CEREAL IMPROVEMENT PROGRAM

Annual Report for 1991

ICARDA

Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is governed by an independent Board of Trustees. Based at Aleppo, Syria, it is one of 16 centers supported by the Consultative Group on International Agricultural Research (CGIAR), which is an international group of representatives of donor agencies, eminent agricultural scientists, and institutional administrators from developed and developing countries who guide and support its work.

The 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.

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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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TABLE OF CONTENTS

1. INTRODUCTION

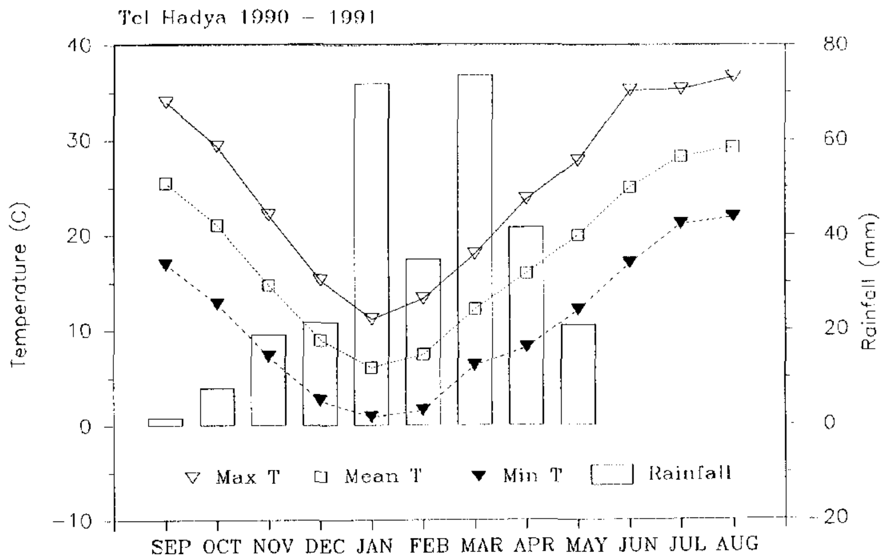
In 1990/91 North Africa and Turkey had excellent seasons and most of the rest of the region had an average season. In Syria there was a very dry February and early March but this was followed by good spring rains in late March and April (Figure 1) also the winter was milder than the previous year, which made screening for cold tolerance in the field difficult, however diseases screening opportunities were often excellent.

As an increasing number of NARS strengthen their human resources in cereal breeding so the focus of the programme is gradually shifting to earlier generation and stress tolerance nurseries. At the same time we are still maintaining advanced nurseries that are generated from the base programme. However we are concerned that by delaying sending out selections until late generations we may be throwing the baby out with the bath water.

The programme is currently reporting in five projects, these are spring and facultative/winter barley, durum wheat, spring and facultative/winter wheats. This report is organized on these lines. As the CIMMYT/ICARDA wheat breeding projects and their technical support are rationalized this may change. We are strengthening barley and wheat breeding efforts in Highland areas and this is expected to continue.

Finally, I would like to thank the NARS scientists and administrators for their contributions which are the mainstay of the Cereal Programme's effort, their efforts on our behalf cannot be over-emphasized. Also thanks are due to Ms. Samira Maksoud for her work in the preparation of the document. If any reader requires further information they should contact the scientists named at the end of each section.

John Hamblin



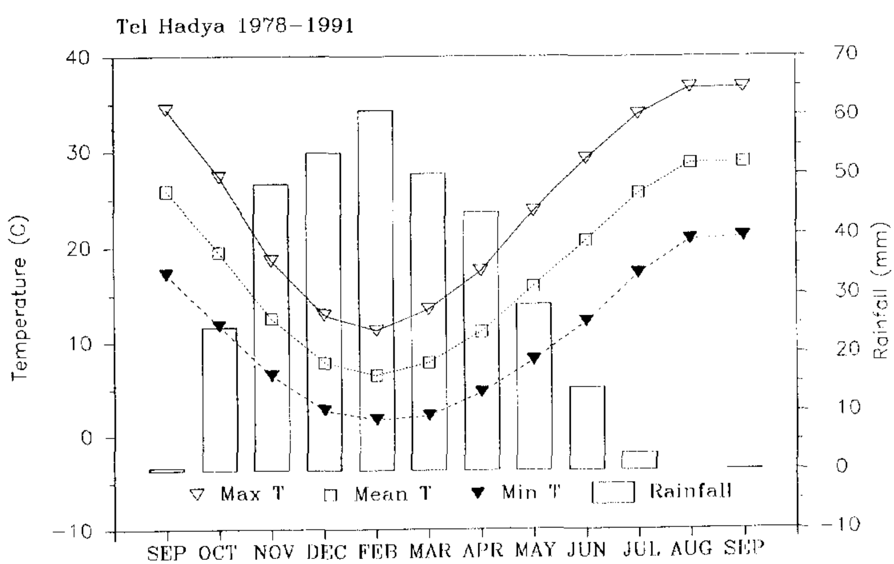


Figure 1. Monthly rainfall and temperature averages at Tel Hadya for the 1990/91 season and from 1978 through 1991.

2. SPRING BARLEY IMPROVEMENT

2.1. Spring Barley Breeding

2.1.1. Introduction

The barley improvement project aims to assist National Program scientists, to increase barley production in WANA.

Barley is grown on about 17 million hectares in developing countries. Growing conditions vary from favorable, including some irrigated areas, to extremely unfavorable. Compared with the other two ICARDA cereal crops, bread and durum wheat, the majority of barley in developing countries is grown in more difficult, lower yielding environments.

The major use of barley is animal feed. However there is renewed interest in using the crop as human food (North Africa) and a growing interest in malting (China).

The major activities of the project are 1) germplasm enhancement, using different approaches and types of germplasm depending on agroclimatic environment and use of the crop, and 2) training of national scientists.

For the last six years comparison of newly developed barley germplasm in contrasting environments, using experimental sites in northern Syria, Lebanon and Cyprus, has been one of the most important activities of the project. This has addressed the question of whether selection for unfavorable conditions should be conducted in favorable or unfavorable conditions. The results indicate that to increase grain yield of barley in unfavorable conditions selection must be conducted in those conditions (Ceccarelli, 1987, 1989; Ceccarelli and Grando, 1989, 1991; Simmonds 1991). Selection can be improved further by using locally adapted germplasm (Ceccarelli and Grando, 1989, 1991). Here we present additional supporting evidence.

Specific adaptation implies that a strong, centralized barley breeding program, where most of the selection is done in one type of stress environment, is difficult to justify. Although segregating populations are distributed in international nurseries, they represent a small fraction of the segregating material available in the program. The majority of germplasm distributed in international nurseries for testing by national programs are fixed lines that have been selected repeatedly in a restricted range of environmental conditions. A more efficient approach may be to conduct selection within countries on segregating materials generated by local scientists. This is expected to have two advantages: 1) increased selection efficiency and a better tailoring of the germplasm to the specific needs of different farming systems, and 2) the strengthening of national barley breeding programs by working in close association with regional scientists. The promotion of self-reliant national breeding programs is essential in fulfilling the mandate of an International Center and is the main objective of the barley improvement project during the next years.

S. Ceccarelli

2.1.2. Achievements in 1990/91

The 1990/91 cropping season in northern Syria was characterized by mild winter temperatures and lower rainfall than average. At Tel Hadya the crop was damaged shortly before harvesting by a hail storm which made it impossible to use yield data from the main station. Therefore we have utilized data from activities conducted in a number of countries and extracted more information from data obtained previously.

The most important achievements in 1990/91, many due to national program scientists, were:

1. Rihane-03 performed well in Morocco, Tunisia and Algeria in a

year with above average rainfall. Named Resana, it was released in Spain: 200 tonnes of certified seed will be produced in 1992.

2. Arta, a pure line selection from the Syrian landrace Arabi Abiad, ranked first for the third consecutive year in the on farm verification trials in Syria (Table 1). It outyielded the two barley landraces by about 11% ($P < 0.05$) as average of three years and one of the most recently released varieties in Syria (Furat 2) by about 12% in 1991.

Table 1. Grain yield (GY) in kg/ha and rank (R) of Arta, a pure line selection from Arabi Abiad, in the on farm verification trials in Syria during the last three cropping seasons. Data are means of 5, 9 and 10 locations in 1988/89, 1989/90 and 1990/91, respectively.

LINE	1988/89		1989/90		1990/91		MEAN
	GY	R	GY	R	GY	R	
ARTA	1814	1	1962	1	2341	1	2039
A.ABIAD	1530	3	1747	8	2229	2	1835
A.ASWAD	1640	2	1855	3	1975	10	1823
FURAT 1					1968	11	
FURAT 2					2086	8	

3. Tadmor, WI 2291 and the local landrace Arabi Aswad have been evaluated in the absence and presence of inputs in Syria as part of the activities of the Mashreq project. On average they outyielded A. Aswad by 15% and 20% in absence of fertilizer, and by 28% and 36% in presence of fertilizer (Table 2).

Table 2. Average grain yield (kg/ha) in 1989/90 (four locations) and in 1990/91 (two locations), and average yield advantage over Arabi Aswad of Tadmor and WI 2291 with and without fertilizer (average plot size = 0.1 ha).(Modified from Mashreq project reports for 1990 and 1991)

LINE	NO FERTILIZER		% OVER A.ASWAD	WITH FERTILIZER[a]		% OVER A.ASWAD
	1990	1991		1990	1991	
TADMOR	237	675	+15.5	362	884	+27.9
WI 2291	199	873	+20.3	312	1112	+36.5
A. ASWAD	185	656		254	781	

[a] 25 kg/ha urea and 100 kg/ha superphosphate

4. Arabi Abiad and Arta have shown good adaptation in the highlands of Balochistan (Pakistan). They outyielded the local check for grain but not in total biological yield (Table 3). A. Abiad also has nutritive advantages compared to the local check (Table 4).

Table 3. Average grain yield (kg/ha), total biological yield and harvest index of Arta, Arabi Abiad, and the local check in four environments of Balochistan Highlands (Pakistan). (Modified from Ahmad et al., 1990).

LINE	GRAIN YIELD	BIOLOGICAL YIELD	HARVEST INDEX %
ARTA	1525	5718	27
A.ABIAD	1465	5633	25
LOCAL	1185	6685	21

5. Arta, Harmal and one pure line selection from a jordanian landrace (JLB 6-38) performed well as dual purpose barleys in Jordan over two cropping seasons (Table 5).

Table 4. Dry matter yield (DM in kg/ha), daily intake (DI in g) and daily liveweight gain (DGL in g) for Arabi Abiad, Frontier 87 and the local check at three maturity stages in Quetta. (Modified from Ahmad et al., 1990).

	STAGE	A. ABIAD	FRONTIER	LOCAL
	Preflowering	1280a	1198a	733b
DM	Flowering	2302a	2007a	993b
	Seed hardening	1956a	1844a	1638a
	Preflowering	288a	241b	250b
DI	Flowering	687a	512b	308b
	Seed hardening	459a	558a	491a
	Preflowering	5a	46a	-150b
DLG	Flowering	267a	103b	-6b
	Seed hardening	113a	106a	-13b

Table 5. Evaluation of ten barley genotypes for dual purpose in Jordan during 1989/90 and 1990/91. (Modified from Mashreq project reports for 1990 and 1991).

GENOTYPES	FORAGE PRODUCTION[a]		GRAIN YIELD		STRAW YIELD	
	1990	1991	1990	1991	1990	1991
Tunis 5	2005	532	211	280	1151	524
Rihane-03	1723	471	122	253	855	493
Emir/Apm/Ch/1905	1465	483	122	250	903	432
Wadi Hassa	2876	842	325	271	1393	447
WI 2291/20/F3 bulk	1904	421	311	178	958	406
Harmal	2730	688	335	291	1003	392
Arta	3258	546	295	273	1128	423
JLB 6-38	3150	755	447	344	1280	506
Tadmor	2415	672	129	334	968	531
Soufara	1417	-	97	-	561	-
Rum	-	433	-	162	-	262
Local	-	561	-	185	-	309

[a] Green matter in 1989/90 and dry matter in 1990/91

6. Two lines selected from ICARDA nurseries distributed in 1986/87 are in the prerelease stage as dual purpose varieties in Iraq.
7. The evaluation of barley landraces conducted by Ethiopian scientists in collaboration with ICARDA has identified one line (accession # 3357-10) which outyielded the local checks in two consecutive cropping seasons at three locations with low levels of inputs.
8. Nepalese scientists have collected and evaluated 313 local landraces (single heads and populations). Some were found to have partial resistance to yellow rust, one of the main yield limiting factors in that country.
9. The evaluation of advanced yield trials in Morocco has been resumed.
10. During 1990 we commenced making crosses to national programmes specifications. About 50 crosses were made for Morocco. A similar service, offered to Tunisia, was not utilized.
11. A special nursery consisting of 360 six row barley lines (F_4 and F_5) was distributed to Morocco, Algeria, Tunisia and Libya. These lines were not selected for yield in Syria and will be used to begin a specific selection program in north African countries. This work will be supported through a special project funded in 1991 by OPEC FUNDS FOR INTERNATIONAL DEVELOPMENT.

S. Ceccarelli and S. Grando

2.1.3. Performance of Barley Lines in International Trials

The international Regional Yield Trials represent the last level of yield testing before lines are either discarded, recycled as parents or selected by national scientists to be tested further. Lines promoted from Observation Nurseries (two rows plots, unreplicated) to Regional Yield Trials (6 rows plots, 2.5 m long, three replications) are usually evaluated for two cropping seasons unless performance in the first is unsatisfactory. Because of year to year variation, it is more useful to analyze the performance after the second year evaluation. Tables 6 and 7 show the results for the Regional Yield Trials 1988/89 and 1989/90 for low and moderate rainfall areas.

In the Regional Yield Trials for Low Rainfall Areas (Table 6) some lines had a higher grain yield and a better average rank than the national checks in a number of countries. For example 'Deir Alla 106//7028/2759' outyielded the national check in Jordan (3 out of 6 locations), in Tunisia (all 3 locations) and in Iran (all 3 locations). This is of particular interest because the national check varies from country to country and often between locations within countries. In Tunisia and Morocco the national checks are recently released varieties.

The results of the Regional Yield Trials for Moderate Rainfall Areas (Table 7) are similar. Some lines such as 'Comp.Cr. 229//As46/Pro', 'WI 2291/3/CI 03309/Attiki//Hja 33' and 'N-Acc 4000-59-80' outyielded the national checks in more than one country. In some of these countries (Cyprus, Tunisia, Morocco and Egypt) the checks were either recently released or recommended varieties.

Table 6. Performance of barley lines tested during two cropping seasons (1988/89 and 1989/90) in the Regional Yield Trials for Low Rainfall Areas.

COUNTRY[a]	LINE	MEAN YIELD (kg/ha)	MEAN RANK	TIMES > THAN NAT. CHECK
JORDAN (6)	Deir Alla 106//7028/2759	2324	8.7	3
	National check (Deir Alla 106, Rum)	2151	10.0	
ALGERIA (4)	Man/4/Bal.16/Pro//Apm/DW II-1Y/3/Api/CM67	2047	4.8	3
	Deir Alla 106//Mzq/DL71	2028	5.5	3
	National Check (Saida 183)	1779	11.0	
EGYPT (8)	Man/4/Bal.16/Pro//Apm/DW II-1Y/3/Api/CM67	2983	8.6	5
	National check (Giza 121,Giza 123,CC 89, Sahrawy)	2316	11.9	
TUNISIA (3)	Deir Alla 106//DL71/Strain 205	2748	2.7	3
	Deir Alla 106//7028/2759	2446	7.7	3
	National check (Rihane-03(2) Martin (1))	2381	9.3	
MOROCCO (6)	WI 2197/Cr.272-3-4	3956	5.0	6
	Comp.Cr.229//Bco.Mr./Dz. 02391	3706	8.0	5
	National check (Asni)	3400	15.3	
IRAN (3)	Deir Alla 106//7028/2759	3446	5.0	3
	Comp.Cr.229//Mzq/DL71	3432	7.7	2
	National check (Zarjo, Gorgan, Karoon)	3078	10.0	

[a] in parenthesis the number of year x location combinations

Table 7. Performance of barley lines tested during two cropping seasons (1988/89 and 1989/90) in the Regional Yield Trials for Moderate Rainfall Areas.

COUNTRY[a]	LINE	MEAN YIELD (kg/ha)	MEAN RANK	TIMES > THAN NAT. CHECK
CYPRUS (2)	Comp.Cr.229//As46/Pro	5862	5.5	2
	National check (Kantara, Mari/Aths*2)	5422	13.5	
ALGERIA (5)	CM67/Apro//Sv.02109/Mari	2782	8.0	3
	Comp.Cr.229//As46/Pro	2913	8.4	3
	National Check (Saida)	2487	12.6	
EGYPT (11)	N-Acc4001-59-80	4480	10.7	6
	WI 2197/Mazurka	4206	10.5	8
	National check (Giza 121,Giza 123,CC 89, Sahrawy, Bonus)	4324	13.4	
TUNISIA (4)	WI 2291/3/CI 03309/Attiki//Hja33	2840	7.0	4
	N-Acc4001-59-80	2378	9.3	3
	National check (Rihane-03(3) Martin (1))	2214	15.3	
MOROCCO (4)	Iris/Nopal'S'	4128	8.0	3
	N-Acc4001-59-80	4056	9.8	2
	National check (Asni)	3877	12.0	
S.ARABIA (7)	WI 2291/3/CI 03309/Attiki//Hja33	4104	8.1	3
	National check (Gustoe)	4295	9.6	

[a] in parenthesis the number of year x location combinations

S. Grando

2.1.4. Reliability of barley under rainfed conditions

Barley is one of the most reliable cereal crops in rainfed agriculture (Hadjichristodoulou, 1974). On farm verification trials conducted in zone B in Syria, having 320 mm average rainfall, include barley, durum wheat and bread wheat. The trials include checks, cultivars currently grown by farmers, and new lines which are tested from one to three years. The trials provide information on the relative performance of the three cereals as they are grown side by side, planted on the same day with the same agronomic practices. The average grain yield for the last nine cropping seasons are given in Table 8. Barley outyielded both durum wheat and bread wheat in all cropping seasons (significantly in 7 out of 9). The years when the yield was not significantly different had severe frost (84/85) and exceptional rainfall (87/88).

Table 8. Average grain yield (kg/ha) of barley, durum wheat and bread wheat in the on farm verification trials in Syria during the last nine cropping seasons. The number of locations in each cropping season is given in parenthesis.

YEAR[a]	DURUM WHEAT	BREAD WHEAT	BARLEY	P[b]
1982/83 (8)	1993b	2115b	2617a	< 0.01
1983/84 (7)	1271b	1459b	1835a	< 0.01
1984/85 (7)	1251	1200	1345	n.s.
1985/86 (6)	2074b	2078b	2571a	< 0.01
1986/87 (7)	1552b	1710b	2354a	< 0.01
1987/88 (9)	3473	3493	3900	n.s.
1988/89 (5)	1045b	907b	1586a	< 0.01
1989/90 (9)	1151b	1227b	1757a	< 0.01
1990/91 (8)	1538b	1440b	2328a	< 0.01
mean (66)	1758b	1796b	2311a	< 0.001

[a] in parenthesis number of locations per year
[b] level of significance of differences within a row

The average yield advantage of barley in the nine cropping seasons was 31% over durum and 29% over bread wheat (P<0.001). The range is shown in Fig. 2. There is a tendency for the yield advantage of barley over durum and bread wheat to increase at lower yield levels.

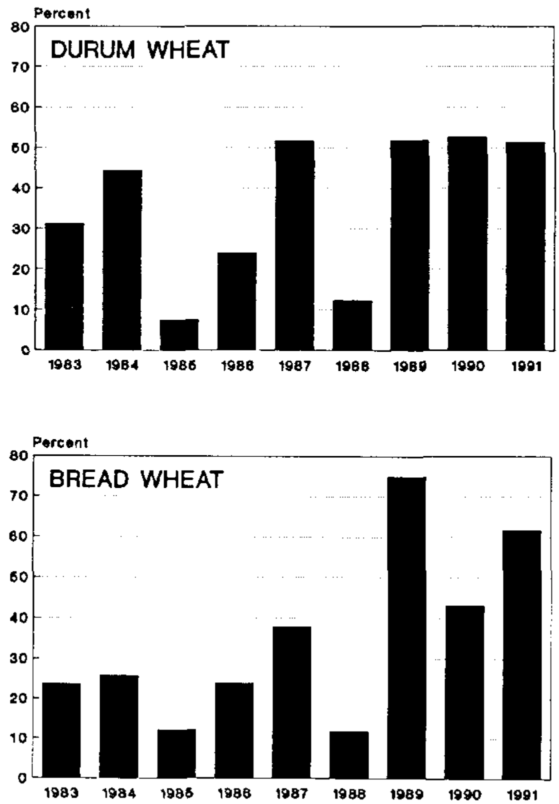
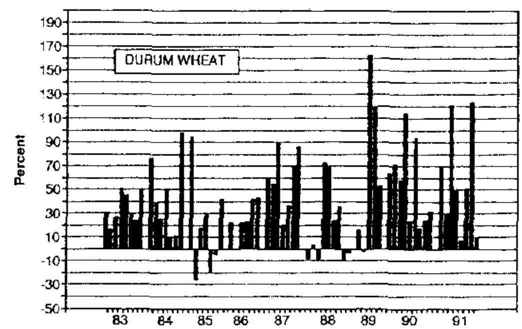


Figure 2. Yield advantage (%) of barley over durum wheat and bread wheat in the on farm verification trials for zone B (average rainfall 320 mm) in nine cropping seasons in Syria.

Barley outyielded both durum and bread wheat at all locations in five cropping seasons (1983/84, 1985/86, 1986/87, 1989/90 and 1990/91) (Fig. 3). Over the 66 locations barley outyielded durum wheat in 57 and bread wheat in 59 locations. At six locations, mostly in 1984/85 and 1987/88, barley was outyielded by both durum and bread wheat. In these locations the yield advantage of durum wheat ranged from 0.5% to 35% (average 9%) and of bread wheat from 0.7% to 25% (average 7%).



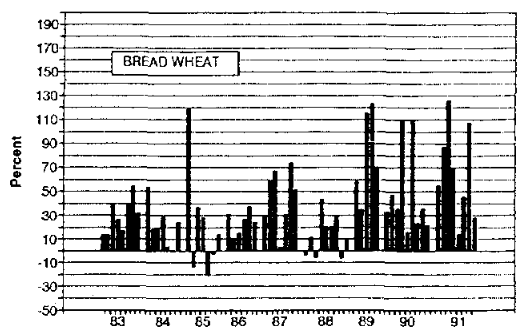


Figure 3. Yield advantage (%) of barley over durum wheat and bread wheat in each of the 66 locations where the three crops in the on farm verification trials for zone B (average rainfall 320 mm) in Syria were harvested.

