CEREAL PROGRAM

Annual Report for 1993

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 18 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 CGIAR seeks to enhance and sustain food production and, at the same time, improve socioeconomic conditions of people, through strengthening national research systems in developing countries.

ICARDA's mission is to meet the challenge posed by a harsh, stressful and variable environment in which the productivity of winter rainfed agricultural systems must be increased to higher sustainable levels; in which soil degradation must be arrested and possibly reversed, and in which the quality of the environment needs to be assured. ICARDA meets this challenge through research, training and dissemination of information in a mature partnership with the national agricultural research and development systems.

The Center has a world responsibility for the improvement of barley, lentil, and faba bean, and a regional responsibility in West Asia and North Africa for the improvement of wheat, chickpea, forage and pasture—with emphasis on rangeland improvement and small ruminant management and nutrition—and of the farming systems associated with these crops.

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.

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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Annual Report for 1993

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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FOREWORD

The crop improvement research on cereals at the International Center for Agricultural Research in the Dry Areas (ICARDA) covers barley, durum wheat and bread wheat. Both spring and winter and facultative types of these cereals are grown in the ICARDA region; hence research issues of both types are addressed. This report includes the results of the work done mainly in the 1992-93 season. The research team was led by Dr. J. Hamblin, who has written an introduction to this report. Dr. Hamblin left ICARDA in November 1993 to take up his new assignment as the Director of CLIMA (Centre for Legumes in Mediterranean Agriculture) in Perth, Western Australia. I would like to thank him for all his contributions to the cereal improvement research at ICARDA.

Effective November 1993 the 'Cereal Program' and the 'Legumes Program' of ICARDA have been merged to form the 'Germplasm Program'. Therefore, in future, the research on both cereals and legumes will be reported together in the Germplasm Program Report.

M.C. Saxena
Leader, Germplasm Program

March 24, 1994.

1. INTRODUCTION

The 1992/3 season was very dry in Morocco and western Algeria, but was average elsewhere. The weather data for Tel Hadya is shown in Fig. 1.

The Program highlights in 1993 include our increasing understanding of the importance of trace element toxicities and deficiencies in the region. Their correction is showing some dramatic yield improvements. As a first step we consider that agronomic approaches are most appropriate for deficiencies and genetic approaches are more suitable for toxicities. In the deficiencies we have indications that copper, zinc and iron are inadequate for maximum plant growth in certain areas. Our Turkish colleagues are finding dramatic responses to zinc applications in deficient sites. In the area of toxicity we are finding significant improvements in yield potential when boron tolerant lines are compared with boron susceptible sister lines. We believe that boron toxicity is far more wide spread in the region than it has been given credit for and we hope to survey this over the coming years as well as being able to provide resistant germplasm.

The work on root rots continues and we have developed a good methodology for testing the resistance of material in the field that uses machine planted split plots, where the pathogen is inoculated using the same approach as that used to apply rhizobium to legume seeds. We are finding significant differences between genotypes for their response to infection, but the relationship of this to yield is complex. We are also aware of the importance of soil-borne nematodes in some areas, but so far have not been able to persuade anyone to fund a cereal nematologist to assist us in identifying the scale and importance of the problem in WANA and to develop cheap and effective screening techniques.

There is an increased interest in hull-less barleys and our work reflects this. This year has seen the release of several hull-less varieties and all barley projects have increased their efforts on these types. At similar yield levels they have improved energy output per ha as the hulls account for between 10 and 13% of the yield of barley and they are fibrous and of low digestibility.

The changes in our breeding approach for barley in the dryland areas of North Africa have been enthusiastically supported by our colleagues from the Maghreb and we see this as something of a pioneering effort and approach. It builds on the considerable complimentary strengths of the national programs and maximizes mutual co-operation and self help between the countries of North Africa. As we gain experience in this approach we will expand this methodology to other regions and species within the CP mandate in WANA.

We have found that cold tolerance in barley for the highland areas is not related to low yield potential in warmer climates. This means that in mild years or in less cold areas highland varieties will not suffer a yield penalty due to high levels of cold tolerance. The prospects of breeding widely adapted varieties in these areas are improved.

The entomology and plant pathology work continues to provide germplasm to NARS that carries resistance to many pests and diseases. Much of this work is done in collaboration with NARS colleagues, particularly in Egypt and North Africa. With Moroccan scientists we have developed durum lines resistant to Hessian fly for the first time.

These and other topics make up this annual report, and if you wish further information please contact the people listed at the end of each section.

As I sit in my office on a wild, wet and cold November day I think about both my imminent departure to the summer in Australia, to working on legumes and to the friends and colleagues that I will leave behind in WANA. I would like to thank you very much your friendship, collaboration and stimulating argument. Science advances by debate and experimentation. If the debate is not strong, vigorous and open, then the science will suffer. I have encouraged this in the Cereal Program and have greatly appreciated my WANA colleagues input into the debate. This is best expressed in the changes we have made to our work in North Africa. Without your lively comments and criticisms these changes would not work. So thank you, friends and colleagues, for your time and efforts that have made my stay in WANA so enjoyable and beneficial to me. I hope it was the same for you. I look forward to seeing your progress in future years, which I am sure it will be considerable. I also hope to continue contact with the region in my new position, and even though it is in legume research, I still have an interest in cereals, both through the technical benefits of including legumes in rotations for cereals and as a farmer.

Thank you all for everything and best wishes for 1994 and the future.

John Hamblin
Leader Cereal Program

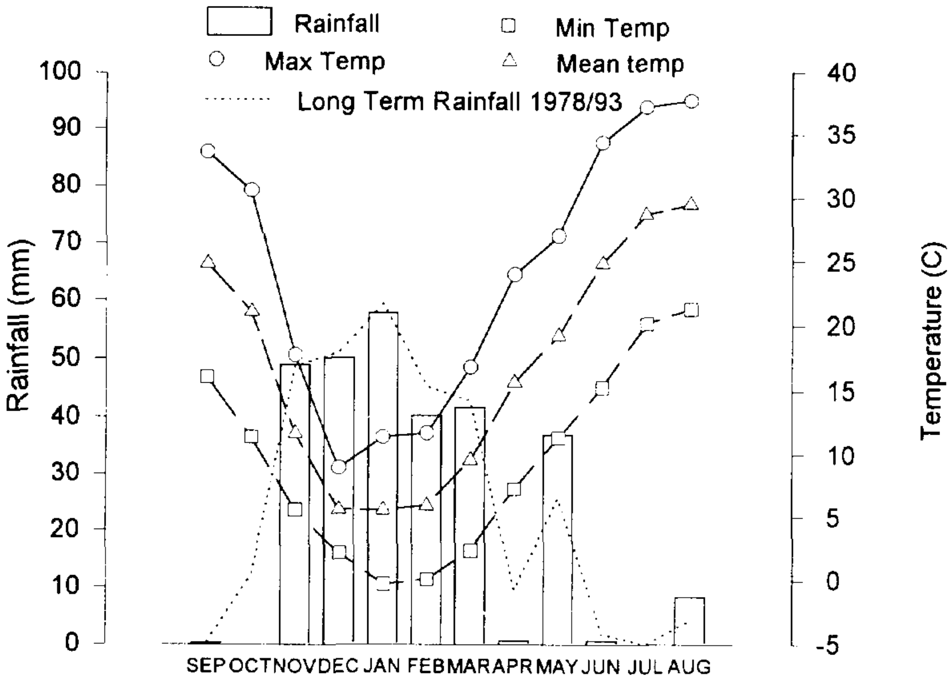

Fig. 1 Tel Hadya monthly weather in the 1992/93 season.

2. BARLEY IMPROVEMENT

ICARDA fulfills its global mandate on barley by organizing the barley improvement work 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

2.1.1. Introduction

The project tests the efficiency of breeding methodologies for different environments and identifies those that can be easily adopted by national programs. We are committed to a strong breeding program at Aleppo to assist in germplasm development, while encouraging national programs to strengthen their own programs.

To exploit specific adaptation better and to use the expertise in national programs the project is gradually replacing the traditional system of germplasm distribution based on fixed or semi-fixed lines, with the distribution of less advanced material. The aim is to distribute mainly F_2 populations and to select the best populations in different environments within and across countries. National programs are directly involved in designing the crosses and in the selection between F_2 and between lines extracted from selected populations. ICARDA staff assists in making the crosses, distributing the germplasm and advancing generations to maintain continuity. This process was initiated in Maghreb (Morocco, Algeria, Tunisia and Libya) where almost 5 million hectares of barley are grown annually and where six-row types predominate. The reaction of NARS after three years of implementation of "decentralized barley breeding" is very positive. In 1993 we began implementing the same approach in other countries where success of traditional germplasm distribution has been limited.

Our work with mixtures has increased in collaboration with the University of Hohenheim. A Ph.D student, Mr. Claus Einfeldt, works on the role of heterozygosity and heterogeneity as buffering mechanisms against unpredictable climatic conditions.

Dr. M. Mayer completed his PhD in early 1993 and joined the project in March 1993. He will share in the responsibility of the breeding program, specifically on straw quality and genetic and environmental effects on dry matter production and its partitioning.

Scientists from Syria, Iraq, Egypt, Nepal and Pakistan visited the project to familiarize themselves with the new breeding methods and field techniques. The project invited Prof. Simmonds (Edinburgh School of Agriculture) to comment on the new breeding methods and strategies.

Collaboration with Ethiopia on the utilization of locally adapted germplasm became a special project supported by the Government of the Netherlands. The project will help the barley program in Ethiopia to implement a new strategy in barley breeding based on three concepts: 1) the majority of testing sites will be on farmers fields, and will be used by all concerned scientists to characterize Ethiopian landraces for disease and pest resistance, quality traits and spectrum of adaptation, 2) while in the past landraces have been used as donors of useful genes, in Ethiopia they will be used as recipient of useful genes to be transferred in an adapted genetic background. 3) the use of inputs in some of the testing sites will add flexibility to the breeding program which will be in a better position to serve the needs of farmers who use inputs as well as those who don't.

A number of technical changes were introduced to increase efficiency. Breeding plots were standardized to a length of 3.75 m or multiples of it and to a width of 8 rows at 20 cm with continuous planting.

Yield data recording was fully automated thanks to a software developed by Mrs. G. Nachit. This has reduced the time between harvesting and data analysis by about 40%.

Pedigree management is gradually shifting from ICADET to a database which allows a) storage of pedigree and data in the same file, and b) greater flexibility in the use of statistical packages others than CRISP. Most yield trials for 1993-94 are large α-lattices. - **S. Ceccarelli**

2.1.2. Barley Breeding for Specific Adaptation

2.1.2.1. North Africa

Decentralization of barley breeding in Maghreb continued in 1992/93 according to the time-table presented in the Annual Report for 1991/92 (Table 2). Three types of special nurseries, namely a yield trial (180 lines), an observation nursery (332 lines) and F_2's (254 populations, some of which derived from crosses designed by NARS), were distributed together with the Regional Yield Trial which is also distributed in many other countries and was distributed in Maghreb for the last time. Frequency of selection from the unreplicated nurseries varied from 12 to 49% (Table 1).

The increased selection of lines in 1992/93 may be due to a better targeting of crosses for the Maghreb countries. We compared the average frequency of selection with the traditional international nurseries. Because of changes in locations used for testing, the comparison is only possible at country level. In Tunisia, Algeria and Morocco there was, in general, a modest increase in the frequency of selection. The advantage of the special nurseries was not evident in Libya where adaptation strongly depends on earliness. This characteristic was already incorporated in most of the lines distributed to that country in 1990-91.

Table 1. Frequency of selection (%) in two new nurseries for Maghreb (F_2 and observation nursery for Maghreb, or SMAG) and average frequency of selection in the traditional observation nurseries distributed between 1986 and 1991.

Country	Location	New Nurseries		Old Nurseries
		F_2	SMAG	International Nurseries 1986-91[a]
Libya	Azizie	16.9	35.2	32.1[b]
	Misurata	33.5	17.8	
Tunisia	Beja	51.6	23.2	16.2
	Kef	42.9	24.7	
	Tajerouine	30.7	13.3	
	Foussana	29.9	-	
Algeria	Khroub	29.5	25.3	16.0
	Setif	22.4	17.2	
	Tiaret	-	26.8	
	Saida	-	12.4	
Morocco	Annaceur	20.0	12.1	12.2
	Merchouch	28.0	25.3	
	Jem al Shaim	18.9	17.2	

[a] Average frequency of selection in the observation nurseries
[b] Data of 1990-91 only

The total number of lines selected from the special nursery (SMAG) was too high to be tested as one Advanced Yield Trial for Maghreb which would inevitably sacrifice lines specifically adapted to one country. To fully exploit specific adaptation in 1993/94 we have designed different yield trials for each country. Each trial (an α-lattice with two replications) contains both lines specifically adapted to that country and lines which were selected in more than one country.

The frequency of F'_2s selected in individual countries and in combination of two, three and four countries (Table 2) suggests that the populations were better adapted to Tunisia and Morocco than to Libya and Algeria. With additional data sets of this type it will be possible to analyze the data at location level. This may rationalize the choice of the selection sites. 4800 individual F_2 plants were extracted from the selected populations. These will be the basis for germplasm development in North Africa in the next two to three years

Table 2. Frequency of selection (%) in a nursery of 254 F_2 populations grown at eight locations in North Africa.

Country(ies)	Frequency of selection
Libya	2.8
Tunisia	9.8
Algeria	2.8
Morocco	7.1
Libya and Tunisia	5.9
Libya and Algeria	1.2
Libya and Morocco	2.0
Tunisia and Algeria	10.2
Tunisia and Morocco	15.0
Algeria and Morocco	3.9
Libya, Tunisia and Algeria	4.7
Libya, Tunisia and Morocco	8.7
Libya, Algeria and Morocco	1.6
Algeria, Tunisia and Morocco	7.1
Libya, Tunisia, Algeria and Morocco	8.3
none	9.5

2.1.2.2. Other Countries

Special nurseries were prepared for a number of countries (China, Pakistan, India, Nepal, Korea, Iraq, Syria, and Egypt). In collaboration with the GRU, landraces from Yemen, Afghanistan, Libya, Algeria, Iran, Jordan, Pakistan, Tunisia and Turkey were introduced in the breeding program and will form the basis for specific crossing blocks. **- S. Ceccarelli, S. Grando**

2.1.3. Performance of Barley Lines in the Regional Yield Trials Over the Last Eight Years

The Regional Yield Trials represent ICARDA's last step of yield testing, and are conducted by NARs. National breeders select promising lines from these trials to be incorporated into their own breeding programs. Each Regional Yield Trial contains 23 lines plus a "national" check which can vary between locations within one country. The following summary refers only to those African and Asian countries which had data for more than five trials between 1984/85 and 1991/92. The data from 381 Barley Yield Trials for Moderate (BYM) and Low (BYL) Rainfall Areas are shown in Table 3. The average number of lines outyielding the national check in at least one year at one location was remarkably high: eight in the BYL and ten in the BYM.

For instance, in Algeria, where 28 trials were grown between 1984/85 and 1991/92 with a total of 644 lines, 344 lines outyielded the national check. However, it is not possible to know whether these lines remain superior over locations and years as in the present testing lines can not be followed further.

The mean yields were, in general, much higher than the national average achieved by farmers (FAO Production Yearbook). Growing conditions on experiment stations are far better than those on farmers' fields.

Two possible reasons are that experiment stations tend to be located in the more favorable environments and that agricultural management on the stations tends to be better than farmers' management. In most countries station yields are so high that they are unlikely to represent even the best farmers in the near future.

However, in some countries (Egypt, Iraq and Turkey) the differences between station yields and the national average yields were low.

Table 3. Summary of Regional Barley Yield Trials for Low (BYL) and Moderate (BYM) Rainfall Areas between 1984/85 and 1991/92[a]: number of trials per country, average number of lines per trial outyielding the national check in grain yield, grand mean of trials, and the national average grain yield between 1985 and 1991[b]. Each trial had 23 lines and one national check.

Country	No. of trials		Avg. no. of ent./trial > nat.check		Grand mean		Nat. avg. mean
	BYL	BYM	BYL	BYM	BYL	BYM	
Algeria	13	15	11.0	13.4	2993	4168	862
Egypt	19	23	9.2	11.5	2798	3855	2698
Ethiopia	3	3	0.7	11.7	1690	3042	1131
Libya	8	12	5.0	7.4	1465	2886	596
Tunisia	8	12	6.6	11.8	3261	3883	735
Morocco	9	7	13.4	11.7	2926	3715	1140
Afganist.	6	1	6.0	23.0	1565	3462	1070
China	3	7	16.7	8.6	5349	3890	2836
Cyprus	6	7	2.2	5.4	3160	4804	1948
Iran	13	18	8.8	8.8	2782	3597	1143
Iraq	7	3	7.1	6.7	945	819	741
Jordan	18	9	6.9	12.1	2294	2820	684
Korea	2	4	16.5	17.0	5311	3262	2578
Lebanon	7	17	2.7	5.4	2319	2828	1884
Pakistan	31	30	7.7	10.3	1897	2275	772
Syria[c]	11	9	15.1	16.9	3417	3367	716
S.Arabia	3	21	4.7	7.3	6610	4280	3887
Turkey	6	10	5.3	12.6	2077	3635	2043
Total	173	208					
Mean			8.2	10.1			

[a] BYM is distributed since 1984/85 and BYL since 1985/86.
[b] From FAO Production Yearbook; data for 1992 not yet available.
[c] Trials on ICARDA stations excluded.

It is not surprising that the large number of lines outyielding the national check is not matched by a corresponding number of varieties released. In many countries it is likely that experiment stations and farmers yields are on opposite sides of a cross-over G x E interaction.

2.1.3.1 Specific Adaptation: How Specific?

The decentralization of the spring barley breeding program raises the question of how far decentralization should go or how specific the specific adaptation should be.

To address this question, and whether further decentralization within North Africa is required, data from 23 lines (BYM) grown at 16 North African locations in 1988/89 were analyzed. Nine trials were planted in the Maghreb region under rainfed conditions, seven in Egypt under irrigation.

Over all locations (Table 4), the G x E interaction was 44 times larger than the genotypic variance. The latter was not significant. Unexplainable deviations from regression and the regression on entry means contributed the largest amount to the interaction. Differences between the regression coefficients on environmental means were not found. After removing all Egyptian locations (which showed the largest deviations and the most diverse regression coefficients) from the analysis, G x E interaction was dramatically reduced, but was still six times larger than genotypic differences. However, the highly significant joint regression and the non significant differences between regression coefficients on environmental means would suggest that the observed G x E interaction does not necessarily lead to changes in the ranking of genotypes.

If this can be considered a general case for the Maghreb region, no further decentralization within Maghreb would be required. However, the environments used for international yield trials certainly do not represent a random sample of all environments, but rather the favorable growing areas (trial means in the Maghreb region in 1989 ranged from 1756 to 4742 kg/ha compared to farmers' national average yields ranging from 485 to 1250 kg/ha). Furthermore the genetic material did not include local germplasm. Experiments based on a wider range of environments and germplasm may yield different results. - **M. Mayer**

Table 4. Genotypic and G x E interaction variances (x 10^{-3}), and heritability of grain yield: 23 lines tested in the Barley Yield Trial for the Moderate Rainfall Areas at 16 locations in North Africa (9 rainfed environments in the Maghreb region and 7 irrigated Egyptian environments) in 1989.

Source	DF	DF[a]	V.C.	V.C.[a]	h^2	$h^{2\ a}$
G	22	22	5.4	26.8*	16.3	45.9
G x E	330	176	236.8**	136.9**		
Subdivision of G x E interaction						
Joint regression	1	1	5.6*	11.3**		
Regression on genotypes	14	7	56.7**	8.9+		
Regression on environments	21	21	5.4	3.3		
Deviation from regression	294	147	169.5**	111.8**		

a Degrees of freedom, Variance components (V.C.) and h^2 (%) when Egyptian environments are omitted.

2.1.4. Performance of Lines in Yield Trials

A total of 3194 barley genotypes were yield tested during 1992/93 (2268 for the first year, 702 for the second year and 224 for the third year). Mean yield ranged from less than 1 t/ha in Bouider, to about 1.5 t/ha in Breda and about 4 t/ha in Tel Hadya (Table 5). Compared with 1991/92, the frequency of lines outyielding the best check selected was generally higher in Tel Hadya and lower in Breda. This is a possible consequence of traditional checks (such as Rihane-03) being the highest yielding in Tel Hadya, and of newly introduced checks (such as Arta and Zanbaka) being generally the highest yielding in the driest sites.

Table 5. Performance (kg/ha) of barley lines in yield trials (1st, 2nd and 3rd year) in three locations in north Syria

	Bouider			Breda			Tel Hadya		
Material	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Rihane-03		778	607	1697	1406	1193	4784	4739	4225
Mari/Aths*2		1375	648	1720	1281	1387	4594	4369	3957
Harmal		1249	1123	1597	1653	1556	4182	4056	3490
A.Aswad		1158	1066	1600	1497	1457	3354	3248	2887
A.Abiad		1018	1105	1894	1554	1105	4243	4213	3661
Arta		1033	1097	1995	1864	1097	4416	4330	3694
Zanbaka		1638	1136	1669	1748	1136	3528	3540	3082
Grand mean		**909**	**779**	**1547**	**1590**	**1170**	**4045**	**3999**	**3671**
% >best check		0.6	1.3	13.2	16.2	4.0	10.2	3.7	8.9
mean yield[a]		1781	1161	2122	2341	1810	5095	5347	4362

[a] Average yield (kg/ha) of lines outyielding the best check

The emphasis on breeding for harsh environments has not reduced efforts to increase yield potential for favorable environments. Data from the highest yielding locations where the Regional Yield Trial for Moderate Rainfall was grown in 1992 (Table 6) indicate that barley lines with yield potential of 7 to 10 t/ha are being continuously generated. **- S. Ceccarelli, S. Grando**

Table 6. Yield potential (kg/ha) of barley lines in various countries.

Country (Location)	Mean yield	Yield and rank (in brackets) of: Nat. check	Best Line	Pedigree of best line
Cyprus	6792	7493 (7)	8808 (1)	Aths/Lignee 686
Iran (Karaj)	8264	9147 (4)	9748 (1)	Arizona 5908/Aths/Lignee 686
S. Arabia (Gassim)	5807	7259 (1)	7207 (2)	ER/Apm//WI2291
Algeria (Setif)	6562	4781 (23)	8068 (1)	ER/Apm//Cerise/3/Lignee 131//ER/Apm
Libya (Sebha)	6359	4708 (22)	8434 (1)	ER/Apm//Cerise/3/Lignee 131//ER/Apm
Tunisia (Mornag)	5434	5040 (18)	7707 (1)	Assala-04
Greece	4653	5808 (3)	6038 (1)	Rihane/Lignee 527
Italy	1018	11200 (5)	11693 (1)	Arizona 5908/Aths/Lignee 686

2.1.5. AMMI Model Confirms Previous Findings on G x E Interaction

The analysis of Genotype x Environment (GE) interaction by parametric linear regression techniques is subject to criticism. Because of the importance of GE in relation to the choice of the selection environment we analyzed 36 barley genotypes grown in 14 environments in Syria and North Africa. Genotypes and environments were classified by a cluster analysis and the interaction was analyzed with an additive main effect and multiplicative interaction model (AMMI). Genotypes were clustered in four groups according to their growth habit (spring or winter) and heading date. Environments were clustered in two groups, low (LY) and high yielding (HY).

Genotypes differing in development and vernalization requirement showed positive interaction with one group of environments and negative with the other. HY environments did not discriminate well between genotypes with different yield in LY environments. Details of this work are in Genotype by Environment Interactions of Barley in the Mediterranean Region, van Oosterom, E.J., Kleijn, D., Ceccarelli, S. and Nachit, M.M., Crop Science, 33:669-674. - **S. Ceccarelli**

2.1.6. Genetic and Environmental Differences for Grain Yield, Total Biological Yield and Straw Quality

We began to investigate the quantitative genetics of total biological yield, its components (grain and straw) and the feeding quality of the straw. Biomass samples of the 112 two-row and 112 six-row lines tested in the Advanced Yield Trials in Tel Hadya, Breda and Bouider were taken in 1993. The straw of each sample was collected to assess metabolizable energy, in vitro digestibility, protein and lignin content, etc. These traits were estimated by near infrared reflectance (NIR) spectroscopy.

Grain and total biological yield were higher in two-row lines (Table 7). Harvest index of two- and six-row types was similar at Tel Hadya, but in Breda and Bouider it was lower in the six-row type. This implies a better ability of two-row types to translocate assimilates into the grain under stress. Although the two-row types were, on average, six days earlier to awn emergence, it is unlikely that their superiority in grain yield is caused by drought escape; due to late rains, earliness was relatively unimportant in explaining variation in grain yield in 1993. It is more likely that the two-row lines examined here are truly more drought tolerant. These results confirm those presented in the Cereal Program's Annual Report for 1992. The in vitro digestibility of the straw, measured as gas production at 8 h of incubation, increased with increasing stress and did not differ among row types.

Table 7. Means of 112 six-row and 112 two-row lines tested in the Advanced Yield Trials at Bouider, Breda, and Tel Hadya in 1992/93 for total biological yield (TBY), grain yield (GY), harvest index (HI) and straw quality measured as in vitro gas production at 8 h of incubation (GP_8).

	6-row type lines				2-row type lines			
	TBY	GY	HI	GP_8	TBY	GY	HI	GP_8
Bouider	2729	674	25.3	18.9	2503	885	35.8	17.3
Breda	3952	1149	29.9	15.2	4183	1496	36.6	15.1
Tel Hadya	7013	2978	43.7	13.6	7593	3133	42.2	14.3
mean	4564	1600	33.0	15.9	4760	1838	38.1	15.6

Table 8. Genotypic standard deviations (σ_g in kg/ha), broad sense heritabilities (h^2 in %) and genetic coefficients of variation (CV_g in %) of grain yield (GY), total biological yield (TBY) and straw quality measured as in vitro gas production after 8 h of incubation (GP 8) in 112 six-row and 112 two-row lines tested at Bouider, Breda, and Tel Hadya in 1992/93.

	GY		TBY		GP 8	
	6row	2row	6row	2row	6row	2row
σ_g	198**	116**	560**	323*	0.79*	0.68*
h^2	52.8	43.2	49.0	32.1	44.3	42.3
CV_g	12.4	6.3	12.3	6.8	4.9	4.4

*,** Treatment mean squares significant at P = 0.05, and 0.01, respectively.

Genotypic differences were found in grain yield, total biological yield and straw quality (Table 8). The heritabilities were similar for all three traits. The small genetic coefficients of variation observed for the straw quality trait imply that selection progress in this trait would be lower than for grain or total biological yield.

The genotypic correlations of total biological yield to grain yield and the straw-quality trait were low, whereas grain yield and straw quality was negatively correlated (Table 9). - **M. Mayer**

Table 9. Genotypic coefficients of correlation between grain yield (GY), total biological yield (TBY), harvest index (HI) and straw quality measured as in vitro gas production at 8 h of incubation (GP 8) of 112 six-row and 112 two-row lines tested at Bouider and Breda in 1992/93.

	TBY	GY	HI
GY	0.19+	-	-
HI	- 0.27++	0.93++	-
GP 8	0.14	- 0.79++	- 0.70++

++, + Coefficient larger than its doubled and simple standard error, respectively.

2.1.7. The Use of *Hordeum spontaneum* Improves Plant Height Under Severe Drought

Seventy-four lines derived from crosses with *Hordeum spontaneum* were tested for four cropping seasons at Bouider, and in 1992/93 also in Breda and Hassake. All environments were severely stressed with grain yield ranging from 340 kg/ha to 755 kg/ha and total biological yield from 1987 kg/ha to 3488 kg/ha. Table 10 shows grain yield and total biological yield of the best four lines compared with the seven checks.

One line derived from the cross SLB 39-60/*H. spontaneum* 41-1 yielded more grain and total dry matter than the checks. Arta was the shortest entry (26 cm) and Zanbaka (34 cm) the tallest (Table 11). The 74 lines ranged from 29 to 40 cm (48 lines were taller than 35 cm).

Some lines combined improved plant height under drought with the tillering ability typical of syrian landraces (Table 11). The three lines highlighted in bold in Table 11 are of particular interest, since they were also selected for grain yield and total biological yield.

Table 10. Grain yield (average of 6 environments) and total biological yield (average of 5 environments) of four lines derived from crosses with *H. spontaneum* compared to seven checks.

Cross/Name	Grain yield[a] kg/ha	Total biological yield[a] kg/ha
SLB 39-60/*H. spontaneum* 41-1	821 ± 326	3437 ± 600
H.spontaneum 41-1/Tadmor	809 ± 217	3288 ± 1022
H.spontaneum 39-2/Tadmor	785 ± 216	3248 ± 698
H.spontaneum 41-1/Tadmor	762 ± 307	3216 ± 973
Checks		
WI2291	732 ± 228	3013 ± 648
Tadmor	745 ± 336	2838 ± 784
Zanbaka	774 ± 264	3035 ± 675
Arta	810 ± 358	3154 ± 799
Harmal	796 ± 255	2806 ± 797
A. Aswad	776 ± 289	3189 ± 424
A. Abiad	721 ± 338	2656 ± 1030

[a] ± Standard deviation.

This new type of germplasm, combining desirable traits from both landraces and *H. spontaneum*, is now ready to be tested on large scale. Its expected advantage is a reduction in the frequency of times farmers are not able to combine-harvest the crop because of reduction in plant height.

Some of the *H. spontaneum* 41-1/Tadmor lines shown in Tables 10 and 11 are resistant to wheat stem sawfly and have been tested for water use efficiency. Detailed results are reported in the Entomology and Physiology sections, respectively. - **S. Grando**

Table 11. Plant height (average of 6 environments) and number of fertile tillers per m^2 (average of 5 environments) of six lines derived from crosses with *H. spontaneum* compared to seven checks.

Cross/Name	Plant height[a]	Number of tillers[a]
***H. spontaneum* 41-1/Tadmor**	35.3 ± 7.6	359.2 ± 75.3
H. spontaneum 41-5/Tadmor	38.6 ± 7.6	343.2 ± 84.7
***H. spontaneum* 39-2/Tadmor**	33.2 ± 6.7	343.1 ± 89.2
SLB 56-83/*H. spontaneum* 41-5	39.3 ± 10.3	332.2 ± 95.2
H. spontaneum 41-1/Tadmor	35.2 ± 8.4	331.6 ± 106.3
SLB 39-60/*H. spontaneum* 41-1	31.4 ± 7.5	326.6 ± 103.1
Checks		
WI2291	32.5 ± 8.2	273.6 ± 68.6
Tadmor	27.6 ± 5.4	326.0 ± 63.2
Zanbaka	33.9 ± 7.0	302.6 ± 88.8
Arta	26.1 ± 5.7	332.0 ± 62.7
Harmal	32.1 ± 7.8	283.9 ± 54.4
A. Aswad	31.3 ± 4.6	305.5 ± 54.4
A. Abiad	27.0 ± 6.8	271.2 ± 60.5

[a] ± Standard deviation.

2.1.8. Differences in Seminal Root Morphology

Differences in root morphology between barley genotypes were first observed in a study on coleoptile length. The differences were investigated in a highly consistent series of experiments. An example is shown in Table 12. Modern germplasm and landraces have similar seed weight and number of seminal roots.

H. spontaneum has consistently smaller seeds and fewer seminal roots than cultivated barley. Landraces have longer seminal roots than modern cultivars. *H. spontaneum* and modern germplasm do not differ in total root length, thus showing that the wild progenitor of cultivated barley has fewer and longer seminal roots than modern germplasm. In addition the seminal roots of *H. spontaneum* had smaller diameters (not reported here). The adaptive value of these differences is unclear. - **S. Grando**

Table 12. Seedling characteristics in three different barley germplasm groups.

Character		Type of germplasm		
		Modern	Landraces	*H.spontaneum*
Seed weight (mg)	mean	49.4 a*	51.6 a	28.5 b
	range	37.4-64.4	36.8-65.2	19.8-36.5
Root number	mean	5.9 a	5.9 a	3.8 b
	range	5.2-6.6	4.8-6.8	3.5-4.0
Max root length (mm)	mean	72.1 b	96.1 a	85.4 ab
	range	48.6-88.2	74.7-119.7	65.5-102.1
Total root length (mm)	mean	270.2 b	396.9 a	239.2 b
	range	187.7-314.0	301.3-564.0	170.3-317.7

* Within rows, means followed by the same letter(s) are not significantly different at the 0.05 probability level.

2.2. Winter and Facultative Barley Improvement

The winter and facultative (W & F) barley project develops improved germplasm tolerant to stresses; trains technical staff of the NARS; and develops linkages with other institutions within WANA and elsewhere.

2.2.1. Breeding for Drought and Heat Tolerance

Grain yield of cold-tolerant lines was assessed under moisture stress and high terminal temperatures at Tel Hadya and Breda. Genotypes with strong vernal gene(s) were lower yielding than spring and facultative types due to their longer growth period. Lines with moderate vernalization and weak photoperiodism requirements performed well.

High yielding lines at both sites were mainly facultative types indicating their adaptability to different stresses (Tables 13 and 14). These were also high yielding at other sites showing the suitability of Breda and Tel Hadya as testing sites for moisture stress and terminal heat. At Tel Hadya and Breda some entries, including CWB117-5-9-5 and Roho/Mazurka, yield the same as the drought resistant checks indicating the possibility of recombining desirable traits. A high positive correlation between cold tolerance and yield was observed in Turkey and Krasnodar (Russia). It is of interest to know if cold tolerance is associated with lower yields. At

Tel Hadya there was no cold damage on spring types. The cold tolerance rating at Kazan Research Farm in Turkey, ranged from score 2 to 5. The coefficient of correlation between cold tolerance at Kazan and yield at Tel Hadya was 0.06, indicating that negative relationship between these two traits can be overcome by breeding.

Table 13. Grain yield (kg/ha) at Tel Hadya.

Line	IWFBYT	IWFBAYT	IWFBON	WFPBSN	WBEL
Rihane 3	4110	4555	3897	4340	5800
Salmas	4110	4440	3990	4220	4950
Tokak	3880	3888	3500	3750	4154
A. Abiad	4330	4166	-		
A. Aswad	-	4160			
No. of lines	24	24	150	252	664
Mean	3552	4174	3612	3746	4630
Top lines:		3	40	38	225
Nr.>Best Check					
CWB117-5-9-5	1	5083			
Walfajer	4344		5100		
Roho/Maz.//ICB...				5150	
CWB117-.../ICB...					
Deir Alla100//Cel...					7300
LSD 0.05	663	722			

Table 14. Grain yield (kg/ha) at Breda.

Line	IWFBYT	IWFBAYT	IWFBON
Rihane 3	2944	2933	2500
Salmas	2244	2660	2000
Tokak	2411	2544	2812
A. Abiad	2788	2833	
A. Aswad	-	2500	
No. of lines	24	24	150
Mean	2108	2176	2425
Top lines:	2833		
Roho/Mazurka		2755	
Lignee131/A.Abiad			
CWB22-6-13/ICB102 893			3125
YEA 762.2/YEA 605.5			3187
LSD 0.05	536	560	610

The highest yield of 7300 kg/ha was obtained in WFBEL for a moderately cold-tolerant line. Many lines (CWB 117-77-97/ICB 102 893, Roho/Mazurka//ICB 103 020) had excellent cold tolerance in Kazan and outyielded Rihane 3 and Salmas at Tel Hadya (Table 15).

Table 15. Performance of top yielding winter barley lines at Tel Hadya.

Line	Cold tol.*	Grow. vig.*	Head date	YLD, kg/ha
Salmas	3	5	16.04	4964
Rihan 3	1	5	14.04	6175
Tokak	5	4	26.04	4400
Rihan 3/ICB105 932	5	5	9.04	6500
ICB102 998//Alger Ceres...	5	4	15.04	6300
Roho/Mazurka//ICB103 020	5	5	16.04	6650
Roho/Mazurka//ICB103 020	5	5	22.04	6500
ICB 101 669//Gaines/Ore'S'	3	5	19.04	6560
Chi Cm/An57//Albert/3/ICB...	4	5	16.04	6240
Kitchin/Mullers Heydla//Sal.	5	5	17.04	5600
Deir Alla106/Cel/4/Cel...	3	5	14.04	7300
Zarjou/80-5151		4	20.04	6050
ICB102 998/3/Alger Ceres...		4	24.04	6300
Rihan 3/Lignee640//ICB...		5	18.04	6450
CWB117-77.../ICB102 893	5	4	19.04	6400
CWB117-77.../ICB102 893	5	5	16.04	6670
CWB22-6.../ICB102 893	5	4	20.04	6150
LSD: 0.05				663

* : Cold tolerance 1-5 (1 susceptible; 5 resistant).
** : Growth vigor on 1-5 scale (1 = poor vigor; 5 very vigorous).

