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CEREAL PROGRAM

Annual Report for 1992

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 focuses its research efforts on areas with a dry summer and where precipitation in winter ranges from 200 to 600 mm. 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, and pasture and forage crops and the associated farming systems.

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

CEREAL PROGRAM

Annual Report for 1992

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. Due to the tight production deadlines, editing of the report was kept to a minimum.

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1. Introduction

The cereal program has spent considerable time during the last year reviewing its objectives and determining its future directions. This is part of the medium term planning process in readiness for the External Program and Management Review which takes place in April-May 1993.

We have concluded we need to continue to produce a range of germplasm with our different collaborators in the region, but we also need to move towards more specific adaptation to the very varied range of abiotic stresses encountered in the region. We will do this within the frame work of no increase, and a possible decrease in resources. Over the next few years we will move towards a greater emphasis on root problems, including root diseases, nematodes and nutrient toxicities. With our partners in the national programs we will test germplasm in earlier generations. This has already commenced and has several advantages. It will improve contacts with national programs and give national programs better targeted material. It will also increase their input into the choice of parents and progeny in our breeding projects and improve the level of specific adaptation in the material to local regional stresses.

To do this without increased resources means we must look at ways of doing things more efficiently, thus freeing up resources so we can take these new objectives on board. We will improve the level of computer data capture and analysis and field mechanization. The resources saved will be used to work on root problems without reducing the emphasis on leaf pests and diseases. Whilst maintaining our work on drought tolerance we will expand work on temperature stress and wind up the agronomy work.

We will reduce the size of our annual report. This lessens the flood of information that threatens to overwhelm everybody. We will give the readers a clear idea of on going projects, present key findings and summarize completed work. We encourage you to contact the scientist(s) concerned directly if you would like further information or germplasm.

Finally I would like to thank our partners in the NARS for their guidance, encouragement, support and data sharing. Without this collaboration we would not be able to function. Thanks are also due to Ms. Sossi Toutounji for her work in preparing the document and all members of the Program for their enthusiastic input towards the goals of the program. - **J. Hamblin**

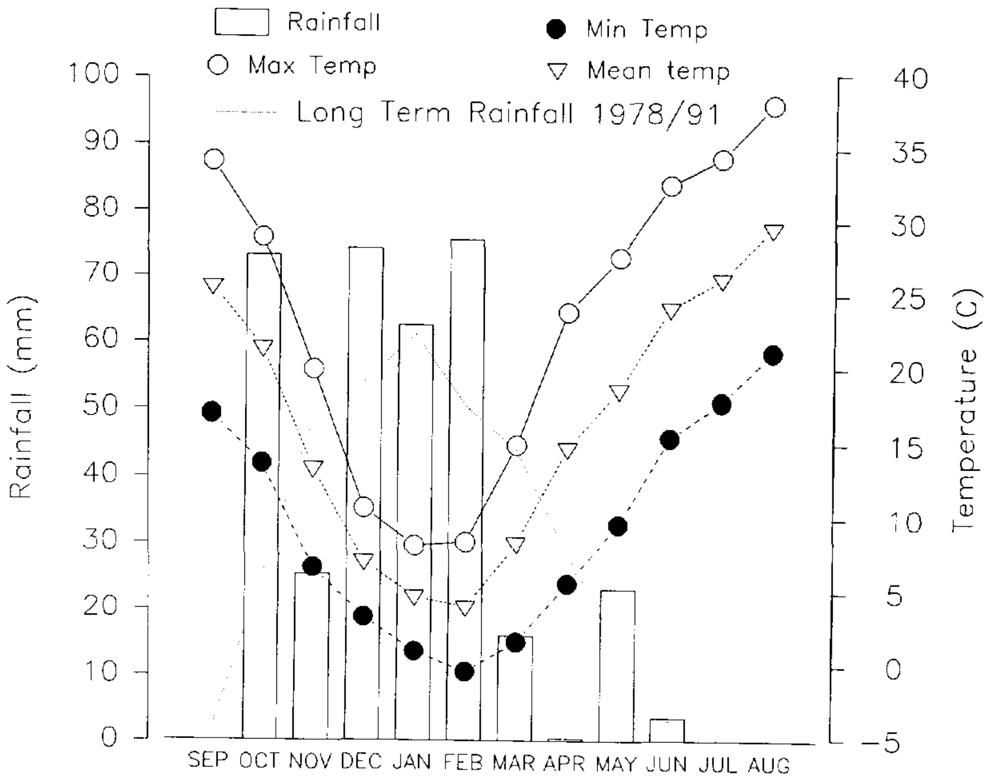

Fig. 1. Tel Hadya Monthly Weather 1991/92

2. Spring Barley Improvement

2.1. Spring Barley Breeding

2.1.1. Introduction

The objective of the barley improvement project is to assist National Program scientists to increase barley production.

Initially the objective was to develop fixed or nearly fixed lines for national program scientists to test and release as varieties. Since 1984 we have emphasized methodologies to use more efficiently the limited resources of national program.

This shift was due to: 1) stress environments represent a major area of barley cultivation, 2) little progress has been made in stress environments, and 3) a centralized breeding program does not cope with the specificity of stresses in different geographical areas.

In 1992 we recognized that a similar shift is justified in favourable environments where biotic stress is the major factor limiting yield factor. Foliar diseases and pests, as well as races of the pathogen and/or pest often differ in different areas.

Therefore, while the structure of the project has not changed, we are decentralizing breeding activities. New germplasm will be yield tested by NARs at an earlier stage than before. This process has started in four north African countries (Libya, Tunisia, Algeria and Morocco) because 1) they represent a large barley growing area (> 4 million hectares) and 2) they grow only six-rowed barley. It is impossible to achieve maximum efficiency when traditional international nurseries contain both two- and six-row germplasm.

The decentralization process is described below. In the medium term, varieties having specific adaptation to local stresses will be identified. This will also free resources for basic studies on adaptation, genotype x environment interaction, heterogeneity and stability, and allow investigation of problems related to root health such as cereal cyst nematodes, boron toxicity, etc.

2.1.2. Barley breeding for the Maghreb Region

Decentralization began in the Maghreb region in 1991 with the distribution of a special six-row barley nursery (see Annual Report for 1991, pg 8). The entries were also evaluated in preliminary yield trials at three ICARDA sites (Tel Hadya, Breda and Bouider). In the Maghreb visual selection occurred, at ICARDA selection was for yield potential, yield under stress, early and late heading. 49 of the 103 entries (47.6%) selected at ICARDA were included in the 154 Maghreb selections (Table 1).

Table 1. Is northern Syria a suitable area to select barley germplasm for Maghreb countries?

Selected In[a]	N	%
Syria	103	35.8
Maghreb	154	53.5
Syria And Magjreb	49	47.6
Syria-Discarded In Maghreb	54	52.4
Maghreb-Discarded In Syria	105	68.2

[a] Initial population size = 288 lines

Of the lines selected in Maghreb 68.2% (105/154) were discarded at ICARDA and of the lines selected at ICARDA 52.4% (54/103) were discarded in the Maghreb. This large proportion of wrongly selected and wrongly discarded lines occurred in a single cycle of selection. All entries were six row and contrasting selection criteria were used at ICARDA. National scientists reacted positively to these results and we have accelerated our new approach to germplasm development for the Maghreb. In consultation with Maghreb scientists the transition between the old system of international nurseries distribution and the new system to develop of specific germplasm for the Maghreb will be implemented through the following steps (Table 2):

Table 2. Developing barley germplasm with specific adaptation to the Maghreb countries.

Year	New Nurseries				Old Nurseries		
90/91	-	-	-	-	BYT	BON	BSP
91/92	SN92	-	-	-	BYT	BON	BSP
92/93	PY93	SN93	-	F_2	BYT	-	-
93/94	AY94	PY93	SN94	F_3-F_4	-	-	-
94/95	NARS	AY95	PY95	SN95	-	-	-

1) 173 lines selected from the special nursery distributed in 1991/92 (SN92) will be tested in 12 locations in 1992/93 as preliminary yield trials (PY93). Lines selected from PY93 will be tested in advanced yield trials (AY94) in 1993/94 and the best lines are expected to enter the national testing systems by 1994/95. This sequence applies to the special nurseries distributed in 1993 (SN93), 1994 (SN94) and so on.
2) A set of 268 F_2's (from 6 x 6 and 6 x 2 crosses) was distributed in 1992 for evaluation as populations in 8 locations. These F_2 populations will be selected visually and single plant selections will be made at Tel Hadya to ensure a common seed source. F_3 families will be increased without further selection at Tel Hadya in 1993/94 and F_2-derived F_4 families will be distributed as the 1995 special nursery (SN95). The SN95 will contain only lines derived from selection within the Maghreb countries.
3) In the spring of 1993 targeted crosses will be designed with national program scientists. Many more crosses than in the past will be made to incorporate resistance to important foliar diseases in north Africa. Resistant parents have been supplied

by Dr. A. Yahyaoui (Ecole Superieur d'Agriculture, Kef, Tunisia) and by Dr. A. Amri, INRA, Morocco). In 1995 F_2 populations from these crosses will be distributed and handled as described in 2. Thus the SN97 will be the first nursery to be specific for the Maghreb Region.

Besides fully exploiting specific adaptation to both abiotic and biotic stresses, two additional advantages expected are: 1) Maghreb expertise particularly in pathology, entomology and virology will be incorporated, into the breeding program. Local scientists will handle segregating populations (F_2 and BC) and generate lines which will then enter the special nursery testing phase, and 2) information will be generated on issues such as selection vs. testing environment, genotype x environment interaction, relationship between yield potential and adaptation to stress, etc.

The ICARDA base-program will 1) make crosses, 2) advance generations (including SSD and possibly double haploid production), 3) produce seed to ensure a uniform seed source, 4) analyze data, and 5) provide coordination.

If successful we will continue to decentralize to other areas. In 1992 we have distributed the first special nursery to the Mashreq region (Syrian, Jordan and Iraq) and we have made a number of targeted crosses for the Arabian Peninsula. A special nursery will be generated for that region in the next two cropping seasons.

2.1.3. Performance of advanced lines

Tables 3 and 4 show the best barley lines in the 1990/91 regional yield trials for five areas.

Table 3. Barley lines outyielding the national check in the Regional Yield Trials 1990-91 in Near East, Arabian Peninsula and Europe.

Region	Country	Pedigree
Near East	Jordan	Soufara-02/3/RM1508/Por//WI2269
		Harmal-02/Roho
		Chaaran-01/WI2291
		Harmal-02/A.Abiad//ER/Apm
		Sawsan/Lignee 527//Arar
		Zambaka
		WI2291/CI 13520
		CI08887/CI 05761//Harmal-02
	Cyprus	Arizona 5908/Aths//Lignee 640
		Harmal-02/A.Abiad//ER/Apm
		Mari/Aths*2//M-Att-73-337-1
		Harmal-02/A.Abiad/3/Api/CM67//Nacta
Arab Penins	Qatar	Arizona 5908/Aths//Lignee 640
	S.Arabia	Lignee 527/NK 1272
		WI2291
Europe	Greece	Arizona 5908/Aths//Lignee 640
		Lignee 527/NK 1272
		Lignee640/Lignee 686
	Spain	Alpha//Sul/Nacta
		Rihane/Lignee 527
	Italy	Arizona 5908/Aths//Asse/3/F208-74
		Harmal-2/A.Abiad//ER/Apm

Table 4. Barley lines outyielding the national check in the Regional Yield Trials 1990-91 in North Africa and Asia.

Region	Country	Pedigree
North Africa	Algeria	Deir Alla 106//Mzq/DL71
		Harmal-02/A.Abiad//ER/Apm
		Mo.B1337/WI2291
		Alpha/Gumhuriyet
	Egypt	Arr/Esp//Alger/Ceres,362-1-1/3/WI2198/Emir
		Arizona 5908/Aths//Lignee 640
		Harmal-02/A.Abiad//ER/Apm
		Mari/Aths*2//M-Att-73-337-1
	Libya	WI2198//ER/Apm
		Harmal-02/A.Abiad/3/Api/CM67//Nacta
		Arizona 5908/Aths//Lignee 640
		Cq/Cm//Apm/3/12410/4/Gizeh 134-2L/5/WI2269
	Tunisia	Harmal-02/A.Abiad/3/Api/CM67//Nacta
		Deir Alla 106//Mzq/DL71
		Lignee 527/NK1272
		Arizona 5908/Aths//Lignee 640
Asia	Iran	Lignee 527/Sawsan//Bc
		Pld10342//Cr.115/Por/3/Bathim 9/4/Ds/Apro
		Arizona 5908/Aths//Lignee 640
		ER/Apm/3/Kv//Alger/Ceres, 362-1-1
		Harmal-02/4/7028/2759/3/69-82//Ds/Apro
	Pak.	Chaaran-01/WI2291
		Soufara-02/3/RM1508/Por//WI2269
		5604/1025//A.Abiad
		Deir Alla 106/3/As46..Avt/Aths/5/As46/Pro-
		Mari/Aths*2//Arizona 5908/Aths
		WI2291/CI 13520
		M-Att-73-337-1
	Afghn.	As46/Pro//Bal.16/Api/4/11012-2/Tern//H252-
		Cr.115/Por//Deir Alla 106
	Korea	Lignee 527
		Lignee 131

Lines outyielding national checks in more than one country included:

Deir Alla 106//Mzq/DL71 (Algeria and Tunisia)

Arizona5908/Aths//Lignee 640 (Egypt, Libya, Tunisia, Iran,

	Greece, Qatar and Cyprus)
Harmal-02/A.Abiad//ER/Apm	(Algeria, Egypt, Jordan and Cyprus)

Some parents, (Lignee 527, Arizona 5908/Aths, Harmal-02) occur frequently in the pedigrees of successful lines. The approach described makes parental selection for different areas more efficient.

In Syria a pure line (Arta) derived from the landrace Arabi Abiad was tested for the fourth year in the on-farm verification trials and in large (1000 m^2) demonstration plots. Arta always ranked first and yielded 1.8 and 52% more than Arabi Abiad and between 2 and 33% more than the next best line (Table 5).

Table 5. Performance of Arta in the last four cropping seasons in the on farm trials[a] in Syria.

Year	Zone	No. Of Sites	Mean Yield	Rank	% Over A.Abiad	A.Aswad	Best Line
1988-89	B	4[a]	1814	1	+18.6	+10.6	+18.6
1989-90	B	9[a]	1962	1	+12.3	+5.8	+3.5
1990-91	B	10[a]	2341	1	+5.0	+18.5	+5.0
1991-92	B	13[a]	3358	1	+31.6	+10.8	+1.8
1991-92	B	4[b]	3263	1	+52.5	-	+33.5

[a] two or three replications with 32 m^2 plots
[b] unreplicated with 1000 m^2 plots

In yield trials conducted at ICARDA (Tables 6 and 7) average yields were about 3.3 t/ha at Tel Hadya and 1 t/ha at Breda. At Tel Hadya (Table 6) the top line yielded 20% more than the best check in the advanced yield trials and 25% more in the initial yield trials. At Breda (Table 7) the top line yielded 21.7% more than the best check in the advanced, 34% more in the preliminary and 49% more in the initial yield trials.

Table 6. Grain yield (kg/ha) in Tel Hadya (352 mm rainfall) in 1992.

	Initial	Preliminary	Advanced
Rihane-03	3399	3847	3816
MARI/ATHS*2	3321	3168	3632
Harmal	3411	3327	3589
A.Aswad	3805	3583	3336
A.Abiad	4259	4287	3660
No. Of Lines	1064	532	180
Grand Mean	3365	3320	3074
Top Line	5321	5025	4396
Nr. > Best Check	49 (4.6%)	24 (4.5%	12 (6.7%)
Mean Yield	4486	4575	4059

Table 7. Grain yield (kg/ha) in Breda (263 mm rainfall) in 1992.

	Initial	Prelimanary	Advanced
Rihane-03	1222	903	1326
MARI/ATHS*2	1198	865	1387
Harmal	938	989	947
A.Aswad	1276	1392	1344
A.Abiad	1197	1274	1359
No. Of Lines	1064	532	180
Grand Mean	1230	1010	1160
Top Line	1901	1873	1636
Nr. > Best Check	483 (40.5%)	75 (14.1%)	27 (15.0%)
Mean Yield	1431	1534	1468

The origin of lines (Table 8) indicates that at Breda selection from Syrian landraces were best, followed by ICARDA breeding lines and accessions from China selected at Bouider in 1991 (see Annual Report for 1991, p 41-42). The low yields of lines from Romania and of some ICARDA lines indicates the poor adaptation of winter types. At Tel Hadya sources of germplasm was less important than at Breda. Both the highest and lowest yielding lines were from either Cyprus or ICARDA.

Table 8. Grain yield (kg/ha) of different types of germplasm in the Initial Yield Trials in Tel Hadya and Breda in 1992.

Lines From	No. of Lines	Tel Hadya		Breda	
		Mean	Range	Mean	Range
China	19	3447	2774-4412	1275	941-1548
Cyprus	42	3302	2022-5232	1177	553-1857
Egypt	10	3060	2305-3591	1091	748-1429
Mexico	78	3438	2323-4598	1108	630-1551
Romania	47	3217	2446-4691	940	302-1473
Landraces	11	3512	2924-4077	1499	1248-1810
ICARDA	856	3371	1340-5321	1256	378-1901
Best Check		4259		1276	

2.1.4. Are two-row barleys better adapted to stress then six-row? Whether six and two-rows barley genotypes differ in stress tolerance is often discussed by breeders. Work of E. Acevedo suggested that two-row types may be better adapted to abiotic stress conditions.

492 six-row and 800 two-row types were tested in a number of locations and years in five cycles including three years yield testing (Table 9). Under stress two-rows barleys had a yield advantage over six-row of between 10 and 37%. The comparison may be affected by two-row adapted landraces (2L) which had the highest yields under stress. However, even when removed, the two-row non-landraces (2I) still maintained a yield advantage over six-row of between 10 and 26%. In the absence of stress the yield of two-row

and six-row barleys is similar if the landraces, with lower yield potential, are removed from the two-row group.

Table 9. Yield potential and yield under stress of six- and two-row (L=landraces, I=non landraces) barley genotypes (number of genotypes in brackets).

		Yield potential		Yield under stress	
Cycle	row type	Kg/ha	6R=100	Kg/ha	6R=100
1986-88	6 (96)	4962	100.0	696	100.0
	2 (236)	4901	98.8	768	110.3
1987-89	6 (97)	5385	100.0	561	100.0
	2 (203)	5135	95.3	644	114.8
	2L (41)	4405	81.8	745	132.8
	2I (126)	5396	100.2	608	108.4
1988-90	6 (120)	3501	100.0	508	100.0
	2 (160)	3426	97.9	695	136.8
	2L (76)	3275	93.5	764	150.4
	2I (58)	3657	104.5	587	115.6
1989-91	6 (80)	4801	100.0	754	100.0
	2 (120)	4808	100.2	955	126.7
	2L (18)	4641	96.7	966	128.1
	2I (102)	4837	100.8	952	126.3
1990-92	6 (99)	4581	100.0	956	100.0
	2 (81)	4682	102.2	1116	116.7

Therefore farmer preference for six-row barley may limit of the full potential of the crop in unfavourable environments.

2.1.5. Yield potential and yield under stress

The relationship between yield potential and yield under stress has important implications on breeding strategies. Published work shows that when appropriate contrasts are used, genotypes combining high yield potential and high yield under stress are very rare. This was confirmed by an analysis of genetic correlation coefficients. A trial was designed in 1991 to compare the best selections for yield potential (YP) with the best selections for yield under stress (YS) in a number of environments which are independent from the selection environments. The trial included selections (YPYS) with the best combination of YP and YS and has so far been conducted for two cropping seasons.

Table 10. Relative yields of barley genotypes selected for yield potential (YP), yield under stress (YS) and both (YPYS) in nine environments.

Locations[a]	Mean yield	YP	YS	YPYS
BO91	353	73	121	100
BR91	705	87	113	97
BR92	1189	90	108	103
HA92	1681	98	97	109
TH91	2000	93	100	103
TH92[1]	3361	98	98	106
TH92[2]	3647	98	100	105
TH92[3]	4230	98	97	107
TH92[4]	4856	99	99	102

[a] BO=Bouider, BR=Breda, TH=Tel Hadya, HA=Hassake, 1,2,3,4 are different fields at Tel Hadya with different P_2O_5 content.

In the lowest yielding environments (Table 10) the YS selections yielded more than either YP and YPYS selections. The yield advantage disappeared at higher yielding sites. The performance of YP selections at high yielding sites (>3 t/ha) was similar to the yield of YS lines. We can not explain this lack of response of YP lines to high yielding environments.

2.1.6. Yield stability

The long term yield stability of local landraces may be due to their genetic heterogeneity. Although a number of pure lines with superior performance have been selected from landraces (Tadmor, Arta, Zambaka), the long term objective is to use the best genotypes available within landraces to reconstitute mixtures (Ceccarelli, 1984; Ceccarelli et al., 1987). These mixtures can be viewed as "improved landraces" and may have higher yields than the unimproved landraces as well as heterogeneity to cope with environmental variability over time.

We are using two approaches. We have tested experimental mixtures of superior pure lines selected from landraces. Three mixtures were evaluated between 1987 and 1989 in 11 environments (Annual Report for 1989, pg 31-32). A second set of mixtures was evaluated in 1990-91 and 1991-92 in 11 environments. Mean yields ranged from 31 to 4405 kg/ha. There were two groups of mixtures, one black seeded and one white seeded. The first group had 5 levels of heterogeneity (72, 34, 17, 9 and 5 components), the second four levels (35, 34, 15 and 5 components). The experiment included 10 pure lines, the mixtures and six checks.

The results of the first two seasons for the two 5-component mixtures, the 10 lines constituting the mixtures and the checks are given in Table 11. The white seeded mixture had an advantage over the five components, combining a high average yield with a good response (b=1.08) and a positive intercept (a=34.1). The highest yielding component (W-3 with 1740 kg/ha) had the greatest response (b=1.27), but a negative intercept (a=-103.9). By contrast, the component with the highest intercept (W-5) was the least responsive and had the lowest average yield (1333 kg/ha).

In the black seeded group the mixture did not have a clear advantage over the components. Although preliminary the results indicate possibly different buffering mechanisms in the two Syrian landraces.

Table 11. Average grain yield (kg/ha), regression coefficient (b) and intercept (a) of two mixtures, ten pure lines and six checks in 11 environments.

Material#	Average yield	b	a
MIX5B	1520	0.98	93.3
B-1	1604	0.98	178.7
B-2	1617	1.04	106.6
B-3	1511	0.93	155.1
B-4	1605	1.07	51.8
B-5	1481	0.97	67.0
MIX5W	1604	1.08	34.1
W-1	1587	1.17	-120.3
W-2	1557	1.10	-39.7
W-3	1740	1.27	-103.9
W-4	1579	1.07	21.7
W-5	1333	0.74	252.4
A. Abiad	1544	1.17	-165.2
A. Aswad	1436	0.91	109.3
Tadmor	1516	0.89	216.7
Zanbaka	1444	0.86	189.5
Arta	1821	1.27	-27.3
Harmal	1482	1.01	12.2

B=black seeded line or mixture, W=white seeded line or mixture.

The second approach is to compare balanced sets of F_2 populations and double haploid lines grown mixtures and pure stands to assess the role of heterogeneity and heterozygosity, on stability. This approach started in 1992 as a collaborative project with the University of Hohenheim.

2.1.7. Acquisition of new germplasm

Boron toxicity and susceptibility to Cereal Cyst Nematodes were recognized during 1992 as two problems affecting root health, particularly in dry areas. Lines with tolerance to boron and/or resistance to Cereal Cyst Nematodes have been acquired from Australia. They will be screened with a large number of lines currently in our crossing block and crosses will be made in 1993.

2.1.8. Methodology

Increasing use is of being made of single seed descent (SSD) to manipulate segregating generations. SSD is used for different purposes:

1) to advance crosses with a high probability of superior recombinant inbred lines for given macroenvironments to homozygosity. Crosses in this category are decided upon based on past performance of lines with common parents.
2) to generate recombinant inbred lines from crosses made for genetic studies including molecular markers technology. In 1992 two of such crosses, Tadmor/WI 2291 and Arta/H.spontaneum 41-1 were made.

We have about 80 populations in various stages of SSD and the number will increase to 100 in 1993. The population size varies from 150 to 200 individuals. One population (Arta/H.spontaneum 41-1) has 1200 individuals as six traits need to be recombined (rachis brittleness, awn roughness, peduncle extrusion, plant height, tillering and kernel size). - **S. Ceccarelli, S. Grando**

2.2. ICARDA/CIMMYT Barley Project

2.2.1. Barley in Latin America

The use of barley in Latin America differs with country. In Mexico and Chile most barley is used for malting with a limited proportion for human consumption and animal feed. At high elevations in Bolivia, Colombia, Ecuador, and Peru people use barley as a staple food.

Mary J. Weismantel, writes in her book, Food, Gender and Poverty in the Ecuadorian Andes (University of Pennsylvania Press, 1988), on the diet of the extremely poor. Often nothing but barley gruel is eaten for days. In fortunate households, it may be flavored with sugar, salt or a lump of fat. A chopped onion or a few potatoes may be added. In season, leaves of weeds are stewed with the grain. But most meals consist solely of ground barley and water. Barley is the major constituent of most meals. On the depleted soil of the region, barley is a most dependable crop.

The main objective of the ICARDA/CIMMYT barley project is to breed barley germplasm that may be released as varieties by NARSs. Multiple disease resistance improves stability of barley for poor farmers.

In 1992, the Ecuadorian National Program released two barley varieties resistant to the main diseases in the country, stripe and leaf rust, scald and Barley Yellow Dwarf virus (BYD). Calicuchima and Atahualpa are names of the covered and hull-less varieties, respectively. Bolivia released a variety, Kantuta, for an area of Cochabamba with high salt content in the soil.

New varieties in the Andes are susceptible to loose smut, a disease easily controlled by chemical seed treatment but it is a problem for farmers who retain seed for the following year's planting. Incorporation of genetic resistance through backcrossing to commercial varieties is in progress.

2.2.2. Studies on the Inheritance of Resistance to Some Diseases and Pests

The inheritance of Calicuchima's resistance to scald, leaf rust, BYDV, and stripe rust, was studied using two methods:

- Double haploids (DH)--120 DH lines originating from a cross between Calicuchima/Bowman were produced in collaboration with Oregon State University.
- F1, F2, and backcross populations obtained by crossing Calicuchima, the resistant parent, with Centinela a susceptible Mexican variety.

2.2.2.1. Scald

Resistance to scald in Calicuchima was controlled by a single dominant gene (Table 12), for DH lines being tested as adult plants under field conditions at Toluca, and as seedling reaction in

Table 12. Inheritance of resistance to scald, R. secalis, using two methods: Double haploid lines or F1, F2 and backcross populations.

Progenitors and Generations	Number of Plants R	S	Expected ratio	P
Centinela		All		
Calicuchima	All			
F1	20			
F2	218	73	3:1	>.975
Backcross	45	0	1:0	>.999
Calicuchima	All			
Bowman*		All		
F1	All			
DH lines	63	57	1:1	.5-.7

* Bowman derivative

populations tested in the greenhouse at El Batan. No attempt was made to inoculate plants with a single isolate of *Rynchosporium secalis*. No information was obtained on the donor source for the resistance as all of Calicuchima's parents, L.B. Iran, UNA 8271, and Gloria/Copal are resistant.

2.2.2.2. Leaf rust

Inheritance of leaf rust resistance was determined in adult plants by testing the 120 DH lines under field conditions using natural infection, to races of Puccinia hordei present in the Yaqui Valley in northwestern Mexico and in Oregon in the USA (Table 13).

The ratio of resistant and susceptible lines fits a monogenic inheritance, that can be traced back to the resistant Calicuchima parent: Gloria/Copal.

Table 13. Inheritance of resistance to leaf rust, P. hordei, using Double Haploid lines from a cross Calicuchima/Bowman derivative in two locations.

Progenitors and locations	Number of Plants R	Ratio S	Expected	P
Calicuchima	R			
Bowman*		S		
Double Haploid lines				
Sonora,Mexico	56	64	1:1	.30-.50
Oregon, USA	55	63	1:1	.30-.50

* Bowman derivative.

2.2.2.3. Barley yellow dwarf virus

Preliminary observations at Toluca in the summer of 1992 for BYDV symptoms on the 120 DH lines, Calicuchima/Bowman showed monogenic inheritance of resistance to BYDV which originated from the Bowman derivative. The number of resistant DH lines was 65 compared to 55 susceptible lines. The results should be verified using artificial infection either in the field or in the greenhouse.

2.2.2.4. Stripe rust

An attempt to study the inheritance to stripe rust, *P. striiformis f.sp. hordei*, race 24 in the greenhouse on seedlings failed. However adult plant reactions in the field were easily recognized. The study was carried out at Toluca Experiment Station under a natural epidemic of stripe rust.

The results (Table 14) showed multigenic resistance, fitting either the two- or three-gene hypothesis, according to the ratios observed and arbitrarily fixed threshold symptom expression. Resistance was inherited as a recessive trait, but the number of genes involved was not determined with precision.

Table 14. Study of the inheritance of the resistance to stripe rust, P. striiformis f.sp. hordei, (Race 24) F1, F2, and backcross populations.

Progenitors and Generations	Number of Plants R	S	Expected ratio	P
Centinela		S		
Calicuchima	R			
F1		S		
F2	8	116	1:15	>.975
Backcross	9	39	1:3	.8-.7

Further studies in Oregon with RFLPs confirm the multigenic hypothesis. Additional evidence comes from the reaction of several

Calicuchima sister lines in the International Barley Observation Nursery (IBON). Some entries were resistant at three locations (Mexico, Bolivia, and Pakistan) while sister lines were resistant at only two locations. This indicates the presence of different virulences in these locations. Therefore, lines resistant at all locations must carry more than one gene for resistance.

The inheritance studies were part of the MS theses of Sergio Sandoval in Mexico and Doris Phren in Oregon.

2.2.2.5. Durable resistance

Calicuchima, a new variety for Ecuador, carries multiple disease resistance but except for stripe rust, resistance depends on single genes that can be overcome easily by new virulent races. In Calicuchima, we failed to pyramid genes for resistance to scald, and thus may have failed to produce durable resistance.

Information on the genetics of resistance in barley lines with superior performance is needed for NARSs breeders and pathologists so they can make more informed choices for varietal release. In our Program, the information is even more important as it guides the crossing program for pyramiding resistant genes.

Barley blends may be a mechanism to improve durability. An experimental blends of four barley lines with similar phenotypes is being studied. The lines differ in their resistance to several diseases (Table 15).

Mechanical blends of all possible combinations of the four lines were yield-tested in a split plot design, where main plots were protected and unprotected with the fungicide Folicur. The experiments were conducted in winter in the Yaqui Valley in northwestern Mexico and during summer at El Batan in central Mexico.

In the Yaqui Valley all four lines were susceptible to spot blotch, a disease that none of the four lines had been tested for.

Table 15. Characteristics of four barley lines used in the blending experiment.

Lines	Stripe rust	Leaf rust	Scald	BYDV
A. Arupo	S	S	S	S
B. Arupo*3/EH21B	S	R	R	S
C. Arupo*2/Jet	R	S	R	S
D. Arupo*2/CI3208.2	S	S	R	R

Arupo (A), the best yielding line in a disease free environment, had the highest yield with fungicide protection, but its yield dropped considerably when it was unprotected (Table 16). By contrast, the lines Arupo*2/Jet (C) and Arupo*2/CI3208.2 (D) had less difference between protected and unprotected plots--a clear case of tolerance to the disease. The tolerant lines C and D when combined with susceptible components in the blend had reduced yield losses compared to the susceptible lines (Table 16). Line D reduced yield losses in the combinations B+D, C+D, A+C+D, B+C+D, and A+B+C+D.

In Tanzania, the concept of spot blotch tolerance was made valid when the variety Kibo-91 was released, after yield tests showed small yield differences in trials with and without fungicide.

In El Batan, the blend experiment determined the reaction to stripe rust. Arupo*2/Jet (C), a resistant component to stripe rust, was highest yielding is a severe epidemic. Arupo (A) yield was reduced compared to the previous season. The combinations A+C, and C+D in (Table 16). did not differ between treated and untreated plots.

When comparisons were made for both seasons, the most stable combinations were: A+C and C+D with average yields for both locations of 4.9 and 4.7 t/ha, respectively, untreated plots. Average yield reductions for spot blotch and stripe rust were 650 kg for A+C, and 400 kg for C+D. In an environment where both spot

Table 16. Yield of four lines and different blends protected and unprotected with fungicide against Helminthosporium sativum in the Yaqui Valley, and Puccinia striiformis f.sp. hordei at El Batan.

Lines and blends	Yield Treated	Spot Blotch t/ha Nontreated	Yield Reduction	Yield Treated	Stripe Rust t/ha Nontreated	Yield Reduction
A	6.6	5.3	1.3	4.9	3.5	1.4
B	5.5	4.1	1.4	5.2	3.5	1.7
C	4.6	4.2	.4	6.2	5.9	.3
D	5.4	5.1	.3	5.0	4.0	1.0
A+C	5.6	4.8	.8	5.4	4.9	.5
A+D	6.2	5.2	1.0	4.8	3.5	1.3
B+C	5.0	4.2	.8	5.9	4.7	1.2
B+D	5.7	5.1	.6	5.0	3.7	1.3
C+D	4.8	4.3	.5	5.4	5.1	.3
A+B+C	5.3	4.3	1.0	5.1	4.4	.7
A+B+D	5.9	4.9	1.0	5.1	3.6	1.5
A+C+D	5.0	4.5	.5	5.3	4.6	.7
B+C+D	5.4	4.8	.6	5.4	4.4	1.0
A+B+C+D	5.2	4.6	.6	5.5	4.4	1.1

blotch and stripe rust are present, mixtures may give higher yields and greater stability.

2.2.2.6. Hull-less Barley

Increased interest in hull-less barleys in the Americas has resulted new hull-less varieties in Canada, Chile, Brazil, and most recently Ecuador. These countries have released naked barley varieties for different reasons:

- Ecuador's variety, Atahualpa-92, will be promoted for human consumption.
- Brazil and Canada's main interest is barley for animal feed.
- Chile is using hull-less barley as a coffee substitute and as a feed grain.

In 1992, 114 new advanced hulless barley lines were tested at El Batan. Most lines were resistant to stripe and leaf rust races present in Mexico and had good threshability. We did not observe any injury of hull-less barley, due to physical damage of protruding embryos. Poor germination is not a major problem when hull-less barleys are threshed by combine or animal threshing. The high test weight of 73 g was reached in the cross: Nepal 1954/Aleli. Table 17 lists lines with yields higher than 4 t/ha.

Protein content of the grain will be determined in all lines. Seeds of the best material were send to Alberta, Canada, for adaptation testing. An informal agreement has been reached with Dr. J. Helms in Canada for increased interchange of Hull-less barley.

