizations will be screened under the biotic and abiotic stresses in Tel Hadya, Breda (dry site), Yabroud and Sarghaya (2 high-elevation sites) in Syria, and will be further screened at the F3 and F4 stages in Turkey for cold tolerance and distributed to NARS in North Africa (for the high plateaux and the Atlas mountains in that region) and the cold and semi-cold areas of Pakistan (Gilget, Quetta), Iran, and Turkey through the joint Turkey-CIMMYT-ICARDA nurseries which also addresses the need of colder areas in Turkey and elsewhere.

(H. Ketata, A. Morgounov, H. Braun, and NARS scientists in Turkey, and Iran)

5.1.2. Breeding for Disease and Insect Resistance

The recent epidemics of yellow rust (*P. striiformis)* during 1991-1995 in several countries of WANA brought up a greater awareness of the devastating effect of this fungal disease and unveiled new races of the causal agent. The epidemics were favored by the widespread use of one type of germplasm (the Veery type, carrying the IB/IR translocation and depending on the Yr9 gene) and a favorable weather (cool and humid atmosphere in early spring) of the f/w wheat growing areas. While breeders and farmers can do little to change the weather in these areas, it is imperative to get rid of the dependence on one unique type of germplasm. Most of crosses made this

year involved at least one parent resistant to yellow rust as determined by plant reaction to prevalent races of yellow rust (see section 6). In addition, about 2,000 f/w wheat genotypes were screened at ICARDA, Syria, under heavy disease pressure, effectively enhanced by artificial inoculation and sprinkler irrigation. The results of this testing were complemented by those made by NARS in Turkey (at Ankara under artificial epiphytotics) and in Iran (at Maragheh under natural infection favored this season by high rainfall, and some additional mist irrigation). It is not only the 80-90% concordance among disease rating in these various sites which merits attention, but also the 10-20% divergence which enables early warning and speeds up the development of germplasm resistant to new races as they first appear in one or the other testing areas.

Common bunt, caused by *Tilletia caries* and *T. foetida* is another important disease of f/w wheat in the highlands. Again, artificial inoculation by the cereal pathologist at ICARDA led to a severe attack and the identification of resistant or tolerant genotypes (<20% infected spikes in a sample of 10 spikes). A special emphasis was placed on early generation material that was not previously exposed to heavy disease pressure. Out of 1400 entries of the preliminary yield trials, 118 entries were found resistant to common bunt. However only 15 genotypes possessed acceptable resistance to both yellow rust and common bunt (Table 5.1.1). These will be used in crosses and will be further retested in 1996 before they are included in a disease nursery for distribution to NARS. Among the widely used cultivars, Bezostaya and Dagdas showed acceptable field resistance to these two diseases.

Advanced materials were also screened for their reaction to Russian wheat aphid (*Diuraphis noxia*) and wheat stem sawfly (*Cephus* spp.). Out of 200 genotypes tested, 20 were tolerant to RWA and 16 were tolerant to WSS. While few of these entries are selected for advanced yield testing, most were not high yielders but will be further used in confirmation tests by the entomologist in 1996 before inclusion in the crossing program. Two facultative lines possessed tolerance to these two insect pests: (1) Sn64//Ske/2*Ane/3/Sx/4/Bz/5/Seri, a high yielding breeding line, but susceptible to yellow rust and (2) Yan 7578.128, a Chinese line, early maturing and

resistant to yellow rust. Virus diseases are common in wheat fields of the highlands in WANA, particularly in facultative-wheat growing areas and when winters are mild.

Table 5.1.1. Entries from preliminary yield trials combining resistance to yellow rust and common bunt, Tel Hadya, 1995.

Name	YR*	Bunt*	GH*
MANNING/SDV1//DOGU88	20MS	20	2
UT1571-40/GOLAN	30MS	10	3
PMF/MAYA//YACO/3/CO693591/CTK	10MR-MS	20	3
PMF/MAYA//YACO/3/CO693591/CTK	10MS	10	3
SDY/OK78047/4/NA160/HN7//BUC/3/F59.71/ GHK/5/SAULESKU#17	30MS	10	3
SDY/OK78047/4/NA160/HN7//BUC/3/F59.71/ GHK/5/SAULESKU#17	15MS-MR	0	2
JUP/4/CLLF/3/1114.53/ODIN//CI13431/ 5/MJI/GLEN//TRT	20MR-MS	20	3
8HAMIDIYE//VEE/KOEL	10MR-MS	10	4
TAST/SPRW//CA8055/3/CSM	5MR-MS	20	1
ARG/R16/BEZ*2/3/AGRI/KSK/5/TRK13	30MS	20	1
TAST/SPRW///LT176.63/3/RAN/NE701136// CI13449/CTK	30MS	0	3
BEZ//BEZ/TVR/3/KREMENA/LOV29/4/KATYA A1	30MS	0	4
LOV29/3/JSW6/LOV13//JSW3/4/KREMENA/LOV2 9/5/BEZ/ERA//LOH1/HIRK/3/LOV25	30MS	20	3
NVRSR3/5/BEZ/TVR/5/CFN/BEZ//SU92/ CI13645/3/NAI160/4/EMU/7/KATYA A1	20MS-MR	20	3
BDFN/PVN//KS5210/3/VPM/MOS83.11.4.8//PEW	30MS	0	3
DAGDAS	20-30MS	0-20	2
BEZOSTAYA	20MS	0-20	2

* YR=yellow rust (modified Cobb's scale); Bunt=common bunt (% inf.); GH=growth habit (1-5 scale: 1=prostrate; 5=erect).

Virus and virus-like symptoms (plant stunting, rosetting, abnormal leaf color, reduction or absence of spikes) were observed in f/w wheat at a highland site (Yabroud, 1200 m) in southwestern Syria, in the Transitional Anatolian Plateau of Turkey, and at Maragheh, in northwestern Iran. BYDV was field-diagnosed and lab-detected on plant samples from Yabroud, Syria, although other factors may be also involved in causing the virus-like symptoms at that site. 41 genotypes with no or little disease symptoms were selected. In Turkey, leaf yellowing at Cumra and plant stunting and poor development at the Eskisehir and Konya regions were ascribed to unknown soil-borne factors, some of which include unidentified viruses, as detected by the

ICARDA virologist. However, several types of nematodes (Heterodera sp. Pratylenchus sp., and Tylenchorhynchus sp.) were detected in a survey conducted by a consultant nematologist (Dr. Nicola Greco from Bari, Italy) in the Eskisehir region of Turkey, the results of which indicated a prevalence of Tylenchorhynchus nematodes and their association with the severe plant stunting.

(H. Ketata, O. Mamluk, N.E. Sharaf Eddin, K. Makkouk, A. Morgounov, H. Braun, M. Jarrah)

5.1.3. Summer Nursery

415 entries were selected in spring 1995 for their disease reaction and facultative growth, and grown in the summer 1995 at Tel Hadya under partial irrigation. This included advanced material and segregating populations. Each entry was planted in a 1m row plot. The crop cycle was from 23 June through 5 October 1995. Large differences among entries were found for growth habit, heading percent (per plot), and heat tolerance. Percentage of winter, facultative and spring types were 85, 9 and 6, respectively with comparatively more winter types within the segregating F3 populations. The results indicate that summer planting at Tel Hadya is a simple and effective tool for discriminating between germplasm with different vernalization requirement and will continue to be used for this purpose. The spring-like genotypes that showed tolerance to heat (normal spike development, non shrivelled grain) will be used in crossing in 1996.

F1 seed from a number of winter x spring, winter x facultative, and facultative x facultative crosses made in spring 1995 were harvested and grown in the plastic house during August-October without vernalization. A total of 112 F2's could be harvested for field planting in the 1995/96 season. Earlier crossing under controlled environment in the future should allow enough time for vernalization of winter x winter or winter x facultative crosses before summer planting thus speeding more effectively the breeding process of facultative and winter wheat.

(H. Ketata, M. Jarrah)

5.1.4. Spike Sterility

Sterility of the upper spike parts was frequently observed in research plots at Tel Hadya and in farmers fields 30 km north of Aleppo (see also section 6). The same phenomenon was observed in Eskisehir and Konya regions of Turkey. Both bread wheat and durum wheat were affected while symptoms on barley were rare and less conspicuous. Quantitative observations were taken on 40 facultative/winter bread wheat genotypes grown at Tel Hadya under rainfed conditions (313 mm) and under supplementary irrigation (additional 55 mm). No sterility symptoms were observed in the irrigated field but spike sterility was frequent in the rainfed field, although the occurrence and severity of damage varied with the genotype and the field location. Generally, a plot was only partially affected, suggesting an initial soil heterogeneity, likely due to uneven previous cropping. Five spikes were taken from the affected and unaffected spots of the rainfed plots (10 spikes/rainfed plot) and from the irrigated plots (5 spikes/plot). Number of spikelets/spike, number of kernels/spike and 1000-kernel weight were estimated, in addition to other traits measured on a plot basis, including yellow rust reaction and heading date. Spike sterility resulted in significant reduction of spikelets/spike and seeds/spike (Table 5.1.2). Kernel weight of spikes affected by tip sterility was relatively high because the kernels of lower spikelets are usually larger than those of the upper spikelets, particularly under rainfed conditions. Spike sterility was not related to yellow rust resistance while its relationship to heading date was inconsistent, and needs further investigation. Assuming tiller number is not affected by the factors that cause sterility, it is easily computed that spike sterility caused 16-20% yield reduction, although the loss was over 30% on certain specific genotypes. In larger fields, the yield loss was visually estimated at 50-60%. The observation that sterility symptoms appear on certain genotypes under rainfed conditions and not under supplementary irrigation points to moisture stress as the major causal factor, although heat, which did occur at grain filling, in 1995, both in Syria and Turkey, can aggravate the damage. From our field observations during the last 12 years, severe

symptoms of spike-tip sterility appear in dry seasons with abrupt temperature extremes (cold or heat). From this year's observations, it appears that one supplementary irrigation at heading will prevent crop loss and may boost the yield up by 30-50% or more if the soil is dry and/or the air temperature rises suddenly above 350C as it did in late spring 1995.

(H. Ketata)

Table 5.1.2. Spike characteristics of 40 facultative or winter bread wheat genotypes as affected by drought and heat, Tel Hadya, 1995.

Spike characteristics	Rainfed Crop Visible sterility	Rainfed Crop Normal appearance	Supplementary irrigation
Fertile spikelets/spike	12.7 a	27.2 b	16.3 c
Kernels/spike	29.6 a	36.9 b	37.8 b
1000-kernel weight	37.3 a	35.8 b	37.2 a

Means within a row not followed by a common letter are significantly ($P<0.05$) different as determined by paired t-tests.

5.1.5. Effect of Yellow Rust and Drought-and-Heat on Yield and Related Traits

Grain yield was estimated for 159 (154 entries plus 5 checks) genotypes in an advanced yield trial using an augmented design with 14 blocks and plots of eight 6.25-m rows and for 25 entries of an elite yield trial using a RCB design with 3 replications and plots of eight 2.80-m rows. The trials were conducted under 2 environmental conditions in neighboring fields of ICARDA's farm at Tel Hadya: (a) rainfed conditions (313 mm) with severe drought stress over the period mid-February through mid-April and a combination of drought-and-heat-stress during May; (b) supplementary irrigation (25 mm applied at stem elongation on 5 March plus 30 mm at early heading on 3 April) and heavy disease pressure caused by the inoculum blown from contiguous inoculated plots and favored by sprinkler irrigation. The 2 environments were effective in differentiating the various genotypes. In the supplementary-irrigated (SIR) field, plant reaction to yellow rust ranged from OR (immune) to S (highly

susceptible, with a complete coverage of all plants with rust pustules). In contrast, disease incidence was much lower in the rainfed (RF) field where susceptible plant reaction rarely exceeded 60S. The disease reaction was converted to a 1-5 score (1=no visible disease symptoms; 5=complete coverage of plant tissues with yellow rust). Drought was severe during the period mid-February (tillering) through mid-April (heading). A heat spell (with maximum temperature reaching over 40oC) hit the crop for 5 days at grain filling. In the SIR field, the susceptible group of genotypes was outyielded by the resistant one with an 18% yield difference (Table 5.1.3).

Table 5.1.3. Mean grain yield (kg/ha) and mean 1000-kernel weight (g) of advanced lines of facultative/winter bread wheat genotypes grouped into 5 categories of reaction to yellow rust, and grown under supplementary irrigation (SIR) and rainfed (RF) conditions at ICARDA, Tel Hadya, Syria, 1994-1995.

Yellow rust score	No. of group lines	Grain yield			1000-kernel weight		
		SIR	RF	(SIR-RF)%	SIR	RF	(RF-SIR)%
1	51	3095a	2843a	8.9a	31.6a	33.9a	7.4a
2	9	2889ab	2535a	14.2a	31.7ab	34.9a	8.9ab
3	30	2936a	2775a	5.5a	30.0ab	33.9a	12.4ab
4	35	2882a	2809a	2.5a	31.2a	35.2a	13.1b
5	34	2575b	2816a	-9.2b	28.2b	34.5a	20.6c
Average	(159)	2895	2799		30.5	34.9	12.6

In contrast, there were no significant yield differences among the 5 disease-score groups in the RF field. Grain yield is little affected by yellow rust when the disease infestation is not heavy. When the comparisons are made across the 2 environments, it is easily seen that limited sprinkler irrigation (55 mm) increased grain yield by 9% for the resistant genotypes and decreased it by a similar fraction for the susceptible genotypes (Table 5.1.3). Therefore, if farmers want to increase and stabilize their wheat production by supplemental irrigation, they can only achieve it if they grow resistant/tolerant varieties. No clear relationship was found between earliness and disease reaction. However, earlier heading genotypes yielded up to 30% higher than later genotypes under SIR and 39% higher under RF conditions (Table 5.1.4). Therefore, both yellow

rust resistance and earliness (drought/heat avoidance) enhanced grain yield (by 18% and 30% respectively) under limited supplementary irrigation, while only earliness was found to increase grain yield (by 39%) under rainfed conditions. Kernel weight was the same for all disease groups in the RF field, but varied across groups in the SIR field with resistant genotypes having 10% heavier kernels than susceptible ones (Table 5.1.5). The difference in kernel weight between RF and SIR conditions, in favor of RF, increased with susceptibility. It is inferred that 65% of this difference is due to heavier disease pressure in the SIR environment and 35% to a higher rate of dry matter translocation into the grain in the more drought-stressed plants.

Except for the susceptible group, early growth vigor, plant height and grain yield were higher in SIR versus RF environments. The trend is similar in other trials (e.g. Table 5.1.5).

Table 5.1.4. Mean grain yield (kg/ha) of advanced lines of facultative/winter bread wheat grouped into 5 categories of heading and grown under supplementary irrigation (SIR) and rainfed (RF) conditions at ICARDA, Tel Hadya, Syria, 1995.

Heading	SIR		RF	
date*	No. of lines	Yield	No. of lines	Yield
1	28	3113a	14	3208a
2	45	3192a	61	3122a
3	41	2816b	40	2764b
4	39	2587c	36	2320c
5	6	2193c	8	1956d
Average	(159)	2895	(159)	2739

* Heading date scores: 1-5 with 1=earliest (class center 132.5 days) and "5" =latest (class center 148.5 days).

The combined effect of yellow rust and "drought and heat" was evaluated in 2 other trials. In the first, 190 facultative or winter wheat genotypes were compared for their kernel weight in two environments under supplementary irrigation at Tel Hadya (SIR) and under rainfed conditions at Breda (BR) where total rainfall was 244 mm. Yellow rust incidence was much lower at Breda. Kernel weight was decreased by yellow rust at both environments, but to a greater extent at the less-dry

environment (SIR). About 50% of the difference in 1000-kernel weight between the two sites (34.0 g for BR versus 27.6 g for SIR) is attributed to the differential effect of yellow rust across these sites.