2.2.2. Breeding for Abiotic and Biotic Stress Tolerance

Genetic variation in cold tolerance, growth habit, vernalization requirement and photoperiodism response play a vital role in the adaptation of germplasm. The germplasm needs of major barley growing areas are different and must be met by using locally adapted varieties such as: Tokak, Bulbul (Turkey), Zarjau, Star, Walfager (Iran), Baluchistan (Pakistan), Cyclone and Monolit (Russia) as checks and comparing selections with them to understand the behavior of agronomic traits in different environments. Different sets of entries are assessed for cold, drought, disease tolerance, earliness and yield in many countries.

The selection of many lines on the basis of cold tolerance in Kazan and Russia (Table 16) indicates progress made in incorporating cold tolerance gene(s) into the germplasm. Beside cold, Kazan is also a hot spot for boron toxicity and field evaluations at this site and Breda showed many lines tolerant to boron toxicity.

Many lines had good tolerance to *Pyrenophora teres* and *Puccinia hordei*. Many awnless genotypes from the Winter Hardiness Uniform Nursery (of U.S.A. origin) possess high levels of resistance to *Pyrenophora teres* (net blotch), *Erysiphe graminis f. sp. hordei* (powdery mildew) and some to *Puccinia hordei* (leaf rust).

Table 16. Breeding of winter and facultative barley for abiotic and biotic stress tolerance.

		Number of lines selected for						
		Tolerance to						
Nursery	Total	Cold	Drought	Disease	Earliness	Yield	Total	Freq. (%)
IWFBTY	24	8	8	7	6	6	6	25.0
IWFBON	150	85	45	13	47	40	44	29.3
IWFBCB	150	119	40	41	35	36	40	26.6
WFPBSN	252	40	43		13	38	46	18.2
WFBEL	2268	304	249		214	342	362	16.0
Germplasm	282	54	33		48	62	101	35.8

Cold-data from Turkey and Russia
Drought-highest agronomical score at Breda, Syria
Disease-complex tolerance to three diseases in wet site in Krasnodar Region

Some Chinese lines showed complete resistance to net blotch; and two had excellent cold tolerance and resistance to boron toxicity and were the earliest of the material. These lines should be excellent parental material. The use of exotic material in the W & F barely project has considerably expanded the genetic base.

2.2.3. Performance of 2-Row Versus 6-Row Barely Types

Traditionally in Turkey two-rowed varieties are dominant while in North Africa, Iran and Pakistan six-rowed ones are widely cultivated. The advantage of two-rowed types over six-row types under stress was shown by S. Ceccarelli & S. Grando (Annual Report, 1992). An analysis of the advantage of two- rowed over six-rowed winter barley material was made covering 586 two-rowed and 294 six-rowed lines, tested in different locations (Table 17).

In some nurseries and locations six-rowed types were higher yielding, but in stress environments two-rowed genotypes had a yield advantage of 6 to 22 %. In Krasnodar, with sufficient late precipitations, six-rowed barley had a yield advantage of 3-17 % over 2-row types. - **M. Tahir, V. Shevtsov**

Table 17. Relative yields (%) of two-rowed and six-rowed winter barley lines.

Nursery	Head type	No. of lines	Testing sites				
			Tel Hadya	Breda	Kazan	Haymana	Krasnodar
IWFBYT	2	10	100	100	100	100	100
	6	13	88	79	94	117	103
IWFBATY	2	8	100	100	100	100	-
	6	15	90	78	78	97	-
IWFBON	2	86	100	100	-	-	100
	6	84	78	77	-	-	113
WFBEL	2	482	100	-	100	-	-
	6	182	92	-	92	-	-

2.2.4. Barley Breeding for Cold Tolerance

Russia and Turkey provide excellent sites for cold tolerance research. The research carried out under collaborative arrangements is reported here:

2.2.4.1. Evaluation at Krasnodar, Russia

Winter barley nurseries were evaluated in the field and in freezing chambers for cold tolerance. Also, 145 ICARDA lines selected in previous years were tested for yield and adaptation in preliminary trials.

In 1992/93 weather conditions were close to normal. Under field conditions only cold-susceptible genotypes such as Rihane-3 and Salmas were damaged by frost.

The level of infection of the economically important diseases *Pyrenophora teres* (net blotch), *Puccinia hordei* (leaf rust) and *Erysiphe graminis* (powdery mildew) was moderate and only very early plantings were affected by Barley Yellow Dwarf

Virus. Yields averaged 4.5 t/ha over 405,000 ha. Experimental plots yield ranged from 3 to 8 t/ha.

The level of cold tolerance in ICARDA's germplasm is increasing yearly. About 60 % of lines equalled or surpassed the local checks for winter survival. A set of 615 ICARDA lines was tested for cold tolerance under controlled conditions in freezing chambers at two temperatures, - 10°C and - 11°C, and in concrete beds at Krasnodar and at the Kuban Branch of the Institute (200 km to the north). Good differentiation was obtained: lines with 0,50 and 100% survival were identified.

The IWBC had a high level of cold-tolerant parental lines. The only susceptible lines were 18 hulless spring barley lines, but genetic variation for this trait existed.

In the WFBON, half of the lines were of 75-100 % survival class. Some of them were as cold-tolerant as the best winterhardy variety Tokak (Fig. 2).

ICARDA material possessed good resistance to *Pyrenophora teres*, moderate resistance to *Puccinia hordei*, and below average resistance to *Erysiphe graminis*, though lines with high resistance to each disease and combinations were identified.

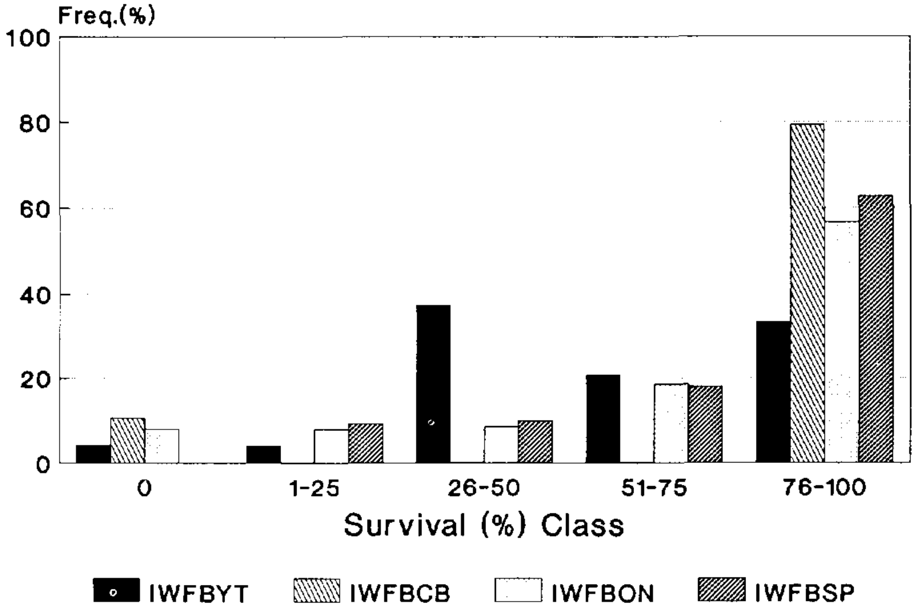

Fig. 2. Cold tolerance in winter barley under artificial freezing at -11°C

An excellent line showing multiple disease and cold tolerance and with good phenotypical stature with a two-rowed dense-head is ICB 101294 which is a valuable parent in future crosses.

The two-rowed line Kenya Research/Belle has been used frequentally as a parent with excellent performance in a wide range of environments.

The early ripening two-rowed cold-tolerant line ICB 100081 has a high rate of initial growth, resistance to major diseases (net blotch, leaf rust and powdery mildew) and stress (cold and drought) tolerance. At Tel Hadya, it yielded 116 %, at Breda 120 % of the best check.

The 6 row American variety Pike has good cold tolerance and agronomic score and has a high selection frequency; it should prove a useful parent. Many awnless lines from Winter Hardiness Uniform Nursery have good resistance to *Pyrenophora teres*, *Erysiphe graminis* and some to *Puccinia hordei*. These include line VA 89-42-9, Trifurcatum form ZDM 477 and Wysor. They have good frost tolerance, yield close to local check A.Abiad and have multiple disease resistance. **- V. Shevtsov, M. Tahir**

2.2.4.2. Evaluation of Grazing Types at Krasnodar (Russia)

Grazing and straw feeding varieties should be smooth-awned. Useful genotypes include ICB 107766 (Turkish origin belonging to Botanical subspecies-ricotense) which is more cold tolerant than Tokak, and is resistant to three diseases. Another line, NE 89-725, with six-rowed smooth-awned dense heads, highly cold tolerant and resistant to net blotch and leaf rust was identified. Action, a tall-stemmed Canadian variety, was tolerant to net blotch, scald, and cold did not show boron toxicity.

A set of Chinese varieties with high resistance to Net Blotch were selected. The early line ZDM 477 had high resistance to rust and net blotch and good resistance to powdery mildew as well as resistance to excess boron.

In yield trials, the line CWB-117-5-9-5 was selected at ICARDA from Cambridge material. This line is a typical European type with stiff straw, high tillering capacity, comparatively late in maturity, resistance to leaf diseases, good two-rowed spikes with uniform grain. It performs well in both dry and wet conditions. For the last three seasons it has ranked among the top yielding lines at ICARDA. This season it was tested at three sites in Krasnodar region and it performed well every where (Table 18). The yield potential of this line is high (Table 19). But more remarkable is its good performance in both wet and dry conditions.

Table 18. Relative yields (% of check) of some ICARDA winter barley lines at Krasnodar during 1992 and 1993.

Line/variety	1992		1993	
	WFBYT	WFBCB	WFBYT	WFBPYT
Vavilon (check)	100	100	100	100
Salmas	95	65	79	66
Rihane-3	105	0	0	0
Tokak	25	50	61	48
Bulbul	45	64	68	62
Lignee 131	90	92	106	88
CBW 117-5-9-5	107	100	118	102
LSD 0.05	8.2	10.2	12.8	8.6

2.2.4.3. Evaluation in Turkey

In collaboration with Field Crops Central Research Center, Ankara, evaluation of advanced material was carried out at Kazan and Haymana Research Farms.

Weather conditions in autumn were not favorable for seedling growth and by the end of March plants were only at the 2-3 leaf stage.

Cool weather and good rains in May and June allowed the development of high biomass and plant heights of 80-110 cm. Diseases did not affect most lines seriously although some were badly affected by scald and barley leaf stripe.

The main yield constraints were cold and drought at all testing sites, and boron toxicity and poor soils (low organic matter, sandy and gravelly) in Kazan. This year cold stress was so severe that despite good conditions for recovery in spring, genotypes with low agronomic score yielded poorly compared to cold tolerant lines (Table 20).

Table 19. Performance of previously selected ICARDA winter barley lines, in preliminary yield trials, Krasnodar, 1993.

Pedigree	GR score	CDT %	DHE	PLH cm	Disease P.h.	Disease P.t.	Disease Er.gr.	YLD kg/h
Vavilon	7	94.2	11.05	90	7	8	6	7900
Sonata	8	41.2	7.05	80	4	7	7	8300
Robur/WA 2196-68	8	64.3	11.05	90	5	8	6	7700
WA1245/B 67-1623	7	62.5	6.05	90	7	3	7	8000
YEA541.1/ YEA606.1	8	42.1	12.05	90	7	6	7	5400
Zarjon	8	8.6	15.05	100	7	7	4	6200
Steptoe/ Lignee640	7	80.0	7.05	100	5	7	7	7300
CWB 117-77-9-7	9	94.1	6.05	85	8	6	5	7400
CWB 117-5-9-5	9	82.1	8.05	95	8	7	7	8200
80-5 001	8	80.0	11.05	100	7	8	8	7400
Nebelia	6	71.8	13.05	100	7	8	8	7700
Vavilon	7	88.9	11.05	90	7	8	6	8000
Perga/SW/ WA1094		80.0	12.05	95	7	7	7	7100
Alpha/Durra	8	93.3	10.05	90	8	8	6	7200
Skorokhod	6	100	3.05	95	7	7	5	6600
Xemus	8	41.2	7.05	95	6	7	7	6300
Rihane-03	9	0.0			forst killing			
Danilo	8	49.4	10.05	90	6	8	7	6800
80-5 001	9	73.7	10.05	90	8	7	7	6500
Marinka	8	53.3	13.05	85	6	7	7	5900
Alpha/Durra	8	77.8	8.05	85	8	6	6	7100
Walfajer	8	8.4	14.05	80	3	7	5	3200
Kavir	9	0.0			frost killing			
NC 83-18	7	100	6.05	100	4	7	7	7400
Vavilon	7	94.2	11.05	90	8	7	6	7100
Cyclon	7	94.5	10.05	100	5	7	7	6400
VA 84-44	7	77.8	5.05	95	5	7	7	7100
ICB 100 002	9	64.7	11.05	110	5	7	7	4800
ICB 105 972	8	47.6	14.05	100	8	7	6	5200
ICB 100 051	8	14.3	12.05	110	7	7	8	5400
LDM 2543	7	33.3	7.05	95	4	8	7	4800
Vavilon	7	94.5	11.05	90	8	7	6	7200
LSD 0.05		9.2						420

Table 20. Relationship between cold tolerance and mean yield in various cold tolerance groups of winter barely.

Cold tolerance class (score)	Average yield, kg/ha			
	Haymana		Kazan	
	IWFBYT	IWFBAYT	IWFBYT	IWFBAYT
1-2	154	1915	1603	1297
2-3	3946	3760	2552	2018
3-4	5268	4931	2816	2666
4-5	5990	6386	3891	3559

At Haymana the top yielding entries were Monolit, K-253, Precoce, 73TH/105 from IWFBYT, Cyclone, Star, Novator, Victoria from IWFBAYT. Victoria failed at Tel Hadya and Breda due to insufficient drought tolerance, lateness and boron susceptibility. Most lines had good cold tolerance which was correlated with yield (Table 21).

Table 21. Coefficients of correlation between main criteria for selection in Turkey 1993.

Characters	Haymana		Kazan	
	IWFBYT	IWFBAYT	IWFBYT	IWFBAYT
Cold tolerance-yield	0.70	0.86	0.82	0.92
Agronomic score-yield	0.75	0.90	0.72	0.92
Cold tolerance-agronomic score	0.57	0.86	0.86	0.93

Yield level in Haymana was twice that of Kazan, yield rankings were similar (Table 22), the rank correlation coefficient being r = 0.52.

At Haymana three lines yielded significantly more than the local check Tokak, and 10 lines had similar yields to Tokak but better disease resistance and cold tolerance.

At Kazan boron toxicity is a serious problem and low yielding lines were susceptible to boron toxicity. Many resistant lines were identified.

The highest yielding lines at both sites were six-rowed varieties from Krasnodar indicating similar soil and climatic conditions. Some of the Russian lines also have higher levels of winter hardiness and cold tolerance than locally improved varieties. Six lines were selected for future yield trials.

Table 22. Yield (kg/ha) of winter barley lines from IWFBYT, Turkey 1993.

Variety	Haymana		Kazan	
	yield	rank	yield	rank
Monolit	7879	1	3873	2
K-253	7362	2	3583	5
Precoce	7221	3	3468	7
73 TH/105	6819	4	3458	6
Rohur/j-126	6507	5	3267	8
NY 005-18	6279	6	1856	23
Tarm-92	6214	7	3867	3
CWB 117-509-5	5559	8	2834	13
Robur/WA	5517	9	2172	21
TX 850 706	5418	10	2258	19
1246/78//1246/105	5303	11	3612	4
Dicto-Ms/WA	5078	12	2921	11
Tokak-check	5002	13	4510	1
Salmas-check	3789	22	1879	22
Rihane3-check	154	24	1328	24
LSD 0.05	1884		1143	

Almost all F2 segregating populations had good cold tolerance, although residual heterosis may have favored overwintering. The best 306 populations were harvested for future testing at Kazan and Ulas. Furthermore, on the basis of agronomic score, and cold tolerance 63 lines out of 482 WBEL (Winter Barley Elite Lines) were selected for further testing at several locations in Turkey. **- M. Tahir, V. Shevtsov**

2.2.5. Effect of High Boron on Barley Grain Yield

Four high yielding, cold tolerant lines derived from a cross involving Zarjou (boron tolerant) and No. 80515 (boron susceptible) were compared with the high yielding cold and boron tolerant variety Bulbul at Kazan and Tel Hadya (Table 23).

The boron susceptible lines WBEL-459 and WBEL-462 developed necrotic spots under excess boron conditions of Kazan whereas the other lines did not.

All selections had significantly higher yields than Bulbul at Tel Hadya under normal soil conditions and there was no significant yield difference between them. However, at

Table 23. Performance of winter barley lines with different boron sensitivity 1993.

LINE/CROSS		KAZAN, TURKEY				TEL HADYA	
		Reaction to excess boron	Cold toler. score	Yield, kg/ha	% of check	Yield, kg/ha	% of check
WBEL-456	Zarjou/ 80 5151	Tol.	5	5800	145	5200	117
WBEL-459	Zarjou/ 80 5151	Sen.	5	3348	83	5250	118
	Bulbul	Tol.	5	4000	100	4420	100
WBEL-462	Zarjou/ 80 5151	Sen.	5	3556	89	5300	120
WBEL-465	Zarjou/ 80 5151	Tol.	5	5044	126	5700	128
	LSD	0.05		456		663	

Kazan, despite similar cold tolerance and disease resistance, the boron susceptible lines (WBEL-462 and WBEL-454) showed toxicity symptoms and yielded significantly less than their boron resistant sister lines. The highest yielding boron resistant line WBEL-456 produced 5800 kg/ha, compared to 3348, and 4000 kg/ha, for the boron susceptible line WBEL-459 and local check Bulbul, respectively (Table 23). The 73 & 51 % higher yield of boron resistant lines compared to the susceptible line (WBEL-459) shows barley production can be significantly increased by developing resistant cultivars for these problematic soils.

2.2.6. Breeding for Quality

Beside high yield, improved quality characteristics such as protein % and high grain weight under stress conditions are important. Screening and evaluation for quality is carried out on all advanced and genetically stable material as well as on the crossing block lines. Lines in four nurseries (IWFBCB, WBON, PBSN, IWFBYT) and the widely grown check varieties (Tokak, Rihan, Bulbul, and Arabic Abiad) were evaluated for protein (%) and thousand-kernel weight (TKW).

The frequency distribution for protein (%) and thousand kernel weight (g) for the tested material are presented in Fig. 3 and Fig. 4. The protein content ranged from 7.8 to >18%. The low protein lines originated from WANA.

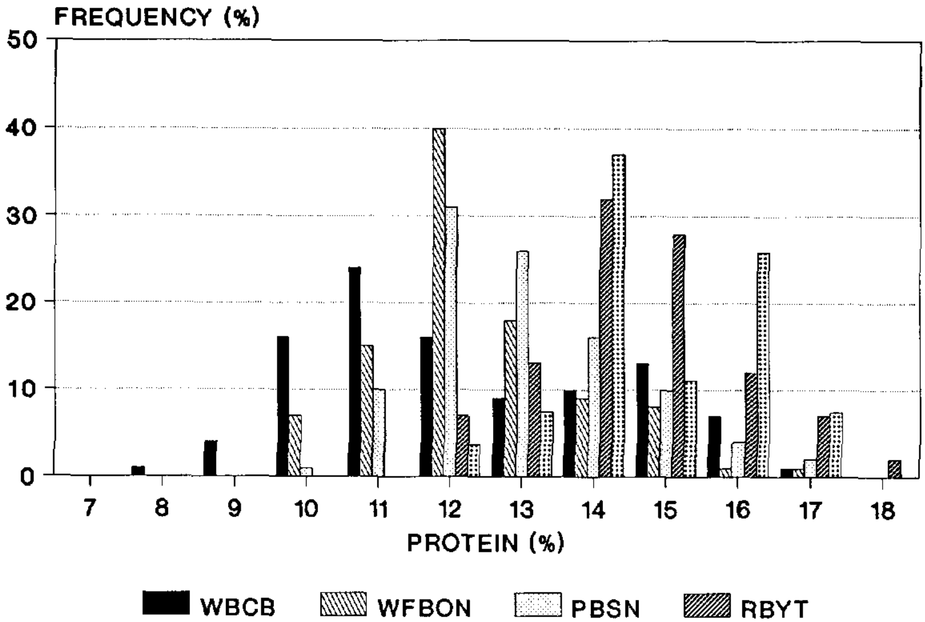

Fig. 3. Protein distribution in winter barely breeding material, 1992-93.

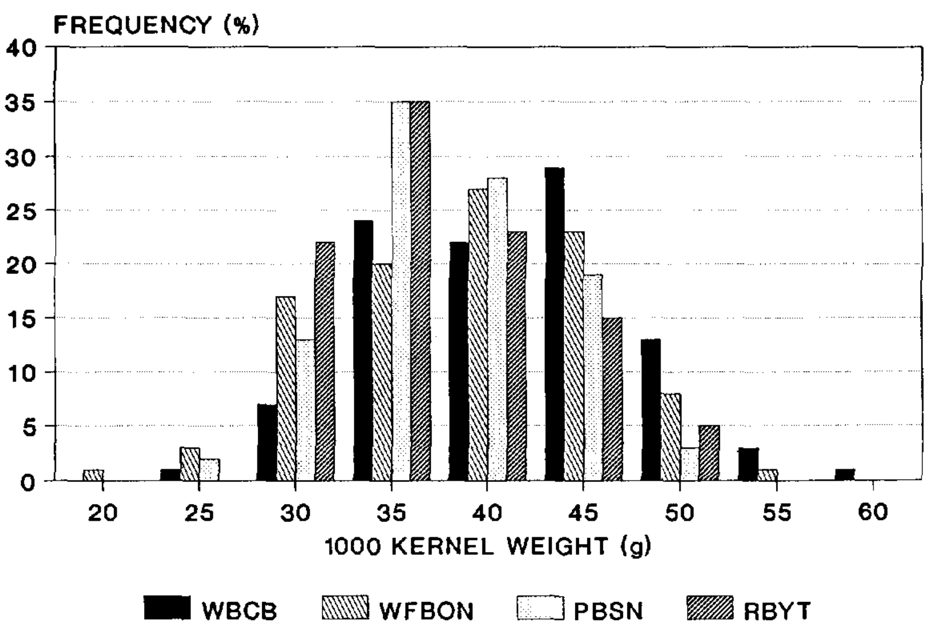

Fig. 4. Thousand-kernel weight, distribution in winter barley breeding material, 1992-93.

The majority of the improved germplasm in the PBSN and RBYT had a protein content from 13 to 18 %, compared to 15, 11.5, 12.7 and 12.2% in check varieties Tokak, Rihan, Bulbul and Arabic Abiad, respectively.

Thousand kernel weight ranged from 20 to 58 g. However, a major portion of the tested material was in the range of 35-45g which compares favorably with 39, 33, 39.4 and 39.2g for the check cultivars, Tokak, Rihan, Bulbul and Arabic Abiad, respectively.

Generally, there is a negative correlation between high TKW and % protein. A few lines with high TKW and % protein were identified and are listed in Table 24.

Breeding to combine these two traits has been successful. Three lines PBSN-76, WFBYT-12 and WFBYT-71 had more than 16% protein and heavier grains than the checks.

Research on hulless barley intensified over the past two years. A number of high yielding lines of naked barley have been identified. However, their quality characteristics as human food have not yet been determined. - **M. Tahir, V. Shevtsov, F.J. El Haramein**

Table 24. Selected lines with high % protein and 1000-kernel weight (TKW) selected from winter barley nurseries, 1992-93.

	Line/Cross	Protein (%)	TKW (g)
IWFBCB-42	Perga/S.W.//WA1094-67	15.5	42.0
IWFBCB-86	YEA 541.1/YEA 605.20	15.4	43.0
IWFBCB-105	Scotia 1/WA 1356-70	15.7	43.0
IWFBCB-149	Viringa "S"	15.4	43.0
WBON-76	3433 Gb/Tok 11	16.4	42.5
PBSN-29	Robur/WA 2196-68	15.5	41.1
PBSN-62	ICB 101 823	15.6	41.3
PBSN-76	ICB 100 024	16.5	45.8
WFBYT-12	73 TH/105//E10 Bulk CI 7321	16.0	48.1
WFBYT-21	1246/78//1246/105	15.2	42.6
IWFBCB-17	ICB 100 002	14.5	47.0
IWFBCB-22	Obruk-86	13.8	48.0
IWFBCB-85	Friberga	14.3	47.0
WBON-38	Kamiak/Belts67-875//WA1094	14.1	47.8
WBON-46	ICB 101 302	13.1	50.0
WBON-58	4679/105//YEA 455-25	13.5	47.5
Checks:	Tokak	14.6	42.2
	Rihane 3	12.6	33.0
	Bulbul	12.7	39.4
	Arabic Abiad	12.2	36.9

2.3. ICARDA/CIMMYT Barley Project

2.3.1. Introduction

This report emphasizes breeding activities on hull-less barley. In 1993, barley breeding activities in the ICARDA Program at CIMMYT concentrated on the development of hull-less types for national programs, as a direct response to a greater demand for this type of grain.

The breeding procedures are the same as those used for covered barley. The major selection pressures are for disease, resistance, large grain size, color and threshability.

Yield potential is not the key element for making the final decision on releasing new hull-less varieties as quality traits are important in farmers adoption.

2.3.2. Nursery Size

The 1993 breeding locations were El Batan and Toluca Experimental Stations (summer) in central Mexico and CIANO Experimental Station (winter) in northwestern Mexico. During the winter some 300 crosses were made using hull-less cultivars (33% of all crosses). About 2,500 F3 hull-less progenies (50% of the total) were planted at CIANO. The 112 entries in the advanced hull-less yield trials grown under rainfed conditions at El Batan were a record number. Half were re-tested under irrigation at CIANO. High yielding lines were distributed internationally.

2.3.3. Yield Performance

None of the hull-less lines equaled the covered check yields (Quina) at El Batan. The highest yielding hull-less line yielded 13% less than Quina (Table 25).

Table 25. Yield (t/ha) for covered and hull-less barley lines in El Batan, Summer 1992, and CIANO, winter 1992-1993.

Lines	Batan	CIANO
Quina (covered check, 6-row)	5.3	3.7
Aleli (covered check, 2-row)	4.8	2.9
Agave/Colorin//Zaraza (hull-less)	4.6	2.9
Lino (hull-less)	4.3	3.7
SE±	0.24	0.17

At CIANO, Quina and the hull-less line Lino yielded the same (3.7 t/ha). Quina's yield was affected by spot blotch, which appeared in epidemic form at CIANO. Lino, a spot blotch-resistant line, did not suffer yield reduction.

Traditionally, lower yields of hull-less barley have been attributed to the lack of husk, equivalent to 10-13% of the dry weight of covered barley. However, Bhatty (1986) proposed that a lack of research was the cause of low yields.

2.3.4. Quality of Hull-less Barley

Increasing interest in hull-less barley is because of increasing international trade;for the first time in history, 15,000 tons were purchased by Japan from Canada.

During 1993, Canada released Falcon, and Australia released Namoi for New South Wales. Both are hull-less and derived from ICARDA germplasm.

In 1992, Ecuador released Atahualpa and Bolivia is increasing seed of Viringa. Both cultivars can be traced back to ICARDA germplasm and have, large white grains. These are valued by farmers, who utilize barley as food and the seed commands high price.

Cooperation between Alberta, Canada and ICARDA/CIMMYT barley project increased in 1993. The best hull-less lines from the two programs were interchanged for observation. Our program will use Alberta's data on the quality parameters (protein % and digestible energy).

2.3.5. Yield, Protein, and Hectolitre Weight

Kernel weight and hectolitre weight are closely associated with some nutrients. These parameters are controlled in part by genotype, but are heavily influenced by the environment (Newman 1992).

An inverse relationship was found between yield and grain protein content for hull-less barley lines tested under rainfed conditions at El Batan (Table 26). The hull-less lines with protein content above 13% yielded from 2.9 to 3.8 t/ha. By contrast, lines yielding more than 4 t/ha, had protein levels from 8.7 to 12.3%.

Table 26. Yield (t/ha), protein content, and hectolitre weight of hull-less barley lines at El Batan.

Line No.	Grain protein %	Hectolitre weight (kg/hl)	Yield t/ha
180	13.7	71	3.4
126	13.7	66	3.6
162	13.6	64	2.9
103	13.5	70	3.5
122	13.4	67	3.8
143	10.4	61	4.6
111	11.6	67	4.5
98	12.3	71	4.4
211	11.6	69	4.2
99	8.7	71	4.2

2.3.6. Multiple Disease Resistance

To enhance adoption of hull-less varieties, we breed for multiple disease resistance. A variety carrying resistance to several diseases is more stable in yield. In Latin America, where the climate is favorable, the most important disease is stripe rust (race 24). Since its appearance in Colombia in 1976, race 24 is found in most countries, from Mexico to Chile. Recently, it was reported in Colorado, USA.

Hull-less barley is important in the Himalayas. Tibet and Nepal are interested in stripe rust-resistant germplasm, although the races of stripe rust are different from those present in the Americas.

In addition to stripe rust, we are incorporating resistance to leaf and stem rusts, scald, BYDV, and spot blotch. For example, in the ICARDA/Canadian cooperative work, crosses to Condor and Falcon, two of the best feed quality hull-less barley varieties from Alberta were made in 1993 to incorporate resistance to stripe rust, leaf rust, scald, and barley yellow dwarf virus.

The best hull-less cultivars carrying multiple disease resistance are presented in Table 27. Higo and Lino, although resistant to leaf rust in Mexico, were susceptible in 1993 to a new race present in Ecuador. Monitoring virulence changes in target areas is essential when breeding for disease resistance.

2.3.7. Disadvantages of Hull-less Barley

Seed germination has not been reported as a major problem in Canada where hull-less barley is grown on a large scale. However, countries with limited experience in producing hull-less barley could have problems due to mishandling. The embryo of hull-less barley protrudes and is easily damaged in threshing. Careful adjustment of machinery is essential. Increasing the seed rate by 15-20% is also recommended to off-set reduced germination.

Table 27. Hull-less barley cultivars with multiple disease resistance to races present in Mexico.

Cultivar	Rust			Scald	Spot blotch	BYDV
name	Stripe	Leaf	Stem			
LINO	R	R	R	R	R	R
HIGO	R	R	R	S	S	R
ATAHUALPA	R	R	R	MS	MS	R
VIRINGA	R	R	R	TMS	MS	R
NISPERO	R	R	R	TMS	S	S
ATACO	MR	R	R	R	TS	R
COMINO	R	R	R	TS	TMS	MR

R = Resistant, MS = Moderately susceptible, MR = Mod. resistant, S = Susceptible, T = Trace.

In breeding hull-less barley, free threshing ability (i.e., separation from adhering hulls) is an important trait. Adhering hulls lower nutritional quality for monogastrics.

Seed of hull-less barley can be contaminated by covered types. Hull-less barley must be planted in a well planned rotation. In Mexico, where barley is planted as a monoculture, seed contamination was found in farmers' fields when hull-less types were used.

White kernel color is preferred by many farmers and by small industries manufacturing barley products in the Andes and Asia. No information is available whether white grain is related to sprouting in the spike, but this may be a problem.

2.3.8. Hull-less Barley for Different Markets

Several types of hull-less barley may be needed for different markets.

Human food market: Hull-less types with a high B-glucan content were found to interfere with fat absorption. Genotypes with the waxy gene were found to lower cholesterol levels. No effort has been made to breed for this.

Swine-poultry market. Hull-less type may increase the digestible energy of barley by 10-15%.

In the program, we are using Condor, Falcon, and other Canadian lines to incorporate high protein and energy digestibility into the breeding material. These two quality parameters are compatible with our goal of producing large, plump kernels for human food. New lines developed in Denmark with high lysine and yield potential are competitive with covered varieties but have small seeds. In the Andean countries, farmers pay up to double for a large plump hull-less barley.

2.3.9. Hull-less Barley Varieties Released

Five countries have released hull-less barley varieties from ICARDA/CIMMYT germplasm sent from Mexico: Australia (Namoi), Brazil (Acumai), Canada (Falcon), Chile (Centauro), and Ecuador (Atahualpa). Bolivia will probably release a variety in the near future. The area sown under these hull-less varieties is relatively small, but increasing. - **H. Vivar**

2.4. Physiology/Agronomy

2.4.1. Adaptation of lines derived from *Hordeum spontaneum* x Barley Crosses

Earlier work has demonstrated the importance of wild progenitors for improving adaptation of cultivated barley to harsh Mediterranean environments. As *Hordeum spontaneum* (HS) is distributed in the driest areas of the Fertile Crescent it may contribute useful genes for tolerance to abiotic and biotic stresses.

Numerous crosses using HS have been made and two crosses using HS with Tadmor (local landrace) and WI 2291 (an improved Australian line) were selected for detailed study. Thirteen F_7 progenies and the three parents were evaluated in seven environments in Syria. Figure 5 shows the mean grain yield of the progenies (11 Tadmor and 2 WI 2291) against grain yield of the two domesticated parents. Mean yield of Tadmor progenies was generally better than the WI 2291 progenies particularly in more favorable environments. Though the mean grain yield of the Tadmor progenies was not better than Tadmor, individual progenies exceeded the parent while in the WI 2291 cross progenies were inferior. In addition, all progenies were taller than their parents. This is important in dry, low yielding environments, where the progenies were, on average, 15 cm taller than the parents. - **V. Mahalakshmi, J.M. Peacock, I. Naji, S. Grando**

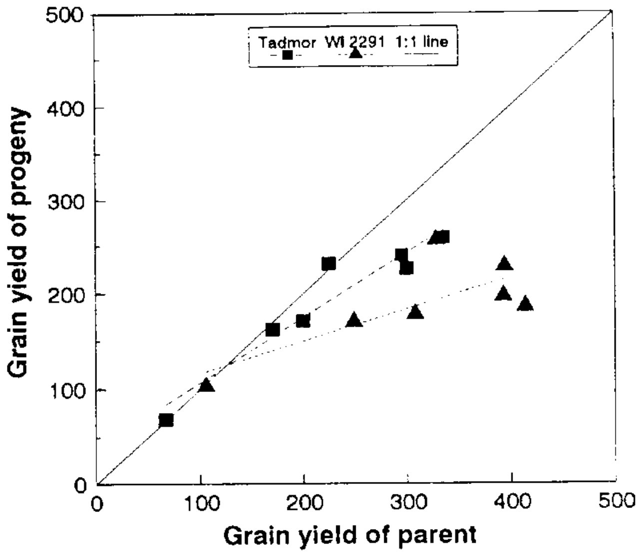

Fig. 5. Regression between mean grain yield of eleven Tadmor progenies and Tadmor [■] and mean grain two W1 2291 progenies and W1 2291 (▲) in the 7 locations.

2.4.2. Agronomy

In order to optimize resources for conducting trials efficiently and effectively a series of row spacings and seed rates trials were conducted on barley, bread and durum wheat at three locations in northern Syria (Breda rainfed and, Tel Hadya rainfed and irrigated).