Hull-less lines were sent to Professor D. Marshall, University of Sydney, who is interested in promoting naked barleys as animal feed in Australia. Hull-less lines were sent to China and Nepal for testing for adaptation in the Himalayas. - **H. Vivar**

Table 17. Yield and Test weight of Hull-less lines resistant to two diseases, stripe and leaf rust at El Batan 1992

Cross and Pedigree	Yield (t/ha)	Test wt (g)
Agave/Colorin//Zarza CMB89-784-0-1Y-1B-1Y-3B-0Y	4.6	61
Mola/Aleli//Mora CMB90-599-E-3Y-10B-0Y	4.5	67
Viringa	4.4	71
Nispero	4.3	71
Lino CMB88A-1008-B-1M-1Y-1B-1B-0Y	4.3	70
Gloria/Come//Lignee640/3/Super Precoz/4/Colorin/Calicuchima CMB90-934-K-1Y-2B-0Y	4.2	67
Mola/Aleli//Mora CMB90-599-E-1Y-1B-0Y	4.2	66
Lino CMB88A-1008-B-3M-1Y-1B-1B-0Y	4.1	67
Gloria/Come//Lignee640/3/Super Precoz/4/Colorin/Calicuchima CMB90-934-K-1Y-1B-0Y	4.1	68
Marco/Colorin//Calicuchima CMB89-340-S-1Y-2B-1Y-3B-0Y	4.1	67

2.3. Physiology/Agronomy

2.3.1. Introduction

This years report will again be brief. Although maintaining a similar format, few results will be presented as many of the projects have been revised or terminated and results will be published in international journals when final conclusions have been drawn. The overall goals and objectives of existing projects were outlined in the 1988 Annual Report.

Our research on adaptation to harsh environments of the WANA region is presented under three headings, barley, durum wheat and bread wheat. As indicated in last years Annual Report all agronomy related research, if conducted, will be presented in the FRMP report.

The physiologists research has consequently become more upstream and more basic. Emphasis has been put on the measurement of thermal stresses and a major objective this year has been the initial organization and development of a laboratory to measure thermotolerance in greater detail. Most of the equipment that arrived has been installed and tested.

Two networks on thermotolerance were formed, the first a regional network for the Nile Valley countries, coordinated by Dr. H.M. Ishag in Sudan and the other an International network to be coordinated by Drs George Kao (AVRDC) and John Peacock (ICARDA) Another objective has been to visit our major collaborators in Europe, USA and WANA to discuss the future organization of projects and assimilation of data sets.

2.3.2. Barley

This continues to be our major research thrust. The 1991/92 growing season represented the **end** of a complete phase of research which has been analyzed and written up and the **start** of a new area on the physiology of crosses involving *Hordeum spontaneum*. A small part of the completed research is summarized here.

2.3.2.1. Adaptation of barley to Mediterranean environments

2.3.2.1.1. Introduction

In the previous Annual Report, two development patterns adapted to Mediterranean environments were identified. The first one is represented by early heading spring types (e.g., WI 2269/WI 2291, Harmal). Development is characterized by good growth vigour early in the season, cold sensitivity, and early heading. This pattern is useful in Mediterranean environments with mild winters. The second pattern is represented by medium early heading winter types (e.g., Tadmor, Arabi Aswad). Development is characterized by a mild vernalization requirement and a strong photoperiodic dependency after the vernalization requirement has been met (Ellis et al., 1988). This pattern is useful in Mediterranean environments with cold winters and stress during grain filling period. The second pattern has a better yield stability under harsh conditions, but a lower yield potential than the first pattern (Annual Report 1991). Here we elaborate on the differences in yield response between the two patterns. First, the effects of rainfall and temperature on grain yield will be discussed. Then we deal with the effect of morphological traits on yield in low- and high-yielding environments. Finally, the potential impact for breeding will be discussed.

2.3.2.1.2. Effect of rainfall and temperature on grain yield

The effect of rainfall and temperature on grain yield of Harmal and Arabi Aswad was studied for 17 environments, including seven growing seasons (1984/85 till 1990/91) and three locations (Tel Hadya, Breda, Bouider).

Total seasonal rainfall was the variable most strongly correlated to the grain yield of Harmal, accounting for 61.1% of the variance. For Arabi Aswad, rainfall from November to January gave the best fit, accounting for 65.8% of the variance. The addition of a temperature variable gave a better fit, accounting for some 80% of the variance in grain yield for both cultivars if winter rainfall was combined with the number of night frosts in spring (Table 18). Arabi Aswad had a smaller response to both rainfall and frost than Harmal (Table 19).

Rainfall in winter (December and January) had the highest contribution to grain yield. Later in the season, the contribution

Table 18. Percentage of variance of grain yield of Harmal and Arabi Aswad, explained by individual meteorological variables or combinations of them, across 17 environments in northern Syria

	Harmal	Arabi Aswad
Rain (Nov-Jan)	48.0**	65.8***
Rain (Nov-Jan)+ frost (March-April)	68.4**[a]	77.1*[a]
Rain (Nov-Feb)	58.5***	61.3***
Rain (Nov-Feb)+ frost (March-April)	81.9***[a]	71.2*[a]

[a]:Level of significance refers to contribution of frost only.

decreased, which may reflect the accumulation of stored water in the soil profile. The results of Tables 18 and 19 show that if winter rainfall is sufficient, frost in spring is the major constraint to grain yield. The lower response of Arabi Aswad to rainfall and frost (Table 19) represents a lower yield in favourable (wet) seasons, but a higher yield stability when unfavourable conditions occur, such as late frost.

Table 19. Parameter estimates for the multiple regression of grain yield (kg/ha) of barley cultivars Harmal and Arabi Aswad on rainfall during November-February (mm) and number of night frosts in March and April, across 17 environments in northern Syria. Standard errors given in parentheses

	Harmal			Arabi Aswad		
Intercept	-874	(428.3)	+	-641	(433.4)	
Rain (Nov-Feb)	20.1	(2.39)	***	15.5	(2.41)	***
Night Frosts (Mar-Apr)	-180.3	(39.98)	***	-100.6	(40.44)	*

2.3.2.1.3. Effect of phenology on grain yield in high- and low-yielding environments

The objective was to see if plant traits measured in winter or spring can be used in favourable environments as criteria for indirect selection for grain yield in stress environments (low winter temperatures and terminal drought stress). The study included 36 two-row barley entries, grown in 14 site x year combinations (environments), nine in Syria and five in North Africa. Adaptation to low winter temperatures was represented by a winter plant ideotype (WPI), a principal component of winter growth habit, winter plant colour, and cold tolerance. Vernalization requiring barleys had high values for WPI; spring types (no vernalization requirement) had low values. Adaptation to terminal drought stress was represented by heading date, scored as the number of days from 1 March to heading. Data for all four traits (growth habit, plant colour, cold tolerance, and heading date) were obtained from three favourable environments (Tel Hadya, Breda, Bouider in 1987/88). Grain yield under favourable and unfavorable conditions was represented by average yields in six high-yielding (HY) and five low-yielding (LY) environments respectively, standardized per environment to a mean of zero and a standard deviation of one. The direct effects of WPI and heading date on yield were calculated by using a path coefficient analysis (Fig. 2).

In LY environments, a high value for WPI (winter types) had a significantly positive effect on yield (Fig. 2). However, this did not result in good yields if it was not combined with an appropriate heading date. Therefore, in LY environments where both low winter temperatures and drought stress during grain filling are likely, early heading winter types are expected to perform best. In HY environments, in contrast, the effect of a high value for WPI on yield was weakly negative, whereas heading date had no effect.

Consequently, the unexplained part of the variation in yield was large. The difference with LY environments in the effect of WPI and heading date on yield is due to the fact that HY environments are wetter and tend to have milder winters than LY environments, reducing the advantage of winter types. The higher rainfall in HY

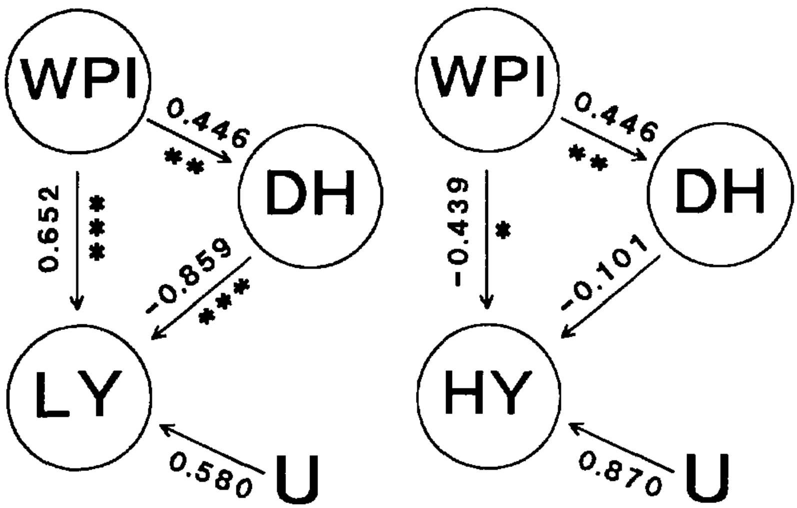

Fig. 2. Path coefficient diagram showing the relationship between winter plant ideotype (WPI), the number of days from 1 March to heading (DH) and average standardized grain yield in five low-yielding (LY) or six high-yielding (HY) Mediterranean environments. WPI and DH were obtained from three HY environments. Arrows indicate direct effects. U=unexplained residual.

environments also reduces terminal drought stress and thus the need for early heading.

The difference between HY and LY environments in direct effect of WPI and heading date on yield indicates that different ideotypes are required for optimum performance in different environments. This supports the conclusion of Ceccarelli et al. (1992) that the alleles controlling yield in both environments are not entirely similar. It also suggests a trade-off between adaptation to LY environments and yield potential.

2.3.2.1.4. Impact on breeding projects

Part of the trade-off between adaptation and yield potential may be due to the fact that winter-types which require vernalization (e.g., Tadmor), have a poorer early growth vigour than spring-types which do not require vernalization (e.g., WI 2269/WI 2291). Time from emergence to the double ridge stage is negatively correlated with early growth vigour ($r=-0.67$, $P<0.001$ at Tel Hadya 1988/89 and $r=-0.50$, $P<0.01$ at Breda 1988/89). Poor growth vigour in winter is associated with low leaf area index (Fig. 3). Poor growth vigour in winter is disadvantageous in terms of water use efficiency (WUE). During winter, when temperatures and air vapour pressure deficits are low, WUE is high. Poor growth vigour when WUE is high can limit the potential dry matter accumulation if water becomes limiting in spring. This may be the price Tadmor pays for its adaptation to low winter temperatures. Combining yield potential with yield stability may be possible if the apical development pattern of Tadmor and Arabi Aswad can be combined with the early growth vigour of WI and Harmal.

The results of the path analysis suggest that selection in HY environments for winter types with an early heading can have a significant positive effect on yield under stress. Several disadvantages are associated with yield testing in early generations under adverse conditions. Small plots in early generations are often inadequate for reliable yield testing. In addition, harsh environments carry the risk of losing all the material in adverse seasons. If adaptation to stress can be adequately assessed in early generations under favourable conditions with a minimum risk of

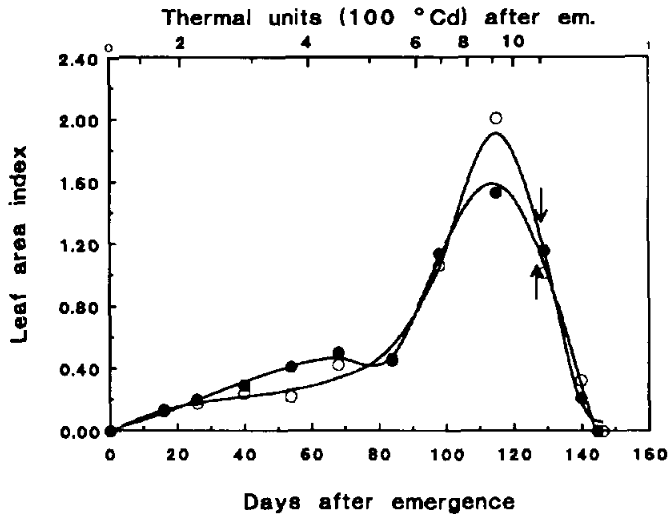

Fig. 3. Leaf area index as a function of time after emergence at Breda 1988/89 for WI 2269/ WI 2291 (●—●) and Tadmor (○-----○). Curves are cubic spline interpolations. Arrows indicate average heading date.

losing adapted germplasm, the efficiency of selection for yield under stress can be improved. Therefore, we propose that in early generations (F_3 - F_4), selection must focus on the identification of plant ideotypes, adapted to the LY target environments. Once a pool of adapted germplasm has been created and sufficient seed is available, yield testing can be done in LY target environments. Ceccarelli & Grando (1989) concluded for barley in Syria that empirical yield selection for LY environments is most efficient if selection is done in a representative environment using adapted germplasm. The proposed selection scheme thus combines ideotype breeding in early generations under favourable conditions with a relatively efficient empirical selection for yield under stress in later generations. - **E. van Oosterom**

2.3.2.2. Carbon-13 discrimination as an indirect selection criterion in dry environments

2.3.2.2.1. Introduction

In 1988-89 we initiated a major research project with the overall aim of increasing the efficiency of selection of barley for drought-prone environments. High transpiration efficiency (TE) is considered to be important to biomass production in such environments. Recent studies have indicated that TE varies between genotypes, and theoretical procedures have established a relation between TE and C^{13} discrimination. The overall objective of this project is to assess the usefulness of C^{13} discrimination as a predictor of yield performance under stress. The project has three main research objectives and associated activities:

2.3.2.2.2. Assessment of the relation between C^{13} discrimination, water use efficiency and yield under different moisture levels

Understanding the relationship between water use efficiency, C^{13} discrimination and yield requires that genotypes with a similar phenology should be grown at various water levels in a single location. This activity commenced in the 1988-89 season, using ten barley genotypes in a line source sprinkler system at Breda. Ten moisture levels, representing a wide range in moisture availability, were assessed. The ten genotypes included both landraces and improved cultivars. They had comparable heading dates, but different adaptation strategies for dry environments and differed in their C^{13} discrimination.

After three cropping seasons, this experiment was completed in 1991. Over 1000 samples from the three seasons were sent to collaborative institutions in Australia and the USA for C^{13} analysis.

2.3.2.2.3. Assessment of the relation between C^{13} discrimination, transpiration efficiency and dry matter production under controlled environmental conditions

This experiment was conducted in the glasshouse in order to (i) investigate whether or not genotype x environment interactions exist for C^{13} discrimination, (ii) assess if results from controlled environments are representative of field experiments, and (iii) identify what factors might determine some inconsistencies in the relation between C^{13} discrimination, TE, and yield.

The same 10 barley genotypes were sown under four different moisture regimes. The experiment started in 1989 and was completed in 1991. Two hundred samples, sent for C^{13} analysis, have recently been analyzed. Detailed results will be presented in later reports. However, preliminary results indicate a strong positive correlation between grain yield under moisture stress and C^{13} discrimination, while TE was negatively related to C^{13} discrimination. The results also showed a high correlation for C^{13} discrimination between different plant parts and between different development stages.

2.3.2.2.4. Divergent selection for C^{13} discrimination and yield

The objectives of this experiment were (i) to determine the efficiency of selection for drought tolerant genotypes based on their C^{13} discrimination when compared with selection based on yield performance, under stress and non-stress conditions, and (ii) to study the genetic parameters and breeding implications for the C^{13} discrimination technique. Seven crosses were made between high and low C^{13} discriminating parents.

All lines in the F_2 generation were analyzed for C^{13} discrimination. In 1991/92, 572 F_2-derived F_5 lines from the seven crosses were planted at Tel Hadya under irrigated conditions and at Breda under rainfed conditions. Two types of selection are planned:

(i) selection based on high and low C^{13} discrimination, and (ii) selection based on high and low yield under water stress (Breda) and non water stress conditions (Tel Hadya, irrigated). Using a 5% selection intensity within each category and performing random selections, 236 lines were selected. All lines in the F_5 generation will be analyzed for C^{13} discrimination. This experiment is expected to provide information on (i) the yield correlation between selections based on high or low C^{13} discrimination, (ii) the appropriate environment for selection, (iii) the efficiency of using C^{13} discrimination as an indirect selection criterion compared with yield, and (iv) the heritability of C^{13} discrimination. - **A. Dakheel, I. Naji, S. Ceccarelli, J.M. Peacock**

2.3.2.2.5. ***Hordeum spontaneum***

We are examining the physiology of promising crosses using *Hordeum spontaneum*. Sixteen lines, comprising the 3 parents (Tadmor, WI 2291, and *Hordeum spontaneum* (HS)), 11 crosses of Tadmor X HS, and 2 crosses of WI 2291 X HS. The crosses were made by the barley breeding project. The material was planted at Tel Hadya (rainfed and irrigated), Breda (early and late), and Bouider. The project continues with a major objective to establish what traits make some of these crosses well-adapted to severe drought conditions. - **J.M. Peacock, A. Dakheel, I. Naji, S. Grando, V. Mahalakshmi**

2.4. Barley Pathology

2.4.1. Introduction

The barley pathology project carries out research to improve plant health in traditional and improved barley cultivation systems. In WANA increased barley demand has intensified cultivation. Intensification has important effects on disease development, especially for those that survive in the soil or on crop debris. We aim to anticipate these problems and to develop sustainable and low cost control strategies. Resistance breeding is the most economical way to control most diseases. Screening of existing or newly developed barley germplasm against important diseases in the WANA region is therefore an important component of the project.

Research activities are presented by diseases. Different diseases interact with each other and new germplasm with high levels of resistance to a single disease may be attacked by pathogens that were of minor importance previously. Therefore our objective is to select germplasm with adequate resistance to major and minor pathogens, rather than select for high levels of resistance to a single disease.

2.4.2. Root diseases

Root disease research is of recent origin in the project, thus much of the work is devoted to documenting the distribution of different root pathogens and to estimating losses caused by them.

2.4.2.1. Survey for barley root diseases in Syria

A systematic survey for root diseases was made for the first time in Syria. The survey team included Dr Karen Bailey (Agriculture Canada, Saskatoon), Dr Tony Rathjen (University of South Australia, Adelaide) and Dr Richard Sikora (University of Bonn, Germany). A total of 80 fields in major barley growing regions of northern Syria were sampled. Subcrown internodes of a random sample of about 20 plants were scored for the presence of rootrot symptoms. Most fields were sampled for the presence of *Heterodera avenae*, the cereal cyst nematode (CCN). Results are summarized in table 20. Most barley fields had a high percentage of plants with severe root rot, especially in the drier areas. Large differences between neighboring fields were observed, generally earlier maturing or more drought stressed crops had higher levels of root rot. Within fields higher levels of root rot were associated with lower tiller number.

Heavy infestations by CCN were found in the western part of the surveyed area, especially in Hama and Aleppo province. However, no cysts were found east of the Euphrates river. The white females of *H. avenae* are only be detected on roots for a short time. Some fields with a high infestations by CCN at the end of April (during anthesis), had no symptoms by the end of May.

Table 20. Root diseases on barley in northern Syria, 1991-92. Severity of root rot symptoms and presence of Cereal Cyst Nematode.

		number of fields[1]					
Date	Region	total	<25	<50	<75	≥75	CCN
north - east							
5-6 May	Gezira / Hassake	18	2	4	7	5	0
26-27 May	Gezira / Hassake	15	0	1	3	11	0
north - west							
14 May	Jinderess	7	3	3	1	0	0
20 May	Al Bab	9	1	0	5	3	3
18 May	Bouider	5	0	0	1	4	3
19 May	Salamieh	17	2	1	11	3	10
24 May	Saraqeb	4	0	2	1	1	-
west							
1 June	Al Ghab	5	1	0	0	4	0

[1] <25 - ≥75: percentage plants with high level of root rot symptoms
CCN: Cereal Cyst Nematode

Some root samples have been plated to determine the causal agents of the root rot. *C. retrad* was identified most frequently, but *Fusarium* spp. were isolated as well. Different media and isolation techniques were tried as saprophytes complicate the identification of pathogenic fungi. Isolations from remaining samples will be made using improved techniques. *C. retrad* and *Fusarium* strains will be tested for pathogenicity. Preliminary tests showed all *C. retrad* , but only few *Fusarium* strains pathogenic.

2.4.2.2. Survey for diseases on rainfed barley in Egypt

A brief survey of the diseases on rainfed barley grown in the coastal area of north-west Egypt was made in March. The surveyed area received high rainfall during 1991-92. This was reflected in the high level of leaf diseases. Septoria passerinii was recorded for the first time in Egypt and attacked upto 10% of the leaf area in some fields planted with the improved cultivar Giza 123. Similar levels of attack by *Rhynchosporium secalis* (scald) were recorded on local landraces (Cereal Program Annual Report, 1991).

Subcrown internodes (SCI's) from 14 sites were scored for root rot symptoms on a 0-5 scale. The average score ranged from 0.0 to 3.3. From the lower scored SCI's (score 0-2), *C. retrad* was isolated from 23%, while 5% yielded red pigmented *Fusarium*. *C. retrad* was isolated from 67% and red pigmented *Fusarium* from 18% of the more diseased SCI's (score 3-5). It can be concluded that *C. retrad* is the major pathogen associated with root rot symptoms. However, the red-pigmented *Fusarium* isolates were found to be highly pathogenic. In pathogenicity tests, using barley plants grown in culture tubes on solidified Hoagland medium, these *Fusarium* strains killed the plants within three weeks. White pigmented *Fusarium* strains were isolated as well, but were non-pathogenic.

Leaf blotching was present in most locations, on both improved cultivars and landraces. Leaf tissue from affected and normal plants of 'Giza 123' from one field in El Kasr were analyzed at the Waite Institute. Affected plants had a high boron content (112 ppm), compared to the non-affected ones (25 ppm). Boron can produce leaf blotching, and is a major problem in wheat producing areas of Australia (T. Rathjen, pers. comm.). Dr R.A. Rizk (Barley Pathologist, ARC, Giza) compared the yield of 50 symptom-free plants with 50 affected plants from the same field in El Kasr. Affected plants were found to have slightly more spikes / plant (5.9 vs 5.5), but a lower yield / spike (1.5 vs 2.1 g), which reduced grain yield / plant (8.7 vs 11.8 g).

2.4.2.3. Differences in resistance to *C. retrad* and crop losses caused by root rot

Losses caused by *C. retrad* were measured for 30 varieties by comparing the yield after seed inoculation with untreated seed. The experiment was planted both in a moderate rainfall (Tel Hadya) and in a low rainfall location (Breda). For inoculated plots the average score (using a 0-5 scale) was 2.4 in Tel Hadya and 4.3 in Breda; for uninoculated plots 1.5 and 3.3 respectively. Statistical analysis showed significant variety and variety x location effects. Inoculation caused significant yield losses at Tel Hadya, but a large interaction between varieties and inoculation was present. At Breda the interaction effect only was significant. The lack of consistent yield responses to inoculation at Breda probably was caused by high levels of inoculum in the field, as shown by high root rot scores in uninoculated plots.

The high level of root rot at Breda was used to evaluate three Regional Yield Trials (RYT's). Lines in the yield trial for low rainfall environments with mild winters (RYT-LM) and for low rainfall with cold winters (RYT-LC) had less root rot than those in the trial for moderate rainfall areas (RYT-M). Average over the 19 lines under testing for the percentage of highly affected plants (score ≥ 4) was 43% for the RYT-LM, 40% for the RYT-LC and 53% for RYT-M (P = 0.016). Six-row lines were more affected than 2-row lines in all three nurseries (Table 21).

Table 21. Performance of 2 and 6-row barley lines within three Regional Yield Trials for Yield, Yield Components and Root Rot Symptoms, Breda, 1991-92.

	RYT-LM		RYT-LC		RYT-M		Average	
	2-r	6-r	2-r	6-r	2-r	6-r	2-r	6-r
score	2.8	3.4+	2.9	3.2**	2.8	3.6+[1]	2.8	3.4
% score ≥ 4	29	54*	36	45*	38	59+	34	54
yield (kg/ha)	1377	1379	1386	993***	1407	1195	1388	1202
days to heading	128	128	129	135***	130	132	129	131
tiller / plant	1.5	1.1*	1.2	1.0	1.3	1.1+	1.4	1.1
entries	8	11	10	9	6	13	24	33

[1] significance level of difference between 2-row and 6-row entries in the same nursery, using nested analysis of variance. + P< 0.1, * P< 0.05, ** P< 0.01 *** P< 0.001

2.4.2.4. Comparison of inoculation methods

C. retrad inoculation for crop loss experiments and variety screening is made by mixing seed with a peat-gum-spore mixture and planting the seed by hand directly afterwards. Machine planting would reduce time and increase precision, but is only possible with dry seed. To check the effectiveness of dry *C. retrad* inoculum, freshly inoculated seed of three barley lines was compared with seed inoculated 9 days previously and kept at room temperature. Apart from an uninoculated control, a soil inoculation treatment by *C. retrad* infested oats (Annual Report 1989) was included. The experiment was hand sown in 7 cm deep furrows. Inoculation with the pea-gum-spore mix increased the level of root rot symptoms significantly (P< 0.001, Table 22), oat inoculation was less effective. Drying the seed after inoculation and keeping it at room temperature did not affect the level of root rot. There were no significant differences in yield among treatments.

Table 22. Effect of different *C. retrad* inoculation methods on yield and on percentage plants with high root rot score of three barley lines, Tel Hadya, 1991-92.

	Yield (kg/ha)				% score ≥ 4			
	Ta	Ar	Fu	mean	Ta	Ar	Fu	mean[1]
uninoculated	2861	2708	2958	2843	22	32	16	23 a
Peat (fresh)	2292	2472	2528	2430	47	54	46	49 c
Peat (dried)	2750	2611	2070	2477	44	56	52	51 c
Oats	3056	2542	2153	2583	34	35	24	31 b
mean	2740	2583	2427	2583	36	44	35	38

[1] means with same letter are not statistically different (P = 0.05) using LSD test.

2.4.3 Scald

Scald (*Rhynchosporium secalis*) is the most wide spread and damaging leaf disease on barley in the WANA region. ICARDA's breeding material is annually evaluated for resistance in the field using artificial inoculation with local isolates. Screening in Syria is confirmed at several 'disease hot-spots' in the region.

2.4.3.1. Comparison of screening at base program and in hot-spots outside Syria

Holetta Research Station in Ethiopia is a hot-spot for scald, a disease with high virulence variability. The performance of 83 lines was compared between the 1992 screening in Holetta and the previous' year screening in Tel Hadya (Table 23). Out of the 23 lines that were moderately resistant to scald in Tel Hadya, 19 were among the more resistant in Ethiopia. No lines were completely free of scald in Ethiopia.

Table 23. Performance of 83 advanced breeding lines for resistance to scald in Ethiopia (season 1992) and Syria (season 1990-91).

	Ethiopia		
	score ≤ 4	score > 4	total[1]
Syria			
score ≤ 4	19	9	28
score > 4	4	51	55
total	23	60	83

[1] Lines scored on a 0-9 scale (0 = no scald). Number of lines per category.

2.4.3.2. Testing of selected germplasm in seedling stage

The Welsh Plant Breeding Station (WPBS) at Aberystwyth (U.K.) is a center of excellence for research on scald and netblotch. Mr Ziad Alamdar (Senior Research Technician, Cereal Pathology) spent 6 weeks at the WPBS to work on seedling tests to screen for resistance to scald. Lines, previously selected for low levels of scald in the field at Tel Hadya in 1990-91, were tested against two U.K. scald strains. Race 0 has a low virulence, while Race 77 is the most prevalent race in the U.K. with a high virulence. The reaction of the lines was classified as either resistant (R) or susceptible (S). Diversity in resistance was demonstrated in landrace lines and breeding material (Table 24), even though the material had never been exposed to these isolates. These results (and 2.4.3.1) demonstrate the efficiency of field screening in Tel Hadya. In germplasm with a high frequency of susceptibility like the Egyptian and Jordanian local barleys, resistant components were identified.

Table 24. Resistance of different types of germplasm, previously selected for resistance to Syrian scald strains, to two different strains of *Rhynchosporium secalis* from the U.K. in seedling test at the WPBS, Aberystwyth.

		lines per resistance group				
	total	race 0	R	R	S	S
Experiments	lines	race 77	R	S	R	S
Algerian landrace lines	18		7	1	1	9
Egyptian landrace lines	6		5			1
Jordanian landrace lines	3		2			1
Syrian landrace lines	24		14	6	1	3
breeding lines	43		27	2	9	5

2.4.4. Barley leaf stripe

Barley leaf stripe (*Pyrenophora graminea*) is a seed-borne disease of importance in wetter areas. The disease is spread from diseased plants to seed of neighboring plants. Research has concentrated on developing reliable techniques for seedling screening and for determining seed infestation.

2.4.4.1. Virulence analysis

The availability of a reliable seedling screening method, makes *P. graminea* well suited to study virulence of isolates from different origins. A total of 28 pathogen strains from 10 countries were tested under controlled environment conditions on 7 barley lines with a known reaction to barley leaf stripe. Table 25 summarizes the results. The average over isolates is given for countries with more than one entry. A large difference in virulence over the 7 lines tested was present among isolates. Differences in specific virulence towards specific host genotypes was significant, but far smaller than the isolate effect (F ratio isolate / isolate x variety: 2.51). This indicates that specific virulence plays a minor role within the pathogen and host populations tested. Germplasm selected for resistance to local Syrian strains is likely to maintain its resistance in other countries. Interestingly two selections from local Syrian landraces ('Tadmor' and 'Zanbaka') possess resistance that equals, or even surpasses, that of lines with reported to have high level of resistance.

Table 25. Percentage of striped plants after inoculating 7 barley lines with *P. graminea* isolates from different countries.

	no	varieties								
Origin	isol	Ar	Ci	Bt	Ta	Va	Za	Be[1]	Mean	Range[2]
Syria	11	46	95	4	5	14	1	29	28	20 - 36
Ethiopia	4	18	78	0	0	5	0	1	15	7 - 20
Turkey	3	18	75	0	2	2	0	17	16	10 - 23
Libya	2	37	90	0	23	3	0	45	29	26 - 31
Denmark	2	8	94	5	0	3	0	0	16	14 - 17
Tunisia	2	0	2	3	6	0	0	14	4	1 - 6
Morocco	1	81	100	0	10	8	0	60	37	
Ecuador	1	62	79	0	0	0	0	10	21	
Italy	1	20	90	0	5	13	0	21	21	
Nepal	1	0	0	0	0	5	0	0	1	
Mean		32	80	2	5	8	0	21	21	

1) Ar; Arta, Ci; CI 6944, Bt; Betzes, Ta; Tadmor, Va; Vada, Za; Zambaka, Be; Beecher.

2) Percentage striped plants averaged over isolates from one country, Range indicates lowest and highest mean over 7 varieties.

2.4.5. Covered smut

Covered smut (*Ustilago hordei*) is present in most farmer's fields throughout the WANA region. It will remain important as long as farmers grow their own seed and don't use seed treatment (see 2.3.6). Breeding lines and landraces vary greatly in the level of resistance (see Annual Report 1991). Screening for resistance, using artificial inoculation with local Syrian smut strains, is carried out in early stages of yield testing and on parental material. Local Syrian germplasm is highly susceptible.

2.4.5.1. Screening of breeding material

For the first time we screened all barley lines in preliminary yield trials as well as those in advanced trials. Table 26 shows the level of resistance for both groups. A large part of the material has acceptable levels of resistance (≤ 5% smutted plants). However, material with levels of smut of > 30% (the level of the susceptible

Table 26. Performance of 530 breeding lines in preliminary yield testing and 180 breeding lines for resistance to Covered Smut, Tel Hadya, 1991-92.

	total	percentage lines / class[1]				
Experiments	lines	0	≤5	≤15	≤30	>30
Prelimary Yield Trials	530	39	21	15	14	11
Advanced Yield Trials	180	39	14	26	14	7

1) Distribution of lines according to percentage smutted plants, classes indicated by upper limit.

checks 'Tadmor' and 'WI2291'), should not be advanced to trials meant to develop germplasm for farming systems where seed treatment is not used.

2.4.5.2. Effect of environment on expression of covered smut

Four highly susceptible barley lines where inoculated and planted in three locations: Breda (low rainfall), Tel Hadya (moderate rainfall) and Jinderess (high rainfall). At Tel Hadya there were two planting dates, for the late planting two sets were grown, one sown directly and one pre-germinated on filter paper for 5 days at 18°C. Temperature during germination seems to play a major role as is shown by the effect of pre-germination and the difference between early and late planting (Table 27). A significant difference in level of smut was present between the high and the low rainfall locations. However, the difference might be caused by the lower temperature at Breda during germination.

Table 27. Effect of environment on percentage smutted plants of four inoculated smut-susceptible barley lines, 1991-92.

	39-03	10-11	Tadmor	WI2291	mean[1]
Breda	35	34	31	18	29 a
Jinderess	55	53	38	12	40 b
Tel Hadya					
- early	37	32	52	22	36 ab
- late, pregerminated	64	59	67	50	60 c
- late	6	7	0	0	3

[1] means with same letter are not statistically different (P = 0.05) using LSD test. Tel Hadya late planting not included in ANOVA.

2.4.6. Seed treatment by fungicides

Fungicide research is a relatively small effort within the project and concentrates on two aspects; (1) Phytotoxic and phytotonic aspects of seed treatment; (2) Control of seed decay.

2.4.6.1. Effect of different fungicides on yield

Previous experiments (Cereal Program Annual Report 1991, 1992) showed that certain fungicides effect plant growth as well as protecting the plants from seed-borne diseases. During the past year three advanced barley lines ('Tadmor', 'Arta' and 'Furat-2') were tested in yield trials with four fungicides (Vitavax, Baytan, Imazalil and Quinelate) in five locations throughout Syria. The first three fungicides were applied both at the recommended and double rates. The experiment formed a part of the collaborative project with the Syrian National Program. No effect on yield was observed. The experiment will be repeated in the coming season.

2.4.6.2. Dry seed decay

Very high seed rates (> 200 kg / ha) are commonly used in WANA. Reasons for this are not clear, but pathogens that affect seed emergence may play a role. *Penicillium* is a saprophytic fungus which is omnipresent in soil and on seed. The fungus can colonize seeds at soil moisture levels that are too low for germination. Dry seeding in years when first rains are delayed provides therefore a good environment for the development of dry seed decay. The use of fungicidal seed dressing is probably the only way to control the decay.

The emergence of seed inoculated with a *Penicillium* spore suspension and incubated for one week at 18 °C and high relative humidity was compared with that of uninoculated, non-incubated seed. Two different planting depths were used to test the effect on seedling vigor. The same varieties and fungicides as described under 2.4.6.1 were used. The experiment was planted on 22 December with adequate soil moisture for germination and plant emergence was noted on 23 January. Inoculation decreased emergence (47% for inoculated, 57% for uninoculated, $P < 0.001$), while shallow planting resulted in a lower plant emergence than deep planting (37% for shallow, 67% for deep planting, $P < 0.001$). A better emergence from deep planting has been observed before in root rot experiments and is probably due to higher soil temperatures at greater seeding depth. Apart from a seed treatment x inoculation interaction ($P < 0.001$) the only significant interaction was planting depths x varieties, caused by the poor emergence of Furat-2 at shallow seeding. Figure 4 shows the effect of inoculation and seed treatment, averaged over depths and varieties. No significant (at P= 0.05) effect of inoculation on emergence was present after seed treatment with the double dose of Vitavax, the double dose of Imazalil or the single dose of Baytan.