Table 5.1.5. Performance of selected entries of the facultative/winter wheat elite yield trial, 1995.

Name	Grain yield (kg/ha)		Plant height (cm)				Heading date (days)				GH	YR	DR	T.kernel weight	
	RF	SIR	RF	SIR	TR	YB	RF	SIR	TR	YB*	BR	SIR	BR	RF	SIR
Pck/Vee SWM834210-	4814	3433	84	90	85	55	133	133	171	1	4	3	3	37.1	33.4
KS 82214/Galves87 SWM16265	3940	4212	79	87	85	70	133	132	166	1	4	3	1	38.7	36.8
Bolal	2981	3177	80	106	120	65	138	136	169	2	3	4	2	33.3	36.7
Gerek	2731	2828	80	105	105	65	136	132	170	2	3	4	3	36.2	32.7
Bezostaya	3588	3522	89	100	100	55	139	139	176	4	2	3	3	38.8	37.0
Atay	2947	3135	80	99	105	50	142	145	179	5	4	3	3	35.7	27.8
Dagdas	3078	3360	73	100	100	40	137	135	168	4	1	3	3	32.4	31.0
Highest yielding	4814	4212	84	87	110	-	133	132	179	-	-	3	-	37.1	36.8
Lowest yielding	2179	1395	70	83	110	-	142	145	179	-	-	4	-	31.0	20.6
Range	2179-4814	1395-4212	69-97	83-110	60-120	30-85	129-142	125-145	164-179	1-5	1-5	1-5	1-5	29.7-40.4	20.6-41.6
Average	3111	3247	80	98	99	57	135	134	170	2	3.8	3.4	2.8	35.6	33.3
LSD (0.05)	785	508	13	7	-	-	2.5	1.2	-	-	-	-	-	3.7	3.6

RF=Tel Hadya, rainfed, SIR=Tel Hadya, suppl. irrigated. TR=Terbol, YB=Yabroud, BR=Breda; GH=growth habit (1=prostrate, 5 erect), YR=yellow rust score (1=resistant; 5=highly susceptible); DR=drought score (1=tolerant; 5=susceptible).
* Heading date at YB recorded on 1-5 scale:1 very early; 5=late.

In the second experiment, 42 facultative or winter wheat genotypes were compared for kernel weight when grown in a plastic house (fully irrigated and rust free) and under the SIR environment. Optimal conditions in the plastic house led to high kernel weight for all genotype groups. In contrast, yellow rust drastically reduced kernel weight in the SIR field environment (Table 5.1.6). The difference in kernel weight between these two environments reflects the combined effect of yellow rust and the drought-and-heat stress. The groups "1" and "2" corresponding to no or low rust field-inoculation were used to single out the drought and-heat effect, which amounted to a 21% reduction in kernel weight, as compared to 26% reduction caused by yellow rust alone.

(H. Ketata, M. Jarrah)

Table 5.1.6. Mean 1000-kernel weight (g) of facultative winter bread wheat genotypes grouped into 5 categories of reaction to yellow rust, and grown under supplementary irrigation in the field (SIR) and under full irrigation in the plastic house (PL) at ICARDA, Tel Hadya, Syria, 1994-1995.

Yellow rust score group	No. of genotypes	PL	SIR	(PL-SIR)%
1	3	46.0ab	34.3a	24.5a
2	6	43.7a	34.3a	19.2a
3	9	55.7c	30.4ab	45.3b
4	19	52.0bc	27.8bc	45.9b
5	5	51.6bc	24.4c	52.6b
Average	(42)	51.1	29.4	41.2

5.1.6. Soil Mineral Problems

Mineral nutrient toxicities and deficiencies were observed in several areas of Turkey and Iran. Turkish scientists (F. Altay, personal communication) reported grain yield increases of up to 500% resulting from Zn applications to deficient soils in the Eskisehir region. Mineral deficiency was diagnosed in a wheat field in July 1995 at the Maraghah experiment station, Iran. Analysis of soil samples brought to ICARDA showed a deficiency in both Zn (0.2-0.4 ppm at 15 cm

and 0.4-0.8 ppm at 30 cm) and Fe (2.0-2.6 ppm at 15 cm and 1.8-2.0 ppm at 30 cm) whereas B and Mn concentrations were normal. Following these results, a plan was made to conduct in 1996 a thorough survey and study of the spread and magnitude of such problems in Maragheh area.

About 330 f/w wheat entries were screened for tolerance to boron (B) toxicity using chosen B soil concentrations (50 mg/kg soil and 100 mg/kg soil) in metal boxes arranged in plastic houses. Table 5.1.7 shows a list of entries with acceptable growth under soil B toxicity . With 2 exceptions, those entries also have a good level of resistance to yellow rust.

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

Table 5.1.7. Facultative and winter wheat entries with acceptable tolerance to soil boron (B) toxicity, ICARDA, 1995.

Entry name	Cross number	Yellow rust*	B*
Kvz/Cut 75/3/Ymh//61.1523/Drc	ICWH850499	R	MT
Tast/Sprw//Zar	ICWH840048	R	MT
Tast/Torim/3/Mlc/4/CWW 339.5/Spn	WXC861128Å	MS-MR	MT
Cllf//BbN1/3/Tjb 368-251/Buc	WRY870793	MR	MT
Tjb 841/1543//Ymh/63-122-66-2/3..	WXY861175A	R-MS	MT
KS82W422/SWA754308//KS831182/KS82W422	X85W663	MR-MS	MT
90ZHONG657		R	T
CA8055		R	T
KS82W409/Stephens		MR	MT
TAM 108		HS	MT
2-62-1/P242-152//No64/3/No57//Probex/4/Mentana	YE4704	MS	MT
C 126-15/Cofn/3/N10B/P14//P101/4/21183/C0652 643/...	YE2453	S	MT
87Zhong2		R	MT

* R=resistant, MR=moderately resistant, MS=moderately susceptible, S=susceptible; HS=highly susceptible, MT=moderately tolerant, T=tolerant.

5.1.7. Multilocational Testing

The backbone of the breeding strategy of the f/w wheat program is the testing of the generated or introduced material in the target areas where varieties will eventually be developed, adopted and grown by farmers. Highlands and continental areas have diverse agroecologies despite the common feature of low winter temperatures. Differences in altitude, latitude, distance from sea coast, rainfall and soil type and topography account for much of the variability within and between countries (see for example "Winter Cereals and Food Legumes in Mountainous Areas", Proceed. Intern. Symposium; 1988, ICARDA).

Introduced and generated germplasm was screened (1) in Syria, for diseases and insect resistance at Tel Hadya, for drought tolerance at Breda, for cold-and-drought tolerance at Yabroud, and evaluated for tolerance to B toxicity and for bread making quality (kernel hardness, protein, dough mixing time and tolerance, using NIRS) at ICARDA, (2) in Turkey for disease resistance (at Ankara and Izmir) for tolerance to soil mineral toxicity and deficiency (Eskisehir and Konya) and for cold tolerance and (3) in Iran for cold tolerance and resistance to diseases, including yellow rust.

During 1995, yellow rust spread widely over large areas of West Asia, including parts of Turkey, Iran and Syria. The disease reaction of several hundreds of wheat lines indicates a prevalence of common races throughout these areas but also differences in the pathogen race spectrum, confirming the usefulness of and the need for multilocational testing. Table 5.1.8 lists the testing sites and selection criteria for most of the facultative/winter wheat germplasm tested through Turkey-CIMMYT-ICARDA Program in Turkey and Syria, 1994-1995.

Table 5.1.8. Testing sites and selection criteria for facultative and winter wheat germplasm.

Nursery/Trial	Testing site	Criteria
F2	Cumra	Rusts (yellow, leaf, stem), yield (Cumra)
F3	Cumra, Eskisehir, Ankara	Rusts (Y, L, S), common bunt, plant "type"
F4 (HR)	Cumra	Yellow rust, plant type
Prelim. Yield Trial	-Cumra, Izmir, Eskisehir, -TH-Syria, Ankara	Yield, rusts (Izmir), grain quality YR, common bunt, plant type, grain quality
Interm. Yield Trial	Cumra (IR, RF), Izmir, Eskisehir, TH-Syria, Ankara	Yield (some sites), rusts, c. bunt, grain quality, plant type
Adv. Yield Trial	Cumra (IR, RF), Izmir, Eskisehir (IR, RF), Ankara, TH-Syria (IR, RF)	Yield, grain quality, rusts, common bunt, plant type

Segregating populations were primarily tested in Cumra, although F3's were also screened at Eskisehir and head selections made there. The total number of populations selected in the segregating populations were 480, 285 and 1366 for F2, F3 and F4 generations. At ICARDA, Syria a limited number of F2's (220) were grown of which 37 were selected, showing the following parents as good combiners Jcam/Emu//Dove; CA8055; Ymh/Tob//Mcd/3/Lira and F900K. From the yield trials, 368, 75 and 84 entries from preliminary, intermediate and advanced trials were retained for further evaluation and/or distribution to NARS's in 1996. Entries of the 1995 advanced yield trials that performed well for one or more traits across testing sites are listed in Table 5.1.9.

Table 5.1.9. Performance* of entries selected from the facultative and winter wheat advanced yield trial, 1995.

Entry	Name/cross		Days to heading			Grain yield(SIR)		Grain yield(RF)		Y.rust (SIR)	Grain yield (ESK)	
			RF	SIR	CUM	t/ha	%Dag das	t/ha	%Dag das		t/ha	%Bolal
9182	CO724377/NAC//SERI	SWM866509	135	134	136	3.35	114	3.55	115	MR	2.97	92
9171	SN64//SKE/2*ANE/3/SX/4/ BEZ/5/SERI	SWM866442	135	136	143	3.88	132	3.76	121	MS-MR	3.16	95
9157	HYS/NCO//7C/3/SPN//63-1 89-66-7/BEZ	WWF860090	148	147	146	2.20	75	2.53	82	MS	2.77	83
9111	DYBR86.1/CHAM6	ICWH890217	133	132	136	3.51	119	3.43	111	MR	2.65	92
9172	SN64//SKE/2*ANE/3/SX/4/ BEZ/5/SERI	SWM866442	137	140	138	2.74	93	3.25	105	S	3.18	95
9168	SN64//SKE/2*ANE/3/SX/4/ BEZ/5/SERI	SWM866442	137	132	136	2.86	97	3.13	101	S-MS	3.56	107
9116	BHR*5/AGA//SNI/3/ TRK13	XWN84305	145	144	143	3.25	110	2.78	90	S-MS	1.76	61
		LSD(.05)				0.65		0.95				

* All entries yielded over 7 t/ha (7.07-7.35) under irrigation at Cumra.
RF=Tel Hadya, rainfed; SIR=Tel Hadya, supplementary irrigation; CUM=Cumra, ELK=Eskisehir.

The Fourth Facultative and Winter Wheat Observation Nursery (4th FAWWON) was distributed to 130 cooperators both within and outside WANA. This nursery is made of 134 entries from diverse origins including commercial cultivars and advanced breeding lines from WANA, East Europe, China and USA, in addition to Turkey-CIMMYT-ICARDA lines. Results from 5 sites in Syria, Turkey and Iran showed that between 5 and 19 entries were selected in one site, with 4 entries selected in 3 or more sites (Table 5.1.10). As more results become available, they will be analyzed and shared with cooperators in 1996. The nursery will evolve in the future for a better targeting of germplasm to specific megaenvironments.

Other nurseries, in smaller quantities were distributed, upon request, to researchers in Turkey and Iran and to visiting scientists from various other countries.

Table 5.1.10. Selection of promising entries from 4th FAWWON in 5 testing sites, 1995.

Entry no.	Name/Cross	Selection site
7	Agri/093.44//Momtchil TE3067	Syria (Tel Hadya, Kamishly, Yabroud), Turkey (Cumra), Iran Maragheh)
66	90-ZHONG150	Syria (Tel Hadya, Yahmoul) Turkey (Cumra), Iran (Maragheh)
112	Au/3/Minn//HK/38MA/4/Ymh... OWA 852265	Syria (Tel Hadya), Kamishly, Yabroud), Iran (Maragheh)
68	90-ZHONG657	Syria (Tel Hadya, Turkey (Cumra), Iran (Maragheh)

(H. Ketata, A. Morgounov, H. Braun, H. Ekiz, L. Cetin, F. Dusunceli, B. Suzen, M. Keser, S. Beniwal. S. Mahfoozi, F.J. El-Haramein)

5.1.8. Collaboration with Iran

The climatic conditions in 1995 were generally favorable in Iran. However, yellow rust developed to an epidemic level in several districts of the country. At Maragheh, annual rainfall (510 mm) was above average but cold weather early in the season hindered germination and early growth, leading to poor stand and low yields on the station.

A suggestion was made for DARI, Maragheh to sow wheat before the onset of cold and generally before the rains but to give one irrigation at planting. This would lead to a real winter crop with perhaps 50-100% yield increase as compared to present technology. New cultivars have to be developed for the new planting technology if it proves successful.

Researchers at Maragheh and other DARI centers (Kermanshah, Ardabil, Sanandaj, Zanjan, Orumieh) grew and evaluated local and introduced germplasm. Three advanced lines were being increased and are considered for release because of their resistance to diseases (including yellow rust) and adaptation to cold rainfed environments of Iran: (1) Jcam/Emu//Dove, (2) Ymh/Tob//Mcd/3/Lira and (3) Pkg 16/Lov 13//Jsw 3/3/Kvz/4/... Other lines performed well in advanced yield trials including: (1) CA8055/6/Pato(R)/Ca 1/3/7C/Bb/... (2) Avg/R16//Bez*2/3/..., (3) Kremena/Lov29 and (4) Century/Csm. They will be yield-tested in Uniform Regional Wheat Yield Trial throughout Iran and simultaneously evaluated for disease resistance under artificial epiphytotics.

The Iranian National Program increased the seed of the breeding line Sxl/Glennson 81 which is resistant to yellow rust (but susceptible to dwarf bunt). The Turkish variety Dogu 88 performed well in Maragheh but will not be adopted because of its susceptibility to yellow rust. More recent germplasm tested at Maragheh revealed improved resistance to yellow rust (Table 5.1.11)

(H. Ketata, S. Mahfoozi, A. Amiri, M. Tahir, H. Braun)

Table 5.1.11. Selected facultative and winter wheat entries with good performance1 at Maragheh, Iran, 1995.

Entry name	Nursery of origin	Characteristic* Y.rust	Mat.	Ht.
Kra/Seri/4/Ymh/Tob//Mcd/3/Lira	YT95-7053	MR	M	T
Atay/Galvez 87	YT95-7131	MR	M	M
6158.19/SK4578//WJ855640	YT95-7214	MR	M	T
ID840425/6/6158.19	YT95-7245	R	ML	MT
Bz/Cno/G11/5/Ldl/3/7C/Cno/Cal/4 /Huac	YT95-7246	MR	M	M
Tirchmir 2/Hunza 2	AYT95-9091	MR	M	T
Kvz/Cut75/3/Ymh//61.1523/Drc	AYT95-9217	MR	ML	M
Kvz/Cut75/3/Ymh//61.1523/Drc	AYT95-9218	MR	ME	M
Him/Cndr//CA8055	AYT95-9219	MR	E	MT
Agri/093.44//Momtchil	4FAWWON-7	M	E	T
Knr/Trakia	4FAWWON-12	R	M	S
F130L1.1321	4FAWWON-34	R	L	S
CH75267	4FAWWON-64	R	L	M
90Zhong150	4FAWWON-66	R	E	S
AU/3/Minn/HK/38MA/4/Ymh/Era/5/.	4FAWWON-111	R	L	M
AU/3/Minn/HK/38MA/4/Ymh/Era/5/.	4FAWWON-112	MR	L	M

1) Based on visual assessment; plots were generally too heterogeneous for a reliable yield estimate.