2.4.2.1. Row Spacing

The effect of increasing row spacing (10 cm to 40 cm) at constant seed rate on grain yield was not significant (Fig. 6). However there was a trend for decline in grain yield with increase in row spacing in all three crops. Barley was more

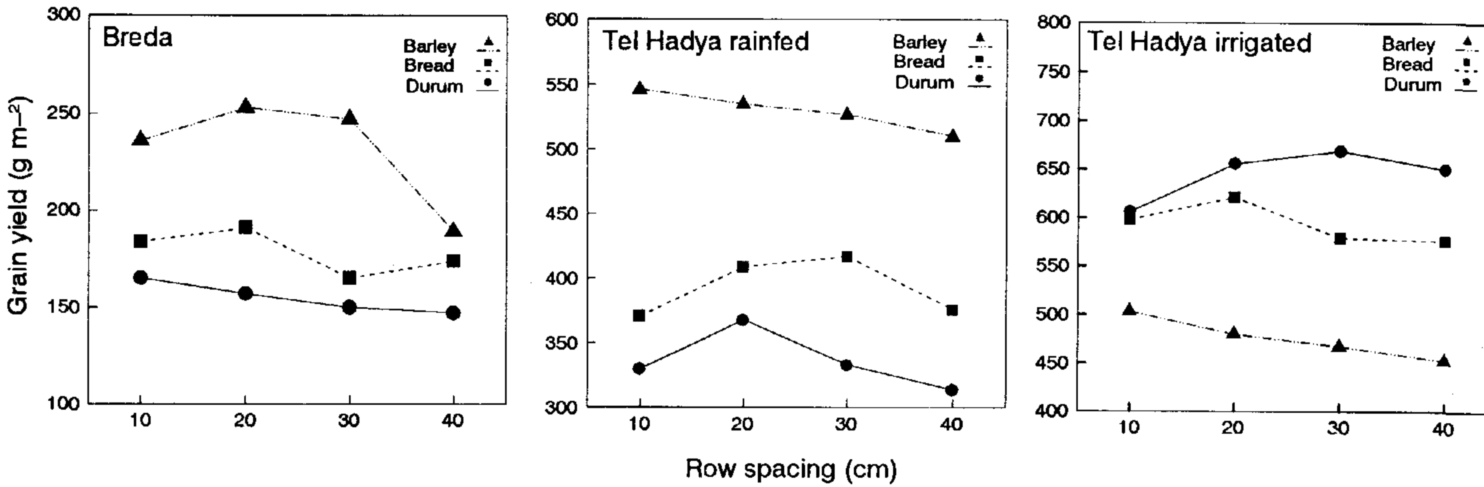

Fig. 6. Relationship between row spacing and mean grain yield of barley, bread and durum wheat in 3 environments.

affected by increased row spacing in the three locations and this was more marked at the dry site (Breda). It was observed that weed growth was more in the wider row spacings. Ground cover occurred sooner in the narrower row spacings because of better plant distribution. Wider row spacing with poor ground cover would generally increase soil erosion.

2.4.2.2. Seed Rate

To determine the optimum seeding rate to maximize grain yield and grain size in bread wheat, five seeding rates (50 to 250 kg h^{-1}) were compared at Tel Hadya under rainfed and irrigated conditions.

There was no significant difference between seed rates under rainfed and irrigated conditions (Fig. 7) though there was a declining trend with increasing seed rate under rainfed

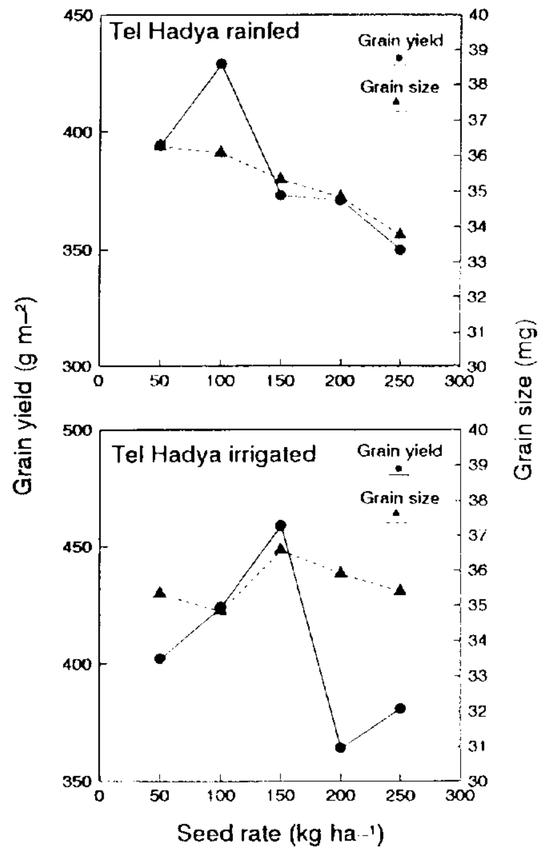

Fig. 7. Relationship between seed rate and grain yield and grain size under rainfed and irrigated conditions at Tel Hadya 1992/93.

conditions. Seed size, however, was significantly reduced by increasing seed rate under rainfed conditions. Water use efficiency did not differ among the seed rates under irrigated conditions and declined after 100 kg ha^{-1} under rainfed conditions (Fig. 8). Therefore, optimum grain yields can be obtained at lower seed rates (100 kg ha^{-1}) which also ensure good grain size under rainfed conditions. Under irrigated conditions the highest yield can be obtained at 150 kg ha^{-1} with no effect on grain size. It should be recognized that these results are site specific as the interaction with cold was not examined. - **I. Naji, V. Mahalakshmi, J. Hamblin, J.M. Peacock**

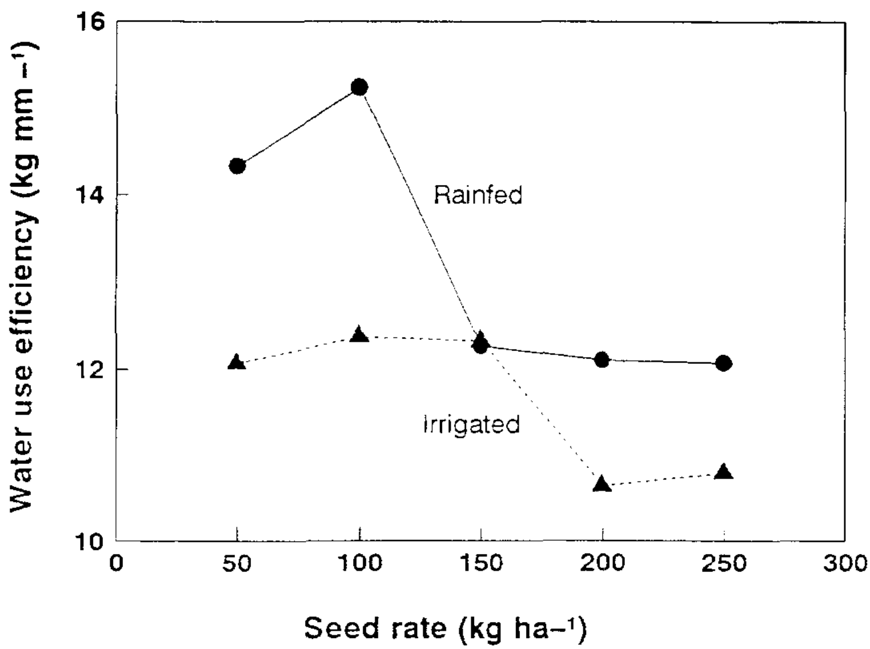

Fig. 8. Effects of seed rate on water use efficiency under rainfed and irrigated conditions at Tel Hadya 1993/94.

2.5. Barley Pathology

The aim of the barley pathology research is to develop disease control strategies that are sustainable and of low cost to the farmer. Resistance is economically the most feasible method for disease control for a low input crop as barley and the improvement of screening methodologies is the most important research component of the barley pathology project. An active disease screening program is as well necessary to back-up the breeding project. Short falls in the feed grain production in the region requires an intensification of barley production. This intensification and especially the tendency to replace the cereal - fallow rotation with continuous cereals will increase the importance of soil and stubble borne pathogens. As little is known on the presence and importance of soil borne pathogens in the WANA region, we have given an increased attention to barley root diseases in the past years.

2.5.1. Root Rots

Our studies on barley root rots are limited to fungi that affect plants in dry-land conditions. Work consisted of: (i) development of methodologies to identify and quantify root rot pathogens, (ii) surveys in Syria, Tunisia, Egypt and Turkey, to document the extend of the disease and to determine causal organisms, (iii) studies on the relation between crop rotations and root rot inoculum, (iv) studies to determine losses caused by root rots both under experimental conditions after inoculation and under field conditions and (v) testing of cultivars for resistance.

A large part of the barley root rot work in the past two years has been a collaborative effort with Dr Karen Bailey of the Agricultural Canada Research Station at Saskatoon.

2.5.1.1. Development of Detection Techniques for Root Rot Pathogens

Detection of and distinction between root rot pathogens and soil saprophytes depends on the time of sampling and the sampling and isolation techniques used. Experiments were conducted to find the most effective surface sterilization method, agar media and incubation environment. Incubation temperature was found to have a large effect on the recovery of *Monographella nivalis*, but not of *Cochliobolus sativus* (Table 28). Recovery of *M. nivalis* at 20°C was low, even with samples from plants that proved to be infested with this pathogen at 8°C. This was probably due to the presence of fast growing, saprophytic, fusaria. Light during incubation did not have a large effect on recovery of *M. nivalis*, but helped in distinguishing between *Fusarium spp*.

Our isolation methods allowed the handling of many samples. It consists of the following steps: crown and subcrown internodes (SCI) were separated after washing and surface sterilization. Each crown and SCI was split in half and plated as a pair on two media, a general medium (amended with antibiotics and fungicides to slow down fungal growth) and one selective for *C. sativus* (amended with antibiotics and benomyl). Representative fungi were tested for pathogenicity on barley seedlings, grown in culture tubes on solidified Hoagland nutrient medium under sterile conditions, in a growth chamber at 20°C with 12 h light/day. Three weeks after inoculation the plants were scored for lesion development and plant mortality on a 0-5 scale. Isolates were considered to be pathogenic if a dark brown lesion of at least 1 cm length was present on the base of stem (score 2 and higher).

Table 28. Recovery of *M. nivalis* at low and high incubation temperature from 45 root pieces, pair-wise plating.

		6°C		
		+	-	Σ [+)]
20°C	+	6	2	8
	-	10	27	37
	Σ	16	29	45

[+)] number of root pieces with (+) and without (-) M. *nivalis*.

2.5.1.2. Survey for Root Diseases in Syria

The past season was the second year of a systematic survey of the major barley growing areas of northern Syria. In 1993, 72 barley fields were sampled during April and May, when plants were between early milk stage and maturity. Per field 50 plants were randomly pulled out and for each plant the number of fertile tillers was counted and the SCI rated for discoloration on a 0-5 scale. Presence on the roots of white cysts of the Cereal Cyst Nematode was recorded as well. In last year's Annual Report a summary of the root rot scores of the 1992 survey was presented. This year the pathogens associated with the 1992 survey were determined, using the techniques described above. In 1993 only plant samples with a SCI score of 4 and 5 were so far used for isolation. Table 29 summarizes the incidence of root rot (percentage of plants with a score of 3 and higher) and pathogen recovery per region and per agricultural stability zone. Results of the first year's survey (Cereal Program Annual Report 1992), showing a higher incidence of root rot symptoms in the drier part of the surveyed area, were confirmed. No relation between the root rot score and the

Table 29. Root rot incidence, tiller number and percentage of three root rot pathogens recovered in barley fields in different agricultural stability zones of Syria during the 1991-92 and 1992-93 seasons.

						Pathogens recovered[4]					
		Incidence[2]		Tillers[3]		*C. sativus*		*M. nivalis*		red fus.	
Zone	N[1]	Avg	Range	Low	High	Avg	Range	Avg	Range	Avg	Range
1991-92 season											
1	12	66	10-100	2.0	1.9	32	0-89	36	0-67	10	0-31
2	24	66	10-100	1.7	1.7	20	0-78	41	5-95	15	0-45
3	12	80	50-100	1.8	1.7	51	0-100	21	0-74	7	0-18
4	5	77	30-90	2.5	2.4	66	20-100	26	0-90	16	0-30
1992-93 season											
1	7	24	8-42	2.3	1.8	65	0-100	49	0-100	9	0-40
2	40	53	12-100	1.7	1.5	34	0-100	72	0-100	10	0-40
3	13	68	36-98	1.5	1.5	75	0-100	39	0-100	25	0-80
4	12	62	26-94	1.5	1.4	53	0-100	52	0-100	13	0-60

[1] number of fields surveyed per zone

[2] percentage plants with a root rot score ≥ 3; average, lowest and highest over fields.

[3] number of tillers for plants with low (≤ 2) and high (≥3) score, averaged over field means.

[4] percentage of *C. sativus*, *M. nivalis* and red pigmented fusaria recovered; average, lowest and highest over fields.

number of fertile tillers was found. In both years cereal cyst nematodes were only found west of the Euphrates river.

For isolations, plants were divided into three root rot categories: clean (score 0-1), medium (score 2-3) and severe score 4-5). The recovery of *C. sativus* and, to a lesser extent, of *M. nivalis*, from the 1992 samples was related to the level of root rot symptoms on the SCI, while no differences were found for the red fusaria (Fig. 9). Infection by *C. sativus* seems to progress from the crown tissue to the SCI; 44 % of the infested samples in the medium category showed the infection only in the crown tissue and 44 % both in crown and SCI; For the severe categories this was 21 % and 69 % resp. This relation was not present for *M. nivalis*; the pathogen was recovered from the SCI solely in 23 %, 26 % and 27 % of the infested samples in the clean, medium and severe category resp (Fig. 9). Isolation frequencies of *C. sativus* and *M. nivalis* were compared between the higher (zone 1 and 2) and lower

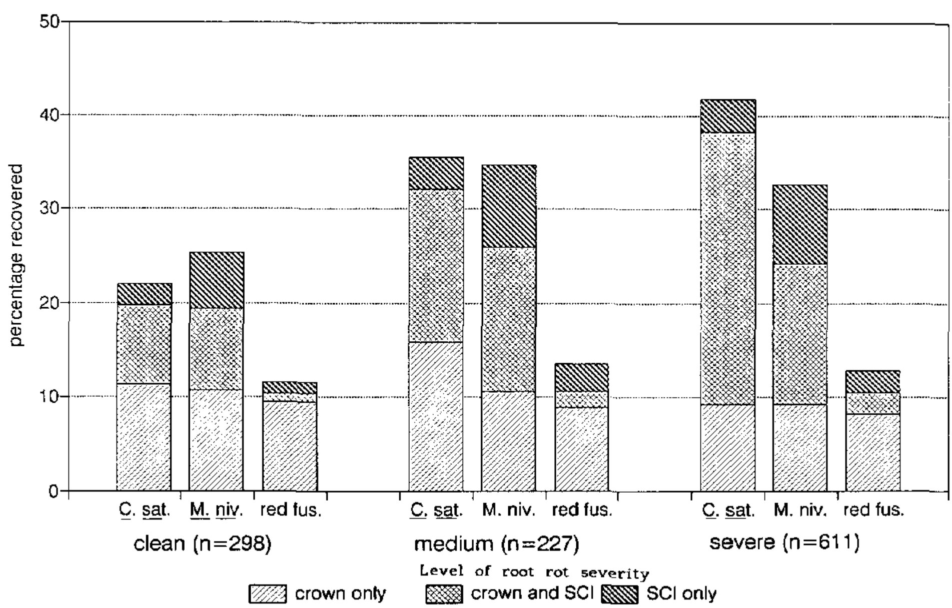

Fig. 9. Isolation of *C. sativus*, *M. nivalis* and red pigmented fusaria from plants with different levels of root rot on the subcrown internode (SCI).

rainfall zones (zone 3 and 4). In both years *C. sativus* was more frequently isolated from fields in the lower rainfall zones ($P < 0.1$ % and < 1 % for 1992 and 1993 resp.), while *M. nivalis* was more frequent in the higher rainfall zones ($P = <$ 5 % and < 1 % resp.). Also, the relative occurrence of both pathogens seems to be related to certain regions and, possibly, cultivation patterns. In Al Bab, an area located in zone 2 where barley is grown continuously, *M. nivalis* was present on 60 % of all samples in 1992 and 83 % of the severely affected samples of 1993, while recovery of *C. sativus* was only 6 and 14 % resp. In the part of the Hama region located in zone 2, where different rotation patterns are practiced, 36 % of all 1992 samples and 71 % of all 1993 samples were infested with *M. nivalis*, while *C. sativus* was found on 30 % and 33 % of the samples resp.

The pair-wise plating of samples on two different media improved the recovery of *C. sativus* only slightly. Of the 1108 root pieces plated from the 1992 survey, the rate of recovery was 30 % on the selective medium and 26 % on the general growth medium. The improvement of recovery rates by plating both SCI and crown on two different media, compared to plating crowns on the general medium only, was small if weighted against the extra effort. However, to compare the results of both years, the methodology was not changed for the 1993 survey.

Figure 10 shows the percentage of isolates from the 1992 survey with low (score < 2), medium (score 2 - 3.5) and high (score > 3.5) levels of pathogenicity. Most *C. sativus* and *M. nivalis*, but few fusarium isolates were pathogenic. Identification of the virulent fusarium strains is presently being carried out by Dr Burgess of the University of Sydney, Australia.

In 1993 four wheat fields were also sampled. The level of root rot was lower in these fields than in neighboring barley fields (Table 30), indicating the higher level of resistance of wheat than barley. Samples of wild barley (*H. spontaneum*) were taken in 3 barley fields and in one irrigated wheat field. No difference in root rot was present between wild and cultivated barley (Table 30). Recovery of *M. nivalis*, but not of *C. sativus*, was lower from wild barley than cultivated barley. No *C. sativus* was isolated from the three durum wheat fields sampled (fields 425/11, 425/04 and 426/02), while a high level of infection was found in the single bread wheat field (field 426/03) surveyed (Table 30).

Twelve fields in the north-east were sampled twice, once on 25-26 April (late flowering - early milk stage) and once on 23-24 May (maturity). The incidence of plants with a score of 3 and higher increased in one month from an average of 51% to 83%. This shows that root rot severity depends strongly on sampling time and plant development and warrants caution when comparisons are made between regions and even fields, unless plant development stage is clearly indicated.

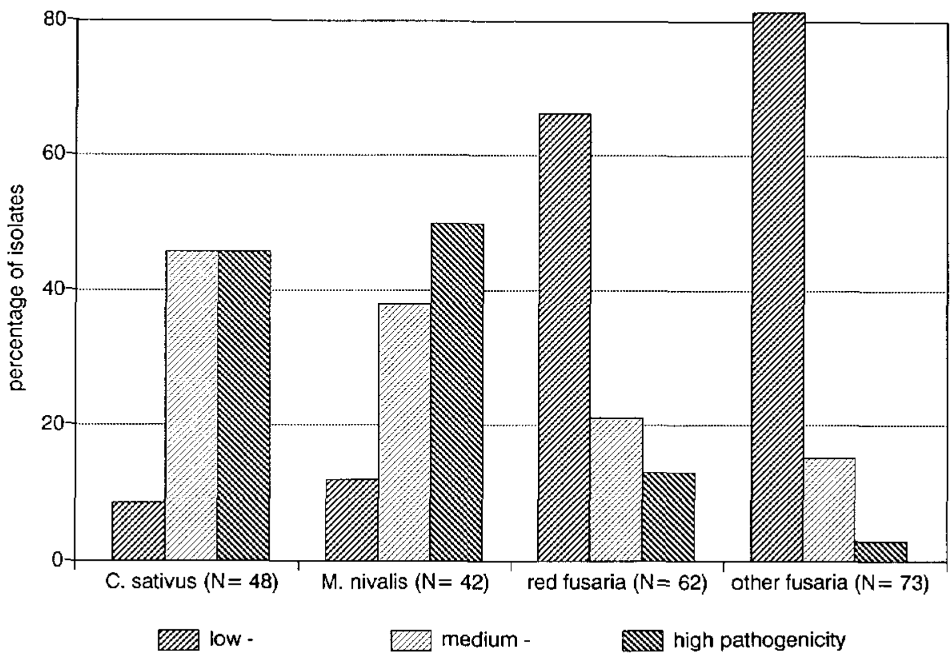

Fig. 10. Pathogenicity of root fungi, isolated from samples with different levels of root rot severity, collected from barley in northern Syria, 1992.

2.5.1.3. Survey for Root Diseases in Tunisia, Egypt and Turkey

Using the same methodologies as in Syria, surveys in three countries were carried out in 1993. A five day survey for root rots in wheat and barley was made in Tunisia together with Dr A. Lyamani (INRA, Morocco), Dr A. Yayaoui (ENSAK, Tunisia) and Dr M. Harrabi (INAT, Tunisia). Short surveys were made of barley fields in the north-west coast of Egypt (with Dr R. Rizk, ARC, Giza) and south-eastern Turkey (with Dr M. Bicici, University of Adana). Table 31 summarizes ratings and pathogens found. In Tunisia, wheat was found to be more affected by root rot than in Syria, but still less than the barley. *C. sativus* was the predominant pathogen on both cereals, but red fusaria were isolated frequently from wheat. However, as in Syria, most of these fusaria appear to be of low pathogenicity (Fig. 11).

Table 30. Comparison of root rot incidence, tiller number and percentage of three root rot pathogens recovered from neigbouring wheat and barley fields and from wild barley and cultivated barley from same field.

Cultivated barley						Wild barley / wheat					
field	N[1]	Inc[2]	*C. sat*	*M. niv*	red fus[3]	field	N[1]	Inc[2]	*C. sat*	*M. niv*	red fus[3]
Cultivated barley < > Wild barley											
425/03	50	28	33	67	33	425/03	19	26	100	50	0
425/15	42	21	0	100	0	425/15	32	38	0	50	0
425/19	50	30	40	60	0	425/19	10	20	0	0	0
426/01	50	68	20	80	40	426/03	22[4]	23	100	0	33
Cultivated barley < > Wheat											
425/10	50	50	80	40	20	425/11	17[5]	18	0	67	0
425/13	50	48	60	60	0	425/04	35	9	0	100	50
						426/02	50	16	0	100	0
						426/03	50[5]	10	100	0	67

[1] number of plants evaluated per fields
[2] root rot incidence; percentage plants with a root rot score ≥ 3
[3] percentage of *C. sativus*, *M. nivalis* and red pigmented fusaria recovered.
[4] wild barley in irrigated field (no. 426/03), located next to the field 426/01.
[5] irrigated fields

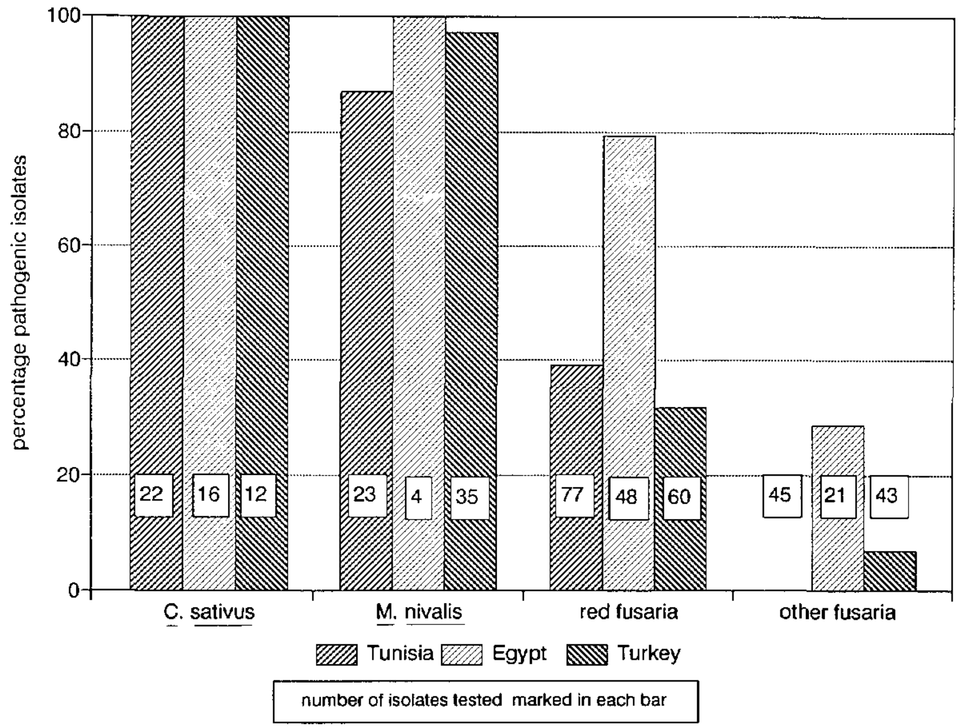

Fig. 11. Percentage of highly pathogenic root fungi, isolated from barley in three countries, 1993.

M. nivalis is present in Tunisia, especially on barley grown in the colder environments of central Tunisia. *C. sativus* was also the predominant pathogen in rainfed barley fields on Egypt's north-west coast, but red fusaria were found in association with plants having severe foot rot symptoms. These fusaria were highly pathogenic (Fig. 11). The north-west coast of Egypt has mild winters, and the cold climate pathogen *M. nivalis* was not isolated frequently. Barley in south-eastern Turkey had a high level of root rot. The predominant pathogen in this region with cold winters was *M. nivalis*. As with the Syrian survey, no relation between the root rot score and the number of fertile tillers was present (Table 31).

Table 31. Root rot incidence, tiller number and percentage of three root rot pathogens recovered in cereal fields in Tunisia, Egypt and Turkey during 1992-93 season.

						Pathogens recovered[4]					
		Incidence[2]		Tillers[3]		*C. sativus*		*M. nivalis*		red fus.	
Crop	N[1]	Avg	Range	Low	High	Avg	Range	Avg	Range	Avg	Range
Tunisia											
barley	18	21	0-71	3.3	3.4	48	0-93	15	0-50	26	0-64
wheat	11	16	0-38	2.3	2.3	35	0-85	6	0-25	32	0-58
Egypt											
barley	12	26	3-67	1.9	1.6	38	0-87	5	0-23	22	0-43
Turkey											
barley	21	66	11-92	1.6	1.7	10	0-38	32	0-100	26	0-67

1 number of fields surveyed
2 percentage plants with a root rot score ≥ 3; average, lowest and highest over fields.
3 number of tillers for plants with low (≤ 2) and high (≥3) score, averaged over field means.
4 percentage of *C. sativus*, *M. nivalis* and red pigmented fusaria recovered; average, lowest and highest over fields.

2.5.1.4. Effect of Crop Rotations on Barley Root Rot

A project, in collaboration with Prof Bassam Bayaa and his students of the University of Aleppo, was started in 1993, to study root rot development within the long-term PFLP / FRMP rotation trials at Breda. Soil inoculum of *C. sativus* was determined using a soil plating method on selective media. Soil samples were taken twice during the growing season from the same spots in five different rotations (Table 32). Inoculum of *C. sativus* was highest under barley following fallow. This effect was consistent over time, even though the number of spores found at maturity was lower than at tillering.

Isolations from barley plants were made at the same time as the soil samples were taken and plants were rated for symptoms on the SCI at the end of the season. Root rot was more severe and recovery of *C. sativus* most frequent after fallow (Table 32). It is therefore unlikely that at this site *C. sativus* is the cause of the yield decline found with continuous barley. *M. nivalis*, however, was high in continuous barley plots. A role of this pathogen in the yield decline should not be excluded, as it was frequently isolated from plants without visible symptoms on the SCI.

Table 32. Number of *C. sativus* per gram soil, recovery of *C. sativus* and *M. nivalis* from barley plants at tillering stage and at plant maturity and the percentage of plants with a score ≥ 3 (PDP) at maturity for different rotations at Breda, 1992-93.

Rotation		Spores / gram soil		*C. sativus*		*M. nivalis*		
91-92	92-93	til	mat	til	mat	til	mat	PDP
Barley	Barley	110	51	27	65	44	65	47
Barley	Fallow	88	52					
Fallow	Barley	436	243	77	94	40	24	64
Barley	Lathyrus	40	28					
Lathyrus	Barley	130	118	29	90	10	17	43

2.5.1.5. Possible Role of *Monographella nivalis* as a Barley Root Pathogen

M. nivalis, is recognized as an important disease of winter cereals in the northern hemisphere. Although the optimum can grow at temperatures just above the freezing point and a deep snow cover provides a favourable environment. The fungus causes leaf rotting (hence the name snow mould), but if the snow cover remains long enough the plant crown gets infected and death may occur. Studies in England have demonstrated that *M. nivalis* can as well be a wheat root pathogen, which can reduce stand and tiller number of plants in cold dry soils, even without snow cover. Only one publication from South Australia describes its potential importance as a barley root pathogen in relatively mild climates. Analysis of weather data at Tel Hadya from 1980 till 1993 showed that the number of days with soil temperatures between 0 and 10°C varied from 37 (1985-86) to 122 (1984-85) days and averaged 77 days per season. *M. nivalis* can develop within this temperature range, while most other root pathogens have a low activity. So far we have no data on yield losses caused by *M. nivalis*, but its high occurrence in different sites through northern Syria and Turkey, its virulence in seedling tests and its possible role in the yield decline associated with continuous barley cultivation justifies further investigations.

2.5.1.6. Yield Losses After Inoculation with *C. sativus*

Cultivars selected from the 1991-92 yield loss experiment (Annual Report 1992) were tested both in Tel Hadya (two planting dates) and in Breda. The experiment was part of a project carried out in collaboration with Dr Wafa Khoury and students of the Lebanese University.

Seed inoculation increased the level of root rot symptoms and decreased grain yield in all three experiments. A large interaction between inoculation and environment was present. Inoculation had the greatest effect in the late planting at Tel Hadya. No clear relation was found between root rot symptoms and loss in grain yield (Table 33).

2.5.1.7. Yield Losses Associated with Root Rot in Uninoculated Conditions

Within the rotation trials in Breda tiller number and grain yield were assessed for 50 plants with a low (≤ 1) disease score and a similar number with severe (≥ 4) symptoms on the SCI. Plants were taken from plots without additional nitrogen and plots that received 20 kg N / ha before planting. Severely affected plants yielded less than clean plants in all rotations (Table 34).

Table 33. Effect of *C. sativus* inoculation on grain yield (kg/ha) and on percentage plants with a root rot score of ≥ 3 (PDP) of 16 barley lines, Tel Hadya (early and late planting) and Breda, 1992-93.

		Tel Hadya - early				Tel Hadya - late				Breda			
		PDP		yield		PDP		yield		PDP		yield	
No	Name	Un	In	Un	In	Un	In	Un	In	Un	In	Un	In [1]
1	JLB 06-038	9	9	3920	3537 *	17	90 ***	4017	4097	21	49 **	2257	2303
2	JLB 06-058	4	11	4263	3777 *	6	93 ***	4571	4400	15	29 *	2726	2464 °
3	SLB 39-003	14	23 °	4160	3886	11	91 ***	4349	4331	12	43 ***	2189	2354
4	SLB 39-058	7	12	4000	3543 *	8	86 ***	4383	4023 *	14	30 *	2606	2703
5	SLB 32-045	5	16 *	4137	3908	14	89 ***	4257	4149	21	41 **	2789	2440 *
6	SLB 32-074	17	22	4268	3920 °	33	95 ***	4246	4537 *	20	44 ***	2554	2360
7	SLB 66-009	10	87 ***	4017	3834	19	75 ***	4097	3886 °	34	94 ***	2246	2074
8	SLB 66-014	4	9	3954	3828	1	88 ***	4383	4463	8	49 ***	2720	2606
9	SLB 42-089	6	23 **	3600	2943 ***	7	69 ***	3320	3251	16	29 °	2457	2257
10	SLB 42-064	18	31 *	3360	2994	18	74 ***	3554	3486	37	45	2428	2486
11	Tadmor	15	24 °	3383	3309	12	67 ***	3749	3623	16	33 *	2520	2291
12	W12291	6	10	4149	3983	7	72 ***	4674	4486	18	41 **	2280	2469
13	Arizona 5908/.	10	90 ***	4177	3663 **	11	94 ***	4829	4274 ***	19	96 ***	2183	1526 ***
14	Local Balawieh	10	24 **	3469	3297	15	92 ***	3166	3120	34	56 **	2286	1914 **
15	Rihane-03	22	23	5200	4880 °	8	73 ***	5417	5280	37	69 ***	2857	2343 ***
16	ER/Apm	3	42 ***	5166	4600 **	6	83 ***	4709	4166 ***	9	55 ***	2846	2451 **
	mean	10	29	4076	3744	12	83	4233	4098	21	50	2496	2315

[1] Un, In: uninoculated and inoculated.
Signicance levels of LSD test between uninoculated and inoculated; ° 10%; * 5%; ** 1%; *** 0.1%

Table 34. Loss of yield associated with root rot symptoms in a rotation trial with and without nitrogen fertilizer at Breda, 1992-93.

Rotation	Fert.	Symptoms	Plts	Heads	He/Pl	Yld/Pl	Yld/He	TKW[1]
Fallow	-	clean	50	176	3.74	2.03	0.54	31.2
		severe	49	155	3.16	1.53	0.48	30.4
Lathyrus	-	clean	35	118	3.37	2.49	0.74	35.6
		severe	32	113	3.53	1.84	0.52	35.6
Lathyrus	+	clean	58	271	4.67	2.77	0.59	32.2
		severe	48	141	2.94	1.67	0.57	34.0
Barley	-	clean	72	156	2.17	0.97	0.45	34.8
		severe	56	73	1.30	0.52	0.40	32.0
Barley	+	clean	50	127	2.54	1.55	0.61	37.2
		severe	49	108	2.20	1.10	0.50	36.8

[1] Plts, number of plants sampled; He/Pl, number of heads per plant; Yld/Pl, grain yield per plant (gram); Yld/He, grain yield per head (gram); TKW (1000 kernel weight) in grams.

2.5.1.8 Testing of Advanced Breeding Lines for Resistance to *C. sativus*

All entries from both the 1991-92 and 1992-93 Regional Yield Trials, entries in the second year of testing in the Observation Nurseries for Low Rainfall and a number of lines selected for root rot resistance from previous experiments were tested at two locations (Tel Hadya and Breda) after seed inoculation with conidia of *C. sativus*. Testing 160 lines was possible using mechanized seeding. Experiments were planted as split-plot with varieties as main treatment and inoculated versus uninoculated in the subplots with five replicates. Each sub-plot consisted of three rows, 2.5 m long, planted at 100 kg seed / ha. At the soft dough stage, 20 plants with a subcrown internode of more than 1 cm were pulled from the border row and rated for discoloration of the SCI. The remaining two rows were harvested. Inoculation increased the incidence of root rot (percentage plants with score $\geq$ 3) from an average of 19% to 40% at Tel Hadya and from 26% to 49% at Breda. Large differences between varieties were found. In Tel Hadya ratings ranged from 7% to 97% after inoculations and in Breda from 3 to 99%. Ratings in the two different locations showed a highly significant correlation (r= 0.81 between the inoculated plots in Tel Hadya and Breda). Analysis of variance of the root rot incidence showed a significant interaction between varieties and inoculation. Table 35 lists the six most resistant lines (incidence lower that 15 % in both Tel Hadya and Breda).

Table 35. Lines with low root rot incidence[1] in inoculated tests in both Tel Hadya and Breda, 1992-93

Name / Pedigree (Nursery)	T. H. un	T. H. in	Breda un	Breda in
Antares//12201/Attiki/3/RM1508/Por//WI2269 ICB82-0232-1AP-0AP-0AP (BYL-W 93)	4	11	5	1
Emir/Arabi Abiad//Roho ICB82-0319-6AP-0AP (BYL-W 93)	15	10	2	2
WI2291/WI2269 ICB78-0594-8AP-3AP-2AP-2AP-0AP (BYL-C 93)	12	10	8	2
WI2198/Harmal-02 ICB82-0833-4AP-0AP-15AP-0TR (BYL-C 93)	9	7	1	2
Mari/Aths*3//Mari/Aths*2 CYB-3649-0D-0AP-2APH-0AP (BOL-C 93)	4	11	2	7
WI2198/Harmal-02 ICB82-0833-4AP-0AP (BYL-C 92)	13	13	5	9

[1] Percentage plants with score ≥ 3 without (un) and with inoculation (in).

2.5.2. Leaf Diseases

The most important barley leaf diseases in the WANA region are scald (*Rhynchosporium secalis*), net blotch (*Pyrenophora teres*) and powdery mildew (*Erysiphe graminis*). The intensification of barley cultivation in the region is likely to encourage diseases that survive on stubble such as scald and netblotch. The importance of these pathogens was highlighted during an international workshop held at ICARDA's headquarters during March 1993.

New activities within the barley pathology project during 1993 were (i) screening under controlled conditions for net blotch and (ii) histological studies on scald infection.

2.5.2.1. Net Blotch

Net blotch (*Pyrenophora teres*) can cause serious yield losses on barley grown in temperate humid regions. Recently, an increased incidence of net blotch has been reported especially in North Africa. Field screening for resistance to netblotch at Tel Hadya is hampered by the climate, which is too cold and dry for the good development of this disease. However, testing is possible under controlled conditions, either in climate rooms for seedling tests or greenhouses for adult plants. In the past season a reliable seedling screening test was developed and virulent Syrian pathogen strains, for use in greenhouse screening, were identified.