Two different experiments were carried out to test the effect of dry-seed decay under controlled environment conditions. In the first the length of the incubation period was varied from one to 25 days. After incubation the seed was placed on wet blotter paper and germination was noted after 10 days. The same varieties and seed treatments were used. The three barley lines responded similarly to the treatments. Figure 5 shows the percentage of germinated seed, averaged over varieties. Under conditions optimal for seed germination, an effect of inoculation was only detected after 11 days incubation, even though fungal infection on the seed was noted after one week. Baytan gave the best protection, even after 26 days incubation. In a second experiment seed was incubated for one week and placed on blotter paper for germination. After 10 days the coleoptile length was measured from seed with a visible infection and from seed without. Figure 6 shows that infested seed had shorter coleoptiles than seed without visible infection and that treating the seed with Baytan reduced coleoptile length. Assuming that coleoptile length is a measurement for seedling vigor, these results support the field data which showed the large effect of inoculation on emergence, even though germination might be only affected after prolonged incubation. - **J. van Leur**

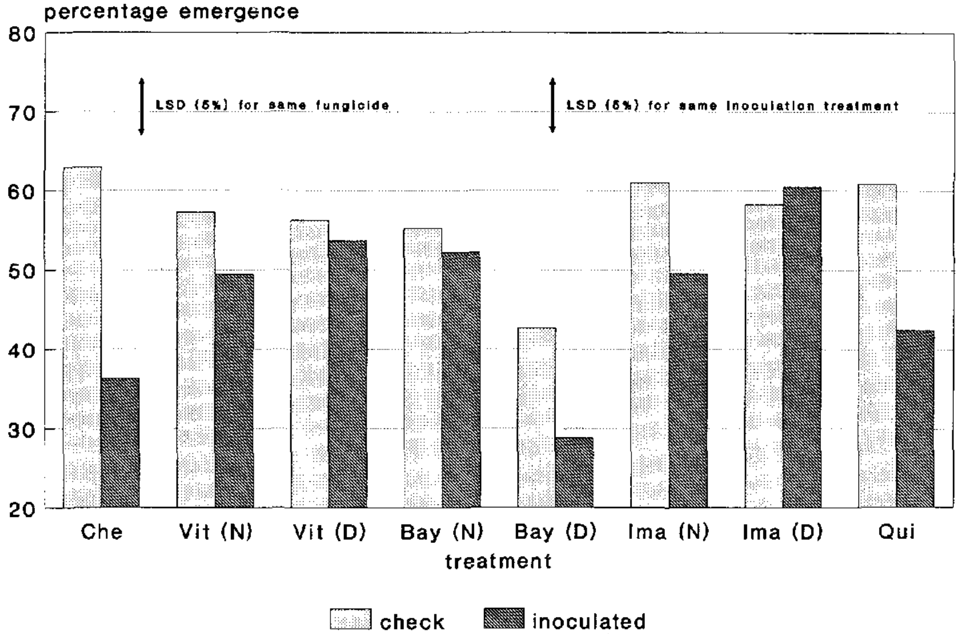

Fig. 4. Effect of fungicide and inoculation with Penicillium on plant emergence, Tel Hadya, 1991-92.

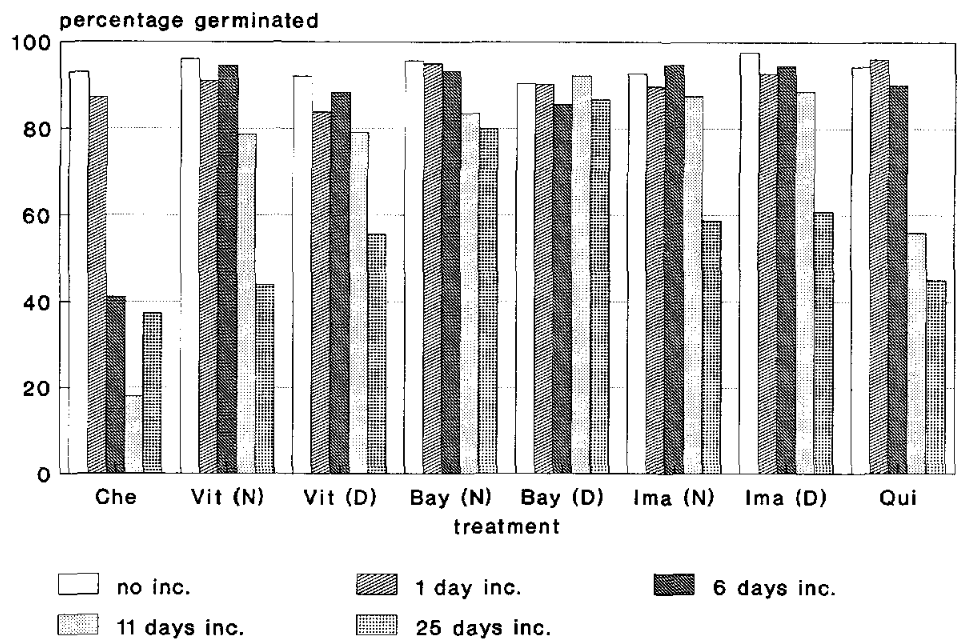

Fig. 5. Effect of fungicide and inoculation with Penicillium on seed germination under controlled environment conditions.

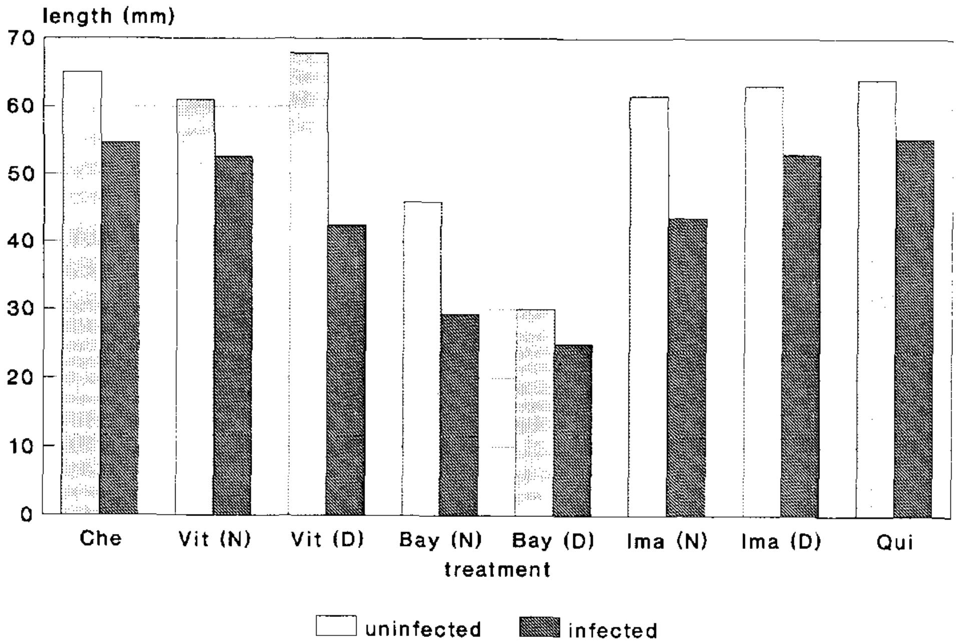

Fig. 6. Effect of Penicillium infestation and fungicide on coleoptile length

2.5. International Nurseries

International barley nurseries available for distribution from ICARDA, Syria, in 1992 remained the same as last season (Table 28). Two specific-trait nurseries, one for naked barley and one for BYDV resistant germplasm, were assembled for the second year.

In 1992 there was no seed shortage except for the Segregating Populations. A total of 388 nursery sets were distributed. This number was about the same as that of last year. - **S.K. Yau**

Table 28. Barley international nurseries for 1992-93.

Nursery	Abbre-viation	No. of entries	No. of sets distributed
Regular Nurseries			
Crossing Block	BCB	92	31
Segregating Populations	BSP	122	19
Observation Nurseries:			
- Low Rainfall Areas (Mild Winter)	BON-LRA (M)	65	39
- Low Rainfall Areas (Cool Winter)	BON-LRA (C)	109	28
- Moderate Rainfall Areas	BON-MRA	113	51
Yield Trials:			
- Low Rainfall Areas (Mild Winter)	BYT-LRA (M)	24	55
- Low Rainfall Areas (Cool Winter)	BYT-LRA (C)	24	37
- Moderate Rainfall Areas	BYT-MRA	24	64
Germplasm Pool			
Naked Barley	BN	80	31
BYDV resistance	BYDV	56	33
Total			388

2.6. Biotechnology

The second biotechnology position was filled by Dr. M. Baum, who holds a Doctor degree in cytogenetics and plant breeding from Göttingen University, Germany and worked as a post-doctoral fellow in CSIRO, Canberra, Australia. He has been involved in molecular genetic research of wheat, rye and triticale.

The main research objectives are to establish the use of RFLP- and PCR-marker techniques for marker assisted selection in breeding populations of barley.

2.6.1. DNA-markers in barley

In barley specific monogenic or oligogenic resistance genes have been described for important diseases and nematodes. The use of markers closely linked to specific resistance genes will allow selection for the marker resulting in resistant breeding material. Through collaboration with the North American Barley Gene Mapping Project (NABGMP) and the German Barley Gene Mapping Project (GBGMP) about 500 mapped DNA-markers for barley are available.

At ICARDA linkages will be established between these RFLP-markers and resistant genes in segregating populations. The cross Tadmor x WI2291 has been selected for the mapping. Tadmor, a selection from a black seeded Syrian landrace (Arabi Aswad), is resistant to scald and root rot but susceptible to powdery mildew. WI2291, a line from Australia, is resistant to powdery mildew but susceptible to scald and root rot.

In order to use well defined homozygous parental lines the cross Tadmor x WI2291 was repeated this year by the barley breeders. The F1 hybrids were grown up a) to produce F2 segregating populations and b) to serve as donor plants for Double Haploid production by anther culture and through crosses with Hordeum bulbosum. F2 embryos were excised out of immature seeds developing on the F1 plants, these were transplanted on to artificial medium (B5) to speed up the plant development process. At the end of this year DNA can be extracted from this segregating population.

Anthers from F1 plants (Tadmor x WI2291) were cultured on artificial media(induction media) in order to induce haploid plant formation. The induced calli were transferred to a regeneration media. Haploid plants are being regenerated. A second set of F1 plants has been grown up and crossed with Hordeum bulbosum to also induce Double Haploids.

2.6.2. Development of the nonradioactive DNA-marker technique

In order to use DNA-markers which have already been mapped elsewhere a bacterial transformation system has to be established. Single copy

DNA-markers are usually inserted as foreign DNA into a bacterial plasmid vector and shipped as dried DNA in this form. Plasmid DNA can be introduced into bacteria by the artificial process of transformation. In this process bacteria are treated with heat shock (or high electric current) to make them temporarily permeable to small DNA molecules. To identify these transformants, a selectable marker (ampicillin resistance) encoded by the plasmids is used.

Several wheat and barley clones have been transformed and grown up after heat shock transformation. They are maintained permanently in a glycerol culture and stored at -45°C. The amplified plasmids have been extracted from the bacteria by mini plasmid preparation. In this form they can serve as a template for labelling with the nonradioactive molecule digoxigenin.

Within the PCR (Polymerase Chain Reaction) DNA sequences can be amplified using the bacterial Taq-polymerase. If one of the artificial nucleotides is substituted by the nonradioactive labeled molecule UTP-digoxigenin it will be build into a double stranded DNA molecule. This labelled DNA sequence can then be used as a labelled probe in a nucleic acid hybridization. We have optimized the conditions for PCR-labelling with our PCR machine. We are able to label single copy sequences (DNA-marker) nonradioactively.

We have adjusted the protocols for *nucleic acid hybridization* of nonradioactive labelled single copy probes and their detection with chemiluminescence. Nonradioactive labelled probes which are hybridized to genomic DNA are detected with an antibody and coloring reaction. - **M. Baum**

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3. Winter And Facultative Barley Improvement

3.1. Winter and Facultative (W&F) Barley Breeding

In the continental Mediterranean environments of WANA winter and facultative barley is grown on approximately six million hectares with an average yield of less than a ton per hectare. It is not only the erratic rainfall distribution and amount which lowers productivity but also the severe cold for prolonged periods. Diseases also play a major role in low yields. Although, the major use of barley is for animal feed, a significant portion is consumed as human food.

The objectives of this project are 1) to develop improved W & F barley germplasm able to tolerate the abiotic and biotic stresses (Refer to earlier Annual Reports) than present cultivars which have higher and more stable yields with improved quality. 2) improve breeding and evaluation methods.

3.1.1. Breeding Material Grown in 1991-92

Breeding activities were carried out in close cooperation of NARS. Collaborative links have been developed with Turkey, Russia, Pakistan and Iran.

The breeding material comprised genetically stable lines, such as advanced breeding lines, screening nurseries, yield trials, local and exotic germplasm; and segregating populations.

The crossing program involved winter x winter, winter x spring, facultative x facultative crosses employing locally adapted and improved exotic germplasm possessing desirable traits against the stresses mentioned above as well as hulless crosses. About 20% top and double crosses were also made.

The segregating populations were planted at several locations for multiple stress evaluation and a complete set was also planted at Tel Hadya. The information gathered from other sites was used to make inter and intra population selections.

Selections from F_2 populations were based on their performance at key testing sites including Iran. A large number of single plants were selected from populations which performed well at 3 or more sites. From F_3 onward, populations which were susceptible to diseases, cold or moisture stress were discarded and only those populations were retained which possessed desirable agronomic traits.

3.1.2. Growth habit

A continuous gradation in growth habit ranging from winter to spring types occurs to cereals grown in the high altitude areas of WANA with continental mediterranean climate (Kihara, et al. 1965, Tahir, 1982 and Tahir and Banisadr, 1991). Therefore germplasm needs of NARS with major high altitude areas must not only embody tolerance to biotic and abiotic stresses but must also have a range of development patterns to fit highly variable regions.

To develop suitable germplasm for these variable agroclimatic conditions winter x spring, and winter x winter hybrids are made to incorporate desirable traits from both gene pools. As the spring type character is dominant, the majority of segregants in winter x spring crosses will be spring types. Material is classified by growth habit before it is supplied to NARS.

In the spring of 1992, 2142 lines of W & F barley were evaluated for growth habit (using the method and scale in Annual Report 1991/92) in early summer when the temperature never goes below 10°C. Results are given in Table 29. In PBSN, EBSN and WBSN-2 a low frequency of facultative and spring types was observed. This is due to earlier selection pressure for cold tolerance. Cold tolerance in general correlates with winter growth habit. However we have made many crosses involving Winter x Spring types to incorporate cold tolerance into spring and facultative types. These have vigorous early growth compared to winter types. They give high yields in the Atlas mountain region of Algeria and Morocco, as well as in West Asia.

In the F_5's a high frequency (53%) of spring types was found. These populations were not evaluated earlier for cold tolerance and have been through accelerated generation advance. All the F_5s were planted at Haymana-Turkey and good differentiation between cold tolerant and susceptible lines occurred.

Table 29. Growth habit of advanced barley breeding material.

Nursery	Winter	Growth habit Facultative	Spring	Total
PBSN	124	11	3	138
EBSN	134	20	27	181
PBSN - Expt. 2	62	4	5	71
Seg. Pop. F5	585	241	925	1751

PBSN: Preliminary Barley Screening Nursery;
EBSN: Elite Barley Screening Nursery.

3.1.3. Breeding for Drought Tolerance

Drought tolerance is a complex character. Most research has used an empirical approach, subjecting large populations to moisture stress and selecting on the basis of yield. The range of growth habit and maturity types makes the application of an empirical approach difficult in the W & F barley project. To select genotypes that perform better under moisture stress without loosing important genetic variability for growth habit and maturity range we use the scale described in last year's annual report.

Lines were evaluated for their moisture stress tolerance at Breda (a moisture stress site in Syria, Table 30). The high selection frequency in IWFBON's is because these lines were selected for moisture stress tolerance in the previous years. Of selected lines 41% were early, facultative types and 59% belonged to the late group primarily winter types. There may be also a few spring types with a photoperiod response. These will be analyzed in the coming years.

The germplasm (350 entries) from WANA countries was also evaluated in the WFBSN. It represented considerable genetic variability in growth habit as well as in moisture stress tolerance. A large number (242) of lines from both early and late groups were selected. - **M. Tahir**

Table 30. No. of selected lines for Drought Tolerance at Breda, 1991-92.

Nursery	Total	No. Selected			% Selected
		Early	Late	Total	
WBCB	200	61	79	140	70
IWFBON	150	84	36	120	80
WFBSN	350	160	82	242	69
PBSN-Expt. 1	252	45	101	146	58
PBSN-Expt. 2	252	22	106	138	55
Seg. Pop. F_3	315	115	98	213	68
Seg. Pop. F_5	1074	592	212	804	75
IWFBYT	24	2	6	8	33

WBCB: Winter Barley Crossing Block;
IWFBON: International Winter and Facultative Barley Observation Nursery
WFBSN: Winter and Facultative Barley Screening Nursery
PBSN: Preliminary Barley Screening Nursery
IWFBYT: International Winter and Facultative Barley Yield Trial

3.1.4. Breeding for Cold Tolerance

The most detrimental abiotic stress reducing yields is low temperature during the severe winters. Efforts were intensified to select winter hardy and cold tolerant material in collaboration with the Turkish national program and the Agriculture Research Institute, Krasnodar-Russia. The winter barley breeding material was planted at four sites, i.e. Ankara and Konya in Turkey, Krasnodar-Russia and Maadar-Syria but data from Ankara and Krasnodar is presented as adequate screening only occurred at these sites.

3.1.4.1. Ankara Site

Under the collaborative agreement with Field Crops Research Center, Ankara a total of 2540 lines were planted and evaluated at Haymana Research Farm (Table 31). The winter was severe and excellent differentiation for winter survival (%) was made. The most widely grown barley variety in Anatolian Plateau, Tokak, had a mean survival of only 35%.

Table 31. No. of winter barley lines evaluated for winter survival at Haymana - Ankara, 1991-92.

	Winter Survival (%) Class						No.
Nursery	Total	0	1-25	26-50	51-75	76-100	selected.
WBCB	200	21	70	69	30	10	48
IWFBON	150	30	75	34	11	0	38
WFBSN (GRU)	298	111	39	22	74	52	69
WBSP - F_3	315	28	129	132	25	1	131
WBSP - F_5	1072	840	125	90	19	0	152
PBSN - 1	252	33	42	59	99	19	135
PBSN - 2	252	73	51	57	48	23	85

Mean survival (%) of check variety Tokak = 35%.

The frequency of cold tolerant lines was highest in the barley screening nurseries (PBSN) whereas cold tolerant lines were in low frequency in IWFBON, WBSP-F_3 and F_5 populations. The F_3 and F_5 populations were in the accelerated generation enhancement program (Ref. Annual Report Cereal Program, 1990) and had not been subjected to cold under field conditions. The growth habit studies revealed that the majority of F_5 populations were spring types. The F_3 segregating populations had a higher frequency of cold tolerant lines. This is due to the use of more cold tolerant parents in the crosses.

Despite cold winter 411 lines had more than 50% survival, compared to 35% survival of Tokak, the Turkish check. Turkish scientists selected 200 lines for further testing. - **M. Tahir, A. Ottekin (Field Crops Research Center, Ankara)**

3.1.4.2. Krasnodar-Russia Site

Four barley nurseries; 1st International Winter and Facultative Barley Yield Trials - (1st IWBFYT - 23 entries), 1st International Winter and Facultative Barley Crossing Block (1st IWFBCB - 83 entries), 2nd International Winter and Facultative Barley Observation Nursery - (2nd IWFBON - 150 entries), 1st International Winter and Facultative Barley Segregating Populations - (1st IWFBSP - 150 entries) were evaluated under field and laboratory conditions for their agronomic performance and cold tolerance.

This winter was mild, and most ICARDA lines in the autumn sowing survived the winter, including Rihane 03 (spring type). Differentiation was observed after artificial freezing in cold chambers. The nurseries were tested as seedlings at -9° C for 24 hours. The data on frequency and survival percentage is presented in Fig. 7.

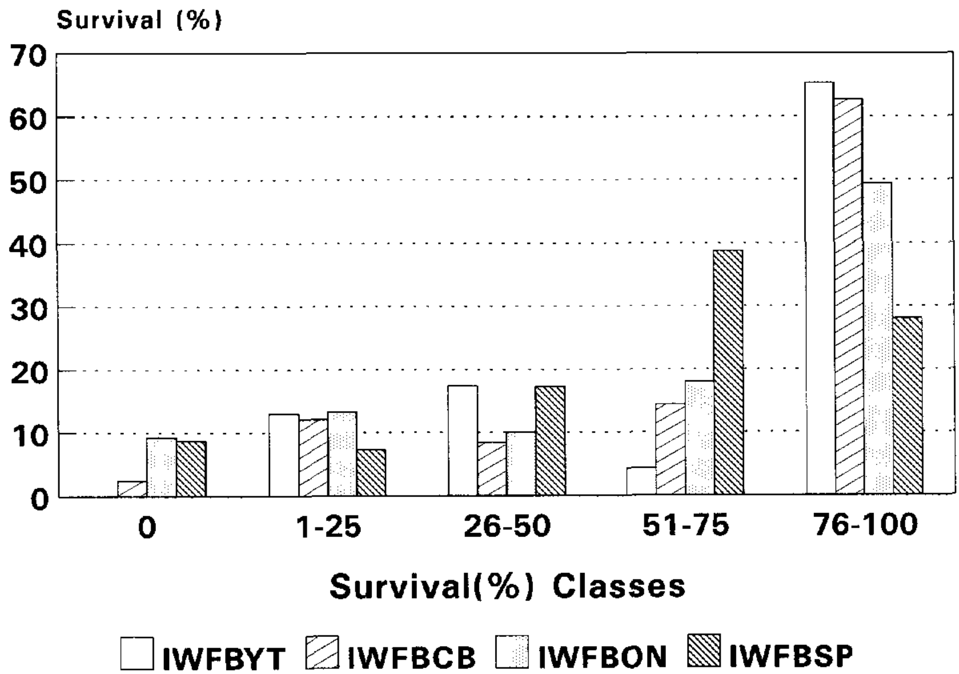

Fig. 7 Winter survival (%) in W & F barley during 1991-92 at Krasnodar-Russia

The main objective was to find good combinations of cold tolerance with good agronomic characteristics. The IWFBSP contained many lines with a high rate of initial growth recombining spring and winter germplasm (Table 32).

Table 32. Number of barley lines selected at Krasnodar - Russia, 1991-92.

Nursery	Total	No Selected					% Selected
		Growth Vigour	Early	Multi. Disease Resis.	Yield	Total	
1st IWFBYT	23	4	2	6	7	7	30.4
1st IWFBCB	83	9	7	15	20	27	32.5
2nd IWFBON	150	15	13	15	44	52	34.6
1st IWFBSP	150	51	29	13	54	64	42.6

In the 1st IWFBYT-1991-92, 13 lines out of 23 have shown frost resistance at the same level as Tokak and considerably higher than Salmas. This advanced nursery had the highest portion of lines in the class of 76 - 100% cold survival. Earlier testing was successful. Moreover 7 lines combined a whole complex of useful traits with high yielding capacity (Table 33). The very early line Mv-46/Mazurka had fast initial growth together with good resistance to *Erysiphe graminis* and *Pyrenophora teres*. Line Kenya Research/Belle combines cold tolerance, high growth rate and resistance to leaf diseases.

The 1st IWFBCB and 2nd IWFBON differed greatly in agronomic characteristics, physiological and morphological traits, including six-rowed and two-rowed forms, dense and lax spikes, awned and awnless, with smooth and rough, short and long awns, early and late ripening, semi-dwarf and very tall. Practically all selected lines belong to different hybrid combinations and have distant parentage, an important factor for transgressive segregation. Some varieties of ecologically and geographically distant origin like Xemus and Productive were included (Table 34).

Entry ICB 100051 with such traits, ranked the first in all nurseries, outyielding the checks 2-3 fold. This line was tall but did not lodge and has a large biomass, which combined with disease resistance gave it a high grain yield.

The majority of productive lines possess good disease resistance (Table 34). The top-yielding lines (Scotia 1/WA 1356, Perga/S.W.WA 1094, ICB 100051) were moderately resistant. Many of them are agronomically similar but differ in resistance to different diseases.

Table 33. Performance of top-yielding barley lines from 1st IWFBYT 1991-92 at Krasnodar - Russia, 1992.

Name or Cross	Frost resist. x) %	Growth rate score	Head time	Plant height cm	Resistance to (score) xx) Er.gr.	Pyr.t.	Puc.h	Yield, gr/plot
Salmas (check)	37.5	7	6.v	70	8	8	5	180
Tokak (check)	76.9	6	19.v	100	8	8	4	240
Vavilon (loc.check)	95.0	6	14.v	80	8	9	8	490
Tipper	77.5	8	12.v	85	8	8	7	550
Mv-46/Mazurka	33.3	9	7.v	80	8	8	4	540
Th.Unk48/Roho/Del.	6.2	8	13.v	95	7	8	7	500
Weiselbur./Ahor	37.5	8	7.v	90	5	8	5	450
Robur/WA 2196	94.1	7	11.v	75	6	8	7	430
WA 1245/B 67 ...	87.5	7	15.v	70	7	8	7	400
Kenya Research/Belle	68.4	8	15.v	85	8	9	8	360
LSD 0.05	10.2							

x) freezing in chambers, temperature -9°C, 24 hours
xx) 1 - very low, 5 - moderate, 9 - very high

Table 34. Performance of top-yielding barley lines at Krasnodar - Russia, 1991-92.

Name or Cross	Nur.	FR,[x] (%)	GR, score	HD	PH (cm)	Resistance to (score) Er.gr.	Pyr.t.	Puc.h	Yield, gr/Plot
Salmas	Check	37.9	7.5	6.v	80	7.5	8	6.5	375
Tokak	Check	68.0	6	19.v	102	8	8	3.5	265
Rihane 03	Check	0	8	6.v	95	6	8	4	665
Vavilon	Loc.check	86.8	6	14.v	85	8	9	8	510
Scotia 1/WA 1356	1st IWFBCB	47.0	7	15.v	105	5	7	6	780
Perga/S.W./WA 1094	1991-92	90.0	6	15.v	95	5	8	7	760
Xemus	1991-92	90.6	8	8.v	95	8	8	7	700
WA 2138/S.W./...	1991-92	75.0	7	19.v	90	5	8	6	700
Productiv.	1991-92	91.1	9	8.v	95	8	8	6	680
Alpha/Durra	1991-92	94.7	7	12.v	80	5	8	7	660
80 - 5001	1991-92	87.5	7	13.v	95	7	8	8	620
Lignee 131/4341 ...	1991-92	79.4	7	9.v	90	7	8	6	540
ICB 100 051	2nd IWFBON	75.0	9	12.v	125	6	8	7	850
Scio/3/G1/12 AB58	1991-92	63.1	8	15.v	100	5	8	8	850
Scotia 1/WA 1356...	1991-92	81.0	8	12.v	105	6	6	8	840
80-5001	1991-92	97.6	8	13.v	100	8	8	7	810
Belt 67-1608/Sl	1991-92	87.6	8	13.v	100	4	8	7	760
VA 84-44-342	1991-92	86.6	8	6.v	105	8	8	7	750
Lignee 131/N/Ortalon	1991-92	62.5	8	11.v	100	7	8	4	650
Salmas/3/Kv/Alger	1991-92	58.7	9	9.v	95	4	8	6	650
M25-84/Attiki//Emir	1991-92	90.0	9	13.v	85	7	8	3	650
Kavir	1991-92	0	9	2.v	105	6	8	2	500
L.S.D. 0.5		10.2							

FR - frost resistance, GR - growth rate, HD - heading date, PH - plant height.

Productive germplasm has been used effectively in the breeding program and some progress in combining desirable characters has been achieved. If this material is also tolerant to drought, it is valuable for future breeding. - **V. Shevtsov (Krasnodar Research Institute of Agriculture, Russia), M. Tahir**

3.1.5. Breeding for Grain Quality

Barley grain is used both as animal feed and human food especially in the mountain regions of WANA. Five hundred fifty one advanced lines were evaluated for grain protein (%) and thousand kernel weight (gms).

3.1.5.1. Thousand Kernel Weight (gms)

The 1000 kernel weight (TKW) of Winter and Facultative Barley Crossing Block (WBCB) (150 entries), International Winter and Facultative Barley Observation Nursery (IWFBON), Preliminary Barley Screening Nursery (PBSN) and International Winter Barley Yield Trial (IWBYT) was assessed along with four check varieties, Tokak, Rihane 03, Salmas and Alger/Ceres. The frequency distribution for TKW is presented in Fig. 8.

More than 25% of the lines in all the nurseries had TKW greater than >50 gm. The best check variety, Tokak, was 49.5 gm.

Many of the tested lines were of winter or facultative types. Under Tel Hadya conditions these suffer terminal moisture stress coupled with rapidly rising temperatures during grain filling. The selected lines, with more than 50gm TKW, show they can with-stand terminal moisture stress and produce plump grains.

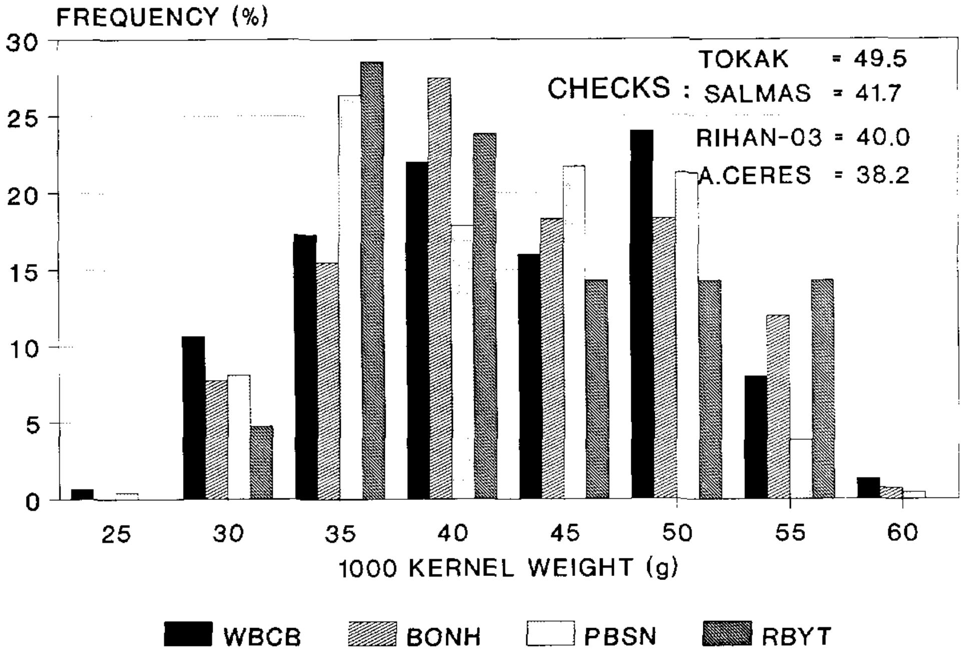

Fig. 8. Thousand Kernel weight (TKW) distribution in winter barley breeding material, 1991-92.

3.1.5.2. Protein Content (%)

The lines were also tested for protein content. The distribution of lines for protein % is illustrated in Fig. 9. The protein content of the WBCB and PBSN ranged from 8 to 17% and more than 70% of the lines had 11-17% protein as compared to 9.7% in the check varieties Tokak and Rihane 03, indicating considerable genetic variability in this character. The protein content in IWFBON and IWBYT ranged from 7-15 and 8-13%, respectively. The Majority of the lines (86%) had protein contents higher than the widely cultivated check varieties Tokak and Rihan-03. Considerable improvement in protein content can been made with continuous selection.

In general high protein is negatively correlated with TKW.

Efforts to combine the two traits and select the lines possessing other desirable agronomic characteristics are being made.

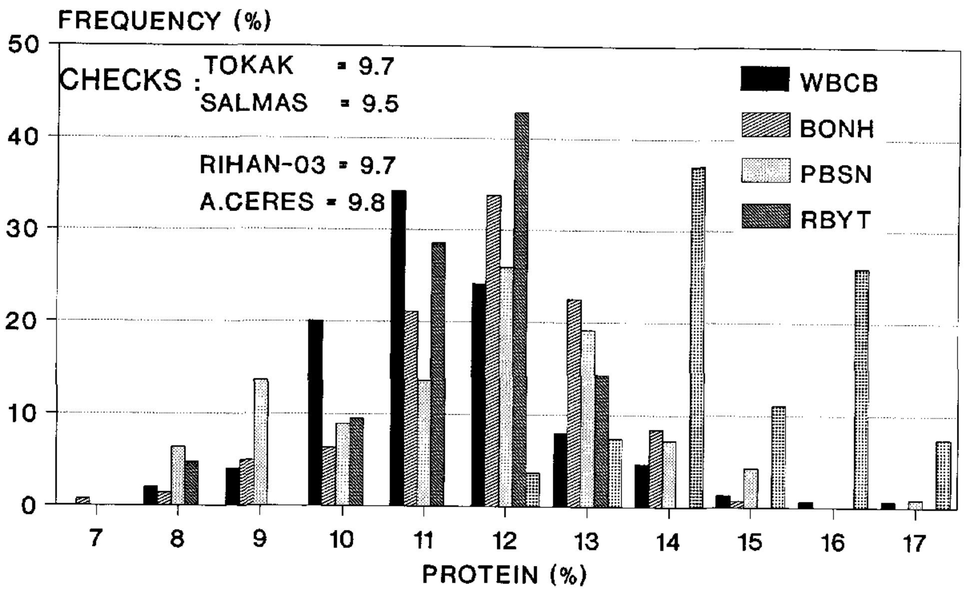

Fig. 9. Protein distribution in winter barley breeding material, 1991-92

Seventeen lines with TKW ranging from 40-56.1 gm, and protein content of 13.6 to 16.3% were selected (Table 35). Three lines, i.e. NB69296/1245//Boyer, F6/3/J-126; OR1871016 and ICB 105966 had more than 52 gms TKW and protein levels of over 15%. - **M. Tahir, F.J. El-Haramein**

Table 35. Lines with high TKW and high protein content (%).

S.N.	Line/Cross	Seed Source	TKW	Protein %
1.	Scio/3/G1/72AB58.F_1// WA1245	WBCB-67	43.0	14.1
2.	YEA 1819/YEA 195-4	WBCB-91	50.2	13.4
3.	1246/1-3//4056/1-3/ 3/Cum 50	WBCB-93	50.6	13.5
4.	3896/1-3/4/1246/1-3/3/3/ 3887/28//3892	WBCB-94	50.1	13.3
5.	11162-19/FB 73258D21- 3H-OH	WBCB-123	48.1	13.3
6.	NB69296/1245//Boyer, F_6/3/J-126	WBCB-131	56.1	15.6
7.	GI/72AB58//WA 1245/3/ SC01/WA 1356/4/LL	WBCB-132	47.6	14.0
8.	OR 1871016	WBCB-137	52.4	16.3
9.	ICB 105966	WBCB-145	52.1	15.0
10.	OR-ID 1861480	IWFBON-15	39.8	14.3
11.	Cussack - OR 1861345	PBSN-3	48.8	14.9
12.	MD 76576-50	PBSN-5	49.5	14.9
13.	ICB 106699	PBSN-114	40.6	14.9
14.	ICB 102496	PBSN-133	46.0	14.7
15.	ICB 100903	PBSN-152	44.3	13.6
16.	ICB 104826	PBSN-196	48.2	14.1
17.	ICB 100136	PBSN-208	50.1	14.0
18.	Tokak (winter-check)		49.5	9.7
10.	Rihane-03 (spring-check)		40.0	9.7

3.2. International Nurseries

The advanced breeding material (Observation Nursery and Yield Trials) and early segregating populations (F_2s) are provided to the NARS and globally on request for their evaluation and possible use. The results of evaluation of advanced material by NARS are briefly presented here.

3.2.1. 1st International Winter and Facultative Barley Observation Nursery

The first International Winter and Facultative Barley Observation Nursery was available for 1990-91. It was prepared in cooperation with Oregon State University (OSU), USA, and replaces the International Winter and Facultative Barley Screening Nursery and the Barley Observation Nursery for High Altitude Areas that used to be assembled and distributed by OSU and ICARDA, respectively.