* E=early, L=late; M=medium; ME=mid-early; ML=mid-late; MR=moderately resistant; MT=mid-tall; R=resistant; S=short; T=tall.

5.2. Double Haploid Production in Winter Wheat

For the initiation of double haploid production in 1995 in winter wheat, only F2 material was available. In general, we found a lower regeneration capacity than in spring wheat. Even though the number of induced calli was comparable to spring wheat the conversion of calli into green plantlets was lower (Tables 5.2.1a, 5.2.1b, 5.2.1c). This means that the quality of embryoids produced is lower. However, for winter wheat like for spring wheat, growing temperature of 18°C for

donor plants appears to be more favourable, especially in combination with the use of R9 regeneration medium.

Table 5.2.1a. Anther culture in F2 plants of winter wheat:cross, number of calli per hundred anthers (calli), number of green plants per hundred anthers (green plants) and number of albinos per hundred anthers (albinos).

Cross	Calli	Green Plants	Albinos
5	8.75	8.8	0
2.	40.2	7.5	0
8.	12.1	5	0.6
7.	9.5	3.2	3.6
6.	6.3	1.9	0
1	12.8	1.4	0.5
3.	15.2	0.7	0.7
4	20.4	0.4	0
average	15.2	2.8	0.8

Genotypes used:"5".Il752534/F999K,"2"MV15/4/YMH/Tob//MCD/3/Lira;"8":TE2479/F900K;"7":.F900K/TK13;"6":PLK70/lIRA//Karl,"1":G02-156-22/4/YMH/Tob//MCD/3/Lira;"3":JVP/H/Clif/3/II.. "4":.F900K//1D13.1/MLT.

Table 5.2.1b. Response of F2 plants to androgenesis using two temperature regimes (150C and 180C). Donor plants (cross), number of calli per hundred anthers (calli), number of green plants per hundred anthers (green plants) and number of albinos per hundred anthers (albinos).

Calli	Green plants		Albinos	
Cross	15^0C	18^0C	15^0C	18^0C
6	5.5	6.3	0	0
7	6.0	27.5	1.2	27.5
8	17	9.2	1.0	0
1	13.2	19.1	0.6	4.5
4	4.8	7.5	0.8	0
5	1.0	1.6	0	0
Total	8.0	11.4	0.7	2.5

Table 5.2.1c. Response of F2 plants at different temperature regimes (15°C and 18°C) to androgenesis using two regeneration media (R9 and PLR):cross, number of calli per hundred anthers, number of green plants per hundred anthers and number of albinos per hundred anther.

	% of calli converting into green plants on			
	R9 medium		PLR medium	
Cross	15°C	18°C	15°C	18°C
6	0	n.t.	0	n.t
7	42.9	100	0	20
8	6.3	0	5.6	0
1	0	36.4	8.3	2.4
4	34.5	0	0	0
5	0	n.t.	0	n.t.
Total	11.6	36.1	5.1	2.8

(M. Baum, H. Ketata)

5.3. Visits and Conferences

Scientists from Algeria, Morocco and Pakistan visited research plots at ICARDA to observe and select materials for their use. Two trainees one each from Algeria and Iran were given 4-month training in facultative/winter wheat improvement and have conducted an experiment on photoperiod and vernalization. The Iranian trainee was able to visit the Turkey-CIMMYT-ICARDA Program in Turkey and participate in selection.

A one-week study tour for wheat breeders was jointly organized in Turkey by the Turkish NARS, ICARDA and CIMMYT. There were 25 participants from: Afghanistan, China, Iran, Kazakhistan, Ukraine, Khyrgistan, Pakistan, Russia, Turkey, Turkmenistan, Ukraine, CIMMYT and ICARDA. The participants made presentations on their national research programs and exchanged views on breeding strategies and methodologies, and visited research plots at three Turkish research institutes where they observed and selected facultative and winter wheat germplasm.

Cooperating scientists from Algeria, Morocco, Tunisia and Turkey involved in the EC/ICARDA Mediterranean Highlands Project conducted surveys and research experiments in their

respective highland areas and discussed preliminary results and plans for the coming season in a meeting at Ankara, Turkey. The project aims at enhancing productivity and sustainability of crop production in the mediterranean highlands by strengthening agricultural research in these areas and enhancing collaboration and exchange of experiences and germplasm among the participating countries and ICARDA. Activities of the project are conducted in a holistic perspective, encompassing such subjects as agroecology, agronomy, germplasm enhancement, socioeconomcis and technology transfer. The improvement of facultative/winter wheat is a component of these activities.

(H. Ketata, S. Beniwal, H. Braun, A. Morgounov, N. Zencirci)

6. PATHOLOGY

Introduction

A severe yellow rust epiphytotic developed in Egypt, mainly in the Delta, and affected several commercially grown cultivars and candidate lines under multiplication. Yellow rust epiphytotics are still prevailing in Yemen and very many of the wheat cultivars grown, especially the semi-dwarf wheats, show high degree of susceptibility to the disease. In Syria and Lebanon, yellow rust spread on the scattered fields of bread wheats, especially those planted to Mexipak. This year's yellow rust epiphytotic in Iran (Moghan, Mazandaran and Shiraz) is a severe one, and of the magnitude of the 1993 epidemic.

Barley leaf stripe was the major disease of barley encountered during a field survey in the Tabriz-Moghan area of Iran. In several fields, disease incidence was more than 50%. This confirms previous observation made in the Central Anatolian Plateau, Turkey, that barley leaf stripe is the most important disease of barley in the high elevation. The barley "Head Sterility" in the major barley growing area of Syria (Bab-Djrablus-Munbedj) seems to be associated with seed-gall nematodes, Anguina sp., reported for the first time to occur on barley in Syria. This "Head Sterility" is a disease complex resulting from monoculturing barley for several years and has affected barley yield substantially. Commercial cultivars as well as cultivars under verification vary in their susceptibility to the disease. Studies on the disease and its cause have been initiated.

Artificially created epiphytotics at Tel Hadya, developed well for all wheat diseases (yellow, leaf and stem rusts, septoria blotch, common bunt) and barley diseases (powdery mildew, scald, covered smut, barley leaf stripe, loose smut). This enabled an excellent screening of the wheat and barley germplasms under testing for resistance to the major diseases in WANA.

Also, a natural leaf rust epiphytotic developed well in the summer cycle at Terbol, Lebanon, and enabled us screening for resistance to the disease of all wheat germplasm planted in the summer cycle.

(O.F. Mamluk)

6.1. Wheat Pathology

6.1.1. Collaboration with NARSs

6.1.1.1. The Wheat Rusts Network of the Nile Valley Countries; Development of a Sub-Network on Yellow Rust

Achievements and Workplans of the Network were presented during the 5th Regional Coordination Meeting of the Nile Valley and Red See Regional Program (Aleppo 24-27 September 1995). The Network concluded its first phase and was extended for another three years. In the second phase, Yemen was included as a full member country of this Network.

A Sub-network has been developed on yellow rust to be executed by Ethiopia and Yemen, with the former as lead country.

O.F. Mamluk, M.B. Solh (ICARDA, Cairo), Eshetu Bekele and Ayele Badebo (IAR, Ethiopia)

6.1.1.2. Collaboration with Aleppo University, Syria

The collaboration with the University of Aleppo aims at monitoring the prevailing races of yellow rust in Syria. This season, more than 40 isolates were obtained from yellow rust samples collected in Syria and Lebanon. In addition, 3 isolates were obtained from samples collected in Yemen. Identification of pathotypes revealed the presence of 11 physiological races from Syria (38 E150; 134 E146; 82 E16; 6 E0; 6 E150; 20 E0; 38 E128; 4 E0; 38 E134; 6 E18; and 6 E144), with 4 races (20 E0; 38 E128; 38 E134; and 6 ABBE) not reported to occur in the country before. The yellow rust bulk inoculum used at Tel Hadya for screening for resistance

constitutes most, if not all, virulences present in Syria (race 38 E150, 134 E146, 82 E16 and 6 E0). Resistant genes Yr1, Yr3, Yr4, Yr5, and several non described resistances remain effective against the pathogen population in the screening field at Tel Hadya.

Isolates from Yemen revealed the presence of race 134 E150 and 166 E150. Isolates from Lebanon are still in the process of analysis.

(O.F. Mamluk; M.S. Hakim (University of Aleppo); M. Naimi)

6.1.1.3. Collaboration with the Seed and Plant Improvement Institute (SPII), Karaj, Iran.

Cereals pathology research activities and achievements of the Dryland Research Institute (DARI) for season 1994/95 were presented at the 3rd Planning and Coordination Meeting (Marageh, 2-5 September 1995) and are shown in the Annual Report of Iran/ICARDA Collaborative Project, 1994/95.

O.F. Mamluk; M. Torabi (SPII)

6.1.1.4 Collaboration with the Institute Agronomique et Veterinaire (IAV Hasssan II), Rabat, Morocco

The Collaborative Research Work on Leaf Rust of Wheat yielded excellent results in its first year of implementation. The Durum Key Location Disease Nursery (DKL-95) and two Leaf Rust Nurseries (WLR-95 and DLR-95) were screened under natural epiphytotics at Safi, Morocco. Epiphytotics at Safi arise from aeciospores developed from the sexual stage of the pathogen on the alternate host Anchusa italica that grows at this site.

Virulence analysis was done on leaf samples collected in Syria, Lebanon, Cyprus, Iran, Yemen, Ethiopia and Sudan. Preliminary results were distributed to concerned breeders. It was interesting to learn that virulence on genes Lr3ka and Lr11 present in the Beqa'a, Lebanon, is not common in Morocco.

Summary of leaf rust virulences in WANA countries is in preparation.

O.F. Mamluk; B. Ezzahiri (IAV Hassan II)

6.1.2. Collaboration with Advanced Institutions

Collaboration with Plant Breeding Institute (PBI), Cobbitty, University of Sydney, Australia, was initiated two years ago. With the study visit of Dr. Colin Wellings to ICARDA (February-June 1995), we were able to expand and strengthen this collaboration. Collaboration aims at (1) testing all the widely grown wheat cultivars in WANA for their reaction to flag smut and rusts at Cobbitty, (2) postulating resistant genes in ICARDA's wheat breeding germplasm, and (3) developing yellow rust field differentials at Cobbitty, ICARDA and in WANA.

Testing of the widely grown wheat cultivars in WANA has been finalized and results will be made available to all NARSs.

Resistance to yellow rust among ICARDA's breeding germplasm was evaluated in the field and greenhouse at Tel Hadya. Pedigree analysis among the most resistant cultivars and advanced lines suggested that: 1) Yr6, Yr7, and Yr9 are common, 2) *Yr2* and *YrSk* varied in frequency, and 3) Yr18 appeared to be present at low frequency.

Isogenic materials developed at PBI and tested under yellow rust epiphytotics at Tel Hadya were shown to have great potential for the field monitoring of pathogenicity characteristics. Twenty three lines from this isogenic material are added to the World and European Differentials (totaling 45 lines) to form a modified set for further testing in WANA. For the season 1995/96 these differentials are planted at Tel Hadya and Kolumsa, Ethiopia. We hope to increase the seed and have the new Differentials Set planted in all yellow rust 'hot-spots' of WANA.

O.F. Mamluk; C.R. Wellings (PBI)

6.1.3. Screening of Wild Triticum for Resistance to Wheat Diseases

During the past season, 214 single-plant progenies of wild einkorn and wild emmer wheat were screened for yellow rust, leaf rust, stem rust, septoria tritici blotch and common bunt. Results showed great variation among the species (see GRU Ann. Report for 1995).

(O.F. Mamluk; J. Valkoun (GRU); M. Naimi)

6.1.4. The Susceptibility of *Aegilops* spp. with D-genome for Yellow Rust

In an attempt to confirm results from previous years on the susceptibility of *Aegilops* D-genome for yellow rust (Germplasm Program, Ann. Report for 1994), 152 Aegilops tauschii, representative for D-genome species, were selected for further evaluation. These were tested under the artificial yellow rust epiphytotics at Tel Hadya. Observations on growth characteristics showed that all entries tested were of the winter growth habit. All, except one entry (#ICAG 400353 IG GEN 46903), were susceptible to yellow rust. Further studies on this phenomenon are initiated.

(O.F. Mamluk; M. Tahir; M. Naimi; A. Saleh)

6.1.5. Concluding the Evaluating of the Center's Aegilops Collection

6.1.5.1. Yellow Rust

191 accessions of the different Aegilops species, selected in the previous season for their resistance to yellow rust, were retested. Out of these, 157 maintained their resistance (Coefficient of Infection less than 6) to the disease.

In addition, all accessions from the different species identified in the past five years as resistant to yellow rust

(578 accessions) were evaluated for the last time this season. This was done to confirm that the resistance identified in the past holds true against the new virulences of the pathogen in our inoculum, i.e., all new virulences found in Syria in the past five years.

Out of the 578 accessions tested, 504 maintained their resistance (CI <6) to the disease.

(O.F. Mamluk, M. van Slageren, J. Konopka, M. Naimi and A. Saleh)

6.1.5.2. Stem Rust

The evaluation for stem rust was conducted in the plastic house on 607 accessions of the 22 Aegilops spp. A high percentage of resistant accessions was found in speltoides, columnaris, neglecta, geniculata, and biuncialis with 84%, 76%, 74%, 65%, and 61% respectively of the tested accessions found resistant to the disease. None of tested accessions of the species *crassa*, *cylindrica*, *juvenalis*, *kotschyi*, *searsii*, *vavilovii*, and *ventricosa* were resistant to stem rust.

(O.F. Mamluk; J. Konopka and M. van Slageren (GRU); M. Naimi; A. Saleh)

6.1.6. Organic Seed-treatment versus Chemical Seed-treatment

The control of common bunt of wheat with organic nutrients has been firstly demonstrated by Becker et al., in 1990[9]. In an attempt to replace chemical seed-treatment of common bunt by organic nutrients, the above technology has been investigated at Tel Hadya in 1994/95 season using skim milk powder with very promising results (Table 6.1.1).

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[9]Becker,J., Weltzien, H.C. and Trankner, A. 1990.[Application of non-toxic organic nutrients for control of common bunt of wheat-results of field trials in 1988/89].

Table 6.1.1. Effect of organic nutrients (skim milk) on the control of common bunt of wheat, *Tilletia tritici* and *T. laevis*.

Treatment*	%head infection	
	Sebou	Bau
(*T. tritici* : *T. laevis*; 1:1) check	86	87
(*T. tritici* : *T. laevis*; 1:1) + vitavax	1	2
(*T. tritici* : *T. laevis*; 1:1) + skim milk	7	10
(*T. tritici*) + vitavax	0	1
(T. tritici) + skim milk	6	8
(T. laevis) + vitavax	0	1
(T. laevis) + skim milk	3	1

*( ) inoculation mode: pathogen; pathogens ratio

The two common bunt susceptible cultivars, Sebou (durum wheat) and Bau (bread wheat) showed an infection of 86 and 87% head infection respectively when inoculated with the two pathogens (*Tillitia tritici* and *T. laevis*) in the ratio of 1:1. The chemical seed-treatment with "vitavax" reduced the common bunt infection down to 1 and 2% respectively, and the skim milk treatment to 7 and 10%. Similar effect on the reduction of head infection via treatment with skim milk has been demonstrated when seed were inoculated with each of the common bunt pathogens separately. Results of this preliminary trial will be verified in the coming season. It is anticipated that skim milk could also be effective in controlling covered smut of barley.