2.5.2.1.1. Screening in Seedling Stage

After preliminary tests of 53 mono-spore *P. teres* isolates from different countries, 15 isolates were selected and used to evaluate 49 cultivars, with reported differences in resistance and of diverse origin. Figure 12 shows the number of varieties susceptible to the different strains used. Some Syrian isolates have levels of virulence, comparable to exotic strains from countries where netblotch is epidemic, like Ethiopia and Tunisia. Six strains were selected and tested twice on 21 varieties (Table 36). Significant differences among isolates and genotypes as well as a significant interaction were present. *P. teres* isolates from different countries, or even within the same country, differed in pathogenicity. The Syrian strain 9303-A had a low overall virulence, but was aggressive on Alexis and Welam. The other Syrian strain tested, 8801-B, was virulent on all cultivars.

Table 36. Seedling reaction[1] of 21 barley cultivars to inoculation with 6 *P. teres* mono-spore isolates from different countries.

	Syria		Tunisia		Eth.	U.K.	
Cultivars	8801B	9203A	8704A	8704A	8705A	9001A	mean
CI 04976	6.2	2.9	3.1	3.7	4.9	1.8	3.8
Emir//Apm/HC1905	4.4	2.7	3.8	2.9	6.3	4.0	4.0
CI 07272	7.1	3.1	4.2	3.0	5.7	1.6	4.1
Rihane-03	5.1	2.6	5.9	4.1	5.7	3.4	4.4
Martin	5.8	1.8	7.4	5.2	4.6	4.0	4.8
Welam	5.1	5.6	2.8	5.7	7.0	3.7	5.0
Athenais	4.3	3.4	6.9	4.6	7.1	3.7	5.0
Tichedrett	5.3	2.9	7.4	5.7	5.8	3.6	5.1
CI 09825	5.5	3.9	5.3	4.5	6.6	4.9	5.1
Emir/Arabi Abiad//Roho	7.2	3.3	5.4	4.6	7.0	4.0	5.3
Debre Zeit local	6.0	2.9	6.7	5.4	7.3	3.4	5.3
N-Acc4000-301-80/IFB974	4.8	4.5	6.3	3.9	7.3	5.0	5.3
Triumph	6.8	4.1	5.5	3.9	6.9	5.7	5.5
78S-412	8.2	3.7	5.6	3.5	6.9	5.0	5.5
Claudia	5.7	3.3	5.8	7.0	7.3	5.3	5.7
Arve	6.3	3.4	7.1	4.6	6.8	6.5	5.8
WI2291	7.5	3.7	5.7	6.5	6.1	5.5	5.8
HB-100	7.1	4.0	6.8	5.6	6.9	4.6	5.9
Clermont	7.7	2.7	7.4	6.7	7.0	7.4	6.5
Betzes	7.8	4.8	7.6	7.5	7.6	7.4	7.1
Alexis	8.0	6.4	8.2	7.4	8.6	7.3	7.6
Isolate mean	6.3	3.6	5.9	5.0	6.6	4.6	5.4

Severity rated on 0-9 scale; 0= clean; 1= < 2.5 %; 2= 2.5-5 %; 3= 5-10 %; 4= 10-20%; 5= 20-30%; 6= 30-40%; 7= 40-50%; 8= 50-75%; 9= >75 % leaf area affected. Scores averaged over two experiments with 3 replicates each.

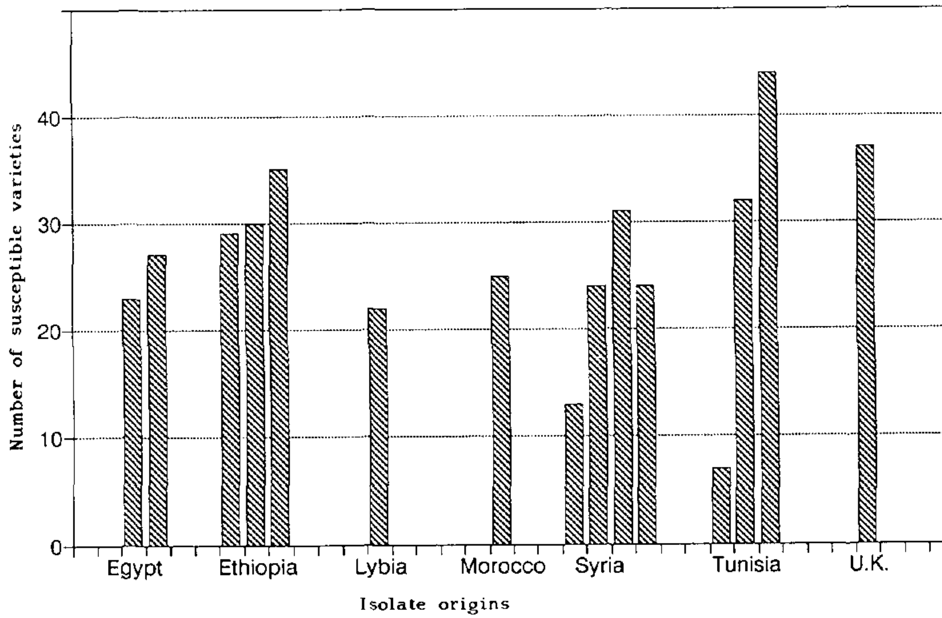

Fig. 12. Reaction of 49 barley cultivars to 15 isolates of *P. teres*, originating from 7 different countries.

2.5.2.2. Scald

Scald, caused by *Rhynchosporium secalis*, develops at lower temperatures than netblotch and is a serious disease throughout WANA. An extensive field screening program is carried out at Tel Hadya and several sources of resistance have been identified, both within the breeding material and within landraces from WANA.

2.5.2.2.1. Histological Studies of the Pre-penetration Development of *Rhynchosporium secalis*.

A better understanding of the nature of resistance will facilitate the development of resistant cultivars. A study was undertaken to relate differences in seedling resistance among barley cultivars, with the histological development of the fungus in the pre- and post-penetration stage. The study was partly carried out by a BSc student of the Lebanese University. Seven barley cultivars were selected that showed a differential reaction to three Syrian and two Tunisian mono-spore *R. secalis* isolates, in seedling tests. Atlas 46 was resistant to the Syrian isolates, but susceptible to the Tunisian ones. WI2291 was highly susceptible to all isolates, while the reaction of the other cultivars varied. Spore germination on detached leaves, placed on water agar amended with 80 mg benzimidazole per liter, was measured 24, 48 and 72 h after inoculation. Compared to the susceptible check, WI2291, germination was lower on all other cultivars 24 h after inoculation. However, after 72 h only some isolate / cultivar combinations showed a reduction (Table 37). Only the reaction of Atlas 46 correlated with the results of the seedling tests: germination of the Syrian isolates, but not of the Tunisian ones, was reduced. No relation between spore germination and seedling response was found for the other cultivars / isolate combinations. For example, Abyssinian showed a consistent reduction in germination, but was susceptible to the isolates 8706-B and 8713-A in the seedling test.

Histological studies of plant-pathosystems have concentrated on the post-penetration stage and few reports exist on resistance operating before penetration. Our findings clearly showed that for certain barley genotypes a resistance mechanism against *R. secalis* operates as well before penetration. Future work will focus on other pre and post-penetration mechanisms of resistance. Preliminary experiments indicated the presence of subcuticular hyphae with the compatible combination WI2291 / 8706-B, 14 d after inoculation, while no subcuticular hyphae were present with the incompatible Atlas 46 / 8706-B combination.

2.5.3. Seedborne Diseases

Seedborne diseases remain important in low-input barley systems in WANA as farmers do not treat seed with fungicides. Routine screening of breeding material is carried out for resistance to covered smut (*Ustilago hordei*), by artificially inoculating seed with the teliospores of the fungus. Field screening is as well carried out for barley leaf stripe (*Pyrenophora graminea*), but is restricted to advanced material as screening is laborious.

2.5.3.1. Covered Smut

A total of 224 lines under advanced yield testing, 702 lines under preliminary yield testing and 305 selections of local Syrian landraces were tested at Tel Hadya and Jinderess. Percentage of smutted plants was estimated at maturity. The average smut percentage in Jinderess was 6 % and in Tel Hadya 4 %. From the advanced breeding lines 50 % were highly resistant (0% smut, averaged over both locations), 23 % moderately

Table 37. Percentage germination of 5 mono-spore isolates of R. secalis spores on detached leaves of 7 barley cultivars, after 3 incubation periods.

	8701-A (Syr)			8703-A (Syr)			8706-B (Syr)			8707-A (Tun)			8713-A (Tun)		
	24 h	48 h	72 h	24 h	48 h	72 h	24 h	48 h	72 h	24 h	48 h	72 h	24 h	48 h	72 h
Atlas 46	21***	39***	55***	21***	53***	66***	26***	59***	69***	72***	85***	98	75***	92	99[1]
Tadmor	52***	71***	88***	66***	78***	96	58***	75***	93***	77**	90	100	84	93	100
Abyssinian	22***	40***	72*	44***	62***	78***	19***	51***	66***	22***	58***	74***	17***	52***	70**
Arta	30***	81*	95	63***	98	100	52***	92	99	55***	91	99	63***	88**	98
La Mesita	36***	78***	97	57***	97	100	72**	94	100	59***	89*	96	67***	95	97
Kitchin	59***	80**	99	71**	94	97	66***	94	99	61***	93***	99	82**	94	100
WI2291	75	88	99	82	93	99	81	91	100	87	95	100	90	97	100

[1] percentages are means of three replicates.
Signicance levels of difference between cultivar and the susceptible check WI2291 * 5%; ** 1%; *** 0.1%

resistant (>0 - ≤ 3 % smut) and 6 % highly susceptible (≥ 10 % smut). From the breeding lines in preliminary yield trials, 41 % were highly resistant, 24 % moderately resistant and 9 % highly susceptible. From the Syrian landrace lines tested, 7 % were highly resistant, 8 % moderately resistant and 56 % highly susceptible. The resistance within the local barleys was especially low within germplasm originating from Hassake province in north-east Syria. From the lines originating from Aleppo province (north-west) 28 % were highly resistant.

2.5.3.2. Barley Leaf Stripe

Barley leaf stripe (*Pyrenophora graminea*) is potentially the most important of the seedborne diseases on barley, especially in more humid environments. Chemical control requires expensive, systemic fungicides. In the past we screened for resistance using seedling tests, where seed was germinated in contact with mycelium of the fungus. In 1991-92 nurseries were planted next to artificially inoculated spreader rows at the Jinderess testing site. This site was chosen because high rainfall provides a good environment for seed infection. Seed harvested from these nurseries was evaluated for infestation during the past season. Methods of estimating seed infestation both in the field and under controlled conditions were improved.

2.5.3.2.1. Evaluation under Field Conditions

Among the nurseries evaluated at Jinderess was a set of the most advanced breeding lines. Out of the 58 lines tested, 14 lines were free of stripe, including the resistant check Betzes. Among the lines free of stripe were the cultivars Harmal and Kantara, which were previously identified as resistant by Dr M. Boulif of the Ecole Nationale d'Agronomie at Meknes, Morocco. The susceptible check, CI 06946, had the highest infection level (6 %). The cultivar ER/Apm, susceptible in farmer's fields in Syria, had 3.7 % striped plants. Eight lines had a higher percentage of striped plants than ER/Apm. Among these lines were ACSAD 176 (4.7 %), Roumi (4.0 %), WI2291 (4.3 %), Arta (4.3 %) and Furat 4484 (4.3 %). ACSAD 176 has been released in several countries in the region. Roumi is a local Syrian cultivar, mainly grown in the Ghab valley, and often shows high levels of stripe infection.

2.5.3.2.2. Evaluation under Greenhouse Conditions

Testing under field conditions gives variable results because of environmental factors. Testing under greenhouse conditions gives more consistent results, but has as the disadvantage that plants can not be grown to the adult stage. Germination at temperatures below 10°C gave the highest percentage of striped plants. Germinating seed on filter paper moistened with a 30 ppm benomyl solution increased the level of stripe. *P. graminea* is tolerant to benomyl, while this fungicide inhibits certain saprophytic seed fungi. Averaged over 396 seed lots (with different levels of infestation) the percentage of infested plants, measured at the 4 leaf stage, increased from 7.2 % to 10.5 % as a result of the addition of benomyl. The evaluation of seedlings under greenhouse conditions was correlated with that of adult plants in the field at Jinderess ($r = 0.2608$, $P < 0.1\%$). - **J.v. Leur, H. Toubia-Rahmé**

2.6. International Nurseries

2.6.1. Spring Barley

2.6.1.1. Screening for Boron Toxicity Tolerance

Boron (B) toxicity caused by high B concentration in soils can substantially reduce cereal grain and straw yield. Available literature indicates that the problem may be wide-spread in dry areas. The Program started investigation into this problem in 1992. B toxicity in barley was identified at Bouider, near Aleppo, Syria, on the NW coast of Egypt, and near Eskisehir and Konya in Turkey. Since treating the soil to remove or reduce the effect of B is not economically feasible, selecting crop cultivars with resistance to B toxicity is the most promising approach.

Screening was conducted in a plastic house. Seeds were sown in trays of soils mixed evenly with boric acid. This avoids the heterogeneity of B toxicity often present in the field. Adding 50 mg B/kg soil (giving a hot water extract of around 27 ppm B) was found to be the level giving good symptom discrimination in 4 weeks. Ten seeds were sown for each entry, and there were 2 replicates. B concentration in plant dry matter for entries showing the least symptoms was also measured.

A total of 394 advanced barley lines, mainly from the 3 international observation nurseries and crossing block, were tested. Significant variation in symptom scores existed between the lines tested. Lines with low B toxicity symptoms and tissue concentration are presented in Table 38. Advanced lines in the two Barley Observation Nurseries for Low Rainfall Areas generally had lower symptom scores than those in the Barley Observation Nursery for Moderate Rainfall Areas. The most susceptible lines, like Pirate and Onslow, were detected in the Barley Crossing Block, which consists of lines having specific expression of particular traits. - **S.K.Yau, J. Hamblin, S. Ceccarelli, S. Grando**

Table 38. Barley lines with least B toxicity symptoms and tissue B concentration 4 weeks after sowing in a soil added with 50 mg B/kg soil.

Nursery	Ent. no.	B conc. (ppm)	Name/cross
BON-LRA-M	41	536	H. spont. 20-4/Arar 28/3/OP/Zy//Alger/Union, 385-2-2
BON-MRA	31	639	Bco.Mr/Avt//Cel/3/Line 257-14/4/Rihane'S'-5
	43		Deir Alla 106//Api/EB8B-8-2-15-4/4/Lth/3/Nopal//Pro/11012-2
	74	665	Sawsan/Badia//Arar
	76	539	Lignee 527/NK1272
BCB	59	552	9Cr.279-07/Roho
	79		As68
Selection from Syrian landraces:			
		529	Zanbaka
		486	SLB 5-95
Checks:			
Tolerant		556	Galleon (from Australia)
		461	Halberd (bread wheat from Australia)
Susceptible			
BCB	48	1196	Onslow
	89	833	Pirate

2.6.1.2. Nursery Distribution in 1993

International barley nurseries available for distribution from ICARDA, Syria, remained the same as last season (Table 39). There was no seed shortage except for the Segregating Populations and Naked Barley Nursery. A total of 305 nursery sets, about 20% less than last year, were distributed. This reduction was partly caused by sending special yield trials, observation nurseries and segregating populations to the 4 North African countries (Algeria, Libya, Morocco and Tunisia) instead of the traditional international nurseries. - **S.K. Yau, S. Ceccarelli, S. Grando**

Table 39. Barley international nurseries for 1993-94.

Nursery	Abbre-viation	No. of entries	No. of sets distributed
Regular Nurseries			
Crossing Block	BCB	52	32
Segregating Populations	BSP	46	16
Observation Nurseries:			
- Low Rainfall Areas (Mild Winter)	BON-LRA(M)	102	36
- Low Rainfall Areas (Cool Winter)	BON-LRA(C)	96	26
- Moderate Rainfall Areas	BON-MRA	108	40
Yield Trials:			
- Low Rainfall Areas (Mild Winter)	BYT-LRA(M)	24	33
- Low Rainfall areas (Cool Winter)	BYT-LRA(C)	24	22
- Moderate Rainfall Areas	BYT-MRA	24	38
Germplasm Pools			
Naked Barley	BN	50	30
BYDV Resistance	BYDV	50	32
	Total		305

2.6.1.3. Inter-site Transferability of Varieties

Improved varieties developed at research stations are targeted to farmers' fields over large areas. Therefore it is important to develop a measure of transferability of varieties over sites. A study was undertaken to establish a statistical measure of inter-site transferability of varieties from the data obtained from multi-location trials.

Let y_{ij} be an estimate of the performance of i-th variety in the j-th environment (i=1...V; j=1...L). The standard error of y_{ij} is $\sigma_j/(r_j)^{1/2}$ where σ_j and r_j are experimental error standard deviation and number of replications, respectively, at j-th location. Let the response -environment relationship for the i-th variety be modeled using linear function as

$y_{ij} = \alpha + \beta X_j + \epsilon_j$

where α and β are intercept and slope of the regression lines, and ϵ_j's are random errors with mean zero and variance σ_j^2/r_j. X_j is an index for the j-th environment and can be measured as mean over all varieties or mean over varieties except the entry for which this index was obtained, at the j-th location. To evaluate the inter-site transferability of i-th variety to environment j, we fit the above model using information from all environments except the j-th to get the least square estimates of α and β as $a_{(j)}$ and $b_{(j)}$. This gives us the predicted response at j-th location as $yp_{ij} = a_{(j)} + b_{(j)}X_j$. The difference, $IS_{ij} = y_{ij} - yp_{ij}$, is termed as an inter-site transfer residual or predicted residual. The plot residuals from the analysis at each location give within-site residuals. A measure of transferability of the genotype (P) is the ratio of inter-site transfer residual sum of squares to within-site residual sum of squares weighted with r_j at the j-th location:

$$P = \sum_j r_j IS_{ij}^2 / \sum_j S_j^2$$

where S_j^2 is residual mean square computed from plot-wise data at the j-th location. P can be expressed as a linear combination of independent chi-square variables. When experimental errors are homogeneous, the distribution of P can be approximated by an F-distribution, while in case of heterogeneous errors P can be approximated by a chi-square.

This statistic was evaluated for each genotype in two sets of international trials on barley and four sets of wheat trials. Correlation between mean and slope was significant in the majority of trials. The strong association between mean and slope limits the scope of selecting slopes and means of the genotypes. The low correlation between P-statistics (and associated probability of inter-site transferability) indicates independence between the mean and the transferability values. It therefore provides a sound basis to select genotypes which are high yielding as well as transferable over target environments represented by the test environments. - **M. Singh, S.K. Yau, J. Hamblin, E. Porceddu**

2.6.2. Winter and Facultative Barley

2.6.2.1. Screening for Boron Toxicity Tolerance

A total of 348 advanced barley lines from the 1992-93 international yield trials, observation nursery and crossing block were tested (for details see Section 2.6.1.1.). Lines with low B toxicity symptoms and tissue concentration are presented in Table 40. The highest diversity in B toxicity symptom development existed in the Barley High Elevation Adaptation Yield Trial, which contains winter/facultative barley lines from different origin. Lines from Europe and Russia (Robur, Novator, Lignee 527, Plaisant, Victoria, and Cyclone) were susceptible, while the landrace varieties from West Asia (like ICB 104042 from Afghanistan, Baluchistan from the high plateau of Pakistan, Walfajr and Zarjou from Iran, Tokak from Turkey, and Tadmor from Syria) had low symptom scores. This suggests that B toxicity may be wide-spread in West Asia. Interestingly, the two USA varieties included in the trial (Steptoe and Kearney) also showed little symptoms. - **S.K.Yau, J. Hamblin, M. Tahir**

Table 40. Barley lines with least B toxicity symptom and their tissue B concentration 5 weeks after sowing in soil added with 50 mg B/kg soil.

Nursery	Ent. no.	B conc. (ppm)	Name/cross
IWFBON	87	540	ZDM 314 (=ICB 116365)
	103	488	ZDM 939 (=ICB 117474)
IWFBCB	7	581	Local B. Kan Mehterzai
	8	612	Baluchistan
	127	626	ZDM 477 (=ICB 116472)
	129	484	ZDM 3485 (=ICB 117093)
	136	581	Viringa 'S'
	145	586	Viringa 'S'
BHEAYT	9	398	ICB 104041
	10	573	Baluchistan
Checks:			
Tolerant		336	Halberd (bread wheat from Australia)
Sensitive			
		767	Stirling (from Australia)
IWFBON	88	938	OACWB74-23/FB73258,F1/3/Kamiak/ Belts67-875//WA1094-67

2.6.2.2. International Winter and Facultative Barley Yield Trial

The International Winter and Facultative Barley Yield Trial was assembled for the first time in 1991. It replaced the Barley Yield Trial for High Altitude Areas. The name of the trial shows that both winter and facultative types are included. It is targeted for areas where winters are severe, not just high altitude areas. Table 41 shows the best lines which significantly (P<0.05, 1-sided test) out-yielded the local checks at different locations in Algeria, Iran and Pakistan in 1991-92.

Table 41. Barley lines outyielding (P<0.05, 1-sided test) the local check in the 1st IWFBYT at different locations in Algeria, Iran and Pakistan in 1991-92.

Country (Location)	Pedigree
Algeria[1] (Setif)	Atem/3/Roho//Alger/Ceres
	NY6005-1B/OWB70173-2H-4H,F1//F1,NY6005-19/J-126
	CWB117-5-9-5
Algeria (Tiaret)	Igri/MOB2639F1//F1P13161/Igri
	Robur/WA2196-68
	Cel/XV2240/3/Choya/Galt//11012-2
	WA1245/B67-1623,F1//J126/3/SC01/WA1356
	Lignee 131//Sul/Nacta
Iran (Neshaboor)	Lignee 131//Sul/Nacta
	CWB117-5-9-5
Iran (Ardabil)	WA 2196-68/Ny6005-18,F1//Scotia 1
Iran (Karaj)	Tokak
	YEA541-1/Tokak
	Alpha/Durra
	CWB117-5-9-5
Pakistan (Loralai)	PI 000505/Alpha
	CWB117-5-9-5
	YEA541-1/Tokak
	NY6005-1B/OWB70173-2H-4H,F1//F1,NY6005-19/J-126

[1] 13 lines significantly outyielded local check; only 3 highest yielding lines presented here.

The line CWB117-5-9-5 appears 4 times in the table suggesting it has wide adaptation. Detailed results of the trial are available in the Annual Report for the International Barley Nurseries 1991-92.

2.6.2.3. Nursery Distribution in 1993

The International Facultative Barley Yield Trial and International Facultative Barley Observation Nursery were two new international nurseries this year, expanding the total regular nurseries available for distribution from ICARDA, Syria, to six (Table 42). As suggested by their names, these two nurseries consist of advanced facultative types of barley, i.e. excluding the more cold tolerant, longer-season winter types. They are assembled for cold areas where winter conditions are not so severe to require true winter types. A total of 103 nursery sets were sent to national scientists upon their requests. - **S.K.Yau, M. Tahir**

Table 42. Barley international nurseries for 1993-94.

Nursery	Abbre-viation	No. of entries	No. of sets distributed
Regular			
Crossing Block	IWFBCB[1]	150	20
Segregating Populations	IWFBSP	150	19
Observation Nurseries:	IWFBON	152	18
	IFBON[2]	152	12
Yield Trial:	IWFBYT	24	10
	IFBYT	24	14
Special			
Yield Trial	BHEAYT[3]	24	10

	Total		103

1 IWF - International Winter and Facultative
2 IF- International Facultative
3 BHEAYT - Barley High Elevation Adaptation Yield Trial

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3. DURUM WHEAT IMPROVEMENT

3.1. Durum Breeding

The main objective of the durum project is to assist Mediterranean countries to enhance durum production in the dry areas by developing productive germplasm resistant to abiotic and biotic stresses with good grain quality; improving dryland breeding methodology; and providing training to NARS. Improved drought tolerant varieties are being used for commercial production in many countries in the region. Cham 3 continues to be released in different countries in the region and is the most widely grown variety in Syria where it was released in 1987. It has also been released in Jordan in 1990 (as Petra), Algeria in 1992 (as Korifla), and Libya in 1993 (as Zahra 5). Further, Heider, Kabir 1, Omrabi 9, Belikh 2 were recently released in Algeria. In Syria two varieties are proposed for release (Omrabi 3 and Lahn); in Libya and Morocco Omrabi 5; and in Tunisia Omrabi 3. - **M.M. Nachit**

3.1.1. Widening Genetic Base of Durum Wheat

Crosses between improved genotypes and landraces as well as with wild relatives were made to incorporate resistances to biotic and abiotic stresses and to broaden the genetic base of durum. In 1992/93 season, more than 60 crosses were conducted with landraces from the Mediterranean Islands (Cyprus, Sicily), Algeria, and Ethiopia.

3.1.2. Use of Recurrent Selection Method

To develop durum wheat Recurrent Selection Populations (RSP) with desirable traits, crosses were made between Mediterranean durum landraces, Kyperounda (KYP-RSP), *T. dicoccoides*, and wild relatives (*Aegilops,* Ae-RSP; *T. monococcum,* Tm-RSP; *and T. carthlicum,* Tc-RSP) with stable and high yielding genotypes. These crosses form the base of the durum wheat recurrent selection program. The Middle East durum wheat recurrent selection population (ME-DRSP) is targeted to continental Mediterranean dryland areas, and the Maghreb-Iberian population (MI-DRSP) to temperate dryland areas. The RSP populations are now in the third cycle. Improvements were shown in earliness for ME-DRSP, MI-DRSP, Tm-RSP, and Ae-RSP; all populations showed improvement in *fertile* tillering ability except for Tm-RSP. Only in the Kyp-RSP and Tc-RSP populations significant improvements were made in spike fertility parameters. Height was reduced in all RSPs. - **M.M. Nachit, A. Asbati**

3.1.3. Use of Wild Relatives

Several crosses between high yielding genotypes and *T. dicoccoides* were made to improve grain quality and resistance to *Septoria tritici* and yellow rust. Also, backcrosses were made to durum to eliminate undesirable traits. A further 55 crosses were made with *T. monococcum* to improve rust resistance, earliness, and early growth vigor. Seventy crosses were made using *Aegilops species* and *T.carthlicum* as well crosses with *T. turanicum compactum*. - **M.M. Nachit, A. Asbati**

3.1.4. Development of Populations for *QTL* Analysis

After screening for polymorphism using initial RFLP markers, two crosses with polymorphic parents were made in 1991/92; these crosses were repeated in 1992/93. The two crosses are: Jennah Khetifa/Cham1 and Omrabi5/*T.dicoccoides* 600545//Omrabi5. The first cross includes Jennah Khetifa, a landrace from Tunisia with good quality traits, common bunt resistance, but with low yield and high susceptibility to yellow rust; and Cham1 with high yield and resistance to yellow rust, but low grain quality. In the backcross material the parents used were Omrabi5 and a *T. dicoccoide* line; Omrabi5 is drought tolerant with good production and adaptation in dryland areas; and *T.dicoccoides* 600545 is resistant to septoria and yellow rust and has good grain quality. More than 200 seeds from F1 plants of each cross were grown using SSD method to advance them to the F5. - **M.M. Nachit, M. Jarrah, M.Baum, M. Sorrells**

3.1.5. Testing in the Double Gradients Selection Technique

Double gradients selection tests were conducted for multiple stress abiotic resistance (drought x heat and drought x cold) and multiple biotic stress resistance (diseases and insects). During the 1992/93 season the screening for resistance to drought, heat, diseases, and insects was effective, while cold screening was inadequate due to the mild winter conditions. Populations and advanced lines combining multiple abiotic and biotic stress resistances were selected. - **M.M. Nachit, A. Asbati, M. Jarrah, M. Azrak, Z. Younes**

3.1.6. Grain Quality

Durum material with strong gluten was crossed to high yielding durums and only lines with high grain quality were advanced. More than 100 crosses were made to upgrade the quality. The sedimentation test was the most important selection criterion. Crosses were made mainly with French germplasm carrying high grain quality parameters. Grain quality of most newly developed lines is either similar to or higher than the quality of the good quality checks: Korifla and Haurani. Material was analyzed for electrophoretic bands. Seed storage proteins are not affected by environment and a single seed is enough to determine a genotype's profile.

3.1.7. Relationship of γ-45 and γ-42 gliadins with of Grain Quality in the Mediterranean Durum Germplasm

High sedimentation values and index were associated with the presence of γ-45 gliadin, and low values with the presence of γ-42 gliadin. Table 43 gives the differences for some quality traits in relation to γ-45 and γ-42 gliadins. Further, 69% of the Mediterranean durum landraces have only γ-45 gliadin and 11% possess only the γ-42 gliadin; 20% had both gliadins present.

Table 43. Relationship of γ-gliadins with some grain quality traits in Mediterranean durum germplasm (n=136).

Traits	γ-45 gliadin (n=117)	γ-42 gliadin (n=19)	Difference
Protein (%)	12.5	12.1	0.4
Vitreousness	94.4	95.3	-1.1
Carotene score	5.5	5.2	0.3
1000-kernel weight	47.0	47.0	0.0
Sedimentation test (SDS)	25.7	18.5	7.2***
SDS index	2.4	1.8	0.6*

*, ***: significant at the probability levels of 5 and .01%, respectively.

3.1.8. Segregation of γ-45 and γ-42 in Two Crosses

F2 segregation in the Jennah Khetifa/Cham1 cross was different from the expected segregation ratio 1:2:1 with slight dominance for γ-45 gliadin; whereas in the HedbaIII/Chaml cross fitted the expected segregation ratio 1:2:1. The γ-42 and γ-45 gliadins were unlinked (Cm>50.0).

Under irrigated conditions high broad sense heritability values were recorded for kernel size, test weight, carotene content, sedimentation test, and sedimentation index; medium values for protein content, and vitreousness; and low values for farinograph stability and farinograph mixing tolerance. Whereas under dryland conditions high heritabilities were found for most studied grain quality traits (Table 44).

Table 44. Broad sense heritabilities for durum grain quality traits.

Trait	Heritability under irrigated and dry conditions	
	Irrigated	dry
Protein content	0.49	0.72
Kernel size	0.97	0.94
Test weight	0.97	0.94
Vitreousness	0.59	0.79
Carotene content	0.97	0.90
Sedimentation test (SDS)	0.93	0.94
SDS index	0.93	0.96
Farinograph stability	0.00	0.90
Farinograph mixing tolerance	0.20	0.93

underlined values>.70

3.1.9. Effects of GE Interactions on Grain Quality Traits in Dry and Irrigated Conditions

Under dry conditions most quality traits were more influenced by genotype than by environment or GE interactions. The exceptions were protein content and vitreousness. Farinograph stability and farinograph mixing tolerance were more influenced by GE interactions than by genotype or environment (Table 45).
- M.M. Nachit, A. Impiglia, A. El-Saleh, A. Asbati, M. Azrak, M. Jarrah

Table 45. Effects of genotypes (G), environments (E), and GE interactions on durum grain quality traits under Mediterranean continental conditions.

Trait	G		E		GE	
	SS	%	SS	%	SS	%
Protein content	40.1	5.1	666.3	84.1	79.1	10
Vitreousness	11269.0	11.4	69425.5	70.0	16779.6	16.9
Carotene content	68.7	41.0	44.9	26.8	46.7	27.9
SDS test	9989.8	58.6	4564.3	27.1	2006.2	11.9
SDS index	27.9	51.3	15.4	28.3	7.2	13.2
Kernel size	1965.8	49.6	1102.1	27.8	808.9	20.4
Test weight	491.5	52.8	129.7	14.0	218.2	23.5
Farinograph stability	62.9	32.9	44.4	23.2	81.5	42.6
Farinograph mixing stability	68901.0	24.6	36094.5	12.9	167676.0	59.9

underlined values>40.0%

3.1.10. Seed Storage Protein

The electrophoretic analysis of seed storage proteins and sedimentation have been studied in Australian Poulard (a landrace originated from Egypt). This cultivar has the rare recombination of ω-33-35-38/γ-45 gliadin and low molecular weight 1 (LMW1). Table 46 compares Australian Poulard with Korifla (ω-35/γ-45 gliadin and LMW2) and Waha (ω-33-35-38/γ-42 gliadin and LMW1). Extensive grain quality testing showed that this cultivar (Australian Poulard) has weak gluten strength (SDS). These results confirm the postive functional properties

Table 46. Different recombinations of associations between Glu-B3 and Gli-B1 loci in different varieties.

Glu-B3	Gli-B1			
LMW	ω-Gli	γ-Gli	SDS test	
1	33-35-38	42	23.7	(Waha)
2	35	45	38.2	(Korifla)
1	33-35-38	45	19.6	(Aus. Poul)

of LMW2 with gluten strength that is known to be related to good pasta making. - **A. Impiglia, M.M. Nachit, A. El-Saleh, A.M. Gallo, D. Lafiandra, E. Porceddu (Univ. of Tuscia, Italy), L.M. Martin (Univ. of Cordoba, Spain)**

3.1.11. Biotic Stresses

3.1.11.1. Disease Resistance

Several crosses were made for *Septoria tritici*, common bunt, leaf rust, stem rusts, and BYDV resistance. All crosses had at least one parent resistant to yellow rust. Crosses with *Triticum dicoccoides* were used to widen the genetic base for resistance to *Septoria tritici* and yellow rust. At Terbol (Lebanon) several segregating populations showed resistance to leaf and stem rust.

3.1.11.1.1. Screening for Root Rot Resistance

Root rot is caused by a complex of pathogens. In Morocco root rot is mainly caused by the fungi *Cochliobolus sativus and Fusarium culmorum* (Baye, 1984; Lyamani, 1988). In 1992/93 season, 1130 accessions representing Moroccan, Iberian, and Ethiopian material were screened for both fungi using seed inoculation with a spore suspension of *Cochliobolus sativus* and *Fusarium culmorum*. Data were collected on plant emergence, tiller number, kernel weight, and white head percentage. From the 1130 accessions tested, 140 accessions showed acceptable performance, 8 of which had high tolerance levels. Most of these originated from Morocco or Portugal. - **M. Mergoum, N. Nasrallah, M.M. Nachit**

3.1.11.1.2. Advanced Screening for Multiple Disease Resistance

To identify advanced high yielding genotypes carrying multiple diseases resistance, 280 genotypes were screened for resistance. Resistance was identified to common bunt (*Tilletia foetida* and *T.caries*), septoria (*Mycosphaerella graminicola*), yellow rust (*Puccinia striiformis*), leaf rust (*Puccinia recondita*), and stem rust (*Puccinia graminis*), powdery mildew, and BYDV. - **M.M. Nachit, O.Mamluk, M. Azrak, A. Asbati, M. Jarrah**

3.1.11.2. Insect Resistance

3.1.11.2.1. Wheat Stem Sawfly

Further crosses were made for resistance to wheat stem sawfly. All segregating populations were subjected to natural attack by stem sawfly at Breda and Tel Hadya. In addition, crosses with solid stem Moroccan landraces were backcrossed to high yielding genotypes. Most of advanced populations and newly developed genotypes have improved levels of resistance.

3.1.11.2.2. Hessian Fly

A total of 4140 populations were tested in the field at Sidi El Aidi (mild attack) and Jema Shaim (heavy attack) in Morocco. In Jema Shaim, only two populations survived Hessian fly attack. The screening in the field at Sidi El Aidi was followed by the greenhouse screening of preselected populations.

Also 89 F2 and 140 F3 segregating populations carrying the H5 gene resistance to Hessian fly and several backrosses with Moroccan durum cultivars were screened in the greenhouse. Resistant lines are being multiplied. These populations are the first durum plants to carry genetic resistance to Hessian fly.

Further, to search for new genes for Hessian fly resistance in wild relatives more than 140 Moroccan and Portuguese *Aegilops* were screened. Several *Aegilops* populations showed resistance. The resistant plants were crossed with durum cultivars, and embryo rescue was used. - **M.M. Nachit, R. Miller, M. Baum, M. van Slageren, A Asbati, N. Nasrallah (INRA/Morocco) , O. Belhabib (INAVHII/Morocco)**

3.1.12. Abiotic Stress Resistance

Several landraces from the Mediterranean Islands and Spain were screened for performance under rainfed conditions at Tel Hadya. Ninety-eight populations were selected for further screening and utilization in the crossing program.