The agronomic characteristics of the 15 lines selected 6 or more times by NARS scientists in 17 locations are presented in Table 36. Most of the selected lines were resistant or moderately resistant to lodging, powdery mildew, and scald. Five lines had a thousand kernel weight of less than 30 g, and their selection is surprising. Six lines had less than 20% survival at -9 °C in the freezing chambers at Krasnodar, Russia, suggesting either that some locations may not need good cold tolerance or that cold weather was not experienced at those locations during the season.

3.2.2. Barley Yield Trial - High Altitude Areas (BYT-HAA) 1990-91

Table 37 shows the grain yield and regression coefficients of the five highest yielding entries in the 1990-91 BYT-HAA. Entry 10 was more stable with a regression coefficient close to 1. The ranking of the three other checks (Beecher, Matnan and Salmas) was 21, 19 and 12, respectively, a reflection that improved entries were included in the trial. Detailed results of the trial are available in the Annual Report for the International Barley Nurseries 1990-91.

Table 36. Characteristics of the most frequently selected entries of the 1990-91 IWFBON (International Winter and Facultative Barley Observation Nursery).

Entry no.	Name/cross	Sum selection	Grain Yield (kg/ha)	Heading days	Maturity days	Powdery mildew	Scald	1000-grain wt.(g)	Lodging (0-9)#	Survival % at -9°C
33	Robur/WA2196-68	7	2346	160	184	3	2	27	2	11
31	Mal/OWB753328-5H, F1//Perga/Boyer	7	2929	162	185	2	1	28	1	40
19	Cyclone	7	3260	159	185	2	3	31	2	38
39	OWB763126-VIP3,F2/F1, OWB773248	6	3045	161	185	4	3	28	1	31
101	Alpha/3/Roho//Alger/Ceres	6	2741	152	182	3	5	42	4	16
107	PI 000505/Alpha	6	3160	158	182	3	4	42	6	0
35	Belts67-1608/Schuyler/ 3/Dicktoo//Hiproly	6	3216	160	183	2	2	30	1	41
108	PI 000505/Alpha	6	2676	155	183	4	3	40	7	0
46	Alpha/Durra	6	2616	158	183	3	4	38	1	42
25	Productive	6	2917	157	184	2	2	32	4	25
41	Athene//Dar69-735/Mrl	6	3150	166	188	2	2	37	1	60
34	Belts67-1608/Schuyler/ 3/Dicktoo//Hiproly	6	2040	162	186	2	2	30	1	41
55	Lignee 131//4341 N/Ortolan	6	2542	159	184	2	3	27	4	17
49	Alpha//Sul/Nacta	6	2566	156	183	3	2	41	1	17
17	Lokus	6	2756	158	183	4	1	28	3	40
No. of locations		17	12	12	8	7	4	3	3	1

0: no lodging; 9: completely lodged

Table 37. Mean grain yield and regression coefficient of the 5 highest yielding lines in the 1990-91 Barley Yield Trial - High Altitude Areas over 12 locations.

Entry no.	Name/cross	Yield (kg/h)	Rank	Regression coef.
17	Lignee 131/Irania	2850	1	1.393*
10	M126/CM67//C63	2839	2	1.020
11	WI2291/3/SP(2H)//Cr.115/Por	2740	4	.933
4	Roho//Alger/Ceres,362-1-1	2734	5	1.129
3	Alt/EH8B-FYE-E-L-7-C	2718	6	.689*
1	Matnan (6-row check)	2392	19	.953
6	Lignee 131 (2-row check)	2818	3	1.307*
12	Beecher (Long-term check)	2275	21	.563
18	Salmas (2-row check)	2505	12	.979

* significantly different from 1.0 at $P<0.05$

The NARS are identifying better varieties in the breeding material, however to create impact the new lines must be tested in on-farm verification and on-farm demonstrations. - **S.K. Yau, M. Tahir**

3.2.3. Nursery distribution in 1992

Regular international barley nurseries available for distribution from ICARDA, Syria, in 1992 remained the same as last year (Table 38). But there was a newly created special trial: Barley High Elevation Adaptation Yield Trial. The trial is an element of a collaborative project on 'Specific adaptation of winter/facultative barleys in high-altitude areas of WANA in relation to local climatice conditions' involving Algeria, Iran, Pakistan, Turkey and ICARDA. A total of 125 nursery sets were sent to national scientists upon their requests. - **S.K. Yau, M. Tahir**

Table 38. Barley international nurseries for 1992-93.

Nursery	Abbre-viation	No.of entries	No. of sets distributed
Regular			
Crossing Block	IWFBCB[1]	150	20
Segregating Populations	IWFBSP	150	27
Observation Nursery	IWFBON	150	41
Yield Trial	IWFBYT	24	27
Special			
Yield Trial	BHEAYT[2]	24	10
Total			125

[1] IWF - International Winter and Facultative
[2] BHEAYT - Barley High Elevation Adaptation Yield Trial

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4. Durum Improvement

4.1. Breeding

The main objective of the project is to assist WANA countries to enhance Durum production by developing germplasm resistant to abiotic and biotic stresses; by improving dryland breeding methodology; and by assisting NARSs to develop manpower.

The four major agro-climatic zones are:

1) Continental dryland,
2) Temperate dryland,
3) Favorable areas,
4) High altitude areas.

Selection environments and traits for adaptation of durum wheat to stress in each zone have been identified. The work on selection environments and traits for adaptation to stress resistance is an ongoing activity.

In the 1991/92 season the western part of WANA region (Morocco and West Algeria) suffered from severe early and intermittent drought, whereas the eastern part (Syria, Jordan, Lebanon, and South Turkey) had late drought and warm weather conditions which caused terminal stress. The latter area also had a long cold period in the vegetative stage. Besides these abiotic stresses, wheat stem sawfly, Hessian fly, root rots, BYDV, tan spot, and yellow rust affected several durum growing areas. Drought tolerant varieties are being used for commercial production in many countries in the region, Cham 3 covers a large area in Syria and already has surpassed Haurani. It must have been a very variable landrace with a common name. - **M.M.Nachit**

4.1.1. Widening genetic base

The crossing program incorporates resistance to biotic and abiotic stresses and broadens the genetic base for productivity traits in dryland Mediterranean conditions. Crosses are made between improved genotypes, landraces and wild relatives.

4.1.2. Use of recurrent selection

Mediterranean *durum* landraces, *T. dicoccoides*, and wild relatives (*Aegilops, T. monococcum, and T. carthlicum*) were crossed with high yielding and stable durum lines that have multiple resistance to biotic and abiotic stresses. The objective is to develop populations with desirable traits from landraces and wild relatives. These crosses form the base of the durum recurrent selection programs. The Middle East durum recurrent selection populations (ME-DRSP) is targeted to continental dryland Mediterranean areas, The Maghreb-Iberian populations to temperate dryland areas (MI-DRSP). - **M.M. Nachit, A. Asbati**

4.1.3. Use of wild relatives

Sixty crosses were made between advanced lines and wild emmer (*T. dicoccoides*) in the 1991/92 season to improve grain quality and resistance to *Septoria tritici* and yellow rust. Backcrossing to durum eliminated undesirable traits. A further ninety-eight crosses were made with *T. monococcum* for earliness, rust resistance, and early plant vigor. Twenty-five crosses were made to *Aegilops species, T. carthlicum* and *T. turanicum compactum*. - **M.M. Nachit, A. Asbati**

4.1.2. Use of single seed descent method (SSD)

One hundred-fifty crosses were advanced four generations per year in the green house. SSD is used for Hessian fly, leaf rust, and *septoria tritici* resistance. The F5 populations will be screened in the 1992/93 for disease and other stress resistances. The F4 and F5 Hessian fly resistant populations were sent to INRA Morocco to be screened under field conditions at Settat. All known resistance genes located on A and B chromosomes were used in these crosses. - **M.M. Nachit, A. Asbati, R.H. Miller, N. Nasrallah (INRA, Settat, Morocco)**

4.1.3. Testing in the double gradient selection technique

Double gradient selection tests multiple abiotic (drought x heat and drought x cold) and biotic stress resistance (diseases and insects). In the 1991/92 season screening for cold, drought, and heat resistance; and to disease and insects resistance was effective and several populations and advanced lines were selected which combined multiple abiotic and biotic stress resistance. - **M.M. Nachit, A. Asbati, M. Jarrah, M. Azrak, Z. Younes**

4.1.4. Development of populations for RFLP markers analysis

Nine crosses were made for RFLP work. Polymorphic parents were used. Three landraces (two from the middle east region and one from the maghreb region) were crossed with each of three improved durum varieties. The crosses were advanced in the green house to F3. The landraces were Jennah Khetifa, Hammari, and Shihani, and the improved varieties were Waha (Cham 1), Brachoua, and Korifla (Cham 3). The parents were screened using RFLP markers. This work is a joint project with Cornell University, USA. - **M.M. Nachit, A. Asbati, M. Sorrells, E. Autrique, S. Tanksely (Cornell University, Ithaca, USA)**

4.2. Grain quality

Parental material having gluten strength, North Dakota varieties, Mediterranean landraces, and diccocoides were used to upgrade grain quality. Advanced populations and lines were tested and only those with acceptable values were selected. Most of the lines had high sedimentation values. The check cultivars were Haurani, Cham 3, and Lahn. Grain quality of new lines is either similar to or higher than the checks. Material was analyzed for electrophoretic bands. Thirty-four lines carried the desirable electrophoretic band number 45. Table 39 gives the means and ranges for some quality traits in advanced lines.

Table 39. Mean and range for some quality traits in advanced durum wheat lines, Tel Hadya, Rainfed, 1991/92.

Trait	Mean	Range
Protein content (%)	13.9	11.2 - 17.5
1000 kernel weight (g)	39.5	27.4 - 50.0
Carotene score	4.6	2.0 - 7.5
Sedimentation value (cm)	35.5	17.1 - 52.1
Sedimentation index	2.5	1.2 - 3.8
Virtuousness (%)	98.4	92.4 - 98.4

Seed storage proteins of landraces are evaluated in collaboration with the University of Tuscia. Two populations were studied. The first consisted of Mediterranean, and the second of Turkish highland landraces. The objective was to study within and between variability for gliadin components.

Mediterranean landraces: Seed storage proteins are not affected by environment and a single seed is enough to determine a genotype's profile. Electrophoretic studies were carried out on single seeds derived from random spikes. A total of 1620 samples were analyzed.

Band Rm42 is thought to be associated with weak gluten strength and Rm45 with strong gluten. Pasta cooking requires strong gluten. Band Rm42 γ gliadins are usually associated with the triplet Rm33-35-38 of ω gliadins of low molecular weight 1(LMW-1), while band Rm45 of γ gliadins are associated with band Rm35 of ω gliadins and low molecular weight 2 (LMW-2). However, a recombination of band Rm42 of γ gliadins with band Rm35 of ω gliadins and low molecular weight 2 (LMW-2) was found in Berillo which has good pata cooking quality.

Most populations had large variation for gliadin components. A recombination at the locus gli-B1 between band Rm45 and the triplet Rm33-35-38 and LMW2 was found in the ICARDA durum accession 12060, called Australian Poulard which was introduced from Egypt (Zeven and Zeven-Hissink: Genealogies of 14000 Wheat Varieties, 1976). Band Rm45 is usually associated with Rm35, and the triplet (Rm33-35-38) is usually associated with band Rm42 (Table, 40). This accession was crossed with Waha (Cham 1) and Korifla (Cham 3) varieties for further genetic studies.

Seed storage proteins of Turkish durum wheat landraces: Variation at the loci Glu-A1, Glu-B1, Gli-B1, and LMW-glutenin subunits was studied in a durum collection of 165 accessions from Turkey. A total of 14 different HMW-glutenin patterns were identified resulting from the combination of 3 alleles in the A genome and 7 in the B genome. Four new allelic variants, one at the Glu-A1 and 3 at the Glu-B1 locus, were identified. Six different allelic variants were detected at the Gli-B1 locus. Two correspond to alleles "42" and "45".

Accessions with the same allelic variant at the Gli-B1 locus were not always uniform in the B group of LMW-glutenin subunits. For example, genotypes characterized by the presence of ω gliadin-35 and γ gliadin 45 had four different LMW-glutenin B subunit patterns, whereas those with ω 33-35-38 and γ 42 had only two types. Seven different LMW-glutenin B subunit banding patterns were identified and two of them corresponded to LMW-1 and LMW-2. Genotypes with ω 35, γ 45 and LMW-2 were also classified into four groups on the basis of differences detected on the LMW-glutenin patterns by two dimensional electrophoretic analysis. The collection was also evaluated for the grain quality parameters; protein content and SDS-Sedimentation.

Table, 40. Different recombinatins of associations between Glu-B3 and Gli-B1 loci in different varieties.

Glu-B3	Gli-B1		Quality	
IMW	ω-Gli	γ-Gli		
1	33-35-38	42	Bad	(Waha)
2	35	45	good	(Korifla)
2	35	42	good	(Berillo)
2	33-35-38	45	good	(ICD12060)

SDS-Sedimentation values of accessions ranged from 34 to 86 mm and 10% of entries had SDS-values significantly higher than the best Italian durums. Gluten quality was strongly associated with the variation for IMW-glutenin B subunits and for HMW-glutenin subunits encoded at the Glu-A1 locus. HMW-glutenin subunits encoded at the Glu-B1 locus, were found in general to be poor indicators of gluten strength, although subunit 20 showed a negative influence on quality. Some new patterns for IMW-glutenin B subunits appear to be very promising for the improvement of gluten visco-elastic properties of durum wheats. - **M.M. Nachit, F.J. Haramein, A. Impiglia, A. Asbati, M. Azrak, M. Jarrah, A.M. Gallo, D. Lafinadra, E. Poceddu (Univ. of Tuscia, Viterbo, Italy), L.M. Martin, I.J. Cubero (Univ. of Cordoba, Spain)**

4.3. Biotic Stresses

4.3.1. Disease resistance

Fifty crosses were made for *Septoria tritici*, 40 for common bunt, 83 for leaf rust, yellow, and stem rusts, and 30 for BYDV. 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 Tel Hadya many segregating populations showed resistance to *Septoria tritici*.

Advanced screening for multiple disease resistance: To identify germplasm carrying resistance to several diseases, one hundred and forty three durum landraces resistant to a single disease were screened for multiple disease resistance. Sixteen landraces were selected. 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*). - **M.M. Nachit, O.Mamluk, A. Impiglia, Z. Younes, M. Azrak, A. Asbati, M. Jarrah.**

4.3.2. Insect resistance

4.3.2.1. Wheat stem sawfly

Forty crosses were made for resistance to wheat stem sawfly. All populations were subjected to natural attacks by stem sawfly at Breda and Tel Hadya. Crosses using solid stem Moroccan landraces, were made to diverify genetic resistance.

4.3.2.2. Hessian fly

In addition to the single seed descent crosses another 61 crosses were made and sent for resistance screening to INRA, Settat, Morocco.

4.3.2.3. Aphids

Inheritance studies for resistance to Russian wheat aphids (RWA) were conducted with crosses involving Russian varieties.

Crosses for Russian wheat aphids are:

Omtel-6 / Saratovskaya-59
Bicre / D 1985
Omtel-6 / D 1984.

All segregating and advanced populations were exposed to natural infestation with Russian wheat aphids in the summer planting at Terbol. Resistant material was selected. - **M.M. Nachit, R.H. Miller, M. Baum, A. Asbati, M. Azrak, N. Nasrallah (INRA, Settat, Morocco), O. Benhabib (INAVHII, Rabat, Morocco)**

4.4. Abiotic Stress Resistance

4.4.1. Germplasm screening

Advanced testing for dryland performance: Selected landraces were rescreened for stress tolerance characters in the rainfed planting at Tel Hadya. They originated from eight different countries in the Mediterranean region. Among the Mediterranean landraces, three Moroccan landraces (M20, M1297, and M1143) and an Italian landrace (Brottu) yielded better under dry conditions than the checks Cham 1 and Cham 3, but not better than Omrabi 5. Several crosses were made with these accessions.

Screening for salinity Tolerance: Durum wheat landraces from Iraq and India and four salt tolerant lines provided by Dr.Dvorack (Davis University, USA) were screened for salinity tolerance using a sand-culture technique in green house. One accession from India and one accession from Iraq showed some tolerance. Davis material showed a high level of salt tolerance. Crosses with salt tolerant material were made last season. This work will continue using Egyptian landraces. - **M.M. Nachit, A. Impiglia, A. Asbati, Z. Younes**

4.4.2. Drought Resistance

Severe early and intermittent drought occurred during the 1991/92 season in Morocco, West Algeria, Spain, and Portugal; and late drought in Syria, Jordan, Lebanon, and South Turkey. The rainfall of the 1991/92 season in Breda station was similar to that of the long term average. Favorable moisture conditions combined with low temperatures prevailed during the vegetative phases (October - February); and stressed moisture conditions with high temperatures during the reproductive stages (March - June). The rainfall distribution for 1991/92 season at Breda station was the reverse of that for 1990/91 (dry conditions during the vegetative phases and wet ones during the reproductive stages).

Table 41 gives the average grain yield (kg/ha) and precipitation (mm) at Breda for the last 7 years. In 1991/92 mean yield was similar to the mean of the last 7 seasons. Grain yields ranged from 409 to 1936 kg/ha. Several lines were identified with yields greater than the stress tolerant cultivars: Haurani, Cham 3, and Omrabi 5. The results confirmed the superiority of Omrabi 5 over Cham 3. Omrabi 5 represents the second cycle of improved durums for

Table 41. 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
Mean		1352	2059	1191

dry areas, whereas Cham 3 represents the first. Drought tolerant durum germplasm is being released in many WANA countries to replace landraces in dry areas. Cham 3 is now the most widely grown durum. These results demonstrate continuous progress in developing drought tolerant durum genotypes.

Table 42 gives the yields of the best lines (Lahn//Gs/Stk = Lagost; Quadalete//Erp/Mal/3/Unkn) in dry conditions at Breda. These originated from crosses made in 1986 and 1987 and were selected under the double gradient of moisture and temperature (Annual reports, 1986, 1987, and 1988). Selection emphasized abiotic and biotic stress resistance (Nachit et al., 1988).

Table 42. Grain yield of drought tolerant promising lines under dryland conditions, 1991/92

			% of increase	
No.	Cross/entry	Grain yield	Cham3	Omrabi5
1010	Lahn//Gs/Stk	1905	161	131
414	Quadalete// Erp/mal/3/Unkn	1850	156	127
815	Blk2//Snip/Magh	1784	150	123
1310	Omrabi3	1750	147	120
1324	Omrabil5/Ru	1749	147	120
	Haurani	1020		
	Cham 3	1187		
	Omrabi5	1455		
	LSD(0.05)	291		

4.4.2.1. Traits associated with yield under moisture stress

The morpho-physiological traits associated with grain yield under dry conditions were peduncle length (. 52> p =0.001), fertile tillering (. 45 > p = 0.001), and spike fertility (.45> p =0.001). These results again demonstrate the importance of peduncle length as a stress resistance trait for dry areas with terminal stress; and confirm earlier findings (Nachit, 1983; Nachit and Jarrah, 1986, Nachit et al., 1992).

4.4.2.2. Screening for moisture stress tolerance
The use of proline accumulation and fluorescence inhibition as predictive tests for drought tolerance in durum was investigated with the University of Montpelier. Proline accumulation and fluorescence inhibition were related to drought susceptibility index for grain yield, biological yield, kernel weight. The relationship with other traits was dependent on seasonal weather conditions. Omrabi crosses showed high values for traits under stressed conditions. - **M.M. Nachit, E. Acevedo, A. Asbati, M. Azrak, T.A. Dib, P. Monneveux (Univ. of Montpelier, France)**

4.4.2.3. Relationship of RFLP markers with drought tolerance traits
The objective is to see if RFLP markers can function as indirect selection criteria for traits associated with drought tolerance. Indirect selection for RFLP markers may have an advantage over direct selection as the "heritabity" of the RFLP phenotype is 1.0; i.e., genotype = phenotype. Direct selection for RFLP marker loci should result in a correlated response increasing the frequency of favorable alleles associated with drought resistance. Preliminary results show that some RFLP markers are linked to stress tolerance traits (Table 43). The results are encouraging and show the possible use of RFLP markers for durum breeding in WANA region. Further studies will be undertaken to study RFLP and PCR techniques in durum breeding.

The genetic diversity of WANA durum wheat landraces was studied using RFLPs. The study was conducted with EcorI as the restriction enzyme and probes that showed high values for polymorphisms in durum. Thirty-nine probes provided 132 polymorphic bands. The data were used to calculate Nei genetic distance between all possible pairs of landraces. Cluster analysis was also used for morpho-physiological data. Three major clusters were identified. The first included landraces from the Middle East, Greece, Italy, and some from the Algerian plateau; The second cluster included most of the landraces from Morocco, Jordan, and Algeria. This cluster also includes many of the improved genotypes for temperate climates; and the third cluster included some landraces and improved genotypes for the Mediterranean continental climate. These results showed a strong similarity between the landraces of Jordan and Morocco. - **M.M. Nachit, M. Baum, and A. Asbati, M. Sorrells, S. Tanksely, E. Autrique (Cornell Univ., Ithaca, USA), P. Monneveux, T.A. Dib (Univ. of Montpelier, France)**

Table 43. Traits that showed relationship with RFLP markers

Trait	Probe x chromosomal location
p.m.leaf rolling	b3x1s7s, b35x2s, i26x6s
a.m. leaf rolling	i28x2s, c19x2s, e1x1s, b37x5l6s
Awns length	d11x3l
Canopy temperature	j19x2s
Leaf color	f19x2s, a37x5l6s, a37x5l6s, i37x5l6s, b8x5l, g19x2s
Waxiness	a19x2s,
Apex development	b28x2s, b28x2s, f15x5l
Water potential	bb28x2s, o19x2s, g19x2s, d1x1s, d31x4s
Early vigor	e28x2s, c4x114l, f15x5l
Chlorophyll b	e28x2s, i37x5l6s
Fertile tillering under stress	k19x2s, f15x5l
Productivity (AS)	b8x5l, g19x2s, f37x5l6s
Spike fertility under stress	d11x3l

4.4.3. Cold and Frost Resistance

The continental Mediterranean dryland and high plateaux of WANA are often cold in the vegetative stage and frosty at anthesis. The cold and frost incidence increases with latitude and altitude (Annual Report 1986, 1987, 1988). The continental areas are also characterized by drought, and terminal stresses. Evapotranspiration in the vegetative stage is low. However, during the grain filling it increases quickly and exceeds precipitation. Cold damage in the field reduces dry matter and tillering, whereas frost reduces spike fertility. Double gradient selection uses early planting to test material for cold and frost tolerance. Screening for cold and frost tolerance was impeded in 1991/92 by a slow temperature fall providing cold hardening. Plants were exposed to near freezing point temperatures during the early growth stages for almost 3 months. This increased the ability of sensitive genotypes such as Stork and Cham 1 to survive low temperatures. However, these conditions were in many regards similar to those encountered on the high plateaux; and may explain the relative good performace of Cham 1 (cold susceptible) in these areas (see annual report of 1991).

Although it was not possible to score canopy damage, differences for grain yields in the cold tolerance nursery were large. The mean yield was 5533 kg/ha and ranged from 2187 and 8627 kg/ha. Omrabi 5 was the best check with an average yield of 6519 kg/ha; its crosses Ru/Omrabi15 and Omrabi/Lahn (Omlahn) yielded 8449 and of 8289 kg/ha, respectively. Durum landraces germplasm from different areas in WANA is present in the genetic background of many advanced lines; e.g., crosses with Kyperounda showed high performance under cold and mild conditions (Table 44).

4.4.4. Resistance to Terminal Stresses

The objective is to improve durum resistance to terminal drought and heat stress. The late planting and summer planting are used to identify resistant material. Table 45 gives the best lines under terminal stress.

Table 44. Grain yield of promising lines under cold conditions in comparison with checks in 1991/92.

No.	Cross/entry	Grain yield	% of increase Omrabi 5	Cham 1
171	Ru/Mrb15	8465	130	150
108	Omlahn	8289	127	147
323	Shwa/stk//Bit/3/ Kyperounda	8264	127	147
318	Omrabi 3	8044	123	143
823	Wadalmez 3	8042	123	143
	Omrabi 5	6519		
	Cham 1	5640		
	LSD(0.05)	271		

Table 45. Grain yield of promising lines under terminal stress conditions in comparison with checks in 1992

No.	Cross/entry	Grain yield	% of increase Stork	Cham 3
721	Wadalmez	1919	208	192
908	Omtel6	1743	190	168
714	Omrabi3	1718	187	166
317	Omlahn	1685	183	162
1017	Genil2	1639	178	158
	Stork	919		
	Cham 3	1037		
	LSD(0.05)	422		

Table 46 shows the highest yielding lines compared to checks for heat tolerance. The mean grain yield was 479 kh/ha and ranged from 214 to 1674 kg/ha. Selections under summer and late planting conditions at Tel Hadya and summer conditions of Terbol identify germplasm with high levels of heat and terminal stress (drought x heat) resistance. - **M.M. Nachit, M. Jarrah, A. Asbati, M. Azrak**

Table 46. Grain yield of promising lines under heat conditions in comparison with checks in 1992.

No.	Cross/entry	Grain yield	% of increase	
			Stork	Cham 3
49	Qna/Kyperounda/Aus1	1620	370	244
208	Fg/Snip//Guerou	1553	355	234
34	Omlahn	1480	339	223
33	Omlahn	1453	332	219
	Stork	437		
	Cham 3	664		
	LSD(0.05)	239		

4.5. Adaptation

4.5.1. Photoperiod and vernalization

Twenty landraces and improved cultivars of durum were tested for photoperiod response and vernalization requirement at Tel Hadya in the green house. In contrast to bread wheat results show that for the durum cultivars tested, photoperiod response was more important than vernalization requirement. Further analysis will assess the interaction between photoperiod response and vernalization requirement in durum and bread wheat. - M.G. Mosaad, M.M. Nachit, G.O. Ferrara

4.5.2. Performance of advanced genotypes with different photoperiod response and vernalization requirements

One hundred and forty three durum lines were screened for photoperiod and vernalization requirements. Nine durum populations were selected for different combinations of photoperiod response (early, intermediate, and late) and vernalization requirement (weak, moderate, and strong). Yield testing was conducted in Rainfed, Early, Late, and Summer planting (Tel Hadya); in Breda; in Terbol (Lebanon); and Dromolaxa (Cyprus). The photoperiod responsive and strong vernalization requiring population was the highest yielding in the Early planting and at Terbol (Lebanon), while the photoperiod responsive (late) and weak vernalization requiring population was highest yielding in Breda (1398 kg/ha), Dromolaxia (2913 kg/ha), late planting (1205 kg/ha), and Rainfed (3320 kg/ha). The photoperiod responsive and moderate vernalization requiring population was best in the hot environment (Summer planting at Tel Hadya). The photoperiod responsive, early population had no significant advantage in any of the environments, although some of the sites were dry and temperate. This finding contrasts with earlier results where earliness was found to be important under dryland conditions. However, it conforms with the phenology of different WANA landraces.

4.5.3. Relationship between RFLP markers with yield

The objective was to associate RFLP markers with grain yield in the environments used in the double gradients selection environments and in some contrasting sites in the region, Shandaweel (irrigated and warm) in South Egypt, Athalassa (dry and temperate) in Cyprus, and Diyarbakir (dry and continental). RFLP markers were associated with grain yields in each site. For instance, high yielding genotypes in the Early Planting correlated with high yielding ones at Diyarbakir and were associated with RFLP markers located on the short arms of the 6 chromosome. High yielding genotypes in the Late Planting associated with ones in Shandaweel and markers were located on the long arms of the chromosomes 5 and 6. These results suggest that RFLP markers could help in understanding durum performance and adaptation in different environments. Two durum single seed descent populations were developed for studying photoperiod response and vernalization requirement and were screened with several markers located on chromosomes: 2S, 2L, 5L, and 7.

4.6. GE interaction

The study to identify site effects on GE interaction, showed that sites' yields and components of GE interaction (first environmental interaction principal component=IPCA1e) were both associated with latitude, altitude, rainfall, irrigation, number of days with temperatures below freezing point, soil type, and nitrogen fertilization. Associations between sites' grain yields, environmental variables, and IPCA1e reflected productivity. The relationship between genotypes' grain yields and some morpho-physiological traits, showed that genotypes' grain yields were associated positively with early growth vigor, productive tillering, spikelets/spike, and leaf rolling index; and negatively with height, anthesis, maturity, and leaf posture. Genotypes' grain yields and genotypes' first Interaction Principal Component Axis (IPCA1g) scores were negatively associated. Thus, IPCA1g scores were correlated negatively with productive tillering, spikelets/spike, postmeridiem leaf rolling, leaf rolling index; and positively with height and peduncle length. Results showed the contribution of morpho-physiological traits to GE interaction in the Mediterranean region.

4.7. Yield Stability

Mediterranean dryland conditions are characterized by a high year-to-year and site-to-site variation, particularly for rainfall and temperature (Nachit, 1986). Climatic conditions between years within an environment can vary from stressed to very favorable. Therefore, varieties need both stress tolerance and yield responsiveness (Nachit, 1989). In low rainfall areas Omrabi lines and their hybrids were the most stable genotypes in the RDYT-LR, 1991. Similar results were also found in moderate rainfall areas. - **M.M. Nachit, M. Jarrah, M. Azrak, A. Asbati**

4.8. Performance under Mediterranean Environments

4.8.1. Identification of desirable traits under different environments

Until recently, durum wheat landraces covered large areas. The landraces had several desirable morpho-physiological traits that improve adaptation to dryland conditions. A joint study with the University of Cukorova, Turkey, determined the relationship of some morpho-physiological traits with grain yields under contrasting environments. Forty-nine durum wheat landraces were grown in four sites representing different environments: Adana (favorable rainfall and temperate environment); Early Planting at Tel Hadya (favorable rainfall and continental environment); Rainfed at Tel Hadya (moderate rainfall and continental environment); and Breda (dry and continental environment). In each environment several morpho-physiological traits were determined. In the favorable rainfall and temperate environment, the main contributors to yield were: fertile tillering and hectoliter weight (44 and 18%); in the favorable rainfall and continental environment: spike fertility (11%); in the moderate rainfall and continental environment: hectoliter weight and spike fertility (29 and 14%); and in the dry and continental environment: earliness and spike fertility (44 and 19%). - **M.M. Nachit, M. Jarrah, I. Genc (Univ. of Cukorova, Adana, Turkey)**

4.8.1.1. Continental Mediterranean dryland

Screening for continental dryland conditions is made at Tel Hadya in rainfed plots. The average trial yield was 3256 kg/ha and ranged from 1665 to 4947 kg/ha. Performance of advanced lines is shown in Table 47.

Table 47. Grain yield of promising lines under continental dryland, 1991/92.

			% of increase	
No.	Cross/entry	Grain yield	Haurani	Cham 3
1310	Omrabi3	4387	131	129
301	Khb1/Amarelo de Barba Branco	4380	131	129
1014	Genil	4371	131	129
1309	Marrout	4349	130	128
	Haurani	3338		
	Cham 3	3394		
	LSD(0.05)	799		

In 4 years testing under farmers dryland conditions in Syria, the line Omrabi 3 outyielded both the local cultivar Haurani and the newly released cultivar Cham 3. The results show the successful combination of moisture stress tolerance with adaptation to seasonal variability. Omarbi 3 is adapted to the Mediterranean continental dryland; and is proposed for release in Syria and Tunisia in the 1992/93 season.

The release and cultivation of high yielding, stress tolerant durum cultivars is expanding in the WANA region. Varieties such as Cham 1, Waha, Petra, Cham 3, Sebou, and Omrabi sister lines are widely grown in dry areas. In Syria, the area sown to Cham 3 is increasing, more than 60.000 tons of certified seed of was distributed to farmers in Syria in 1991/92 for commercial production. Cham 3 is also released in Algeria under the name of Korifla.

4.8.1.2. Temperate Mediterranean dryland

Screening for temperate dryland conditions occurs in collaboration with the Cyprus program at Dromolaxia and is targeted at areas with dry but temperate conditions. The trial averaged 2895 kg/ha and ranged between 793 and 5693 kg/ha. Several lines yielded better than Cham 1 (Table 48). Cham 1 is similar to the national check Karpasia.

In North Africa, Omrabi and Brachoua had high and stable yields. Omrabi lines 3, 5 and 6 are being considered for release in Tunisia, Morocco and Algeria respectively. Brachoua is being increased in Libya. In Jordan, Omrabi-5 and Brachoua are under large scale testing in farmers fields.

Table 48. Grain yield of promising lines under temperate dryland Dromolaxia, Cyprus, 1991/92.

No.	Cross/entry	Grain yield	% of increase Cham 1
1024	Wadalmez	5088	141
301	Genil1	4910	136
701	Chahba88	4790	133
1101	Gta/Tc60//Stk/3/Haurani	4674	130
	Cham 1	3596	
	Cham 3	3179	
	LSD(0.05)	1299	

4.8.1.3. Favorable areas

Table 49 shows the performance of advanced durum lines tested under continental favorable conditions. The average yield was 4269 kg/ha and ranged between 2589 and 5520 kg/ha. These resuts confirm earlier findings, showing success in combining stress tolerance with high yield (Nachit, 1988). The high yielding cultivar Lahn combines yield potential with cold resistance, multiple disease resistance, and grain quality. Crosses between high yielding and stress tolerant genotypes give well adapted germplasm for the favorable Mediterranean areas. The cross Stn/Agia is promising in these areas.

The cultivar Lahn is grown extensively by farmers in high rainfall and irrigated areas of Syria. Because of its cold tolerance and better grain quality, Lahn is now replacing Cham 1 and already covers more than 100.000 hectares in Syria. Further, Chen/Altar was released in 1991/92 for high rainfall areas in Tunisia.

Table 49. Grain yield of promising lines under continental conditions, Terbol station, Lebanon, 1991/92.

No.	Cross/entry	Grain yield	% of increase	
			Cham1	Stork
1303	Omlahn	6408	146	144
1301	Sabil1	6080	138	137
501	Mrb3//Fg/Cit	5934	135	133
1304	Awali/Bit	5613	128	126
413	Lahn/scoo	5534	126	124
508	Stn/Agia	5467	126	124
	Cham 1	4392		
	Stork	4449		
	LSD(0.05)	1250		

4.8.1.4. High Altitude Areas

Development of durums adapted to high altitude areas with resistance to cold and biotic stresses was given a high priority in 1991/92. Crosses and selections were made with the national program of Algeria for the high plateaux. Similar activities will be initiated in 1992/93 with the Turkish program. - **M.M. Nachit, M. Jarrah, A. Asbati, M. Azrak, A. Benbelkacem (ITGC, Khroub, Algeria)**

4.9. Physiology/Agronomy

4.9.1. Introduction

For the fourth season, 81 durum wheat genotypes were sown at Tel Hadya and Breda under rainfed conditions. In addition, an irrigated control was sown at Tel Hadya. The genotypes included landraces from northern Africa, southern Europe, and western Asia, as well as improved genotypes. The genotypes were also planted in France, as a part of a collaborative project with Dr. P. Monneveux at ENRA/INSA, Montpellier. The objectives of the physiology durum wheat project were listed in the 1991 Annual Report. A brief report on the 1991/92 environment only will be presented here.