(O.F. Mamluk; M. Naimi)

6.1.7. Crop Loss Assessment Trial

This season's crop loss assessment trial for yellow rust included 16 cultivar's, 8 each of durum wheat and bread wheat, under verification from the joint Collaborative Research and Training Program with DSAR, Syria. The fungicides used were triademenol, zeneb and mancozeb. Cultivar performance was assessed for Average Coefficient of Infection (ACI), grain yield/ha, tillers/m, seed/spike and

1000 KW. Interaction between cultivar and fungicide treatment was significant ($P < 0.01$) for disease score and ACI, and grain yield, but not for tiller number, seed/spike and 1000 KW. Significant difference in cultivar effect was observed for the above traits.

O.F. Mamluk; M. Singh (CSU)

6.2. Barley Pathology

Barley pathology activities in the season 1994/95 were restricted to the screening for disease resistance and to the selection of lines for the special purpose disease nurseries. Lines selected for these nurseries will be retested in several locations to develop germplasm pools for sources of resistance. These pools are made available to breeders at the Center and to NARSs for use in their breeding programs. Special purpose disease nurseries established for the 1995/96 season are Barley Scald Nursery (SBSC-96), Barley Powdery Mildew Nursery (SBPM-96), Barley Covered Smut Nursery (SBCS-96), Barley Loose Smut Nursery (BLS-96), and Barley Leaf Stripe Nursery (BST-96).

This season, screening was done in the field at Tel Hadya for scald, powdery mildew, and covered smut on 7082, 7082 and 1632 entries respectively. In addition, 50 entries of the Barley Elite Disease Nursery (BED-94) were evaluated for barley leaf stripe and loose smut after being artificially inoculated in 1993/94. Data on screening for disease resistance are compiled in QPRO files together with breeding data to facilitate selection.

Levels of infection used as selection criteria in the screening for resistance were: 0.5% coverage (for the upper 1/3) of the plant and 3% coverage of the plant for scald and powdery mildew respectively. For the seed-borne diseases, 0% head infection for covered smut and loose smut, and 0% plant infection for barley leaf stripe were used.

Figure 6.2.1 shows the performance of the different spring barley germplasm to powdery mildew, covered smut and scald. With the exception of the Iranian landraces (IRA-L), all other germplasm showed a high rate of resistance to powdery mildew. The highest percentage of resistant lines

(54%) was found in the parental germplasm (PARE94) and the least (29%) in the farmers fields verification trials (FFVTs). None of the tested Iranian landraces showed resistance to powdery mildew. Both germplasms tested for covered smut showed good resistance to the disease, with 46% of the line tested in FFVTs and 44% in BIT95 (Barley Initial Trials 95) being resistant. For scald the highest percentage of resistant lines (25%) was found in BIT95 and the lowest (7%) in IRA-L. However, a larger number of entries (39) in the BIT95 showed multiple disease resistance to powdery mildew, covered smut and scald. These lines were No. 39, 53, 106, 113, 122, 152, 194, 197, 303, 320, 331, 359, 653, 755, 817, 831, 857, 860, 916, 940-942, 989, 1000, 1019, 1036, 1051, 1054, 1055, 1066, 1087, 1100, 1104, 1121, 1149, 1226, 1368, 1495, and 1537.

Out of the 50 entries in BED-94 evaluated for barley leaf stripe and loose smut, 25 and 22 respectively were confirmed to be resistant to these diseases.

Figure 6.2.2 shows the performance of the different winter/facultative barley germplasm to powdery mildew, covered smut and scald. A relatively high percentage of resistant lines (ranging from 60 to 54%) was found in the winter/facultative barley germplasm tested: Winter Barley Observation Nursery (WBON), Facultative Barley Yield Trial (FBYT), Winter/Facultative Barley Yield Trial (WFBYT) and Facultative Barley Observation Nursery (FBON). Also for covered smut, the germplasm tested for the disease exhibited a high percentage of resistant lines with 58 and 46% for WFBYT and FBYT respectively. For scald, the highest percentage of resistant lines (39%) was found in FBON, followed by WBON (38%), WFBYT (25%) and FBYT (21%). One entry (# 20) of the WFBYT and one (# 2) of the FBYT have multiple disease resistance to powdery mildew, covered smut and scald.

(O.F. Mamluk; Z. Alamdar; A. Saleh)

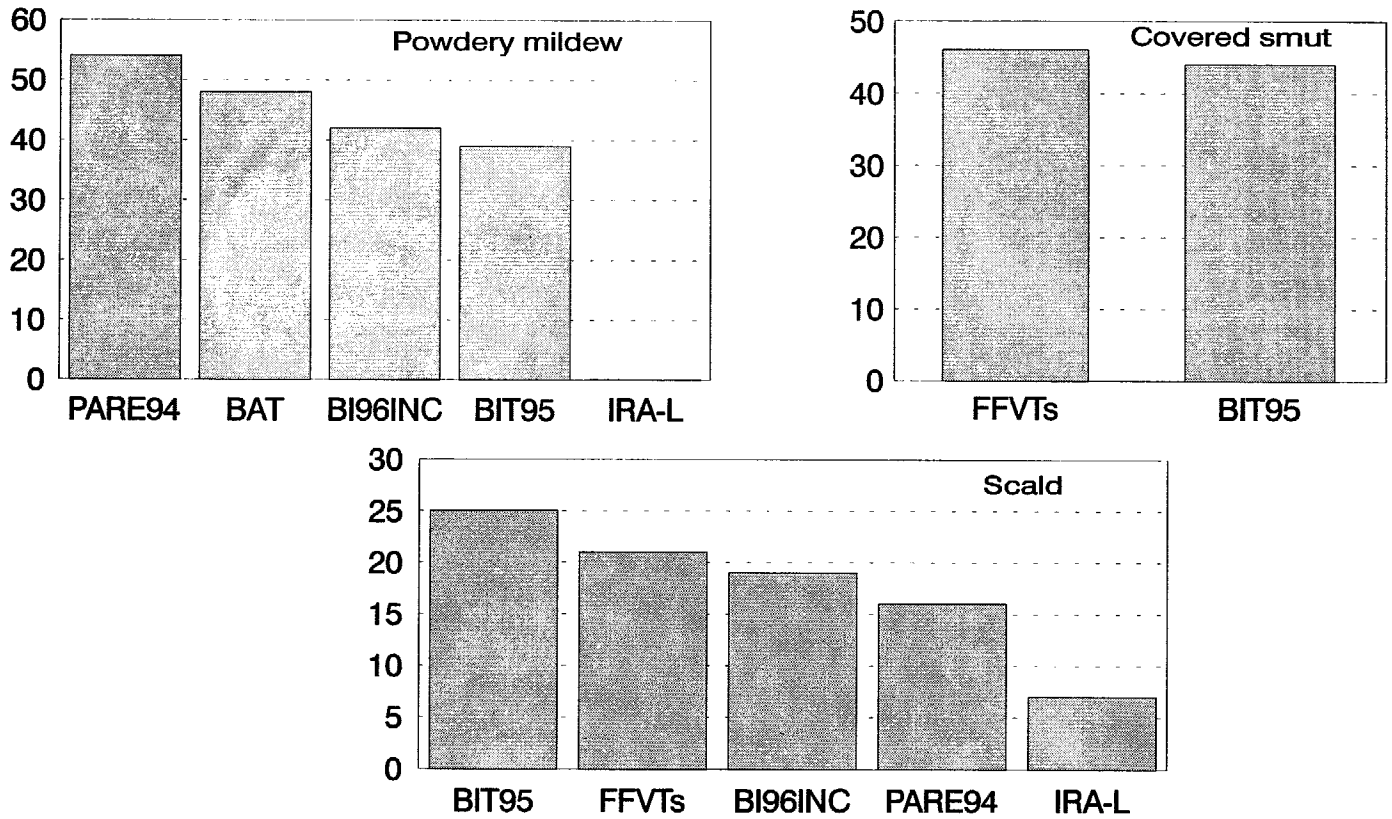

Fig. 6.2.1. Performance (% of resistant lines) of spring barley germplasm to the different diseases

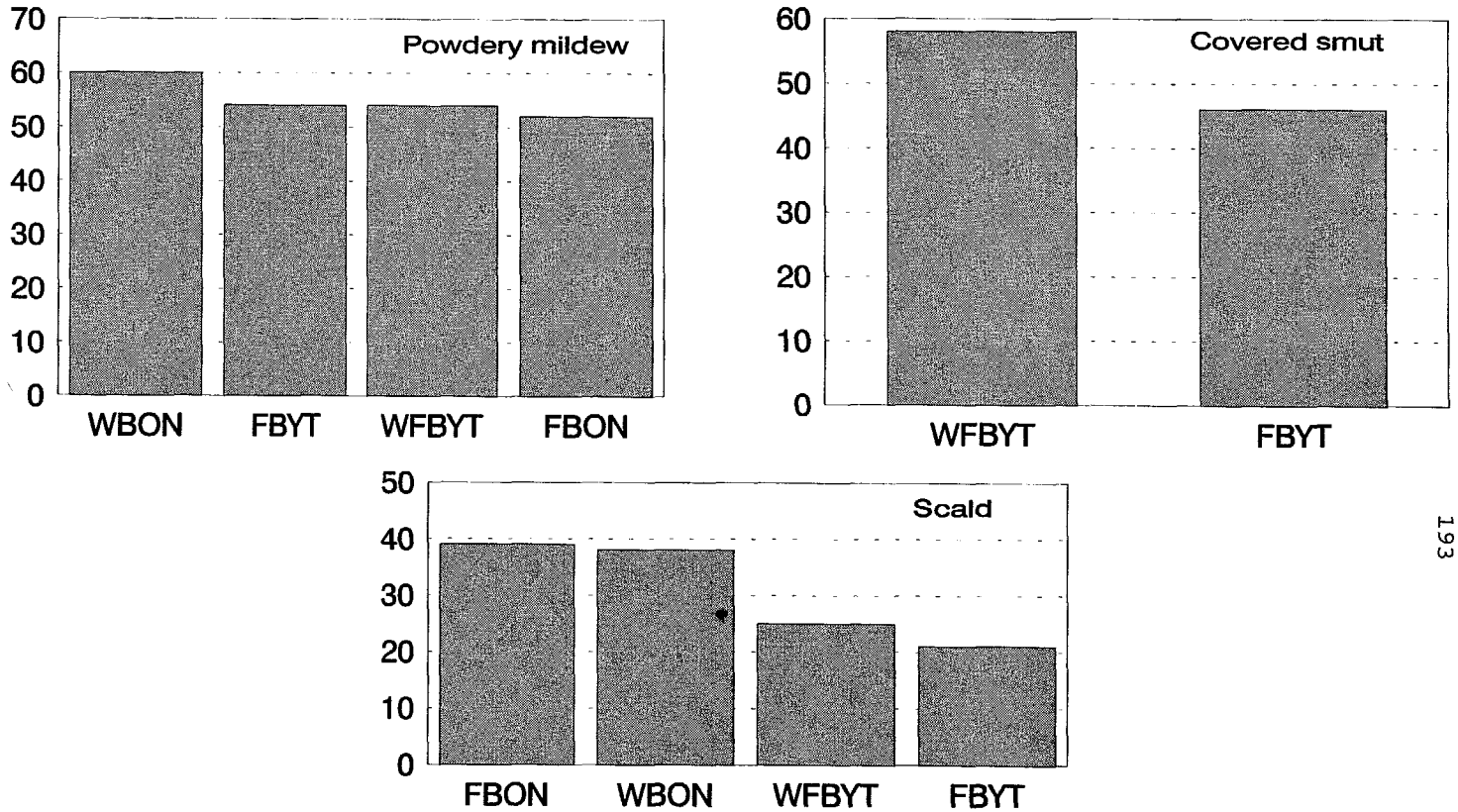

Fig. 6.2.2. Performance (% of resistant lines) of winter/facultative barley germplasm to the different diseases.

6.3. Bread Wheat Pathology

6.3.1. Summary of Disease Data in the Key Location Disease Nursery (WKL-94)

Disease data were received from Safi/Morocco for tan spot; from Tel Hadya/Syria, Terbol/Lebanon, Ciano/Mexico, Gemmeiza, Sakha and Zarzora/Egypt for leaf rust; from Tel Hadya and Lattakia/Syria for septoria tritici blotch; from Tel Hadya and Sakha for stem rust; from Tel Hadya and Terbol for yellow rust; and from Tel Hadya for common bunt. Selection criteria were 10% or less plant coverage for tan spot, <5 ACI for rusts, an average score of <5 (on a 0-9 scale) for septoria, and 15% head infection or less for common bunt.

Fig. 6.3.1 shows the performance of the lines in the WKL-94 (108, checks excluded) against the different diseases in multilocations. A good number of lines (38%) in the WKL-94 were resistant to tan spot, to leaf rust (31%), septoria (30%) and stem rust (26%). A low percentage of lines showed resistance to yellow rust (5%) and bunt (3%).

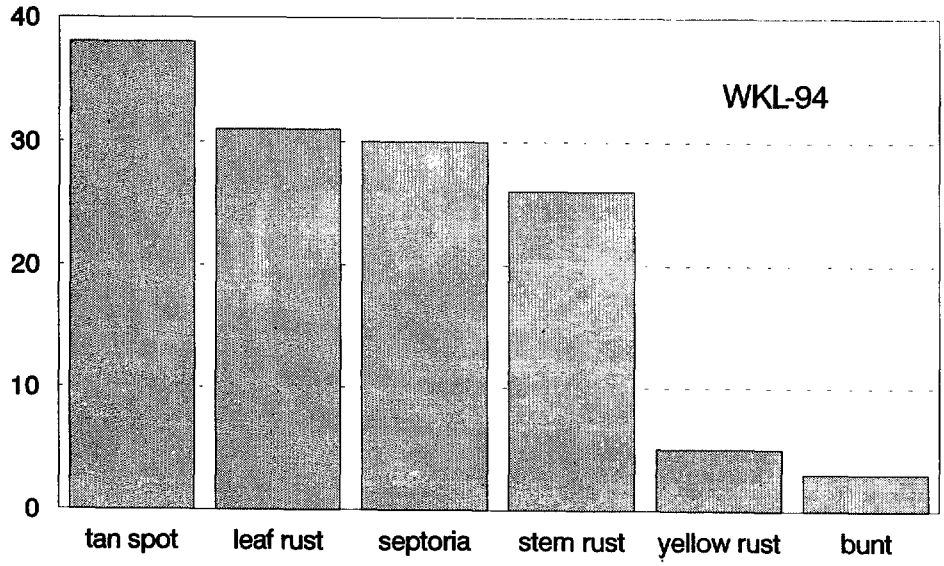

Fig. 6.3.1. Performance (% of resistant lines) of the Bread Wheat Key Location Disease Nursery (WKL-94) to wheat diseases in multilocation.

6.3.2. The Performance of Lines in Bread Wheat Nurseries to Wheat Diseases in 1994/95

The bread wheat germplasm screened for yellow rust, leaf rust, stem rust and septoria blotch was the following: Bread Key Location Disease Nursery (WKL-95), Wheat Preliminary Disease Nursery (WPD-95). In addition, the special purpose disease nurseries such as Wheat Yellow Rust Nursery (WYR-95), Wheat Leaf Rust Nursery, Wheat Stem Rust Nursery (WSR-95), and Wheat Septoria Nursery (WST-95) were each screened for its corresponding disease. Germplasm screened for resistance to common bunt was WKL-95 at Tel Hadya.