Barley yields were slightly less variable (C.V. = 48.7%) than both durum (C.V. = 57.7%) and bread wheat (C.V. = 56.8%).

In some years and especially for bread wheat, the number of varieties tested was limited (4 or 5) and the yield of the checks may have significantly affected the comparison with new lines under test. However, the exclusion of the checks changed the results described only slightly increasing marginally the superiority of barley over both durum and bread wheat.

The data confirm the yield advantage of barley over wheat in areas where abiotic stresses are not as severe as in areas where barley is the officially recommended crop.

M. Michel, S. Grando and S. Ceccarelli

2.1.5. Performance of Advanced Lines in Morocco

Twelve advanced yield trials, each comprising 20 lines and five checks, were evaluated at Merchouch and Annaceur in 1991.

Yield levels (means of each trial) ranged between 4.3 and 5.7 t/ha at Merchouch and between 2.0 and 2.9 t/ha at Annaceur. Table 9 shows the number of lines that outyielded (both significantly or not) four of the five checks common to all trials. The fifth check (Arabi Aswad, adapted to Syria) is not adapted to North Africa and was not used for this comparison. The lines outyielding the checks non significantly are included to show the yield level of the material.

Table 9. Number of lines outyielding (significantly or not) the four checks in twelve advanced yield trials in two locations (Merchouch and Annaceur) in Morocco (individual trial lattice analysis).

Checks	Merchouch		Annaceur	
	$P<0.05$	n.s.	$P<0.05$	n.s.
ER/Apm[a]	1	19	44[d]	121
Harmal[b]	16	134	27	84
Rihane-03[c]	4	73	107	170
Mari/Aths*2	34	146	29	87

[a] released with the name of Aglou
[b] released with the name of Tessaout
[c] released with the name of Annaceur
[d] based on 11 trials only

In Merchouch the best check was ER/Apm with an average yield of 5.9 t/ha. Only one line, an F_2 bulk (Soufara-02/WI 2269 ICB87-1564-0AP), outyielded it significantly (by almost 35%). Other 19 lines had yields similar to ER/Apm. Four lines outyielded the second best check (Rihane-03) and 73 had similar yields.

In Annaceur the overall performance of the test material, compared to the checks, was better than at Merchouch. The best check was Harmal (2.8 t/ha) followed by Mari/Aths*2 (2.7 t/ha) and ER/Apm (2.2 t/ha). These three checks were outyielded significantly by 27, 29 and 44 lines, respectively. The line which outyielded significantly ER/Apm at Merchouch also significantly outyielded (by between 32% and 76%) the checks at Annaceur.

The results of Annaceur, although based on one year only, are encouraging because barley improvement for the mountains is often considered a weak point in national barley breeding programs. Most of the lines outyielding the best checks were two row while the preference of Moroccan farmers is for six row. The special six row North Africa nursery should make more suitable germplasm available to national programs.

A. Amri and S. Ceccarelli

2.1.6. Yield Under Stress and Yield Potential

All the environments used in northern Syria were either severely stressed or damaged by a hail storm. It was not possible to obtain estimates of potential yield from these trials. However the advanced yield trials were grown also at Merchouch (Morocco) and the average grain yield was 4871 kg/ha. This allowed the best performing advanced lines at Merchouch to be compared with the best performing advanced lines at Bouider (average grain yield = 1031 kg/ha) (Table 10).

The lines which were highest yielding at Merchouch (average 6299 kg/ha) yielded less than the best check at Bouider, and significantly less than the best lines at Bouider (1040 kg/ha vs 1693 kg/ha). By contrast, the top yielding lines at Bouider were low yielding at Merchouch. They yielded about 1100 kg/ha less than the best check and 1400 kg/ha less than the lines with the highest yield potential. This result has been frequently found and the data are summarized in Table 11 for six out of the last seven seasons (there was a crop failure in Bouider in 1990).

Table 10. Top yielding advanced barley lines (best 5%) in Bouider (207 mm rainfall) and in Merchouch (559 mm rainfall).

LOCATION	LINE	DAYS TO HEADING	GRAIN YIELD[a]	
			BOUIDER	MERCHOUCH
MERCHOUCH	WI2197/CI 13540//Arar	106	1037	6403
	WI2291/Mzq//DL71/3/-	110	1142	6049
	WI2291/Bgs//Harmal-02	110	950	6018
	WI2291/Bgs//Harmal-02	109	1287	6468
	A.Abiad/Emir	110	988	6426
	Soufara-02/WI2269	113	1047	6625
	Bgs/Badia//Lignee 1242	114	1063	6158
	Rihane-05//As46/Aths*2	120	941	6091
	Lignee 131//Roho/Delisa	116	843	6470
	Harmal-02/A.Abiad/-	116	1103	6280
	means	112	1040b	6299a
BOUIDER	ER/Apm//WI2291/Bus	111	1705	5747
	WI221/A.Abiad	111	1559	4395
	Aths//Cr.366-15-2/	111	1673	5054
	WI2269/Esp	113	1724	4853
	Esp/1808-4L//Harmal-02	113	1614	4653
	Kv//Alger/Ceres362-1-1/	115	1842	5646
	WI2269/Esp	113	1763	4561
	WI2269/Esp	114	1672	4664
	Harmal-02/A.Abiad/3/Api	112	1670	4765
	Roho/Harmal-02	114	1704	4609
	means	113	1693a	4894b
	BEST CHECK		1265	5974

[a] means followed by the same letter(s) do not differ significantly ($P<0.05$)

Table 11. Grain yield (kg/ha) under stress (upper part) and under non stress (lower part) of the top 5% of the barley lines for either grain yield under stress or grain yield under non stress.

TESTING SITE			TOP YIELDING LINES SELECTED UNDER	
YEAR	RAINFALL		STRESS	NON STRESS
1985	178		1686	929
1986	180		2699	1833
1987	164	STRESS	1002	668
1988	382		2960	2710
1989	184		1191	991
1991	207		1693	1040
1985	373		3935	6367
1986	316		6186	6842
1987	343	NON STRESS	2603	3494
1988	499		4669	4513
1989	214		3184	3561
1991	559		4894	6299

Under non stress conditions the high yielding lines under stress conditions had an average yield reduction of 18% compared to the top yielding lines under non stress. Under stress conditions the situation was reversed and the lines with the highest yield potential had yield reduced by 27% when compared with the high yielding lines selected under stress conditions. These data confirm the ineffectiveness of indirect selection (selection in the absence of stress to improve yields in the presence of stress) and the effectiveness of direct selection (selection in the presence of stress).

The relative efficiency of indirect versus direct selection can be predicted from the magnitude of the heritability and the genetic correlation coefficient. If y is the trait to be improved in a stress (s) environment by selecting in a non stress (ns) environment then (Falconer, 1981):

$$CR_s/R_s = r_G\, h_{ns}/h_s$$

where CR_s is the correlated response in the presence of stress when selection is done in the absence of stress, R_s is the direct response when selection is done in the presence of stress, r_G is the genetic correlation coefficient between y_s and y_{ns}, h_{ns} and h_s are the square roots of heritabilities of y in the two environments.

It is obvious that the maximum value of CR_s/R_s is 1 when $h_{ns} = h_s$, and $r_G = 1$. When heritabilities are the same, direct selection will always be more effective because the genetic correlation coefficient will always be somewhat less than one. When h_{ns} is twice as large as h_s, r_G must be larger than 0.5 before CR_s becomes larger than R_s (Fig. 4). With low genetic correlation coefficients (0.1 - 0.2), h_{ns} must be more than 10 to 5 times higher than h_s for CR_s to become higher than R_s. Estimates of r_G, h_{ns} and h_s will contribute in clarifying further the effect of selection environment(s) on performance in the test environment(s), a question which is of strategic importance to breeders in both international and national programs.

Estimates of the genetic correlation coefficients were obtained from advanced yield trials conducted in 1987, 1989, 1990, and 1991 for sites with highly contrasting site means. There were 17 trials in 1987, 15 trials in 1989, 14 trials in 1990 and 12 trials in 1991 (25 genotypes in each trial: 5 genotypes were common, the remaining 20 differed over trials and years). The 58 genetic correlation coefficients were either not significantly different from zero or, if significant, were negative (Table 12). Positive and significant correlation coefficients were mostly found when YNS was about or below 3 t/ha. The only exception to this pattern (trial 2 in 1991) deserves two comments. First, taking the two heritabilities into account, the CR/R ratio is 1.06. Second, one genotype (A. Aswad) had a marked effect on this correlation coefficient. Its removal changes r_G from .813 to .534. Although heritability estimates are not reported, they add little. Regardless of the relative magnitude of heritabilities in the two environments, selection in high yielding environments will produce at best no correlated response, and at worse a negative correlated response in low yielding environments.

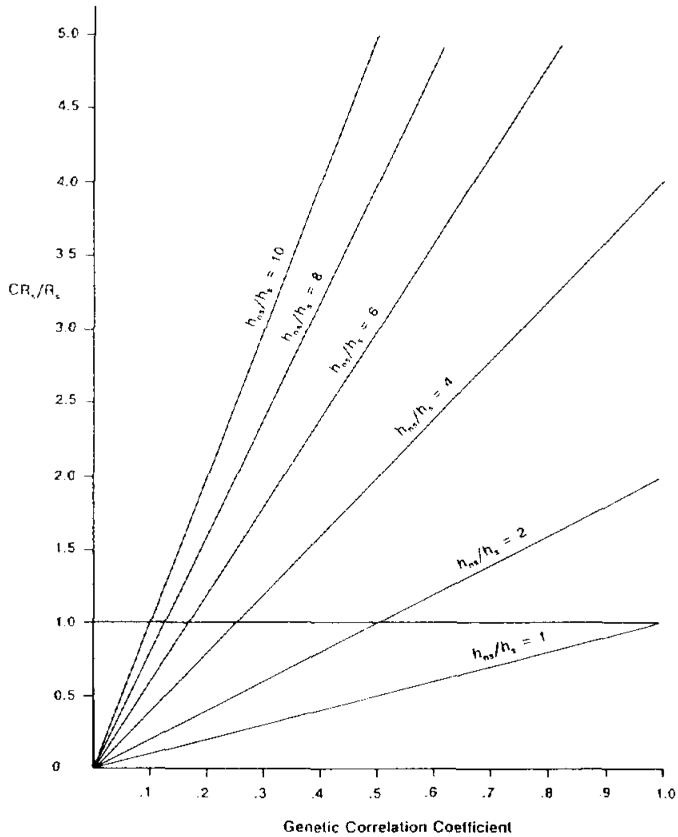


Figure 4. Selection under stress (s) and under non stress (ns): relative efficiency of correlated versus direct response to selection CR_s/R_s) as a function of genetic correlation coefficient and of the ratio between heritability in absence of stress (h_{ns}^2) and heritability in presence of stress (h_s^2).

Table 12. Genetic correlation coefficients between grain yield under stress (YS) and grain yield under non stress (YNS) in two cropping seasons.

TRIAL	1986/87			1988/89			1989/90			1990/91		
	YS	YNS	r_G	YS	YNS	r_G	YS	YNS	r_G	YS	YNS	r_G
1	612	3280	.315	458	5321	.083	463	3308	.148	888	4612	-.120
2	325	3180	.600	291	5070	-.857	520	3463	-.075	920	4834	.813
3	538	2374	-.206	465	5035	-.022	436	3328	.043	1052	4642	.280
4	338	2361	-.262	285	5341	-.827	588	3100	.077	1039	4546	.081
5	681	2241	-.428	478	6106	.119	600	3096	-.288	1041	4807	.340
6	534	2415	.326	274	6766	-.080	603	3192	-.020	982	4681	.493
7	658	3137	.417	421	6404	-.707	528	3323	-.199	993	5013	.028
8	858	2269	-.713	316	6269	-.658	476	3703	.324	854	4839	-.295
9	540	2342	-.039	414	5262	-.815	376	3109	-.399	973	4599	-.028
10	857	2653	1.114	361	5408	-.737	497	3365	.108	921	4626	.083
11	998	3191	.178	762	5337	-.610	443	3634	.216	1002	4583	.191
12	598	2642	.253	309	5791	-.320	406	3582	.070	993	4429	.413
13	1083	2395	-.115	227	6206	-1.055	339	3508	.111			
14	1051	2423	.885	241	5800	-.470	449	3479	.113			
15	996	2991	.737	338	5565	-.999						
16	961	2475	.312									
17	618	1812	1.064									

critical values of r_G are 0.396 ($P < 0.05$) and 0.505 ($P < 0.01$)

To clarify the issue of the choice of the selection environment there is a need for orthogonal experiments where breeding lines selected in low or high yielding environments are tested in similar environments (Simmonds, 1991). To provide an orthogonal comparison we have designed a trial where genotypes selected in either a low or a high yielding environment in previous cropping seasons (1985-1987, 1986-1988 and 1988-1990) are compared in different environments. The objective of the trial is to estimate response to selection (and hence realized heritability) in low and high yielding testing environments which are independent of the selection environments. The trial needs to be continued for at least three cropping seasons to provide reliable estimates of grain yield under low and high yielding conditions.

The experiment consists of three groups of genotypes:

a) 22 genotypes selected for high yield under low yielding conditions (YD)

b) 22 genotypes selected for high yield under high yielding conditions (YP)

c) 14 genotypes selected for high yield in both low and high yielding conditions (YDYP).

Groups a) and b) contain three subgroups (of 8, 6 and 8 genotypes) based on the breeding cycle in which they were selected (1986-88, 1987-89 and 1988-90, respectively). Group c) is divided in two subgroups selected for YDYP in 1986-88 (YDYP88) and in 1987-89 (YDYP89). No genotypes were found to combine YD and YP among the lines evaluated during 1988-90.

The design is a 8 x 8 triple lattice with 58 selected genotypes and 8 checks, and plot size of 9 m^2 (8 rows at 20 cm, 5 m long). The trial was planted in Bouider, Breda and in three environments in Tel Hadya (early planting with supplementary irrigation, normal planting rainfed and late planting rainfed). Because of the hail storm only the data from Bouider and Breda are available for a preliminary assessment of the response to selection under low yielding conditions (Tables 13 and 14).

Table 13. Grain yield (Kg/ha) in Bouider (207 mm rainfall) and in Breda of barley lines selected for grain yield under drought (YD), for grain yield under favorable conditions of for a combination of YD and YP (YDYP) in the previous cropping seasons.

SELECTION CRITERION	NUMBER OF LINES	GRAIN YIELD		DAYS TO HEADING	
		BOUIDER	BREDA	BOUIDER	BREDA
YD	22	427a	796a	96.9b	89.2a
YP	22	256c	612b	98.2a	91.8a
YDYP	14	353b	681b	97.4a	91.8a

The average yield of 22 lines selected for YD significantly outyielded the 22 lines selected for YP at both Bouider and Breda, while the 14 YDYP lines were intermediate (Table 13). The YP lines headed later than the YD lines but the difference was significant only in Bouider. The comparison between YD and YP lines within each subgroup for average grain yield at Bouider and Breda, which is a better estimate of yield under drought (Table 14), indicates that the lines selected for YD outyielded the lines selected for YP in the same breeding cycles, however the difference was not significant in 1987-89.

Based on one year's data preliminary estimates of realized heritability were relatively high (between 29% and 34%).

Table 14. Average grain yield in Bouider and Breda of barley lines selected for grain yield under drought (YD) or for grain yield under favorable conditions (YP) in 1986-88 (88), in 1987-89 (89) and in 1988-90 (90).

SELECTION CRITERION	NUMBER OF LINES	GRAIN YIELD[a] (Kg/ha)	REALIZED HERITABILITY (%)
YD88	8	543a	28.8
YP88	8	328b	
YD89	6	635a	31.8
YP89	6	442a	
YD90	8	663a	34.0
YP90	8	534b	
mean YD	22	612a	30.9
mean YP	22	434b	

[a] Mean of Bouider and Breda in 1991

S. Ceccarelli and S. Grando

2.1.7. Genetics of Drought Resistance

The analysis of data collected in 1989 and 1990 indicates that some of the differences for grain yield under stress conditions are associated with specific genotypes.

The analysis was done on the average grain yields in Bouider 1989 (144 mm rainfall) and Tel Hadya 1990 (234 mm rainfall) as estimates of grain yield under stress. Two types of analysis were conducted.

In the first analysis we sampled the population of 640 lines for which the data were available extracting the lines having a given parent in common in their pedigree. The sampling was repeated for each of the 51 parents (21 two row and 30 six row) listed in Table 15. We will use the term "groups" to indicate these 51 samples.

Table 15. Parents used to sample a population of 640 barley breeding lines.

NR	PARENT (6 ROW) IN COMMON	SAMPLE SIZE	NR	PARENT (2 ROW) IN COMMON	SAMPLE SIZE
1	Lth/Nopal/Pro	4	31	Delisa	1
2	Mezquite	11	32	PI 386540	15
3	Harma-03	13	33	WI 2197	23
4	Godiva	12	34	Arr/Esp	13
5	Lignee 527	6	35	Pld 10342	6
6	Atlas 46	5	36	Esperance	28
7	Giza	24	37	Salmas	20
8	Puebla	6	38	Ceres 362,1,1	29
9	Ager	6	39	Roho	47
10	Kenya/Research	3	40	Arabi Aswad	86
11	Arar	58	41	Emir	31
12	Briggs	5	42	Mazurka	10
13	Beecher	40	43	WI 2269	62
14	Robur	5	44	WI 2291	122
15	Cr. 115	24	45	Lignee 131	8
16	Apam	47	46	ER/Apam	48
17	Deir Alla 106	27	47	Arabi Abiad	84
18	CM 67	45	48	Harmal	81
19	Harma-02	3	49	Esp/1808-4L	10
20	Astrix	2	50	Moroc 9-75	15
21	BKF Maguelone 1	7	51	Tadmor	17
22	Nopal	6			
23	Apro	30			
24	Aw Black	1			
25	ROD 586	7			
26	Mzq/Aths	9			
27	Athenais	52			
28	Rihane	35			
29	Lignee 640	3			
30	Quinn	12			

The second type of analysis was to apply a χ^2 for independence to 2 x 2 contingency tables based on observed and expected number of lines (within each group) falling in the upper and lower 5% for yield under stress. The null hypothesis under testing in both analysis is that the differences in grain yield under stress are only of environmental nature. If the hypothesis is correct, the 51 samples should have the same mean of the original population within the limits of sampling error and the χ^2 for independence should not be significant.

The average grain yield under stress of the 51 groups listed in Table 15 are given in Fig. 5.

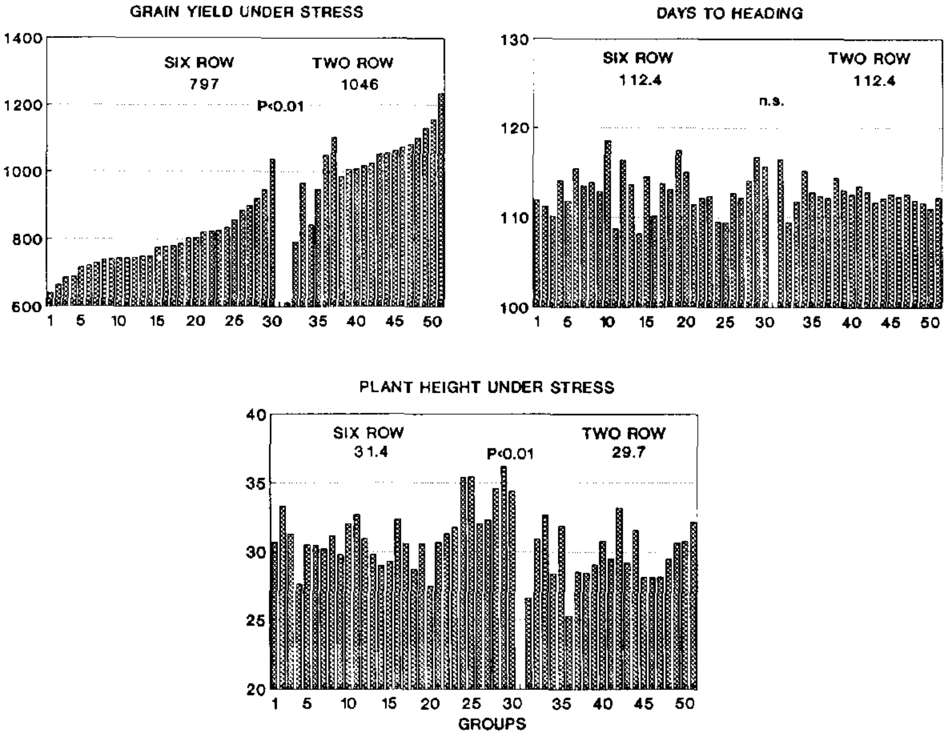


Figure 5. Grain yield under stress, days to heading and plant height under drought of 51 groups of barley lines each with a different parent in common (see Table 15 for parent name).

The two row groups outyielded the six row groups by 31% ($P < 0.01$) with a large variation between groups within the same row type. Most of the two row groups (except six) and only the six row group having Quinn as a common parent yielded more than 1 t/ha. The differences in grain yield under stress were not associated with phenology but the two row groups were in general shorter than six row under drought. The two rows were more prostrate, suffered less cold damage and hence had a better ground cover despite the lower growth vigor (Fig. 6).

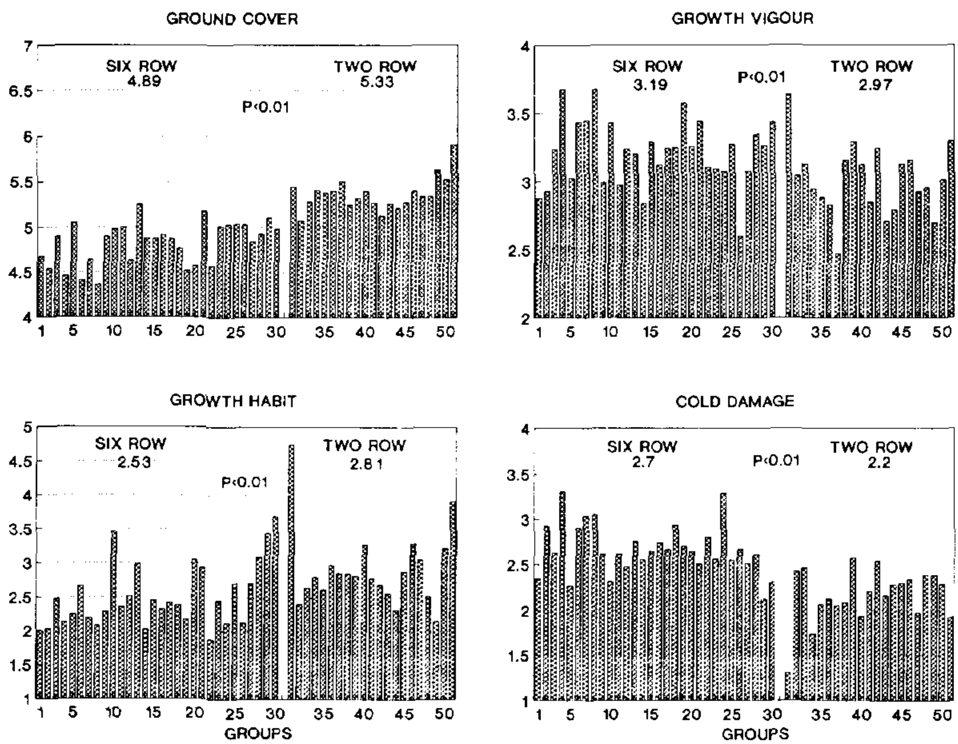


Figure 6. Ground cover, growth habit, growth vigor and cold damage of 51 groups of barley lines each with a different parent in common (see Table 15 for parent name).