The 1991/92 season was characterized by severe frost. The number of days when temperatures dropped below 0°C at Breda was 66, the drier site, and 53 at Tel Hadya (60 and 52 days of frost from emergence until harvest respectively). Rainfall was higher this season than during the previous three, and was 260 mm at Breda and 349 mm at Tel Hadya. However, distribution was characterized by severe moisture stress during the period of maximum growth and spike development. Rainfall in March and April was only 16.2 mm at Breda and 18.4 mm at Tel Hadya. Average grain yield at Breda was 93 g/m^2, at Tel Hadya 288 g/m^2 and under irrigation 467 g/m^2. The differences in yield between the two rainfed environments were related to more stored soil moisture stored early in the season at Tel Hadya, to the higher evaporation between heading and maturity at Breda (627mm at Breda and 499mm at Tel Hadya), and to frost which caused extensive damage to spike development at Breda.

Data from nine environments (year x location combinations) are now being analyzed in detail and will be submitted for publication in international journals later this year.

4.9.2. The Role of Glaucousness as a Selection Criterion for Drought tolerance in Durum Wheat

The importance of glaucousness (a waxy layer on the vegetative parts of cereal plants) in increasing yield of durum was assessed in seven pairs of isogeneic lines under irrigated and rainfed conditions in Tel Hadya and under rainfed conditions in Breda. A detailed study of the relation between glaucousness and yield performance, transpiration efficiency and other physiological traits was carried out under controlled conditions in a plastic house.

Four isogeneic lines were planted in plastic pots, under three water regimes. The first treatment was field capacity throughout the plant life cycle, the second at one third field capacity, and the third at field capacity until heading and at one third field capacity thereafter (terminal moisture stress). Each moisture treatment was maintained by daily weighing of each pot and adding the amount of water lost by evapotranspiration. The proportion of water lost via direct evaporation was estimated from pots without plants. In each moisture treatment harvests were made at the tillering stage, at heading, mid grain filling and at maturity. Water use efficiency, biological yield and other physiological traits were estimated at each stage.

Results showed that the grain and biological yield of glaucous isolines was significantly higher than nonglaucous lines. Under unlimited moisture conditions (field capacity treatment), glaucous lines had a 9% increase in grain yield and 7.5% increase in biological yield compared to nonglaucous lines. Under moisture stress, glaucous lines were 17.8% higher in grain yield and 19% in biological yield than the nonglaucous lines. Under terminal moisture stress the yield increase of glaucous lines was lowest (Fig. 10).

Glaucousness on vegetative parts should increase TE by increasing reflection of solar radiation. This will reduce leaf temperature and transpiration for a given photosynthesis rate. Measurements of TE also demonstrated that glaucous isolines had significantly higher rates. At full field capacity glaucous lines had a 12.1% higher TE than nonglaucous lines. In the water stressed treatments, TE was 8.4% higher in glaucous lines than the nonglaucous ones.

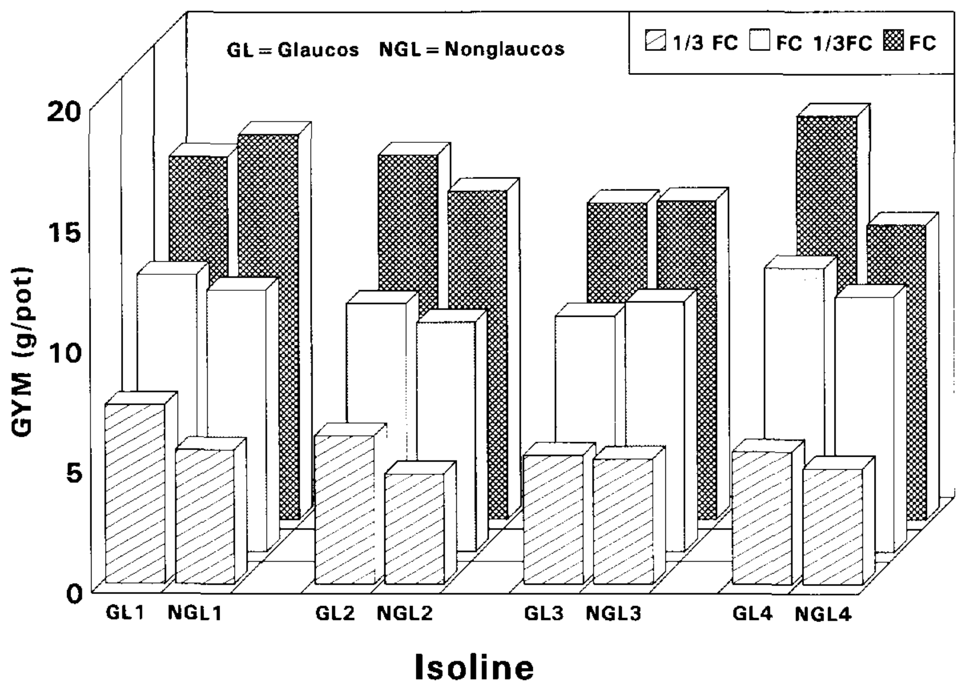

Fig. 10. Grain yield of four glaucous and non-glaucous durum wheat isolines grown under three moisture regimes.

The pattern of higher TE in glaucous isolines was maintained at all harvest stages and moisture levels, except at the early development stage under no moisture stress where nonglaucous lines had a higher TE (Fig. 11). Instantaneous measurements of photosynthesis and transpiration rates also showed that photosynthesis rates where similar or slightly higher in nonglaucous lines, while TE was higher in glaucous lines, although statistically insignificant.

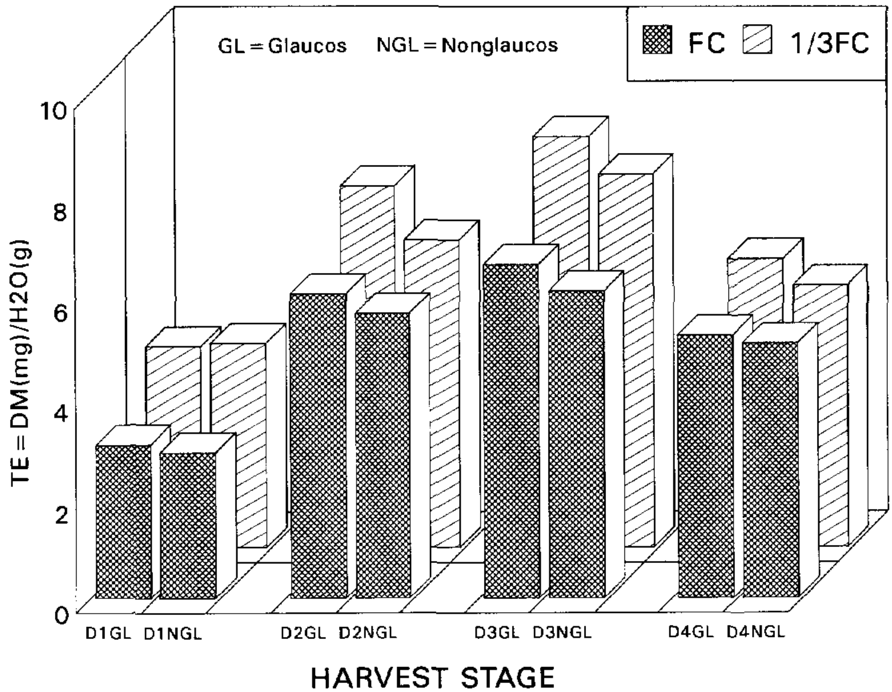

Fig. 11. Transpiration efficiency of four glaucous and non-glaucous durum wheat isolines under two moisture level at four development stages.
D1 = tillering; D2 = heading; D3 = mid grain filling; D4 = maturity.

Under field conditions, in all three environments, the two groups of genotypes had similar grain and biological yields (Table 50). This response differs from the 1990/91 season, when glaucous isolines had higher grain and biological yields in the moderately stressed environment (Tel Hadya). In the highly stressed environment (Breda) both were similar in their yield response. Severity and duration of low temperature during the 1991/92 field season may have caused this inconsistency. This will be examined further in 1992/93. - **A. Dakheel, F. Makdis, I. Naji, V. Mahalakshmi, M.M. Nachit, J.M. Peacock.**

Table 50. Grain and biological yield of glaucous and nonglaucous isolines in three environments.

	Tel Hadya irrigated	Tel Hadya rainfed	Breda rainfed
GYM (g/m^2)			
glaucous isolines	337	243	78
nonglaucous isolines	323	259	77
LSD	29	12	10
CV%	14	8	21
BYM (g/m^2)			
glaucous isolines	1275	920	356
nonglaucous isolines	1256	949	357
LSD	91	109	26
CV%	12	19	17

4.10. Pathology

This report covers data from the Key Location Disease Nursery, from sources of resistance to diseases, from crop loss assessment trials and studies of host-pathogen systems.

4.10.1. Summary of Disease Data from the Key Location Disease Nursery (DKL-91)

Data summary of the Durum Key Location Disease Nursery 1990/91 (DKL-91) was completed in October 1992. Table (51) shows the useful sites from which disease information was received. The results are presented in Fig. (12). Out of the 216 lines in the nursery, there were 111 (51%) lines resistant to powdery mildew, 79 (37%) lines resistant to BYDV, 53 (24%) lines resistant to yellow rust, 37 (17%) lines resistant to common bunt, 33 (15%) lines resistant to *Septoria tritici* blotch, 11 (5%) lines resistant to stem rust, and 2 (1%) lines resistant to leaf rust. One entry (# 30) showed multiple resistance to the three rusts, three (entries # 64, 154, 187) to

Septoria blotch, powdery mildew and BYDV, eight (entries # 5, 15, 73, 173, 188, 231, 232) to yellow rust and common bunt and three (entries # 64, 154 and 155) for multiple resistance to yellow rust, septoria blotch, powdery mildew and BYDV. - **O.F. Mamluk, A. Yaljarouka**

Table 51. Screening site and disease for the Durum Wheat Key Location Disease Nursery (DKL-91).

Site	Disease*							
	YR	LR	SR	ST	PM	TS	BYDV	CB
Syria								
Tel Hadya	+	+	+	+	+		+	+
Latakia		+		+				
Lebanon								
Terbol	+	+	+		+			
Egypt								
Sakha		+	+					
Ethiopia								
Debre Zeit			+					
Tunisia								
Beja				+				
Portugal								
Elvas				+				
Algeria								
Guelma						+		

*Disease: YR = yellow rust, LR = leaf rust, SR = stem rust, ST = septoria tritici blotch, PM = powdery mildew, TS = tan spot, CB = common bunt.

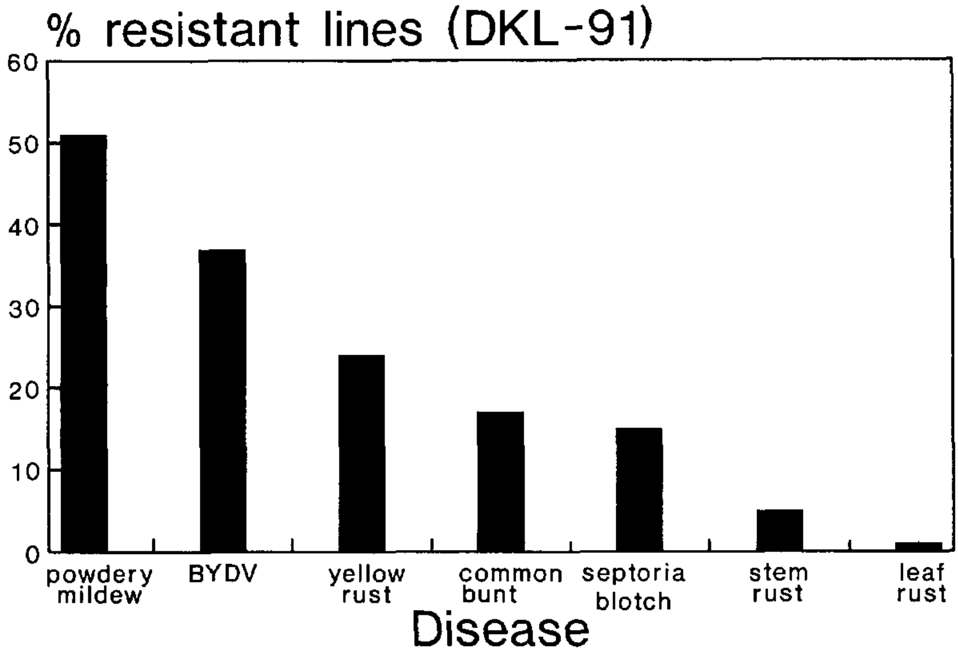

Fig. 12: Percent resistant lines in the Durum Wheat Key Location Disease Nursery (DKL-91) to the different diseases; selection criteria: powdery mildew, BYDV and septoria = score 5; common bunt = 15%head infection; yellow rust = 2 ACI; stem and leaf rusts = 5 ACI.

4.10.2. Germplasm Pools for Sources of Resistance to Wheat Diseases

Three germplasm pools with resistance to yellow rust, stem rust and common bunt are available to collaborators upon request. The performance of lines to the target as well as to non-targeted diseases is shown in Tables 52 - 54.

The Durum Wheat Germplasm Pool for Yellow Rust Resistance (DYRGP 92) has 22 lines which have performed well against this disease over several seasons at Tel Hadya, Syria (Table 52). The selection criterion used was <15MR (severity and reaction type) in 11 seasons.

Table 52. The performance [1] of selected durum wheat lines to yellow rust, *Puccinia striiformis*, and other diseases (DYRGP92).

		Screening year				Other diseases [2]					
Ent.	Cross or Name	1988	1990	1991	1992	LR	SR	ST	PM	BY	CB
1.	BYE*2/Tact//AA/3/Sham 1	5R	tR	tR	5R	0.9	27.0	6	9	6	48
2.	Cfn/2/Lan/Dwf F2 Lan	tR	tR	tR	tR	2.0	-	6	-	-	-
3.	Chahba 88/Mrb11	-	10MR	5R	tR	19.3	0.6	6	3	7	20
4.	Cp/GVZ 156//Kobak 2916/3/...	15R	tR	tMR	5R	4.9	14.0	6	9	6	63
5.	Creso Mutant//Cr/USA-5o2229	10R	tR	tR	tR	5.5	0.0	5	7	-	-
6.	D.Dwarf S15/Cr/3/Plc	10MR	tR	tR	10MR	2.0	-	2	-	-	-
7.	Ente/Mario/Cando	tR	tR	5R	tR	-	-	4	-	-	-
8.	F6D85 No218	tR	tR	tR	tR	6.2	1.7	5	7	6	57
9.	Fg/Jo/3/Gu/61-130/Lds/...	tR	tR	tR	tR	16.0	4.0	8	0	-	-
10.	Ggo 447/Sham 1	-	5R	tR	15MR	8.0	-	7	-	-	21
11.	Hau27/Cando	5R	tR	tR	5MR	5.6	0.0	7	9	6	82
12.	Jo/Ru	tR	tR	tR	tR	4.9	0.0	7	8	6	63
13.	Karasu	10R	tR	10MR	15MR	5.3	0.0	6	7	6	65
14.	Ld 357E/*2Tc//Jo/3/Fg/4/...	10R	5MR	tR	tR	6.0	0.0	7	6	-	-
15.	Omguer	-	tR	tR	tR	6.0	0.2	5	2	-	16
16.	Ru/F.9-3	15MR	tR	tR	tR	-	-	4	7	-	-
17.	Ru/Mrb115	-	tR	5MR	tR	16.0	0.3	6	2	5	19
18.	Ru/Mrb15	-	tR	tR	10R	13.0	17.5	6	4	8	18
19.	Ru/Mrb15	-	5MR	tR	tMR	5.0	2.7	6	3	7	14
20.	Sb12	tR	5MR	tR	5MR	3.0	0.3	6	9	6	18
21.	Sca/3/GdoVZ512/Cit//Ruff/Fg	5R	tR	tR	tR	7.0	0.0	7	0	-	-
22.	Shwa/Ptl	5R	tR	tR	tR	4.8	23.7	5	0	6	53

[1] Performance : % severity and reaction type; [2] Other diseases : LR = leaf rust and SR = stem rust as ACI; ST = septoria tritici blotch, PM = powdery mildew and BY = barley yellow dwarf virus on 0-9 scale; CB = common bunt, % head infection.

Table 53. The performance [1] of selected durum wheat lines to stem rust, *Puccinia graminics*, and other diseases (DSRGP92).

		Screening year and site [2]							Other diseases [3]					
		1989	1990		1991			1992						
Ent.	Cross or Name	TH	TH	TE	TH	TE	SA	TH	YR	LR	ST	PM	BY	CB
1.	Akrache 1	10M	tMR	10MS	tMR	-	tR	5MR	5.0	20.0	4	7	6	36
2.	Awl2/Bit	-	-	-	10MR	-	5MR	10MR	10.0	14.8	7	6	6	9
3.	Awl2/Bit	-	-	-	10R	-	5MS	5MR	16.0	22.2	5	2	6	20
4.	Brachoua	5R	1MR	10M	tMR	-	5MR	tMR	4.1	9.5	7	-	6	25
5.	Chen/Altar84	10MR	tR	-	tR	10MS	-	tMR	0.6	24.1	5	3	-	-
6.	D68-1-93A-1A//Ruff/Fg	10MR	tMR	-	5R	10MS	-	tR	0.3	17.7	5	5	6	46
7.	FLAMINGO SIB/USA IV 718	5MR	tR	-	5MR	15MS	-	5R	-	-	-	-	-	-
8.	Khb1/Amarelo De Barba...	-	5MS	tMS	tR	-	-	t	6.0	12.0	6	6	-	36
9.	Krf/5/ZF/Lds//Kobak...	15MR	tMR	-	tR	10MS	-	tMR	0.8	26.0	5	-	5	19
10.	Loukos 3	-	tMR	5MS	10MR	5MS	-	tMR	0.2	14.5	6	4	6	14
11.	Mrb16/Ru	-	5MR	tMR	tR	20MS	tMR	10MR	7.3	8.0	5	3	5	32
12.	Omtel-6	-	tR	tR	tR	-	-	5R	3.0	8.0	6	-	-	26
13.	Qfn/Somo	15MR	tR	-	5MR	10MS	-	tMR	0.8	16.6	5	-	5	33
14.	Rufom-4	-	5MR	tMR	tMR	15S	5MR	5MR	2.0	13.5	5	5	5	28
15.	Rufom-9	15MR	5MR	tR	tR	tMS	tMR	tMR	1.0	8.2	5	6	5	33
16.	Rusomar-1	15R	tR	-	10MR	10MS	-	5MR	0.8	33.3	4	-	5	6
17.	Stn/Attar 84/3/Gs/Fg//...	20MR	tR	-	tR	tMR	-	tR	0.8	12.0	6	0	-	-

[1] *Performance* : % *severity and reaction type.* [2] Screening site : TH = Tel Hadya/Syria; TE = Terbol /Lebanon; SA = Sakha/Egypt. [3] Other diseases : YR = Yellow rust and LR = leaf rust as ACI; ST = septoria tritici blotch, PM = Powdery mildew and BY = barley yellow dwarf virus on 0-9 scale; CB = common bunt, % head infection.

Table 54. The performance [1] of selected durum wheat lines to common bunt, *Telletia foetida* and *T.aries*, and other diseases [2] (DCBGP92).

Ent.	Cross or Name	Screening Year						Other diseases [3]					
		1987	1988	1989	1990	1991	1992	YR	LR	SR	ST	PM	CB
1.	AA/Br//V-01658/....	7	3	0.4*	1.8*	-	-	1.0	-	-	-	-	-
2.	Alf//Fg/Cr	-	15	2	3.5*	-	-	4.0	-	-	-	-	-
3.	Awl2/Bit	-	-	-	2	10	8.6*	2.3	15.0	6.0	5	-	-
4.	Awl2/Bit	-	-	-	4	5	10.1*	0.2	8.3	3.0	6	3	7
5.	Awl2/Bit	-	-	-	5	9	7.1*	3.0	27.3	0.6	7	3	6
6.	Awl2/Bit	-	-	-	8	3	6.9*	5.5	12.0	8.0	5	-	-
7.	BD272/C Jucci	-	-	0	4	6.2*	-	1.0	-	-	-	-	-
8.	Brachoua	-	15	3	4.3*	-	-	0.2	5.7	40.0	5	5	4
9.	Fg/Rabi//Valselva	-	-	4	6	13	2.8*	5.5	-	-	-	-	-
10.	Fg/Rabi//Valseva	-	-	1	4	2	3.8*	7.4	-	-	-	-	-
11.	Hau/4/Mexi//21563* //...	-	-	0	3	11	7.3*	17.9	-	-	-	-	-
12.	Jennah Khetifa RP 4	6	3.1*	-	-	-	-	6.0	-	-	4	-	-
13.	Mrb3/Tunisian Durum...	-	-	-	6	13	9.7*	4.0	1.1	0.3	6	3	6
14.	P67/1114/Kkc1133//...	-	10	1	10.6*	-	-	8.0	-	-	-	-	-
15.	Ru/Mrb15	-	-	-	9	11	8.2*	1.0	11.0	0.3	7	4	7
16.	W-2057	12	7.7*	-	-	-	-	12.5	-	-	-	-	-

[1] Performance : % head infection using composite isolates from Syria; *average of 11 different isolates from WANA (2 Syria, 3 Turkey, 2 Iran, one each Lebanon, Tunisia, Morocco, Pakistan).

[2] Other diseases : YR, LR, SR, = yellow, leaf and stem rust as ACI; ST = septoria tritici blotch, PM = powdery mildew and BY = barley yellow dwarf virus on 0-9 scale.

The Durum Wheat Germplasm Pool for Stem Rust Resistance (DSRGP 92) has 17 lines which performed well against the disease over at least two seasons at three sites (Table 53). The main site was Tel Hadya in Syria, where the selection criterion used was <20MR, severity and reaction Type.

The Durum Wheat Germplasm Pool for Common Bunt Resistance (DCBGP 92) has 16 lines which performed well against the disease over two to four seasons at Tel Hadya (Table 54). Selection criterion was <15% head infection when tested against a bulk of Syrian isolates, or <11% head infection when tested against 11 different isolates from WANA. - **O.F. Mamluk, M. Naimi**

4.10.3. Crop Loss Assessment Trials

The crop loss assessment trial on yellow rust at Tel Hadya in 1991/92 included 16 cultivars, 8 each of durum and bread wheat, used in the Farmers Field Verification Trials of the collaborative program DSAR/Syria. Protection treatments were applied, these were triadimenol (Bayfidan EC 250), applied three times; and zineb (Zinat 70% WP), applied six times; as well as a control without any chemical protection. The infection level is presented as a score and as an average coefficient of infection (ACI). ACI was analyzed using logit transformation. Cultivar performance was assessed for a number of traits using the common experimental error from the 16 cultivars. However, data are presented in two tables, one for durum wheat (Table 55) and the other for bread wheat (Table 71).

For durum wheat, both fungicides were effective in reducing disease score substantially in susceptible cultivars, e.g., Haurani 27 and Douma 13715. Fungicide I increased yields Bouhoth 5, Awal/Bit, Haurani 27, Douma 13715, and Om Rabi 3 by 13%, 13%, 12%, 11%, and 11% respectively. This increase was not statistically significant (P = .05) for any of the cultivars. The increase in

Table 55. Effect of yellow rust (*Puccinia striiformis*) on grain yield and yield components of durum wheat cultivars; Tel Hadya, Syria 1992.

Cultivar	Treatment	Yellow rust Score	ACI	Yield t/ha	% Yield increase	No. Tillers per m	No. seed per spike	1000 KW (gr.)
Cham 1	Infected	1 R-MR	0.3	3.67		112	30	40.1
	Fungicide I	1 R-MS	0.4	3.91	6.2	115	32	35.4
	Fungicide II	1 R	0.2	3.61	-1.5	114	25	36.5
Haurani 27	Infected	28 MS	22.7	2.82		132	20	38.2
	Fungicide I	6 M-MS	4.4	3.20	11.8	113	26	39.8
	Fungicide II	5 MS	4.3	3.03	6.7	116	23	39.1
Bouhoth 5	Infected	8 M-MS	6.3	3.31		90	31	44.1
	Fungicide I	4 MR-M	2.1	3.81	12.9	100	31	41.6
	Fungicide II	5 MR-MS	4.1	3.69	10.3	88	31	42.1
Douma 13715	Infected	20 MS	16.0	3.33		97	28	45.2
	Fungicide I	4 MR-MS	3.0	3.75	11.1	110	29	44.7
	Fungicide II	2 M-MS	1.8	3.52	5.3	95	28	46.2
Douma 15149	Infected	2 R-MS	1.5	3.93		98	29	43.1
	Fungicide I	1 R-M	0.3	4.05	3.0	110	31	40.5
	Fungicide II	1 R-M	0.4	3.58	-9.6	99	27	38.1
Om Rabi 3	Infected	5 M-MS	3.7	3.69		102	31	42.7
	Fungicide I	1 R-M	0.5	4.14	10.7	109	31	42.4
	Fungicide II	2 MR-MS	1.7	3.89	5.0	109	31	42.1
Awal/ Bit 1	Infected	5 MS	4.0	3.81		107	32	40.4
	Fungicide I	2 R-M	1.1	4.35	12.5	104	31	41.6
	Fungicide II	2 M-MS	1.7	3.67	-3.8	101	30	40.2
Douma 11337	Infected	1 M-MS	0.7	3.50		108	29	35.2
	Fungicide I	1 R-M	0.3	3.63	3.6	115	31	32.2
	Fungicide II	1 R-M	0.3	3.38	-3.6	109	28	35.0
Standard error of means:		SE 1		0.24		9.61	1.88	2.1
		SE 2		0.22		8.25	1.67	1.7
CV%				11		12	10	8

Figures = mean of 3 rep. each 7.2m^2, harvested 3.6m^2, from split plot in RCBD (treatment as main plot factor; cultivar as subplot); Infected = artificial inoculation applied twice; Fungicide I = Triadimenol (Byfidan EC 250), 0.5 l/ha, applied three times; Fungicide II = Zeneb (Zinat 70 % WP), 0.9 kg/ha, applied six times; SE 1 to compare treatment at same or different levels of cultivars; SE 2 to compare cultivar at same levels of treatment yield from Fungicide II was slight and never exceeded the increase obtained with Fungicide I; moreover, Fungicide II caused some yield reduction of 10%, 4%, 4% and 2% in cultivars Douma 15149, Awal/Bit, Douma 11337 and Cham 1 respectively. - **O.F. Mamluk, M. Singh, M. Naimi, S. Khawatmi, A. Yaljarouka.**

4.10.4. Studies on Host-pathogen Systems

The Pathogenicity of Septoria Tritici Blotch (*Mycosphaerella graminicola*) and Common Bunt (*Tilletia foetida* and *T. caries*) on *Aegilops spp.*

Aegilops species vary considerably in susceptibility to wheat diseases, such as yellow rust (Ann. Repr. GRU, 1991 and 1992), leaf rust and stem rust. However, hardly any infection by *Septoria tritici* blotch and common bunt on *Aegilops* was observed in the field. Therefore, several pathogenicity tests were conducted to evaluate the resistance/immunity of the genus *Aegilops* to *Septoria tritici* blotch and common bunt (Ann. Repr., CP, 1991).

In the season 1991/92, 483 accessions from 18 *Aegilops* species were tested in the seedling stage in the greenhouse against *Septoria tritici* blotch. There were 140, 107, 60, 43, 38, 27, 16, 14, 9, 7, 7, 5, 3, 2, 2, 1, 1, and 1 accessions of the species *Ae. ovata*, *Ae. triuncialis*, *Ae. biuncialis*, *Ae. triaristata*, *Ae. peregrina*, *Ae. speltoides*, *Ae. columnaris*, *Ae. caudata*, *Ae. ventricosa*, *Ae. squarrosa*, *Ae. cylindrica*, *Ae. vavilovii*, *Ae. crassa*, *Ae. umbellulata*, *Ae. juvenalis*, *Ae. searsii*, *Ae. kotschyi*, and *Ae. uniaristata* respectively. Check plants of wheat, Mexipak and Gezira 17, were included every 10th accession. All check plants exhibited a high degree of infection.

Together with the previous year's testing, a total of 1188 accessions from 22 *Aegilops* species have been tested for their resistance to *septoria blotch* (Table 56). In field testing over the last four seasons, only one species, *Ae. cylindrica*, out of the 22 tested showed a slight infection of septoria with pycnidial formation. In seedling tests in the greenhouse, 10 species remained

Table 56. *Aegilops* species tested for resistance to common bunt in the field and to *Septoria tritici* blotch in the field (a) and in greenhouse (s); seasons 1988/89-1991/92.

Aegilops spp.	Common bunt No. years	Common bunt No. accessions	Septoria blotch No. years	Septoria blotch No. accessions
1. *Ae. bicornis*	1	2	1	11^{s*}
2. *Ae. biuncialis*	3	57	4	160^{a+s*}
3. *Ae. caudata*	3	3	4	26^{a+s}
4. *Ae. columnaris*	3	9	4	35^{a+s*}
5. *Ae. comosa*	2	5	2	4^{a+s}
6. *Ae. crassa*	3	7	4	17^{a+s*}
7. *Ae. cylindrica*	3	4	4	35^{a*+s}
8. *Ae. juvenalis*	1	2	1	2^{s}
9. *Ae. kotschyi*	3	8^{*}	4	28^{a+s*}
10. *Ae. longissima*	3	5	3	5^{a+s}
11. *Ae. mutica*	1	2	1	4^{s}
12. *Ae. ovata*	2	102	3	309^{a+s*}
13. *Ae. peregina*	2	8	3	81^{a+s*}
14. *Ae. searsii*	1	2	2	23^{s*}
15. *Ae. speltoides*	2	17	3	52^{a+s}
16. *Ae. squarrosa*	2	9^{*}	3	22^{a+s}
17. *Ae. triaristata*	2	10	3	78^{a+s*}
18. *Ae. triuncialis*	2	59	3	227^{a+s*}
19. *Ae. umbellulata*	2	9	3	21^{a+s}
20. *Ae. uniaristata*	2	3	2	2^{a+s}
21. *Ae. vavilovii*	2	2	3	26^{a+s*}
22. *Ae. vertricosa*	2	3	3	20^{a+s*}
		328		1188

*species with typical disease symptoms

immune with no disease symptoms. These are *Ae. caudata*, *Ae. comosa*, *Ae. cylindrica*, *Ae. juvenalis*, *Ae. longissima*, *Ae. mutica*, *Ae.*

speltoides, *Ae. squarrosa*, *Ae. umbellulata*, and *Ae. uniaristata*. The remaining 12 species were susceptible and exhibited symptoms of septoria blotch, i.e., necrosis and pycnidial formation. Percentage pycnidial formation on the affected accessions of susceptible species ranged between 6 and 35, with the highest on *Ae. vavilovii* and *Ae. searsii*. The least pycnidial formation was on *Ae. triuncialis*.

To confirm the results obtained in previous seasons on common bunt, 24 *Aegilops* accessions of 12 species were tested in the 1991/92 season for their resistance to the disease. The species were: *Ae. bicornis*, *Ae. comosa*, *Ae. juvenalis*, *Ae. kotschyi*, *Ae. longissima*, *Ae. mutica*, *Ae. peregrina*, *Ae. searsii*, *Ae. speltoides*, *Ae. umbellulata*, *Ae. uniaristata*, and *Ae. ventricosa*. The test was conducted in two replicates. Susceptible checks had 85.6% head infection by common bunt.

Together with the testing of previous years, a total of 328 accessions from 22 species were screened for their resistance to common bunt (Table 56). All species tested over the last four seasons remained disease free, except *Ae. kotschyi* and *Ae. squarrosa* with slight infection of 3.6% and 1% head infection respectively. It can be concluded that *Aegilops* species present an excellent source of resistance to *Septoria tritici* blotch and common bunt of wheat. - **O.F. Mamluk, M. van Slageren, M. Naimi, S. Khawatmi.**

4.11. Entomology - Hessian Fly Screening

A collaborative project between ICARDA, INRA (Morocco), and INAV (Morocco) was initiated to identify sources of Hessian fly resistance in wheat relatives and durum wheat landraces and to incorporate resistance genes into commercially acceptable varieties using tissue culture. Screening and tissue culture is performed in Morocco, while backstopping and some crosses are made at ICARDA. More information on crosses is contained in the section on Durum Wheat Breeding. - **R.H. Miller**

4.12. International Nurseries

Regional durum wheat nurseries assembled by the joint CIMMYT/ICARDA durum wheat project at ICARDA in 1992 are given in Table 57. There were 13 different nurseries/germplasm pools with a total of 423 sets being distributed. This year the Crossing Block was not prepared, but a special nursery called "Durum Segregating Populations - Crosses with Wild Relatives" was assembled. The agreement between CIMMYT and ICARDA on spring wheat nursery preparation and distribution was implemented starting last season. Under this agreement the names of the observation nurseries were changed 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 nurseries included lines supplied from the CIMMYT base program in Mexico (with seed multiplied at Tel Hadya, Syria) and were restricted to the WANA region. Three germplasm pools for sources of resistance to yellow rust, stem rust and common bunt, respectively, were made available by the wheat pathologist. - **S.K. Yau**

Table 57. Durum wheat international nurseries for 1992-93.

Nursery	Abbre-viation	No. of entries	No. of sets distributed
Mediterranean Coastal and Continental Areas:			
Regular Nurseries			
Segregating Populations	DSP	103	33
Observation Nurseries:			
- Semi-arid Areas	DON-SA	312	33
- Favorable Areas	DON-FA	312	35
Yield Trials:			
- Low Rainfall areas	DYT-LRA	24	47
- Moderate Rainfall Areas	DYT-MRA	24	64
Specific-trait Nurseries			
Drought & Heat Tolerance Obs. Nur.	DHTON	48	43
Drought & Cold Tolerance Obs. Nur.	DCTON	48	25
Special Nursery			
Segregating Populations - Crosses with Wild Relatives	DSP-WR	45	15
Germplasm Pools for Sources of Disease Resistance			
Yellow Rust	DYRGP	22	31
Stem Rust	DSRGP	17	30
Common Bunt	DCBGP	16	29
Mediterranean Highland Areas:			
Regular Nurseries			
Observation Nursery	DON-HAA[1]	110	22
Yield Trial	DYT-HAA	24	16
Total			423

[1] HAA - High Altitude Areas

4.13. Wide crosses in durum

Aegilops species which are not crossable in the field but carrying important resistance genes were chosen for wide crossing with durum wheat. Hybrid embryos will be rescued on artificial medium and backcrossed with durum wheat. Cytological control will ensure a tetraploid ploidy level and recombination between Aegilops and durum chromosomes. - **M. Baum**

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5. Spring Bread Wheat Improvement

5.1. Spring Bread Wheat Breeding

5.1.1. Introduction

Bread wheat is the most important crop in West Asia and North Africa (WANA). It comprises approximately 70% of the total wheat (bread wheat + durum) grown. Some 16 million ha are rainfed, of this 7-8 million ha have less than 400 mm annual rainfall. In these areas variation in rainfall and temperature is large. Diseases and insect pests also constrain wheat production.

The CIMMYT/ICARDA spring bread wheat breeding project emphasizes germplasm development for rainfed areas in WANA by breeding material with high and stable grain yields. This is combined with tolerance to local abiotic and biotic stresses. Multilocation testing, including different planting dates, has proved a powerful selection strategy. Coupled with targeting material, this has increased germplasm adoption by NARS, particularly in low-rainfall environments.

One visiting scientist and two graduate students joined the project during 1992. This has allowed upstream research in breeding/physiology with the physiologists to identify morphophysiological traits associated with yield under moisture stress. Some parental lines have been characterized for their response to vernalization and photoperiod. Cooperation continued with biotechnology, pathology, entomology, grain quality, specialists in the cereal program and with FRMP in nitrogen/moisture use and wheat adoption studies.