Screening sites for the different diseases were Tel Hadya and Sakha and Dhamar/Yemen for yellow rust; Tel Hadya, Terbol (summer cycle), Sakha, Zarzora and Safi for leaf rust; Tel Hadya, Sakha and Gemmeiza for stem rust; and at Tel Hadya and Meknes/Morocco for septoria.

Selection criteria used were: for rusts and in one location, <2 CI, in more than one location <5 ACI; for septoria <3 score on a 0-9 scale, and for common bunt 15% head infection or less.

Fig. 6.3.2 gives an overview of the performance of the wheat germplasm towards the different diseases. Except for yellow rust, the special purpose disease nurseries showed the highest percentage of resistant lines, WLR (91 %), WSR (100%) and WST (93%). For yellow rust, the WKL followed by the WPD are having a good number of resistant lines, with 42 and 36% respectively.

Not a single line was selected for its resistance to common bunt; the great majority of lines in the WKL showed a very high % head infection.

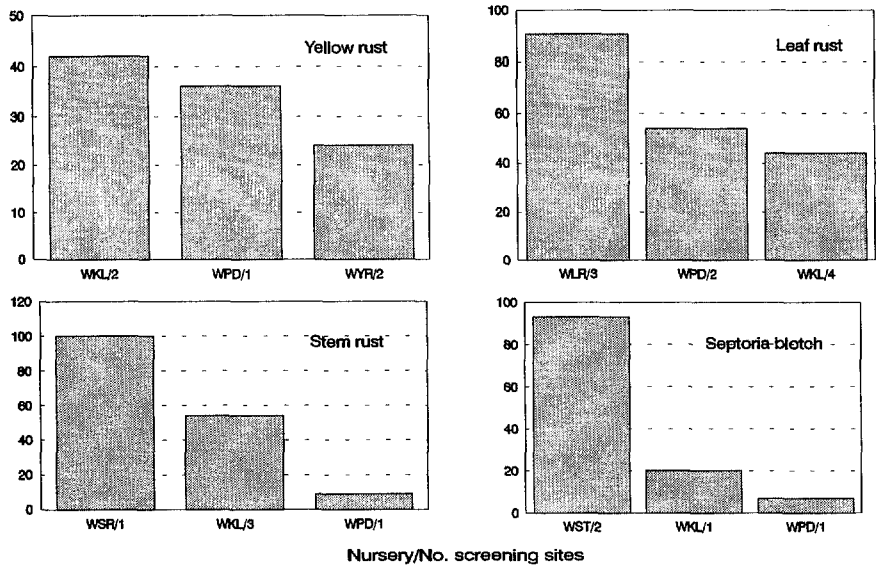

Fig. 6.3.2. Performance (% of resistant lines) of bread wheat germplasm screened for resistance to the major diseases in 1994/95.

6.3.3. Crop Loss due to Infection by Yellow Rust

Results obtained from crop loss assessment trial are presented in Table 6.3.1. A substantial increase in yield was noticed for the cultivar Mexipak, a long-term check, under treatment with Fungicide I that suppressed the infection from 85 to 13.3 ACI. Significant differences were found in ACI of Mexipak, Bohouth 6, FOW and ACSAD 305 for Fungicide I as compared to the infected treatment. Significant increase in yield ($P<0.05$) due to fungicide application was found in cultivars Mexipak, Bohouth 6, Towpe and ACSAD 305, where the increase in latter two cultivars was due Fungicide I only. The five cultivars, each loses 17.2, 18.6, 15.5 and 18.6% respectively of their yield, when infection level is at ACI level of 85.0 (=85S), 49.3 (=61.7MS), 2.0 (=5.0MR) and 50.7 (=63.3MS), respectively. The highest increase in Mexipak due to Fungicide I may have been attributed to the significant difference in tiller number, seed/spike or 1000 KW.

(O.F. Mamluk; M. Singh (CBSU); M. Naimi; A. Saleh; I. Maaz)

Table 6.3.1. Effect of yellow rust (*Puccinia striiformis*) on yield and yield components of bread wheat cultivars; Tel Hadya, Syria 1995.

Cultivar	Treatment	Yellow rust Score	/	ACI	Yield t/ha	%Yield increase	No.tillers per m	No.seed per spike	1000KW (gr.)
Mexipak	Infected	85.0	S	85.0	1.86		58.0	32.7	29.2
	Fungicide I	20.0	MR-MS	13.3	4.04	117.2	74.7	39.7	34.9
	Fungicide II	85.0	S	85.0	2.33	25.3	60.3	33.0	32.9
Bohouth 6	Infected	61.7	MS	49.3	3.98		70.7	39.7	37.7
	Fungicide I	6.7	MR-MS	4.3	4.72	18.6	73.3	40.3	39.3
	Fungicide II	66.7	S-MS	58.3	4.61	15.8	77.0	40.3	39.6
KAPSW	Infected	5.0	MR	2.0	4.03		88.7	35.3	32.6
	Fungicide I	5.0	R-MR	1.3	4.46	10.7	81.3	37.0	35.0
	Fungicide II	5.0	MR-M	2.3	4.35	7.9	92.7	36.7	35.4
MEMOF2	Infected	10.0	MR-MS	5.3	4.33		84.3	39.3	34.0
	Fungicide I	5.0	MR-R	1.7	4.70	8.5	89.3	41.7	34.5
	Fungicide II	21.7	MS-MR	15.3	4.36	0.7	82.3	42.0	35.0
TOWPE	Infected	5.0	MR	2.0	3.81		65.7	40.0	41.9
	Fungicide I	5.0	R-MR	1.3	4.40	15.5	68.0	40.3	43.6
	Fungicide II	5.0	MS-MR	3.0	4.13	8.4	64.7	39.3	43.1
FOW	Infected	16.7	MS	13.3	4.38		85.3	38.3	36.1
	Fungicide I	5.0	R-MR	1.3	4.26	-2.7	81.3	37.3	35.5
	Fungicide II	6.7	MS	5.3	4.28	-2.3	87.7	36.3	35.5
Bocro 2	Infected	6.7	MR-MS	3.3	3.51		72.0	34.3	41.8
	Fungicide I	5.0	R	1.0	3.69	5.1	76.3	35.7	41.9
	Fungicide II	5.0	M-MR	2.7	3.87	10.3	68.7	36.3	42.9
ACSAD 305	Infected	63.3	MS	50.7	3.60		67.3	39.3	38.7
	Fungicide I	6.7	MR-S	5.3	4.27	18.6	72.3	39.3	39.9
	Fungicide II	48.3	S-MS	43.0	3.84	6.7	68.7	39.0	38.1
	SE 1				±0.19		±5.34	±1.53	±1.34
	SE 2				±0.16		±5.01	±1.41	±1.05
	CV%				7%		12%	7%	4%

Figures = mean of 3 rep. each 7.2 m2, harvested 3.6 m2, from RCBD (treatment as main plot factor, cultivar as subplot). Infected = artificial inoculation applied twice. Fungicide I = triadimenol (Bayfidan EC 250), 0.5 l/ha, applied twice. Fungicide II = zeneb (Zinat 70% WP), 0.9 kg/ha, applied once; thereafter mancozeb (Agrispor 80-wp), 0.8 k/g ha , applied six times. SE 1 to compare treatment at same or different levels of cultivars; SE 2 to compare cultivar at same levels of treatment.

6.4. Durum Wheat Pathology

6.4.1. Summary of Disease Data on the Key Location Disease Nursery (DKL-94)

Disease data were received from Tel Hadya and Terbol for yellow rust, from Tel Hadya and Lattakia for septoria, from Tel Hadya for common bunt, for tan spot from Safi, for leaf rust from Tel Hadya, Terbol and Shandaweel/Egypt, and for stem rust from Tel Hadya and Gemmeiza. Selection criteria were <2 ACI for yellow rust and <5 ACI for leaf and stem rust, for septoria <3 score (on 0-9 scale), for bunt <15% head infection and for tan spot 10% plant coverage or less.

Fig. 6.4.1 highlights the reaction of the durum wheat lines in the DKL-94 (162 lines checks excluded) against the different diseases in multilocation screening. With even <2 ACI, 46% of the lines in the DKL were resistant to yellow rust. However, the DKL-94 lacks resistance to leaf rust and stem rust, since only 4% and 3% respectively showed resistance, <5 ACI, to the diseases.

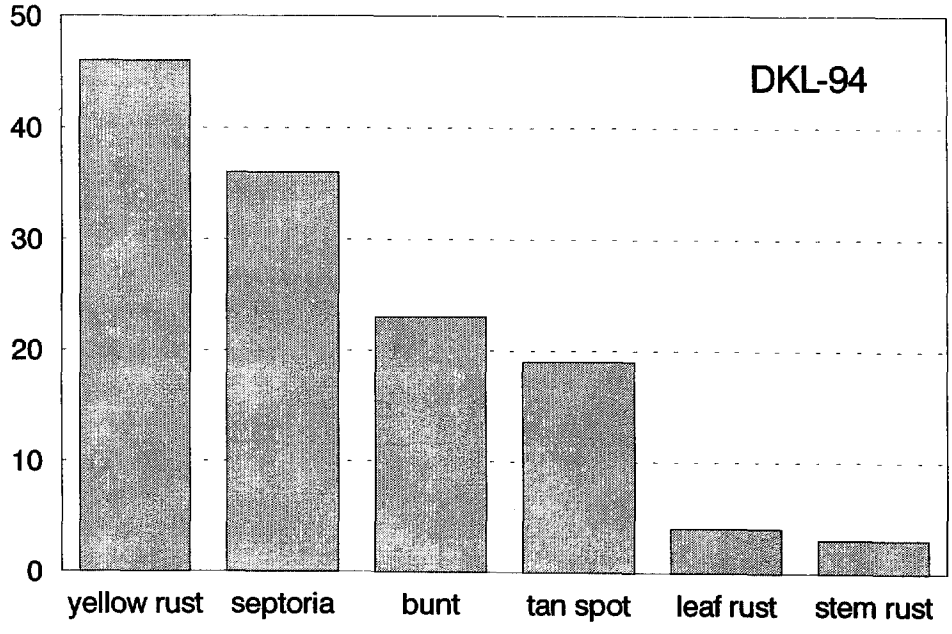

Fig. 6.4.1. Performance (% of resistant lines) of the Durum Wheat Key Location Disease Nursery (DKL-94) to wheat diseases in multilocation.

6.4.2. Performance of Lines in Durum Wheat Nurseries to Wheat Diseases in 1994/95

The following durum wheat germplasm was screened for yellow rust, leaf rust, stem rust and septoria blotch: Durum Key Location Disease Nursery (DKL-95), Durum Preliminary Disease Nursery (DPD-95), and Durum Aleppo Crossing Block (DAC-95). In addition, the special purpose disease nurseries were each screened for its corresponding disease, Durum Yellow Rust Nursery (DYR-95), Durum Leaf Rust Nursery DLR-95), Durum Stem Rust Nursery (DSR-95), and Durum Septoria Nursery (DST-95). Germplasm screened for common bunt at Tel Hadya were DKL and DAC.

The following screening sites were used for the different diseases: Tel Hadya for yellow rust; Tel Hadya, Terbol (summer cycle) and Safi for leaf rust; Tel Hadya for stem rust and septoria. However, we received valuable information from Casaccia (Roma) on the screening of DSR for stem rust and on the screening of DST from Meknes/Morocco for septoria.

Selection criteria were: <2 CI for yellow rust, <5 ACI for leaf and stem rust, <3-5 average score for septoria, and <15% head infection for common bunt.

Fig. 6.4.2 gives an overview of the performance of the durum germplasm screened for resistance to the diseases. The special purpose disease nurseries exhibited the highest % of resistant lines for each of the corresponding diseases. For yellow rust, 83% of the screened lines were resistant, but also a relatively high percentage of resistant lines were found while in the rest of the germplasm the percent of resistant lines was as follows: DPD (68%), DKL (66%), and DAC (55%). For leaf rust, except DLR, all germplasm showed a low percentage (<10%) of lines resistant to the disease. Also for stem rust, the DKL and PDP showed a low percentage of resistant lines. For septoria, the DKL had 16% followed by DAC and PDP with 13% and 11% of the lines resistant, respectively. Only one entry of the DAC (#96) was resistant to the disease.

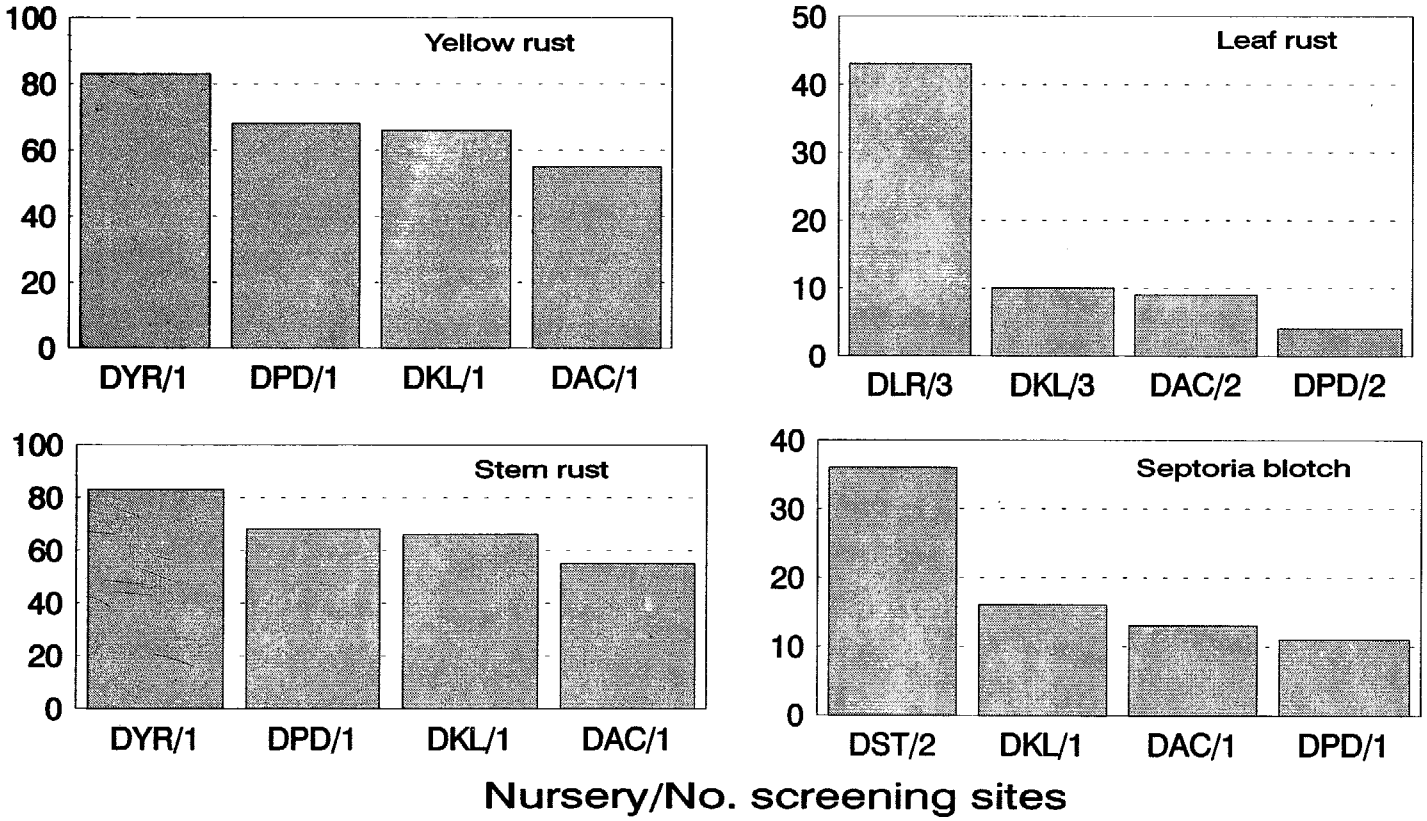

Fig. 6.4.2. Performance (% of resistant lines) of durum wheat germplasm screened for resistance to the major diseases in 1994/95.