Fifty durum wheat landraces from Egypt were screened using a sand-culture technique in green house for salinity tolerance. Four populations showed some tolerance. Material from University of California, Davis, that showed high level of salt tolerance, was crossed to advanced material, the most successful crosses were with the cultivar Lahn. A RSP for salt tolerance will be developed, and germplasm that shows resistance or acceptable tolerance such as the selected populations from India, Iraq, and Egypt will be used with the Davis material. - **M.M. Nachit, A. Impiglia, A. Asbati, Z. Younis**

3.1.12.1. Drought Resistance

Grain yields ranged from 1233 to 3166 kg/ha when tested under dry conditions. Several lines outyielded the checks Haurani, Cham3, and Omrabi5. Table 47 shows the yields achieved in the dry site, Breda, over the last 7 seasons. The average yield was high in 1992/93.

Table 47. Grain yield (kg/ha) of advanced durum yield trials (ADYT) at Breda for last 7 years.

		Grain yield (kg/ha)		
Season	Rainfall (mm)	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
Mean	246	1489	2197	1341

The yields of the best lines in dry conditions at Breda are in Table 48. The best line was Omrabi-3, which will be released soon in Syria. It was extensively tested in the on farm trials and the large scale testing in Syria and Tunisia.

Table 48. Grain yield of drought tolerant promising lines under dryland conditions, 1992/93.

			% of	
No.	Cross/entry	Grain yield	Haurani	Cham3
823	Omrabi-3	3167	133	127
808	Genil-5	3067	123	123
704	Awl-1/Sbl-4	3019	127	121
	Haurani	2385	100	-
	Cham 3	2490	-	100
	LSD(0.05)	410		

The morpho-physiological traits strongst associated with grain yield in this year under dry conditions were heading date ($r = 0.42 > p = 0.01$), fertile tillering ($r = 0.32 > p = 0.01$), and spike fertility ($r = 0.36 > p = 0.01$). - **M.M. Nachit, A. Asbati, M. Azrak**

3.1.12.2. Resistance to Terminal Stresses

The late and summer planting are used to identify material resistant to terminal stress (drought x heat). Table 49 shows the best lines under terminal stress. Wadamez crosses and Mediterranean Islands germplasm continue to be the best germplasm for these conditions.

Table 49. Grain yield of promising lines under terminal stress conditions in comparison with checks in 1992

No.	Cross/entry	Grain yield
123	WadalmezA	1764
310	Qna/Kyp//Aus1	1733
309	WadamezB	1559
308	Heider//Mt/Ho	1549
	Awl2/Bit	1547
	Cham1	768
	Cham3	583
	LSD(0.05)	358

Table 49 shows the highest yielding lines compared to checks for heat tolerance. The mean grain yield was 863 kg/ha and ranged from 192 to 1764 kg/ha. Selections under summer and late planting conditions at Tel Hadya and summer conditions of Terbol include germplasm with leaf and stem rust resistance and high levels of heat and terminal stress (drought x heat) resistance.

3.1.13. Yield Stability

The most stable genotypes in the RDYT-MR, 1991/92 were Omrabi lines (Table 50). These lines are also the most abiotic stress tolerant ones. Stress tolerance and yield stability are closely linked. - **M. Nachit, M. Jarrah, M. Azrak, A. Asbati, Z.Younes**

Table 50. Grain yield and stability of durum wheat lines in the Mediterranean areas with favorable climatic conditions, RDYT-MR, 1991/92.

No.	Entry	Mean yield (kg/ha)	Mean sites' rank	Rank standard deviation
5	Sabil1	4736	5.7	4.7
3	Omrabi3	4726	5.9	5.1
2	Omrabi5	4686	6.2	4.2
9	Stojocri3	4660	6.3	5.6
12	Cham1	4605	11.3	5.1

3.1.14. Performance under Mediterranean Environments

Morpho-physiological traits that are associated with adaptation to dryland conditions and related with grain yields in the four main Mediterranean agro-ecological zones were studied (dry-cold; dry-temperate; favorable rainfall and cold; favorable rainfall and temperate). In each zone several morpho-physiological traits were measured. In the dry-cold environment, the main contributors to grain yield were spike fertility (36.6%), earliness (5.3%) and fertile tillering ability (2.8%). In the dry-temperate environment, the main contributors to yield were early heading (68.7%) and grain filling duration (2.5%). As for the favorable rainfall and cold conditions, fertile tillering ability (71.4%) and dwarfness (3.2%) were the main contributors; and for the moderate rainfall and cold conditions, spike fertility (59.3%), peduncle length (9.3%), early vigor(5.2%), and grain filling duration (2.0%) were important. - **M.M. Nachit, M. Azrak, M. Jarrah**

3.1.14.1. Mediterranean Dryland Environment

Durum lines developed under Mediterranean dryland conditions at ICARDA/Syria (97 lines) and at CIMMYT/Mexico (131 lines) with 5 checks were assembled in a joint nursery (DON-LR 1991/92) and sent to NARSs of WANA region for testing in their research stations. This nursery is targeted to dryland areas, however, some NARSs programs are also testing it under irrigated conditions. The objective of this nursery is to provide material from both the CIMMYT base and CIMMYT/ICARDA programs to NARS. It also allows some initial assessment of the relative adaptation of the two sets of material for WANA conditions

(Table 51). Yield data were sent back from the following research stations:

Rainfed: Athalassa/Cyprus (321mm), Tel Amara/Lebanon (1090mm), Izra54/Syria (480mm), Izra64/Syria (443mm), Himo/Syria (478mm), Hassakeh/Syria (282mm), Beja/Tunisia (512mm), Le Kef/Tunisia (488mm).

Irrigated: Sids/Egypt, Mattana/Egypt, Mallawy/Egypt, Ismailia/Egypt.

The results show that using 11 rainfed stations (282-1090mm) and 4 irrigated stations that the average yield per site for the best performing 25 durum genotypes out of 260 was 39.8% higher for CIMMYT/ICARDA germplasm than the germplasm developed at CIMMYT base program (Table 52). Although the durum lines included in the DON-LR were targeted to low rainfed areas, they were tested in irrigated stations in Egypt and under high rainfall conditions up to 1090 mm. The germplasm originated from CIMMYT base program was better yielding in Egypt by 28.6% than that from CIMMYT/ICARDA program. Taking the average for both environments the germplasm originated from the CIMMYT/ICARDA was 15.1% better yielding than that from CIMMYT base program. The performance of the CIMMYT/ICARDA germplasm was much better in the environments with low rainfall.

Table 51. Comparison of the best 25 durum lines at each site in WANA region for durum germplasm developed at CIMMYT/ICARDA and CIMMYT base programs, 1991/92.

Site/country	Site's average yield (t/ha)	% of best 25 lines coming from	
		ICARDA/CIMMYT	CIMMYT
Hassakeh/SYRIA	1.312	16.7	3.6
Tel Amara/LEBANON	1.776	13.3	6.4
Himo/SYRIA	2.575	14.2	5.6
Athalassa/CYPRUS	2.594	8.3	10.7
Izra'a A/SYRIA	3.816	8.3	10.7
Ismailia/EGYPT	4.062	7.5	11.4
Le Kef/TUNISIA	4.252	11.4	7.9
Izra'a B/SYRIA	5.009	10.0	9.3
Beja/TUNISIA	5.950	8.3	10.7
Sids/EGYPT	6.031	7.5	11.4
Kena/EGYPT	6.483	10.0	9.3
Mallawy/EGYPT	7.006	8.3	10.7

Table 52. Comparison of best 25 durum lines at each site in WANA region for durum germplasm developed at joint (CIMMYT/ICARDA) and base (CIMMYT) programs, 1991/92.

Moisture regime	% of best 25 lines		(Joint/Base)x100
	Joint	Base	
Rainfed	11.3	8.1	139.8
Irrigated	8.3	10.7	77.7
Total	10.3	8.9	115.1

A regression line was estimated between the % of the best lines from each program at each site and the site's grain average yield, to study the response of each material in relationship to site's productivity. The regression equation for joint program lines from DON-IR was: Y=-1.09X+14.9; and for CIMMYT-base program was: Y=0.92X+5.06; where Y represents the number of lines selected at each site, X represents the average grain yield of the site in tons/ha. From these computed regression equations the % performance of each program germplasm was calculated for environments different in yielding potential. These results clearly demonstrate the advantage of the joint breeding program germplasm over the CIMMYT-base germplasm in environments having a yield potential of less than 5 tons/ha. However, the material included in this nursery was intended for the dry areas with an average yields of 1.5 ton/ha. The material designed for moderate to high rainfall and irrigated areas will be discussed later.

Table 53. Estimated performance of joint and base durum germplasm under different yielding environments

Yield environment	(%)of best lines (%) coming from		Ratio
	CIMMYT/ICARDA	CIMMYT	
1 ton	13.81	5.98	2.30
2 " "	12.72	6.90	1.84
3 " "	11.63	7.82	1.49
4 " "	10.50	8.74	1.20
5 " "	9.45	8.74	1.08
6 " "	8.36	10.58	.79
7 " "	7.27	11.50	.63

During the growing season, visual selections were made at several research stations of WANA (Izra/Syria, Beja/Tunisia, Le Kef/Tunisia, Zidane/Algeria, Merchouch/Morocco). The results of this selection showed that 31% of the test lines of CIMMYT/ICARDA durum germplasm were selected, whereas from the CIMMYT/Mexico durum germplasm only 10%. These results clearly demonstrate the advantage of the germplasm originating from the dryland project at ICARDA and the sound decision taken by the two centers (CIMMYT and ICARDA) to establish a decade ago a joint breeding program for Mediterranean dry areas at ICARDA, where 80% of the total durum wheat area in the developing world is found.

3.1.14.2. Mediterranean Favorable Environment

Durum lines developed under Mediterranean favorable conditions at ICARDA/Syria (101 lines) and under irrigated conditions at CIMMYT/Mexico (103 lines) with 5 checks were assembled in a joint nursery (DON-MR 1991/92) and sent to NARSs of WANA region for testing in their research stations. This nursery is targeted to favorable rainfall areas; however, some NARSs programs also tested it in dry areas. The objective of the testing of this nursery was to study the performance of advanced lines from both programs (CIMMYT/ICARDA in Syria and CIMMYT in Mexico) in WANA, in order to find which program is producing the most adapted germplasm to the favorable areas of WANA region. Yield data were sent back from 16 research stations. Rainfed location (with seasonal rainfall in parenthesis) were Dromolaxia/Cyprus (574mm), Karaj/Iran (300mm+30mm), Gachsaran/Iran (779mm), Tel Amara/Lebanon (1090mm), EL Ghab/Syria (870mm), Jelleen/Syria (553mm), Akcakale/Turkey (240+350mm), Tajoura/Libya (280mm), Benghazi/Libya (208+384mm), Beja/Tunisia (512mm), Le Kef/Tunisia (488mm). The irrigated locations were Sids, Mattana, Mallawy, Ismailia, Elkharga, all in Egypt.

In the favorable and irrigated areas, the DON-MR main average yield per site for the best performing 25 durum lines (out of 204) was 63.7% higher for the durum lines originated from the joint breeding program at ICARDA than for lines from CIMMYT-base program in Mexico (Table 55). Further, the lines originated from the joint CIMMYT/ICARDA breeding program outperformed in both favorable (195%) and irrigated (137.8%) conditions the lines from CIMMYT base. The yield performance of the germplasm originating from CIMMYT/ICARDA was particularly higher in the environments with favorable rainfed conditions than in the irrigated ones (Table 54).

Table 54. Comparison of best 25 durum lines at each site in WANA region for durum germplasm developed at joint CIMMYT/ICARDA and CIMMYT base, 1991/92.

Site/country	Site's average yield (t/Ha)	% of best 25 lines coming form	
		CIMMYT/ICARDA	CIMMYT
Cyprus03	3.483	14.8	9.7
Iran02	3.228	21.8	2.9
Iran17	3.377	15.8	8.7
Lebanon02	1.643	15.8	8.7
Syria53	5.526	13.9	10.7
Syria61	5.589	20.8	3.9
Turkey15	2.775	16.8	7.8
Egypt04	6.165	13.9	10.7
Egypt07	7.420	15.8	8.7
Egypt09	9.073	9.9	14.6
Egypt14	1.603	10.9	13.6
Egypt17	5.111	18.8	5.8
Libya01	1.421	17.8	6.8
Libya16	4.748	9.9	14.6
Tunisia01	6.317	10.9	14.6
Tunisia02	3.549	16.8	7.8

Table 55. Comparison of best 25 durum lines at each site in WANA region for durum germplasm developed at the joint and base durum breeding programs at CIMMYT/ICARDA and CIMMYT base, 1991/92.

Moisture regime	% of best 25 lines coming from		Ratio
	CIMMYT/ICARDA	CIMMYT	
Favorable	16.3	8.4	1.95
Irrigated	14.2	10.3	1.37
Total	15.3	9.3	1.63

3.2. Physiology/Agronomy

3.2.1. Genotype x Environment Interactions

The genotype x environment interactions of 81 durum wheat genotypes grown for four years at two locations in northern Syria(Tel Hadya, rainfed and irrigated and Breda, rainfed only) were analyzed. The genotypes, assembled in 1988, were collected from various parts of north Africa, southern Europe and west Asia, and included landraces, and improved and advanced genotypes.

Mean grain yields across the environments ranged from 43 to 598 g m^{-2} and among genotypes from 124 to 229 g m^{-2}. The genetic variance for grain yield was higher in the moderately and non-stressed environments than in the severely stressed environments. Mean grain yield of genotypes was poorly correlated with performance in moderate to severe stress environments affected by cold temperatures but was better correlated in water deficit environments. Days to heading was delayed by low temperatures during early crop growth which also reduced the genetic variance but mean heading date was well correlated with heading dates in other environments. Heritability for days to heading was higher than grain yield. Genotype X environment interactions were significant for both grain yield and days to heading. Clustering of genotypes to the point where within cluster variance was not significant, resulted in 30 clusters. Genotypes clustered together either based on their area of adaptation or their area of origin. Improved cultivars developed for high input situations clustered together in a group which was responsive but was not necessarily adapted to low yielding environments. Some of the landraces from cold regions were high yielding and adapted to the low yielding environments but were not very responsive to improving environments. **- A. Dakheel, V. Mahalakshmi, I. Naji, M. Nachit, J.M. Peacock**

3.2.2. Agronomy

See pages 37-40.

3.3. Pathology

Results cover the work on sources of resistance, the Durum Wheat Key Location-Disease Nursery, crop losses due to yellow rust, and studies of the host-pathogen system.

3.3.1. Germplasm Pools for Sources of Resistance to Diseases

Between 1988 - 1993, several germplasm pools with resistance to yellow rust, common bunt, septoria tritici blotch and stem rust have been developed (Table 56). These pools represent the endproduct of our screening work. The performance of lines in these pools against the respective disease, together with other disease data are available from the Cereal Program. Seed of these pools are preserved in the Genetic Resources Unit of the Center for further use and future studies. - **O.F. Mamluk, M. Naimi**

Table 56. No of lines in the germplasm pools for sources of resistance to durum wheat diseases and the number of sets distributed (1988-1993).

Germplasm pool for	No resistant lines	No sets distributed
Yellow rust	48	59
Common bunt	35	58
septoria blotch	19	29
Stem rust	17	29

3.3.2. Sources of Resistance to Common Bunt in Durum Wheat

The screening of advanced durum wheat germplasm for resistance to common bunt resulted in the identification of 26 resistant genotypes. The screening used 9 different common bunt isolates from WANA. The correlation, principle components and cluster analyses, grouped the isolates into 3 clusters representing different ecological areas and the wheat varieties from which the isolates originated. Wheat genotypes formed 3 clusters. Resistance appears to come from three major sources, the J. Khetifa source, the S. Cappelli/Haurani source, and the Mindum source. Cultivar S. Cappelli maintained its resistance to common bunt for 7 years and is therefore assumed to be of durable type. These sources of resistance are used in our breeding program to improve bunt resistance in durum wheat germplasm. - **O.F. Mamluk, M.M. Nachit**

3.3.3. Key Location Disease Nursery

Useful disease information on the Durum Wheat Key Location Disease Nursery 1991/92 (DKL-92) were received from Tel Hadya and Lattakia in Syria and from Terbol in Lebanon. Results are presented in Fig. 13. Out of the 234 lines in the DKL 92 nursery 44 (14%) were resistant to stem rust, 29 (12%) to barley yellow dwarf virus[1], 16 (7%) to common bunt, 15 (6%) to septoria tritici blotch and 10 (4%) to leaf rust. Five lines (Nos. 8, 65, 69, 75 and 254) were resistance to both leaf rust and stem rust. - **O.F. Mamluk, A. Yaljarouka**

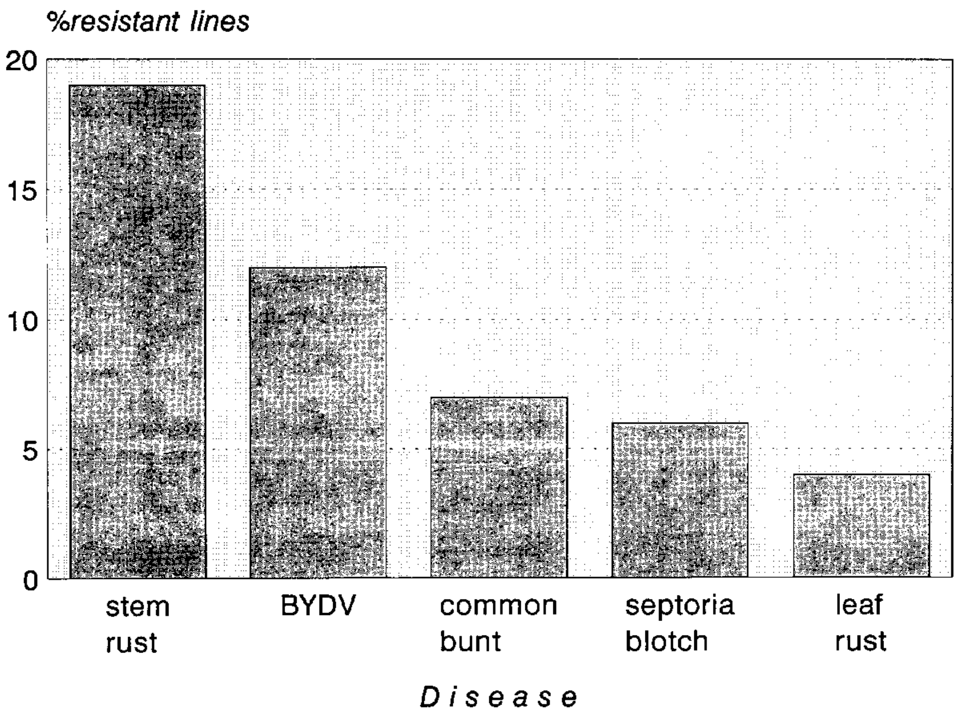

Fig. 13. Percent resistant lines in the Durum Wheat Key Location Nursery (DKL-92) to the different diseases; selection criteria: stem rust and leaf rust = 5 ACI; BYDV and septoria tritici = score 5 on 0-9 scale; common bunt = 15%head infection.

3.3.4. Crop Losses due to Yellow Rust

This season's crop loss assessment trials on yellow rust at Tel Hadya included 16 cultivars, 8 each of durum and bread wheat. These are cultivars being grown in farmers field verification trials in Syria. Protection was provided by triadimenol (Bayfidan EC 250) applied twice and zineb (Zinat 70% WP), applied five times; there was also a control treatment. The

[1]Data from Virology Lab./ICARDA

infection level is a score (severity and reaction type) and as average coefficient of infection (ACI). ACI was analyzed using log transformation. Significant differences were found for the treatment, and cultivar effects, and for their interaction (P = <0.01). Cultivar performance was assessed for a number of traits using common experimental error from the 16 cultivars. However, data for durum wheat (Table 57) and for bread wheat (Table 70)are presented separately.

For durum wheat, both fungicides reduced disease score in cultivars Haurani, Cham 3, Geruma, and Douma 15149 (Table 57). There was a slight increase in disease score with fungicide I on Douma 11337. However, there was no significant differences among the treatments. Yieldwise, there was yield increase due to fungicide treatments ranging from 1.1 - 24.1%, but again no significant differences were found. Negative effect of the fungicide, reflected in yield decrease ranging from -2.2 to -12.8%, was observed in several cultivars. Differences in yield decrease were not significant. **- O.F. Mamluk, M. Singh, M. Naimi, S. Khawatmi, A. Yaljarouka**

3.3.5. Studies of the Host-Pathogen System

Pathogenicity of septoria tritici blotch (caused by *Mycosphaerella graminicola*) on *Aegilops* was assessed. In 1992/93, 391 accessions from 21 *Aegilops* species were tested as seedlings in the greenhouse, using septoria inoculum from bread wheat and durum wheat in the ratio of 1:1 (Table 58). Seven species (*bicornis*, *logissima*, *neglecta*, *searsii*, *sharonensis*, *speltoides*, and *ventricosa*) did not show any typical disease symptoms. The highest percentage (ranging from 50 - 100%) infected accessions were in the species *juveniles*, *umbellulata*, *caudata*, *crassa*, *vavilovii*, and *ovata*. **- O.F. Mamluk, M. van Slageren (GRU), M. Naimi, S. Khawatmi**

Table 57. Effect of yellow rust (*Puccinia striiformis*) on yield components of durum wheat cultivars; Tel Hadya, Syria 1993.

Cultivar	Treatment	Yellow rust Score	/	ACI	Yield t/ha	%Yield increase	No.tillers per m	No.seed per spike	1000KW (gr.)
Haurani 27	Infected	6.7	MS	5.3	3.34		84	22	38.4
	Fungicide I	1.0	MR-MS	0.6	3.66	9.7	80	27	37.4
	Fungicide II	1.0	M-MS	0.7	3.14	-5.9	73	26	39.8
Cham 3	Infected	1.0	R-M	0.4	3.98		66	32	42.5
	Fungicide I	1.0	R	0.2	3.27	-17.9	86	27	41.9
	Fungicide II	1.0	R	0.2	3.73	-6.3	71	31	40.2
Om Ruf 2	Infected	3.7	R	0.7	3.83		67	34	39.8
	Fungicide I	1.0	R	0.2	4.52	17.8	70	38	40.4
	Fungicide II	3.7	R	0.7	3.68	-4.0	63	35	41.1
Geruma 1	Infected	2.3	R	0.5	3.78		84	29	40.0
	Fungicide I	1.0	R	0.2	3.91	3.4	56	32	45.1
	Fungicide II	1.0	R	0.2	3.48	-8.1	70	30	42.9
Douma 11337	Infected	1.0	R	0.2	4.05		72	37	38.1
	Fungicide I	2.3	R	0.5	4.35	7.3	72	39	36.7
	Fungicide II	1.0	R-MR	0.3	3.86	-4.7	66	39	38.4
Douma 15879	Infected	1.0	R-MR	0.3	3.36		66	28	45.4
	Fungicide I	1.0	R	0.2	4.17	24.1	81	27	45.4
	Fungicide II	2.3	R	0.5	3.40	1.1	73	29	46.1
Douma 15149	Infected	2.3	R	0.5	4.23		91	32	42.1
	Fungicide I	1.0	R	0.2	4.13	-2.2	77	32	46.4
	Fungicide II	1.0	R	0.2	3.69	-12.8	69	30	43.7
Bohouth 5	Infected	1.0	R-MS	0.5	3.63		69	30	45.0
	Fungicide I	1.0	R	0.2	4.40	21.2	70	36	46.4
	Fungicide II	1.0	R-M	0.3	4.23	16.4	69	30	50.0
	SE 1				0.25		6.9	1.57	1.44
	SE 2				0.22		6.1	1.51	1.14
	CV%				9.8		14	8.2	5.1

Figures = mean of 3 rep. each 7.2 m^2, harvested 3.6 m^2, from single splitplot design (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 five times. SE 1 to compare treatment at same or different levels of cultivars; SE 2 to compare cultivar at same levels of treatment.

Table 58. ***Aegilops spp.*** **tested in seedling stage for resistance to septoria tritici blotch; season 1992/93.**

Aegilops spp.	No. accessions tested	infected*
1. *Ae. bicornis*	1	0
2. *Ae. longissima*	4	0
3. *Ae. neglecta*	4	0
4. *Ae. searsii*	3	0
5. *Ae. sharonensis*	1	0
6. *Ae. speltoides*	4	0
7. *Ae. ventricosa*	19	0
8. *Ae. biuncialis*	22	1
9. *Ae. caudata*	6	3
10. *Ae. columnaris*	6	2
11. *Ae. comosa*	12	1
12. *Ae. crassa*	15	7
13. *Ae. cylindrica*	72	11
14. *Ae. juvenales*	5	5
15. *Ae. kotschyi*	14	4
16. *Ae. ovata*	27	12
17. *Ae. peregina*	51	10
18. *Ae. tauschii*	58	3
19. *Ae. triuncialis*	45	2
20. *Ae. umbellulata*	4	2
21. *Ae. vavilovii*	18	8

* With typical disease symptoms and pycnidial formation.

3.4. International Nurseries

3.4.1. Screening for Boron Toxicity Tolerance

A total of 246 advanced CIMMYT/ICARDA durum lines from the 1992-93 regional observation nurseries were tested (for details see Section 2.6.1.1.). There was only a small variation (mean score of 2.0 to 3.5) in symptom development among the lines. Lines with low B toxicity symptoms and tissue concentration are presented in Table 59. It is interesting that the best durum lines had symptom score as low as the tolerant bread wheat check (Halberd) but none of the durum lines had lower or comparable B concentrations as Halberd. Durum may be more tolerant than bread wheat, or at least Halberd, to higher B concentration in plant tissue. The cross Awl 2/Bit appears 3 times on Table 59, indicating that it contains gene(s) for tolerance. - **S.K.Yau, J. Hamblin, M. Nachit**

Table 59. Durum lines with least B toxicity symptom and tissue B concentration 5 weeks after sowing in soil added with 50 mg B/kg soil.

Nursery	Ent. no.	B conc. (ppm)	Name/cross
DON-SA	72	613	T.A73-74/D.Coll-01.1Y/3/Pg/Chap//21563/4/Crosby
	287	610	Deraa2/Bicre
DON-FA	66	580	Ru/Mrb15
	69	595	Awl 2/Bit
	120	618	Awl 2/Bit
	145	576	Awl 2/Bit
	167	633	Zud2/Kbr3
	168	599	Bicre/Kbr3
	200	625	Awl 1//Memo/Goo
Checks:			
Tolerant		477	Halberd (bread wheat from Australia)
Sensitive			
		734	Schomburgk (Australian bread wheat)
DON-SA	49	937	Khb1/4/Rabi/3/Gs/AA//Plc

3.4.2. Nursery Distribution in 1993

Regional durum wheat nurseries assembled by the joint CIMMYT/ICARDA durum wheat project at ICARDA are given in Table 60. There were 13 different nurseries/germplasm pools with a total of 423 sets being distributed. The agreement between CIMMYT and ICARDA on spring wheat nursery preparation and distribution was implemented starting the 1991-92 season. Under this agreement the names of the yield trials were changed this year from 'Low Rainfall' to 'Semi-arid' and from 'Moderate Rainfall' to 'Favorable' in order to reflect better the target areas of the nurseries. These two trials included the best lines from previous years' joint observation nurseries, which consist of materials supplied from the CIMMYT base program in Mexico (with seed multiplied at Tel Hadya, Syria). Both observation nurseries and yield trials were restricted to the WANA region. The three germplasm pools for sources of resistance to yellow rust, stem rust and common bunt were made available by the wheat pathologist for the second year. - **S.K. Yau, M. Nachit**

Table 60. Durum wheat international nurseries for 1993-94.

Nursery	Abbre-viation	No. of entries	No. of sets distributed
Mediterranean Coastal and Continental Areas:			
Regular Nurseries			
Segregating Populations	DSP	84	34
Observation Nurseries:			
- Semi-arid Areas	DON-SA	240	28
- Favorable Areas	DON-FA	408	27
Yield Trials:			
- Semi-arid Areas	DYT-SA	24	40
- Favorable Areas	DYT-FA	24	41
Specific-trait Nurseries			
Drought & Heat Tolerance Obs. Nur.	DHTON	48	39
Drought & Cold Tolerance Obs. Nur.	DCTON	48	26
Special Nursery			
Segregating Populations - Crosses with Wild Relatives	DSP-WR	63	27
Germplasm Pools for Sources of Disease Resistance			
Yellow Rust	DYRGP	22	28
Stem Rust	DSRGP	17	26
Common Bunt	DCBGP	16	24
Mediterranean Highland Areas:			
Regular Nurseries			
Observation Nursery	DON-HAA[1]	134	25
Yield Trial	DYT-HAA	24	18
Total			423

[1] HAA - High Altitude Areas

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4. SPRING BREAD WHEAT IMPROVEMENT

4.1. Spring Bread Wheat Breeding

4.1.1. Introduction

During 1993, the CIMMYT/ICARDA spring bread wheat breeding project continued to emphasize the development of improved, adapted germplasm for the variable and unpredictable environments of West Asia and North Africa, with special attention to rainfed and low-rainfall areas (less than 400 mm annual rainfall).

The list of research priorities by agroecological zone and the relative importance of the stresses for each area were reported in the 1990 annual report of ICARDA. A detailed description of these two zones was also reported in ICARDA's 1988 annual report. This included geographical area, production, and the main stresses responsible for reduced yields. Since then, the low rainfall environments of the region have received highest priority.

Research this year focussed on breeding and identifying parental material possessing high grain yield and stability, with tolerance to abiotic stresses such as terminal drought, cold and terminal heat, and on biotic stresses such as yellow rust, Septoria, common bunt, sawflies, Hessian fly, suni bugs and aphids.

Attention was given to developing and verifying breeding methodologies. The single seed descent (SSD) and modified bulk methods of selection were used to complement breeding efforts for specific qualitative traits such as resistance to yellow rust, and Hessian fly, and to enhance adaptation. Multilocation testing continued and emphasis was placed on the selective exploitation and use of exotic material including landraces.

In close collaboration with the physiologists and agronomists, special efforts were made to characterize bread wheat cultivars from key national programs in the region for their photoperiod and vernalization response. Cooperation also continued with biotechnologists; more than 400 double haploids were produced for Hessian fly resistance.

For this year's annual report, we present data on the progress made in distributing genetic stocks and targeted segregating crosses to NARS in WANA to evaluate the enhancing of adaptation of our germplasm. We report the progress made in jointly identifying germplasm with national programs in the region. Data showing the rate of adoption and the impact of CIMMYT/ICARDA's bread wheat cultivars in the rainfed areas of the region is also presented. - **G. Ortiz Ferrara**

4.1.2. Identification and Distribution of Genetic Stocks

Our breeding strategy is to develop and identify genetic material with tolerance to the abiotic and biotic stresses of the region (Ortiz Ferrara and Deghais 1988; Ortiz Ferrara et. al. 1989). The project has identified genetic material with tolerance to the above mentioned stresses. This material is made available to national programs in the region for further use in their own breeding programs.

Table 61 presents the number of bread wheat lines that have been selected and distributed to national programs in WANA during the last seven years (1987-93). This material is

Table 61. Number of bread wheat lines with desirable genetic traits distributed to national programs as genetic stocks during the last seven years, 1987 to 1993.

Genetic traits	Average No. per year	Total over six years
High yield and stability	37	259
Abiotic stress resistance		
Terminal drought	24	168
Cold	12	84
Terminal heat	14	98
Biotic stress resistance		
Yellow rust	15	105
Leaf rust	10	70
Stem rust	5	35
Septoria leaf blotch	12	84
Common bunt	10	70
Wheat stem sawfly	15	105
Hessian fly	3	21
Selected landraces	7	49
Bread making quality	9	63
Total		1211

distributed in the form of crossing blocks to decentralize our breeding activities and encouraging national programs to take more responsibility for generating new sources of genetic variability.

In addition to these gene pools and other improved, semi-finished germplasm, the bread wheat project has also distributed early segregating populations (F2's and F3's) to NARS in WANA. This operation started in 1979 with the objectives of a) providing increased genetic variability and b) allowing national programs to select breeding material under their local conditions. Table 62 lists the number of F2 and F3 segregating populations that have been distributed to NARS in WANA, and the number of locations where these crosses have been tested during the last 11 years (1983-93).

Table 62. Early segregating populations distributed to national programs in WANA during 1983 to 1993.

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
Total	1410	4710	6120	333	58

More than 6000 segregating populations have been distributed to 391 location-years within the region. The experience 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 CIMMYT (Byerlee and Moya 1993). Research infrastructure, budget availability, and overall strength of NARS are the main factors accounting for these differences. - **G. Ortiz Ferrara, M.A. Mousa, M.G. Mosaad, S.K. Yau**

4.1.3. Breeding for Abiotic Stress Resistance

Terminal drought, cold, and terminal heat are the main abiotic stresses responsible for reduced yields in the rainfed, Mediterranean environments of the region. In selecting and identifying germplasm with tolerance to these stresses, the project emphasizes the use of multilocation testing. This is done at two different levels: (1) international multilocation testing, in which data from 50 to 75 locations in the region is obtained through the CIMMYT/ICARDA International Nurseries System, and (2) regional multilocation testing, consisting of five different environments in Syria and Lebanon. In the latter, segregating populations and advanced lines are tested and selected under different moisture and temperature conditions. Table 63 shows the number and percentage of bread wheat lines that have been identified as higher yielding than the local and improved checks in four different environments during the last two years in Syria and Lebanon.

Table 63. Number and percentage of bread wheat lines yielding higher than the local and improved checks in different stressed environments in Syria and Lebanon, AWYT's 1992 and 1993.

Environment	Year	Checks						All three checks	
		Mexipak		Cham4		Cham 6			
		No.	%	No.	%	No.	%	No.	%
Terminal drought	1992	122	46	130	49	30	11	15	6
(Breda)	1993	159	63	138	55	28	11	18	7
	Mean	141	55	134	52	29	11	17	7
Cold	1992	229	87	94	36	65	25	54	20
(TH-EP)	1993	218	86	43	17	68	27	38	15
	Mean	224	87	69	27	67	26	46	18
Terminal heat	1992	208	79	195	74	61	23	50	19
(TH-LP)	1993	203	80	111	44	55	22	46	18
	Mean	206	80	153	59	58	23	48	19
High input	1992	93	35	97	37	159	60	58	22
(Terbol)	1993	126	50	55	22	110	44	48	19
	Mean	110	43	76	29	135	52	53	21

N = 264 (1992), N = 252 (1993); TH-EP = Tel Hadya early planting; TH-LP = Tel Hadya late planting.

A larger number of genotypes were superior to the local check (Mexipak 65) than to the improved checks Cham 4 and Cham 6. Cham 6, a commercial variety released for the low-rainfall (250-350 mm) areas of Syria, is more difficult to beat in the drier environment of Breda. Cham 4, released for the irrigated and higher rainfall and irrigated areas of the country, shows better performance under the optimum environment Terbol. These four environments play an important role in identifying germplasm with multiple abiotic stress resistance. Cham 4 and Cham 6 have also been released in other countries in the region. - **G. Ortiz Ferrara, M.A. Moussa, M.G. Mosaad, N. Rbeiz**

4.1.4. Enhancing Disease and Insect Pest Resistance

Evaluation of disease and insect pest reaction is based on the use of multilocation testing, the modified bulk method of selection, artificial inoculation and close cooperation with the pathologists, entomologists, and national program scientists in WANA. This has increased the level of disease and insect pest resistance in bread wheat germplasm. For example, most entries in the international wheat observation nursery for favorable areas have good levels of disease resistance to the main foliar diseases found in the region. However the levels of *Septoria tritici* blotch resistance should be improved. Promising lines with resistance to wheat stem sawfly, Hessian fly and aphids have been identified. These and other activities are presented in the pathology and entomology sections of this report. - **G. Ortiz Ferrara, M.A. Moussa, M.G. Mosaad, O.F. Mamluk, R.H. Miller**

4.1.5. Evaluation of Double Haploids for Hessian Fly Resistance Breeding

ICARDA's biotechnologists produced some 300 double haploids from F1 crosses between drought tolerant, disease resistant and Hessian fly tolerant bread wheat lines. These included Saada, a Moroccan bread wheat variety containing the H5 gene for HF resistance and two CIMMYT/ICARDA bread wheat lines (NS732/Her and Shi #4414/Crow's') with excellent drought and disease resistance.