Within the six and two row groups there were highly significant differences between groups differing for the common parents. If we ignore those groups with less than 10 lines each, the highest yielding two row groups were those having Tadmor, Moroc 9-75, Esp/1808-4L as common parents, with 1198, 1143 and 1132 kg/ha, respectively. Among the six row the highest yielding groups were those having Quinn, Rihane and Athenais as common parents, with 1037, 918 and 898 kg/ha, respectively. The lowest yielding two row were those having PI 386540, WI 2197 and Arr/Esp as common parents, with grain yields of 791, 967 and 942 kg/ha, respectively. The lowest yielding six row were those having Mezquite, Harma-03 and Godiva as common parents, with grain yield of 690, 688 and 712 kg/ha, respectively. The L.S.D. for comparing these means was 99.7 for $P < 0.05$ and 131 for $P < 0.01$. The range between groups was 349 kg/ha in the six row and 407 kg/ha in the two row.

An example of the results obtained with the second type of analysis is shown in Fig. 7. A number of cases was found where lines having given parents in common were more frequent than expected in either the upper 5% or in the lower 5% of the distribution for grain yield under stress. Examples of the first case are the first five parents in the upper part of Fig. 7 (Tadmor, WI 2291, Arabi Abiad, Moroc 9-75, Harmal). Examples of the second case are shown in the lower part of Fig. 7. As a comparison we also have included the progenies of three parents (WI 2269, Rihane and Roho) which were distributed in the top and/or bottom 5% with frequencies not significantly different from those expected at random.

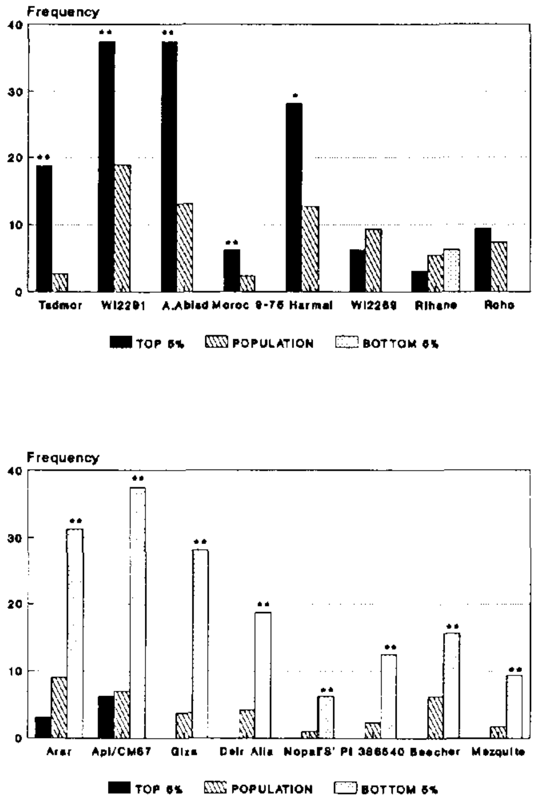


Figure 7. Frequency of lines with a given parent in common (on the X axis) included in the top or bottom 5% for grain yield under drought and χ^2 for independence (* P < 0.05; ** P < 0.01).

We recognize that this analysis is far from being genetically accurate because 1) parents not in common are not necessarily the same in each group (and particularly so in the comparison between two and six row), and 2) large differences in sample size. However, these results do not rule out the hypothesis that some parents may possess one or more attributes which are inherited by the great majority of their progenies regardless of the other parent(s). These attributes seem to be associated with a better performance under stress. This hypothesis is in contradiction with previous findings (Ceccarelli et al., 1991) which suggested that different genotypes are able to achieve a similar grain yield under stress through different pathways. In view of the importance of this issue in relation to the general problem of increasing efficiency of breeding under stress conditions specific crosses need to be designed and analyzed in details. The use of molecular markers to associate parental and random inbred lines polymorphism with either specific traits (e.g. growth habit, growth vigor, cold tolerance) or overall performance could be extremely valuable.

S. Ceccarelli and S. Grando

2.1.8. Use of Genetic Resources

2.1.8.1. Landraces

Results of the last five cropping seasons showed that adaptation plays an important role in stress conditions (Cereal Program Annual Reports 1986, 1987, 1988, 1989 and 1990). Also we have shown that a breeding program is more efficient if adapted germplasm instead of exotic germplasm is used (Ceccarelli and Grando, 1989, 1991). Therefore we encouraged barley breeders in countries where landraces are still widely grown to use the variability presumably present in their local germplasm. The success of this 'methodology transfer' has been variable. In some countries (Iraq and Tunisia) locally adapted germplasm is already used by some breeders. In others, like Iran, local landraces have been collected but not used. In three countries (Syria, Ethiopia and Nepal) barley breeders have begun this type of work in collaboration with ICARDA.

Syria

Within a collaborative project with the Syrian Ministry of Agriculture and Agrarian Reform (SMAAR) on evaluation, selection and utilization of locally adapted germplasm, three groups of lines extracted from Syrian landraces were tested during 1990/91 season. The first group consisted of 34 lines selected in 1988/89 and 1989/90 (see Annual Report for 1990, pp. 24-25). Forty-four lines selected in 1989-90 were included in the second group. The third group comprised 221 lines from three collection sites in Raqqa province: 83 lines from Raqqa-Duchan (site n. 14), 76 from Raqqa-Qantari (site n. 15) and 62 from Raqqa-Qantari (site n. 16). These lines were tested for first time.

The first group was evaluated at three locations (Hassake, Karatha and Breda) with five checks (A. Aswad, A. Abiad, Zanbaka, Tadmor and Arta). The second group, with the same five checks, was tested at two locations (Hassake and Breda).

The lines in the third group were organized in three separate trials, each included 75 lines and six checks (WI2291, Tadmor, Zanbaka, Arta, A. Aswad and A. Abiad). The trials were planted at Karatha, Hassake and Bouider.

In the first group two lines outyielded the best check (A. Aswad) significantly at Breda (Table 16). At Hassake and Karatha none of the lines yielded significantly more than the best check (Zanbaka in both locations). Six lines, selected for performance over three years, will be planted in demonstration plots at Breda and increased for on farm testing.

Table 16. Grain yield (kg/ha) of selected lines of Syrian landraces tested in three locations in Syria during 1990/91 season.

Line	Grain yield (kg/ha)			
	Breda	Hassake	Karatha	Average
SLB 2-47	1163.3*	745.7	291.7	731.1
SLB 5-63	1146.1*	767.2	449.6	788.8
SLB 2-04	935.6	928.7	112.9	684.3
SLB 5-10	903.1	909.9	325.8	721.2
SLB 2-24	797.3	729.0	480.7	682.7
SLB 1-18	787.2	581.0	480.5	606.6
A. Aswad	922.8	800.5	247.1	644.0
Zanbaka	898.9	935.9	474.9	759.3
$LSD_{0.05}$	203.3	188.4	235.9	n.s.

* significantly higher than the best check ($P < 0.05$)

In the second group three lines yielded above the best check (Zanbaka at Hassake and Tadmor at Breda) in both locations, although not significantly (Table 17). The three lines were all collected at Furqlos (collection site n. 12) in Homs province. This site has a high frequency of tall high yielding lines in dry conditions (Ceccarelli et al., 1987).

Table 17. Average plant height (cm) and average grain yield (kg/ha) of three lines selected from a Syrian landrace population, Zanbaka and Tadmor (Hassake and Breda, 1991).

Line	Plant height	Grain yield
SLB 12-59	40.0	883.3
SLB 12-24	36.8	876.7
SLB 12-42	34.3	856.7
Zanbaka	42.0	773.3
Tadmor	32.5	844.2
$LSD_{0.05}$	4.0	158.7

Table 18 shows mean and range of variation for days to heading, plant height and grain yield in the three populations evaluated for the first year. Of 15 lines outyielding Zanbaka, 11 were collected in Raqqa-Qantari (site 15). The majority of tall lines were collected in a different site (site 16) of the same area.

Table 18. Mean and range of variation for days to heading, plant height and grain yield in three landrace populations collected in Raqqa province (Bouider, 1991).

Population/ Entry	n	Days to heading		Plant height		Grain yield[a]	
		$\bar{x}$	range	$\bar{x}$	range	$\bar{x}$	range
Duchan(14)	83	103.2	100.2-108.6	29.1	17.1-35.5	83.3	28.5-144.7
Qantari(15)	76	102.4	99.0-104.9	29.6	23.3-38.5	96.8	47.3-193.9
Qantari(16)	62	103.5	99.6-108.4	29.8	21.8-42.8	74.9	22.2-133.2
Best check[b]		100.8		33.9		110.4	

[a] g/plot
[b] Zanbaka

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Ethiopia

Two groups of pure lines extracted from Ethiopian landraces were evaluated during 1990/91. The first group included 32 lines selected in 1989/90 (see Annual Report for 1990, pp. 25-26). The second group consisted of 300 pure lines yield tested for the first time.

The first group was evaluated at three locations (Holetta, Sheno and Bekoji) without fertilizer, herbicide and seed treatment together with a local check (different at each location) and three improved lines (Ahor-880/61, Ardu 12-60B and HB42). The second group was tested in 5 separate lattices, each including 60 pure lines, three original bulks and one local check. The trials were managed as described earlier.

In the first group line 4-57 (accession 3357-10) outyielded significantly the best improved check at all locations (Table 19). It also outyielded the local check (as in the previous cropping season) although the difference was significant only in Bekoji. Three other lines outyielded the local checks, two at Sheno and one at Holetta.

Table 19. Average grain yield (g/plot) of pure line selections of ethiopian barley landraces tested in 1990/91 in three locations in Ethiopia.

LINE (acc #)	Holetta	Sheno	Bekoji	Average
4-57 (3357-10)	<u>649</u>	<u>925</u>	<u>590</u>*	721
8-17 (3336-20)	<u>549</u>	<u>1073</u>*	463	695
4-45 (3357-13)	<u>592</u>	896	503	664
4-16 (3390-05)	501	<u>1086</u>*	352	646
5-56 (3410-15)	<u>718</u>	756	447	640
5-24 (3410-09)	<u>723</u>*	657	429	603
8-38 (3336-03)	<u>612</u>	842	493	649
4-08 (3390-08)	330	<u>975</u>	487	598
4-56 (3291-15)	380	<u>920</u>	400	567
Local check	629	831	404	-
Ahor-880/61	357	773	393	509
Ardu 12-60B	426	834	366	542
HB42	377	955	504	612

* and ___ indicate lines outyielding significantly ($P<0.05$) the local check and the best improved check, respectively.

In total 10 lines outyielded significantly the best improved check. Two lines, accessions 3390-05 and 3336-20 were found to be resistant to scald. Based on grain yield, agronomic characteristics and disease reaction nine lines were selected for further testing in 1991/92. One mixture of the two lines resistant to scald will also be tested. These two lines will also be used in crosses with the four highest yielding lines.

Among the 300 lines tested for the first year 32 were selected based on grain yield, agronomic traits and disease reaction (Table 20). These lines will be tested again in 1991/92.

Table 20. Average grain yield (g/plot) of 32 pure lines selected from 300 ethiopian barley landraces tested in 1990/91 in three locations in Ethiopia.

LINE	Holetta	LINE	Sheno	LINE	Bekoji
3-33	359	3-25	710	1-33	394
3-42	346	3-43	671	1-56	373
3-20	344	3-63	668	1-26	361
3-41	332	3-32	661	1-40	355
3-45	327	3-49	635	1-36	341
3-54	322	4-11	774	1-41	339
3-11	318	5-24	821		
3-37	310	5-17	761		
3-53	301	5-44	647		
3-60	275	5-59	620		
4-41	296	5-16	618		
5-5	376	5-01	602		
5-33	366	5-64	592		
		5-33	713		
check	199		472		316

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Nepal

In the 1990 Annual Report we indicated that a new collection of individual heads from nepalese barley landraces was made in 1989. The objective was to start a program of evaluation and selection similar to that in Ethiopia.

During 1990 and 1991 313 head-rows progenies and populations were evaluated by nepalese scientists using an unreplicated design with the cultivar Bonus (a two row recommended variety), as a systematic check. The material was evaluated for several traits as well as maturity, 1000 kernel weight and reaction to yellow rust and powdery mildew. There was a wide variability in both phenology and kernel size (*Fig. 8*) but of more immediate interest was the variability in reaction to powdery mildew and yellow rust.

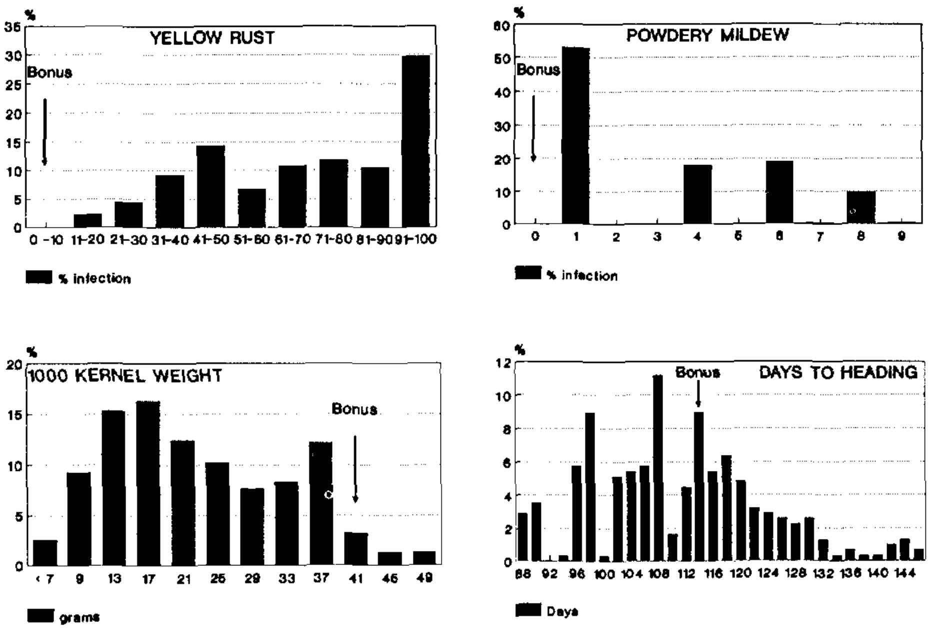

Figure 8. Frequency distribution of reaction to yellow rust, to powdery mildew, 1000 kernel weight and days to heading in 313 nepalese landraces.

The mean reaction of Bonus is shown by the arrow. More than half of the lines were resistant to powdery mildew, but only 7% of the lines were moderately resistant to yellow rust (coefficient of infection < 30%). However the potential benefit to the nepalese barley breeding program is large because this partial resistance is in an adapted genetic background. The most promising lines for reaction to yellow rust are listed in Table 21.

Table 21. Lines from Nepalese landraces showing partial resistance to yellow rust.

Accession nr.	Elevation (m a.s.l.)	Reaction to yellow rust 1990	1991	Reaction to powdery mildew	Days to heading	1000 kw
1591	-	32	4	0	130	50.7
6285	1500	32	0	3	111	30.0
6285	1500	32	8	5	113	26.7
6286	2800	8	32	5	106	36.8
1594	2800	30	8	7	106	40.4
2009	800	30	0	7	122	21.6
1617	3450	32	0	0	108	38.8
1628	2750	24	8	5	117	23.2
Bonus[a]	-	8.8	0	0	113	40.0

[a] recommended variety for Nepal

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Tunisia

The barley breeding program at l' Ecole Superieur d' Agriculture (ESA) at Kef (northwest Tunisia) is partially based on the utilization of local landraces in a male sterility facilitated recurrent selection (MSFRS) program. Although largely independent of the ICARDA barley program, part of this work was supported by ICARDA during 1990/91. It is strategically important in developing breeding methodologies for North Africa.

Three sets of data are presented: the first compares Rihane-03 and Martin (a widely grown adapted cultivar), the second compares locally adapted germplasm, and the third includes barley lines selected at Bouider in 1990. This trial was evaluated at two locations in northwest Tunisia characterized by low rainfall (200-300 mm) and cold winters to test the hypothesis that mechanisms of adaptation in the two environments may be similar.

The data of Table 22 are derived from a larger set of data obtained during the evaluation of commercial varieties and promising lines at eight locations. Three locations were in the northwest of the country and five in the center-south. Even in a very wet season (Tunisia in 1990/91 had record cereal production) there was the familiar cross-over type of interaction which has been found so often in northern Syria.

Table 22. Grain yield (kg/ha) of Martin and Rihane-03 in northwest (NW) and central-south (CS) Tunisia in 1990/91.

LOCATION		RIHANE-03	MARTIN
KEF	NW	7220	7630
SELIANA	NW	7000	4750
THALA	NW	4460	4400
MEANS OF NW		**6230**	**5600**
FOUSSANA	CS	2210	2750
SBEITLA	CS	2240	1710
JELMA	CS	1610	2750
SIDI BOUZID	CS	810	1120
GAFSA	CS	890	1170
MEANS OF CS		**1550**	**1900**

Rihane-03 outyielded Martin by about 11% in the three northwest sites. By contrast, Martin outyielded Rihane-03 by 23% in the five center-south sites. A similar pattern occurred when five local populations were compared to Rihane-03 and Martin (Table 23). None of the populations outyielded Rihane-03 at the highest yielding site (Kef), they performed at least as well as Rihane-03 at Seliana, and two of them performed extremely well under the less favorable conditions of Foussana. Low yielding sites are essential to identify genetic differences that are not manifested in high yielding environments.

Table 23. Grain yield (kg/ha) of Martin, Rihane-03 and 5 local populations in 3 locations in Tunisia in 1990/91.

MATERIAL	KEF	SELIANA	FOUSSANA	AVERAGE
LOCAL POPULATION 1	7790	5510	1870	5060
LOCAL POPULATION 2	7530	5440	1740	4900
LOCAL POPULATION 3	7310	5420	4140	5620
LOCAL POPULATION 4	7870	5230	4680	5930
LOCAL POPULATION 5	7620	5060	2030	4900
RIHANE-03	8510	4890	1850	5130
MARTIN	5950	4880	1890	4230
AVERAGE	7511	5204	2600	5110

The yield data of the third group of trials were taken from two rows plots. Nevertheless in the combined analysis of two locations four lines had higher yields than Rihane-03 (Table 24). All four lines had Syrian landraces in their pedigree. The first two are early bulks, and the second two are lines selected through the bulk-pedigree method.

Table 24. Names/pedigrees and average grain yield (kg/ha) in two sites in Tunisia (YT[a]) of four barley lines outyielding Rihane-03.

LINES/PEDIGREES	YT
Moroc 9-75/Arabi Aswad ICB86-0606-0AP	6432
Arabi Aswad//ER/Apm ICB85-0254-3AP-0AP	6494
Harmal-02/Arabi Abiad/3/Api/CM67//Nacta ICB82-0352-0AP-0AP-0AP-52AP-0AP	6576
Arabi Abiad/WI 2291 ICB82-0613-0AP-0AP-0AP-1AP-0AP	6732
Rihane-03	5215

[a] means of El Kef and Krib

A.H. Yahyaoui

2.1.8.2. Use of Hordeum spontaneum

In 1990/91, 74 F_5 families were tested for the second year at Bouider. Data were recorded on: days from emergence to heading, plant height, number of spikes per m^2, total biological yield, grain yield and 1000 kernel weight.

Table 25 compares the data for the best five families for total biological yield with four barley lines and two lines of H. spontaneum used in the crosses. The best families combined the earliness and the improved plant height under stress of the H. spontaneum parents but maintained the levels of grain and total biological yield, the 1000 kernel weight and the tillering ability of the best Hordeum vulgare lines. Of particular interest was the family SLB 39-60/H.spont.41-1. The H. vulgare parent in this family is derived from Arabi Abiad and therefore the correct comparison is with Arta, a line which becomes very short under severe stress. This family shows that it is possible to increase significantly plant height under drought and earliness without loosing tillering and yielding ability of the landraces.

Table 25. Biological yield (BY), grain yield (GY), days from emergence to heading (DH), plant height (PH), number of spikes/m² (S/m²) and 1000 kernel weight (KW) in 5 F_5 families, 4 checks and 2 lines of Hordeum spontaneum (Bouider, 1990/91).

Entries	BY kg/ha	GY kg/ha	DH	PH cm	S/m²	KW g
SLB 39-60/Hsp 41-1	3907	1225	96	41	389	26.5
SLB 37-74/Hsp 41-5	3661	955	94	59	364	27.5
SLB 37-74/Hsp 41-5	3630	741	95	52	350	25.0
SLB 56-83/Hsp 41-5	3313	911	95	51	391	24.4
SLB 45-40/Hsp 41-1	3229	901	96	49	355	20.9
Zanbaka	3619	1074	99	41	364	23.5
Tadmor	2793	878	100	31	349	26.6
Arta	3374	1032	99	25	388	27.5
WI2291	3082	816	101	41	251	27.7
H. spont. 41-1	1648	303	96	48	180	16.2
H. spont. 41-5	1594	303	96	54	202	16.4
$LSD_{.05}$	795	284	2	9	103	4.1

S. Grando

2.1.8.3. Evaluation of New Collections

During 1991 we evaluated 258 barley lines from China (160), Algeria (40), Egypt (36) and Syria (22). These lines were selected for the preliminary evaluation conducted by the Genetic Resources Unit in 1990.

The lines were yield tested at Bouider. Days to heading and grain yield were expressed as differences from a reference check (Harmal, for days to heading and Arabi Aswad for grain yield) commonly used in the barley yield trials.

A number of lines earlier than Harmal was found among the chinese (8 lines or 5% of the total), the egyptian (8 lines or 22%

of the total) and the syrian material (2 lines or 9.5% of the total) (Fig. 9). The chinese germplasm included both spring and winter types, the latter with a very strong vernalization requirement. The wide range in variation for days to heading reflects the diversity of this germplasm. The chinese accessions with the lowest grain yield did not head although this material was planted in autumn. Some of the highest yielding lines were of egyptian or syrian origin, but none outyielded Arabi Aswad. Some lines will be yield tested in 1991/92.