Table 6.4.3. Effect of yellow rust (*Puccinia striiformis*) on yield and yield components of durum wheat cultivars; Tel Hadya, Syria 1995.

Cultivar	Treatment	Yellow rust Score	/	ACI	Yield t/ha	%Yield increase	No.tillers per m	No.seed per spike	1000KW (gr.)
Haurani 27	Infected	35.0	MS	28.0	2.95		84.0	30.3	40.0
	Fungicide I	5.0	R-M	2.0	3.10	5.1	76.7	29.0	41.3
	Fungicide II	25.0	MS-M	18.7	3.34	13.2	71.3	29.7	42.6
Douma 19615	Infected	8.3	MS-MR	5.7	3.94		85.7	35.0	39.5
	Fungicide I	5.0	R	1.0	4.01	1.8	76.0	35.0	39.5
	Fungicide II	10.0	MR-M	5.3	4.32	9.6	78.3	36.7	40.8
Om ruf 3	Infected	6.7	M-R	3.3	3.88		74.7	34.0	41.5
	Fungicide I	5.0	R	1.0	4.25	9.5	66.7	33.0	42.7
	Fungicide II	5.0	M-R	2.0	4.25	9.5	68.0	38.0	40.2
Stojocri 3	Infected	8.3	MS-R	5.3	4.34		89.3	28.7	48.3
	Fungicide I	5.0	R	1.0	4.37	0.7	72.3	34.7	47.8
	Fungicide II	5.0	MR-R	1.7	4.19	-3.5	67.3	31.7	49.4
Douma 20195	Infected	5.0	MR-R	1.3	4.15		71.7	37.0	45.5
	Fungicide I	5.0	R	1.0	4.51	8.7	67.7	39.3	41.6
	Fungicide II	5.0	R	1.0	3.95	-4.8	70.3	37.3	44.7
Douma 20196	Infected	8.3	MS-MR	5.7	3.82		66.3	33.7	48.6
	Fungicide I	5.0	R	1.0	4.12	7.9	68.3	37.0	47.9
	Fungicide II	5.0	R-MR	1.3	3.74	-2.1	67.3	34.0	46.5
Genil 4	Infected	6.7	MR-R	2.0	4.01		74.3	31.3	49.4
	Fungicide I	5.0	R	1.0	4.44	10.7	78.3	33.3	47.8
	Fungicide II	5.0	R	1.0	4.23	5.5	76.0	31.7	50.4
ACSAD 323	Infected	13.3	MS-R	9.3	3.23		61.3	28.3	50.3
	Fungicide I	5.0	MR-R	1.3	3.85	19.2	67.7	30.0	49.8
	Fungicide II	18.3	M-MR	10.7	3.40	5.3	64.7	29.3	50.5
	SE 1				±0.19		±5.34	±1.53	±1.34
	SE 2				±0.16		±5.01	±1.41	±1.05
	CV%				7%		12%	7%	4%

Figures = mean of 3 rep. each 7.2 m2, harvested 3.6 m2, from RCBD (treatment as main plot factor, cultivar as subplot). Infected = artificial inoculation applied twice. Fungicide I = triadimenol (Bayfidan EC 250), 0.5 l/ha, applied twice. Fungicide II = zeneb (Zinat 70% WP),0.9 kg/ha, applied once; thereafter mancozeb (Agrispor 80-WP), 0.8 kg/ha, applied six times. SE 1 to compare treatment at same or different levels of cultivars; SE 2 to compare cultivar at same levels of treatment.

6.4.3. Crop Loss due to infection by Yellow Rust

Results obtained from crop loss assessment trial are presented in Table 6.4.3. Except for Haurani 27, the long-term check, all durum cultivars included in the trial showed a relatively low infection level. Increase in yield was observed in Genil 4 and ACSAD 323 when treated with Fungicide I. In this situation, infection level varied from 2.0 to 1.0 ACI in Genil and from 9.3 to 1.3 ACI in ACSAD. Significant differences in ACI was found only in Haurani for Fungicide I, while significant yield increase was found only in ACSAD. ACSAD loses about 19% of its yield, when infection level is 9.3 ACI or 13.3 MS-R.

(O.F. Mamluk; M. Singh (CBSU); M. Naimi; A. Saleh; I. Maaz)

6.4.4. Germplasm Pools for Sources of Resistance

Sources of resistance to major wheat diseases identified in previous years, retested in the special purpose disease nurseries to confirm their resistance (some in multilocation), and selected for acceptable agronomic types were pooled and multiplied in the 1994/95 season to form germplasm pools for sources of resistance. Lines in these pools were carefully selected for the target disease, but also for non-target diseases in WANA. Established pools for the season 1995/96 are Durum Yellow Rust (12 lines), Durum Leaf Rust (18 lines), Durum Stem Rust (12 lines) and Durum Septoria (15 lines). These Pools were furnished to collaborators in WANA and beyond in 40, 40, 35 and 35 set respectively.

(O.F. Mamluk; M. Naimi; A. Saleh; I. Maaz)

7. TRAINING AND VISITS

The following training activities were conducted during 1995.

7.1. Long-term Course in Cereal Improvement

The annual course on cereal improvement continues to attract NARS and donor institutions. In 1995, 10 participants from 7 countries - Algeria (2), Iran (1), Libya (2), Morocco (1), Syria (2), Tunisia (1) and Yemen (1) - were trained for 4 months (12 March-13 July 1995) on various aspects of wheat and barley improvement. As in the previous year, training was individualized to respond to the specific need and interest of each trainee, although few training sessions were common to all trainees, particularly those that covered pathology, biotechnology, grain quality, physiology and experimental design. Reports and course evaluation by the trainees showed that the course was very useful to them. This was confirmed by the technical evaluation of trainees' performance at the end of the course. It is expected that this course will continue to appeal to NARS's.

7.2. Advanced Short-term Course on Breeding Methodologies for Cereal and Legume Crops

A 3-day advanced course on "breeding methodologies for cereal and legume crops" was held at ICARDA during 30 April-2 May 1995. Participants were 9 experienced researchers from NARS in 8 countries (Table 7.1). The following general topics were covered: (1) breeding for disease resistance (2) improving plant tolerance to abiotic stresses, (3) novel methods for plant improvement and (4) statistical tools for plant breeders. The course was at a senior-researcher level and took the form of a workshop with active participation and intervention of all persons involved. From the overall assessment of the course, it was judged very useful but a suggestion was made to hold separate courses for cereals versus legume crops instead of a unified course for both types of crops in the future.

Table 7.1. Participants in the ICARDA advanced course on breeding methodologies for cereal and legume crops, 30 April-2 May, 1995, ICARDA, Aleppo, Syria.

Name	Degree	Profession	Institution/ country
Selo-Sito Murad	MSc.	Legume Breeder	ARC, Iraq
Faisal Rjoub	PhD.	Cereal Breeder	NCARTT, Jordan
Suleiman Sebai	MSc.	Cereal Breeder	ARC, Libya
Azzeddin Douyissi	PhD.	Cereal Breeder	INRA, Morocco
Gamel ElKheir Khalifa	MSc.	Cereal Breeder	ARC, Sudan
Ahmed El Kaderi	BSc.	Cereal Breeder	DASR, Syria
Mohamed Al-Maula	BSc.	Legume Breeder	DASR, Syria
Mohsen Boubaker	PhD.	Agronomist/ Breeder	ESAK, Tunisia
Nukhet Atikyilmaz	BSc.	Legume Breeder	SEARI, Turkey

7.3. DNA Molecular Markers Techniques

The course on "DNA molecular marker technique for germplasm evaluation and crop improvement" was again requested by NARS and conducted on 17-28 September 1995 at ICARDA. 12 trainees from 7 countries participated including two supported by AOAD and one by the ICARDA-Iran project (Table 7.2). Part of the course cost was covered by the UNDP-ICARDA funded biotechnology project. The participants were breeders, senior researchers or students. As in the previous season (refer to GP Cereal Annual Report of 1995, p.238-239) they attended lectures on genetics and current research issues in biotechnology and spent most of their time working in the laboratory where they carried out such activities as DNA extraction and purification, gel electrophoresis, RFLP, and PCR. The participants rated the course highly beneficial and few wished it were longer.

7.4. Database and Pedigree Management for Plant Breeders

Upon a specific request from Egyptian NARS, a 4-day intensive course on "database and pedigree management for plant breeders" was organized at Cairo, during 28-31 January 1995. Two instructors from ICARDA's Germplasm Program delivered the training that consisted of an

introduction to handling pedigrees and data, an initiation to a spreadsheet software and its use in combination with another statistical software to produce field books, prepare a crossing program, and analyze data from planned experiments.

Table 7.2. Participants in the ICARDA course on DNA molecular marker techniques for germplasm evaluation and crop improvement, 17-28 September 1995, ICARDA, Aleppo, Syria.

Name	Degree	Institution/country
Jaladat M.S. Jubarel	PhD.	IPA/Iraq
Aref Amiri	MSc.	DARI/Iran
Fouad Maalouf	MSc.	(Student)/Lebanon
Mohamed El-Hadi	MSc.	INRA/Morocco
Ismahane El-Ouafi	MSc.	IAV/Morocco
Sakr Bouazza	PhD.	INRA/Morocco
Mohamed Afzal	MSc.	PGRE/Pakistan
Abderrahmane Kalhout	PhD.	DASR/Syria
Salam Lawand	Diploma	Dam.Univ./Syria
Hussein Abu Hamzeh	Diploma	DASR/Syria
Maisoun Hamameh	Diploma	AU/Syria
Imren Baran	PhD.	CRIFC/Turkey

Trainees were 12 senior wheat/barley breeders from Egypt. They appreciated the practical nature of the course which they found useful and informative. The NVRSRP covered all associated costs.

7.5. Cereal Disease Methodology

An in-country course on "cereal disease methodology" was organized at the Agricultural Research Center in Oroumieh, Iran during 21-29 May 1995. The course was sponsored by AREEO of Iran. The trainees were 5 pathologists from PPDRI, 6 from SPII and 1 from AREEO, and 3 instructors from Iran (2) and ICARDA (1). Course activities were (a) lectures on major cereal diseases in Iran and their epidemiology, diagnosis, assessment and control, (b) practical lab sessions, and (c) field visits. The participation of the trainees was active throughout the course. A special emphasis was placed on yellow rust epidemics and ways of alleviating them.

7.6. Diagnosis of Plant Viruses

A regional course on "diagnosis of plant viruses" was jointly organized by ICARDA and AGERI (Agricultural Genetic Engineering Research Institute) of Egypt at Cairo on 10-21 September 1995. Support to the course and training participants was provided by ICARDA, AGERI, UNDP, GTZ, NVRSRP and ICARDA-Iran project. Fifteen participants attended the course including 10 from Egypt and one each from Iran, Morocco, Syria, Turkey an Yemen (Table 7.3).

The course covered: characterization of viruses, methods of virus detection, and diagnosis of plant virus diseases. It also included lab sessions on agar gel diffusion, ELISA (enzyme-linked immunosorbent assay), dot-blot ELISA, TBIA (tissue-blot immunoassay), and PCR. The course evaluation was positive and the course is expected to attract more demands and support in the future.

7.7. Management of Cereal Research Experiments

An in-country training course, sponsored by INRA and DERD of Morocco and ICARDA was conducted by Moroccan scientists on 14-16 June 1995 at Mehdia, Morocco for the benefit of 16 Moroccan participants (15 INRA technicians from different experiment stations and 1 extension service agent). The objective of the course was to improve participants' skills in effectively managing and ameliorating the quality of research experiments and demonstration plots. During the first two days, presentations and discussions were held focusing on appropriate agronomic packages, breeding techniques and methods, diseases of cereals in Morocco, experimental design in agricultural research, and role of technicians in the successful management of research experiments.

Table 7.3. Participants in the regional course on diagnosis of plant viruses, 10-21 September 1995, Cairo, Egypt.

Name	Degree	Institution/country
Dr. Abdel Aziz Ali Sallam	Ph.D.	Suez Canal Univ./ Egypt
Mr. Ahmed Mohamed A. Awad	MSc.	Doddy, Pest. Cent. Lab./Egypt
Dr. Atef Shoukry Sadik	PhD.	Ain Chams Univ./ Egypt
Ms. Azza Galal Farag	BSc.	ARC/Egypt
Ms. Iman Mohamed El Abagy	MSc.	ARC/Egypt
Ms. Fatma Hussein Roshdy	BSc.	ARC/Egypt
Mr. Hamed Mohamed Moursi	BSc.	IPM Project/Egypt
Mr. Hemaid Ibrahim Ahemaidan	BSc.	Desert Res. Center/ Egypt
Mr. Ismail Aly Mohamed A. Hamid	MSc.	AGERI/Egypt
Mr. Monir Aly Abd El Naby	MSc.	CAS/Egypt
Mr. Kareh Bananej	MSc.	AREEO/Iran
Ms. Fatiha Chadly	BSc.	INRA/Morocco
Mr. Abdel Rahmane Darwich	MSc.	DASR/Syria
Mr. Birol Akbas	MSc.	Cukurova Univ./ Turkey
Mr. Khaled Mohamed El-Mahfadi	BSc.	ARA/Yemen

On the third day, a visit was made to Merchouch experiment station to observe trials and demonstrate some of the issues discussed during the previous days (e.g. diseases, experimental design). The course emphasized the role of the technician in the improvement of research experiments. It was highly valued by all participants.

7.8. On-farm Verification and Demonstration of New Varieties

Twenty-two participants from Lebanon were involved in a 2-day training workshop on "on-farm verification and demonstration of new varieties" held at Terbol, Lebanon on 26-27 October 1995. This included 10 staff members of ARI, Tel Amara, 7 from Terbol Station, 2 from UNDP, Baalbak Hermil Project, one from the Lebanese University and two from ICARDA, Syria.

The participants discussed various aspects of on-farm testing and demonstration including planning, design and implementation, technical and socio-economic follow up, etc. The discussions covered the planning of on-farm verification and large scale demonstration in 1995-96.

Farmers will manage the demonstration plots, while researchers will manage the verification trials. Field visits are planned to take place throughout the season during which farmers' feedback will be sought on the new methodology.

7.9. Individual Training

A large number of researchers and students came to GP for individual non-degree training, around 50% of whom were from Syria. Topics of training covered breeding, biotechnology, pathology, virology, grain quality physiology or data analysis. The duration of training varied between one week and 4 months (Table 7.4). More emphasis is placed by NARS on having their researchers acquire specific skills to conduct independent research. Only two persons were accepted for a short period.

Table 7.4. Individual non-degree training* in cereal crops at Germplasm Program, ICARDA, 1995.

Country	No. of trainees	Total duration (person-month)	Topic
Syria	13	19	Virology, biotechnology, breeding, pathology, quality, data analysis.
Egypt	3	4.5	Durum breeding, wheat breeding, cereal biotechnology.
Algeria	1	2	Physiology/breeding.
Morocco	1	1	Biotechnology.
Spain	1	3	Durum physiology.
Vietnam	1	2	Barley breeding.
Yemen	1	2	Cereal improvement.
Iraq	1	1	Biotechnology.
Iran	1	0.5	International nurseries.
Lebanon	1	0.25	Cereal quality.
France	1	0.25	Cereal improvement.
Total	25	36	

* Includes 4 undergraduate students from Aleppo University (4 p.m.)