A comparative yield trial is currently under field and laboratory evaluation in joint collaboration with the national program of Morocco. This will evaluate the potential of double haploids in a breeding program and the effectiveness of the HF resistance gene (s) in those crosses. - **G. Ortiz Ferrara, W. Haj Jumaa, M. Merghoum, M. Jlibene, M. El Bouhssini, A. Amri (INRA-Morocco), J.H. Hatchett (USDA/Kansas State University), M.S. Mekni, R.H. Miller**

4.1.6. Characterization of Bread Wheat Germplasm for Photoperiod and Vernalization Response

Information regarding vernalization (V) and photoperiod (P) requirements is needed to enhance the adaptation of the crop, and to better target germplasm to the different environments and to determine the optimal planting date of varieties. Screening techniques which allow the characterization of large number of genotypes to these factors are important in breeding programs for abiotic stresses.

Twenty bread wheat genotypes, divided into two groups on selection history for heat stress in field conditions, were evaluated for V and P. Two techniques were compared for characterizing these genotypes. Vernalized and unvernalized seedlings were transplanted to pots and placed in three separate growth cabinets inside a plastic house with 8, 12, and 16 h of light. The same experiment was simultaneously carried out in growth chambers conditions. Vernalized genotypes were earlier than the unvernalized ones, especially those that were sensitive to both light and temperature. A correlation coefficient of 0.88 for days to anthesis was found between the data of the plastic house and the conviron.

Table 64 summarizes the response of the 20 genotypes to P and V. All genotypes were found to be insensitive to P under both techniques. Genotypes that had 3-4 cycles of selection for heat stress (HY-11 to HY-20) were insensitive to V. These results confirm the value of the summer heat environment to select for photoperiod and vernalization insensitivity. - **G. Ortiz Ferrara, M.G. Mosaad, V. Mahalakshmi**

4.1.7. Enhancing Germplasm Adaptation

Adapted, improved germplasm is distributed to NARS in WANA upon request. The objectives are: (1) to provide promising lines for potential release (2) collecting information on adaptation. Multilocation testing and targeting of germplasm has increased adoption of material by NARS, particularly in low-rainfall environments. Table 65 gives the yields of six promising bread wheat lines in the dry areas of WANA. The 13 locations in West Asia and 3 in North Africa were characterized by having low rainfall (<350 mm). These lines were selected by NARS for further national testing and/or for use in their breeding programs as parents possessing high yield and good adaptation.

The adaptation of bread wheat germplasm in moderate to high rainfall areas (>400 mm) of WANA is illustrated in Table 66. The yield advantage of these lines over the national checks, widely grown commercial varieties in those locations, ranged from 114% to 144%. Tevee-2 (Tsi/Vee, CM 64335-3AP-3AP-1AP-0AP), Momtaz (Vee/Lira, CM 73996-04AP-300AP-1AP-0AP), Gomam (WW33/Vee, SWM 11619-2AP-4AP-1AP-2AP-0AP), and Dove/Buc, CM 58808-6AP-2AP-1AP-1AP-0AP, are under extensive testing in those countries. Most lines are disease resistant, which is important in high rainfall environments of the region. - **G. Ortiz Ferrara, M.A. Moussa, M.G. Mosaad, S.K. Yau, National Program Scientists**

Table 64. Days to anthesis in 16h daylength with seed vernalization (basal vegetative period - BVP), changes due to daylength (ΔP), and vernalization (ΔV) for the 20 wheat genotypes (G) under plastic house and conviron.

	Plastic House			Conviron		
G	**BVP**	**ΔP**	**ΔV**	**BVP**	**ΔP**	**ΔV**
LY-1	48.4	0.6 (-)	17.2 (+)	53.8	15.8 (-)	19.6 (+)
LY-2	46.8	8.6 (-)	6.6 (-)	55.2	7.8 (-)	6.0 (-)
LY-3	50.6	4.8 (-)	15.2 (+)	61.0	13.2 (-)	9.0 (+)
LY-4	51.2	-1.4 (-)	13.4 (+)	57.2	6.6 (-)	14.2 (+)
LY-5	50.8	0.0 (-)	17.9 (+)	56.8	12.6 (-)	17.4 (+)
LY-6	46.8	2.8 (-)	19.8 (+)	51.2	11.2 (-)	22.4 (+)
LY-7	46.8	4.0 (-)	14.2 (+)	52.8	7.2 (-)	13.8 (+)
LY-8	51.3	1.5 (-)	9.3 (+)	54.0	10.2 (-)	15.8 (+)
LY-9	51.6	3.2 (-)	4.4 (-)	49.2	13.2 (-)	15.2 (+)
LY-10	47.4	1.9 (-)	4.2 (-)	53.8	8.0 (-)	6.0 (-)
HY-11	47.0	3.4 (-)	-2.5 (-)	54.6	12.4 (-)	1.2 (-)
HY-12	43.8	4.4 (-)	6.5 (-)	48.8	12.6 (-)	14.6 (+)
HY-13	47.4	9.2 (-)	0.6 (-)	46.8	12.0 (-)	-0.8 (-)
HY-14	49.8	0.4 (-)	-3.8 (-)	51.6	14.4 (-)	6.5 (-)
HY-15	45.4	2.0 (-)	-0.4 (-)	50.0	9.2 (-)	3.4 (-)
HY-16	45.0	1.6 (-)	1.0 (-)	53.0	8.8 (-)	4.0 (-)
HY-17	44.0	4.6 (-)	9.6 (+)	50.0	12.0 (-)	11.8 (+)
HY-18	44.2	3.8 (-)	-1.4 (-)	56.2	11.0 (-)	-1.2 (-)
HY-19	45.2	2.2 (-)	-2.2 (-)	48.2	14.2 (-)	6.2 (-)
HY-20	45.8	2.7 (-)	0.4 (-)	54.6	10.0 (-)	0.6 (-)
Stork	46.0	-2.7 (-)	1.6 (-)	49.2	10.0 (-)	5.4 (-)

( ) = response to photoperiod (P) and vernalization (V);
\+ = sensitive, - = insensitive.

Table 65. Mean relative yield (MRY), rank (R) and standard deviation (S.D.) of the top yielding entries in West Asia (*)and North Africa (**). RWYT-LRA 1991-92.

Cross and Pedigree	MRY	R	S.D.
WEST ASIA			
Gomam SWM 11619-2AP-4AP-1AP-2AP-0AP	1.101	1	0.149
Inia/RL4220//7C/3/Yr'S'/5/12300 ... ICW80-0745-4AP-1AP-3AP-0AP	1.067	2	0.119
Tr 380-16-3A614/Chat'S' CM 64868-1AP-1AP-3AP-1AP-3AP-0AP	1.052	3	0.168
Mean yield (Kg/ha)	2846	-	-
No. of locations	13	-	-
NORTH AFRICA			
Tr 380-16-3A614/Chat'S' CM 64868-1AP-1AP-3AP-1AP-3AP-0AP	1.186	1	0.358
Vee 'S'/Nac CM 67404-7AP-1AP-3AP-0AP	1.147	2	0.406
Vee 'S'/3/Hork'S'/Ymh//Kal/Bb CM 78045-06AP-300AP-3AP-300L-0AP	1.111	3	0.283
Mean yield (Kg/ha)	3625	-	-
No. of locations	3	-	-

MRY = Entry yield divided by trial mean yield and then averaged over trials. (*) = Afghanistan, Iraq, Syria, Turkey and Lebanon; (**) = Algeria, Morocco and Tunisia.

4.1.8. Wheat Germplasm Adoption

Before they can have any impact on cereal production improved cultivars must reach farmers. To assist in this we collaborate with NARS in conducting on-farm trials in Syria, Algeria, Sudan, Lebanon, Morocco, Tunisia, and Egypt. A number of bread wheat varieties have been released as a result of this collaboration. Many countries requested and obtained small amounts of seed of newly bred cultivars registered in the region.

Table 66. Performance (*) of bread wheat germplasm in the rainfed (>400 mm) or supplementary irrigated and moderate temperature areas of WANA. Regional Yield Trials for Moderate Rainfall Areas 1991-92.

Country (Site)	Line	Grain yield (kg/ha)	% > NC	LSD.05 / CV (%)	F
Iran	Tevee-2	3757	120	257/6	3
(Gachsaran)	NC	3121			
Lebanon	Momtaz	2244	118	284/11	1
(Kfardan)	NC	1900			
Yemen	Dove/Buc	6258	133	558/12	4
(Dhamar)	NC	4700			
Algeria	Tevee-2	9667	114	1333/12	0
(Khroub)	NC	8489			
Tunisia	Tevee-2	6931	115	635/8	1
(Beja)	NC	6019			
Libya	Gomam	3754	144	807/19	3
(Sebha)	NC	2599			

* = 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.

An adoption study conducted in Syria by the FRMP of ICARDA during 1991 showed that modern high-yielding varieties (HYV's) account for 87% of the area planted and are grown by 86% of the farmers surveyed (FRMP Ann. Rep. 1991).

Since 1983, the Syrian national program has released six improved bread wheat varieties. These are: Bohouth 2, 4, and 6; and Cham 2, 4, and 6. The amount of seed produced by the Government Organization for Seed Multiplication (GOSM) of Syria for these varieties is presented in Table 67. Assuming a seed rate of 150 kg/ha, this would translate in approximately 241,000 ha during the 1992-93 crop season and about 200,000 ha during 1993-94. These figures are conservative and actual area covered may be more because most farmers in Syria retain their own seed for the next crop cycle. During the last two years, GOSM has reduced the amount of seed produced of Mexipak 65 (local variety), and Cham 4, an improved CIMMYT/ICARDA cultivar has become the leading variety grown by farmers. The data in Table 67 supports the adoption study findings.

Table 67. Bread wheat varieties and amount of seed produced by the Government Organization for Seed Multiplication (GOSM) of Syria, and distributed to farmers during 1992 and 1993.

Variety	YR		Seed quantity (tons)			
			1992	1993	Total	% I>L
Mexipak 65	(L)	1969	5500	-	5500	100
Cham 2	(I)	1984	-	-	-	-
Cham 4	(I)	1986	16500	14400	30900	562
Bohouth 4	(I)	1987	10000	9500	19500	355
Cham 6	(I)	1991	4000	4600	8600	156
Bohouth 6	(I)	1991	175	200	375	7
Total			36175	28700	64875	

L = Local; I = Improved; YR = Year of release.

Results from our joint on-farm verification yield trials in Syria show two new promising bread wheat lines (Chorizo, ICW 80-0679-2AP-1AP-5AP-0AP, and Ghurab-2, SWM 11623-9AP-3AP-7AP-2AP-1AP-0AP). These two lines are higher yielding than the local and improved checks, Mexipak 65 and Cham 6. They are still being tested in farmers fields. - **G. Ortiz Ferrara, A. Shehade, M. Michael, M.A. Moussa, M.G. Mosaad**

4.2. Physiology/Agronomy

4.2.1. Physiological Aspects of Water Use Efficiency of Selected Bread Wheat.

In Syria, bread wheat productivity like other crops, is reduced by low water availability. It is less clear whether or not cultivars differ in their reaction to drought. Theory predicts that there are a number of morphological, physiological and phenological traits that may affect a cultivar's productivity in a dry climate.

Preliminary results from the collaborative project of Utrecht University (The Netherlands) and ICARDA indicate that there exists considerable variation in these traits in our germplasm collection. Research continued during the 1992-1993 season with three experiments at Tel Hadya: 1. a comparison of the development/growth and water use of nine cultivars in rainfed and irrigated field plots; 2. a comparison of the development/growth and water use of two cultivars sown at five different seeding rates in rainfed and irrigated field plots; 3. a pot experiment to study the physiological aspects of water use efficiency in detail.

The field experiments produced further basic data on a range of cultivars of different origin and morphology, and investigated the extent to which seed rate/plant density affects crop development, water use and water use efficiency. Results are currently being analyzed.

The pot experiment used the same approach as in 1992. Individual plants were exposed to the daily weather. Special pots allowed the measurement and manipulation of soil water content and the recovery of the root system.

The experiment provided a detailed description of growth and water use through time under well-watered and water-limited conditions. The two varieties used (Katya A1 and Mexipak 65) were the same as in 1992. They differ in a number of traits that may affect WUE. In 1992, Katya invested more biomass in leaves and roots and had more prominent stems than Mexipak. Mexipak compensated for this smaller investment in leaves and roots by having a higher activity in these organs. Its growth was similar and its water use higher than Katya's. However, gas exchange measurements of the youngest leaves were not significantly different for photosynthesis and transpiration. Thus differences at the plant level may be due to differences in the older leaf population. In 1993, special attention was given to leaf area development and senescence, and age-dependent gas exchange.

Katya and Mexipak differed in the rate at which successive leaves emerged and expanded. Mexipak produced its leaf area faster. The increase of leaf area stopped sooner for Mexipak, and senescence was also faster. Mexipak leaves were on average, older than Katya leaves during much of the experiment.

Gas exchange measurements on the youngest, second and third youngest leaves showed no significant cultivar- or age-dependent differences. Drought reduced gas exchange rates to the same extent in both cultivars.

Major differences between the genotypes may be in leaves that are older than the ones measured here. For water loss, leaf sheaths and stems, and nocturnal transpiration may be important. Differences in growth may be due to differences in respiratory losses affecting the conversion of assimilates to biomass. In any given environment there is likely to be an optimal combination of organ size and activity.

A number of conclusions can be drawn from this experiment. 1. the experimental set-up is adequate for comparative studies of the functioning of above- and below ground parts of plants growing under close-to-natural conditions; 2. leaf observations provide an incomplete picture of plant level processes; 3. observations on roots are essential to analyse plant responses to drought; 4. further research on biomass allocation is desirable to find optimal combinations for specific environments. - **E. Veneklaas, R.v.d. Boogard (Univ. of Utrecht)**

4.2.2. Determination of Cardinal Temperatures of Selected Bread Wheat

In Sudan, bread wheat is grown under irrigation and at sowing, high temperatures may lower crop establishment and seedling survival. Genotypes differ in their ability to establish and survive at high temperatures.

We determined the cardinal temperatures for germination of 14 spring bread wheat varieties. Twenty five seeds were placed on moist filter paper at different temperatures (5 to 40° C) in a one-way thermogradient plate. Temperatures in each cell were monitored and the rate of germination at each temperature for each genotype was determined as the inverse of time taken for 50% of the seeds to germinate. Figure 14 shows data for the variety Debiera. Rate of germination for each genotype at different temperatures was plotted against temperature to determine the base (T_b), optimum (T_o) and maximum (T_m) temperatures for germination (Fig. 15 and Table 68). Response of germination to temperature for each genotype was determined as the slope of the equation between T_b and T_o (Table 68). Lines differed in their optimum temperatures and Mexipak had the lowest (Table 68). Though base temperatures differed between genotypes, it was not significant. Genotypes differed in their rate of response to temperature with Gomam having the lowest rate, implying that it was slow to respond to increasing temperatures. Debiera and Nesser had a similar response. Some of the lines which had performed well in the regional yield trials had the highest response rate.

Combining higher optimum temperatures with higher response rates should result in better adapted germplasm for regions where high temperatures occur at sowing. - **Z.I. Ali, V. Mahalakshmi, G.O. Ferrara, J.M. Peacock**

Table 68. Optimum, base temperature and rate of response of germination to temperature for a selection of bread wheat genotypes.

Genotype	Optimum temp (°C)	Base temp (°C)	Germination response ($10^{-3}hr^{-1}\,°C^{-1}$)
Nesser	26.6	0.07	1.45
Flk/Hork	28.0	1.98	1.57
Katya	26.0	0.51	1.55
Vulture	26.6	0.25	1.35
Seri-82	26.2	0.48	1.35
Maya/Sap	26.7	0.33	1.47
RBS/anza	29.8	0.00	1.28
Mexipak	22.1	0.80	1.38
Gomam	24.9	0.66	1.22
Debeira	26.9	0.00	1.36
Sakha	24.2	2.04	1.65
RWYT MR-92-8	26.3	1.28	1.64
RWYT MR-92-10	23.5	0.88	1.65
RWYT MR-92-21	25.5	1.34	1.61

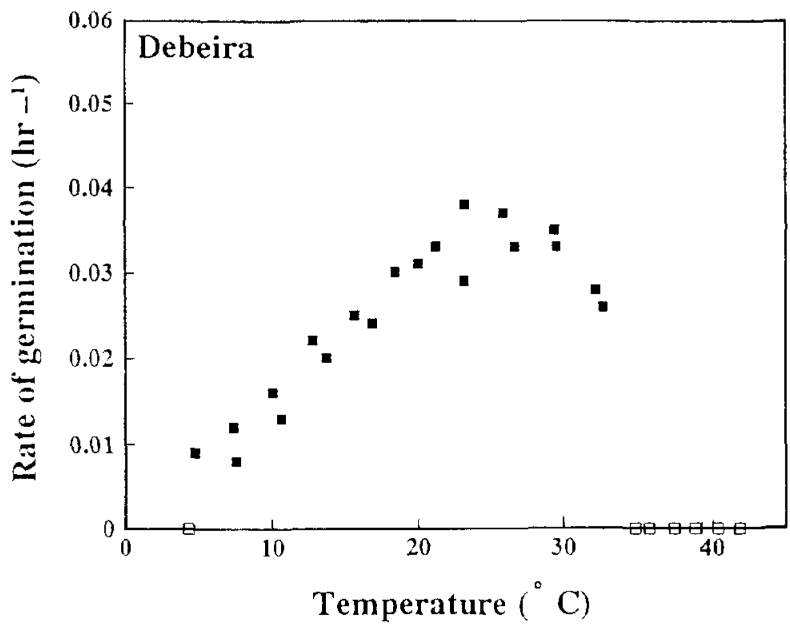

Fig. 14. Effect of temperature on the rate of germination in bread wheat cultivar Debeira.

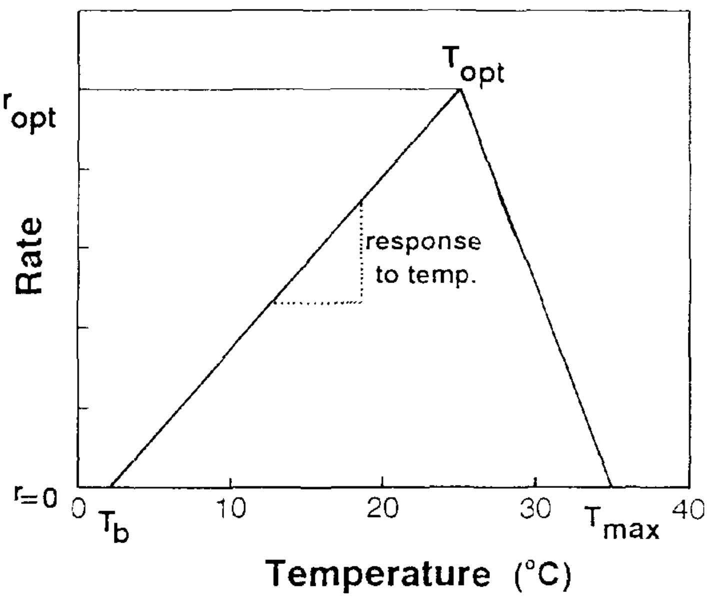

Fig. 15. General response of rate of germination to temperature, where T_b = base temperature, T_{opt} = optimum temperature and T_{max} temperature for germination.

4.2.3. Agronomy

See pages 37-40.

4.3. Pathology

Results highlight work on germplasm pools for sources of resistance to diseases, the Bread Wheat Key Location Disease Nursery results, and losses due to yellow rust.

4.3.1. Germplasm Pools for Sources of Resistance to Diseases

During the 1988 - 1994 seasons, several germplasm pools for sources of resistance to bread wheat diseases have been developed (Table 69). The pools include 311 lines: 118 for yellow rust, 66 for leaf rust, 64 for septoria tritici blotch, 39 for common bunt, and 24 for stem rust. The performance of the lines against the respective disease, together with other disease data are available from the Cereal Program. Seed of these pools are preserved in the Genetic Resources Unit of the Center for further studies. - **O.F. Mamluk, M. Naimi**

Table 69. No of lines in the germplasm pools for sources of resistance to bread wheat diseases and the number of sets distributed (1988-1994).

Germplasm pool for	No of resistant lines	No of sets distributed
Yellow rust	118	170
Leaf rust	66	127
Septoria blotch	64	140
Common bunt	39	76
Stem rust	24	40

4.3.2. Key Location Disease Nursery

Usefull information on the Wheat Key Location Disease Nursery was received from Tel Hadya on septoria tritici blotch, barley yellow dwarf virus (BYDV)[2], and common bunt (Fig. 16). Out of the 252 lines in the Nursery, 73 (29%) showed resistance to septoria, and 50 (20%) to BYDV. All were susceptible to common bunt. However, 17 lines (7%), (Nos. 1, 3, 25, 37, 56, 114, 121, 124, 126, 147, 156, 179, 189, 201, 202, 256, and 263) had resistance to septoria blotch and BYDV. - **O.F. Mamluk, A. Yaljarouka**

4.3.3. Crop Losses Due to Yellow Rust

Results of the crop loss assessment trials are presented in (Table 70). Both fungicides suppressed yellow rust development substantially on the susceptible cultivars, Mexipak, Cham 4, Ghurab, Cham 6, and Bohouth 6, however, no significant differences were found among the treatments. Except in cultivar Shuha, both fungicides caused a yield increase of the cultivars ranging from 1.5 - 22.2%. - **O.F. Mamluk**

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[2]Data from Virology Lab./ICARDA

Table 70. Effect of yellow rust (*Puccinia striiformis*) on yield and yield components of bread wheat cultivars; Tel Hadya, Syria 1993.

Cultivar	Treatment	Yellow rust Score		/ ACI	Yield t/ha	%Yield increase	No.tillers per m	No.seed per spike	1000KW (gr.)
Mexipak 65	Infected	83.3	S	83.3	3.60		68	33	35.3
	Fungicide I	11.7	MS-S	10.0	4.29	19.2	76	36	35.5
	Fungicide II	25.0	M-S	22.7	3.98	10.6	71	37	34.3
Cham 4	Infected	68.3	S	68.3	3.75		90	28	30.4
	Fungicide I	10.0	MS-S	9.7	4.59	22.2	104	31	32.4
	Fungicide II	10.0	MS-S	9.3	3.82	1.8	93	29	33.4
Kanari	Infected	1.0	R	0.2	3.56		72	29	39.7
	Fungicide I	1.0	R	0.2	4.32	21.5	76	32	41.8
	Fungicide II	1.0	R	0.2	3.75	5.3	69	31	41.2
Ghurab	Infected	51.7	MS-S	49.7	4.03		68	38	38.6
	Fungicide I	11.7	MS-S	10.3	4.77	18.2	74	38	40.2
	Fungicide II	10.0	MS-S	9.0	4.13	2.5	71	40	38.6
Cham 6	Infected	70.0	S	70.0	3.77		94	27	31.9
	Fungicide I	11.7	MS-S	11.0	4.38	16.1	102	29	33.9
	Fungicide II	5.3	MS-S	4.9	3.92	3.9	90	30	33.6
Shuha	Infected	1.0	R	0.2	3.90		85	31	36.9
	Fungicide I	1.0	R	0.2	4.19	7.4	87	31	35.4
	Fungicide II	1.0	R	0.2	3.71	-4.8	90	31	35.9
Douma 9013	Infected	2.3	R	0.5	3.90		104	29	32.4
	Fungicide I	1.0	R	0.2	4.39	12.6	91	32	32.3
	Fungicide II	1.0	R	0.2	4.10	5.2	79	32	31.4
Bohouth 6	Infected	80.0	S	80.0	4.07		75	36	34.8
	Fungicide I	16.7	MS-S	15.7	4.35	6.7	73	37	37.4
	Fungicide II	7.0	MS	5.6	4.13	1.5	70	37	38.1
	SE 1				0.25		6.9	1.57	1.44
	SE 2				0.22		6.1	1.51	1.14
	CV%				9.8		14	8.2	5.1

Figures = mean of 3 rep. each 7.2 m^2, harvested 3.2 m^2, from single splitplot design (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 five times. SE 1 to compare treatment at same or different levels of cultivars; SE 2 to compare cultivar at same levels of treatment.

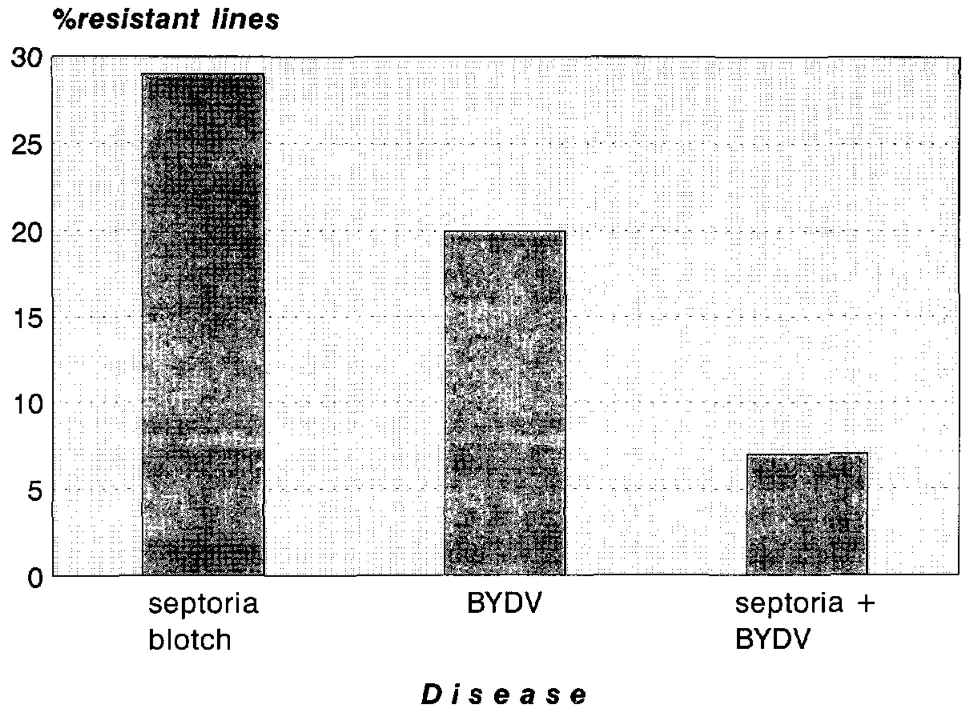

Fig. 16. Percent resistant lines in the Bread Wheat Key Location Nursery (WKL-92) to septoria tritici blotch and barley yellow dwarf virus (BYDV); selection criteria: score 5 on 0-9 scale.

4.4. International Nurseries

4.4.1. Screening for Boron Toxicity Tolerance

A total of 140 entries from the 1992-93 Bread Wheat Crossing Block were tested (see Section 2.6.1.1 for details). There was a large variation in symptom development among the lines. Lines with low B toxicity symptoms and tissue concentration are presented in Table 71. It is significant that 6 entries had a symptom score as low as, and B concentration lower than, Halberd, the tolerant check. The cross Shi#4414/Crow'S' appears 3 times in Table 71, indicating it processes gene(s) for tolerance. Entries 4, 72 and 73 were very sensitive to B toxicity, displaying 'mid-leaf necrosis' symptom. Whether they are efficient in B uptake when grown in B deficient areas needs to be investigated. - **S.K. Yau, J. Hamblin, G. Ortiz-Ferrara**

Table 71. Entries in the 1992-93 Bread Wheat Crossing Block having least B toxicity symptom and tissue B concentration 5 weeks after sowing in soil added with 50 mg B/kg soil.

	Ent. no.	B conc. (ppm)	Name/cross
	33	280	Shi#4414/Crow'S'
	37	416	Shi#4414/Crow'S'
	47	411	C182.24/C168.3/3/Cno*2/7C//Cc/Tob
	64	308	T.aest. Ast/Sprw'S'//Ca8055
	105	295	NS.12.5.3/Atfn
	134	272	Shi#4414/Crow'S'
Checks:			
Tolerant		447	Halberd (from Australia)
Sensitive			
	49	937	Zidene 89

4.4.2. Nursery Distribution in 1993

Regional bread wheat nurseries assembled by the joint CIMMYT/ICARDA bread wheat project at ICARDA are given in Table 72. The Regional Crossing Block was not assembled this year. There were 6 nurseries and 4 germplasm pools, with a total of 465 sets distributed. The agreement between CIMMYT and ICARDA on spring wheat nursery preparation and distribution was implemented starting 1991-92. Under this agreement the names of the yield trials were changed this year from 'Low Rainfall' to 'Semi-arid' and from 'Moderate Rainfall' to 'Favorable' in order to reflect better the target areas of the nurseries. These two trials included the best lines from the 1991-92 joint observation nurseries which consist of lines supplied from the CIMMYT base program in Mexico (with seed multiplied at Tel Hadya, Syria). Both observation nurseries and yield trials were restricted to the WANA region. Three new germplasm pools (for yellow rust, leaf rust and septoria tritici blotch resistance) were assembled by the wheat pathologist, in addition to the stem rust resistant germplasm pool made available last year. - **S.K. Yau, G. Ortiz-Ferrara**

Table 72. Bread wheat Regional Nurseries for 1993-94.

Nursery	Abbre- viation	No. of entries	No. of sets distributed
Regular Nurseries			
Segregating Populations	WSP	130	40
Observation Nurseries:			
- Semi-arid Areas	WON-SA	216	39
- Favorable Areas	WON-FA	202	45
Yield Trials:			
- Semi-arid Areas	WYT-SA	24	44
- Favorable Areas	WYT-FA	24	54
Specific-Trait Nurseries			
Heat Tolerance Obs. Nur.	HTON	54	49
Sub-total			271
Germplasm Pools for Sources of Disease Resistance			
Stem Rust	WSRGP	24	40
Yellow Rust	WYRGP	27	53
Leaf Rust	WLRGP	40	57
Septoria tritici blotch	WSTGP	23	44
Sub-total			194
Total			465

5. FACULTATIVE AND WINTER WHEAT (FWW) BREEDING

5.1. Introduction and Observations

For several years, there have been hints of major crop limiting factors on the Anatolian Plateau (and hence in other facultative and winter wheat production environments in WANA). However, it is difficult to tailor breeding methodologies to continually re-defined objectives. It now appears as if micronutrient deficiencies and toxicities, and hyper-occurrence of nematodes, may greatly influence FWW cereal production systems throughout WANA. What is gratifying is that an inquisitive spark has ignited a fire storm of interest, research and inquiry, both within the international centers and, of perhaps greater importance, in national agricultural research programs.

Micronutrient trials conducted in cooperation with the Bahri Dağdaş, Konya, and Transitional Zones, Eskisehir, agricultural research institutes showed a large response of cereals to elemental zinc application. In some cases, grain yield doubled as a result of zinc application. Boron toxicity is also thought to be wide spread on the Anatolean Plateau. Micronutrient deficiencies are of particular concern for cereal breeding in this region not only because of production limitation but because of their influence on reproductive sterility. Zinc and copper deficiency may not overtly influence general plant phenotype and thereby result in a deceptively good-looking plant which is selected by observation. But in fields known to be deficient in zinc, correlations between phenotypic score (appearance) and grain yield and weight are low. Thus, breeding for these stresses will require quantitative in situ selection.

Two nematological surveys were conducted in Turkey with the assistance of Dr. Gerhard Lung, University of Hohenheim and the Turkish Ministry of Agriculture. Cereal cyst (CCN, Heterodera avenae) and root lesion (Pratylenchus spp.) nematodes were found across the Anatolean Plateau. At several locations, the CCN density was higher than the economical threshold and significant yield losses were expected. An association between the occurrence of CCN and soil zinc deficiency was also found. Infection with CCN may begin in autumn, unlike elsewhere, thus two generations per year may be expected. High autumn densities of Pratylenchus spp. on wheat seedling were found. The influence of autumn infestation vis a vis apparent spring "winter kill" in winter wheat and barley on the Plateau is a topic being further investigated.

Dr. Lindsey Penrose, Wagga Wagga, Australia has assisted in enhancing our understanding of the importance of vernalization in wheat to FWW environments. When sown at Tel Hadya in the autumn, little difference in time of spike initiation for spring, facultative and winter wheats is observed. This is because all genotypes are exposed to similar growth-repressing cool temperatures and the often sudden break between winter and spring temperatures. Vernalization may effect cereal production to a greater extent where autumn stand establishment is important, however, its influence in defining a distinction within the facultative/winter complex remains dubious.

5.2. Methodology and Philosophy

The year 1993 marked the completion of integrating the CIMMYT/ICARDA Facultative, and the CIMMYT/Turkey Winter Wheat breeding programs into one, jointly coordinated, Facultative and Winter Wheat (FWW) Breeding Program. Dr. Hans-Joachim Braun, Winter Wheat Breeder based at CIMMYT/Ankara, is the project co-leader. Integration entailed identifying common goals and strategies, standardizing nurseries, eliminating duplication in germplasm and work activities, coordinating and targeting crossing activities, and exploiting available resources and talents thereby increasing the efficiency and effectiveness of the joint FWW program.

Because of the re-thinking involved in joining two breeding programs into a unified FWW team, I summarize our breeding methodology. We recognize that only through the team approach can our resources (material and human) be utilized effectively resulting in improved germplasm for the facultative and winter wheat environments of WANA. Without the assistance of any of the individuals and organizations footnoted in the following text, our mission would be much more difficult and less meaningful.

5.2.1. Crossing

Izmir. WxW simple ~100 crosses. (WxW)xW top ~250.
Tel Hadya. WxW simple ~350. (SxW)[3]xW top ~250.

Simple and top cross combinations are designed in advance of anthesis. Crosses made by the FWW program, regardless of

[3] Dr. Sanjaya Rajaram, Head, Germplasm Improvement, Wheat Program, CIMMYT, Mexico.

actual location of crossing, are designated by the code "CIT" reflecting the cooperative association of the FWW program between CIMMYT, ICARDA and the Ministry of Agriculture of Turkey. Detailed parental information is assessed and gleaned throughout the following breeding methodology.

The FWW program utilizes exotic X adapted simple cross combinations. Exotic germplasm may contribute specific disease or quality characteristics, or yield potential/adaptation genes important in other agro-ecological mega-environments. Fundamental to this philosophy is the use of spring X winter (SxW) cross combinations. Elite FWW germplasm is sent to CIMMYT/Mexico[3] where crosses are designed to exploit yield potential, broad adaptation, and disease resistance of the spring wheat parents.

Simple use of exotic germplasm in a crossing program necessitates reliance on top crossing to re-establish general adaptation to the target environment(s). True F_1 seed is returned from Mexico to the FWW program where top crosses are made to incorporate traits required for specific adaptation to WANA FWW environments (e.g., photoperiod, resistance to yellow rust (*Puccinia striiformis*), common bunt (*Tilletia tritici*) or smut (*Ustilago tritici*), tolerance to cold or boron).

5.2.2. F_2

Cumra[4], Eskisehir[5], Tel Hadya,
~1000 entries.

F_2 Shuttle.

To facilitate rapid generation advancement, F_2 seed harvested in May from F_1 plots at Tel Hadya is dispatched to Bethlehem, SA[6] for increase, observation (e.g., winter kill, *Diuraphis noxia*, leaf (*P. recondita tritici*) and stem (*P. graminis tritici*) rust, maturity, quality) and selection. F_3 seed is returned to Izmir for planting in December of the same year, allowing observation (e.g., leaf, stem and yellow rust,

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[4] Dr. Engin Kinaci, Director, Bahri Dağdaş International Winter Cereals Research Center, Konya, Turkey.

[5] Dr. Fahri Altay, Director, Transitional Zones Agricultural Research Institute, Eskişehir, Turkey.

[6] Dr. Hugo van Kiekirk, Grain Crops Research Institute, Bethlehem, South Africa.

maturity) selection and harvest in June of the subsequent year.

5.2.3. F_3

Ankara[7], Cumra, Eskisehir, Edirne[8], Tel Hadya, ~800 entries.

5.2.4. Segregating Populations (SegPop)

Ankara, Cumra, Eskisehir, Edirne, Iran[9], Tel Hadya, ~600 entries.

Multi-location testing is an integral component of the FWW program breeding methodology. Environmental variability, typical within WANA, necessitates a serendipitous approach to data gathering; some location-years will provide reliable data, some may provide unexpected data, while others may provide little useful information. Nurseries containing segregating germplasm (i.e., F_2, F_3, Segpop) are screened for tolerance to cold, reaction to leaf, stem and yellow rust, maturity and height, phenotypic score, grain yield, and grain quality.

Introduced segregating populations, grown in Cumra, are routinely obtained from Oregon State University[10] (OrSU), the Great Plains of the USA[11], Bulgaria[12], and the Turkish National Wheat Improvement Program[13].

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[7] Mr. Vedat Uzunlu, Director, Field Crops Improvement Center, Ankara, Turkey.

[8] Dr. Ahmet Bulbul, Director, Trakya Agricultural Research Institute, Edirne, Turkey.