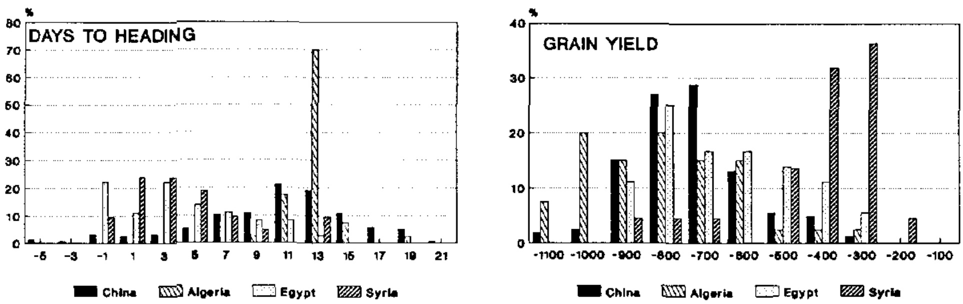

Figure 9. Frequency distribution of days to heading (deviations from Harmal) and grain yield (deviations from Arabi Aswad) in barley accessions collected in China, Algeria, Egypt and Syria.

J. Valkoun and S. Ceccarelli

2.1.9. Genotype x Management Interaction

In most national and international breeding programs selection is conducted on experimental stations with improved agronomic practices (water availability, fertilizer, rotations, soil preparation, etc.) often not used in farmers' fields. The justification is that genetic differences are maximized when growing conditions are optimized. It has been argued (Ceccarelli, 1989; Atlin and Frey, 1990) that, with the exception of disease resistance, genetic differences with high levels of inputs are irrelevant to target environments with low inputs.

This trial, conducted in collaboration with the Farm Resources Management Program for two years, is designed to test this hypothesis.

During 1991, the trial was planted in 11 locations, one at the ICARDA substation in Breda and the others on farmers' fields. The treatments were 22 barley lines (11 adapted to moderate rainfall and 11 to low rainfall, 1 line was contaminated and not included in the analysis), absence or presence of fertilizer (40 kg/ha of nitrogen and 60 kg/ha of P_2O_5) and high (120 kg/ha) and low (80 kg/ha) seed rate.

Despite the dry conditions total biological yield, grain yield, plant height and number of heads/m^2 were measured at all sites. Grain yields ranged from 77 to 800 kg/ha, total biological yields from 400 to 2880 kg/ha. Average increases in total biological yield due to fertilizer were 83.6% and 77.0% in the lines for wet and dry environments, respectively (Table 26). There were no significant differences between the two groups of lines.

Grain yield of lines for dry environments was always significantly higher than grain yield of lines selected for wet environments (Table 27). The yield advantage of lines selected for dry environments was independent of fertilizer level. The grain yield increase due to fertilizer was also similar for the two groups (53 to 54%).

Table 26. Total dry matter yield (kg/ha) of 10 barley lines adapted to wet environments and 11 barley lines adapted to dry environments with and without fertilizer (means of 11 locations).

Environment of adaptation	Line	without fertilizer	with fertilizer
WET	Rihane-03	2178	3777
	ER/Apm	1415	3150
	CI08887/CI05761	1750	2827
	Giza 121/-	1815	2983
	Cm/3/Api/-	1702	3481
	Pitayo/-	1569	3238
	Roho/Mazurka	1736	3163
	Salmas	1542	2721
	As46/Aths*2	2152	3775
	Iris/Nopal'S'	1996	3690
	means	1786b	3280a
DRY	Harmal	1510	3014
	Tadmor	1648	3374
	Arta	1787	2974
	SLB 39-60	1882	3071
	SLB 39-10	1741	3175
	WI 2291	2259	3175
	WI 2269	1538	2911
	Wadi Hassa	1646	2907
	Deir Alla/DL71	2033	3714
	Arabi Aswad	1897	3337
	Zanbaka	1874	3406
	means	1801b	3187a
$L.S.D._{0.05}$			
Lines x Fert.	814		
Groups x Fert.	251		

Table 27. Grain yield (kg/ha) of 10 barley lines adapted to wet environments and 11 barley lines adapted to dry environments with and without fertilizer (means of 11 locations).

Environment of adaptation	Line	without fertilizer	with fertilizer
WET	Rihane-03	483	709
	ER/Apm	405	767
	CI08887/CI05761	504	705
	Giza 121/-	400	517
	Cm/3/Api/-	377	511
	Pitayo/-	406	690
	Roho/Mazurka	506	784
	Salmas	389	574
	As46/Aths*2	426	690
	Iris/Nopal'S'	385	606
	means	428d	655b
DRY	Harmal	471	801
	Tadmor	549	843
	Arta	604	923
	SLB 39-60	664	906
	SLB 39-10	608	907
	WI 2291	535	669
	WI 2269	468	748
	Wadi Hassa	544	866
	Deir Alla/DL71	273	449
	Arabi Aswad	501	837
	Zanbaka	542	828
	means	523c	807a
$L.S.D._{0.05}$			
Lines x Fert.	195		
Groups x Fert.	60		

In the absence of fertilizer the lines selected for dry environments had a higher number of heads/m^2 but were slightly shorter (Table 28). Zanbaka was an exception and was the tallest entry independent of fertilizer. All locations in 1990 and 1991 were dry or very dry.

Table 28. Plant height and number of heads/m^2 of 10 lines adapted to wet environments and 11 lines adapted to dry environments with and without fertilizer (means of 11 locations).

Environment of adaptation	Line	PLANT HEIGHT		NR HEADS/M^2	
		F+[a]	F-	F+	F-
WET	Rihane-03	34	33	311	216
	ER/Apm	26	23	281	234
	CI08887/CI05761	26	25	285	210
	Giza 121/-	28	27	251	189
	Cm/3/Api/-	30	27	288	221
	Pitayo/-	27	25	318	253
	Roho/Mazurka	27	26	332	254
	Salmas	30	30	226	157
	As46/Aths*2	33	31	349	212
	Iris/Nopal'S'	34	32	351	265
	means	30a	28c	299a	221c
DRY	Harmal	32	29	340	260
	Tadmor	30	30	389	319
	Arta	24	23	328	271
	SLB 39-60	25	25	297	246
	SLB 39-10	25	25	296	254
	WI 2291	33	32	282	256
	WI 2269	32	29	303	240
	Wadi Hassa	25	24	323	257
	Deir Alla/DL71	28	28	272	230
	Arabi Aswad	32	31	348	297
	Zanbaka	38	35	320	251
	means	29b	28c	315a	262b
$L.S.D._{0.05}$					
Lines x Fert.		3		55	
Groups x Fert.		1		17	

[a] F+ with fertilizer, F- without fertilizer

The trial will be repeated during the next cropping season to verify that the lines selected for wet environments do actually perform better than the lines selected for dry environments at high rainfall sites.

M. Jones and S. Ceccarelli

2.1.10. Collaboration with Perugia University

In the framework of the collaborative project "Improving yield and yield stability of barley in stressful environments" three major research activities were conducted at the Plant Breeding Institute of the University of Perugia:

1. evaluation of barley genotypes under low input conditions;
2. evaluation of barley genotypes under field conditions and under rainshelter;
3. evaluation of genetic differences for growth rate at low temperatures.

2.1.10.1. Evaluation of Barley Genotypes under Low Input Conditions

Trials were conducted without fertilizer to exploit genetic difference at lower input levels than those presently used in Italy. In the first group 18 barley lines selected from nurseries sent from Aleppo were compared with 7 commercial varieties recommended for cultivation in Central Italy. Two sets were planted, one with and one without fertilizer.

The average grain yield of the seven commercial varieties was 6949 kg/ha with fertilizer and 6207 kg/ha without fertilizer. In the fertilized trial the grain yield of the best commercial variety (Fleuret) was 7644 kg/ha. In absence of fertilizer the best commercial variety was Robur with 6955 kg/ha. Three ICARDA lines yielded more than Robur (7444, 7389 and 7022 kg/ha). A second group comprised 190 ICARDA lines and 6 commercial varieties. The best commercial variety was Fleuret (5910 kg/ha). Among the best 20

ICARDA lines that yielded more than the average of the checks (4420 kg/ha) three outyielded Fleuret (6489, 6200 and 5978 kg/ha). Out of the 20 ICARDA lines tested in the third group, five outyielded the best check (Jaidor, 5922 kg/ha). In the fourth group one ICARDA line yielded better than the best check (Barberousse).

2.1.10.2. Evaluation of Lines under Rainshelter

The lines tested in this trial belong to three types of germplasm: commercial varieties, ICARDA lines unrelated to Syrian landraces and Syrian landraces. The trial was conducted at Perugia under field conditions (603 mm rainfall) and under rainshelter (140 mm rainfall). Under rainshelter grain yield was much higher than in 1990 (Cereal Program Annual Report 1990, p.30), one of the reasons being the high humidity level throughout the season.

Table 29. Grain yield (kg/ha) of 6 commercial varieties, 12 ICARDA lines and 7 Syrian landraces under field conditions and under rainshelter (Perugia, 1991).

Material	Field conditions (603 mm)	Rainshelter (140 mm)
Commercial varieties	5530	2330
ICARDA lines	4620	2500
Syrian landraces	3990	2150

Under field conditions commercial varieties outyielded both ICARDA lines and Syrian landraces by 20% and 39%, respectively. Under rainshelter conditions ICARDA lines outyielded commercial varieties by 7% and Syrian landraces by 16% (Table 29).

2.1.10.3. Growth Rate at Low Temperatures

Six barley genotypes were grown for two cropping season (1989/90 and 1990/91) in a field experiment at Leonessa (925 m a.s.l.). Two random samples of 30 cm row were collected on each plot at four different times during the growing period in both season. Total dry weight was recorded in both years, number of plants in the samples was recorded only in 1990/91. Temperatures in 1990/91 were lower than those of the previous season and Harmal did not survive. Alger/Ceres had the highest dry matter production followed by SLB 39-60 and Tadmor. These data confirm previous findings which suggest that germplasm adapted to cool-mediterranean environments have higher growth rates at low temperatures. This is an additional facet to the complex of traits that we call 'adaptation'.

A. Grillo and R. Petti

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2.1.11. ICARDA/CIMMYT Barley Project

2.1.11.1. Development of high yielding barley germplasm with multiple disease resistance for Latin America

The objective is to provide barley varieties, through national programs, to farmers in the Andean Region. These varieties must be resistant to rust (leaf, stripe, and stem) scald, net blotch and BYDV, to reduce the risk of crop losses from these diseases.

Ninety advanced lines were sent for yield tests in Bolivia, Colombia, Ecuador, and Peru.

Fifteen cultivars with good malting quality, as determined by the micro-malt test by IMIT in Mexico, were sent for yield tests in Argentina, Bolivia, Colombia , Ecuador, and Argentina.

Yield data from Cochabamba, Bolivia, showed the highest yielding line produced 7.1 t/ha. Among the malting types, Gloria/Come yielded 6.4 t/ha, compared to the best check variety which yield 5.5 t/ha.

During a May visit to Central and Northern Ecuador, several regional trials were observed. After harvesting these trials, seed of the best four lines will be increased in Cuenca. Possible candidates for release are:

* Cardo"S", CMB 85A-1300-E-15B-5E-0E
* LB Iran/UNA 8271/Gloria/Come, CMB84-1127-D-2B-1Y-2M-0Y
* LB Iran/UNA 8271//Gloria/Come, CMB84-1127-D-1Y-6M-0Y

The last two lines were classified as malting types by both IMIT in Mexico and the INIAP laboratory.

Over summer at El Batan 15 malting types were yield tested at two planting dates (May and June). The May planting was affected by a storm that caused heavy lodging. Stripe rust infection was low as shown by low scores in the susceptible variety, Centinela. By contrast, the June planting had a heavy stripe rust infection. Yield of the highest genotype, Gloria/Copal, was 8.2 t/ha including the border effect.

During Winter at CIANO 275 advanced lines were yield tested under irrigation. During the Yaqui season, a severe epidemic of net blotch naturally infected all barley plots. There was good selection pressure for net blotch resistance as well as for stem and leaf rust.

Because of high temperatures in February a large number of crosses failed. Yields in the Yaqui Valley were considerably lower than the previous year. A check line, 79 W 40762/Puebla de Guzman//Gloria/Copal, had the highest yield (8 t/ha); in the previous year, it yielded 9.2 t/ha.

Cultivars yield tested for the first time in the Andean Region were higher yielding than the best local checks. Ecuador is moving to preliminary seed increase of potential varieties to be released in 1992.

New varieties released in the Andean Region are superior in yield and have good resistance to prevalent diseases; however, diseases such as loose smut, that are easily controlled by seed treatment, could become 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.

H. Vivar

2.1.11.2. Developing early maturity barley with disease resistance

Early maturity is an important trait. Its incorporation into the ICARDA-CIMMYT germplasm provides national programs with an opportunity to select varieties for specific circumstances, such as a cash crop in a rotation that involves several crops per year, or for its utilization in a short season growing period.

Thirty advanced early maturing barleys (EMB) were sent to the Andean Region for yield testing. In the summer at El Batan 60 advanced EMB were yield tested at two planting dates (May and June). The June planting was attacked by stripe rust.

Two lines from INIFAP (M 9872 and M 10080) and two lines from the Program are being increased by Impulsora Agricola as possible candidates for release in Mexico (Table 30). PMI 520 was also selected in Ecuador. Preliminary data are available on its malting quality, determined by IMIT.

Table 30. Yields of 4 lines at El Batan 1991 season.

Line	Days to Heading	Stripe rust leaf	Stripe rust spike	Height	Yield
M9878	49	40 S	50	90	5.6
M10080	49	20 S	10	105	4.9
PMI 520	51	10 S	T	115	5.0
PMI 522	49	5 S	T	105	4.0

Standard error of the mean: 0.314.

During the winter 75 new advanced EMBs were yield tested under irrigation in the Yaqui Valley. The highest yielding EMB (Encino) yielded 1.2 t/ha less than in the previous year. However, the EMBs were less affected by high temperatures in February than normal maturity lines. The Encino line had specific adaptation to conditions present in the Yaqui Valley.

ICARDA-CIMMYT Barley, Project Updates

YAGAN, released in West Australia, is derived from ICARDA-CIMMYT germplasm. Unfortunately the pedigree was lost.

EMBs were promoted for specific circumstances. In Ecuador, the possibility of growing two crops per year is being studied. An early line has been identified and, in 1991, another attempt to plant the line in October will be made.

Seed of a hooded early maturing barley was increased so that large-scale testing can be done. The line will be grown as a companion crop with ryegrass for grazing experiments to be conducted in the Yaqui Valley in a farmer's field.

H. Vivar

2.1.11.3. Developing Hull-less barley with multiple disease resistance

The development of Hull-less barley for hill countries provides farmers with options that reduce work in food preparation, such as sieving to separate bran from the flour.

Thirty advanced hull-less barley lines (six- and two-row) were sent for yield testing in Bolivia, Colombia, Ecuador, Morocco, Nepal, Peru, and the USA (Oregon). Most of the two-row lines have large grains and are sister lines from a cross with "Viringa". Yield of hull-less lines in Bolivia reached 5.2 t/ha. The yield experiments were planted at San Benito Experimental Station in Cochabamba.

In Ecuador, seed of a hull-less 2-row barley line is being increased for potential released as a variety in 1992.

F2 progeny from crosses between NB 1054, an early hull-less barley from Nepal, and sources of stripe rust resistance were selected in Toluca for scald and yellow rust resistance. One plant with better grain type was planted in the greenhouse and two generations (F3-F4) were rapidly obtained in the F5 seeds of 101 lines will be tested for their reaction to stripe rust in both Nepal and El Batan under field conditions. Another group of hull-less lines were tested against different biotypes of BYDV in Mexico under field conditions. Some of these lines showed resistance in Ecuador and Toluca, Mexico.

Poor germination of hull-less barleys in the Yaqui valley has been attributed to using a Pullman thresher, which caused embryo damage.

In Brazil, ACUMAI was released as a commercial variety. It was sent as part of the 5th IBYT, and corresponds to a Japanese variety, Shikoku Hadaka 47, characterized by its high yield and stiff straw.

H. Vivar

2.1.11.4. Developing early barley germplasm with scab and Barley Yellow Mosaic Virus (BYMV) resistance

The farmers of the Yangtze Basin in China require barley varieties with resistance to both Scab and BYMV.

Some crosses were made with Zhedar 1 and Zhedar 2, sources of scab resistance, and Zhedar 4 and Zhedar 5, sources of BYMV resistance. All of these varieties were provided by the Zheijiang Academy of Agricultural Sciences. New crosses were made with winter cultivars that have resistance to BYMV in Europe; among them: Franka, Birgit, Ogra, Melusine, and Torrent. The Bulk Method is used for generation advancement; fungicide is used to protect the lines against rust. In F5 populations, five individual plants per line were advanced for selection, based on agronomic merit and a range of maturities that cover very early types to a maturity similar to the variety Gobernadora.

A set of 186 advanced lines were sent to eight locations: 5 in China, 1 in South Korea, and 1 each in Japan and Thailand.

The variety Gobernadora continues to expand in nine Chinese provinces: Zheijian, Jiangzu, Anhui, Hebei, Hubei, Hunan, Fujian, Guandong, and Shanghai. The total area under cultivation is not known, but in Shanghai Province Gobernadora is grown on 20,000 ha. In Shanghai, a new line, similar in maturity and yield but shorter, could be released soon. In Sichuan Province, the area planted with V-24 is 40.000 ha; yields have reached 20% to 30% over commercial varieties.

Germplasm bred for China was not well adapted to Vietnamese conditions, mainly due to spot blotch susceptibility. Parents resistant to spot blotch were field-tested, and many crosses were made to incorporate spot blotch resistance into early maturing barley. The cultivars Hlla/Gob/Hlla and BRB2 were identified as resistant under Mexican conditions. The variety BRB2 is resistant to spot blotch in Thailand.

H. Vivar

2.1.11.5. Agronomy, medic-barley rotation

Barley monoculture, as practiced in the Upper Plateau of Mexico, has resulted in low yields and great foliar disease pressure. The rotation of a legume with barley is expected to break the life cycle of scald and net botch. Furthermore, the legume could fix N and improve the soil. Ley farming is been presented as a solution to the problem.

The study was carried out on FIRA property where 10 kg of medic seed (Medicago polymorpha) was broadcast on 1 ha previously fertilized with 30 kg of P2O5. The seed was buried by a horse-pulled tree branch. The seed bed was not well prepared, which resulted in a large number of weeds germinating at the same time as the medic.

Heavy grazing was utilized for weed control; a supplementary pass was made with a rotary mower. In some areas, due to weed competition, only a few medic plants established. By October, 60% of the total area had a good medic cover and grazing was stopped so that plants could produce seed.

No bloating was observed in sheep grazing on the medic--mainly due to the large number of weeds present.

Several field days were organized by FIRA personnel to demonstrate the feasibility of Ley farming in Mexico.

At El Batan, seed pod production of M. polymorpha was higher than that of a M. truncatula introduction from Australia.

FIRA personnel will conduct the grazing and extension parts of the Ley farming study.

H. Vivar and I. Ortiz-Monasterio

2.1.11.6. Development of barley resistance to Dwarfing of Narino, BYDV, and leaf and stripe rust for Colombia and Ecuador

Cultivation of barley in southern Colombia and Northern Ecuador suffers from a unique disease complex, that require insecticide application during early growth stages to control the insect vector of Dwarfing of Narino.

Segregating generations from crosses made with resistant parents introduced from Colombia were advanced using the bulk method. Advanced lines, obtained from individual plant selections, are available for testing in Colombia. These lines are resistant to stripe rust (Batan and Toluca) and leaf rust (CIANO) present in Mexico and require testing for Dwarfing of Narino at Sindagua Experiment Station in southern Colombia.

A problem in Colombian germplasm is weak straw that causes lodging. Crosses have been started to incorporate stiff straw.

H. Vivar

2.1.11.7. Development of barley germplasm tolerant to Russian Wheat Aphid

The Russian Wheat Aphid (RWA) is an important pest in several countries of the world. The damage caused by the aphid in barley is severe. Chemical control adds to the cost of barley production. Genetic resistance is the cheapest way to control the pest.

Study on the inheritance of resistance to RWA were commenced. Crosses were made among resistant (Gloria/Come and Ase/2CM//B.7.6.B.B) and susceptible parents (Esperanza and Shyri).

F1 and F2 populations from these crosses were planted at El Batan during the 1990-91 winter cycle. Backcross populations to resistant and susceptible parents were also included in the winter planting at El Batan.

Lines identified as resistant to the RWA were screened for other diseases, such as leaf rust, stem rust, and net blotch, in the Yaqui Valley. Previously, the same lines were scored for their reaction to stripe rust (race 24).

Field scores recorded on barley seedlings for RWA symptoms showed an inheritance mechanism for resistance that may be a dominant trait governed by a single gene. F3 populations will be planted to confirm these results during 1991-92 winter cycle.

Several RWA-resistant lines were also confirmed to be resistant to several diseases. A miscellaneous RWA nursery was established. In the Yaqui Valley, a heavy epidemic of net blotch showed that some lines identified for their resistance to the RWA were extremely susceptible to this disease--and for that reason were discarded.

H. Vivar, P. Burnett, and J. Robinson

2.2. Physiology/Agronomy

2.2.1. Adaptation Strategies Associated with Terminal Drought Stress

Two adaptation strategies to terminal drought stress in Mediterranean environments have been observed. The first strategy, represented by early entries, like WI 2269/WI 2291, WI 2269, Harmal, S BON 96 (Pallidum 10342//CR115/Por/3/Bahtim 9/4/Ds/Apro/5/WI 2291), and Roho, is based upon avoidance of terminal drought stress. Here early heading is combined with good early growth vigor, and an ability to recover from cold damage.

The second strategy, represented by landraces from east and north east Syria (SLB-03 and SLB-45), includes tolerance to low winter temperatures and terminal drought, by combining medium early heading with slow early development: this implies a prostrate winter growth habit and poor early vigor. Since differences in early development are due to a difference in vernalization requirement, the success of each adaptation strategy depends upon the temperature regime in the target environment.

Heading date, and especially consistency of date of heading, is related to the adaptation strategy through vernalization requirement. Irrespective of sowing date the emergence date in northern Syria can vary greatly if the first significant rain is delayed. The range for optimum heading date is between late March and early April. A heading date which is independent of emergence date is important to prevent flowering outside this optimum period. Syrian landraces attain this stability by combining their vernalization requirement with a strong photoperiodic response. With early emergence (end of October), Arabi Aswad is about one week later in heading than WI 2291/WI 2269; with late emergence (early January), the difference is reduced to only three days (Figure 10). The warmer temperatures associated with early seedling emergence slow down vernalization and lengthen the photoperiod insensitive phase of the apex (i.e. the phase prior to spikelet initiation); consequently heading is delayed. The strong photoperiodic response of the landraces from east and north east Syria, which is apparent from their quick development after their vernalization requirement has been met, ensures a stable heading date. The vernalization requirement and strong photoperiodic dependency are the major mechanisms through which local landraces attain a flowering date within the optimum range.