Fourteen graduate students (9 MSc. and 5 PhD. candidates) from 6 countries were supported by GP in 1995 (Table 7.5). Two students graduated and another completed his research at ICARDA during this year. Graduate-degree training continues to gain more interest both from NARS and ICARDA scientists. Thesis subjects are focused on NARS research priorities. In general, the research is partially or completely conducted at ICARDA under the supervision of a senior ICARDA scientist. In few cases, it is entirely conducted at the University (Table 7.5).

Table 7.5. Graduate students working on cereal crops at GP, ICARDA, 1995.

Name	Degree	Topic	Country
Mohsen Shehata*	PhD.	Bread wheat breeding	Egypt
Ahmed Shawki El-Sebae	MSc.	Wheat breeding	Egypt
Berhane Lakew**	MSc.	Barley breeding	Ethiopia
Uwe Scholz	MSc.	Cereal pathology	Germany
Claus Einfeldt	PhD.	Barley breeding	Germany
Alfredo Impiglia	PhD.	Durum wheat breeding	Italy
El Tair Ahmed A.A.**	MSc.	Crop physiology	Sudan
Moahmed I. Ismail**	MSc.	Cereal agronomy	Sudan
Sleiman Raad	PhD.	Durum wheat quality	Syria
Ramez Mahmoud	MSc.	Cereal quality	Syria
Ghassan Naassa	PhD.	Barley breeding	Syria
Fareed Maqdees*	MSc.	Cereal physiology	Syria
Zuhair Wassouf	MSc.	Durum wheat quality	Syria
Hassam Abeido	MSc.	Wheat pathology	Syria

* Completed research/left ICARDA or graduated in 1995.
** Research conducted outside ICARDA.

7.10. Scientific Visits and Meetings

In 1995 a large number of visitors were hosted by the Germplasm Program for varying periods. Scientists from Australia, Canada, Ethiopia, Iran, ICRISAT, Lebanon, Netherlands, Pakistan, Syria, and USA (North Dakota) visited GP for short (1 week) periods for familiarization with GP activities, exchange of information or selection of germplasm. CIMMYT scientists visited GP to discuss collaborative work and exchange information on durum wheat, facultative/winter wheat, and pedigree management systems.

Official delegations to ICARDA from Iran, Russia

(Saratov), IFAD, and USA (Arizona) visited GP within the framework of the collaboration between ICARDA and their respective institutions.

Visiting scientists from Australia, Egypt and Pakistan spent longer periods (1-4 months) at ICARDA to work with GP scientists in the areas of cereal pathology, physiology, and winter cereal breeding, respectively.

Groups of students and teachers from Syrian universities visited the Program to learn about ICARDA's work on cereal improvement.

A 3-day meeting was held on 20-22 March 1995 at ICARDA to discuss the strengthening of durum wheat work in the region and initiate a research network among durum wheat growing countries where NARS scientists take a major role in intercountry collaboration. The meeting was attended by 38 participants from Algeria, Canada, Egypt, France, Germany, Greece, Italy, Jordan, Lebanon, Libya, Morocco, Spain, Syria, Tunisia, Turkey, USA and from IFAD, CIMMYT and ICARDA.

A 4-day travelling workshop in Syria was organized for cereal breeders from Algeria, Egypt, Libya, Morocco, Syria, Tunisia and Turkey in addition to scientists from CIMMYT and ICARDA. The participants visited research plots at ICARDA's stations and on-farm trials in farmers' fields, and discussed ways of improving the work efficiency of cereal researchers.

(H. Ketata and A. Sabouni)

8. COLLABORATIVE RESEARCH

8.1. West Asia Regional Program

8.1.1. Multiplication of Rihane-03, a new released variety in Iraq

Rihane-03, the barley variety released in 1994 for the rainfed areas of northern Iraq exceeded the local barley landrace by 14% in straw yield and 31% in grain yield.

In 1994, farmers planted about 500 ha in Rihane-03 and achieved an average yield of 1544 kg/ha. In 1995 the areas planted expanded to 5000 ha. The expected area to be planted in 1997 is 250,000 ha. Rihane-03 was popular among farmers for its lodging resistance, high yield, and sutability for bread making when mixed with wheat.

8.1.2. Barley Production Technology Contest in Jordan

The Mashreq project in Jordan organized a contest between barley farmers. A technical committee was established to evaluate farmers fields and measure their yield. The fifteen farmers who got the highest yield by following the barley technology of early sowing, fertilization, use of the improved cultivar and of the seed drill, were selected as winners. In a celebration day H.E. Minister of Agriculture met with the farmers and gave each winner recognition certificates and in kind contribution of 1/2 ton fertilizer.

8.2. North Africa Regional Program

8.2.1. ICARDA/Maghreb Collaboration in Germplasm Improvement

During 1994-1995 the germplasm program played a catalytic role in consolidating the partnership withthe countries of the region. Its activities in North Africa covered a wide array of research and training. Although the Germplasm Program responded directly to the specific needs of each country, it also encouraged the expertise available in individual NARS to service all the region. Some

activities in Morocco and Tunisia were complementary to research work carried out at Aleppo, while the activities in Algeria and Libya were concentrated on the planning and implementation of the season workplans, and by various levels of training for programs development. GP/NARS interactions focussed on the rainfed dry areas of Morocco, Algeria, Tunisia and Libya. In addition to the evolutive nature of partnership that made use of increased capacity of NARS to benefit the whole region, a new dimension, was added, consisting of interaction with the Mashreq region and Turkey's highland regional program, encouraged by the Mashreq and Maghreb (M&M) project for integrated crop/livestock productions in rainfed dry areas and the Mediterranean highlands projects, respectively funded by AFESD/IFAD and EEC.

8.2.2. Weather and Crop Production in 1994/95: the drought

For the first time in the past 10 years, a prolonged drought affected every site in the Maghreb and no rainfall was received anywhere between mid-November to mid-February (Table 8.1).

Table 8.1. 1994/95 season rainfall and number of days of continuous drought prior to anthesis at three key research sites in Morocco.

Research	Rainfall (mm)		Number of days of early drought
	Sept-Dec	Jan-March	
Marchouch	64.5	65.0	101
Douyet	104.5	64.1	114
J. Shaim	27.0	71.0	96

This most generalized drought on record enabled the identification of wheat, barley, lentil and forage cultivars that do produce economic yield in very bad years.

8.2.3. Research Activities Implemented

The activities carried out during the 1994/95 season could be divided into two types of collaborative research. Some

activities involved only the NARS of Maghreb, while others represent ICARDA/North Africa National Programs joint implementation of complementary research operations developed annually during the regional coordination meeting. The latter dealt with technical support to research, build-up of local capacity to carry out independent research through training, develop workplans for country and regional projects and arrange coordination meetings, seminars and travelling workshops.

Indeed, the activities undertaken during the season 94/95 aimed at:

- Linkages of Maghreb to other regional, programs in order to mutually benefit from experiences and use complementary research strength were expanded.
- Linkages with other institutes involved in related activities were also expanded.
- Forged ties by implementing research activities with individual projects in the Germplasm Program at Aleppo were coordinated.
- The exchanged of information, the germplasm and the communication line between ICARDA and its partners and among NARS were facilitated.
- Algerian and Libyan NARS were helped to identify and prioritize research thrusts and participated in the execution of related research programmes.
- NARS were assisted in the development of inter-regional collaborative research networks within the Mashreq and Maghreb, AFESD/IFAD funded project and the EEC funded Mediterranean highland project.
- A new Maghreb socio-economic research network was established.

8.2.4. NARS-NARS Collaborative Activities

The manpower skills available in Morocco in cereal germplasms development, and in Tunisia, mainly for legume research, were utilized to support researchers in Algeria and Libya. A positive development on the Maghreb scene is the emergence of potentially reliable research leaders for the whole of North Africa:

- Dr. El-Bohssini, for insect resistance research

work.

- Dr. A. Amri, for barley improvement research.
- Dr. H. Halila, for legume research.
- Settat Center, for heading "Not commodity-based" regional research and physiology and agroecological characteristics, and related models developed and testing simulation.

These inter-country ties benefited from the Mashreq/Maghreb project for Integrated Crop/Livestock production and the EEC funded project for increased products in the mediterranean highlands. These projects mainly strengthened the North Africa, lentil, chickpea, barley, durum and bread wheat yield trials (NAYT). They have also strengthened technology transfer activities.

8.2.4.1. Morocco

Cereal production and research were severely curtained by prolonged and widespread drought during the crop season 1994/95. Table 8.2, shows the reduction in area, yield and production of major cereals.

Table 8.2. Area production and yield of barley, bread wheat and durum wheat in the last two cropping seasons in Morocco.

Species	Season	Area (100 ha)	Production (1000 qx)	Yield (Q/ha)
Barley	1993/94	2583.0	37199.1	14.4
	1994/95	1578.0	5500.0	3.5
Bread Wheat	1993/94	1713.9	31808.8	18.6
	1994/95	1170.0	7100.0	6.2
Durum Wheat	1993/94	1335.8	23423.3	17.5
	1994/95	820.0	3900.0	4.7
Total	1993/94	5632.1	92431.0	-
	1994/95	3568.0	16500.0	-

INRA cereals research is carried out within 25 projects, grouping over 100 types of activities, among which 20, implemented in close collaboration with ICARDA, have yielded excellent results. The areas of collaborative research are mainly in:

1. Implementation of collaborative barley breeding for

specific North Africa environments.

2. Durum Wheat resistance breeding for diseases and insects (Hessian Fly, Tan Spot, Root Rots).
3. Screening for Hessian Fly resistance in the wild relatives and transfer of effective resistance genes into wheat.
4. Exchange of bread wheat germplasm resistant to Septoria, Rusts and Hessian Fly.
5. Development of varieties adapted to high elevation areas.
6. Maghreb Joint yield trials for characterization of adaptation of commercial cultivars and promising lines.
7. Transfer of technologies to farmers.
8. Agroclimatic characterization ok key growing environments.
9. Initiating joint activity in water harvesting and supplemental irrigation.
10. Morocco scientists helped the Germplasm Program develop a project proposal for Durum improvement in the mediterranean region.
11. Dr. El-Bouhssini entomologist lectured in the Insects course provided at Aleppo which several junior scientists attended.

The highlights of the season in cereals research can be summarized as follows:

8.2.4.1.1. Germplasm Collection and Evaluation

- Samples of wild *Hordeum*, *Triticum*, *Avena* and *Aegilops* (82 total) were collected in the mountain regions. *Triticum* and *Aegilops* species from Morocco were screened and most of the accessions were found resistant to Hessian fly.
  Screening of Durum collection (world and north Africa): one durum accession appears to be resistant to Hessian fly.
- Electrophoresis of Gliadins and Hordeins showed a large diversity between and within local populations of Durum and Barley collections, respectively.

8.2.4.1.2. Germplasm Development

Development of synthetic hexaploid wheats (durum x *A. squarrosa*) resistant to Hessian fly. Crosses and backcrosses were performed between Wheat and Wild species (*T. araraticum*, *T. monococcum* and *T. boeticum*) (Table 8.3).

Table 8.3. Hybridizations interspecific and intergeneric in durum and bread wheat during 1994/95.

Male parent	Female parent	Cross objective	Result
T. tauschii	*T. durum*	Bread wheat synthetic	12 hybrids
T. mococococum	*T. durum*	Transfer of genes	4 hybrids
Ae. ovata	*T. durum*	Transfer of genes	36 hybrids
T. araraticum	*T. durum*	Transfer of genes	47 hybrids
T. tauschii	*T. aestivum*	Transfer of genes	12 hybrids

T. = *Triticale*
Ae. = *Aegilops*

- Resistance to Septoria, Hessian fly and Rusts were combined in bread wheat using of double haploid technique.
- H^{11}, H^{24} and other genes in PI's are in the process of being introgresse into Durum wheat.
- Genes controlling the anther regeneration ability in Durum wheat are found to the located on chromosomes in 2B and 5B.

8.2.4.1.3. Insects Research

- 6000 lines were screened for Hessian fly. The salient results are presented in Tables 8.4, 8.5, and 8.6.

Table 8.4. Reaction of an ICARDA assembled *Aegilops* collection for resistance to Hessian fly, Settat-Morocco, 1995.

Species & Genome	Origin	No.Accessions Tested	No.Resistant Accessions
Ae.ovata (UM)	Morocco (14) Portugal (5) Syria (1)	88	20
Ae.triuncialis (UC)	Morocco (2) Portugal (4)	41	6
Ae.triaristata (UM)	Morocco	8	1
Ae.cylindrica (CD)	Turkey	4	1
Ae. squarrosa (D)	Unknown	7	5

Table 8.5. Reaction of a Moroccan collection of *Aegilops* for resistance to Hessian fly in Morocco.

Species & Genome	Origin	No.Accessions Tested	No.Resistant Accessions
Ae.ovata (UM)	North of Morocco	36	5
Ae.triuncialis (UC)	Tetouan		
Ae.triaristata (UM)	Ksar El Kebir	3	1
Ae.ventricosa (CD)	Azrou, Sefrou	4	2

New genes for Hessian fly resistance were found effective in Morocco: H^{25} and 3 other unnamed yet. In addition one Durum accession was found resistant. These are found in ICARDA provided international collections, screened for the region, both at Aleppo and Morocco.

Table 8.6. Reaction of ICARDA and international durum wheat collections for resistance to Hessian fly in Morocco.

Line	% Resistant plants	Mechanism of resistance
CM 829	78.5	ANTIBIOSIS/TOLERANCE
CI 112	75.0	ANTIBIOSIS
CI 113	100.0	ANTIBIOSIS
CI 115	100.0	ANTIBIOSIS
BD MS3	41.0	ANTIBI./TOL
NASMA	0.0	SUSCEPTIBLE CHECK
SAADA	100.0	ANTIBIOSIS (RES. CHECK)

Table 8.7. Reaction of 30 double haploid lines for resistance to Hessian fly in Morocco.

Line	Number of plants tests	% resistant plants
DHP1	20	100
DHP2	14	100
DHP3	18	100
DHP4	19	100
DHP5	18	100
DHP6	25	100
NASMA (SUSC. CHECK)	19	0
SAADA (RES. CHECK)	50	100

First sources of resistance to barley cecidomyie found in *Hordeum* species.
Source of resistance to Russian Wheat Aphid were found in barley (6), and bread wheat (2).

8.2.4.1.4. Wheat Improvement

Durum wheat fixed lines resistant to Hessian Fly are evaluated in the catalogue trials for registration. Several durum backcross derived lines using H5 gene are now fixed and will be tested in the Maghreb cooperate yield trials.
Many double haploid Hessian fly resistant bread wheat lines were developed (Table 8.7).

8.2.4.2. Tunisia

8.2.4.2.1. Selection for drought tolerance

Drought prevailed in Tunisia for the second year in a row. Nevertheless, yields of promising lines reached 45 q/ha at Beja, 38 q/ha at Krib, and 30 q/ha with partial irrigation at Bou Salem. The highlight of this very dry season is that promising lines of the previous years confirmed their superiority under crop failure conditions. Om-Rabia-3 and D86-189 in durum; Manel in barley; and Attila (BT 2715) and Bow "W"/Dougga 74 in bread wheats were selected for release.