[9] Dr. T. Mahlooji, Director General, SPII, Karaj, Iran.

[10] Dr. Warren Kronstad, Wheat Breeder, Oregon State University, Corvallis, OR, USA.

[11] Dr. C. James Peterson, USDA Regional Coordinator, University of Nebraska, Lincoln, NE, USA.

[12] Dr. Dora Boyadjieva, Head of Wheat Breeding, K. Malkov Institute, Sadovo, Bulgaria.

[13] Mr. Nusret Zencirci, Coordinator, Turkish National Wheat Improvement Program, Ankara, Turkey.

5.2.5. Headrows

Cumra,
~30,000 headrows.

From (generally) F_3 populations deemed worthy of further selection (based on multi-location/year observations or population cross-combination objectives), individual spikes are selected in Cumra. Populations are represented by 96, 48 or 12 spike "headrows" depending on the origin of the population, cross combination objectives, and degree of selection in previous generations.

Periodic plots of "Bezostaya" and "Gerek 79" are used to orientate location in the headrow nursery, and act as maturity and height standards, and disease inoculum sources. The nursery is mist-irrigated and artificially inoculated with yellow rust to encourage epiphytotic development. Select populations are also inoculated with common bunt to allow discrimination of susceptible genotypes.

In addition to the headrow nursery, the **SegPop** nursery represents the respective headrow populations grown in bulk and allows one further cycle of population performance evaluation prior to headrow selection, as well as a germplasm reserve should problems occur prior to harvest of the headrows.

Selection of a headrow, per se, is based on multi-location/year population performance (F_2, F_3, Segpop) and distinction between headrows within a population based on disease reaction, maturity, height, vigor, and general phenotype.

5.2.6. Preliminary Yield Trial (PYT)

Cumra, Eskisehir, Izmir[14], Tel Hadya.

Preliminary yield trials (~1500 entries) are single replicate nurseries with alternating Gerek 79 and Bolal checks every tenth plot. Selection is based primarily on reaction to leaf and yellow rust, maturity, phenotypic score, grain yield and grain grading (size and color). Spacial statistical analysis is used (e.g., Two-D) to obtain grain yield rankings within a location.

Because germplasm entering the PYT nursery is from a relatively early generation F3-derived headrow, genotypic

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[14] Dr. Ertuğ Firat, Director, Aegean Agricultural Research Institute, Menemen, Turkey.

heterogeneity may occur. If the heterogeneity is too severe (e.g., for extremes in plant height, maturity or disease susceptibility), the "population" is discarded. Lines with a moderate to low level of heterogeneity are not discriminated against, but are advanced in the yield performance evaluation scheme. The reasoning behind retention of "mixed" lines is two-fold: 1) That population heterogeneity may lend itself to performance stability in variable stress environments, and 2) CIMMYT develops germplasm in cooperation with national programs. One division of labor in this partnership envisions germplasm generation by the former and testing, purification and multiplication by the latter group of organizations.

5.2.7. Yield Trial (YT)

Ankara, Cumra, Eskisehir, Tel Hadya, Diyarbakir[15], Edirne, Erzurum[16], Iran, Izmir, Romania[17], CIMMYT/Mexico, OrSU.

Regional yield trials (~500 entries) are planted in replicated nurseries at Ankara, Cumra, Eskisehir and Tel Hadya, and single replicate yield nurseries at Diyarbakir, Edirne, Erzurum and Iran. Standard check genotypes are planted every tenth plot to facilitate spacial statistical analysis. Opportunistic disease observation occurs at all locations, while at Izmir, Tel Hadya and Romania intensive screening for leaf and yellow rust occurs. Tel Hadya also provides screening for industrial quality[18] (NIR spectral analysis for protein concentration, particle size index, and kernel weight), common bunt, and response to vernalization and photoperiod.

Genotypes are currently sorted into yield trial sub-groups based on grain color (red/white) and presumed target environment (rainfed/dual-purpose/irrigated) based on plant height and maturity). Future yield trial genotypic segregation will also be based on response to photoperiod. Germplasm developed through the FWW program will be classified as

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[15] Mr. Irfan Özberk, Wheat Breeder, Southeast Anatolia Agricultural Research Institute, Diyarbakir, Turkey.

[16] Mr. Muammer Savas, Director, East Anatolia Agricultural Research Institute, Erzurum, Turkey.

[17] Dr. Marijana Ittu, Wheat Pathologist, Cereals Institute, Fundulea, Romania.

[18] Mr. Fouad Jaby El-Haramein, ICARDA, Syria.

photoperiod neutral "facultative" types (suitable for northern Syria, southeastern Turkey, the Atlas Mountains, and areas in Iran), or photoperiod responsive "winter" types (suitable for the Anatolian Plateau, Iran, and Afghanistan) from screening for maturity at Edirne, Izmir, and Tel Hadya. All FWW germplasm will respond to vernalization, a trait with implied advantage in the WANA target drought environments, and by association be cold tolerant.

5.2.8. International Nurseries

Ankara, Cumra, Eskisehir, Edirne, Erzurum, Iran, CIMMYT/Mexico, OrSU, Tel Hadya.

Candidates International **(CANINT)** is a nursery (~300 entries) composed of introduced germplasm, sent from non-WANA FWW programs, to be considered for inclusion in the **Facultative and Winter Wheat Observation Nursery (FAWWON)**, which is distributed in partnership between CIMMYT, ICARDA, the National Wheat Improvement Program of Turkey, and Oregon State University. The FAWWON is currently distributed to 133 FWW breeding programs in sixty countries.

The FAWWON is a collection of FWW advanced lines and cultivars. In addition to volunteered, introduced germplasm (from **CANINT**), principle germplasm contributors included CIMMYT/ICARDA/Turkey (from **YT**), CIMMYT/Mexico-Turkey, CIMMYT/OrSU, and the National Wheat Improvement Program of Turkey (from **CANTUR**).

5.2.9. Advanced Yield Trial (AYT94)

Ankara, Cumra, Eskisehir, Tel Hadya, Diyarbakir, Edirne, Samsun[19].

Outstanding CIT FWW germplasm is tested in a three replicate, triple imbedded lattice (~75 entries including checks). This is the precursor nursery to a planned Regional Yield Trial. Germplasm is intensively screened for yellow rust, common bunt and tolerance to boron at Tel Hadya[20,21], high molecular weight

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[19] Mr. Hasan Ozcan, Wheat Breeder, Black Sea Agricultural Research Institute, Samsun, Turkey.

[20] Dr. Omar Mamluk, Wheat Pathologist, ICARDA, Syria.

glutenin bands and industrial quality parameters at CIMMYT/Mexico[22]. AYT CIT germplasm, and outstanding FAWWON entries, are introduced into Crossing Block Facultative and Winter (**CBFW**). - **T.S. Payne**

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[21] Dr. S. K. Yau, Wheat Breeder, ICARDA, Syria.

[22] Dr. R. Javier Peña, Cereal Chemist, CIMMYT, Mexico.

6. ENTOMOLOGY

6.1. Describing Polymorphic Complexity of Aphids with RAPD-PCR

Aphids are among the most important of more than 60 insect species that attack wheat and barley in WANA. Many aphids are native to central and western Asia. Greenbug, *Schizaphis graminum*, bird cherry-oat aphid, *Rhopalosiphum padi*, corn leaf aphid, *Rhopalosiphum maidis*, and Russian wheat aphid, *Diuraphis noxia*, often cause economical losses in wheat and barley. They have been extensively studied in Europe, and in North and South America, but relatively little is known of their biology, distribution, dispersion and economic importance in WANA, and even less about their natural enemies-the parasitic microhymenoptera and predatory Coleoptera and Diptera. Surveys in rainfed areas of Turkey and Syria (Miller et al., in press) show that if insecticide use is low then natural enemies are widespread. Natural enemies are adversely influenced by large scale applications of nonspecific insecticides. This, coupled with increasing tolerance to insecticides by some aphid species, has disrupted natural homeostasis in parts of WANA. To reestablish or protect this homeostasis naturally occurring bioagents must be adequately described and enhanced.

RAPD-PCR is a DNA analytical technique that allows the separation of genetic differences among species and races of organisms. RAPD-PCR analysis was conducted on field samples of aphids and natural enemies from Syria, Iran and the USA at the Department of Entomology at Washington State University (WSU) using facilities and protocols developed by Dr. Lynell Tanigoshi. The initial analyses identified PCR primers useful in analyzing Russian Wheat Aphid (RWA) and its natural enemies, and examined the use of ethanol preserved specimens for PCR analysis.

Distinct banding patterns for parastoids and RWA were achieved using the A4 primer (Fig. 17)(Operon Technologies Inc.(1000 Atlantic Ave., Alameda, CA 94501). Lyophilized samples, fresh samples, and ethanol preserved samples all yielded similar banding patterns, although ethanol patterns were slightly lighter than those from fresh or lyophilized samples. Different banding patterns were observed from identical species of RWA originating from different geographic localities and from different species of natural enemies.

Ethanol preserved collected material from remote areas of WANA can be used for PCR analysis. These data suggest that the A4 primer adequately discriminates between species and races of RWA and its hymenopterous parastoids. BAM, ECO and CO1 primers also have this capacity (Black, et al., 1992).

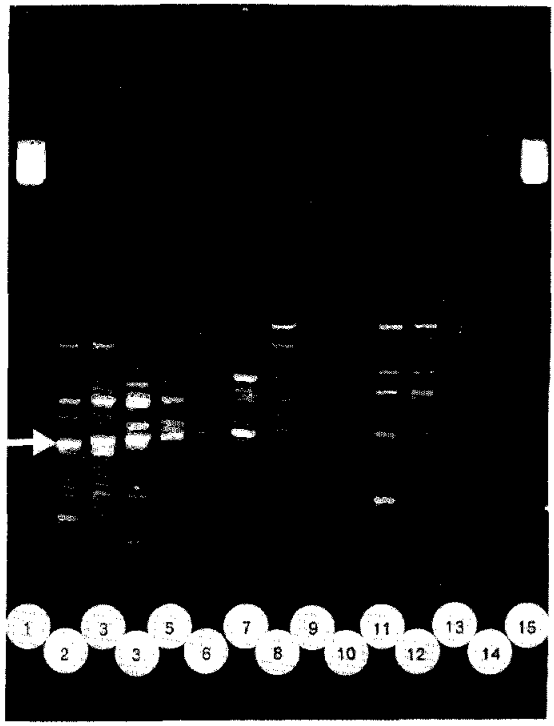

Fig. 17. Banding patterns resulting from RAPD-PCR analysis (A4 primer) of RWA and various natural enemies prepared from fresh and ethanol-preserved samples. Single insects were used to generate each band. Bands are from 1) DNA marker, 123 base pair interval, 2) *Aphidius asychis* (USA), 3) *A. asychis* (USA, ethanol), 4) *Aphidius varipes* (USA), 5) *A. varipes* (USA, ethanol), 6) *Aphidius albopodus* (USA), 7) *A. albopodus* (USA, ethanol), 8) *Diaeretiella rapae* (Iran), 9) *D. rapae* (Syria, lyophilized), 10) *D. rapae* (USA, ethanol), 11)RWA (Syria,lyophilized), 13) RWA (USA, ethanol), 13) RWA (USA, ethanol), 14) H_2O control, 15) DNA marker, 123 base pair interval. Arrow indicates major band located at approximately 738 BP as estimated from DNA markers.

6.2. Russian Wheat Aphid

Ms. Nada Rechmany (Lebanese University) and Mr. Anas Ahmed F. Elmulla (Sudan) surveyed Russian wheat aphid natural enemies in wheat and barley, and compared the performance of one, *Diaeretiella rapae*, at different aphid densities in the plastic house. Natural enemies observed (Table 73) included syrphids, chamaemyids, coccinellids, *D. rapae*, *Aphidius sp.*, and some as of yet unidentified microhymenoptera. Barley harbored the most

RWA and *D. rapae*. Predators were more numerous on wheat. However the total number of natural enemies was greater on wheat as were the number of aphid mummies in which the parasite had died. The most *D. rapae* mummies were collected about 6 days from oviposition (Fig. 18). This was most easily observed at aphid densities of 100 or more in cages where 2 adult females were initially released for 24 h. At densities of 10 aphids no peak in parasitoid emergence was noted and essentially all aphids were parasitized.

These results reveal a rich natural enemy fauna that should be preserved and may be enhanced. Microhymenoptera and chamaemyid flies are especially interesting against RWA because of their ability to enter tightly curled leaves caused by RWA infestation. *D. rapae*, a known generalist parasitoid, may be effective against high populations of several aphid species in the absence of insecticide contamination or adverse cultural practices.

Table 73. Results of survey for RWA and its natural enemies conducted on RWA screening hill plots at Tel Hadya, 1993.

Variable	Barley	Bread Wheat
RWA Damage Score	3.72	3.80ns
% Inf. tillers/hill	49.50	38.80*
RWA/10 tillers	204.52	185.28ns
Predators/10 tillers	2.28	3.64*
Parasitoids/10 tillers	55.64	63.60ns
D. rapae/10 tillers	16.48	10.56*
Unknown parasitoids/10 tillers	15.76	17.56*
Syrphids/10 tillers	10.4	1.44ns
Chamaemyids/10 tillers	0.64	1.00*
Coccinellids/10 tillers	0.36	1.2ns
Dead mummies/10 tillers	23.40	35.48*
Total natural enemies/10 tillers	57.92	67.24*

ns = $P > 0.05$; * = $0.01 \leq P \leq 0.05$; $P \leq 0.01$

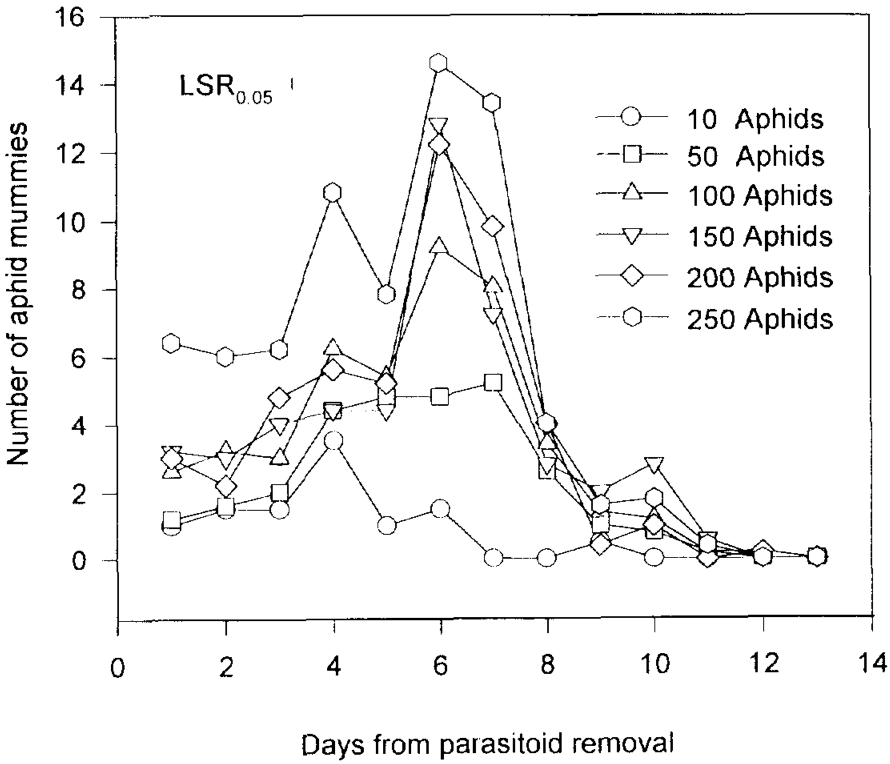

Fig. 18. Performance of *D. rapae* in cage trials under different aphid densities. Two adult female *D. rapae* were placed in a cage containing aphids for 24 h, after which they were removed. Mummies were counted and removed from the cage as they appeared. Data were collected by Ms. N. Rechmany and Mr. A. Elmulla.

6.3. Wheat Stem Sawfly (WSS) Screening Trials

Table 74. shows results of WSS screening under natural infestation in a farmer's field at Saraqueb approximately 20 km south of Tel Hadya. Insufficient reared sawflies were available to produce uniform sawfly coverage in caged screening trials conducted at Tel Hadya and are not reported.

Table 74. Best performing barley, durum, and bread wheat varieties in WSS trials at Saraqueb in 1992/93. Also shown are results from past years screenings where data were available.

Crop and genotype	Pedigree	Source	No.	87	88	89	90	91	92	93
Barley										
H.SPONT.41-1/TADMOR	ICB87-1833-61AP-0AP	F6HS92	3	-	-	-	-	-	-	0.0
As46/Rihane-05	ICB85-0380-3AP-2AP-0TR-4AP-0TR-0AP	BPT92N	7073	-	-	-	-	-	1.67	1.67
Avt/1763-2L//Kenya/Cam	ICB84-1082-3AP-2AP-0AP-0AP	BAT92N	216	-	-	-	-	-	0.83	2.50
As46//Deir Alla 106/Strain205	ICB85-0383-1AP-4AP-0TR-1AP-0TR-0AP	BPT92N	1049	-	-	-	-	-	1.67	2.50
H.SPONT.41-1/TADMOR	ICB87-1833-125AP-0AP	F6HS92	5	-	-	-	-	-	-	2.50
H.SPONT.41-1/TADMOR	ICB87-1833-61AP-0AP	F6HS92	3	-	-	-	-	-	-	2.50
H.SPONT.41-1/TADMOR	ICB87-1833-150AP-0AP	F6HS92	9	-	-	-	-	-	-	2.50
Deir Alla 106/4/Deir Alla 106//Api/EB89-8-2-15-4/3/Robur/CI 11577//F3	Bulk Hip ICB85-0316-1AP-1AP-0AP	BAT92N	213	-	-	-	-	-	1.67	3.33
Arabi Abiad	Local Check	-	-	-	-	-	-	-	-	3.34
H.SPONT.41-1/TADMOR	ICB87-1833-139AP-0AP	F6HS92	6	-	-	-	-	-	-	3.34
Ager//Api/CM67/3/Cel/WI2269//Ore	ICB81-1275-0SH-1AP-0AP-0AP	BAT88	405	-	7.50	5.03	0.83	16.67	5.00	5.83
FB73-075	-	BAB85	14	0.83	2.08	2.93	5.00	13.33	8.33	10.00
Durum Wheat										
D-2/Sham 1	ICD79-0282-10AP-3AP-2AP-1AP-0SH	DAB87	140	-	8.33	5.00	0.00	10.83	0.42	0.00
Awalbit-6	ICD84-0322-ABL-5AP-TR-AP-15AP-0TR	DAT92	1304	-	-	-	-	-	0.42	0.84
Awl2/Bit	ICD84-0322-ABL-7AP-TR-AP-21AP-TR-2AP-0TR	DAT92	617	-	-	-	-	-	0.83	0.84
Mrb11//Snipe/Magh	ICD85-0538-ABL-TR-9AP-0TR	DAT92	812	-	-	-	-	-	0.83	0.84
Marrout	CD 52612-7AP-4AP-0AP DAT92 1309	DAT92	1309	-	-	-	-	-	0.83	0.84
Heider//Mt/Ho	ICD86-0414-ABL-0TR-2AP-0TR-10AP-0TR	DAT91	801	-	-	-	-	10.83	0.00	1.67
IC 19939 (MOR)	-	DGR92	46	-	-	-	-	-	-	1.67
GdoVZ 512/Cit//Ruff/Fg/6/Ruff/5/Plc/Cr/4/ZB /Lk//60-120/3/Gll	ICD86-0149-ABL-3AP-0TR-6AP-0TR	DAT92	409	-	-	-	-	-	0.00	1.67
GdoVZ 512/Cit//Ruff/Fg/6/Ruff/5/Plc/Cr/4/ZB /Lk//60-120/3/Gll	ICD86-0149-ABL-21AP-0TR-22AP-0TR	DAT92	412	-	-	-	-	-	0.83	2.50
Heider//Mt/Ho	ICD86-0414-ABL-0TR-4AP-0TR-9AP-0TR	DAT92	1218	-	-	-	-	-	0.42	2.50
Haurani	Local Check	-	-	-	-	-	-	-	-	5.00
Gezira 17/Scaup	ICD-HA81-1917-3AP-1AP-1AP-0AP	DCB87	37	0.83	5.00	3.35	0.42	11.67	3.75	7.50

Bread Wheat										
BOL "S"/Pvn "s"	CM58696-5AP-2AP-1AP-1AP-0AP	WOM87	42	2.91	10.00	7.50	3.75	35.83	2.00	0.84
Snb'S'//Flk'S'/Hork	ICW87-0050-300AP-0L-4AP-0L-0AP	WAM92	322	-	-	-	-	-	0.75	1.67
Fta/W71//Imuris	CMH80A-276-1B-2Y-1B-2Y-2B-0Y	WCB87	71	0.83	5.42	1.70	2.08	26.67	0.50	1.67
Vee'S'//Ald'S'/Huac'S'	ICW86-0605-08AP-300L-3AP-0L-0BR-0L-0AP	WAM92	314	-	-	-	-	-	0.75	1.67
Pato/On//Maya74/4/Bb/3/Pato//Inia/Napo/5/Ald'S'/Pima77/3/CMH24A.630/Bu	ICW84-0205-08AP-300L-4AP-300L-0AP	WAL90	204	-	-	-	0.42	13.33	0.75	1.67
Ures.81/Genaro.81	CW85-0063-300L-300AP-300L-4AP-0L-2AP-0L	WAL92	421	-	-	-	-	-	0.50	1.67
Tsi/Vee'S'//Lovrin24/Coc75	ICW89-0775-0L-0Br-2AP	WS592	703	-	-	-	-	-	-	2.50
Kvz/Cgn/5/Maya74'S'/On//II60.147/3/Bb/Gll/4/Chat'S'	ICW86-1101-300AP-0L-11AP-0L-0AP	WAL92	610	-	-	-	-	-	0.50	2.50
Pvn'S'/Sprw'S'//W3918A/Jup	ICW87-1052-0L-1AP-0L-0AP	WAL92	216	-	-	-	-	-	0.50	2.50
Tsi/Vee'S'/5/RBS/Anza/3/Kvz/Hyz//Ymh/Tob/4/Bow'S'	ICW89-0773-0L-0Br-2AP	WS592	701	-	-	-	-	-	-	2.50
Golan	Local Check	-	-	-	-	-	-	-	-	2.50

6.4. Wheat Stem Sawfly Yield Trials

Small scale yield trials were again conducted to examine yield loss due to wheat stem sawflies using more varieties than in previous years and a susceptible and resistant check (Table 75). Results are shown from trials planted in a farmer's field at Saraqueb, a WSS "hot spot" 20 km south of Tel Hadya. WSS infestations were inadequate for differentiation at Tel Hadya and are not reported. In all cases the susceptible checks had significantly higher rates of sawfly infestation than did other lines. Yield results were mixed with some lines in each commodity outyielding the susceptible check. Most WSS resistant lines had moderately to good yields across commodities. The barley line FB73-075, a forage barley that has experienced the lowest sawfly infestations over the past few years, was similar to the susceptible check this year. This suggests that this line frequently escapes WSS infestation. WSS escape in barley may be the best resistance mechanism available as no solid stem barleys have yet been reported. In bread wheat the cross Shi#/4414/Crow'S' gave high yields with good sawfly resistance. Offspring of this cross have also shown Hessian fly tolerance in field trials in Morocco. - **R.H. Miller**

References

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Miller, R.H., K.S. Pike, L.K. Tanigoshi, L.L. Buschman, and S. Kornosor. Distribution and ecology of the Russian wheat aphid, *Diuraphis noxia* Mordvilko (Homoptera: Aphididae) in western Asia and northern Africa. Arab. J. Plant Prot. in press.

Table 75. Results of small scale yield trials for wheat stem sawfly resistant wheat and barley conducted at Saraqueb, Syria.

Crop and genotype	Pedigree	Source	Source No.	% Inf	Yield(g)/m²	1000KW
Barley						
7028/2759/3/69-82//Ds/Apro/4 /As46/Aths*2	ICB85-1728-2AP-1AP-0AP	BIT89N	904	5.83ab	670.7b	30.0b
Harmal-02/3/Arr/Esp//Alger/C eres,362-1-1	ICB83-1546-0AP	BAT89	212	6.11ab	820.0b	41.0b
INRA55-86-2/V1701	ICB82-1140-13AP-0AP	BAT89	209	8.33a	714.7b	40.0b
Ager//Api/CM67/3/Cel/WI226	ICB81-1275-0SH-1AP-0AP-0AP	BAT88	405	8.89ab	640.7b	30.0a
Apm/HC1905//Robur/3/Arar9// Ore	ICB85-0121-7AP-2AP-0AP	BAT91	207	9.16ab	622.0ab	40.0b
FB73-075	-	BAB85	14	10.55a	618.7a	30.0a
Arabi abiad	-	Check	1	12.31b	636.0b	42.0a
Durum Wheat						
Aw12/Bit	ICD84-0322-ABL-7AP-TR-AP-21 AP-0TR	DAT92	110	0.27a	454.0ab	40.0a
Ru/Mrb15	ICD84-1257-8AP-0TR	DAT91	121	0.55a	545.0ab	36.6a
Bit/Creso	34346-2TR-2AP-1AP-0AP	DCB87	20	0.83	435.0b	38.3a
D-2/Bit	20796-4AP-6AP-2AP-0AP	DAT87	116	1.11a	481.0a	36.6a
Rufom-4	ICD84-1257-14AP-TR-13AP-0TR	DAT91	505	2.22a	405.0ab	35.0a
16143	-	SOLSTE	72	4.44a	365.0ab	36.6a
Haurani	-	Check	1	11.75b	489.0ab	35.5a
Bread Wheat						
Tsi/Vee's'	64335-3AP-3AP-1AP-0AP	WOL88	12	0.00a	363.0a	31.6a
Bol'S'/Pvn'S'	58696-5AP-2AP-1AP-1AP-0AP	WOM87	42	0.27	401.0ab	36.6a
Shi#4414/Crow'S'	SWM11508-1AP-1AP-4AP-1AP-5A P-0AP	WAT88	613	1.11a	533.0ab	35.0a
Kasyon/Glennson.81	ICW85-0025-05AP-300AP-300L-5AP-0L-1AP-0L	WAM92	320	1.39a	416.0b	36.6a
Fta/W71//Imuris	CMH80A-276-1B-2Y-1B-1Y-1B-0 Y	WCB87	72	1.39a	349.0ab	33.3a
66.122.66.2/No66//Lov2F1/3/F 1Kvz.Hys/4/7C//Tob/Cno'S'/3/ kal/6/Mb*2//In	ICW84-0440-04AP-300L-7AP-30 0L-0AP	WAL90	217	1.67a	391.0a	36.6a
Golan	-	Check	1	8.05b	499.0ab	32.2a

Means within each commodity group followed by the same latter are not significantly different at $P \leq 0.05$.

7. BIOTECHNOLOGY

7.1. Rye Introgressions into Wheat

7.1.1. The Crossability between Wheat and Rye

Many varieties in the world carry all or part of chromosome 1R from *Secale cerale*. The rye chromatin has provided an important, additional source of disease resistance for wheat as well as better adaptation. Due to the widespread use of wheat-rye translocations/substitution lines most of the resistance genes conferred by the rye chromosome have been more or less broken (Pm8 powdery mildew, Sr31 stem rust, Lr 26 leaf rust, Yr 9 yellow rust).

This research attempts to introduce new rye chromatin into locally adapted wheat germplasm to identify new resistance genes or different alleles. Fifteen inbred rye lines (kindly provided by G. Scoles, Saskatoon, Canada and T. Lelley, University of Vienna, Austria) were crossed to 20 locally adapted bread wheat varieties. Amphihaploid hybrids were obtained without the help of embryo rescue. A crossability percentage of between 0-5% indicates that all wheat varieties used carried the dominant crossability genes Kr1 and Kr2. The germination rate of the hybrids was low. Successful hybrids are easily distinguishable from selfings as the seeds are small and shrivelled. Hybrids were grown up and colchicine treated (0.1%) to induce diploidisation. The amphidiploids (8x-triticale) are being backcrossed to the wheat parents to produce a haploid rye genome. Because of trivalent pairing (one rye and two wheat chromosomes) in the meiosis of such hybrids, selfing will produce spontaneously rye introgressions in the progeny.

In collaboration with Dr. A.B. Almouslem, Aleppo University, C-banding is used to monitor rye introgression. Rye specific repetitive sequences (DNA-marker) are being evaluated to follow the rye introgression into wheat on southern blots (psc 7, 33, 119.1.3, 119.2.1, 5.3 H3 and 7235.1). These sequences can also be used for *in situ* hybridizations on metaphase chromosome spreads. - **M.Baum, A.B. Almouslem, T. Lelley**

7.2. The Barley Mapping Project

This study uses a system of marker (RFLP, PCR) assisted selection. A collaborative research program has been developed with the University of München, Weihenstephan (Prof. Dr. G. Fischbeck). The cross Tadmor x WI2291 was choosen for this study. Tadmor, is susceptible to powdery mildew and resistant to scald and root rot. WI2291, is resistant to powdery mildew, susceptible to scald and root rot. In the segregating populations a likely monogenic (powdery mildew), oligogenic (scald) and polygenic (root rot) inherited traits are segregating.

Crosses with purified parents have been performed in both directions and several F2 populations have been produced. One F2 population will be advanced further using Single Seed Descent (SSD) to F6. At the same time a DH population from F1 hybrids is being developed at ICARDA. The parents are being analysed for marker polymorphism in Weihenstephan and at ICARDA. - **M.Baum, S. Ceccarelli, S. Grando, A. Gland, A. Jahoor, G. F. Fischbeck**

7.3. The Durum Mapping Project

In 1993 a cross was made between Jennah Khatifa (resistant to: *Septoria tritici,* drought, common bunt and good grain quality) and Cham 1 (resistant to yellow rust, dryland root rot, responsiveness to high input conditions and having good adaptation). For mapping purposes three populations of this cross are being advanced further using SSD. The population will be made available to other researches in the durum network for mapping purposes. Two different *T. dicoccoides* lines have been crossed and backcrossed to Omrabi5 and Korifla. The parents differ for yellow rust, septoria, leaf rust, and quality. The populations are also being advanced by SSD to produce a homozygous mapping population. - **M.Baum, M. Nachit, M. Sorrells, P. Monneveux**

7.3.1. The Mapping Approach

Currently, already mapped RFLP-clones (see table below) are being prepared for their use in the parental screening:

RFLP-marker available at ICARDA	supplied from	plant species developed for	number of clones
CDO library	Cornell	oats	102
BCD library	Cornell	barley	102
WG library	Cornell	wheat	60
MWG library	German Barley Mapping Project	barley	56
NABGMP set	Washington State University	barley	70
Kyoto set	Tzunewaki/Liu	wheat	150

The plasmids containing the RFLP-sequences are transformed into a bacterial host using a heat shock system. The insert size of the clones is checked using a miniplasmid preparation (Fig. 19). If the insert size is appropriate the clone is labelled with the non-radioactive steroid digoxigenin. The labeling efficiency of clones is checked after clones are electrophoretically separated and blotted onto nylon membranes. Visualizing is performed with the non-radioactive labelling and detection system developed by Boehringer, Mannheim.

As in the International Triticeae Mapping Initiative (ITMI) RFLP- analysis of the parents uses five restriction enzymes (EcoRI, EcoRV, HindIII, BamHI, and Dra I). When polymorphisms are detected between parents (Fig. 20) the marker/enzyme combination is used in segregating population for linkage analysis.

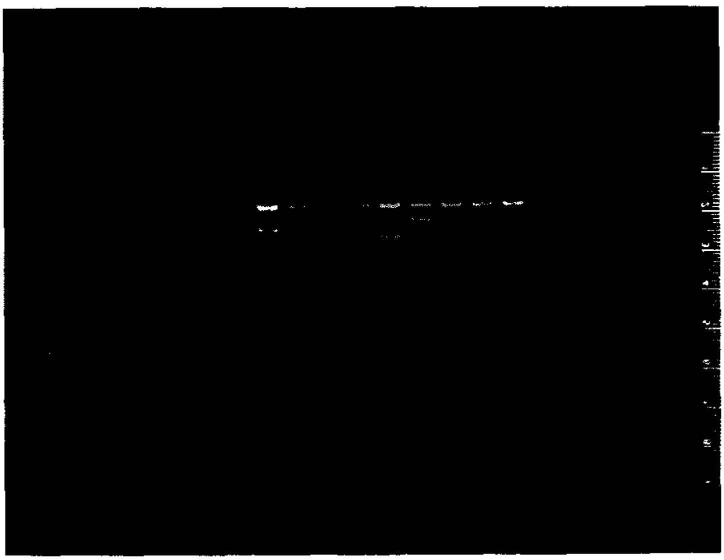

Fig. 19. Restriction endonuclease digest of miniplasmid preparations of cereal RFLP-clones. Upper band, plasmid (pUC 19); bottom band insert DNA with various fragment length.

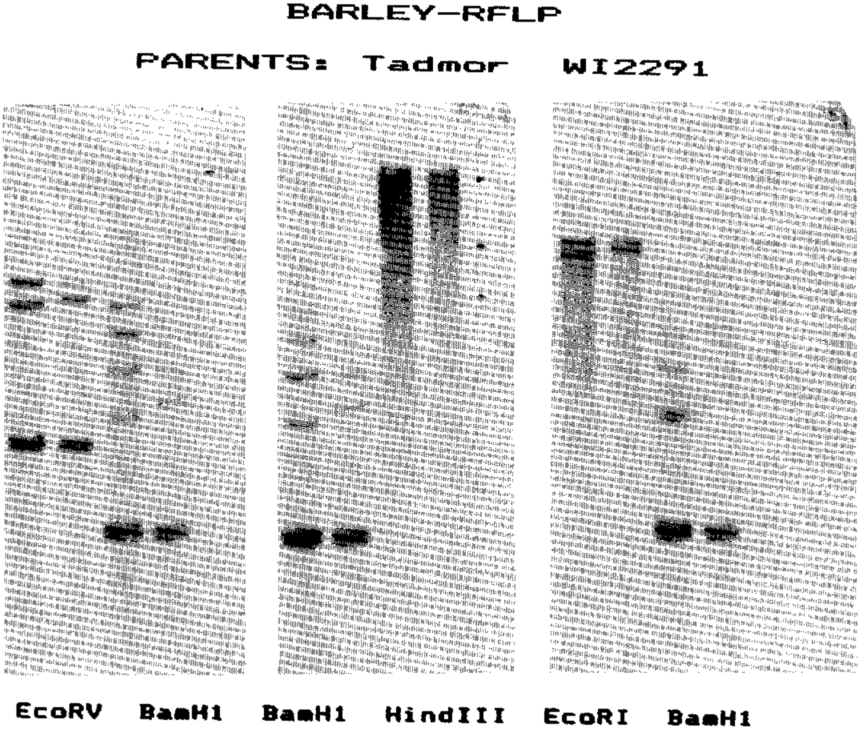

Fig. 20. Clone C4 (Rrn1&2) of the North American Barley Gene Mapping Project was hybridized to total genomic DNA of Tadmor and WI2291, restricted with the restriction endonucleases indicated. Restriction fragments hybridized with this probe are located on chromosome 6S and 7S. Polymorphic bands can be seen in the EcoRV, BamH1, and EcoR1 digest.

7.3.1.1. Sequence-Tagged-Site (STS) Primer

A sequence-tagged-site is a short, unique sequence, amplified by PCR, which identifies a known location on a chromosome. To date all STSs have been derived from well characterized DNA probes or sequences. STS primers can be developed from sequence data of previously published DNA sequences.

T. Blake, Montana State University, provided a set of 28 STS primers between 18 and 22 base pairs long. STS primers enable more stable and repeatable products in PCR amplifications even though polymorphisms between parental lines are reduced.

The cross Tadmor x Wi2291 was screened with STS primers for polymorphism, only a few primers revealed differences between the parental lines (Fig. 21). A much bigger number of this type of primer has to be produced to become useful in a breeder-friendly approach of marker-assisted selection.

Fig. 21. STS primer analyses of Tadmor and WI2291. From the left to the right *(bottom part of the gel)*: Primer pair TB14/KV14 used in PCR amplification with Tadmor lane 1, WI2291 lane 2, primer pair ABG20 with Tadmor lane 3 and WI2291 lane 4, etc.