The vernalization requirement also affects yield potential and yield stability. The early entries, with the first adaptation strategy, have significantly higher yields under favourable conditions than the Syrian landraces, indicating the higher yield potential of these early entries. In contrast, yields under stress of the two groups are comparable.

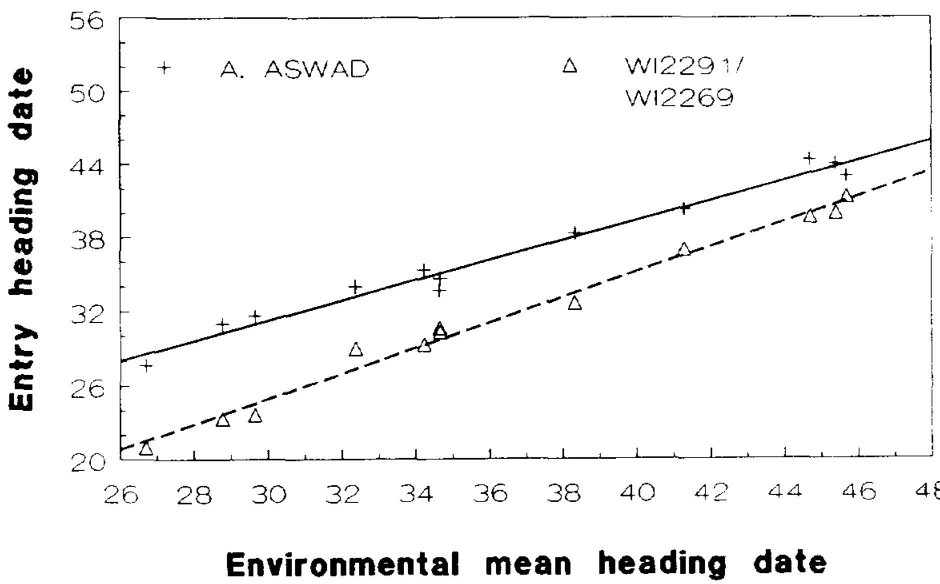


Fig. 10. Number of days from 1st March to heading as a function of the nursery mean number of days from 1st March to heading.

Under stress the landraces show lower year to year yield fluctuations than the early entries. In four environments with a similar yield level (130-150 g/m²), but a range in number of frost days (14 to 44), four out of the five early entries with a high yield potential had a standard deviation which exceeded that of all the landraces (Figure 11). The occurrence of low winter temperatures has an impact upon the yield stability of the crop. Since yield stability is important, especially in lower yielding environments, the probability of occurrence of low winter temperatures in the target environment is an important factor in determining the optimum development strategy. The adaptation strategy of barley breeding material forms the basis of some of our future research.

E. van Oosterom

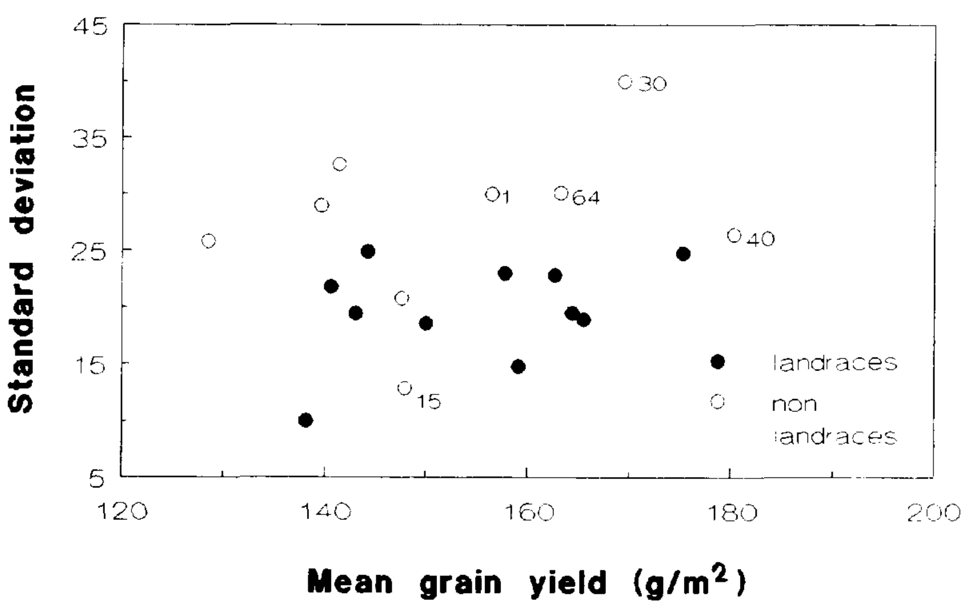


Fig. 11. Relationship between mean grain yield (g/m^2) and standard deviation for two-rowed barley across four environments with similar yield level (Bouider 1985/86, Breda 1985/86, Breda 1986/87, Breda 1988/89) but contrasting winter temperatures. 1, 15, 30, 40 and 64 represent Harmal, WI 2269, WI 2269/WI 2291, Roho, and 5 BON 96 respectively, entries selected for grain yield in both high yielding and low yielding environments.

2.3. Barley Pathology

2.3.1. Introduction

Barley pathology research aims to control barley diseases for present and improved farming systems in countries of the WANA region. Rapidly changing agricultural practices in the region will have a large effect on several barley diseases. Resistance remains the most sustainable method of disease control and the testing of material generated by ICARDA's and NARS' breeding projects takes most of the barley pathology resources. Presently germplasm is screened in the field for four diseases, scald (Rhynchosporium secalis), powdery mildew (Erysiphe graminis), covered smut (Ustilago hordei) and common root rot (Cochliobolus sativus). Seedling tests are carried out for barley leaf stripe (Pyrenophora teres) and netblotch (Pyrenophora graminea). For the 1991-92 season it is planned to improve field screening for leaf stripe and netblotch as well as for loose smut (Ustilago segetum).

Rather than selecting for high levels of disease resistance, the objective of our screening work is to eliminate susceptible lines as the environments in which barley is normally cultivated in WANA do not encourage the development of most leaf diseases. However, highly susceptible lines will suffer losses, as can be seen with scald in Syria. Determining the level of resistance needed and developing methods to measure this quantitatively are a high priority.

Barley pathology research focussed on diseases of special importance in the dry areas. Resistance to seedborne diseases is necessary in marginal regions as farmers do not protect seed by fungicides. The importance of dryland rootrots is not yet fully understood and our research aims to determine its relevance in different agro-ecological zones.

2.3.2. Covered smut

Since the introduction of effective and relatively cheap seed treatments, there has been a decline internationally in studies on cereal smuts . However, germplasm for the ICARDA mandated region needs adequate levels of resistance. Chemical protection is unrealistic for the time being as fungicides are not always available, and the development of fungicide tolerance within the pathogen is also possible.

Smuts are present in most farmer's fields throughout the region, but incidence is usually low. The large variability in disease resistance within local barley populations could provide stable protection against smut epidemics. Varieties released without proper testing may encounter problems. Jordanian farmers noticed high levels of loose smut (Ustilago segetum) on the variety Acsad 176, while in 1991 over 10% covered smut (Ustilago hordei) was present on the Czechoslowakian malting variety 'Crystal' grown on large scale at Tel Hadya.

Six years ago a screening program for resistance to covered smut was started. Breeding material is rated after seed inoculation with a mixture of Syrian pathogen strains. Inoculation methods were modified to cope with the large number of entries (Cereal Program Annual Report, 1986). During the first two seasons, trials were sown at a high seed density and the percentage of smutted heads was noted at the end of the season. Since 1987, trials are space planted to enable the evaluation of individual plants. The number of smutted tillers per plant is noted and the percentage of plants with at least one smutted tiller is calculated.

Comparing experiments over years shows considerable variation in the performance of different varieties. Data on five varieties, planted as checks in different nurseries, show that 'Faiz' and 'Harmal' remained rather constant in their performance between years. However, the susceptible checks 'WI2291','Tadmor' and 'Heines standard' differ greatly from one year to the other (Table 31).

Covered smut is highly variable in its virulence. Multi-location screening, as used for leaf diseases, cannot be employed for seedborne pathogens as all outgoing seed is treated with fungicides. The variation within and between years, as well as differences in virulence within the WANA region would make field screening of questionable use. The virulence of the mixture of Syrian smut strains used for inoculation was checked during the 1990-91 season on a set of differentials supplied by Dr P.L. Thomas (Agriculture Canada, Winnipeg). All differentials were affected (Table 32), indicating the presence of a wide range in virulence.

ICARDA's barley breeders have not so far tried to incorporate smut resistance. On the contrary, a number of highly susceptible lines have been used extensively in the crossing program. Out of the 240 advanced breeding lines tested for resistance to covered smut during 1990-91, 76 lines were derived from crosses with WI2291, WI2269 , WI2198 or WI2197. Average smut infection of these lines was 11%, as compared to 7% for the other 164 lines. Crosses with local Syrian germplasm rated more susceptible (13% for 13 lines). Avoiding susceptible parents would improve the level of smut resistance. However, even within crosses involving susceptible parents there is variability among sister lines which allows negative selection against susceptibility.

Table 31. Performance of check varieties in six years covered smut tests.

Percentage smutted heads, based on 5 g seed per 2 meter row

Name	1985-86 Mean	sd	range	N	1986-87 Mean	sd	range	N
Faiz	0.0	-	-	2	0.7	1.2	0-42	0
Rihane-03	0.0	-	-	6	(not tested)			
Harmal	0.0	-	-	2	0.4	0.8	0-2	20
WI2291	4.2	2.0	2-7	6	3.8	2.5	0-11	20
Tadmor	13.2	3.9	7-18	6	5.1	4.4	2-8	2
Heines st.	8.5	2.6	4-14	20	1.3	1.3	0-4	20

Percentage smutted plants, based on 20 seeds per 2 meter row

Name	1987-88 Mean	sd	range	N	1988-89 Mean	sd	range	N
Faiz	2.3	3.8	0-10	10	4.4	8.1	0-18	8
Rihane-03	0.0	-	-	10	0.0	-	-	8
Harmal	2.5	4.3	0-12	10	3.9	7.2	0-17	8
WI2291	7.8	6.6	0-20	10	3.5	6.5	0-14	8
Tadmor	(not tested)				10.8	8.4	0-25	8
Heines st.	13.2	11.9	0-33	10	5.2	7.4	0-17	8

Percentage smutted plants, based on 50 seeds per 4 meter row

Name	1989-90 Mean	sd	range	N	1990-91 Mean	sd	range	N
Faiz	3.8	8.0	0-25	10	4.4	4.5	0-12	8
Rihane-03	0.0	-	-	8	0.8	2.1	0-6	8
Harmal	3.5	3.8	0-8	8	8.8	4.9	4-17	6
WI2291	34.2	17.6	5-59	8	58.4	15.3	32-83	8
Tadmor	35.4	21.2	10-69	8	51.5	6.7	40-59	6
Heines st.	(not tested)				(not tested)			

Table 33 lists crosses with three or more sister lines in the advanced yield trials, of which at least one line showed more than 15% smutted plants. In 11 out of 13 crosses significant differences among sister lines were present.

The landrace line 'Tadmor' is highly susceptible to covered smut and within the advanced breeding lines tested, crosses with 'Arabi abiad' were often susceptible as well. However, sources of smut resistance can be identified in local Syrian germplasm. Out of 300 lines from 15 different collection sites, 14 lines were highly resistant (< 1% smutted plants) and 35 were moderately resistant (< 5 %) in two consecutive years of testing.

Table 32. Reaction of eight covered smut differentials to inoculation with a mixture of Syrian strains of Ustilago hordei in field tests at Tel hadya, 1990-91.

Cultivar	% smutted plants[1)] Mean	sd	% smutted tillers[2)] Mean	sd
Himalaya	11.8	6.1	81	22.0
Trebi	13.3	5.9	72	32.4
Excelsior	15.5	4.4	93	14.0
Hannchen	18.5	3.7	86	20.3
Pannier	23.5	4.9	58	17.0
Lion	23.5	6.2	83	10.8
Nepal	66.5	47.4	59	58.7
Odessa (univ. susc.)	35.0	15.6	100	0.0

1) % plants with at least one smutted tiller
2) % smutted tillers of plants with at least one smutted tiller
Means based on four plots of 4 m each planted with 50 seeds.

Lines with acceptable level of resistance were even found in the landrace population from which 'Tadmor' originated. Table 34 summarizes the results of two years testing, in which 20 other single head progenies from the same collection site (SLB-03) were compared to 'Tadmor'. Results show that the susceptibility of 'Tadmor' is an exception within this landrace, all other single head progenies tested were significantly less smutted.

Table 33. Variability in covered smut resistance among of sister lines[1].

Cross	Code	Aver.	range	N[2]
Kv//Alger/Ceres,362-1-1/3/WI2198	83-0369	4.6	0-17	5
Arr/Esp//Alger/Ceres,362-1-1/.....	83-0435	5.8	1-16	4
WI2291/Bgs//Harmal-02	83-0297	6.1	0-15	10
ER/Apm//Lignee 131	83-0556	7.0	0-26	5
WI2269/Salmas	83-0799	7.7	0-18	7
ER/Apm//Espe	83-0560	8.5	4-16	6
Apm/HC1905//Robur/3/Arar	85-0121	8.5	0-20	4
Esp/1808-4L//Harmal-02	82-0783	11.3	0-30	6
WI2269/Espe	83-0806	11.4	0-24	11
Harmal/Arabi Aswad	85-1566	12.0	6-16	3
Rihane-05/Arar	83-0077	12.7	0-26	3
Weeah 11//WI2291/Bgs	83-1826	14.0	10-16	3
Arar/PI 386540	84-1739	22.8	8-40	5

LSD ($p = 0.05$) among the 72 lines tested 11.7

[1] Crosses with at least three sister lines in Advanced Barley Yield Trials 1990-91, of which at least one had 15% or more smutted plants.

[2] Average percentage of smutted plants per cross, least and highest affected line and number of sister lines per cross. Each line tested in two replicates, each planted with 50 inoculated seed.

Table 34. Variability in covered smut resistance among 20 single head progenies originating from the same population as 'Tadmor' (collection site SLB-03)[1].

Sel No.	89-90	90-91	Aver.	Sel No.	89-90	90-91	Aver
010	6.0	31.0	18.5	059	11.5	31.5	21.5
081	22.5	36.0	29.3	061	8.5	19.5	14.0
026	5.0	26.0	15.5	067	30.0	43.5	36.8
029	9.0	36.0	22.5	068	12.0	31.5	21.8
030	3.0	24.0	13.5	071	10.0	39.0	24.5
035	21.0	54.0	37.5	079	4.5	36.0	20.3
043	13.5	35.5	24.5	088	4.5	20.5	12.5
047	17.0	26.5	21.8	095	8.5	41.5	25.0
051	4.0	11.5	7.8	096	13.0	34.5	23.8
054	13.0	18.5	15.8	100	0.0	10.5	5.3
Tadmor	33.5	64.0	48.8				

[1] Percentage of smutted plants (based on two replicates each planted with 50 inoculated seed), for two years tests.
LSD ($p = 0.05$) among averages = 10.6.

Root rot studies

The reasons for intensifying research on Common Root Rot (CRR, Cochliobolus sativus) were given in the 1990 Annual Report. Experiments were carried out on inoculation methodology, pathogenicity tests of different isolates, resistance screening (both in the field and using seedling tests in growth chambers), crop loss experiments and the effect of fungicides. Field screening for resistance and crop loss studies are reported here. The effect of seed treatment with fungicides is discussed later.

Resistance screening

One hundred and fourteen barley lines (100 pure line selections from Syrian and Jordanian landraces and 14 lines from other sources) and three wheat cultivars were field tested for response to CRR inoculation at Tel Hadya. A mixture of C. sativus strains originating from last year's root rot experiments was used. Significant differences in CRR symptoms were found among and within the tested landraces as well as among improved lines. The wheat lines (Mexipak, Nesser and Haurani) had few symptoms, confirming reports of the higher susceptibility of barley to CRR (Piening et al., 1976). An interaction between variety and inoculation was noted for emergence. Tests in growth chambers showed that these differences were related to the effect of inoculation on coleoptile length. The methodology used and varietal differences in expression of CRR symptoms after inoculation are described elsewhere in detail (van Leur 1991b).

Crop loss experiments

The effect of CRR seed inoculation on yield was tested for five barley lines. 'Local Balawieh White' is a landrace from a farmer next to Tel Hadya research station. Two lines ('Tadmor' and 'Arta') are pure line selections from local landraces, the other two lines ('WI2291' and 'Furat 2') originate from the Waite Institute (Glen Osmond, South Australia). In contrast to the results described above, inoculation had no effect on seedling emergence (Table 35). Possibly this effect is only detectable at low seedrates.

At maturity around 40 plants per plot were evaluated for rootrot symptoms by estimating the percentage of the subcrown internode (SCI) covered with dark-brown lesions. Response to inoculation was variety dependent (significant interaction Table 35). Inoculation increased symptoms on 'Arta', 'WI2291' and 'Local Balawieh White'. In seedling tests 'Tadmor' is one of the most C. sativus resistant entries. In the field it shows a high degree of discoloration in check plots, but CRR symptoms are hardly increased by inoculation. In the variety screening experiment described above a number of other landrace lines showed a similar behavior.

Table 35. Effect of seed inoculation with Cochliobolus sativus on seed emergence and root rot symptoms on subcrown internode.

Variety	No. seedlings /m			perc. SCI affected			
	Check	Inoc.	Ave.	Check	Inoc.	Ave.	
Tadmor	81	82	82	10.0	13.5	11.8	
Arta	79	70	75	4.0	19.8	11.9	*)
Local Balawieh	80	78	79	3.3	14.0	8.6	*)
WI2291	82	80	81	2.8	9.5	6.1	*)
Furat 654	46	45	46	2.5	7.5	5.0	
average	74	71	73	4.5	12.9	8.7	
MS values and significance							
Variety (V)	6459 (0.000)			79.4 (0.029)			
Inoculation (I)	234 (ns)			697.2 (0.000)			
V x I	111 (ns)			48.9 (0.056)			

*) Significant difference ($p = 0.05$) between check and inoculated.

Presently we are determining whether this discoloration is of pathogenic origin. The severity of CRR depends strongly on environmental factors (El-Nashaar and Stack, 1989). As plants react differently to different abiotic stresses, it is likely that resistance will vary over years or environments. Four of these varieties have been tested in inoculated (albeit with different methods) experiments for three consecutive years. Both Australian lines showed large differences among years, while the locally adapted 'Tadmor' and 'Arta' are consistent in their response to inoculation.

No significant effect of inoculation was found on straw yield. The effect of CRR inoculation on grain yield was anomalous (Table 36); The two most susceptible lines had a significant grain yield increase of 10% after inoculation. This may be due to both these landrace lines having large root/shoot ratios, resulting in a limited yield potential under favorable growing conditions. The experiment was irrigated two weeks after planting and growing conditions were highly favorable, as can be seen by the high yield levels. Reduction of the root volume by C. sativus therefore may be an advantage, especially at the end of the season, and result in larger kernels. Kernelweight showed a significant increase of thousand kernel weight for 'Arta' after inoculation (37.0 g vs 41.0 g), but not for 'Local Balawieh'.

'Negative' yield losses associated with CRR have been encountered by other researchers working with C. sativus, but are rarely reported. However, Grey et al. (1991) found in a line-source sprinkler study that inoculation resulted in a yield decrease when plants were under drought stress, but resulted in a yield increase if stress was not present. Inoculation of 'Arta' in the 1988-89 and 1989-90 seasons (both dry years, with resp. 2.3 and 0.9 t grain/ha for check plots) resulted in 15% loss for both years (Cereal Program

Annual Reports 1989 and 1990). C. sativus is an important disease under dry conditions, and it is tempting to speculate about its impact in more favorable environments. Both the pure line selection 'Arta' and the landrace 'Local Balawieh' originate from such environments. The local landrace populations are highly variable for CRR resistance. In favorable years susceptible components might have a yield advantage, while in dry years resistant components will yield more. This hypothesis will be tested next year.

Table 36. Effect of seed inoculation with Cochliobolus sativus on straw and grain yield.

Variety	Straw (t/ha)			Grain (t/ha)			
	Check	Inoc.	Ave.	Check	Inoc.	Ave.	
Tadmor	4.93	4.80	4.86	3.30	3.20	3.25	
Arta	5.83	5.33	5.58	4.05	4.45	4.25	*)
Local Balawieh	5.15	5.23	5.19	3.55	3.83	3.69	*)
WI2291	5.63	5.60	5.61	4.23	4.23	4.23	
Furat 2	5.05	4.75	4.90	4.18	4.03	4.10	
Average	5.32	5.14	5.23	3.86	3.95	3.90	
MS values and significance							
Variety (V)		1.022 (ns)			1.476 (0.011)		
Inoculation (I)		0.306 (ns)			0.072 (ns)		
V x I		0.104 (ns)			0.116 (0.027)		

*) Significant difference (p= 0.05) between check and inoculated.

Evaluation of local germplasm

Evaluation of local material is a high priority for barley pathology. Local material is already adapted to the target environment and farmers' preferences and is therefore more useful in a crossing program than exotic material. Our previous work with Syrian and Jordanian landraces showed large variations in resistance within and between collection sites for all diseases tested. The major conclusions of this work are; (i) evaluation of disease resistance is only meaningful if pure lines are tested, (ii) lines with acceptable levels of resistance to a specific disease as well as very susceptible lines can be found in most populations, (iii) the presence of resistance to a specific disease is not always related to selection pressure of this disease at the collection site, (iv) a large population size is needed to identify lines with combined resistance to more than one disease, and (v) the variability in disease resistance is likely to result in durable disease control.

Future studies on local germplasm will focus on the identification of sites having a high frequency of disease resistance and on the evaluation of large numbers of homogeneous lines from sites where breeders have identified lines with good agronomic performance.

In 1990-91 we used the methodology developed with Syrian and Jordanian germplasm to evaluate landraces from other countries. ICARDA's Genetic Resources Unit collected barley landraces in Algeria, where a favorable environment for the development of barley scald (Rhynchosporium secalis) exists. Nine populations, each one represented by 20 single head progenies, were inoculated with a mixture of Syrian scald strains in the field at Tel Hadya. Nine barley landraces collected from the northwest coast of Egypt were tested in a similar way. The climate of the Egyptian northwest coast is warm and dry (contrasting to that of the collection sites in Algeria) and is unfavorable for scald development. Table 37 shows the variability of the 18 populations for growth habit and for scald.

Table 37. Variability of growth habit and resistance to scald and barley leaf stripe within Algerian and Egyptian barley landraces.