Interaction with NARS has included training, germplasm evaluation and selection, farmers field verification trials, consultancy, and participation in program planning meetings where research results, networks, and future areas of collaboration were discussed. Details of activities and achievements follow.

5.1.2. Reliability of bread wheat under rainfed conditions

On farm verification trials in Syria and Algeria confirm the reliability of bread wheat in dry environments of the region (annual rainfall less than 350 mm). Current varieties and promising selections were tested by NARS in farmer's fields using, recommended agronomic packages. Table 58 gives grain yields for ten years in Syria, and three in Algeria. Bread wheat outyielded durum in 7 out of 10 years in Syria by 5%, and in all years in Algeria by 25%.

Table 58. Average grain yield of bread wheat and durum in the dry (< 350 mm) areas of Syria and Western Algeria. On farm verification yield trials 1983 to 1992.

Year	Grain Yield (kg/ha)							
	Syria				Algeria			
	BW	DW	% BW>DW	NL	BW	DW	% BW>DW	NL
1982/83	2115	1993	106	8	-	-	-	-
1983/84	1792	1492	120	7	-	-	-	-
1984/85	1200	1250	96	7	-	-	-	-
1985/86	2078	2074	100	6	-	-	-	-
1986/87	1710	1552	110	7	-	-	-	-
1987/88	3440	3400	101	10	-	-	-	-
1988/89	920	938	98	5	-	-	-	-
1989/90	1227	1151	107	9	7185	5940	121	3
1990/91	1440	1468	98	8	2581	2161	119	4
1991/92	2867	2671	107	10	2565	1798	143	3
Mean	1879	1798	105	-	4110	3299	125	-

BW = bread wheat; DW = durum wheat.
NL = number of locations.

This confirms that bread wheat is as reliable as durum in areas where drought is the main constraint to production. CIMMYT/ICARDA varieties Cham 6 in Syria and Zidane 89, Zidi Okba, and Nesser in Algeria have been released and increasingly are grown by farmers.

Cham 6, released in 1991 as a commercial variety in Syria for areas with less than 350 mm was identified through the international testing program. Table 59 gives its performance in WANA for three years in a minimum of 27 dry locations per year. It outyielded the national checks by between 105 and 123 percent. The data confirms the competitiveness of bread wheat with durum in harsh environments.

Table 59. Grain yield and agronomic attributes of Cham 6, improved bread wheat variety, in the dry areas (< 400 mm) of West Asia and North Africa. Regional Durum Yield Trials for Low Rainfall Areas 1989 to 1991.

Year	Cultivar	Yield (kg/ha)	% > NC	DHE	DMA	PHT (cm)
1989	Cham 6 (IBWC)	2933	112	119	153	68
1990	Cham 6 (IBWC)	2412	105	112	145	63
1991	Cham 6 (IBWC)	3228	123	111	149	71
1989	Om rabi 5 (TYDE)	2866	109	118	154	81
1990	Om rabi 3 (TYDE)	2395	103	116	151	75
1991	Om rabi 5 (TYDE)	2976	113	111	151	83
1989	Cham 3 (IDWC)	2630	100	118	154	71
1990	Cham 3 (IDWC)	2298	99	112	146	68
1991	Cham 3 (IDWC)	2788	106	108	148	74
1989	National check (NC)	2628	100	119	154	78
1990	National check (NC)	2311	100	113	146	72
1991	National check (NC)	2622	100	109	149	76
1989	No. of locations	35	35	29	22	27
1990	No. of locations	30	30	25	13	28
1991	No. of locations	27	27	25	15	26

DHE = Days to heading; DMA = Days to maturity; PHT = Plant height; IBWC = Improved bread wheat check; TYDE = Top yielding durum entry; IDWC = Improved durum wheat check.

The Government in Syria distributed 4000 tons of certified seed of Cham 6 to farmers for the 1992-93 crop season. Full cross details of lines in all Tables are in the Annual Report for CIMMYT/ICARDA Regional Bread Wheat Nurseries 1990-91, CP-ICARDA, Syria.

Zidane 89, Zidi Okba, Nesser, and other promising varieties were tested in nine regions across Algeria during 1991 in the National Yield Trial program. The locations covered a wide range of rainfall, temperature, and biotic stresses. Table 60 gives the results, Nesser and Zidi Okba had a yield advantage of 179% and 166%, respectively, over the widely grown local variety Mahon Demiaz. Due to their potential, the area grown to these two varieties may be expanded to other regions of the country.

5.1.3. Enhancing germplasm adaptation

The breeding strategies used in our project have been published elsewhere (Ortiz Ferrara, G. et al., 1987, Ortiz Ferrara, G. and Deghaiz, M., 1988, Ortiz Ferrara, G. et al. 1989). Multilocation testing, the project's most important strategy for selecting and identifying material tolerant to different stresses, occurs at two levels: (1) international multilocation testing, in which data from 50 to 75 locations in the region are obtained through the CIMMYT/ICARDA International Nursery System, and (2) ICARDA based multilocation testing, consisting of five different environments in Syria and Lebanon. The latter provides initial screening of segregating populations and advanced lines under different moisture and temperature conditions.

Improved germplasm is distributed, taking in account local agroclimatic conditions, to NARS in WANA upon request. Two objectives when distributing germplasm are: (1) providing promising lines for potential release as commercial varieties, and (2) collecting information on adaptation. Multilocation testing and

Table 60. Results of the bread wheat National Yield Trial grown in six locations in Algeria. (Modified from: ITGC, Syntheses du Reseau National - Recolte, 1991).

Variety	Khroub	B. Slimane	Saida	O. Smar	Setif	Laghmara	Ave.	% > LC
Cham 6 = Nesser	10500	3325	2333	6125	3400	4433	5019	179
Cham 4 = Zidi Okba	7900	3075	2833	5850	4333	4000	4665	166
Arz	9850	3150	1733	5300	4367	3467	4644	165
HD 1220	8800	3350	2100	5750	3967	3433	4566	162
Dougga	7900	3175	2700	5750	3767	2867	4359	155
Anza	9950	2225	2200	5925	2867	2433	4266	152
Strampelli	7550	3425	1967	5675	3667	2900	4197	149
Zidane 89	8350	2600	2100	5275	3233	3267	4138	148
Chelif	7225	3350	2000	5250	3733	2900	4076	145
Ziad	9375	2725	1733	5550	2133	2733	4041	144
Inia/Napo//Tob	7675	2450	1800	5225	3600	3067	3969	141
Siete Cerros	6425	2950	2500	4750	3700	3367	3948	140
Mexicano	6225	2825	1800	5950	3467	3267	3922	139
Acsad 59	7050	2175	1500	5225	2400	2367	3452	123
M. Demiaz (LC)	4325	2325	1600	2575	3100	2900	2804	100

LC = Local check.

targeting of germplasm has increased adoption of material by NARS, particularly in low-rainfall environments. Tables 61 gives the yields of promising lines in seven dry locations in WANA. The seasonal rainfall for these locations ranged from 200-350 mm. The yield improvement of these lines over the national checks, which are widely grown varieties at each location, ranged from 110% to 205%.

Table 61. Performance* of bread wheat germplasm in the low-rainfall (< 400 mm) temperate areas of WANA. Regional Yield Trials for Low Rainfall Areas 1990-91.

Country	Line	Grain Yield (kg/ha)	% > NC	LSD.05 / CV (%)	F
IRAN (Gachsaran)	Koel/Vee 's'	2722	155	539/19	6
	NC	1756			
SYRIA (Breda)	F 134-71/Crow	1042	112	130/8	0
	NC	933			
AFGHANISTAN (Farkhar)	Vee/Lira	1213	110	223/18	6
	NC	1102			
ALGERIA (S.B.Abbes)	Vee/Lira	3293	192	790/21	15
	NC	1714			
TUNISIA (Le Krib)	Bow/Crow	5094	205	949/17	20
	NC	2483			
PAKISTAN (Quetta)	Snb/Pima	2889	200	895/21	6
	NC	1444			
JORDAN (Rabbah)	Ghurab-2	2064	130	421/20	1
	NC	1583			

* = Based on its statistical superiority over the national check variety at each particular location.
F = # of lines yielding significantly higher ($p < 0.05$) than the national check.
C = national check.

Many lines significantly outyielded the checks (P<0.05), especially in Tunisia and Algeria.

These are being extensive tested by national programs. Some are used in NARS breeding programs as parents possessing high yield and good adaptation.

The adaptation of bread wheat material in moderate to high rainfall areas (>400 mm) of WANA is illustrated in Table 62. The

Table 62. Performance(*) of bread wheat germplasm in the rainfed (> 400mm) or supplementary irrigated and moderate temperature areas of WANA. Regional Yield Trials for Moderate Rainfall Areas 1990-91.

Country	Line	Grain Yield (kg/ha)	%> NC	LSD.05 CV (%)	F
JORDAN (Maru)	Kvz/4/Cc/Inia/...	4300	153	803/18	3
	NC	2811			
ALGERIA (Khroub)	Gomam	9667	119	1347/13	1
	NC	8133			
TUNISIA (Beja)	Tevee-2	7185	121	896/11	5
	NC	5943			
EGYPT (Sakha)	Gomam	6101	113	507/7	2
	NC	5417			
LIBYA (Benghazi)	Gonbara	3249	112	637/20	1
	NC	2902			
S. ARABIA (Riyadh)	Gonbara	8140	108	1317/15	1
	NC	7524			
TURKEY (Izmir)	Tevee-2	7550	112	917/13	0
	NC	6758			

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

F = # of lines yielding significantly higher ($P < 0.05$) than the national check. NC = National check.

yield advantage of these lines over the national checks ranged from 108% to 153%. Gomam, Gonbara, and Tevee-2 are under extensive testing in North Africa. These lines are disease resistant, a common problem in the high rainfall environments of the region.

5.1.4. Grain yield and yield stability

Three major crop agroecological zones have been identified in WANA based on moisture availability and temperature regimes. These are: (1) areas of low rainfall associated with low temperature, (2) areas of moderate rainfall with moderate to high temperature, and (3) irrigated areas.

We develop germplasm suitable for zones 1 and 2, and rely on CIMMYT-Mexico for zone 3. Grain yield and stability are the most important objectives in zones 1 and 2. Table 63 shows the stability of promising bread wheat germplasm compared to improved bread and durum checks for at least 18 dryland locations in WANA in each of four years. The top yielding entries (TYE) differed each year. The results allow stability over locations of the TYE to be compared with the improved checks Cham 6 and Belikh.

5.1.5. Identification and distribution of genetic stocks

In collaboration with NARS staff in WANA, a number of improved genetic stocks have been identified. These have desirable traits and are available as parental material to NARS for use in their breeding programs.

Table 64 gives the number and attributes of bread wheat lines that have been identified and distributed to NARS in WANA during the last six years. They are distributed as crossing blocks to decentralize our breeding activities to national programs so they can generate new sources of genetic variability.

Table 63. Yield and yield stability of bread wheat germplasm in the low-rainfall (< 400 mm) areas of West Asia and North Africa. RWYT-LRA 1988 to 1991.

Year		TYE	Cham 6 (IBWC)	Belikh (IDWC)	No. Of Sites
1988	GY	2850	2845	2741	35
	Rank	1	2	10	35
	b Coef.	1.042	1.056	1.114	25
	d^2	154454	168662	198422	25
1989	GY	2808	2771	2621	24
	Rank	1	2	4	24
	b Coef.	1.198	1.074	1.137	24
	d^2	51680	154595	34469	24
1990	GY	2886	2878	2623	18
	Rank	1	2	14	18
	b Coef	1.082	1.138	1.138	18
	d^2	64349	45732	184747	18
1991	GY	3626	3417	3265	26
	Rank	1	8	15	26
	b Coef	1.102	0.919	0.970	26
	d^2	166837	54225	241203	26

TYE = Top yielding entry; IBWC = Improved bread wheat check; IDWC = Improved durum wheat check; GY = Grain yield; d^2 = deviation mean square; RWYT-LRA = Regional wheat yield trial for low-rainfall areas.

5.1.6. Wheat germplasm adoption and technology transfer

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 newly bred cultivars registered in the region.

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).

Table 64. Number of bread wheat lines with desirable genetic traits distributed to national programs as genetic stocks during the last six years, 1987 to 1992.

Genetic Traits	Average No. Per Year	Total
High yield and stability:	37	222
Abiotic stress resistance:		
Terminal drought	24	143
Cold	12	71
Terminal heat	14	81
Biotic stress resistance:		
Yellow rust	15	91
Leaf rust	10	57
Stem rust	5	27
Septoria leaf blotch	12	73
Common bunt	10	59
Wheat stem sawfly	15	89
Hessian fly	3	16
Selected landraces:	7	42
Bread making quality:	9	53
Total		1024

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 list of the 5 bread wheat varieties multiplied by GOSM during 1991-92 and distributed to farmers for the 1992-93 season is presented in Table 65. Approximately 350,000 ha will be planted this year with these varieties. The data in Table 65 supports the findings of the adoption study carried out by the FRMP of ICARDA.

Due to pricing policy in Syria, durum is grown on a larger area than bread wheat (the ratio was 70:30 in 1991). A new policy introduced this year is to balance (or even reverse) that ratio to approximately 40:60 over the next five years. Prices for bread wheat have been increased and a new bread wheat cultivar (Gomam) has been submitted for release as a commercial variety.

Table 65. Bread wheat varieties and amount of seed produced by the Government Organization for Seed Multiplication of Syria and distributed to farmers for 1992-93.

Variety		Year of release	Quantity (Tons)	% of total bread wheat	% I > L
Cham 4	(I)	1986	16500	45.6	300
Bohouth 4	(I)	1987	10000	27.6	182
Mexipak	(L)	1969	5500	15.2	100
Cham 6	(I)	1991	4000	11.1	73
Bohouth 6	(I)	1991	175	0.5	3
Total			36175		

I = improved; L = local

Table 66 gives data on another promising bread wheat line (Chorizo). In 1992, the average yield superiority over the local check was 8% and 5% in dry areas of Syria (<350 mm). It also performed better than the checks in 28 rainfed locations of WANA during 1990. Chorizo has been included in on-farm trials for a second year and seed is being multiplied by ICARDA's seed unit.

Four years of collaboration with the national program of Algeria in conducting joint on-farm verification trials has resulted in the release of three CIMMYT/ICARDA bread wheat varieties: Zidane 89 (=Gv/Ald), Zidi Okba (Cham 4), and Nesser. On average these varieties were reported to yield respectively 97, 80, and 87% more than the local check Mahon Demiaz under farmers conditions, at three dry locations in West Algeria.

Table 66. Performance of Chorizo, promising bread wheat line, in comparison to the improved and local checks in low-rainfall locations of WANA and Farmer's Field Verification Trials (FFVT) in Syria.

Cultivar	Grain Yield (kg/ha)			
	1990		1992	% > LC
	WANA	RANK	FFVT	FFVT
Chorizo	2476	2	3113	108
Cham 6 (IC)	2496	1	2977	103
Mexipak 65 (LC)	2305	15	2879	100
No. of sites	28		10	-
All sites mean	2307		2867	-
LSD 5%	-		577	-
CV (%)	-		10.7	-

WANA = West Asia and North Africa; IC = Improved check; LC = Local check.

There are approximately 250,000 ha of wheat in the dry areas of West Algeria (Tiaret and Sidi Bel Abbes). Farmers there have already adopted Zidane 89, Cham 4, and Nesser. Table 67 presents results of the IFAD/IDGC/ICARDA Technology Transfer Project conducted in Western Algeria. It compares differences between local and improved-released varieties of bread wheat with durum wheat and barley in farmer's fields (FS) and on research stations (OSS). The three bread wheat varieties substantially overyielded the local check under OSS. Only Nesser, a variety released in Syria for the less than 350 mm areas, maintained its yield superiority under FS. Table 67 also shows the advantages bread wheat varieties have over the durum and barley cultivars under those harsh conditions.

Table 67. Comparative differences between local and improved-released varieties of bread wheat, durum, and barley within farmer's and on-station sites in Western Algeria, 1991-92. (Modified from Maatougui M. 1992).

	Grain Yield (kg/ha)				
Varieties	FS[a]	I > L	OSS[a]	I > L	OSS-FS
Bread wheat					
Mahon Demias (L)	1765	-	1869	-	104
Cham 4 (I)	1450	-315	2064	195	614
Nesser (I)	2450	685	2255	386	-195
Zidane 89 (I)	-	-	2341	472*	-
Durum wheat					
Oved Zenati (L)	1310	-	1419	-	109
Waha (I)	1735	425	1927	508*	192
Kebir (I)	-	-	2390	971*	-
Barley					
Saida 183 (L)	1550	-	1085	-	-465
Rihane (I)	1750	200	1699	614	-051
Badia (I)	-	-	1430	345	-
WI 2269 (I)	-	-	1297	212	-
No. of sites:	2	2	3	3	5

I = Improved; L = Local
FS = Farmer's sites; OSS = On-station sites
* = Significantly different ($p < 0.05$).
a = Plot size 0.5 ha

5.1.7. Special studies

5.1.7.1. Characterization of wheat germplasm for their response to photoperiod and vernalization

The main objectives of this study were: (1) to characterize parental wheat germplasm for their response to photoperiod and vernalization, (2) to compare test environments (plastic house vs conviron), and (3) to identify potential genetic variability for their response to these two factors. 20 bread wheat and 20 durum promising cultivars from WANA, having a wide range of genetic variability were tested for their response to photoperiod (8, 12 and 16 hours light) and with and without vernalization. The experiment was conducted in a plastic house and in controlled conditions in "conviron" cabinets. Results show a wide range of genetic variability among the genotypes tested. The development data from the plastic house and the conviron correlated well (r = 0.887). Screening in the plastic house is adequate for testing a larger number of genotypes. Crop modeling studies using the collected data are under way in collaboration with other scientists at ICARDA.

5.1.7.2. Moisture regimes experiment

The main objective was to identify morphophysiological traits associated with yield under four watering regimes (35%, 55%, 75%, and 95% of field capacity). Four bread wheat and four durum wheat genotypes with a wide range of genetic variability were evaluated for 30 agronomic traits in a plastic house. Results show that some traits may be useful as selection criteria for drought tolerance. The results supported findings reported in the literature that bread wheat uses water more efficiently than durum wheat. Plant growth and development was also studied and the data will be used in crop modeling. In collaboration with program's physiologists the results will be validated under field conditions in the 1992-93 season. - **G. Ortiz Ferrara, M.A. Moussa, M.G. Mosaad.**

5.1.8. Bread Wheat Grain Quality

5.1.8.1. Determination of bread wheat flour strength by Near-infrared analyzer

Flour strength is reported to be the most important quality factor used in classifying wheats for end-product potential (Williams, P.C. et al, 1988).

The most widely used methods for measuring bread wheat flour strength are the Brabender Farinograph and Chopin Alveograph. Disadvantages of these methods include the large flour sample and the time required to perform the tests. Because of this, a reliable test which could measure flour strength in early segregating population is not available.

As a result of the cooperation between the Canadian Grain Commission and ICARDA, a paper was published (Williams, P.C. et al, 1988) which describes a small scale test to determine wheat strength using a near-infrared analyzer.

The cereal quality laboratory at ICARDA is now using an advanced near-infrared analyzer (model NIRSystem 5000) for measuring flour strength. Other quality parameters such as protein and hardness are also measured with this equipment. The advantages include the small sample (5 g) required and the availability to run 200-300 sample per day.

During 1992, calibrations were developed using the NIRSystem 5000 to predict farinograph stability time, protein and hardness in bread wheat samples. Table 68 summarizes the efficiency of prediction for the three quality parameters measured. Results indicate that all parameters were predictable and highly accurate so guaranteeing its use in the breeding program. - **F. Jabi El-Haramein, G. Ortiz Ferrara**

Table 68. Accuracy of prediction of bread wheat quality by near infrared reflectance "NIRSystem 5000".

Parameter	SEP[a]	$\bar{d}$	r
Farinograph stability	1.20	1.29	0.87
Protein	0.17	0.17	0.998
Hardness	1.30	1.42	0.985

[a]SEP = Standard error of performance = standard deviation of differences.
$\bar{d}$ = Mean difference.
r = Coefficient of correlation between near-infrared reflectance and reference analyses.

5.2. Physiology/Agronomy

5.2.1. Introduction

This research forms part of a collaborative project with the Department of Plant Ecology and Evolutionary Biology, University of Utrecht, The Netherlands. Dr. E. Veneklaas from Utrecht worked in Syria from January to July, during the growing season, and at Utrecht for the remainder of the year. During the year the project in Syria was visited by Professors Hans Lambers and Marinus Werger and by a Phd student, Hendrika van den Boogaard. John Peacock also visited the group in Utrecht. The aim of the project is to identify the physiological and morphological plant traits that determine the efficiency of water use. Experiments were conducted on two selected varieties grown in tubes in growth rooms in Utrecht and in the field at Tel Hadya and on eight contrasting genotypes in the field at Tel Hadya and Breda. Results of the experiments described here will be available in 1993.

5.2.2. Water Use efficiency of bread wheat genotypes

At the crop level, water use efficiency (WUE) can be defined as the yield (total dry mass or grain) per unit water used (consisting of soil evaporation and crop transpiration). Earlier investigations at ICARDA showed a linear relation between yield and seasonal rainfall (or irrigation level), but in most cases the differences among genotypes were insignificant. Based on an analysis of all available information, a selection of eight bread wheat genotypes was made to test for differences in productivity in dry versus moist conditions. The genotypes were Nesser, Flk/Hork, Katya, Vulture, Seri 82, Maya/SAP, RBS/Anza and Mexipak. The material was grown at Breda (rainfed) and Tel Hadya (rainfed and irrigated).

At the plant level, WUE was defined as the rate of dry matter accumulation per unit of transpiration. To investigate the importance of physiological traits in determining WUE, a detailed pot experiment was carried out. The genotypes Mexipak and Katya were grown in tubes (1.5 meter length; 12.5 centimeter diameter) that were placed in holes in the field at Tel Hadya. A rain shelter was placed above the experiment. Water content of the tubes was monitored and manipulated to create two treatments: moist and dry. Frequent samplings allowed a detailed analysis of growth. In addition photosynthesis, transpiration and water relations were measured.

In the leaves, CO_2 is fixed and water is lost. The gas exchange processes in the leaves are the most important, but are not the only processes determining plant WUE. Both assimilation and transpiration are greatly affected by the stomatal conductance. At the leaf level,

$$WUE_l = \frac{A}{E} = \frac{g_c\ (p_a-p_i)}{g_v\ (e_i-e_a)}$$

A net photosynthesis,

E transpiration,

g_v, g_c leaf conductances for water vapour and CO_2,

p_a, p_i ambient and leaf internal CO_2 pressure,

e_i, e_a ambient and leaf internal vapour pressure.

Since the ratio of g_v and g_c is constant, leaf conductance would not seem to be important for WUE. However, a lower conductance (due to e.g. drought) will cause a decrease in CO_2 pressure in the leaf and thus a reduction of photosynthesis. Transpiration will decrease as well, causing leaf temperature to rise, especially in dry and sunny conditions. Since at higher leaf temperatures e_i will also be higher, the reduction of transpiration will not be proportional. Photosynthesis is also temperature-dependent; it may either increase or decrease when the leaf temperature rises.

The use of carbon isotope (C^{13}) discrimination to screen for differences in WUE is based on the above theory. Especially in extreme climates the simplifications of the theory may complicate the use of the C^{13} technique. Extensive measurements were made at Tel Hadya in June to test the interrelationships of these physiological variables under field conditions. - **E. Veneklaas, A. Dakheel, I. Naji, G. Ortiz Ferrara, J.M. Peacock**

5.3. Pathology

We are highlighting results on the Bread Wheat Key Location Nursery, on the germplasm pools for sources of resistance to diseases, and on crop loss assessment trials.

5.3.1. Summary of Disease Data from the Key Location Disease Nursery (WKL-91)

Data summary of the Wheat Key Location Disease Nursery (WKL-91) was completed in September 1992. Table 69 shows the sites from which useful disease data were received. The performance of the lines in the WKL-91 is presented in Fig. 13. Out of the 234 lines in the nursery, there were 195 (83%) lines resistant to powdery mildew, 113 (48%) lines resistant to BYDV, 81 (35%) lines resistant to yellow rust, 63 (27%) lines resistant to stem rust, 29 (12%) lines resistant to leaf rust, 24 (10%) lines resistant to *Septoria tritici* blotch and 1 (0.5%) lines resistant to common bunt.

Table 69. Screening site and disease for the Bread Wheat Key Location Disease Nursery (WKL-91).

Site	Disease*						
	YR	LR	SR	ST	PM	BYDV	CB
Syria							
Tel Hadya	+	+	+	+		+	+
Latakia				+			
Lebanon							
Terbol	+	+	+				
Egypt							
Sakha			+				
Gemmeiza		+	+				
Iran							
Sari		+			+		
Ahwaz			+				
Gorgan				+	+		
Kermanshah				+			
Mexico							
Ciano		+					
Portugal							
Elvas				+			

*Disease: YR = yellow rust, LR = leaf rust, SR = stem rust, ST = septoria tritici blotch, PM = powdery mildew, TS = tan spot, CB = common bunt.

However, four lines entries (# 92, 167, 168 and 192) showed multiple resistance to the three rusts, eleven (entries # 6, 8, 21, 39, 181, 182, 183, 252, 257, 258 and 259) to septoria blotch, powdery mildew and BYDV, and two entries (# 8 and 21) with multiple resistance to stem rust, leaf rust, septoria blotch, BYDV and powdery mildew. - **O.F. Mamluk, A. Yaljarouka**

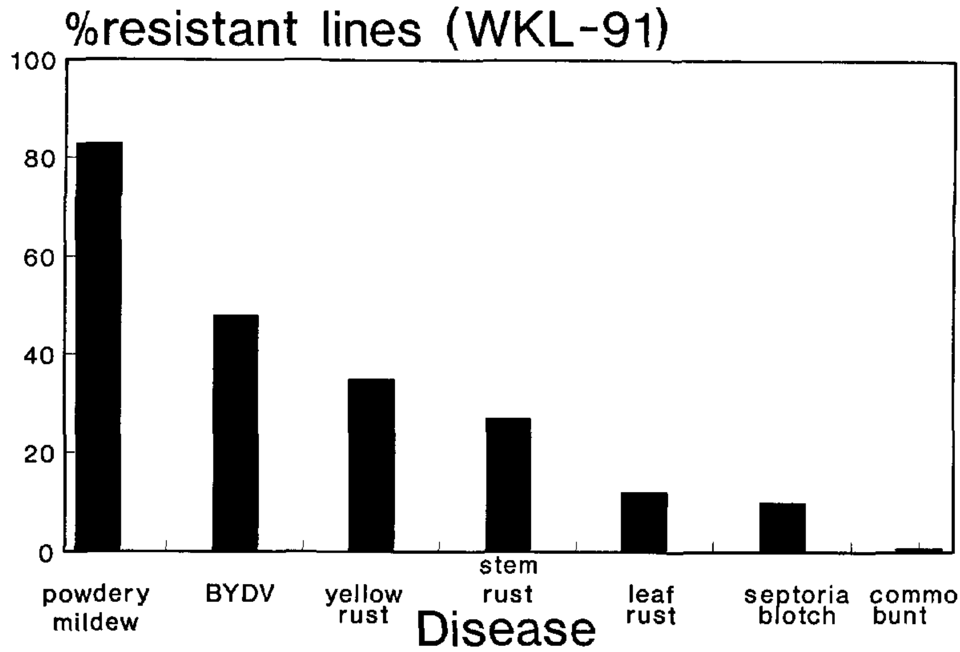

Fig. 13. Percent resistant lines in the Bread Wheat Key Location Disease Nursery (WKL-91) to the different diseases; selection criteria: powdery mildew, BYDV and septoria = score 5; yellow rust = 2 ACI; stem and leaf rusts = 5 ACI; common bunt = 15%head infection.

5.3.2. Germplasm Pools for Sources of Resistance to Wheat Diseases

Forty sets of the Bread Wheat Germplasm Pool for Stem Rust Resistance (WSRGP 92) were dispatch to collaborators in WANA and beyond for the 1992/93 season. This pool includes 24 lines which performed well against the disease over three seasons at Tel Hadya, Syria, the main screening site. Selection criterion was <15MR (severity and reaction type) in any of the seasons (Table 70). The performance of the lines to non-targeted diseases yellow and leaf rusts, septoria tritici blotch, and common bunt, in our multilocation screening is also included in the table. - **O.F. Mamluk, M. Naimi**

Table 70. The performance[1] of selected bread wheat lines to stem rust, *Puccinia graminis*, and other diseases[2] (WSRGP92).

Ent.	Name or Cross	Screening Year			Other diseases[2]			
		1989	1990	1991	YR	LR	ST	CB
1.	Ald/Bow	10MR	5MR	tR	60S	15R	8	-
2.	Au/Kal/Bb/3/Bon/4/Bow	10R	tR	5R	tR	tR	6	-
3.	Au/Kal/Bb/3/Bon/4/Bow	10R	tR	tR	tR	tR	7	-
4.	Bow	5MR	tR	tR	5R	-	-	-
5.	Bow	5MR	tR	5R	tR	-	-	-
6.	Bow	10MR	tR	tR	tR	-	-	-
7.	Bow/Nkt	5R	tR	tMR	10MR	tR	5	-
8.	Dove/Bow	tR	tMR	tR	tR	10MR	3	2
9.	Era/Chm/Sal75/3/ Cndr/....	10R	tR	tMR	tR	5R	7	-
10.	HI 660/Pavon/2/ Nacozari 76	10MR	tR	tR	tR	-	-	-
11.	Hahn *2/Prl	tR	tR	tR	5R	5R	8	-
12.	Jup 73/Bjy/Bow	tR	tR	tR	tMS	20MS	7	28
13.	Kvz/3/Corre Caminos/	5MR	tR	tR	10R	-	-	-
14.	Kvz//Cno67/Pj62/3/ IA78112	5MR	tMR	5R	tMS	tR	4	-
15.	Kvz//Cno67/Pj62/3/ IA78112	5R	tR	tR	tR	tR	4	-
16.	Kvz//Cno67/Pj62/3/ Pj/....	10MR	tR	tMR	tR	10R	7	-
17.	Kvz//Cno67/Pj62/3/SNB	5MR	tR	5R	tR	5R	4	-
18.	Maya/Sap	15MR	tMR	tMR	5R	tR	4	-
19.	Pato/On/Maya74/4/Bb/ 3/....	10R	tR	tMR	tMS	tR	2	-
20.	Rbs/Anza/3/Kvz/Hys/ Ymh/....	10R	tR	tR	5R	5MR	-	-
21.	Rbs/Anza/3/Kvz/Hys/ Ymh/....	10MR	tR	tR	tR	5R	-	-
22.	Rbs/Anza/3/Kvz/Hys/ Ymh/....	10R	tMR	tR	5R	5R	2	-
23.	Rbs/Anza/3/Kvz/Hys/ Ymh/....	tR	tR	tR	tR	5MR	8	63
24.	Vee/Snb	10R	tMR	5R	tR	tR	7	-

[1] Performance : % severity and reaction type.[2] Other diseases : YR and LR = yellow rust and leaf rust; ST = septoria tritici blotch in 0-9 scale ; CB = common bunt,% head infection.

5.3.3. Crop Loss Assessment Trials

Results of this season's trials on yellow rust for the bread wheat cultivars are presented in (Table 71). Both fungicides reduced disease score, mainly on susceptible cultivars, i.e., Mexipak 65, Cham 6, Bouhoth 6 and Cham 4. A significant yield increase (P = .05) due to either of the two fungicides was observed only in Bohouth 6 and Cham 4. The treatment with Fungicide I affected the yield negatively in cultivar Tevee and an adverse affect on yield was also observed when using Fungicide II on cultivar Douma 9013. - **O.F. Mamluk, M. Singh (CBSU), M. Naimi, S. Khawatmi, A. Yaljarouka**

Table 71. Effect of yellow rust (*Puccinia striiformis*) on grain yield and yield components of bread wheat cultivars; Tel Hadya, Syria 1992.

Cultivar	Treatment	Yellow rust Score /	ACI	Yield t/ha	% Yield increase	No. Tillers per m	No. seed per spike	1000KW (gr.)
Mexipak 65	Infected	85 S	85.0	3.11		121	25	31.5
	Fungicide I	23 M-MS	20.0	3.43	9.2	139	28	31.9
	Fungicide II	32 MS-S	28.7	3.46	10.2	143	26	31.6
Tevee	Infected	13 MR-MS	9.0	3.92		104	35	33.5
	Fungicide I	4 R-MS	2.9	3.78	-3.7	100	35	34.4
	Fungicide II	4 MR-MS	2.2	3.45	-13.4	99	33	34.4
Douma 9013	Infected	1 MR-M	0.5	3.70		137	29	28.2
	Fungicide I	2 R	0.5	4.33	14.5	150	30	28.8
	Fungicide II	1 R	0.2	4.06	8.7	146	30	28.6
Douma 11055	Infected	12 MS-S	10.3	3.81		111	26	38.7
	Fungicide I	5 R-MS	4.1	3.83	0.5	118	27	36.5
	Fungicide II	1 MR-MS	0.6	3.45	-10.4	105	25	38.2
Chorizo	Infected	37 S	36.7	3.32		108	33	31.0
	Fungicide I	7 MR-MS	4.9	3.98	16.5	109	32	31.5
	Fungicide II	4 MR-MS	3.0	3.42	2.7	134	29	28.7
Cham 6	Infected	80 S	80.0	3.29		157	24	27.0
	Fungicide I	12 M-S	10.3	3.85	14.7	154	25	32.8
	Fungicide II	18 MS-S	17.3	3.82	14.0	157	27	30.4
Bouhoth 6	Infected	68 S	68.3	3.06		104	30	30.6
	Fungicide I	17 M-S	14.3	4.12	25.8	122	32	32.8
	Fungicide II	30 MS-S	26.7	3.94	22.5	114	32	35.0
Cham 4	Infected	72 S	71.7	3.06		170	22	27.6
	Fungicide I	17 M-S	15.0	4.25	28.1	163	24	31.7
	Fungicide II	23 S	23.3	4.08	25.2	171	25	29.4
Standard error of means:	SE 1		0.24		9.61	1.88	2.1	
	SE 2		0.22		8.25	1.67	1.7	
CV %			11		12	10	8.0	

Figures = mean of 3 rep. each 7.2m², harvested 3.6m², from split plot in RCBD (treatment as main plot factor; cultivar as subplot)
Infected = artificial inoculation applied twice
Fungicide I = Triadimenol (Byfidan EC 250); 0.5 l/ha, applied three times
Fungicide II = Zeneb (Zinat 70 % WP); 0.9 kg/ha, applied six times
SE 1 to compare treatment at same or different levels of cultivars
SE 2 to compare cultivar at same levels of treatment

5.4. Entomology

5.4.1. Wheat Stem Sawfly Screening

As in past years, bread wheat and durum wheat lines with relatively solid stems generally performed better than hollow stemmed lines (Table 72). The threshold infestation level to retain lines for further testing prior to inclusion in germplasm pools is 10%. Adequate rainfall during the growing season reduced the screening anomalies reported in 1989/90. With the formulation of a core of sawfly-resistant wheat and, to a lesser extent, barley lines, future efforts will be directed primarily to testing offspring of crosses between lines of proven resistance and lines with good yield and other desirable characters. The selections are now in the F_4 or higher generation.