7.4. DH-Line Production in Barley Using Anther Culture

In previous years ICARDA produced successfully Double Haploids in wheat using anther culture and in barley using crosses with *Hordeum bulbosum*. Even though producing DH-lines in barley through anther culture is currently difficult, the potential application for routine DH production urged us to investigate the possibility of this technique.

The ideal mapping population for polygenic traits are double haploid populations. WI2291 has shown a good *in vitro* response whereas Tadmor is recalcitrant (Dr. A. Gland, pers. communication). In an first experimental cycle F1 anthers were cultured *in vitro* using three different regeneration media. Though numerous calli were produced all regenerated plants were only albinos. Using Dissa, a german barley cultivar known for good *in vitro* response to optimize culturing conditions, plants were successfully regenerated and chromosomes were doubled by colchicine treatment.

A new Tadmor x WI2291 cycle has started using different media (Dr. A. Comeau, Agriculture Canada). The initial *in vitro* response of the cross has been improved greatly (Fig. 22). - **M.Baum, A. Glan, A. Comeau**

Fig. 22. Induction of barley embryogenic calli on tissue culture media. Anthers were obtained from F1 hybrids of the cross Tadmor x WI2291. Induction of calli was observed three weeks after anthers were plated and kept in the dark at 25^{0}C.

7.5. Transfer of Hessian Fly Resistance to Durum Wheat

Hessian fly is a major biotic stresses for durum producers in North Africa and resistance is lacking. Hessian fly resistance occurs in mainly tetraploid *Aegilops* species. To transfer this resistance to *T. turgidum* var. *durum* a wide crossing program has started between INRA/INAV Morocco and ICARDA.

To broaden the genetic base of Hessian fly resistance in durum wheat 150 accessions of mainly *Aegilops ovata* and *A. triuncialis* were screened. Individual Plants have to be screened because individuals vary in their resistance towards Hessian fly. Resistant plants at Settat, Morocco, have been crossed with durum and bread wheat. Sixty crosses have been made but, as expected, seed set was low. From 19 hybrid seeds, embryos were excised and cultured on a MS media. Eleven hybrid plantlets were regenerated. Root-tips chromosome analysis verified that they are hybrids. Information was also obtained on the vernalization and day-length requirements of the wild *Aegilops* species. In the second crossing cycle heading dates for *Aegilops* and durum-bread wheats were better synchronized to enable a higher crossing success. - **M.Baum, M.N. Nachit, M. van Slageren, A. Comeau, O. Belhabib, N. Nassrallah**

7.6. Application of Molecular Marker Technology to Durum and Barley Improvement

In a collaborative research program between ICARDA/Cornell-University and INRA-Montpellier, the diversity of the Mediterranean durum germplasm was assessed using RFLPs and morphophysiological traits.

7.6.1 QTL Mapping of Agronomic Traits in Barley

An RFLP map of the Proctor x Nudinka barley cross was developed at Cornell University by Dr. M. Heun. A total of 113 anther-culture derived double haploid lines of this cross have been evaluated for Quantitative Trait Loci (QTL). Fourteen traits were measured in Syria in 1991, 1992 and Ithaca in 1992. Mapmaker/QTL software was used to identify QTL loci. QTLs were found for plant vigor, growth habit, tillering, powdery mildew reaction, rust reaction and test weight. No QTL were detected for leaf color, awn length and spike fertility at ICARDA in 1991. In 1992, 6 loci were detected for spike fertility. At Ithaca in 1991, QTL were detected for heading date, plant height and grain yield, while in 1992 QTL were only detected for test weight, height and grain yield. Chromosome 2 had the most significant loci while chromosome 6 had the fewest. Chromosome 2 most likely has important loci for vigor, growth habit, tillering, heading date, maturity, plant height, spike fertility, mildew resistance, test weight and grain yield. - **M. Baum, M.N. Nachit, M. Heun, M. Sorrells**

7.6.2. Association of Morphophysiological Traits in Durum Wheat with RFLP Markers

Twenty five durum wheat genotypes from CIMMYT/ICARDA program were analysed for morphophysiological traits and RFLPs at ICARDA, INRA-Montpellier and Cornell-University. A 1-9 scale was used for the morphophysiological traits (Table 76). For RFLP analysis, clones of the Cornell barley library cDNA (BCD), oats (CDO) and wheat genomic (WG) libraries were used. The genotypes were analyzed with 39 probes for their respective RFLP pattern. They gave rise to 132 polymorphic bands. The 25 genotypes were divided into two populations according to the presence or absence of each RFLP marker.

Table 76. Traits (morphological and morphophysiological) that are associated with RFLP markers in durum wheat

Trait/ RFLP marker	Population means presence	absence	difference
Leaf rolling index			
BCD348m	2.01	3.60	-1.59**
Canopy temperature			
CDO1406c	1.44	2.44	-1.00*
Chl. flu. inhibition			
BCD758g	58.52	39.50	19.02***
Leaf water potential			
BCD758g	-2.18	-1.97	-0.16**
Proline content			
BCD758g	141.80	90.52	51.28**
Awn length			
BCD348c	4.33	5.91	-1.58*
Peduncle length			
BCD782c	5.89	7.33	-1.44***
Early growth vigor			
BCD758g	6.00	8.25	-2.25**
Spike fert. under stress			
BCD348j	5.27	6.20	-0.93**
Kernel weight			
BCD342i	51.13	46.32	4.81*
Grain yield (kg/ha)			
CDO395b	3091	2487	604*
CDO395c	2487	3091	-604*
BCD1661e	2241	2730	-489*

Some markers were associated with grain yield under dry conditions and with morphophysiological traits for drought tolerance. The presence of the RFLP marker CDO395b and the absence of CDO395c and BCD1661e in a genotype were associated with high grain yields. RFLP markers are particularly useful when evaluating plant traits that are highly affected by environmental variation. Several RFLP markers were found to be associated with physiological traits related to drought tolerance: leaf water potential, canopy temperature, chlorophyll inhibition and proline content. Surprisingly, some markers were associated with more than one trait, e.g. BCD758g was associated with chlorophyll fluorescence inhibition, leaf water potential and proline content.

The associations found are not linkages between the trait and the markers. True linkages have to be determined in segregating populations using linkage analysis. Nevertheless, the associations found preselect the numerous markers available and indicate possible linkages. - **M.N. Nachit, M.Baum, P. Monneveux, M. Sorrells**

8. COLLABORATIVE RESEARCH

8.1. Maghreb Region Program Report

8.1.1. Introduction

The Cereal Improvement Program's support to the Maghreb NARS varies between countries. In Morocco and Tunisia, advantage was taken of the prevailing climate stresses and related biological and abiological constraints to identify superior germplasm. Ties between the various research and education institutions in regional disease and insect surveys and in training were strengthened. In Algeria and Libya, the main activities involved planning and implementation of research and related activities, and on-the job training of junior research workers. The activities of the 1992-93 season can be summarised as follows:

a. Technical support to cooperative regional improvement research within barley and wheat breeding and diseases networks.

b. Building national cereal research capacity through guidance and staff development.

c. Arranging the exchange of data and nurseries.

d. Organizing regional meetings and travelling workshops.

e. Accelerating transfer of improved technology to farmers.

f. Establishing an inter-regional variety testing network.

8.1.2. Seasonal Conditions

The 1992-1993 season was particularly unfavorable for crop growth. The four Maghreb countries usually grow ten million hectares of small grains annually; however, due to the severe drought in Morocco and western Algeria, the area planted in 1992-93 was about eight million hectares, and the area harvested still less. Average yields were generally low, except in some areas of northern Tunisia and north eastern Algeria, and from irrigated fields (around 400,000 hectares). Drought and damage caused by Hessian Fly, Sawfly, BYDV and Russian Wheat Aphid, resulted in very poor crops in the western half of North Africa. Production in Morocco and Algeria was a low 2.0 million ton each as compared to an average of 3.5 and 6 million tons for Algeria and Morocco, respectively. In Tunisia, early rainfall was accompanied by below average temperatures (November to March), while April and May were dry and warm. Nevertheless, Tunisia's grain (around 2.0 million tons) and straw production was above average. In Libya, barley area expanded further into traditional wheat growing areas and covered some 85% of the total cereal acreage. There, weather conditions were good in Eastern Jabal Akhdar region, but drier and warmer than average elsewhere.

Impact of improved agronomic practices throughout North Africa are the highlights of this season. This has made it possible for small farmers to harvest a crop in areas where less than a decade ago, similar stresses resulted in crop loss. The biggest advances were obtained in Algeria, through weed control and fertilizer use.

8.1.3. Regional Cooperation

8.1.3.1. Breeding Activities

Table 77 shows the types of nursery and their distribution in North Africa. Maghreb Cooperative Trials (MCT) are a new addition. They were assembled to allow a better choice for imports of seed of commercial cultivars from one country to another in years of drought and to expose national varieties to a wide range of testing environments across North Africa. These joint variety and site-characterization trials were assembled for bread wheat, durum wheat and barley. There were three testing sites per country. The trial will be maintained for two consecutive seasons prior to changing entries, to get reliable data.

Excluded from this table, is the nursery CDMN. The responsibility for its preparation and distribution now rests with network leaders in UNDP project on Disease Surveillance and Germplasm Enhancement. POM (Pépinière d'Observation Maghrebine) bread wheat, durum wheat and barley, however, included groups of lines having septoria, tan spot and net blotch resistance, respectively.

Table 78 lists the most promising genotypes identified as valuable germplasm or for future release to farmers. It shows that in Algeria and Libya , in particular, the bulk of the germplasm is coming from introduced nurseries.

Table 79 lists the varieties released by the national programs. Table 80 shows that seed and insect transmitted diseases can be very important in dry years. They were identified by surveys in the region. These five tables give a broad overview of the regional breeding activities in North Africa.

Table 77. Nursery distribution in North Africa 1991/92.

Country/ site	Nursery(1)								
	POM			MCT			H.F	Sept.	BYDV
	B	D	W	B	D	W			
ALGERIA									
Khroub	x	x	x	x	x	x	x	x	x
SB Abbes	x		x	x	x	x			
Tiaret				x	x	x			
Guelma								x	
El-Harrach								x	x
LIBYA									
Khoms					x	x	x	x	
El Marj					x				
Zahra		x		x	x	x			
Azizie	x		x	x		x			x
Fataeh				x					
MOROCCO									
MCH	x	x	x	x	x	x	x	x	x
J.Shaim	x	x	x	x	x	x	x		x
Tassaout	x	x	x						x
Douyet	x	x	x	x	x	x	x	x	
Annoceur	x	x	x	x	x	x			x
TUNISIA									
Beja	x		x	x	x	x	x		
Kef	x			x	x	x	x		
Mornag								x	x
Tajerouine				x	x	x			

(1) Pépinière d'Observation Maghrebine (POM): The POM provides elite germplasm from Morocco, Tunisia and Algeria. These POM are important in distributing local, adapted germplasm from NARS. Many lines were selected for further testing. H.F. and Sept nurseries carry specific resistance to hessian fly and septoria, respectively. These were also supported by the UNDP project. Some of these nurseries were also grown at ICARDA Tel Hadya, in Syria. B = Barley, D = Durum, W = Wheat.
MCT = Maghreb Cooperative Yield Trials.

Table 78. List of promising genotypes identified by each country from exchanged germplasm for further testing or as valuable parental material.

Country	Barley	Durum wheat	Bread wheat
TUNISIA	31 BSNNA lines Orge 1255 (CRG 13/CRG 133)	Stn/OMR.SH Stn/Gote	BT 2715=Attila CM85836 Kea"S"/4/Kvz/3/Cc/Inia Cno/Elgan/Sn64= (ICW84)
	Lignee527/NK1272 (ICB 84-323)	Stn/Agia	Cno67/Mfd/Mon"s"/3/ Seri=(WON 90/91ICARDA)
	Lignee527/3/ Harbing/Avt//Aths	Stn/Fg//ALTAR	Lira"S"/Buc"S"/ Pvn"S"=(CM 88143)
		Golo 512/Cit// Ruff/Fg/3/DWL	HD2206/Ho"z"//Buc "s"/Bul"s" 5023 (CM88500)
		OMR SH/Rabi/ Gs/Cit CHEN/OMR.SH OMR 16/Gerou 1 OMR 15/Ru Awl 2/Bit	Hahn*2/Prl"s" CM43598
ALGERIA	SLB 47-81 WI 2291//M2q/DL71	AJAIA 5	Vee"S"/Lira"S" AJAIA 11Van"S"//Bb/Kal
		Shwa3/Ptl/5/ Shap/21563...	Bow"s"/Crow"S"//Gamam
			Pvn"S"/Sprw"S" Vee"S"/Nac Vee"S"/Ghs Fch 3/Sni//Nkt
LIBYA	Aths/lignee 686 Mari/Aths Kanthara Moroc 9-75	Om-Rabi 5 Om-Rabi 9 ACSAD 299	Acsad 574 Zahra 4 Zahra 314
MOROCCO	**BSNNA:** 5-8-33-34- 37-54-55-61-62-63- 64-98-115-175-176-	Om-Rabi 5	# 3: Lancofen/Chova's' 98-Prl's'
	185-203-226-235- 248-249-275-328	Aconchi 89	# 6: Mrng/Aldan's'/249 Sara
		CHEN/ALTAR 84	# 38:HD2206/Hork's'// Buc's'/Bul's',
	NA-BYT: 28-42-48- 54-64-70-105-108- 125-127-128-133-		# 85: HD2206/Hork's'// Buc's'/Bul's'
	144-146-147-154- 179		# 147:And"s"/HN4/Coc

Table 79. Varieties released by National Programs in 1992-1993.

Country	Barley	Durum Wheat	Bread Wheat
Algeria	Dahbia	HOGGAR	ZIBAN
	RIHANE 03	HIDDAB	MIMOUNI
	NAILIA	CHEN"s"	AIN ABID
	HAMRA	KEBIR	SIDI OKBA
	ACSAD 60		
Libya	ARIG 8		
	ER/APAM		KARIM
	WI 2291		MARZAK
Morocco	Cr279/07/Bgs	INRA 1749	BT90-I-112
		INRA 1750	DR.88/154
		INRA 1751	Potam*3/Ks81126-5
		Yav*2/Sapi//Sln3	Saiss*3/Ks14-2
		T.Turgidum/3/AA/G/CC/ Bit	
		D67-3/Gta//Boyero/Bit //Mex	

Table 80. Incidence of major diseases and pests in the Maghreb countries in the 1992-93 growing season[1].

	Diseases and pests2											
	NB	PM	SD	LS	CS	YR	ST	TS	BYDV	H.F	SF	RWA
Algeria												
B	xx	x	xxx	xx	x				xx			xxx
DW						x	x	xx		x	xx	x
BW						x	xx			xx	xx	
Libya												
B	x	xxx	xxx	xxx	xxx				xxx			x
DW						x		x				
BW						x	x					
Morocco												
B	x	xxx	x						xx	x		xx
DW						x	x	xx	x	xx		
BW						x	xx			xxx		x
Tunisia												
B	xx	xx							x			
DW		xx				x	xx	x				
BW						x	xxx			x	xx	

1. Severe drought North Africa experienced in 1992-93 season, has shown that seed and insect transmitted diseases were prevalent on all cereals. In addition, PM and NB on barley, ST and TS of wheat remain the most widespread diseases even in dry years. Disease incidence: x = Small; xx = moderate; and xxx = heavy.
2. NB = Net Blotch; PM = Powdery mildew; SD = Barley stripe disease; LS = Loose smut; CS = Covered smut; YR = Yellow rust; ST = Septoria; TS = Tan spot; BYDV = Barley Yellow Dwarf Virus; H.F = Hessian Fly; SF= Sawfly; RWA = Russian Wheat Aphid.

8.1.4. Other Activities

8.1.4.1. Cereal Travelling Workshop

Two barley scientists each from Morocco, Tunisia, Algeria and Libya and two ICARDA scientists participated in a barley Travelling Workshop organized during the first week of April 1993 in Tunisia. The classical Cereal Travelling Workshop has been replaced by a barley Travelling Workshop to take advantage of the presence of barley workers, gathered by ICARDA to finalize the new strategy in collaborative barley development for North Africa. Barley workers carried out selection on national, international and ICARDA special barley nurseries for North Africa at Beja, Le Kef, Mornag, Tajerouine and Foussana sites.

8.1.4.2. Barley Development for North Africa

This second year of testing special six-row barley nurseries developed by ICARDA for North Africa, has confirmed the first year's conclusions, and has allowed a larger percent of lines to be selected, because of selection done in target environments and to capitalizing on the specific types of climates and stresses in North Africa. Timely note taking, selection, and data return to Aleppo facilitated the shift from the old system of germplasm generation to the new one.

8.1.4.3. Technology Transfer

This activity has become a major thrust of cereals research across Maghreb. A large number of farmers field demonstration trials have been planted.

Routine verification of newly developed cultivars and related practices have also expanded, because of additional support from IFAD project on technology transfer.

Large multiplications of most widely grown as well as newly developed cultivars have been carried out under rainfed and full irrigation. The largest multiplications were in Libya.

Supplementary irrigation studies have expanded. They confirmed greater benefits from one irrigation at tillering than at heading or grain fill. Moreover, supplementary irrigation of cereals proved more profitable compared to other traditional cash crops.

The following practices proved significantly superior to traditional farmer practices.

- Earlier maturing, newer genotypes were superior to older ones in both high and low fertility environments as demonstrated by on-farm verification trials (64 sites)
- Weed control and fertilizer application helped small farmers get a harvestable crop in dry 1992-93 season. Total crop failures were experienced by farmers in similar years of drought.
- High seed rates and legumes as previous crops (except chickpeas) were better than low seed rates and weedy fallow.

8.1.4.4. Characterization of Cereal Collections

The financial support coming from the UNDP project on disease surveillance and germplasm enhancement, enhanced the building of complementary networks and consolidated inter-country regional cooperation. During 1992-93, ICARDA-Maghreb NARS cooperation was targeted at identification of sources of resistance to the most prevalent pathogens on durum wheat:

- 1130 accessions from the world collection were screened for Tan spot in Morocco and sources of resistance were identified (See Table 81).
- 3000 North African durum accessions and 1140 accessions from world collection were evaluated for resistance to Hessian fly and root rots. No resistance to Hessian fly was found but several accessions were tolerant to root rots.

8.1.5. Training

In addition to training at ICARDA headquarters, Cereal Program continued to encourage mutual scientific support and helped Moroccan and Tunisian scientists train a large number of junior staff from Maghreb countries in specialized courses including, inoculum preservation of *Helminthosporium tritici repentis*; wheat insect transmitted disease identification and scoring; characterization of BYDV isolates; and leaf rust virulence analysis.

Training at Aleppo was complementary to in-the region training. It covered cereal improvement (3 trainees); DNA molecular marker techniques (2); insect control in legumes and cereal crops (3); use of electrophoresis in germplasm evaluation (3), as well as the training of a Libyan mechanical engineer in harvesting equipment maintenance and repair.

Table 81. New sources of resistance identified in the region.

Crop species	Diseases	Source of resistance
Barley	NB	Asni; CI9699; CI9820; NDB112; CI10379
	BYDV	Th. Unk 23 Giza 121/Co.6248/4/Apm/CM67/3/ Pro//Sv.0404/Mari
	Leaf Rust	Harma o2//11012/CM67
	Yellow Rust	Lignee 527/NK1272
Durum Wheat	*F.gramineum*	Om-Rabia
	Tan spot	HB1149; ST-6; Erik; Salamouni;
Bread Wheat	Septoria	POM92 BW#24 Tob"s"/8156//450E/Kal/4/ MRS//Kal/Bb/$A2_2$ Tegyey Bow"s" Achtar
	Leaf rust	Khair Marchouch

8.1.6. Other Activities

a. Biotechnology research had started in the Maghreb with support from ICARDA Cereal Program. Activities were initiated in three areas:

   - Embryo rescue in Durum wheat x Aegilops crosses for H. fly resistance
   - Haploid production in durum
   - Variability for androgenesis of local durum wheat germplasm

b. Another dry season permitted excellent screening for salt stress. Research on salt tolerance identified the major types of salts encountered in the dry southern areas, and their relative effect on germination, growth and development of wheat, barley and triticale.

c. The line Annoceur "Rihane" continued to perform well and few lines produced higher yield. This well adapted check allows effective selection for the mountain regions where cold and terminal heat stresses predominate.

d. Good study of the Barley Gall Midge biology, and effect on barley as well as screening of local collections has been carried out, within the framework of a Ph.D. thesis research.

e. Constraints to the adoption of new barley varieties were researched. Preliminary results indicated that adoption is more widespread than currently presumed; that farmers appreciated most varieties which combine high grain yield with suitability for human consumption and high straw yield; farmers access to certified barley seed of the new varieties was the key constraint to rapid adoption. - **M.S. Mekni**

9. TRAINING AND VISITS

Training supported by CP over the last 10 years is listed in Table 82.

Table 82. Number of participants in various training courses 1984 - 1993.

	Type of training				
	Residential	Individual			
Year	(long-term)	Non-degree	Degree	Short*	In-country*
1984	8	7	2	36 (2)	20 (1)
1985	15	8	4	49 (2)	47 (1)
1986	18	14	4	15 (1)	44 (2)
1987	12	18	8	29 (2)	88 (3)
1988	18	18	14	41 (4)	57 (2)
1989	18	19	12	31 (4)	91 (3)
1990	20	23	13	44 (4)	47 (3)
1991	11	11	9	34 (3)	70 (3)
1992	13	11	7	46 (4)	36 (2)
1993	14	25	5	22 (2)	10 (1)

* Number of courses in parentheses

9.1. Headquarters Courses

9.1.1. Short courses

Two specialized courses offered in 1993 were conducted with other ICARDA programs.

9.1.1.1. DNA Molecular Marker Techniques for Germplasm Evaluation and Crop Improvement

The joint course (19-30 September) by the Cereal and Legume programs is supported by the United Nations Development Program (UNDP) biotechnology project and ICARDA. There were 12 participants from 9 countries (Table 83) and one instructor from Germany. The course introduced theoretical and practical aspects of DNA Molecular Marker Techniques (RFLP, PCR) and their application to germplasm identification, evaluation and improvement.

Table 83. List of Participants in "DNA Molecular Marker Techniques" Course, 1993.

Participants	Title	Degree	Country
Ms. Aid Aini	Biologist	Ph.D	Algeria
Mr. Mohamed Cherquaoui	Researcher	MS.c	Morocco
Mr. Ahmed A. El Sidiq	Researcher	MS.c	Sudan
Mr. Frew Mekbib	Lecturer	MS.c	Ethiopia
Mr. Ismail Kusmenoglu	Ph.D Student	MS.c	Turkey
Mr. Mohamed Labdi	Ph.D Student	MS.c	Algeria
Mr. Sami Said Adawy	Res. Assistant	MS.c	Egypt
Mr. M. Imad Eddin Arabi	Researcher	Ph.D	Syria
Ms. Roba Ismail	Assistant Prof.	Diploma	Syria
Ms. Ouafae Benlhabib	Lecturer	Ph.D	Morocco
Ms. Mejda Cherif	Res. Assistant	MS.c	Tunisia
Ms. Farhat Fatima Jamil	Researcher	Ph.D	Pakistan

9.1.1.2. Use of Electrophoresis in Germplasm Evaluation

This course conducted from 10-21 October had participants from 8 countries (Bulgaria, Egypt, Lebanon, Morocco, Syria, Tunisia, Turkey and Yemen). The course was conducted jointly with Legume Program and Genetic Resources Unit of ICARDA. The course offered participants theoretical and practical knowledge of electrophoresis in general and its use for improvement in cereals and legumes in particular.

9.1.2. Long Term Course

The long term course continues to meet the need of WANA countries for training in barley and wheat improvement for stress environments (breeding, pathology, physiology, entomology, grain quality, seed production, research techniques and applied statistics and experimental design). The course objectives are achieved through lectures (25%), field work, seminars, discussions and assigned research projects. The course (1 March - 30 June 1993) was attended by 14 researchers from 9 countries (Algeria, China, Ethiopia, Libya, Iran, Oman, Sudan, Syria and United Arab Emirates).

9.1.3. Individual Training

Individual non-degree training in specific areas was provided to 25 researcher from 11 countries (Algeria, Egypt, Lebanon, Libya, Iran, Morocco, Pakistan, Sudan, Syria, Tunisia and Turkey) who spent periods from 2 weeks to 5 months in wheat or barley breeding, disease or insect control, physiology and data analysis. Most of these trainees conducted a research project in collaboration with an ICARDA scientist (Table 84).

Five students continued Ph.D or MS.c research at ICARDA under supervision of CP scientists. Several final year undergraduates from universities in the region were trained in breeding, cereal pathology, entomology and grain quality as part of their graduation project. They spent upto 4 months in the Cereal Program.

Table 84. Specialized non degree individual training at the Cereal Improvement Program, ICARDA, 1993.

Subject	No. of participants	Duration	Country
Barley breeding for high elevation	1	6 weeks	Morocco
Barley breeding	1	5 months	Syria
Durum wheat breeding	1	5 months	Syria
Bread wheat breeding	1	5 months	Syria
Bread wheat breeding	1	1 month	Egypt
Wheat diseases	1	3 months	Syria
Barley diseases	1	3 months	Syria
Wheat diseases	1	4 months	Pakistan
Barley pathology	2	3 months	Lebanon
Barley pathology	1	1 month	Turkey
Disease scoring	1	2 weeks	Syria
Cereal entomology	1	2 months	Lebanon
Cereal insects	1	3 months	Syria
Cereal physiology	1	5 months	Syria
Wheat physiology	1	2 months	Sudan
Barley physiology	1	1 month	Egypt
Cereal improvement	1	2 months	Turkey
Variety description	2	3 weeks	Syria
Data analysis	1	2 weeks	Tunisia
Data analysis	1	2 weeks	Turkey
Data analysis	1	2 weeks	Algeria
Use of electrophoresis	1	1 month	Iran
Harvest machinery	1	1 month	Libya

9.2. Training In The Region

A regional course was conducted in Egypt in collaboration with NARS in Nile Valley region. This course focussed on cereal disease research methodology with emphasis on cereal rusts (examination, identification, collection, purification, preservation, multiplication and inoculation, breeding for resistance, etc.). The course (28 March - 6 April 1993) was attended by 10 researchers from Ethiopia, Egypt and Sudan.

9.3. Visits

More than 300 students and scientists visited the Cereal Program for orientation on program activities or to discuss collaborative research and results with program scientists. Visiting scientists worked in the Cereal Program for one year or more; one scientist from India worked on cereal physiology, another on nematode distribution in Syria; one scientist from Egypt worked on bread wheat breeding, and one post doctoral fellow from Lebanon on barley pathology; one scientist from Russia worked in the program within the framework of the collaboration between Krasnodar Institute and ICARDA, and a further 60 senior visitors or consultants visited the program for various periods of time to get acquainted with ICARDA activities. **- H. Ketata, M. Nachit, A. Sabouni**

10. PUBLICATIONS

10.1. Journal Articles

Craufurd, P.Q., Flower, D.J., and **Peacock**, J.M. 1993. Effect of heat and drought stress on sorghum (*Sorghum bicolor* L. Moench). 1. Panicle development and leaf appearance. Experimental Agriculture 29:61-76.

Craufurd, P.Q., and **Peacock**, J.M. 1993. Effect of heat and drought stress on sorghum (*Sorghum bicolor* L. Moench). 2 Grain yield. Experimental Agriculture 29:77-86.

Dakheel, A.J., **Naji** I., **Mahalakshmi**, V. and **Peacock**, J.M. 1993. Morphophysiological traits associated with adaptation of durum wheat to harsh Mediterranean environment. Aspects of Applied Biology. 34: 297-307.

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Simane, B., **Peacock**, J.M., and Struik P.C. 1993. Differences in developmental plasticity and growth rate among drought-resistant and susceptible cultivars of durum wheat. Plant and Soil 157:155-166.

Simane, B., Struik, P.C., **Nachit**, M.M., and **Peacock**, J.M. Ontogenetic analysis of yield *components* and yield stability of durum wheat in water-limited environments. Euphytica 71:211-219.

Singh, M., **Ceccarelli**, S. and **Hamblin**, J., 1993. Estimation of heritability from varietal trials data. Theor. Appl. Genet. 86: 437-441.

Tahir, M., and Singh, M. 1993. Assessment of screening techniques for heat tolerance in wheat. Crop Science 33: 740-744.

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Van Oosterom, E.J., Kleijn, D., **Ceccarelli**, S., and **Nachit**, M.M., 1993. Genotype x environment interactions of barley in the Mediterranean region. Crop Sci. 33:669-674.

Van Oosterom E.J., and **Peacock**, J.M. (1993). Apex development patterns: the physiological basis to adaptation of barley to harsh Mediterranean environments. Aspects of Applied Biology 34:289-295.

10.2. Conference Papers

Banisadr, N. and M. **Tahir**, 1993. Heat and cold tolerance in *Triticum aestivum* L. and *T. turgidum* var. durum from Iran. 8th International Wheat Genetic Symposium - Beijing, China.

Ceccarelli, S., 1993. Plant breeding technologies relevant to developing countries. In : "Animal Production in Developing Countries", (M. Gill, E. Owen, G.E. Pollot and T.L.J. Lawrence, eds) Occasional Publication No.16 - British Society of Animal Production, pp 37-46.

Damania, A.B., Pecetti, L. and **Kashour**, G., 1993. Salinity tolerance in genetic resources of wild *Triticum* species. In: International Wheat Genetic Symposium, 20-25 July, 1993. Beijing, China. pp. 6.

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Tahir, M. 1993. Breeding of *Hordeum vulgare* L. for continental Mediterranean environments. 1st Iranian Cong. on Crop Prod. & Breeding. Sep. 6-9, Karaj: 62 (Abstract in Persian).

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Van Leur, J.A.G, Bailey, K., and Sikora, R. 1993. Survey for barley root diseases in Northern Syria. 6th International Congress of Plant Pathology, Montreal, Canada.

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Impiglia, A., **Nachit**, M.M., Lafiandra, D., and Porceddu, E. 1993. Relationship among 81 genotypes based on RFLPs, gliadin and glutenin components effect on gluten Strength in durum wheat. Seminar on Durum Wheat Quality in the Mediterranean Region, Zaragoza, Spain, 17-19 November.

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Vivar, H.E., 1993. The role of ICARDA in international barley improvement. In 15th North American Barley Research Workshop and Barley *Genome Mapping Workshop*. Guelph, Ontario, Canada. July 11-15.

Weigand, F., **Baum**, M., and Udupa, S. 1993. DNA molecular marker techniques. Technical Manual No. 20, ICARDA, Syria.

11. CEREAL VARIETIES RELEASED BY NATIONAL PROGRAMS.

Country	Year of release	Variety
Barley		
Algeria	1987	Harmal
	1992	Badia
Australia	1989	Yagan
	1991	High
	1993	Kaputar
	1993	Namoi
Bolivia	1991	Kantuta
	1993	Kolla
Brazil	1989	Acumai
Canada	1993	Falcon
Chile	1989	Leo
	1989	Centauro
China	1988	Shenmai 1
	1989	V-24
Cyprus	1980	Kantara
	1989	(Mari/Aths*)
Ecuador	1989	Shyri
	1992	Calicuchima-92
	1992	Atahualpa-92
Ethiopia	1981	BSH 15
	1984	BSH 42
	1985	Ardu
Iran	1986	Aras
	1990	Kavir
	1990	Star
Jordan	1984	Rum (6-row)
Kenya	1993	Ngao
Libya	1992	Wadi Kuf
	1992	Wadi Gattara
Morocco	1984	Asni
	1984	Tamellat
	1984	Tissa
	1988	Tessaout
	1988	Aglou
	1988	Rihane
	1988	Tiddas
Nepal	1987	Bonus
Pakistan	1985	Jau-83
	1987	Jau-87
	1993	Jau-93
	1987	Frontier 87
Peru	1987	Una 87

Country	Year of release	Variety
Barley		
Peru	1987	Nana
	1989	Bellavista
Portugal	1982	Sereia
	1983	CE 8302
	1991	Ancora
Qatar	1982	Gulf
	1983	Harma
S. Arabia	1985	Gusto
Spain	1987	Resana
Syria	1987	Furat 1113
	1991	Furat 2
Thailand	1987	Semang1
	1987	Semang2
Tunisia	1985	Taj
	1985	Faiz
	1985	Roho
	1987	Rihane"S"
	1992	Manel 92
Vietnam	1989	Api/CM67//B1
Yemen AR	1986	Arafat
		Beecher
Durum wheat		
Algeria	1986	Sahl
	1986	Waha
	1991	Korifla
	1992	Omrabi 6
	1982	ZB S FG'S'/LUKS GO
	1984	Timgad
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
Jordan	1988	Korifla=Petra

Country	Year of release	Variety
Durum wheat		
Jordan	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
	1985	Fazan
	1992	Khiar 92
Morocco	1984	Marzak
	1989	Sebou
	1989	Om Rabi
	1991	Tensif
	1992	Brachoua
	1992	Omrabi 5
Pakistan	1985	Wadhanak
Portugal	1983	Celta
	1983	Timpanas
	1984	Castico
	1985	Heluio
Saudi Arabia	1987	Cham 1
	1983	Mexa
	1985	Nuna
Syria	1984	Cham 1
	1987	Cham 3
	1987	Bohouth 5
	1992	Omrabi 3
Tunisia	1987	Razzak
Turkey	1984	Susf bird
	1985	Balcili
	1988	EGE 88
Bread wheat		
Algeria	1982	Setif 82
	1982	HD 1220
	1992	Zidane
	1992	Nesser
	1992	Cham 4=Sidi Okba
	1992	Siete Cerros=Rhumel

Country	Year of release	Variety
Bread wheat		
Algeria	1992	Alondra=21AD
	1992	DouggaXBJ=Soummam
	1992	ACSAD 59=40DNA
Egypt	1982	Giza 160
	1988	Giza 162
	1988	Giza 163
	1988	Giza 164
	1991	Gammeiza 1
	1988	Sakha 92
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
Jordan	1988	NASMA=Jubeiha
	1988	L88=Rabba
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
Syria	1984	Cham 2

Country	Year of release	Variety
Bread wheat		
Syria	1986	Cham 4
	1987	Bohouth 4
	1991	Cham 6
	1991	Bohouth 6
	1992	Gomam
Tanzania	1983	T-VIRI-Veery 'S'
	1983	T-DUMA-D6811-Inrat
	1983	69/BD Tunisian release.
Tunisia	1987	Byrsa
	1987	Salambo
	1992	Vaga 92
Turkey	1988	Kaklic 88
	1988	Kop
	1988	Dogu 88
	1989	Es14
	1990	Yuregir
	1990	Karasu 90
	1990	Katia 1
Yemen AR	1983	Marib 1
	1988	Mukhtar
	1988	Aziz
	1988	Dhumran
Yemen PDR	1983	Ahgaf
	1988	SW/83/2

12. STAFF LIST

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Dr. Ross Henry Miller	Cereal Entomologist
Dr. John Michael Peacock	Cereal Physiologist
Dr. Mohamed Tahir	Winter Barley Breeder
Ir. Joop A.G. van Leur	Barley Pathologist
Dr. Franz Weigand	Biotechnologist
Dr. Guillermo Ortiz-Ferrara	Bread Wheat Breeder (CIMMYT-Liaison)
Dr. Miloudi Nachit	Durum Wheat Breeder (CIMMYT)
Dr. Thomas Stewart Payne	Winter Wheat Breeder (CIMMYT)
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Mr. Issam Naji	Agronomist
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Mr. Mohamed Mushref	Research Assistant
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Mr. Izzat Ghannoum	Senior Research Technician
Mr. Haitham Sayed	Senior Research Technician
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Mr. Zuhair Haj Younes	Research Technician
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Mr. Salem Farrouh	Research Technician
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Mr. Ala'a Yaljarouka	Research Technician
Mrs. Wafa Haj Juma'a	Research Technician
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Mr. Abdalla Steif Abdalla	Assistant Technician
Mr. Obeid El-Jasem	Farm Labourer
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Ms. Raghad Rahwan	Secretary
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Visiting Scientists:

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Dr. V. Mahalakshmi	Physiology
Dr. Victor Shevtsov[5)]	Winter Barley Breeding
Dr. André Comeau[6)]	Visiting Scientist

1) Left in November 1993
2) Left in December 1993
3) Joined in March 1993
4) Joined in January 1993 and left in October 1993
5) Joined in January 1993
6) Joined in September 1993

* Left in Ocotober 1993
** Left in November 1993
*** Left in December 1993

المركز الدولي للبحوث الزراعية في المناطق الجافة

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