	Growth habit			Scald			Leaf stripe*)		
Location	Mean	Range	CV	Mean	Range	CV	Mean	Range	CV
Algerian germplasm									
DZ-01	3.7	3.0 - 4.3	9	7	3 - 12	36	23	13 - 32	32
DZ-09	3.7	2.5 - 4.5	18	19	5 - 52	67	30	4 - 72	90
DZ-21	3.9	3.3 - 4.5	10	4	2 - 11	71	32	15 - 54	57
DZ-22	3.9	3.3 - 4.5	8	7	3 - 16	58	29	12 - 53	53
DZ-38	4.0	3.5 - 4.5	8	7	1 - 21	63	28	22 - 33	19
DZ-40	4.0	3.5 - 4.5	7	4	2 - 7	35	23	7 - 38	58
DZ-43	4.3	3.3 - 5.0	10	3	1 - 7	55	21	4 - 37	75
DZ-48	4.1	3.5 - 4.8	9	6	2 - 18	73	22	5 - 43	70
DZ-50	3.7	2.8 - 4.8	16	15	4 - 62	92	33	9 - 79	86
Mean	3.9		11	8		61	27		60
Egyptian germplasm									
89004	3.0	1.3 - 4.0	28	53	19 - 82	37	41	18 - 72	56
89013	3.4	1.8 - 4.0	14	48	17 - 80	37	44	16 - 68	48
89021	2.4	1.5 - 4.0	26	58	29 - 87	28	57	15 - 97	59
89023	3.3	1.3 - 4.0	25	39	22 - 57	28	46	30 - 63	30
89028	2.9	1.5 - 4.0	30	37	3 - 70	62	67	18 - 91	45
89032	1.1	1.0 - 1.3	13	81	64 - 92	9	95	84 -100	8
89033	2.8	1.8 - 4.0	25	48	8 - 78	32	44	30 - 55	29
89037	2.5	1.3 - 4.3	40	46	16 - 74	38	30	17 - 53	51
89025	3.8	3.0 - 4.5	11	67	57 - 76	9	11	0 - 29	102
Mean	2.8		24	53		31	48		48

*) Growth habit: 1-5 scale (1= erect, 5= prostate);
Scald: Percentage leaf area affected, 20 single head progenies planted in two replicates.
Leaf stripe: Percentage plants affected, 5 single head progenies planted in five replicates.
Range and coefficient of variation among single head progenies means within a population

Five randomly chosen single head progenies per population were also tested for resistance to a Syrian monospore strain of barley leaf stripe (Pyrenophora graminea), a disease important in both area's of origin. The testing method used is described elsewhere (van Leur 1991a).

The Egyptian material showed a high degree of variability within collection sites. The average CV for growth habit is twice as large as that of the Algerian material. Table 38 summarizes readings on growth habit and scald infection for four Jordanian and 11 Syrian landraces, tested in the same nursery. Variability in growth habit within the West Asian barley landraces is similar to the Algerian material. Most of the Algerian populations (all 6 row barleys) are prostrate, similar to those originating from north and northwest Syria (all 2 row barleys).

The Algerian germplasm had a high level of resistance to the Syrian scald strains used, like the Syrian landraces. The Egyptian populations were generally highly scald susceptible, but lines with a high level of resistance (< 10% scalded leaf area) were identified within the populations 89028 (6 lines) and 89033 (1 line). Lines with a moderate level of resistance (< 20% scalded leaf area) were present in populations 89004 (1 line), 89013 (2 lines) and 89037 (1 line). During the coming season selected lines will be tested against pathogen strains having high levels of virulence, at ICARDA and by cooperating institutions elsewhere.

Apart from population 89025 (which is the only 2-row landrace in all the North African material tested) the Egyptian material is more susceptible to barley leaf stripe. However, in both Algerian and Egyptian variation in resistance was large.

Table 38. Variability of growth habit and resistance to scald within Jordanian and Syrian barley landraces

Location	Growth habit			Scald[1]		
	Mean	Range	CV	Mean	Range	CV
Jordanian germplasm						
JLB 06	3.1	2.7 - 3.8	9	40	13 - 65	40
JLB 07	3.2	2.2 - 4.2	14	35	13 - 48	27
JLB 36	3.3	2.8 - 4.0	9	45	20 - 63	26
JLB 68	2.6	1.2 - 3.8	20	16	5 - 50	71
Mean	3.1		13	34		41
Syrian germplasm						
SLB 39	3.2	2.0 - 4.3	16	18	9 - 33	36
SLB 10	3.5	2.3 - 4.8	17	18	5 - 41	51
SLB 32	3.6	3.0 - 4.5	11	12	3 - 24	61
SLB 66	3.6	2.7 - 4.3	12	4	1 - 23	114
SLB 30	3.7	3.0 - 4.2	10	8	1 - 17	56
SLB 12	4.0	2.7 - 5.0	19	7	1 - 21	73
SLB 40	4.1	3.3 - 5.0	12	7	0 - 32	110
SLB 03	4.2	3.0 - 5.0	13	4	0 - 15	90
SLB 42	4.6	4.0 - 5.0	8	6	1 - 24	85
SLB 19	4.5	1.0 - 5.0	20	4	0 - 17	113
SLB 22	4.3	3.5 - 5.0	10	5	0 - 19	112
Mean	3.9		13	8		82

[1] Growth habit: 1-5 scale (1= erect, 5= prostate);
Scald: Percentage leaf area affected
Population averages and Coefficient of Variation among lines within a population based on 20 single head progenies planted in three replicates.

The North African germplasm confirmed our conclusions from Syrian germplasm, especially on the first three points; (i) The potential for this material in breeding programs for Algeria and Egypt is obvious; (ii) Especially for the highly variable Egyptian populations it is questionable whether the most resistant lines would have been identified if bulk accessions rather than pure lines were used for the evaluation; (iii) The presence of lines with a high level of scald resistance in Egyptian material was unexpected. We will continue the evaluation of this and other North African material, especially for resistance to netblotch (Pyrenophora teres), a disease with increasing importance in this region.

Seed application of fungicides

In the 1990 Annual Report an effect of fungicide seed dressing on frost damage was reported. The experiments were repeated this year at two locations (Tel Hadya and Breda), using five varieties differing in growth habit and frost tolerance. Two fungicides Vitavax 200FF (17% Carboxin, 17% Thiram, recommended rate 2.5 ml / kg seed) and Baytan Universal WS 28.3 (22% Triadimenol, 3% Fuberidazol, 3.3% Imazalil, recommended rate 1.5 g / kg seed) were used.

Effects on cold damage could not be confirmed, as no major frost occurred in the 1990-91 season. Imazalil (one of the components of Baytan Universal) is reported to protect against Common Root Rot (Chinn et al., 1980). The experiment in Tel Hadya was evaluated for CRR by scoring the extend of the discoloration of 20 subcrown internodes (SCI's) per plot. Plants in Breda could not be evaluated as SCI's were too short. Analysis showed differences in the percentage SCI with dark-brown lesions between treatments (p= 0.0003) and varieties (p= 0.0138). The Imazalil containing fungicide Baytan Universal reduced CRR symptoms dramatically, while Vitavax has no significant effect (Table 39). Treating seed with Baytan resulted in shorter SCI's (averaged over varieties 17 and 14 mm for recommended and double rate, compared to 24 mm for the check). This might have an effect on infection by CRR, while deeper crowns will be an advantage for plants recovering from frost damage.

Table 39. Effect of seed dressing on CRR symptoms[1] in Tel Hadya.

Variety	check	Vitavax recom.	Vitavax double	Baytan recom.	Baytan double	mean
Roumi	34.0	19.5	12.0	8.0	2.0	15.1
Local white	22.0	10.5	17.5	5.0	0.5	11.1
Wadi hassa	13.5	16.0	15.0	0.5	1.0	9.2
Arta	4.5	12.0	2.5	1.5	1.5	4.4
Harmal	9.0	5.0	7.0	0.5	0.5	4.4
Mean	16.6	12.6	10.8	3.1	1.1	8.8

[1] Percentage SCI covered with dark brown lesions
LSD (p=0.05) between Varieties or between Treatments = 6.75, between Variety - Treatment combinations = 15.12

The experiment at Tel Hadya was harvested after the hail storm of 22 May and yield data are unreliable. Yield data from Breda are presented in Table 40. Differences in yield among varieties

Table 40. Effect of seed dressing on grain yield[*] in Breda.

Variety	check	Vitavax recom.	Vitavax double	Baytan recom.	Baytan double	mean
Roumi	984	959	958	975	834	942
Local white	850	650	784	1034	667	797
Wadi hassa	792	858	1067	1146	784	929
Arta	1008	692	1125	1017	925	953
Harmal	1000	1009	1158	1175	1109	1090
Mean	927	833	1018	1069	863	942

[*] grain yield in kg/ha
LSD (p=0.05) between Varieties or between Treatments = 158, between Variety - Treatment combinations = 355

(p = 0.0182) and treatments (p= 0.0244) were present, but no clear tendency could be distinguished. Doubling the rate improved yield for Vitavax, but depressed yield for Baytan. Phytotoxic effects of Baytan have been reported (Goos et al., 1989), while the higher yield for the double Vitavax and the lower Baytan rate could be due to control of dry seed decay as Imazalil gives far better control of Penicillium spp. than Carboxin and Thiram (Mathre and Johnston, 1991).

Within the present experiment no interaction between varieties and seed treatment was detected for yield or CRR symptoms. However, during the past two seasons we have found that fungicides, applied to control seedborne diseases, have effects on frost resistance and on non-target diseases like Common Root Rot and Dry Seed Decay. Within the barley germplasm pool differences exist for resistance to these stress factors. The use of fungicides for seed dressing is necessary to avoid contamination of outgoing material with seedborne diseases. However, breeders should realize that these chemicals influence the performance of the germplasm, and that selected lines might perform differently under farmer's conditions when other or no fungicides are used.

J. van Leur

2.4. Entomology

2.4.1. Wheat Stem Sawfly

Screening

Table 41 summarizes several years data for wheat stem sawfly resistance over the years for selected lines in caged screening trials at Tel Hadya.

Several lines which had, in the past, formed the core of wheat stem sawfly resistant germplasm pools suffered high infestation this season. Even though drought depressed spring sawfly populations in the field, the caged sawfly screening trials using laboratory reared sawflies were more effective than those of 1989/90. Percent sawfly infestation of all lines tested was high and normally distributed (Fig. 12). The screening procedure was more discriminating this year than last. This may be due to better synchronization of sawfly introduction to the test plants with the window of optimum plant susceptibility. The window of susceptibility was widened by the initial uniform plant development generated by supplemental irrigation of seedlings in the fall and timely spring rains. In 1989/90, when no supplemental irrigation was employed, sawfly infestations under cages were low and the distribution among lines skewed from normal (ICARDA 1990). The threshold infestation level for retaining newly screened lines for further testing or inclusion in the germplasm pool was about 11% for barley and durum wheat and 20% for bread wheat. Several lines that had consistently been rated sawfly resistant in the past, such as the bread wheat FTA/W71/Imuris, were heavily infested this season and will be retested to ascertain why they performed poorly this season. Supplemental irrigation of sawfly screening trials ensures uniform screening conditions. However, it may also mask linkages between drought tolerance and sawfly resistance that are crucial for sustaining grain yield in the variable rainfed environments of WANA.

Yield Trials of Sawfly Resistant Lines

Sawfly resistant barley, bread and durum wheat were compared with susceptible check varieties at Tel Hadya and on a farmers field 20 km southeast of Tel Hadya near Saraqueb. Agronomic

Table 41. Best performing wheat and barley lines tested for wheat stem sawfly resistance in 1990/91.

Name	Pedigree	Source	SN	%Inf87	%Inf88	%Inf89	%Inf90	%Inf91
Bread Wheat								
Tsi/Vee's'	CM 64335-3AP-3AP-1AP-0AP	WOL88	12	-	-	-	0.83	0
WIR 56915		USSR	548	-	-	-	0.42	0
Spektr-5	-	USSR	4	-	-	5	0	11.67
TI/3/Fn/Th//Nar59*2/ 4/4Bol'S'	CM565569-1AP-1AP-5AP-1AP-1AP-1AP-0AP	WAT88	715	-	6.67	9.18	4.58	15
Fta/W71//Imuris	CMH80A-276-1B-2Y-1B-0Y	WCB87	72	2.91	5	7.10	1.25	37.5
Fta/W71//Imuris	CMHBOA-276-1B-2Y-1B-2Y-2B-0Y	WCB87	71	.83	5.42	1.70	2.08	26.67
Bol'S'/Pvn'S'	CM58696-5AP-2AP-1AP-1AP-0AP	WCM87	42	2.91	10	7.50	3.75	35.83
Rbs/Ti Resel	SWM4781-2S-3AP-0AP-1AP-0AP	WCB87	43	5	8.75	7.90	0	34.17
G11/Ti/3/Kvz//Kal/ Bb/4/Kal/3/Cno/ Chr//On	CM54580-3AP-1AP-2AP-0AP	WCB87	33	3.75	8.75	8.33	0.83	33.33
Y50E/Kal*3//Rg'S'/ Soty/3/Sx/We/4/Bork	CM39867-2S-1AP-0AP-3AP-2AP-0AP	WCB87	159	5.41	7.50	6.68	1.25	35.83
Durum Wheat								
Bit/Creso	CD34346-2TR-2AP-1AP-0AP	DCB87	20	0.83	9.85	7.05	0	11.67
Gezira 17/Scaup	ICD-HA81-1917-3AP-1AP-1AP-	DCB87	37	0.83	5	3.35	0.42	11.67
D-2/Bit	CD20796-4AP-6AP-2AP-0AP	DAT87	116	1.66	9.58	4.58	0.42	14.17
Can2101/Magh//Stk/3/ W11s/65150	CD15111-3S-2AP-2AP-3AP-0AP	DCB87	19	0.83	8.75	6.25	2.92	13.33
Stojocri-6	ICD83-0050-4AP-14AP-TR-3AP-0TR	DAT90	1006	-	-	-	0.42	3.33
Awalbit-1	-	DM	12	-	-	-	0.42	6.67
Cfn/Ian F4 Lan//Jo/ Cr/4/Yel/Sapi/3/ BD1814//BD1708/BD1543	ICD84-0418-3LA-0TR-0AP-0TR	DAT89	108	-	-	6.68	0.83	9.17
Ruff/Fg/Turk 1	ICD81-1033-2AP-2AP-2AP-0AP	DAT89	421	-	-	2.76	0.42	9.17
F/Jo/3/Gu/61-130// Lds/4/D62-11/G11*2// T.dic.V.Vernum	ICD82-1243-16AP-3AP-0AP	DPT87	315	-	7.5	2.93	0	10
Omtel-3	ICD-BM-ABL-413-0AP	DAT89	208	-	-	4.98	2.50	10
D-2/Sham 1	ICD78-0282-10AP-3AP-2AP-1AP-0SH	DAB87	140	-	8.33	5	0	10.83
Barley								
FB73-075	-	BAB85	14	0.83	2.08	2.93	5	13.33
Ager//Api/CM67//3/	ICB81-1275-0SH-1AP-0AP-0AP	BAT88	405	-	7.5	5.03	0.83	16.67
Apm/11012-2// Np CI 00593/3/IFB974	ICB84-1485-4AP-0AP	BAT90	308	-	-	-	2.92	1.67
Arr/Esp//Alger/ Ceres,362-1-1/3/ Kantara	CYB-3778-0AP	BAT89	1202	-	-	6.23	2.5	3.33
Arabi Aswad/WI2269	ICB84-1717-0AP	BAT89	603	-	-	7.90	3.75	8.33
Harmal-02/3/Arr/ Esp//Alger/Ceres, 362-1-1	ICB83-1546-0AP	BAT89	212	-	-	6.23	2.5	7.5
Vino'S'/NS2375// Mari/Aths*2	CYB-3837-0AP	BAT89	520	-	-	10.5	0.83	7.5
Kataja//Esp/1808-4L	ICB81-0738-1AP-0AP-0AP	BAT89	112	-	-	10	2.5	7.5
INRA55-86-2/V1701	ICB82-1140-13AP-0AP	BAT89	209	-	-	6.65	1.25	7.5

SN = Source number; 90 INF 87...91 = percent sawfly infestation in a given year.

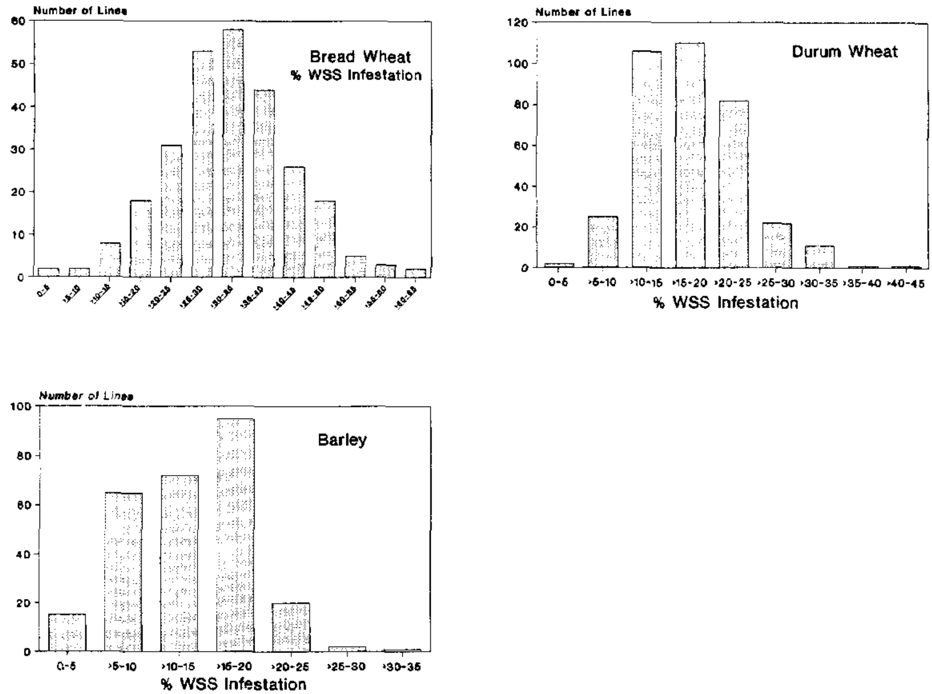


Fig. 12. Frequency distribution of classes of wheat stem sawfly infestation in bread and durum wheat and barley infested in cages in 1990/91.

characteristics as well as yield and percent sawfly infestation were measured (Table 42). The Tel Hadya experiment was irrigated. Within-species differences between resistant and susceptible varieties were harder to detect at Tel Hadya than Saraqueb. All differences in resistance within species were statistically significant at Saraqueb only. However, the only significant difference in grain yield was for barley planted at Tel Hadya where the susceptible outyielded the resistant line.

Table 42. Results of a small scale yield comparison trial in two sawfly infested areas of northern Syria in 1990/91.

	Till/Plnt		Hds/Plnt		% Inf.		Yld/Plnt	
Tel Hadya								
Bar R	2.6	a	0.7	c	0.0	d	0.4	d
Bar S	2.6	ab	2.1	a	4.1	cd	0.8	c
DW R	2.0	c	1.2	b	9.3	abc	1.2	ab
DW S	2.4	bc	2.0	a	13.2	a	1.5	a
BW R	2.4	bc	2.1	a	6.3	bc	1.1	bc
BW S	2.2	bc	1.7	a	10.5	ab	1.4	ab
Saraqueb								
Bar R	1.9	ab	0.8	c	1.6	b	0.4	a
Bar S	2.4	ab	*1.9	ab	8.1	a	0.6	a
DW R	2.2	ab	1.8	ab	0.6	b	9.4	a
DW S	2.5	ab	1.6	abc	12.6	a	0.4	a
BW R	1.8	b	1.2	bc	1.2	b	0.7	a
BW S	2.8	a	*2.2	a	10.2	a	0.6	a

a) Means in columns followed by the same letter are not significantly different at $P < 0.05$.

b) Bar R = resistance barley; Bar S = susceptible barley; DWR = resistant durum wheat; DWS = susceptible durum wheat; BWR = resistant bread wheat; BWS = susceptible bread wheat.

Effect of Row Spacing

Results from a row spacing trial at Breda were inconclusive (Table 43). While resistant varieties had lower infestation rates than susceptible varieties, grain yield differences between varieties and the effects of spacing were not apparent except for a few instances in durum wheat (Table 43). These results support the suggestion that wheat stem sawflies in marginal wheat and barley producing areas affect straw quality rather than in grain yield, an area yet to be examined.

Table 43. Effect of row spacing interval on % sawfly infestation and grain yield per plant, Breda 1990/91.

	% Infestation		Yield/Plant(g)	
	R	NR	R	NR
Barley				
10 cm	2.9 a	4.9 a	0.76 a	0.32 b
20 cm	4.1 a	3.8 a	0.68 a	0.46 ab
30 cm	4.2 a	4.2 a	0.61 a	0.57 a
40 cm	4.6 a	4.7 a	0.68 a	0.37 b
	4.0	4.4	0.68	0.43
Durum				
10 cm	0.0 b	3.2 b	0.39 b	0.47 b
20 cm	3.2 ab	4.3 a	0.40 b	0.40 b
30 cm	3.4 ab	3.0 a	0.47 ab	0.53 b
40 cm	4.1 a	3.6 a	0.64 a	0.77 a
	2.7	3.5	0.48	0.54
Bread Wheat				
10 cm	4.4 a	4.5 a	0.91 a	1.06 a
20 cm	5.4 a	4.3 a	0.69 a	0.70 a
30 cm	2.6 a	6.2 a	0.59 a	0.69 a
40 cm	2.4 a	4.2 a	0.55 a	1.03 a
	3.7	4.8	0.69	0.87

1) Means within a column followed by the same number are not significantly different at $P < 0.05$.

2.4.2. Screening for Russian Wheat Aphid

Barley varieties were screened for resistance to Russian wheat aphid in a plastic house maintained between 25 C and 15 C with a light dark regime of 16L:8D. Five plants of each test line were germinated in a small pot. After two weeks at least one aphid was placed on each plant with a fine paint brush. Leaf striping, rolling, and plant stunting were evaluated on a weekly basis beginning four weeks after plant emergence. Arabi Aswad was used as a susceptible check. Fig. 13A-C presents results of screening a collection of 13 barleys obtained from the Plant Science Research Laboratory (USDA-ARS) in Stillwater, Oklahoma, USA which had been evaluated as tolerant to the US strain of RWA. Fig. 13D presents pooled results of all lines tested for RWA. The USDA barleys had less severe RWA symptoms than the local check. Resistance to stunting in later developmental stages was especially apparent. However, these lines were extremely susceptible to powdery mildew when planted in the ground in the plastic house and lodged prior to heading, the RWA resistance genes need to be transferred into backgrounds more suitable to WANA conditions. The plastic house environment itself may have masked the expression of RWA symptoms, making identification of RWA tolerance levels difficult. The use of hill plots inoculated with RWA in the field, a technique successfully used by CIMMYT to screen for RWA resistance in Mexico, may allow better discrimination between susceptible and resistant varieties and will be tested here. None of the other lines tested showed significant deviation from the susceptible checks.