Table 72. Best performing wheat and barley lines tested for wheat stem sawfly resistance in 1991/92.

Name	Pedigree	Source	SN	%Inf87	%Inf88	%Inf89	%Inf90	%Inf91	%Inf92
Bread Wheat									
Fta/W71//Imuris	CMH80A-276-1B-2Y-1B-1Y-1B-0Y	WCB87	72	2.91	5	7.10	1.25	37.5	0.25
Tob'S'/8156//Y50E/ Kal(3)/4/Mrs//Kal/ BB/3/AZ	ICW82383-023AP-300AP-1AP-300L-4AP-300L-0	WAL91	211	-	-	-	-	22.5	0.25
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
Kasyon//Pvn'S'/Sprw'S'	ICW86-0860-300L-300AP-0L-0AP	WAM91	311	-	-	-	-	20.83	0.75
66.122.66.2/No66// Lov2F1/3/F1Kvz.Hys/4/ 7C//Tob/Cno'S'/3/Kal/ 6/Mb*2//In	ICW84-0440-04AP-300L-7AP-300L-0AP	WAL90	217	-	-	-	0.42	18.33	0.75
Snif4414/Crow'S'	SWM11508-1AP-1AP-4AP-1AP-1AP-5AP 0AP	WAT88	613	-	8.33	9.25	0.83	17.50	0.75
Ald'S'/Pima 77/3/ Cmh74A-630/Bui'S'// Cmh74A-630/4/R37/ G1121//Kal/Bb	ICW83-0268-015AP-300AP-300L-1AP-300L-0AP	WAM91	207	-	-	-	-	16.67	0.75
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
Tsi/Vee's'	CM64335-3AP-3AP-1AP-0AP	WOL88	12	-	-	-	0.83	0	1.75
Bol'S'/Pvn'S'	CM58696-5AP-2AP-1AP-1AP-0AP	WOM87	42	2.91	10	7.50	3.75	35.83	2
Durum Wheat									
16143	-	SOLSTE	72	-	-	-	0	10	0

D-2/Sham 1	ICD79-0282-10AP-3AP-2AP-1AP-0SH	DAB87	140	-	8.33	5	0	10.83	0.42
TALLO SOLSTM DW NO 12	-	TALLO	12	-	-	-	0.42	10.83	0.42
12167	-	SOLSTE	45	-	-	-	0	10.83	0.42
8160	-	SOLSTE	3	-	-	-	0	10	0.42
10247	-	SOLSTE	25	-	-	-	0	8.33	0.42
Awalbit-6	ICD84-0322-ABL-5AP-TR-AP-15AP-OTR	DAT91	506	-	-	-	-	7.5	0.83
Rufom-4	ICD84-1257-14AP-TR-13AP-0TR	DAT91	505	-	-	-	-	7.5	0.83
D-2/Bit	CD 20796-4AP-6AP-2AP-0AP	DAT87	116	1.66	9.58	4.58	0.42	14.17	0.83
Bit/Creso	CD 34346-2TR-2AP-1AP-0AP	DCB87	20	0.83	9.85	7.05	0	11.67	1.25
Gezira 17/Scaup	ICD-HA81-1917-3AP-1AP-1AP-0AP	DCB87	37	0.83	5	3.35	0.42	11.67	3.75
Barley									
7028/2759/3/69-82//Ds/ Apro/4/As46/Aths*2	ICB85-1728-2AP-1AP-0AP	BIT89N	904	-	-	-	1.25	6.67	0.83
Apm/HC1905//Robur/3/Arar	ICB85-0121-7AP-2AP-0AP	BAT91	207	-	-	-	-	8.33	0.83
As46/Aths	ICB86-0516-6AP-0TR-3AP-0TR-0AP	BAT92N	501	-	-	-	-	-	0.83
Lignee 527/NK1272	ICB84-0323-4AP-1AP-1AP-0TR-2AP-1AP-0AP	BAT92N	319	-	-	-	-	-	0.83
Soufara-03//WI2197/ Arabische	ICB84-0469-7AP-3AP-0AP	BAT91	102	-	-	-	-	1.67	1.67
WI2291//EH20-F3-81-Arar	ICB84-1725-2AP-0AP-14APH-0AP	BIS91N	506	-	-	-	-	3.33	1.67
INRA55-86-2/V1701	ICB82-1140-13AP-0AP	BAT89	209	-	-	6.65	1.25	7.5	3.33
Harmal-02/3/Arr/Esp// Alger/Ceres, 362-1-1	ICB83-1546-0AP	BAT89	212	-	-	6.23	7.5	7.5	3.33
Ager/Api/CM67/3/Cel/ WI2269//Ore	ICB81-1275-0SH-1AP-0AP-0AP	BAT 88	405	-	7.5	5.03	0.83	16.67	5
FB73-075	-	BAB85	14	.83	2.08	2.93	5	13.33	8.33

SN = Source number; 90 INF 87-92 = percent sawfly infestation in a given year.

5.4.2. Wheat Stem Sawfly Yield Trials

Two resistant varieties and the respective checks of barley, durum wheat, and bread wheat were planted in six rows 2.5 m long. Plants were exposed to naturally occurring wheat stem sawfly populations and infestation rates and yields were measured (Table 73). In barley, the check line outyielded the WSS-resistant lines but also had the highest level of infestation. In durum wheat, both WSS-resistant lines outyielded the check and had substantially lower infestation rates. Similarly, WSS-resistant bread wheats outyielded the check, though with a lower margin than durum wheat, and had significantly lower sawfly infestation.

5.4.3. Russian Wheat Aphid

Subsequent to the publicity generated by the Russian wheat aphid's, Diuraphis noxia Mordvilko (RWA), devastating impact in North America since 1986, ICARDA has teamed with other organizations to determine its distribution and impact worldwide.

In early April 1990, scientists from Washington State University, ICARDA and the Morocco-based USAID-MIAC project surveyed North Africa and the eastern Mediterranean for RWA and natural enemies in Morocco, Jordan, Syria, and south-central Turkey (Pike et al., 1990; Miller et al., 1992). In general, RWA density was low to moderate in all the regions sampled. Some sites had a high percentage (about 80%) of infested plants and natural enemies. RWA was most often found in low-humidity areas where plants were sparse and subjected to moderate drought stress. RWA occurred least in humid environments with high plant density and vigorous plant growth.

In early May 1992, scientists from ICARDA, Washington State University, and Cukurova University (Adana, Turkey) surveyed northern Syria and central Turkey. RWA and numerous natural enemies

Table 73. Results of yield wheat stem sawfly yield trials conducted at Tel Hadya in 1991/92 under natural infestation[a].

Variety	% Infestation	Adjusted Yield MG/ha
Barley		
FB73-075	10.28a	4.004ab
Ager//Api/CM67/3/ cel/WI2269//Ore	7.78a	3.585a
Arabi Abiad (check)	22.64 b	4.401 b
Durum wheat		
Gezira 17/Scaup	7.64a	4.144 b
Bit/Creso	9.45a	4.498 b
Haurani (check)	67.64 b	3.747a
Bread wheat		
Tsi/Vee'"s"	9.03a	3.518a
Bol's'/Pvn's' CM58696	9.17a	3.332a
Golan (check)	34.86 b	3.280a

[a]numbers followed by the same number are not statistically significant at P = 0.05).

were again located in drought-stressed, isolated plants near Aleppo in northern Syria. Densities were lower than in 1990 because of the unusually cool, rainy spring weather in 1992. In Turkey, RWA was found in sparsely planted wheat and rye fields in the Tarsus-Aladaglar Range near Pozanti at about 1200 m elevation and in foothills north of Tarsus. A heavy infestation devoid of natural enemies other than syrphids was found in a patch of wheat located east of Kahramanmarash near the village of Narli. No RWA were found on the Anatolian Plateau from Konya to Nevsehir, probably because of the severe winter and cool spring the region experienced in 1992. Concurrently with this survey, RWA was identified in wheat at

ICARDA's Terbol research farm in Lebanon's Beka'a Valley, near Zahle, and on a nearby farm operated by the American University of Beirut. RWA is widespread throughout the rainfed wheat- and barley-producing areas of western Asia and northern Africa (Fig. 14). Its impact on production in these regions appears to be closely linked to precipitation received during the growing season. In years of normal rainfall, RWA is relegated to isolated reservoir populations along the edges of irrigated fields and in drought-stressed patches on eroded hills and in isolated canyons. During periods of prolonged drought, RWA populations expand to infest large areas, threatening the most productive wheat- and barley-growing areas. However, the actual impact of RWA during these years is difficult to separate from crop losses associated with abiotic stresses such as water stress, cold, and heat. In addition, RWA symptoms frequently have been, and often still are, confused with those of drought, heat, and cold which makes impact assessment difficult.

RWA will probably continue to be a marginal pest in most areas of Africa and western Asia, with the exception of southern Africa, Ethiopia, Yemen, and perhaps the Maghreb states of North Africa where its past performance suggests that it can cause serious economic loss unless managed properly. RWA will probably become a more serious pest if wheat and barley are sown in increasingly marginal rainfed environments, as is currently the trend in cereal-deficient countries of western Asia.

Some RWA-resistant wheats and barleys have been identified at ICARDA (Table 74) for use in the Mediterranean region, but almost all exotic varieties have proven highly susceptible to local diseases and maladapted to the unpredictable, harsh climate typical of the region (ICARDA, 1992). More promising are sources of resistance from landraces or from lines originating in areas long infested by RWA (Fig. 15). With this in mind, ICARDA has increased

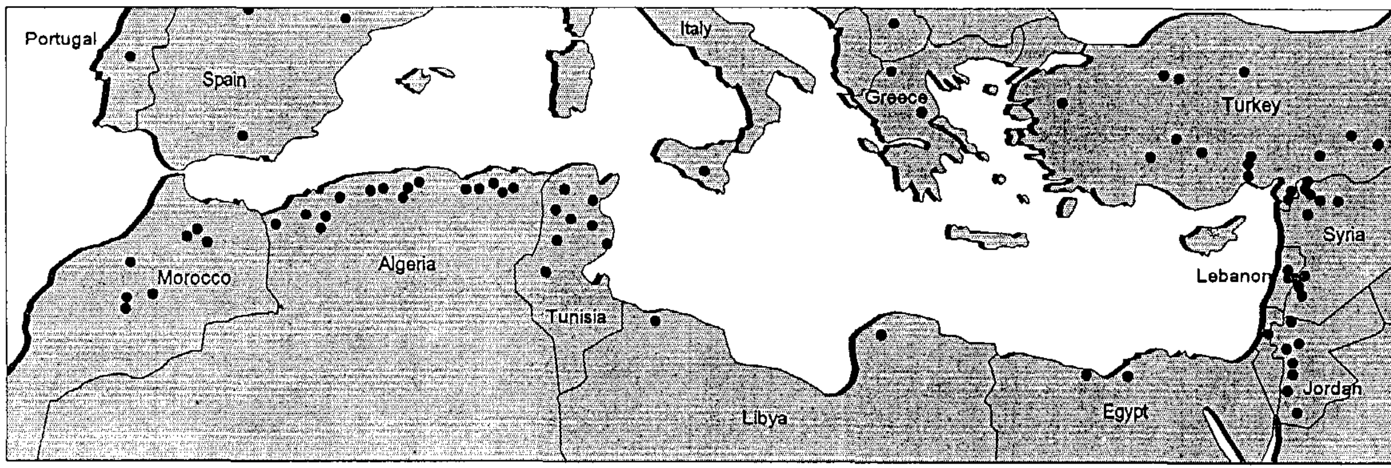

Fig. 14. Distribution of Russian wheat aphid in Mediterranean rim countries (after Miller et al., in press).

Table 74. Selected barley and wheat lines showing resistance to Russian wheat aphid in hill plot screening trials at Tel Hadya in 1991/92.

Line ID	Mean Score	1000KW	Yld/head (g)
Barley			
68-004	0.15	0.00	0.00
36-012	1.35	10.63	0.01
36-031	1.35	7.72	0.00
30-038	2.50	45.75	0.06
22-001	2.50	30.17	0.02
10-003	2.65	39.21	0.05
10-004	2.65	19.12	0.05
66-023	2.65	35.72	0.04
30-005	2.65	34.15	0.04
19-037	2.65	32.70	0.04
30-035	2.65	43.56	0.02
66-091	2.65	27.61	0.00
Egyptian bread wheat			
136X5.69 629/6	0.65	10.40	0.13
768/2	1.00	17.45	0.40
757/3	1.00	13.70	0.28
714/3	1.00	10.75	0.20
697/1	1.00	10.15	0.11
772/4	1.15	14.05	0.39
786/2	1.15	10.85	0.35
134X5.69 494/1	1.15	14.05	0.34
136X5.69 456/3	1.15	12.25	0.19
723/2	1.15	10.20	0.14
784/2	1.15	0.00	0.12

Table 74 (Cont'd.)

134X5.69 519/3	1.15	9.85	0.09
134X5.69 614/1	1.15	10.15	0.06
136X5.69 472/2	1.15	7.91	0.06
136X5.69 604/3	1.15	11.30	0.03
DASR wheats			
Cham 1	2.00	17.60	0.15
Doma SH-1343	2.00	12.50	0.12
Cham 2	2.35	0.00	0.00
Tzpp*2/Ane	2.50	0.00	0.00
H-2120	2.70	21.80	0.37
Lahn	2.70	18.36	0.25
Omrabi 5	2.70	13.85	0.09
Cham 3	2.85	18.20	0.27
ST-13358	2.85	12.71	0.26
Doma H-2313	2.85	21.24	0.17
H-2220-B	2.85	14.60	0.02
DR-12807	2.85	18.85	0.25
ACSAD65	3.00	17.85	0.15
ICARDA bread wheat			
201205 GRU 22	1.35	5.30	0.05
202276 GRU 79	2.50	0.00	0.00
201197 GRU 21	2.70	0.00	0.00
202095 GRU 65	2.80	0.00	0.00
Tsi/Vee'SCM64335-3APWCB11	2.80	0.00	0.00

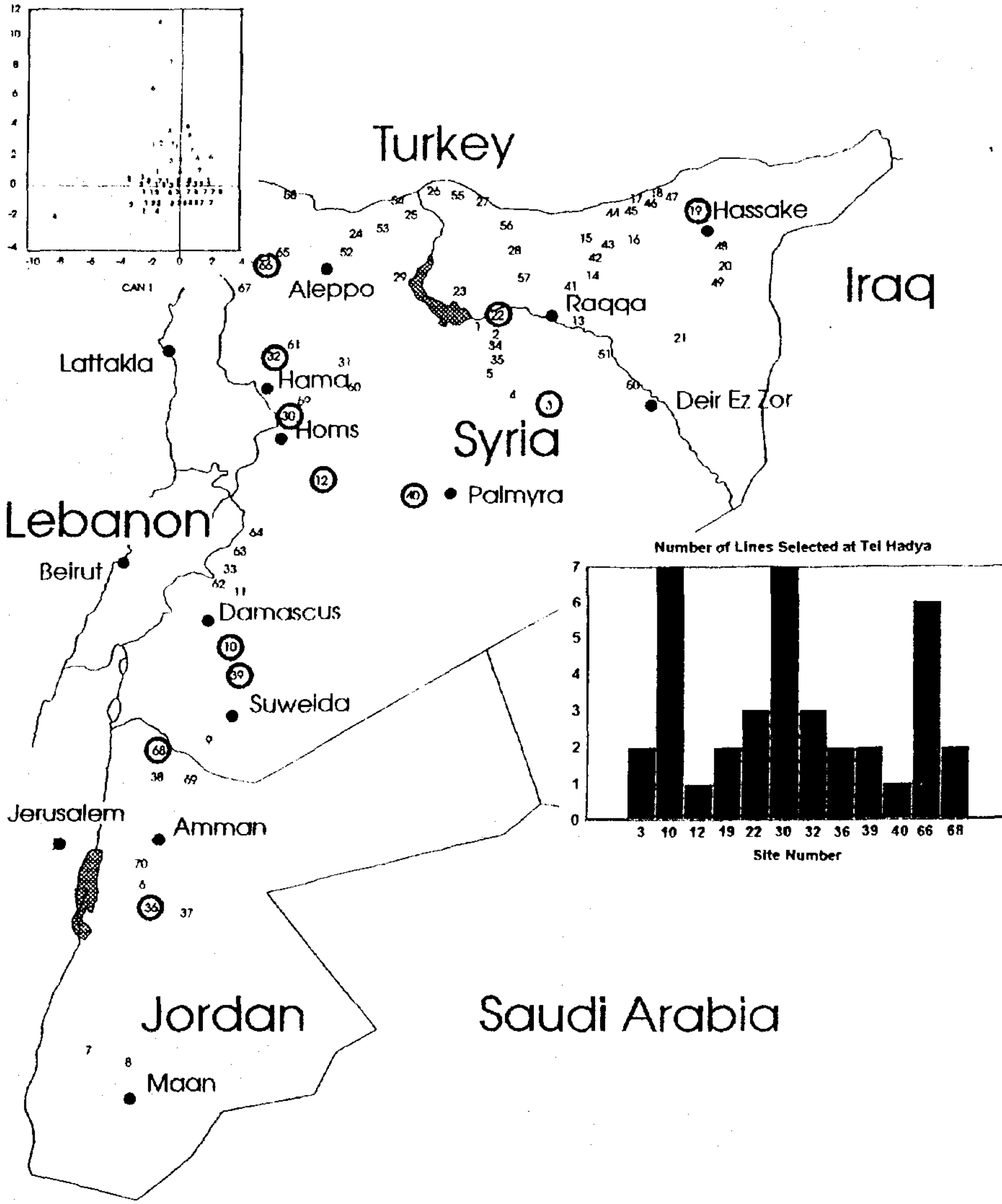

Fig. 15. Frequency of selection (lower insert) and collection sites of barley lines (circles) resistant to RWA at Tel Hadya. Low variation in tested lines among sites is shown by the densely clustered plots of the first two canonical variables (upper insert).

its RWA screening program, concentrating on wheat and barley landraces, wild relatives and advanced lines originating within WANA. Very effective field screening techniques, including a 6 point scoring system combining plant damage due to the aphid's saliva with aphid density per plant (1=resistant, 6=highly susceptible), were adapted from those developed at CIMMYT (Robinson, et al., 1992). As might be expected, most wheats and barleys initially screened were susceptible to highly susceptible, although some lines showed tolerance to salival toxins and will be retested (Fig. 16). ICARDA's breeding program seeks to combine RWA resistance with heat and drought tolerance and with disease resistance in both wheat and barley. We hope that the use of RWA-resistant varieties, coupled with the preservation and enhancement of endemic natural enemies, will provide adequate protection against RWA outbreaks in the low input wheat and barley areas of the region.
- **R.H. Miller**

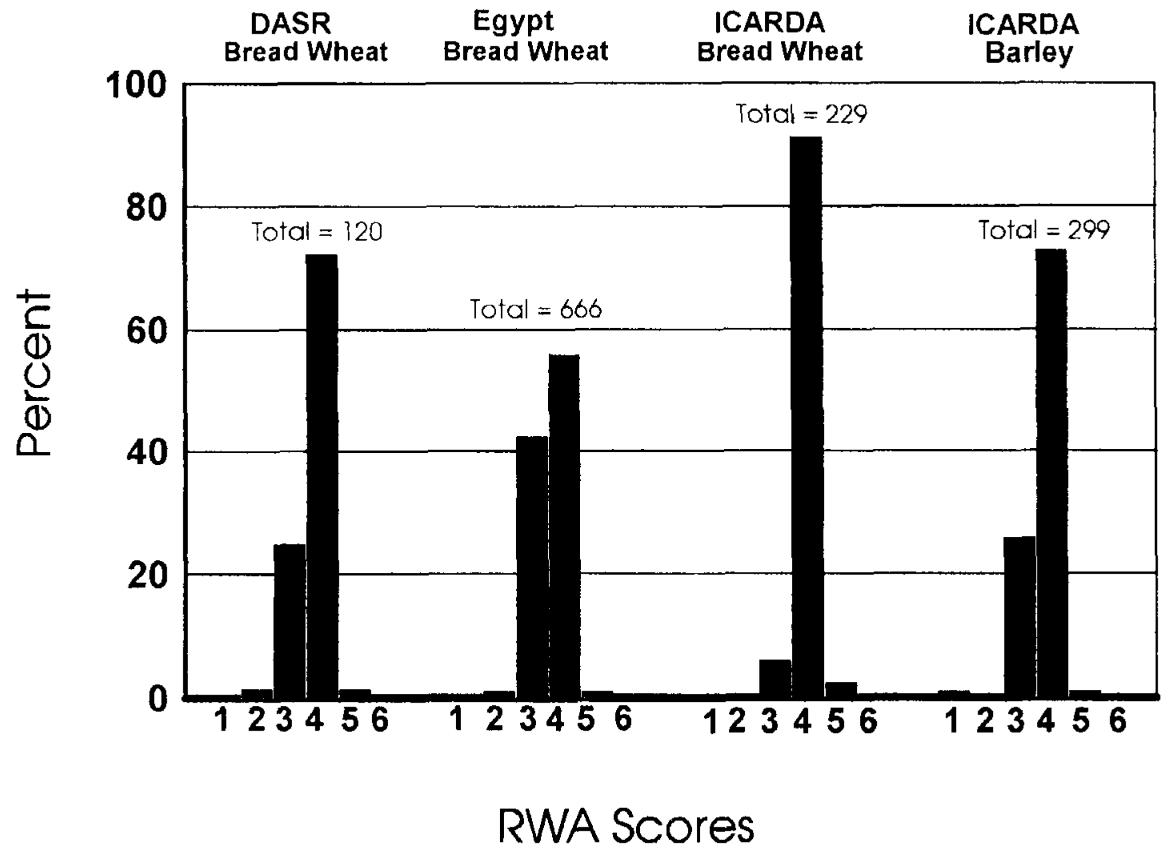

Fig. 16. Distribution of RWA scores on wheats and barley screened at Tel Hadya during 1991/92 (1=resistant, 6=highly susceptible).

5.5. International Nurseries

Regional bread wheat nurseries assembled by the joint CIMMYT/ICARDA bread wheat project at ICARDA in 1992 are given in Table 75. There were 7 nurseries and 5 germplasm pools, with a total of 452 sets being distributed. The regular and trait-specific nurseries remained unchanged from last year. The agreement between CIMMYT and ICARDA on

Table 75. Bread wheat regional nurseries for 1992-93.

Nursery	Abbre-viation	No. of entries	No. of sets distributed
Regular Nurseries			
Crossing Block	WCB	140	39
Segregating Populations	WSP	135	25
Observation Nurseries:			
- Semi-arid Areas	WON-SA	291	37
- Favorable Areas	WON-FA	278	41
Yield Trials:			
- Low Rainfall areas	WYT-LRA	24	58
- Moderate Rainfall Areas	WYT-MRA	24	79
Specific-trait Nurseries			
Heat Tolerance Obs. Nur.	HTON	60	51
Sub-total			330
Germplasm Pools for Sources of Disease Resistance			
Stem Rust	WSRGP	24	41
Yellow Rust	WYRGP	65	20
Leaf Rust	WLRGP	26	21
Common Bunt	WCBGP	13	20
Septoria Tritici Blotch	WSTGP	25	20
Sub-total			122
Total			452

spring wheat nursery preparation and distribution was implemented starting last season. Under this agreement the names of the observation nurseries were changed 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 nurseries included lines supplied from the CIMMYT base program in Mexico (with seed multiplied at Tel Hadya, Syria) and were restricted to the WANA region. A new germplasm pool for stem rust resistance was assembled by the wheat pathologist, in addition to the four disease resistant germplasm pools made available last year. - **S.K. Yau**

5.6. Biotechnology

5.6.1. 1B/1R-substitutions in wheat

In collaboration with Prof.T.Lelley University Vienna, and the Plant Breeding Institute in Göttingen 1R chromosomes from 15 different rye lines will be introduced into 10 of the best local wheat lines. The initial cross between wheat and rye-lines was started this year, the chromosome number of the hybrids has to be doubled using colchicine. The hybrids will be backcrossed to wheat, spontaneous substitutions and/or translocations will occur. The substitutions will be monitored and described. C-banding of the wheat and rye chromosomes and DNA-marker techniques will be used to identify the substituted chromosomes.

Wheat lines used were: Cham 4, Cham 6, Sawari-I, NS 732/Her, Pri/Pew, SHI#4414/Crow, Dove/Buc, TR 380-16-3A617/Chat, BB/Pato (3)/Coc, and Chori 20. Rye lines used included 10 inbred rye lines from Dr.G.Scoles, Saskatoon, Canada and 5 inbred rye lines from Dr. T. Lelley, Vienna. - **M. Baum**

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6. Facultative Bread Wheat (FBW) Breeding

6.1. Introduction

Assessment of project method and direction was stimulated by visits of Peter A. Portmann, Department of Agriculture, Western Australia and Tony Rathjen, Waite Institute, South Australia. The standardization of methods, and honing of objectives were the hallmarks of their reviews.

Cereal Program project plot size at Tel Hadya, and other ICARDA/Syria locations has been standardized. This will facilitate cooperation between programs, projects and Farming Operations. All yield trials will be grown in 8 row, 3.25m plots, 20cm separating individual rows. Mechanization of all aspects of the Program, especially sowing and harvest, is gradually being accepted by all projects.

Border trimming of yield trial experiments is an operation that may conflict with peak demand labor supply, and can introduce random error due to uneven edge trimming. A deviation of 10cm in driving the straight plot/buffer line would result in a maximum error of 8% (actual error around 4%) in harvest area of a 5m plot. This is the level of genotypic difference which our yield trials are designed to detect. Plot technique errors may obscure results.

A technique gleaned from experience at Nebraska and Western Australia, allows simultaneous marking of both ends of the plot range with nozzles fixed to a spray boom. Constant plot widths are achieved with one tractor pass across the field. Errors in plot/alley placement or marker-driving will thus result in variable alley widths (<u>not plots!</u>). This technique allows full vegetative coverage of the field, from plant emergence to physiological maturity. This increases land area utilized and decreases bare ground (thereby reducing erosion and weed habitat), and provides an inter-range (between plot ends) competitive buffer. To maintain a competitive buffer between ranges, marking is delayed until the crop has just reached heading. In environments similar to that at Tel Hadya a significant portion of stored soil moisture has been utilized at heading and further rainfall is unlikely.

In collaboration with Jurgen Diekmann and Peter Eichhorn, a spray boom was designed, constructed and tested in FBW fields at Tel Hadya A small width (100cm), 4 wheel drive vineyard tractor served as the tool carrier. The boom allows full alley-width coverage behind the tractor, and half alley-width coverage on boom arms extending (plot + alley width) either side of the tractor. The alleys covered by the half width units are where error corrections for driving irregularities occur, tractor sprayed alleys and plots will have a constant width across the field. Standardization of plot size, across the Cereal Program 1992/93, will allow this technique to be used by other projects for their plot management.

Concern of possible herbicide residue effects resulted in design, construction and testing of hydraulically powered mower unit that allowed simultaneous sickle bar cutting of a full alley-width in front of the tractor, and half alley-width cutters on boom arms extending either side of the tractor. The hydraulic power required to operate these mower units, however, exceeded that available from the tractor particularly when the cutter bar ran perpendicular to the planted rows, and row upon row of lush, green plants entered (and ultimately clogged) the cutter bars. In comparison, the herbicide "cutting" method was preferred because of the simplicity in equipment manufacture and operation.

6.2. Simplifying the tedious

A comparison of Days to Heading, versus Physiological Developmental Score, as an indicator of relative maturity. In taking "days to ..." heading or flowering notes, intensive data collection for a relatively simple trait requires repeated observation of entire nurseries, with several recordings per week over an extended period--all making one wish there were a simpler, more efficient method to collect relative development or maturity data.

In most breeding programs, the desired maturity class of germplasm is achieved through selection in situ of material adapted to a particular site or area. Merely defining outlier genotypes in terms of "very early", "early", "late", and "very late" is sufficient to characterize relative maturity. Differentiation should be based on development relative to check cultivars, or basic species differences (e.g., "very early" barley versus "late" wheat).

This simple segregation is sufficient for most breeding programs. However, if the data collected is intended to depict specific relative performance differences across a range of genotypes, a developmental growth stage score may be more appropriate. Scores may be based on gross morphological appearance, or by dissection of a particular event to determine when it occurs (e.g., embryonic spike initiation, pollen maturity or dehiscence, ovule fertilization, or initiation of caryopsis growth and differentiation).

The H. M. Fisher Phenological Development Scale categorizes gross morphological vegetative and reproductive plant development into 51 stages. Using this score, material can be classified with one or two visits to the trial, rather than the 6-10 visits required for "days to..." data, resulting in a reduction in workload by 80% or more. Those stages appropriate to relative maturity classification are:

Score	General stage	Description
27	Flag leaf emergence and head development	Tip of flag leaf (FL) emerged.
28		FL auricle appearing.
29		FL well emerged.
30		"Boot" stage--head well developed.
31	Head emergence and anthesis	"Head Peep" stage--Head appearing.
32		Head emerged.
33		Base of ear level with FL auricle.
34		Base of ear above FL auricle.
35		Head on extended peduncle
36		"Anthesis"--anthers extruded.

Days to heading (HD) and the Fisher Phenological Development Scale (PDS) data were recorded for the Winter, Facultative, Spring Wheat Comparative Yield Trial (WFSYT92, seventy two entries, 3 replications) grown at Tel Hadya in 1992 with supplementally irrigated (IRR) and rainfed (RF) conditions.

Comparison	Correlation	Entries	Equation	r^2
IRR	HD:PDS	all	33.87 - 0.0421x	0.0037
		WF	33.38 - 0.0301x	0.0019
		S	36.43 - 0.1176x	0.0278
RF	HD:PDS	all	36.48 - 0.1473x	0.3252
		WF	37.31 - 0.1776x	0.4215
		S	34.40 - 0.0709x	0.1092
HD	Irr:RF	all	26.14 + 0.0671x	0.0029
PDS	Irr:RF	all	23.49 + 0.2711x	0.3037

The association between HD and PDS was higher in the rainfed trial, and separation of entries into vernal habit groups affected the correlations between HD and PDS. Between trials, PDS data were more closely associated than were HD data.

General observations.
--The low correlation between HD:PDS in the IRR trial indicates that either parameter may be a poor indicator of relative development.
--High correlation between HD and PDS is not expected because HD data will reflect changes in crop development, as influenced by the environment, over a period of time. PDS will reflect genotypic developmental differences, at a particular point in time.
--One problem that was observed in using the Fisher PDS was that the scoring system records progressive vegetative changes that lead to a culmination of certain reproductive events. However, developmentally, the step wise progression from flag leaf emergence--head development--head emergence to anthesis is an untenable association. We observed instances in which reproductive anther extrusion (stage 36) occurred during the vegetative stage 32. Perhaps this is an issue that is more applicable to Tel Hadya where a forced anthesis may occur. Given this constraint, a PDS that is more suitable to our conditions will be investigated. A better definition of the actual vegetative-to-reproductive transition (embryological spike initiation) and inflorescent fertilization is needed.

6.3. Summer planting at Tel Hadya

The FBW project uses a summer planting at Tel Hadya (sown early July) to screen germplasm for degree of vernalization requirement. The nurseries planted in this test are intended for observational screening purposes only, seed is not required. Any appreciable quantities of seed obtained from this nursery will be from genotypes with low vernalization requirement; just the genotypes to be discarded.

Association between Field and Hill observations was tested in 1FAWWON, WFSWYT92, and CBFW-Turkey92. Conventional yield plots have been used in the past to screen for this trait. However, the area allocation is wasteful. Fifty hill plots occupy an area equivalent to one conventional macro yield trial plot.

Year	Field area (ha)	Plot type	No. genotypes tested
1991	0.8	Macro ($4.5m^2$)	1500
1992	0.16	Mini ($3.3m^2$)	400
	0.02	Hill ($0.09m^2$)	1382
1993*	0.03	Hill ($0.09m^2$)	2000

*Projected summer land use requirement (12.5 x 24m).

However large conventional plots may be advantageous if a genotype is heterogeneous for response to vernalization.

Score			No. Entries			
	HILL vs	MINI	WFSWTY92	1FAWWON	CBFW-T92	Total
1	same	same	61	98	100	259
2	1-4	seg/mix	6	9	2	17
3	0	seg/mix	4	4	25	33
4	seg/mix	0-4	1	7	4	12
						321

Score
0=Vegetative
1=Tiller elongation
2=Booting
3=Heading
4=Past anthesis

tr=trace
s=segregating
e=early, l=late
-=missing

The data above shows that, development in hill plots accurately reflects mini-field plots. In 86% of plot:plot comparisons, the same, or similar, scores were recorded (category 1+2). In 10% of the comparisons, hill-plot sample size was apparently insufficient to account for segregation or mixture variability observed in the field plot trials (category 3). In 4% of the comparisons, hill-plots incorrectly identified field plot response (category 4). Category 4 errors are most troublesome, yet may point to a planting density by response to lack of vernalization interaction that may be worth investigating.

Use of hill-plots to screen for response to lack of vernalization is warranted, given the land savings involved and associated savings in nursery maintenance (sowing, watering, weeding, data collection, etc.), and the low error rates.

6.4. Characterization of Tel Hadya-derived FBW germplasm

FBW germplasm selected at Tel Hadya has diverse vernalization requirements. Unfortunately, a preponderance of low vernalization requiring genotypes may result from unrestricted selection, particularly in material from spring by winter crosses due to genetic dominance for low vernalization requirement.

Twenty seven Tel Hadya-derived FBW genotypes (ICWH- cross identifiers), entries in the 1FAWWON, were characterized for vernalization requirement by summer sowing in hill plots at Tel Hadya. Response to (lack of) vernalization is presented in Table 76 for these entries, and standard check cultivars. Though a relatively small sample, it represents elite germplasm developed as "FBW germplasm", through selection and yield trials at Tel Hadya. Fifteen of the 27 lines screened were low vernalization requiring types. In addition, twenty five percent (137/546) of entries in the previously unscreened (for vrn response) FBW92 Advanced Lines nursery were low vernalization requiring genotypes.

Because these low vernalization types are thought to be more sensitive to frost and cold, constraints of primary concern in facultative and winter wheat environments, population shifts toward vernal requiring genotypes is desired. Summer planted screening of early selection advanced lines will allow identification of low vernalization requiring genotypes, allowing efforts to be concentrated on facultative and winter genotypes.

6.5. Performance of vernalization requiring wheat to northern Syria

Fifty five facultative and winter wheat genotypes of diverse origin, and 17 spring wheat genotypes were grown in a replicated yield trial (WFSYT92) at Tel Hadya under supplementally irrigated and rainfed field conditions in 1992. This germplasm was also sown in a summer planting at Tel Hadya, under high temperatures to screen for (lack of) vernalization response.

Figures 15 and 16 represent the association between grain yield (g m^{-2}) and vernalization score (0="winter", vernalization requiring genotypes; 8="spring", non-vernalization requiring genotypes) for WFSYT92 entries. Under supplementally irrigated conditions, little difference is noted between grain yield and vernalization requirement (Fig. 17). Genotypes that have a vernalization requirement, however, appear to be better adapted to conditions of increased stress (Fig. 18).

Five hundred forty six facultative and winter wheat advanced lines (FBW AL92)--hitherto selected in previous years on phenotypic appearance, relative performance and frost tolerance--and checks were grown in a replicated yield trial (supplementally irrigated) and non-replicated yield trial (rainfed) at Tel Hadya in 1992. This germplasm was also sown in a summer planting at Tel Hadya, is hot conditions, to screen for (lack of) vernalization response.