The ICARDA-Maghreb barley joint development research proved most useful, as 31% of the lines in the special barley segregating populations (SEGMAG) were superior to Rihane-03, the most widely adapted and cultivated barley in North Africa.

8.2.4.2.2. Disease Breeding

Net blotch of barley, the most common disease in North Africa caused by *Pyrenophora teres*, has been discouraging barley breeders from releasing germplasm which lacked adequate resistance. During the past few years, research was stepped up in Tunisia with the support of ICARDA's barley program. During 1995, resistance has been identified in lines with good agronomic background. Several good sources are shown in Table 8.8.

Table 8.8. New sources of resistance to net blotch.

Line 527/NK 1272 ICB 84-323-8 AP-0 AP
Trebi CI 936
Turk CI 14400
LA Mesita
Can Lake Shore (CI 2750)
Tifan(CI 14373)
CI 6688

Septoria Tritici of Wheat

Research carried out at INAT in Tunis showed that:

- Strains isolated from durum wheat are specific to this species; they are more aggressive and quite distinct from those isolated from bread wheat.
  Bread wheat varieties are more tolerant than durum wheat. The best varieties were: BYRSA (2.8% foliar infection) and RAZZAK (18% foliar infection)

Moreover, three fungicides C. Prochloraz, Carbendazim, Tebuconazole have been found to control satisfactorily septoria when applied at tillering.

8.2.4.3. Algeria

In 1994/95 season, drought in Algeria was less severe than in Tunisia, Morocco and Libya. However, the high plateau areas suffered from other stresses and particularly from very low temperatures. Through the season, frost affected crop growth at Setif, Tiaret and Saida which had 88, 42, and 83 frosts days, respectively.

Germplasm received from Aleppo was in general of excellent quality, mainly from the following nurseries:

Species	Location and Nurseries	Useful characters in Nurseries
DW	Khroub (MRA) Tiaret (MRA and HAA)	Yield Potential and Disease Resistance
BW	S.B. Abbes (LRA)	Drought, heat and frost
Barley	Setif (LRA)	Terminal drought

Therefore, 83 bread wheat, 179 durum; and 263 barley 263 lines were found superior in F_2 segregating populations received from ICARDA.

In the yield trials and nurseries the following fixed line were the most valuable. They are selected for final evaluation in the nation wide yield trials:

Durum wheat : Khronos; Titan; Araldur; OM. Rabi-6; Bidi 17* 2/WAHA
Bread wheat : Vee "S"/Nac.; As 81189.
Barley : S/1617; Vertige; ER/Apm//Ac253

Table 8.9 gives an idea of the usefulness of fixed germplasm received from ICARDA.

Table 8.9. Number of lines selected in Algeria from both international and special nurseries

Nurseries	Number of selected lines		
	BW	DW	B
Durum W.			
DCTON		29	
DON-4AA		42	
DWON		09	
Bread W.			
WOMFM	14		
FAMWON	19		
BWHTON	10		
BWONSAA	10		
BWON	04		
Barley			
BNNA			14
SGMG			39
BOW			08
Naked Barley			08

8.2.4.4. Libya

ARC research activities were well supported by ICARDA, and Maghreb NARS scientists. These collaborative activities still need strengthening mainly in areas such as disease and insect pest resistance, and development of food legume cultivars.

Because of severe reductions in staffing, in addition to the lack of facilities in the past few years ARC-Tripoli, relied heavily on ICARDA to generate germplasm for all field crops; mainly for barley crosses between North African land races adapted to abiotic stress and high yielding types available at ICARDA. The ARC-Tripoli strategy is presently to receive, in addition to international nurseries for low rainfall areas, early generations (F_2's primarily) of crosses to grow and select at several sites in Libya, in order to select types for the specific local needs of Libyan farmers. To carry out this selection effort efficiently, ARC-Libya research capabilities need to be strengthened, especially in pathology, entomology, and legume research. Moreover, ICARDA scientists still need to visit at crucial selection

times. In cereals, the country still uses very old cultivars (for example: Mexipak breadwheat).

The number of trained staff requires urgent increase mainly in key research areas of disease and insect resistance and legume breeding. Therefore, scientific interactions with ICARDA, Aleppo pathologists and legume breeders and specialized visits to relevant programs will be helpful. Moreover, Libya NARS needs to be acquainted with modern biological technologies in terms their application to crop improvement.

8.2.4.4.2. Insects Cereal Crops

Insects pests constitute a disproportionate problem to production, when compared to other North African countries. It is therefore necessary to screen genetic materials of cereals for insect resistance, and to survey major insects affecting cereal production. In addition, ARC needs to train local personnel in these areas.

8.2.4.4.3. Training

Libya needs more and better trained scientists to increase the training opportunities for national scientists in short and long term as well as local courses, giving special consideration to individual training courses.

Libya needs to take advantage ICARDA's international relations with some European and other universities so that local personnel may be given opportunities to better qualify in various fields.

8.2.4.4.4. Research on Triticale

Work was limited to germplasm evaluation of advanced trials, as well as seed multiplication of some varieties obtained from CIMMYT and Algeria.

8.2.4.4.5. Barley

During 1994/95 season work continued in screening and

selecting from F_2 six-rowed barley crosses and observation lines obtained from ICARDA within the framework of ICARDA/Maghreb collaboration. A number of genotypes was tested in advanced yield trials. It was possible to obtain a number of promising varieties using this new collaborative avenue. The number of lines selected and crosses that provided useful segregant will be reported in the ARC-annual report. More attention must be given to germplasm screening for salt tolerance and for naked barley varieties development.

8.2.4.4.6. Cereal Pests and Diseases

A major cereal insects survey is needed in Libya to enable developing a screening programme for diseases and pest resistance of importance. Training opportunities for young scientists in this respect will be useful. Cooperation is needed in initiating a breeding programme for insect resistance especially in barley

8.2.4.4.7. Bread and Durum Wheat

The followings are the areas where improvement of the existing collaboration are possible:

- Intensified cooperation efforts are needed with the other national programmes in the region in the field of germplasm exchange.
- Increase and support of scientific visits exchange between scientists from national programmes in the region.
- Implementation of recommendations identified within durum wheat network between ICARDA and the Maghreb NARS; with special attention to new technologies, for faster durum wheat improvement.

(M. Mekni)

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10. CEREAL VARIETIES RELEASED BY NATIONAL PROGRAMS.

Crop	Country	Year of release	Variety
Barley	Algeria	1987	Harmal
		1992	Badia
		1993	Rihane-03
	Australia	1989	Yagan
		1991	High
		1993	Kaputar
		1993	Namoi
	Bolivia	1991	Kantuta
		1993	Kolla
	Brazil	1989	Acumai
	Canada	1992	Seebe
		1993	Falcon
		1994	Tukwa
		1995	Kasota
	Chile	1989	Leo
		1989	Centauro
	China	1988	Zhenmai 1
		1989	V-24
		-	Api/CM67//B1
		1989	CT-16
	Cyprus	1980	Kantara
		1989	Mari/Aths*
	Ecuador	1989	Shyri
		1992	Calicuchima-92
		1992	Atahualpa-92
	Egypt	1993	Giza 125
	Ethiopia	1981	BSH 15
		1984	BSH 42
		1985	Ardu
	Iran	1986	Aras
		1990	Kavir
		1990	Star
	Iraq	1994	Rihane-03
		1994	IPA 7
		1994	IPA 9
		1994	IPA 265
	Jordan	1984	Rum
	Kenya	1984	Bima
		1993	Ngao
	Lebanon	1989	Rihane-03

Crop	Country	Year of release	Variety
Barley	Libya	1992	Wadi Kuf
		1992	Wadi Gattara
	Mexico	1986	Mona/Mzq/DL71
	Morocco	1984	Asni
		1984	Tamellat
		1984	Tissa
		1988	Tessaout
		1988	Aglou
		1988	Annaceur
		1988	Tiddas
	Nepal	1987	Bonus
	Pakistan	1985	Jau-83
		1987	Jau-87
		1987	Frontier 87
		1993	Jau-93
		1995	AZRI-95
	Peru	1987	Una 87
		1987	Nana 87
		1989	Buenavista
		1984	Una-94
	Portugal	1982	Sereia
		1983	CE 8302
		1990	Ancora
	Qatar	1982	Gulf
		1983	Harma
	S. Arabia	1985	Gustoe
	Spain	1987	Resana
	Syria	1987	Furat 1113
		1991	Furat 2
		1994	Impr.A. Abiad
	Tanzania	1991	Kibo
	Thailand	1987	Semang 1
		1987	Semang 2
		-	BRB-8
	Tunisia	1985	Taj
		1985	Faiz
		1985	Roho
		1987	Rihane-03
		1992	Manel 92
	Turkey	1993	Tarm 92
		1993	Yesevi 93

Crop	Country	Year of release	Variety
Barley	Turkey	-	Orza
	U.S.A.	-	Poco
		-	Micah
	Vietnam	1989	Api/CM67//B1
	Yemen	1986	Arafat
		1986	Beecher
Durum wheat	Yemen AR	1986	Arafat
		1986	Beecher
	Algeria	1986	Sahl
		1986	Waha
		1992	Korifla
		1992	Omrabi 6
		1984	Timgad
		1993	Heider
		1993	Kabir 1
		1993	Omrabi 9
		1993	Belikh 2
	Cyprus	1982	Mesoaria
		1984	Karpasia
	Egypt	1979	Sohag I
		1988	Sohag II
		1988	Beni Suef
		1990	Sohag III
		1990	Beni Suef I
	Greece	1982	Selas
		1983	Sapfo
		1984	Skiti
		1985	Samos
		1985	Syros
	Iraq	1994	'Waha Iraq'
	Jordan	1988	Korifla=Petra
		1988	N-432=Amra
		1988	Cham1=Maru
		1988	Stork=ACSAD75
	Lebanon	1987	Belikh 2
		1989	Sebou
	Libya	1985	Marjawi
		1985	Ghuodwa
		1985	Zorda
		1985	Baraka
		1985	Qara

Crop	Country	Year of release	Variety
Durum wheat	Libya	1985	Fazan
		1992	Khiar 92
		1993	Zahra 5
	Morocco	1984	Marzak
		1989	Sebou
		1989	Omrabi
		1991	Tensif
		1992	Brachoua
		1992	Omrabi 5
		1995	Omrabi 6
	Pakistan	1985	Wadhanak
	Portugal	1983	Celta
		1983	Timpanas
		1984	Castico
		1985	Heluio
	Saudi Arabia	1987	Cham 1
	Spain	1983	Mexa
		1985	Nuna
		1989	Jabato
		1991	Anton
		1991	Roqueno
	Syria	1984	Cham 1
		1987	Cham 3
		1987	Bohouth 5
		1994	Cham 5
	Tunisia	1987	Razzak
		1993	Omrabi 3
		1993	Khiar
	Turkey	1984	Susf bird
		1985	Balcili
		1988	EGE 88
		1990	Cham 1
		1991	Kizilton
		1994	Firat 93
		1994	Aydin 93
		1995	Haran=Omrabi 5
Bread wheat	Algeria	1982	Setif 82
		1982	HD 1220
		1989	Zidane 89
		1992	Nesser = Cham 6

Crop	Country	Year of release	Variety
Bread wheat	Algeria	1992	Cham 4=Sidi Okba
		1992	Rhumel
		1992	Alondra=21AD
		1992	Soummam
		1992	ACSAD 59=40DNA
		1994	Mimouni
		1994	Ain Abid
	China	1994	Mayoun 1
		1995	Dong Feng-1
	Egypt	1982	Giza 160
		1988	Giza 162
		1988	Giza 163
		1988	Giza 164
		1988	Sakha 92
		1991	Gammeiza 1
		1991	Giza 165
		1993	Sahel 1
		1994	Sids 1
		1994	Sids 2
		1994	Sids 3
		1994	Giza 166
		1994	Giza 167
		1995	Giza 167
		1995	Sids 4
		1995	Sids 5
		1995	Sids 6
		1995	Sids 7
		1995	Sids 8
	Ethiopia	1984	Dashen
		1984	Batu
		1984	Gara
	Greece	1983	Louros
		1983	Pinios
		1983	Arachthos
	Iran	1986	Golestan
		1986	Azadi
		1988	Darab
		1988	Sabalan
		1988	Quds
		1990	Falat
		1995	Tajan

Crop	Country	Year of release	Variety
Bread wheat	Iran	1995	Atrak
		1995	Nicknejad
		1995	Mahdabi
		1995	Darab 2
	Iraq	1989	Es14
		1994	Hamra
		1994	Abu Ghraib
	Jordan	1988	NASMA=Jubeiha
		1988	L88=Rabba
		1988	Nesser
	Lebanon	1990	Seri
		1991	Nesser
		1995	Roomy
	Libya	1985	Zellaf
		1985	Sheba
		1985	Germa
	Morocco	1984	Jouda
		1984	Merchouche
		1986	Saada
		1989	Saba
		1989	Kanz
	Oman	1987	Wadi Quriyat 151
		1987	Wadi Quriyat 160
	Pakistan	1986	Sutlej 86
	Portugal	1986	LIZ 1
		1986	LIZ 2
	Qatar	1988	Doha 88
	Sudan	1985	Debeira
		1987	Wadi El Neel
		1991	Neelain
		1993	Sasarieb
	Syria	1984	Cham 2
		1984	Bohouth 2
		1986	Cham 4
		1987	Bohouth 4
		1991	Cham 6
		1991	Bohouth 6
	Tanzania	1983	T-VIRI-Veery 'S'
		1983	69/BD
	Tunisia	1987	Byrsa
		1987	Salambo

Crop	Country	Year of release	Variety
Bread wheat	Tunisia	1992	Vaga 92
	Turkey	1986	Dogankent-1
		1988	Kaklic 88
		1988	Kop
		1988	Dogu 88
		1989	Es14
		1990	Yuregir
		1990	Karasu 90
		1990	Katia 1
		1995	Kasifbey
		1995	Basribey
	Yemen	1983	Marib 1
		1983	Ahgaf
		1988	Mukhtar
		1988	Aziz
		1988	Dhumran
		1988	SW/83/2

11. STAFF LIST

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5.	Dr John M. Peacock	Ecophysiologist
6.	Dr Franz Weigand	Molecular Biologist
7.	Dr Muhammad Tahir	Winter & Facultative Barley Breeder
8.	Dr Guillermo Ortiz-Ferrara	Bread Wheat Breeder (CIMMYT)
9.	Dr Milouid Nachit	Durum Wheat Breeder (CIMMYT)
10.	Dr Hugo Vivar	Barley Breeder, LARP (Mexico)
11.	Dr Stefania Grando	Barley Breeder
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30. Mr Mohamed Azrak	Senior Research Technician
31. Mr Adnan Ayyan	Senior Research Technician
32. Mr Bassam Shammo	Senior Research Technician
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36. Mr Salem Farrouh	Research Technician
37. Mr Hani Hazzam	Research Technician
38. Ms Nadia Fadel	Research Technician
39. Mrs Wafa'a Haj Juma'a	Research Technician
40. Mr Ahmed El-Saleh	Research Technician
41. Ms Sawsan Tawkaz	Research Technician
42. Ms Iman Maaz	Research Technician
43. Ms Aman Sabbagh	Research Technician
44. Mr Asaad El-Jasem	Labour Foreman
45. Mr Abdalla Steif	Assistant Technician
46. Mr Hasan El-Khatib	Assistant Technician (Terbol)
47. Mr Michael Abou Nakad	Assistant Technician (Terbol)
48. Mr Obeid El-Jasem	Farm Labourer
49. Ms Rita Nalbandian	Executive Secretary
50. Mrs Sossi Toutounji	Secretary
51. Ms Raghad Rahwan	Secretary