2.4.3. Effects of Cold on the Expression of BYDV

Following a preliminary study (ICARDA 1990) on the effects of cold stress on BYDV resistance in barley, an expanded experiment was conducted in a Conviron growth chamber using four varieties, Atlas-68, Atlas-57, Corris, and Harmal. The first two lines are genetically similar, but Atlas-68 possess the yd2 gene for BYDV resistance while Atlas-57 does not. Corris also possesses the yd2 gene, but in a background different to the Atlas lines. Harmal is a BYDV-susceptible line commonly grown in Syria. ELISA tests were

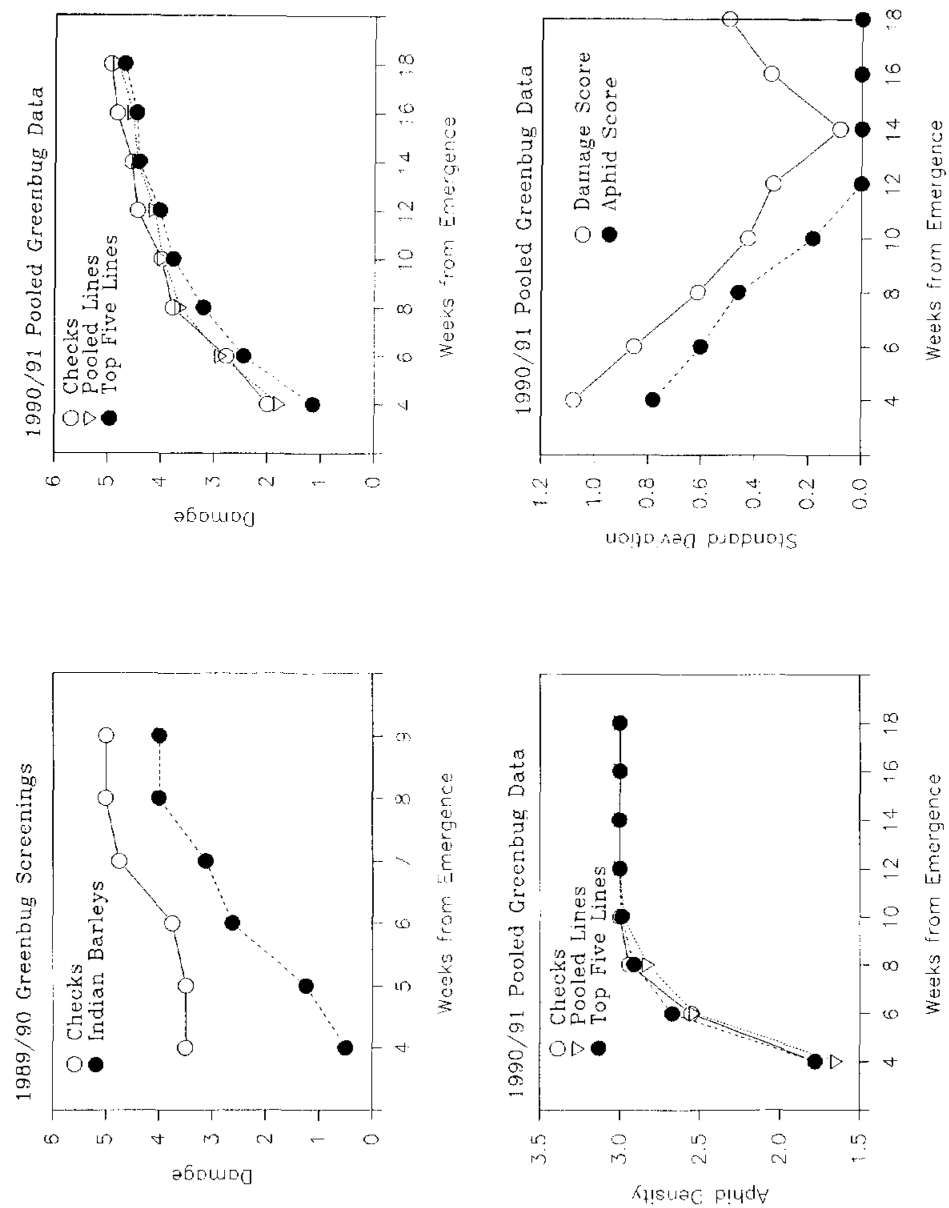


Fig. 13. Results of testing barleys (mean ± SE) against Russian wheat aphid in the plastic house in 1990/91.

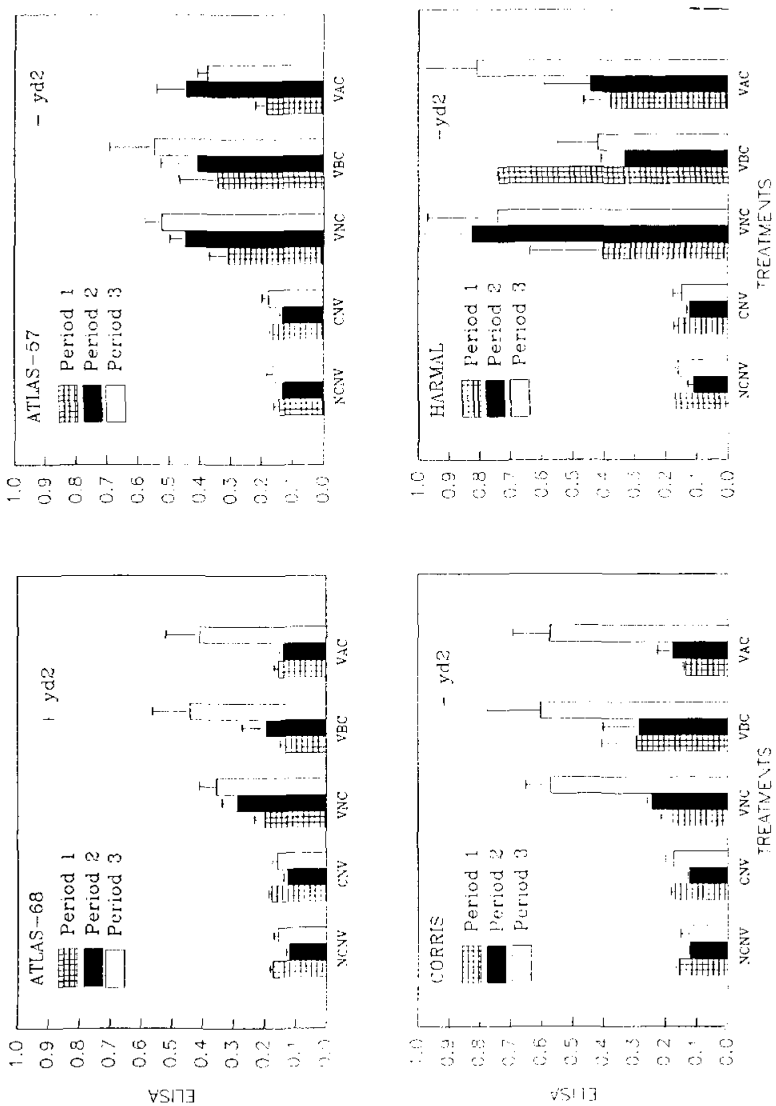


Fig. 14. Elisa values (mean ± SE) for barley lines exposed to various treatments of cold exposure and BYDV inoculation in the growth chamber in 1990/91. NCNC = no cold treatment, no virus inoculation; CNV = cold treatment, no virus inoculation; VNC = virus inoculation, no cold treatment; VBC = virus incoculation before cold treatment; VAC = virus inoculation after cold treatment.

performed on leaves collected from plants on three occasions following different cold regimes and to exposure to BYDV (Fig. 14). ELISA readings, which indirectly reflect virus multiplication levels, were consistently lower in Atlas-68 and Corris than in the susceptible varieties at each sampling period. The effect of exposure to cold was generally greater in Atlas-57 and Harmal than in Atlas-68 and Corris. Virus multiplication levels were similar between Atlas-68 and Corris. The pattern of virus development in the BYDV-susceptible lines was different, with Harmal producing higher but inconsistent ELISA readings. Data from this experiment are being analyzed to isolate the effect of the yd2 gene on ELISA values in the two Atlas lines and its response to cold.

2.5. International Nurseries

2.5.1. Types and Numbers of Nurseries

International barley nurseries available for distribution from ICARDA, Syria, in 1991 are given in Table 44. The spring-type regular nurseries remained the same as last season, except that the segregating populations were not divided into three nurseries. Two specific-trait nurseries, one for naked barley and one for BYDV resistant germplasm, were introduced for the first time.

The winter-type nurseries were upgraded in line with the increased emphasis being placed by the Program on winter barley improvement. The winter and facultative crossing block was a newly assembled nursery. It was the second year that the International Winter and Facultative Barley Observation Nursery was prepared in cooperation with Oregon State University (OSU), USA, to replace the

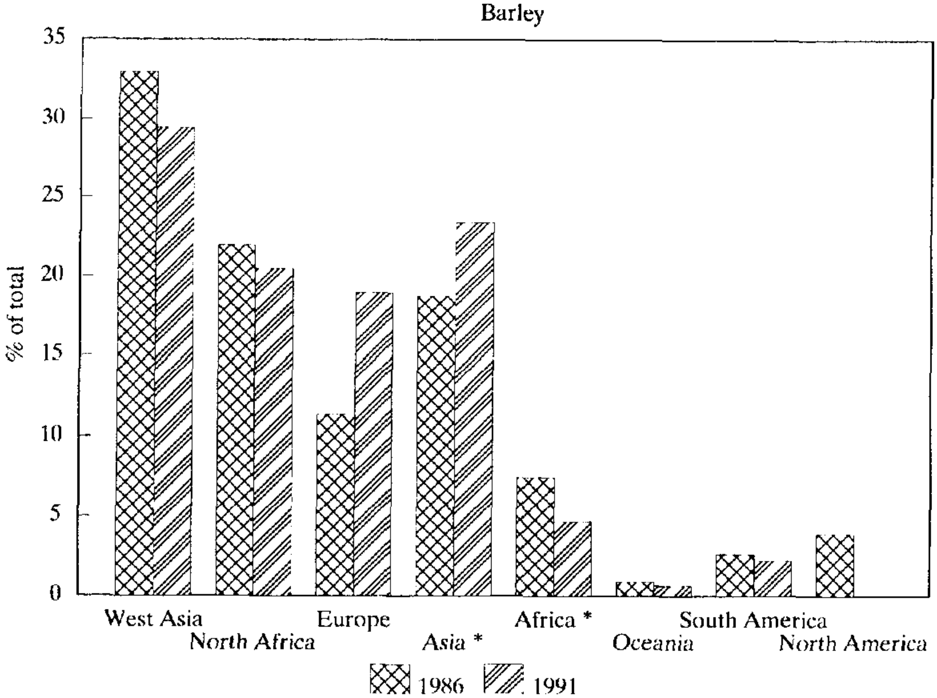
International Winter and Facultative Barley Screening Nursery that used to be assembled and distributed by OSU. The names of other winter and facultative nurseries for high altitude areas were also changed during the season to carry the title of 'International Winter and Facultative'. The change better reflected the ICARDA's world mandate for barley. These nurseries are not restricted to high altitude areas of WANA. The nurseries sent from Mexico through the joint ICARDA/CIMMYT project are not reported here.

In 1991, 499 sets of nurseries were sent to national scientists. Since 1986, the year when a record number of sets (564) were dispatched, nursery distributions are scrutinized more carefully to ensure a better match of nursery to larger environments. There was a seed shortage this year in many nurseries/trials, due to annually increasing requests.

2.5.2. Distribution of Nurseries

The distribution of nursery sets for 1986 and 1991 is compared in Fig. 15. Requests for international nurseries were received from cereal scientists worldwide. In both periods West Asia received the largest share (30%-33%), followed by North Africa and Asia; while Australia, North America and South America received the least number of sets. In 1991, relative to 1986, a larger percentage (19%) of nurseries were sent to Europe, reflecting an increase in requests for winter nurseries.

S.K. Yau



* Asia: excluding West Asia; Africa: excluding North Africa

Fig. 15. Distribution of barley nursery sets in 1986 and 1991.

Table 44. Barley international nurseries for 1991.

Nursery	Abbre-viation	No. of entries	No. of sets distributed
Spring Types			
Regular Nurseries			
Crossing Block	BCB	61	40
Segregating Populations	BSP	66	16
Observation Nurseries:			
- Low Rainfall Areas (Mild Winter)	BON-LRA(M)	66	38
- Low Rainfall Areas (Cool Winter)	BON-LRA(C)	100	39
- Moderate Rainfall Areas	BON-MRA	96	53
Yield Trials:			
- Low Rainfall Areas (Mild Winter)	BYT-LRA(M)	24	51
- Low Rainfall areas (Cool Winter)	BYT-LRA(C)	24	38
- Moderate Rainfall Areas	BYT-MRA	24	61
Germplasm Pool			
Naked Barley	BN	70	27
BYDV resistance	BYDV	21	24
Sub-total			387
Winter and Facultative Types			
Regular Nurseries			
Crossing Block	IWFBCB[1]	83	22
Segregating Populations	IWFBSP	150	22
Observation Nursery	IWFBON	150	41
Yield Trial	IWFBYT	24	27
Sub-total			112
Total			499

[1] IWF - International Winter and Facultative

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3. SPRING AND FACULTATIVE DURUM WHEAT IMPROVEMENT

3.1. Spring Durum Wheat Breeding

Environmental conditions this season impaired the development of early yield components and caused leaf rust post anthesis. Selection for resistance was made in all breeding material. Grain yield was more influenced by size and weight of kernels than by tillering.

The release and cultivation of high yielding and stress tolerant durum wheat cultivars has increased in the WANA region. High durum wheat yields were achieved largely because of the use of stress tolerant and stable varieties, in both dryland and irrigated areas. Varieties such as Cham 1, Waha, Petra, Cham 3, Sebou, and Omrabi are grown over large areas of the region. Six years after release Cham 1 is grown on more than half million hectares in Syria; similar results have occurred in other countries of the WANA region. In addition, the area sown to Cham 3, a drought tolerant cultivar adapted to the Middle East increased greatly as it has high yield performance under drought and good grain quality. In 1990/91 season 62.000 tons of certified seed of Cham 3 was produced in Syria whereas only 40.000 tons of Cham 1 was produced. The new cultivar Lahn is being grown extensively in high rainfall and irrigated areas of Syria. It is replacing Cham 1 and already covers more than 15.000 hectares. In North Africa, Omrabi and Brachoua show high and stable performance. Omrabi lines have been released in Tunisia, Algeria, and Morocco, and Brachoua is under increase in Libya.

M. Nachit

Work Done During Sabbatical Leave

1) GE interaction studies

Linear regression techniques and the Additive Main effects and Multiplicative Interaction (AMMI) models were compared using the durum wheat multilocation trials from WANA. The AMMI model sum of squares (SS) explained 3 times more of GE interaction variation than the regression model. The first Interaction Principal Component Axis (IPCA) was associated with site grain yield, nitrogen fertilization, irrigation, latitude, altitude, and rainfall.

The association of morpho-physiological traits with genotypes' grain yield across environments, and the first Interaction Principal Components Axis (IPCA1) were also analyzed. Genotype grain yields and IPCA1 were strongly associated. Grain yields were associated positively with early vigor, productive tillering, spikelet/spike, and leaf rolling index, and negatively with height, anthesis, maturity, and leaf posture. IPCA1 however was correlated negatively with productive tillering, spikelet/spike, postmeridian leaf rolling, leaf rolling index, and positively with height and peduncle length. Morpho-physiological traits showed strong positive associations between early growth vigor and productive tillering with leaf rolling index, and strong negative associations with the phenology traits: days to anthesis and maturity. Grain filling period was correlated positively with peduncle length and leaf posture and negatively with canopy temperature.

The relationships between environmental parameters and morpho-physiological traits with IPCA1e and IPCA1g reflected the yield of sites and genotypes. Stable genotypes had IPCA1g score close to zero, while specifically adapted genotypes had large scores. Superimposition of cluster analysis on a IPCA1-IPCA2 biplot produced five main clusters that were environmentally and biologically interpretable.

2) Use of RFLPs techniques in durum wheat breeding

A preliminary survey in durum wheat using one restriction enzyme and 56 single copy genomic DNA clones from Cornell University showed 65% of clones were polymorphic. When three restriction enzymes and 22 single copy genomic DNA clones were used 90% of the clones were polymorphic. The variability in the landrace Haurani and T. monococcum accessions was studied using RFLP. The landrace Haurani is composed predominantly of two genotypes.

M. Nachit

Breeding and Selection Methods

To broaden the genetic base of durum wheat, crosses were made with landraces from different countries in the region, as well as wild relatives.

1) Utilization of landraces

Crosses with landraces from Turkey (5), Maghreb countries (76), and Cyprus (79), were used to improve durum wheat lines, particularly those carrying disease and wheat stem sawfly resistance.

2) Utilization of wild emmer

Twenty three crosses between advanced lines and wild emmer (*T. dicoccoides*) were made in the 1990/91 season to improve grain quality and resistance to *Septoria tritici* and yellow rust. Back-crossing to durum wheat was used to eliminate undesirable traits.

3) Utilization of wheat relatives

Forty-seven crosses were made with *T. monococcum* to incorporate earliness, rust resistance, and early plant vigor in durum wheat. Twenty backcrosses followed. Several crosses were also made with *Aegilops* ssp., *T. carthlicum*, *T. turanicum*, *T. compactum*, *T. timopheevii*, *T. araraticum*, and *T. dicoccum*.

4) Recurrent selection

Landraces, *T. dicoccoides*, and wild relatives were crossed with advanced durum wheat lines having high grain yield, yield stability, multiple biotic and abiotic stress resistance in the recurrent selection program. The Middle East durum wheat recurrent selection population (ME-DRSP) is for continental Mediterranean climate and the Maghreb-Iberian population for Mediterranean areas with mild winters (MI-DRSP). *T. dicoccoides*, *Aegilops* ssp., *T. monococcum*, and *T. dicoccum* were also crossed to advanced durum wheat genotypes and recurrent selection populations developed. The objective is to have durum wheat populations carrying desirable traits from *T. dicoccoides*, *Aegilops*, *T. monococcum*, and *T. dicoccum*.

5) Single seed descent

Four generations per year are grown under green house conditions. The single seed descend method was used for Hessian fly, leaf rust, and Septoria tritici resistance screening. Only resistant plants were selected. In addition, crosses with Hessian fly resistance material were made and advanced to F4 generation.

6) Selection and screening techniques

Gradient selection techniques were used to test for multiple abiotic stress tolerance (drought x heat and drought x cold). Disease resistance was acceptable for yellow and stem rusts, and Septoria tritici. Several lines were developed combining multiple stress resistance.

M. Nachit, A. Asbati, M. Jarrah, and M. Azrak

7) Genetic studies

In a long-term study of selection efficiency using different strategies 4 crosses were grown at Tel Hadya in 2 environments (rainfed and semi-irrigated) and at Breda under rainfed conditions. Visual observations of diseases, agronomic traits, and grain yield were made. Promising F7 families were selected for re-evaluation in contrasting environments in 1992. This will allow the selection efficiencies to be compared.

H. Ketata, A. Sabouni, and M. Nachit

Biotic Stresses

1) Disease resistance

135 crosses were made for *Septoria tritici*, 25 for common bunt, 110 for leaf rust, 40 for stem rust, 32 for BYDV and 67 for multiple disease resistance. All crosses had at least one parent resistant to yellow rust. Crosses with *Triticum dicoccoides* are used to widen the genetic base of resistance to *Septoria tritici* and yellow rust, and to improve nutritional quality.

At Lattakia, large numbers of the segregating populations showed resistance to *Septoria tritici*. The results show a gradual accumulation of resistance genes from different parental materials.

Screening for Leaf rust was performed this year at the following sites. a) Lattakia (also used for *Septoria tritici* and BYDV), b) Tel Hadya for yellow rust; c) and in the summer cycle at Terbol for stem rust, Russian aphid, and BYDV. The results indicate that the summer and winter rust populations are different. Resistance to leaf rust was lower than for the other diseases discussed above. However in the F2, F3, F4, and F5 generations 40% of lines are resistant; in F6 and F7, over 50%.

For multiple disease resistance (*Septoria tritici*, yellow, leaf, and stem rust), 25% of the segregating populations were resistant. However durum wheat leaf rust resistance from Mexico is not holding up in WANA.

2) Insect resistance

a) Wheat stem sawfly

All material is subjected to natural attacks by wheat stem sawfly at Breda and Tel Hadya to identify resistant lines and populations. Several advanced and segregating generations showed acceptable levels of resistance. Resistance in advanced material is not based on the solid stem trait. However, recent crosses with solid stem Moroccan cultivars were made to upgrade resistance.

b) Hessian fly

F4 populations of Hessian fly resistant crosses were sent to the Hessian fly entomology laboratory, INRA, Settat, Morocco, for resistance screening.

c) Aphids

All segregating and advanced materials were exposed to natural infestations of Russian aphid in the summer planting at Terbol. Resistant material was selected and advanced for further selection.

M. Nachit, M. Azrak, A. Asbati, and M. Jarrah

Yield Potential in Mediterranean Environments

Table 45 shows the high performance of Lahn in the farmers' verification trials and in large scale testing. Lahn combines high yield potential with multiple disease resistance, cold resistance, and grain quality.

Abiotic Stress Resistance

1) Drought Resistance

The lack of early rains combined with mild temperatures during the vegetative stage reduced grain yields. Table 46 shows average grain yield (kg/ha) and precipitation (mm) at Breda for 6 consecutive seasons.

Table 45. Performance of Lahn, and the commercial varieties (Cham 1, and Gezira 17) under irrigated conditions in farm verification trials (FVT) and large scale testing in three seasons, 1987/88, 1988/89, and 1989/90.

	Average grain yield (Kg/Ha)	
Cultivar	FVT (1986-1988)	Large scale testing (1989-1991)
Lahn	9529	7695
Cham 1	8995	6125
Gezira 17	7973	5700

FVT = Farm Verification Trials

Table 46. Grain yield (kg/ha) of durum in advanced yield trials (ADYT) at Breda for last 6 years (from 1985/86 to 1990/91).

		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
Mean	286	1359	2079	1198

In 1990/91, the average grain yields of the advanced yield trials was only 68.4% of the average for last 6 seasons. Grain yields of the advanced yield trials ranged from 601 to 1248 kg/ha.

Table 47 shows the yields of most promising lines (GdoVz512/Cit//Ruff/Fg/3/DWL5023 = Wadalmez; GdoVz512/Cit// Ruff/Fg/3/Nile= Genil) under the dry conditions of Breda. These lines originated from crosses made in 1986 and selected in a double stress gradient (moisture and temperature, Annual reports, 1986, 1987, and 1988). Selection emphasized abiotic stress tolerance as well as diseases and sawfly resistance . A modified pedigree/bulk technique with multilocation testing was used. Population selection is made across sites, whilst individual plant selections within populations are made in rainfed conditions at Tel Hadya. Table 47 also shows the performance of Cham 3 and Omrabi 5, newly released cultivars for dry areas in several WANA countries.