Table 76. Tel Hadya derived FBW 1FAWWON entries screened for response to lack of vernalization under high minimum temperature summer planted field conditions, in hill plots planted on July 1, 1992, at Tel Hadya. Where 0=Vegetative, 1=Tiller elongation, 2=Booting, 3=Heading, and 4=Past anthesis developmental stages.

		Date observed				
ENTRY		07.IX	21.IX	05.X	18.X	Vrn requirement
101	BEZOSTAYA	0	0	0	0	High
102	SERI82	2	3	4	4	Low
103	BOLAL	0	0	0	0	High
104	GEREK79	0	0	2	3	Facultative
105	ATAY85	0	0	0	0	High
97	ICWH-	4	4	4	4	
98	ICWH-	0	0	0	0	
99	ICWH-	3	3	4	4	
106	ICWH-	4	4	4	4	
107	ICWH-	4	4	4	4	
108	ICWH-	2	3	4	4	
109	ICWH-	1	3	4	4	
110	ICWH-	0	0	0	0	
111	ICWH-	2	3	4	4	
112	ICWH-	2	3	4	4	
113	ICWH-	2	3	4	4	
114	ICWH-	3	3	4	4	
120	BEZOSTAYA	0	0	0	0	
121	ICWH-	3	3	4	4	
122	ICWH-	2	3	4	4	
123	ICWH-	2	2	4	4	
124	ICWH-	3	3	4	4	
125	ICWH-	0	0	1	3	
126	ICWH-	0	0	3	3	
127	ICWH-	0	0	2	3	
128	ICWH-	0	0	2	3	
129	ICWH-	0	0	0	0	
130	ICWH-	0	0	0	0	
131	ICWH-	0	2	3	4	
132	ICWH-	3	3	4	4	
133	ICWH-	0	0	0	2	
134	ICWH-	0	0	3	4	
135	ICWH-	0	0	2	4	
140	SERI82	2	3	4	4	

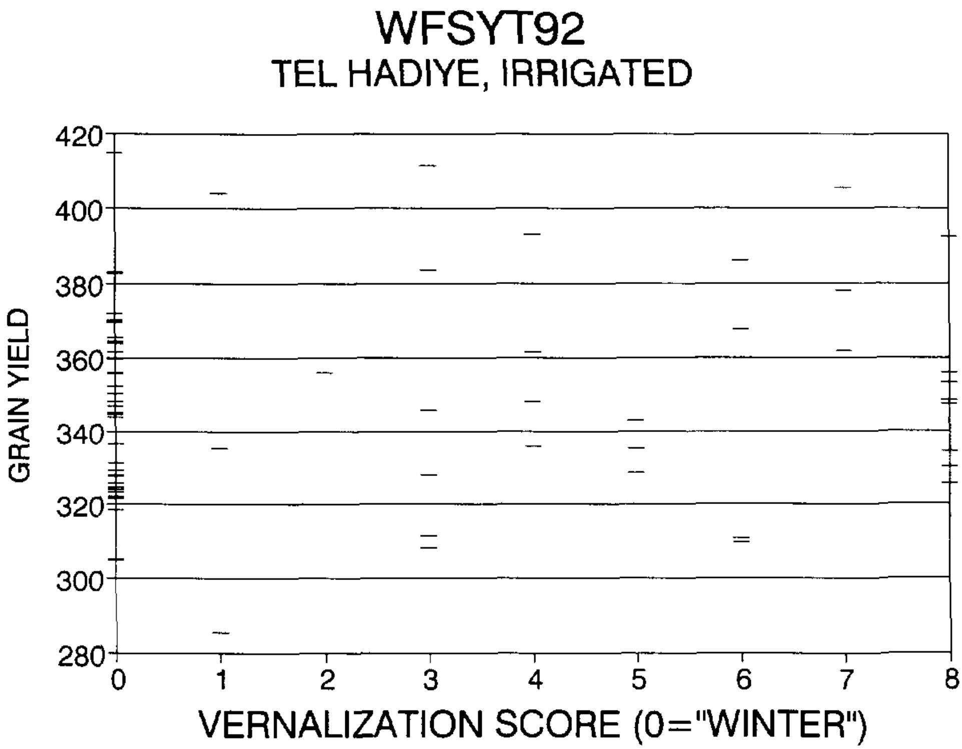

Fig. 17. Association between grain yield (g m^{-2}) and vernalization score (0=strong vernalization requirement, "winter" type) for 72 bread wheat entries grown in the Winter Facultative Spring Wheat Yield Trial, 1992 at Tel Hadya, Syria under supplementally irrigated field condition.

The FBW AL92 represented a diverse range in response to vernalization with nearly 25% categorized as low vernalization requiring genotypes. Figures 19 and 20 represent the association between grain yield (g m^{-2}) and vernalization score for the top 10% of FBW AL92 entries. Under supplementally irrigated conditions, little difference is noted between grain yield and vernalization requirement (Fig. 19), though one "facultative" and one "spring" genotype were superior performers. Genotypes that have a vernalization requirement, however, appear to have an advantage in conditions of increased stress (Fig. 20).

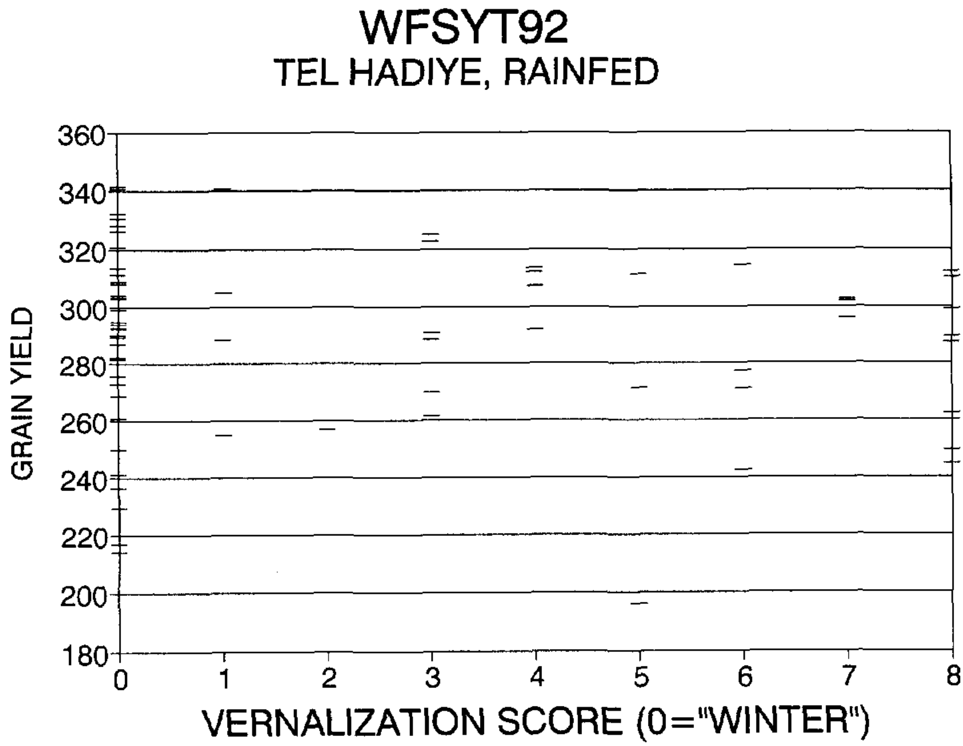

Fig. 18. Association between grain yield (g m^{-2}) and vernalization score (0=strong vernalization requirement, "winter" type) for 72 bread wheat entries grown in the Winter, Facultative, Spring Wheat Yield Trial, 1992 at Tel Hadya, Syria under rainfed field condition.

Categorical definition of an "ideal" genotype fit for an environment is difficult, if not impossible, to make, particularly in transitional environments. Future research will move away from inter-varietal comparisons, and toward assessing the affect on performance and adaptation of distinct genes controlling various aspects of genotype adaptation and performance (e.g., micronutrient tolerance or efficiency, nematode resistance, plant height, vernalization, or photoperiod). Through this research, it is our ultimate goal to define better the complex agronomic constraints, and breeding objectives, prevailing throughout WANA, "drought" and "winter hardiness". - **T.S. Payne**

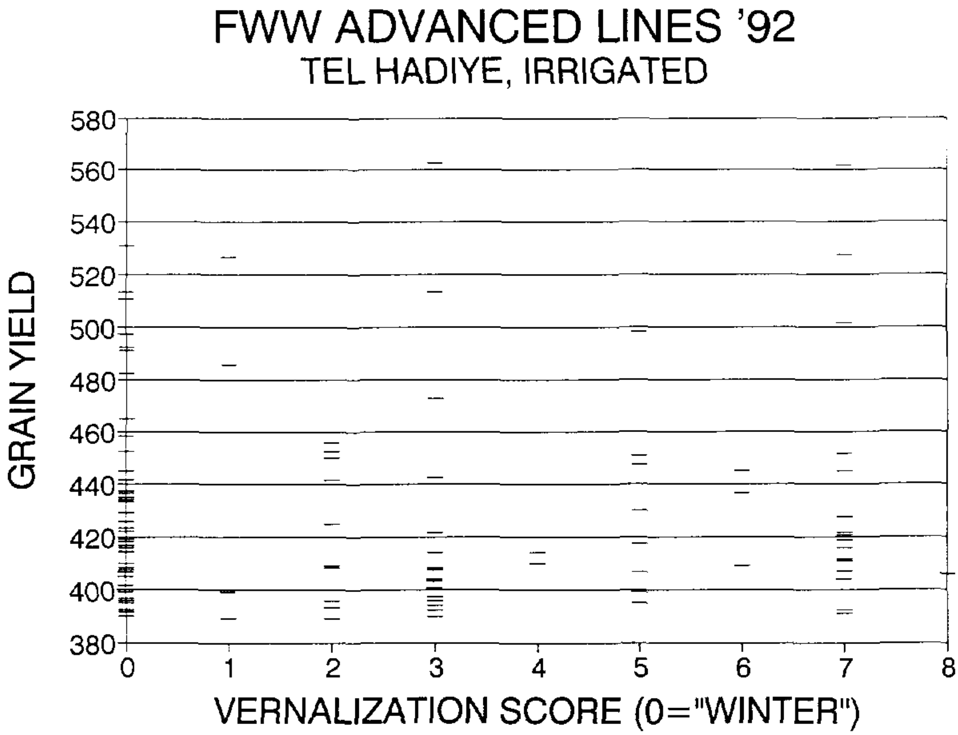

Fig. 19. Association between grain yield (g m^{-2}) and vernalization score (0=strong vernalization requirement, "winter" type) for the top 10% yielding bread wheat entries grown in the Facultative and Facultative and Winter Wheat Advanced Lines, 1992 at Tel Hadya, Syria under supplementally irrigated field condition. (Note: FBW Advanced Lines '92 contained 546 entries, 137 of which were classified with a vernalization score of 7 or 8).

6.6. Facultative Bread Wheat

6.6.1. Sunn Pest Integrated Pest Management

A joint FAO/ICARDA fact-finding mission was conducted in the spring of 1992 to assess the need for, government interest in, and potential for success of a regional integrated pest management (IPM) project on sunn pest. The mission was organized in Syria, Turkey,

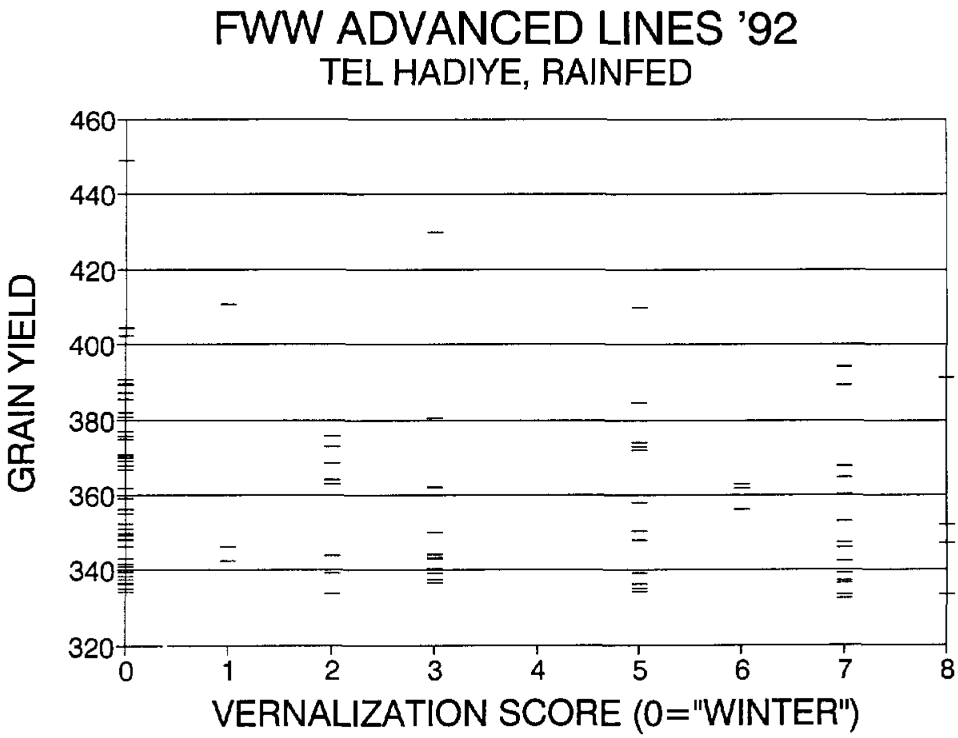

Fig. 20. Association between grain yield (g $^{-2}$) and vernalization score (0=strong vernalization requirement, "winter"type) for the top 10% yielding bread wheat entries grown in the Facultative and Winter Wheat Advanced Lines, 1992 at Tel Hadya, Syria under rainfed field condition.

and Iran in response to requests from national programs to FAO for help with sunn pest control, and to ICARDA for research activities dealing with sunn pest. Ministry officials from the institutes responsible for pest control and agricultural research, and university staff involved in sunn pest research were consulted in each country.

The history and present methodology of sunn pest control in each country follows a common thread. In the 1950's and 1960's FAO organized several working groups on sunn pest in the region. These groups met several times to discuss the impact and methods of controlling sunn pest. Control projects based on cultural techniques and biological control were initiated in several countries and met with some success. In the mid-1960's effective chemical pesticides were developed and targeted for use on sunn pest. These chemicals were so effective that interest waned in alternative control techniques. Extensive spray programs were developed for sunn pest in Turkey and Iran, technology which was later adopted by other countries in the region including Syria. A negative side effect was that research on nonchemical methods virtually ceased in all sunn pest affected areas, a condition which persists to this day.

The governments of Syria, Turkey, and Iran assume responsibility for controlling sunn pest, as they feel it is beyond the means of the private sector and individual farmers. As a result farmers have little input into sunn pest controls applied to their own fields. Additionally, there is little attempt to monitor the overall cost of sunn pest control. Each pest control group is cognizant of the amount spent on its particular activity, such as the cost of renting spray aircraft, for example, but many "hidden" costs are not accounted for. These hidden costs primarily include labor and maintenance expenses and contribute to the perception that sunn pest control is inexpensive.

We estimate that the total annual outlay for sunn pest control in these three countries is about $250,000,000 US, based on current market prices for chemicals and the amount of labor and equipment needed.

In some cases government policy promotes the use of pesticides over alternative control methods. In Turkey, for example, the chemical industry itself conducts efficacy trials within the country, bearing all associated expenses. The government then uses these data to determine whether or not to approve the compound for use.

Another "hidden cost' encountered was the lack of monitoring of the effect of pesticides on the environment and on the health of those living in treated areas or engaged in pesticide application.

In all countries, ministry officials were supportive of the idea of reducing dependency on chemical pesticides to control sunn pest, and were generally surprised at the amount the current control programs were costing their countries, both environmentally and economically. The successful control of sunn pest over the past 10 or so years by chemical sprays has lead to complacency among pest managers, and has perhaps contributed to the under funding and dismantling of research institutes and projects that could provide cheaper, more effective, and safer sunn pest control.

The mission concluded that sunn pest IPM could significantly reduce pest control outlays in wheat and barley, protect the environment and health of the regions inhabitants, and contribute to the sustainability of wheat and barley in WANA. Potential sunn pest management techniques include enhancing natural enemies, using double tier harvesting, improving scouting and application methods, and employing other cultural control techniques. Towards this end an expert consultancy has been planned for the spring of 1993 where government designated experts from interested countries will discuss the sunn pest problem and formulate strategies to resolve it. - **R.H. Miller**

7. Collaborative Research

7.1. Maghreb Region Program Report

7.1.1. Introduction

The activities reported here were carried out primarily by national program scientists assisted by ICARDA scientists based in both North Africa and at base. Algeria and Libya received most support and collaborative selection, survey and training activities took place primarily in these countries. Training opportunities at Aleppo also were aimed at these two countries. This is to increase the strength of these programs to the level of those in Morocco and Tunisia. Collaborative research activities were varied. Together Maghreb scientists carried out wheat and barley disease and insect surveys and trained staff.

7.1.2. Production Conditions

The climatic conditions of the 1991-1992 crop season were favorable in eastern North Africa. Rainfall was generally above average and well distributed. Temperatures were favorable for cereals growth except in February, when temperatures were above average. In Tunisia, production exceeded two million tons despite unfavorable weather conditions in central and southern areas. Yields in Northern Tunisia were as high as those of the previous year's record crop. In Libya barley was predominant and covered some 80% of the cereal acreage. Weather was favorable in Eastern Jabal Akdar region but average elsewhere.

In western Algeria and Morocco, temperatures and rainfall were unfavorable to cereal production . An early drought (November to March) was followed by heavy rains (April and May). Total crop losses occurred even in high rainfall areas. Production of all cereals in Morocco fell from 8.5 million tons in 1990/91 (a record), to 2.2 million tons (the lowest level in 45 years). Production in

Algeria (3.5 million tons) was similar to the previous season, despite drought in parts of the country. Lack of rain in some areas was compensated for by improved agronomic practices mainly in the eastern regions.

7.1.3. Regional Cooperation: Breeding Activities

Table 77 shows the types of nursery and their distribution in N.Africa. Table 78 lists the promising genotypes identified for further testing from the nurseries by country and Table 79 lists varieties released by the national programmes. Table 80 shows the diseases identified by surveys as important in 1991/92 by country and Table 81 lists new sources of resistance to diseases. These five tables summarize the regional breeding activities in North Africa.

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

Country/ Site	Nursery(1)						
	POM			H.F.	Sept.	CDMN	BYDV
	B	D	W				
Algeria							
Khroub	X	X	X	X	X	X	X
SB Abbes	X		X			X	
Tiaret							
Setif		X					
Guelma					X	X	
El Harrach					X	X	X
Oued Smar					X	X	
Libya							
EL Marj				X	X	X	
Misrata	X	X	X				
Zahra		X					
Azizie	X		X			X	X
Morocco							
Marchouch	X	X	X		X	X	X
J.Shaim	X	X	X	X		X	X
Tassaout	X	X	X	X		X	X
Douyet	X	X	X		X	X	
Annaceur	X	X	X			X	X
Tunisia							
Beja	X		X	X	X	X	
Kef	X			X	X	X	
INAT LAB				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 supported by the UNDP project. CDNN (Cereal Disease Monitoring Nursery) nursery monitors pathogen virulence changes in priority wheat and barley diseases. It was also grown at ICARDA Tel Hadya, in Syria. B = Barley, D = Durum, W = Wheat.

Table 78. Promising genotypes[1] identified in North Africa from regional trials in 1991/92.

	Barley	Durum wheat	Bread wheat
Algeria	Soufara Begoha Badia DA106/DL//ST205	Win"S"/USA"S" Chen"s"/Altar 82 FG/Pale85/129C OM-RABI 17 BELIKH	Seri 82 Pun"S"/Prl"S" Seri 82 Yaco/Junco Pun"S"/Prl"S" Trt"S"/Gh"S" Vee"S"
Libya	C-BYT 1 2 BON-LRA 1 1 BSNNA 1 347 BYT-ACSAD 1 10	Zahera 3 Zahera 5 Zahera 1 RDYT 1 16 ADYT 1 22	Bohoth 202 Misurata II Misurata VI Germa Zahera IV Zahera VIII Zahera II Misurata VIII Bohoth 106 AWYT 1 106 WON-LRA 1 33
Tunisia	BYT-MRA:1-2-4 5-11-16-21 BYT-LRA-cold 1-5-7 BYT-LRA: 1-3-18-22-23	F3 (Sel.Eth.135-85)/2Dz STN"S"/3/TEZ"S"/YAV79/HUI"S"	BOW"S"/IMU SOUDAN#3 MAYA"S"/SAP"S"
Morocco	BON-LRA (COOL): 10-27-48 BSNNA: 75-124 129-139 166-264 288-297 329-339	RDYT-HAA:103-124 DON-HAA:34-41-50	WYT-MRA: 103-109-111-114- WYT-LRA: 104-108-117-118-119 WON-MRA: 1-2-24-56-73-85-217-238-244-248-259

[1] Are considered promising genotypes among selected entries, those lines identified as valuable parental material, or for direct advanced testing.

Table 79. Varieties released by national programmes in 1991/92.

Country	Barley	Durum	Bread Wheat
Algeria[1]	BADIA		NESSER ZIDENE
Libya	WADI KUF WADI GATTARA		
Tunisia	MANEL 92	KHIAR 92	VAGA 92
Morocco[2]	TWO LINES	TWO LINES	TWO LINES

1 Official variety registration catalog is being established in Algeria where more than 10 varieties per crop species are awaiting registration.

2 Six lines, two of each for barley, bread wheat and durum wheat, already registered in the Morocco Varietal Catalog, will be officially released to farmers after two years of extensive testing in farmers fields.

Table 80. Major diseases by country in the 1991/92 growing season.

	Disease and Pests																
	LR	SR	YR	ST	PM	NB	SC	BL	BYDV	CB	TS	LS	CS	FS	CR	FR	HF
Algeria																	
Barley								X				X	X				
Durum			X	X						X	X						
Bread wheat			X	X						X	X						
Libya																	
Barley									X								
Durum										X	X						
Bread wheat										X	X						
Morocco																	
Barley					X		X		X	X		X	X				X
Durum				X							X				X	X	X
Bread wheat				X							X				X	X	X
Tunisia																	
Barley					X	X						X	X				
Durum				X						X					X	X	
Bread wheat				X						X					X	X	X

LR = leaf rust; SR = stem rust; YR = yellow rust; ST = septoria tritici; PM = powdery mildew; NB = net blotch; SC = scald; BL = barley leafstripe; CB = common bunt; TS = tan spot; LS = loose smut; CS = covered smut; FS = flag smut; CR = common root rot (C. sativus); FR = foot rot (Fusarium); HF = hessian fly.

Table 81. New sources of resistance.

Crop species	Disease	Source of resistance
Barley	NB	- H83-194 RA3 # 41
	BYDV	- 8-81 BQEB-10
		- M64.76/BON//YORK/3/M5/GALT.NK272
		- LIGNEE 527/A54(BKL89-278)
		- UC 76252/NK 71
		- GIZA 121/PUE.
	PM	- CI16155
Durum	H. fly	- H_{22} and H_{23}: from T. Tauschii
	BYDV	- STK/4/JO/3/JO/Cr/CIT 71
		- YAV 79/12.IDSN 227
Bread wheat	ST	- BYRSA
		- IAS 20
		- RPB 709.71/COC
	BYDV	- CN 079*2/PRL "S"
		- ANB "S"/YACO "S"
		- IAS 20
		- SWM 12686
	H. fly	- NS 732/HER

Other Activities:

Cereal Travelling Workshop

Scientists from Algeria, Libya, Morocco, Tunisia, CIMMYT and ICARDA participated in the 1992 cereals travelling workshop held in Algeria, May 16-21, 1992. Participants selected material at Guelma, EL Khroub, Setif, Tiaret, Saida and Sidi Bel Abbes stations and discussed inter-Maghreb cooperation. It was a good training opportunity for junior staff. Joint Maghreb Trials for variety and site characterization were planned for 1992-1993 season.

7.1.4. Training

Regional expertise was used in training throughout the region and included: selection, disease and insect screening, inoculum preservation, note taking and data collection. The cereal program encourages mutual scientific support, self reliance and devolution of responsibilities to NARS to exploit their expertise for regional and international benefit. In cooperation with ICARDA, Moroccan, Tunisian and Algerian scientists trained large numbers of junior staff from all Maghreb countries in diseases identification and screening at ESAK-KEF in Tunisia and on cereal breeding techniques at El Khroub, Algeria. Various intensive, specialized courses were also run. These included evaluation of hessian fly resistance (Morocco), isolation, evaluation and multiplication of barley powdery mildew (Tunisia).

7.1.5. Virulence studies

Virulence studies and development of screening techniques occurred for physiological races in *Septoria tritici* (Tunisia), net blotch (Tunisia), powdery mildew (Tunisia) and yellow rust (Tunisia), the gall causing fly attacking barley was identified as *Mayetiola hordei* Keiffer (Morocco). It is called Barley Gall Midge. Techniques for evaluating and screening for root rot and tan spot resistance are being developed (Morocco).

7.1.6. Others

The dual purpose use of barley as a grazing and grain crop was demonstrated on large scale in farmers fields (Morocco).

If only one supplementary irrigation is possible, it is more beneficial if applied at tillering rather than at other growth stages (Morocco).

It was shown that up to 30% barley grain can be mixed with bread wheat for bread making and two row pearled barley can be used as a rice substitute (Morocco).

Assistance was given in on-farm agronomic trials (Algeria, Morocco). - **M.S. Mekni**

8. Training and Visits

In 1992, CP in collaboration with other ICARDA Programs and NARS in WANA have conducted 5 group courses and individual training at headquarters and two short courses in the region. The decrease in total number of participants (113 versus 145 in 1991 and 147 in 1990) reflects the Center's strategy on priorities and resource allocation to germplasm enhancement activities as described in the MTP.

8.1. Training at Headquarters

There were 77 participants in training activities conducted at Tel Hadya (Table 82). The large number of trainees from Syria, the host country, is largely due to two short courses requested by NARS in this country.

While the long-term course covers breeding and several related disciplines, the other courses are highly specialized. Participants in the DNA course were senior researchers or university professors. In other courses, they generally have the BSc level. There is still a large demand for the insect control and the DNA courses both of which will be offered the coming season. Details on course contents are found in respective course brochures and CP Annual Report for 1991.

Individual non-degree training was offered to young researchers in the areas of breeding, pathology, entomology and biotechnology. Most of these trainees conducted a small research project under the supervision of ICARDA scientists. This appears as the most effective way of imparting training to young researchers from NARS, and will be emphasized in the future, with a better balance among requesting NARS. Five students, supported by CP graduated in 1992, and 7 others started or continued PhD or MSc research at ICARDA with financial support from ICARDA (3 students) or other sources (4 students).

Research topics included cereal breeding, pathology, and physiology.

Table 82. Number of participants in cereal courses conducted at Tel Hadya, 1992.

Country	Course*							Total
	LTC	B&C	DDS	INS	DNA	IND	IDG	
Algeria	1			1	1		1	4
China	2				1			3
Colombia					1			1
Cyprus					1			1
Egypt						2	1	3
Ethiopia				1			1	2
India					2			2
Iran		4		2	1			7
Jordan			1		1			2
Lebanon			1	1	1			3
Libya		1		1				2
Morocco				1	1			2
Netherlands							1	1
Oman			2					2
Pakistan	1		1	1				3
Sudan				1	1	1	1	4
Syria	2	6	5	1	4	7	2	27
Tunisia	1			1		1		3
Turkey	1			2	1			4
Yemen			1					1
Total	13	6	11	13	16	11	7	77

LTC = long-term course on cereal improvement; B&C = application of biometrical methods and computers in agricultural research; DDS = cereal diseases: diagnosis and scoring; INS = insect control in legumes and cereal crops; DNA = DNA molecular markers techniques for germplasm evaluation and crop improvement; IND = individual non-degree training; IDG = individual degree training.

8.2. Training in the Region

Two courses were conducted in North Africa (Table 83) in collaboration with NARS in this region. The first course focussed on field handling of cereal research experiments (including disease and insect scoring, hybridization, and selection) and the second course - implemented by CBSU and NARS, Tunisia- dealt with experimental design and data analysis.

Table 83. Number of participants in cereal courses conducted in the Region, 1992.

Country	Course*		Total
	CIT	DAE	
Algeria	19	2	21
Libya	2	1	3
Morocco	2	3	5
Tunisia		7	7
Total	23	13	36

CIT = Cereal improvement techniques, Khroub, Algeria.
DAE = Design and analysis of experiments for variety trials, Tunis, Tunisia.

8.3. Visits, Meetings, and Workshops

CP scientists visited NARS in WANA and other countries to observe germplasm and discuss collaborative work. A change in CP breeding strategy was proposed to NARS in North Africa in a move to decentralize breeding and test early-generation germplasm in the target environment rather than northern Syria. The proposal was accepted and will be further discussed with NARS for implementation in the coming season.

In 1992, around 70 scientists from within and outside WANA visited the Program for mutual consultation, exchange of information, selecting germplasm, discussing joint projects etc.

A large number (161) of students and researchers from Syria came for a one day visit to the Program as part of tour of ICARDA's facilities and on-going research and training activities.

8.4. Training Strategy

The review of CP training activities of the last decade showed differences among countries for their training needs and a gradual shift of these needs. The steady improvement of cereal research capabilities in some countries is attributed to increased country commitment to staff education and to a fruitful partnership in research with regional and international organizations. While certain NARS now provide hands-on training to their junior staff, others still want to send some of their staff to ICARDA for long-term training. Although such needs are recognized by CP, the prioritization of research and training activities within the CGIAR (more work on resource management and less on germplasm enhancement) will mean less emphasis on the long-term training course in the future.

With respect to short courses, some are requested on a regular basis and will be offered in the region wherever feasible (e.g. disease methodology). Other courses, (e.g. DNA markers techniques) of more a sophisticated nature, and requiring specific equipment are not always available in the region. These will continue to be held at headquarters. Training workshops will be strengthened and may be held at headquarters and in the region. Individualized training, will emphasize initiation to research project planning and implementation with supervision by ICARDA scientists. The Cereal Program will therefore decrease its training of research technicians and assistants and emphasize senior level training. - **H. Ketata**

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10. Cereal Varieties Released By National Programs.

Country	Year of release	Variety
Barley		
Algeria	1987	Harmal
	1992	Badia
Australia	1989	Yagan
	1991	High
Bolivia	1991	Kantuta
Brazil	1989	Acumai
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)
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
	1987	Frontier 87
Peru	1987	Una 87
	1987	Nana
	1989	Bellavista
Portugal	1982	Sereia
	1983	CE 8302

Country	Year of release	Variety
Barley		
Portugal	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
	1988	Cham1=Maru
	1988	N-432=Amra

Country	Year of release	Variety
Durum wheat		
Jordan	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	Omrab 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
	1992	Omrab 3
	1992	Lahn
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

Country	Year of release	Variety
Bread wheat		
Algeria	1992	ACSAD 59=40DNA
	1992	Cham 4=Sidi Okba
	1992	Siete Cerros=Rhumel
	1992	Alondra=21AD
	1992	DouggaXBJ=Soummam
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

Country	Year of release	Variety
Bread wheat		
Syria	1984	Cham 2
	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

11. Staff List

Dr. John Hamblin	Program Leader
Dr. Salvatore Ceccarelli	Spring Barley Breeder
Dr. Habib Ketata	Senior Training Scientist/ Breeder
Dr. Omar Farouk Mamluk	Cereal Pathologist
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[1]	Biotechnologist
Dr. Guillermo Ortiz-Ferrara	Bread Wheat Breeder (CIMMYT-Liaison)
Dr. Miloudi Nachit	Durum Wheat Breeder (CIMMYT-Liaison)
Dr. Thomas Stewart Payne	Winter Wheat Breeder (CIMMYT)
Dr. Mohamed Saleh Mekni	Cereal Scientist (North Africa)
Dr. Hugo Vivar	Barley Breeder (Mexico)
Dr. Stefania Grando	Barley Research Scientist (Special Project)
Mr. Issam Naji	Agronomist
Dr. Sui Kwong Yau	International Nurseries Scientist
Dr. Hala Toubia-Rahme[2]	Post-Doctoral Fellow Barley Pathology/Breeding
Dr. Abdullah Dakheel	Consultant - Physiology
Mr. Alfredo Impiglia	Durum Research Associate (Special Project)
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Mr. Abdel Jawad Sabouni	Training Assistant
Mr. Antoine Pierre Asbati	Research Assistant-II
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Mr. Adonis Kourieh	Research Assistant-II
Mr. Michael Michael	Research Assistant-II

Mr. Mohamed Mushref	Research Assistant-II
Mr. Munzer Naimi	Research Assistant-II
Mr. Henri Pashayani	Research Assistant-II
Mr. Riad Saccal	Research Assistant-II
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Mr. Mazen Jarrah	Research Assistant-I
Mr. George Kashour	Research Assistant-I
Mr. Haitham Kayali	Research Assistant-I
Mrs. Anette Sayegh[3]	Research Assistant-I
Mrs. Sonia Sultan[4]	Research Assistant-I
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Mr. Ziad Alamdar	Senior Research Technician-I
Mr. Mohamed Azrak	Senior Research Technician-I
Mr. Adnan Ayyan	Senior Research Technician-I
Mr. Omar Muhandess	Senior Research Technician-I
Mr. Zuhair Murad	Senior Research Technician-I
Mrs. Suzan Khawatmi	Senior Research Technician-I
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Mr. Bassam Shammo	Research Technician-II
Mr. Mohamed Tarakji	Research Technician-II
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Mr. Salem Farrouh	Research Technician-I
Mr. Riad Lutfi	Research Technician-I
Mr. Mohamed Mosbahi	Research Technician-I (Tunis)
Mr. Fahd Rahmani[6]	Research Technician
Ms. Nadia Fadel	Research Technician
Mr. Ghassan Haj Mousa	Research Technician
Mr. Malek Korani	Research Technician
Mr. Ziad Owaira	Research Technician
Mr. Ala'a Yaljarouka	Research Technician
Mr. Asaad Ahmed El-Jasem	Labour Foreman-II

Mr. Abdalla Steif Abdalla	Assistant Technician
Mr. Obeid El-Jasem	Farm Labourer
Mr. Hasan El-Khatib	Assistant Research Technician (Terbol)
Mr. Michael Abu Nakad	Assistant Research Technician (Terbol)
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Ms. Samira Maksoud	Secretary
Ms. Najla Nakeshbandi[7]	Secretary
Ms. Sossi Toutounji	Secretary
Ms. Raghad Rahwan[8]	Secretary

Research Fellows:

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Ms. Antonella Grillo[9]	Barley Improvement (Perugia)
Mr. Rudi Petti	Barley Improvement (Perugia)
Ms. Aaika Mihamou[10]	Biotechnology (Paris)

Students:

Mr. Farid Makdis
Mr. Ghassan Na'ase
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Mr. Amir Mohamed Hussein
Mr. Belay Simane
Mr. Mohsen Shehata

Visiting Scientists:

Dr. Mousa Guirgis Mosaad[11]	Visiting Scientist
Dr. V. Mahalakshmi[12]	IARC Visiting Scientist

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[2] Joined the Program as Post Doctoral Fellow, November 1992
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[4] Left the Program, June 1992
[5] Joined the Program, November 1992
[6] Left the Program, October 1992
[7] Left the Program, April 1992
[8] Joined the Program, June 1992
[9] Left the Program, April 1992
[10] Left the Program, April 1992
[11] Joined the Program as Visiting Scientist, July 1992
[12] Joined the Program as Visiting Scientist, January 1992

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