Table 48 shows the performance of Omrabi 17 under farmers' dryland conditions for four consecutive seasons. In 1987/88 climatic conditions were favorable and yields were above average. Omrabi 17 also outyielded Haurani, the widely grown Syrian landrace from dry areas in the less favorable seasons of 1988/89, 1989/90, and 1990/91. Cold and drought were severe during the vegetative stage in 1988/89, in 1989/90 frost stress occurred at anthesis and heat and drought at the reproductive stage, while in 1990/91 early drought and leaf rust were the major stresses. The results show the successful combination of moisture stress tolerance and responsiveness to favorable conditions of Omrabi 17.

Table 47. Grain yield of promising lines under dry conditions in comparison with dryland cultivars in 1990/91.

No.	Cross/entry	Grain yield	% of Cham 3	% of Haurani
320	Wadalmez 3	1248	128	147
623	GdoVz512/Cit//Ruff/Fg/3/Pin/Gre//Trob	1248	128	147
704	Genil 1	1169	119	138
321	Wadalmez 4	1122	115	133
301	Blk2//Snip/Magh	1114	114	132
720	Blk2//Snip/Magh	1111	114	132
224	Omguer 2	1098	112	130
820	Khb/Amarelo de barba branco	1094	112	130
102	Omrabi 5	1087	111	128
	Cham 3	978		
	Haurani	846		
	LSD(0.05)	177		

Table 48. Performance of Omrabi 17 and Haurani under dryland conditions in experimental stations and farm verification trials (FVT) and large scale testing (LST).

Variety	1987/88 Bouider	1987/88 Breda	1987/88 FVT	1988/89 FVT	1989/90 FVT	1990/91 LST
Omrabi 17	2420	4372	3469	1118	1261	1270
Haurani	1521	3022	2828	981	1050	957
Omrabi 17 / Haurani	159	145	123	114	111	133
LSD (0.05)	628	539	160	113	102	-
CV	12.8	7.8	9.3	16.6	14.1	-
No. of sites	1	1	10	8	10	2

B-Zone = Low rainfall areas with less than 350 mm in 1987/88, and less than 250 mm in 1988/89 and 1989/90.

2) Trait Association in Dry Conditions

Morpho-physiological traits (Table 49) associated with grain yields for the last three consecutive years were: early anthesis, fertile tillering, and peduncle length. These results are in agreement with earlier findings (Nachit and Jarrah, 1986). Other traits, however, varied from season to season. In 1990/91, grain yield was associated with most morpho-physiological traits, the exception was plant vigor. However, compared with previous years, fertile tillering showed a weak association with grain yield.

Table 49. Correlations between grain yield under dry conditions and some morphophysiological traits in three seasons.

Trait	Correlation Coefficient		
	1988/89	1989/90	1990/91
Plant vigor	0.51 ***	0.11	0.11
Days to anthesis	-0.53 ***	-0.53 ***	-0.34**
Days to maturity	-0.36 **	-0.09	-0.30**
Fertile tillering	0.33 **	0.64 ***	0.200**
Peduncle length	0.27 *	0.67 ***	0.370***
Spikelets/spike	-0.23 *	0.48 ***	0.49***
Kernels/spikelet	0.01	0.51 ***	0.44***
Plant height	0.02	0.60 ***	0.33***
1000 kernel weight	0.01	-0.08	0.56***

*, **, *** Significant at 5, 1, and 0.1% levels, respectively.

3) Cold and Frost Resistance

Screening for cold and frost tolerance was impeded by the absence of cold spells in 1990/91. The results of joint studies with University of Hohenheim confirmed the results of previous years:

Parameters of spike development of a genotype are related to the winter temperatures. Slow spike development was associated significantly with cold and frost tolerance. The results of this work will be presented as a Ph.D thesis.

4) Resistance to Heat and Terminal Stresses

Table 50 shows the best lines (Lahn//Gs/Stk; GdoVz512/Cit//Ruff/Fg/3/Nile= Genil) under terminal stress (Late planting at Tel Hadya) in 1991. Genil performed well in both dry and terminal stress conditions (Table 50).

Table 50. Grain yield of promising lines under terminal stress conditions in comparison with checks in 1990/91

No.	Cross/entry	Grain yield	% of Stork	% of Cham 3
809	Lahn//Gs/Stk	1131	171	192
704	Genil 1	1039	157	176
113	Rufom 6	977	148	169
318	Genil 2	977	148	169
823	Mrb3/4/Bye*2/Tc//ZB/W/3/Cit	969	147	165
	Stork	661		
	Cham 3	589		
	LSD (0.05)	182		

Late planting with irrigation is used to test for earliness and heat tolerance. Table 51 shows some advanced lines outyielded high performing cultivars under high temperature conditions. Selections under summer and late planting conditions at Tel Hadya and summer conditions of Terbol have generated durum wheat material with high levels of heat and terminal drought stress tolerance.

Table 51. Grain yield of promising lines under heat conditions in comparison with checks in 1990/91

No.	Cross/entry	Grain yield	% of Stork	% of Cham 3
519	Omtel	1428	190	141
317	Genil 4	1372	183	135
318	Genil 2	1305	174	129
419	Mrb3/Lahn	1238	165	122
906	Khb1//BD2014/Rabi	1231	164	121
	Stork	750		
	Cham 3	905		
	LSD(0.05)	372		

Table 52 shows the correlations between grain yield and some morpho-physiological traits under terminal drought stress.

Table 52. Relationship between grain yield and some morphophysiological traits under terminal drought stress conditions.

	Correlation Coefficient			
	1988	1989	1990	1991
Grain yield with:				
Early plant vigor	0.52 ***	0.41 ***	.72 ***	.61***
Days to anthesis	-0.53 ***	-0.61 ***	-0.31 **	-.66***
Spikelets/spike	0.19	0.40 ***	0.36 **	.32**
Kernels/spikelet	0.42 ***	0.46 ***	0.38 **	.38**
Fertile tillering	0.71 ***	0.67 ***	0.62***	.47***
Peduncle length	-0.16	0.36 **	0.63 ***	.80***
Plant height	0.15	0.21 *	0.62 ***	.53***
1000 kernel weight	-0.02	0.07	0.10	.37**

*, **, *** significant at the 5, 1 and 0.1% levels, respectively.

M. Nachit, M. Jarrah, A. Asbati, and M. Azrak

Yield Stability

Mediterranean dryland conditions are characterized by high year-to-year and site-to-site variation, particularly for rainfall and temperature (Nachit, 1986). Climatic conditions between years within an environment can oscillate from stressed to very favorable. Although most seasons are dry, favorable ones occur. Therefore, varieties need stress tolerance and responsiveness to favorable seasons (Nachit, 1989).

Five durum wheat genotypes combining yield performance and stability had higher grain yields and better values for stability than Cham 1 (Table 53). Further, these genotypes are also stress tolerant (Omrabi sister lines or crosses). In addition, earlier results (Cereal Annual Report, 1990) showed yield stability was associated with plant vigor, leaf rolling mechanisms, fertile tillering ability, earliness, leaf temperature, peduncle length, plant height, and number of spikelets/ spike.

Table 53. Yield stability of durum lines in the Mediterranean dry areas, RDYT-LR, 1989/90.

No.	Entry	Mean yield (kg/ha)	Site mean rank	Rank standard deviation
20	Omrabi 3	2733	6.8	6.4
18	Omrabi 5	2618	8.1	5.7
15	Omguer 2	2557	9.9	6.2
21	Korifla	2546	11.1	7.4
14	Omguer 1	2524	10.2	5.0
12	Cham 1	2468	11.4	6.5

In moderate rainfall areas (Table 54) Omrabi 3, 5, and 6 were again the most promising genotypes in the RDYT-MR, 1990. The mean grain yield difference between low and moderate rainfall areas was about 1000 kg/ha. Stress tolerant lines also had high yields in moderate rainfall conditions. These results show that it is possible to combine stress tolerance with productivity in moderate rainfall areas.

Table 54. Grain yield and stability of durum wheat lines in the Mediterranean areas with favorable climatic conditions, RDYT-MR, 1989/90.

No.	Entry	Mean yield (kg/ha)	Site mean rank	Rank standard deviation
19	Omrabi 3	3417	13.0	17.4
15	Omrabi 5	3426	13.9	16.3
20	Omrabi 6	3576	11.2	17.1
12	Cham 1	3398	14.1	18.9

Several new promising genotypes for both dry and moderate rainfall areas were selected from the durum observation nurseries in low and moderate rainfall areas for inclusion in regional nurseries and trials by NARS.

M. Nachit, M. Jarrah, and M. Azrak, A. Asbati

Grain Quality

Advanced segregating populations and lines are tested for grain quality. Only populations and lines with acceptable sedimentation test values, carotene content, and seed size are selected and advanced further. Most of the advanced durum wheat lines have high sedimentation values. The check cultivars for quality are Haurani, Cham 3, and Lahn. Grain quality of new lines must be either similar to or higher than the checks. Electrophoresis is also performed on advanced material to identify lines with desirable electrophoretic bands. Thirty-four out of 44 advanced durum wheat lines carry the desirable electrophoretic band number 45. Table 55 shows means and range for some quality traits in durum wheat.

Table 55. Mean and range for some quality traits in advanced durum wheat lines, Tel Hadya, Rainfed, 1991.

Trait	Mean	Range
Protein content (%)	16.6	13.4 - 20.0
1000 kernel weight (g)	26.7	19.6 - 36.4
Carotene score	5.1	3.0 - 6.5
Sedimentation value (cm)	41.8	12.0 - 58.0
Sedimentation index	2.5	0.8 - 3.4
Virtuousness (%)	98.0	91.0 - 100.0
Test weight (kg/l)	77.0	74.0 - 80.0
Farinogragh:		
1) Development time (min)	2.2	1.5 - 3.3
2) Stability time (min)	2.3	1.0 - 7.2
3) Mixing tolerance (Bu)	103.6	40.0 - 185.0

M. Nachit, A. Sayegh, A. Asbati, and M. Azrak, M. Jarrah

3.2. Facultative Durum Wheat Breeding

The facultative durum wheat breeding activities of last decade emphasized the development and distribution of adapted germplasm to high altitude areas. As it is difficult to breed adapted germplasm from Aleppo, more emphasis will be given to working with national programs working to improve durum wheat for high altitude areas. Resistance breeding will continue to focus on cold, yellow rust, and common bunt. In addition, training will be targeted to national programs with major durum growing areas in high altitude areas. 100 crosses between germplasm carrying winter growth habit and cold tolerance and germplasm adapted to high altitude areas were made. Parental material was also selected for yellow rust resistance. Fourteen populations were selected for further screening. From the advanced lines, 38% were selected for regional testing.

The performances of advanced genotypes in the Regional durum Yield in High Altitude Areas (RDYT-HAA) for the 1989/90 season are shown in Table 56. Two facultative durum wheat genotypes in Karaj/Iran, five in Setif/Algeria, one in Tiaret/Algeria, and nine in Granada/ Spain, have outyielded the national check significantly.

Table 56. Average grain yield and stability of high altitude durum wheat lines in RDYT-HAA, 1989/90.

No.)	Entry	Mean yield (kg/ha)	Mean sites' rank	Rank standard deviation
18)	Stk/Rabi//Cham 1	2617	10.7	7.3
22)	Ruff//Jo/Cr/3/Cham 1	2576	9.3	9.3
01)	Cham 1	2565	10.5	7.2
12)	Haurani	2459	13.3	7.4

M. Nachit, H. Ketata, M. Jarrah, A. Impiglia, A. Asbati, and M. Azrak

3.2. Physiology/Agronomy

3.2.1. Introduction

The objectives of the physiology durum wheat project are:

1. Assessment of morphological, physiological and developmental traits important in determining yield and adaptation to rainfed stressed Mediterranean environments.
2. Develop selection criteria for these environments.
3. Identify potential sources of drought tolerance traits, suitable for these stressed environments.

The 1990/91 season was slightly wetter than the previous two seasons: Tel Hadya received 253 mm (from planting to harvest) and Breda 210 mm. Supplementary irrigation assured that the water received was approximately equal in all seasons. Rainfall distribution however varied between the three seasons: in 1988/89 and 1989/90 rainfall was higher during autumn and winter than spring, while in 1990/91, rainfall in April-May was substantially higher than the previous two seasons.

Difference in minimum temperatures between 1990/91 and 1988/89, 1989/90 seasons however were considerable, in both the number of days when temperature dropped below 0 °C and the severity of cold (Table 57).

Table 57. Variation in minimum temperatures from emergence to harvest. Tel Hadya, 1988/89, 1989/90, 1990/91.

Time from emergence to harvest	Cropping Season		
	1988/89	1989/90	1990/91
No. of days when temperature below 0 °C	47	46	17
Average minimum temperature	(-3.9)	(-4.3)	(-2.8)
No. of days when temperature below -5 °C	15	17	1
Average minimum temperature	(-7.4)	(-7.2)	(-5.5)

3.2.2. Morpho-physiological Traits Associated with Adaptation

Ground Cover

Cover was correlated significantly with biological and grain yield, especially at Breda. However, the correlation this season was negative, which contrasts with previous seasons. Moderate winter temperatures, which prevailed during the 1990/91 season, in comparison with the previous two seasons, might have contributed to the negative correlation, by promoting early leaf growth, which is usually slow in durum wheat. At the time of terminal moisture stress, an extensive ground cover may also increase the effect of moisture stress on grain development and filling by early depletion of soil moisture reserve.

Plant Color

A negative correlation was observed between grain yield and light plant color, both early and late during this season, especially at the drier site, Breda. This strongly contrasts with observations from the two previous seasons (see CIP Annual Reports 1989/90). Such a correlation with a light color throughout the season may also reflect an interaction between temperature and moisture conditions. Low temperatures may cause a dark coloration by enhancing the formation of dark pigments, such as anthocyanin, whereas moderate temperatures may not induce this dark color. Color may still be an important trait in selecting genotypes for drought prone environments but the reason needs to be better understood before being readily adopted in a breeding program.

Canopy Architecture

Leaf architecture expressed as leaf position (CIP Annual Report 1988) on the main stem, again correlated significantly with yield, particularly in Tel Hadya. A vertical leaf position later in the growing season was significantly and positively correlated with grain yield. Another important structural feature is flag leaf shape. Again a high positive correlation between flag leaf length and biological and grain yield was observed, especially at the drier site. The correlation with leaf width was slightly negative, suggesting preference for a narrow long flag leaf. Plant height and peduncle length were again positively correlated with grain yield.

Crop Phenology

Earliness is a stable measure of drought avoidance in terminally stressed environments and has been shown to be consistently and highly positively correlated with grain yield, especially in the harsher environments. This season the correlation was again high at both locations.

Yield Components

Head weight per unit area, grain number, harvest index, biological yield and the number of fertile tillers (no. heads/m^2) are all important measures of yield potential under drought conditions and were again significantly correlated to yield, particularly in the more harsh environment of Breda.

Threshing Percentage

Moisture stress reduces sink development and terminal stress limits yield by reducing the grain filling period and/or the grain filling ability of a genotype.

Threshing percentage is a measure of the percent of grain weight to total head weight and expresses the ability of a genotype to fill the potential sink sites in the spike.

There was great variability in grain filling between the various genotypes especially at the drier site, Breda (4-64%). Also the trait showed highly significant positive correlation with yield at both moisture environments (r=0.52*** in Tel Hadya and 0.91 *** in Breda). Figure 16 shows the relation of threshing percentage (TR) and grain yield in Breda for the 1990/91 season.

In an analysis combining three years, the trait correlated highly with grain yield at both sites (r= 0.90 in Breda and r= 0.72 in Tel Hadya). This trait will now be included in our routine screening as it may have practical application for genotype assessment in severely moisture stressed environments.

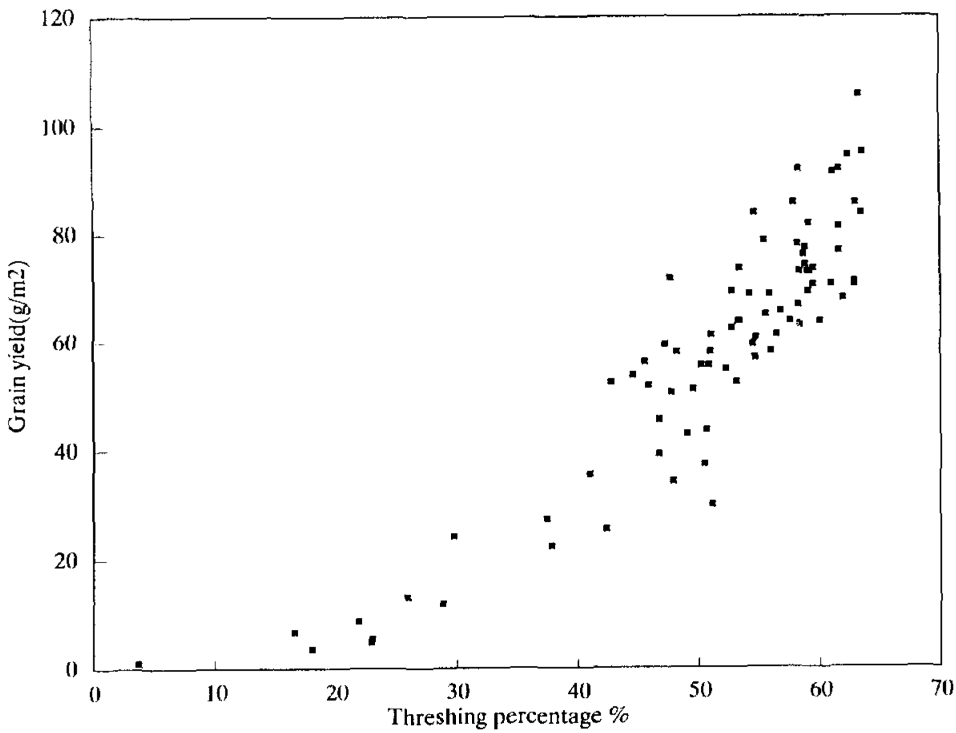

Fig. 16. Relation between grain yield and threshing percentage in 81 durum wheat genotypes. Breda, 1990/91.

3.2.3. Drought Response Indexes

Genotype performance under drought was also assessed by using indices developed by Bidinger et al. (1987) (Drought Response Index, DRI), and by Fischer & Maurer (1978) and Fischer & Wood (1979) (Drought Susceptibility Index, DSI). (See CIP Annual Report 1989).

These indices have the advantage of evaluating genotype performance under drought after eliminating the effects of yield potential and days to heading measured under favourable conditions. Both indices correlated highly with grain yield at the drier site (Figure 17 and 18). Analysis of three years of data from the durum wheat physiology nursery showed high correlation between the indices and yield under high moisture stress in Breda (r= 0.56 for DRI and r=0.73 for DSI).

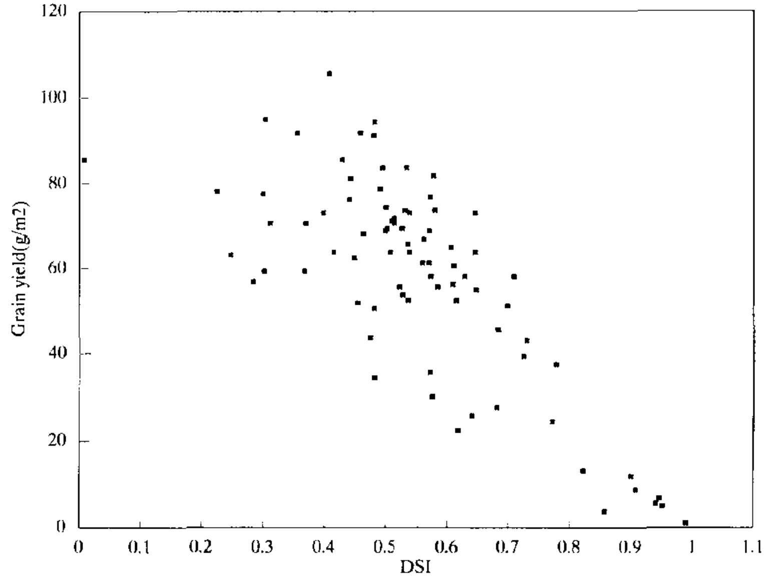

Fig. 17. Relation between grain yield and drought susceptibility index in 81 durum wheat genotypes. Breda, 1990/91.

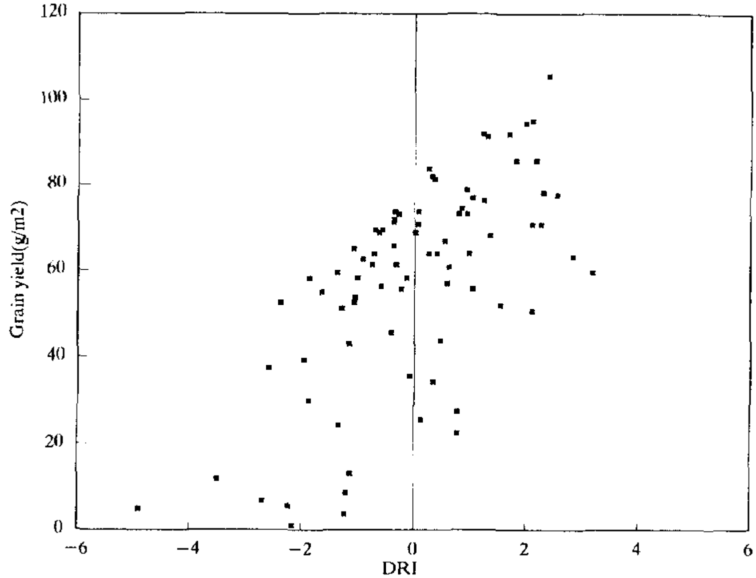

Fig. 18. Relation between grain yield and drought response index in 81 durum wheat genotypes. Breda, 1990/91.

Genotype Ranking

Tables 58 and 59 show the top and bottom five genotypes (from the eighty one) for grain (GYM) and biological yield (BYM) at Tel Hadya and Breda.

The improved varieties, Omrabi 14, Omrabi 5, Loukos 1 and Daki were among the top ranking genotypes, while the Italian collection were the bottom ranked genotypes.

Table 58. Top and bottom ranked durum wheat genotypes in grain (GYM) and biological yield (BYM). Tel Hadya, 1990/91

Rank	Genotype	BYM	Genotype	GYM
TOP				
	Omrabi 14	971	Omrabi 14	206
	Quadalete	916	Sajur	200
	Loukos 1	877	Loukos 1	194
	Jordan 86-No 44	831	Omrabi 5	182
	Gr/Boy	846	Daki	179
BOTTOM				
	Nile	568	M 1090	71
	Jordan 86-No 53	608	Scorsonera	74
	Sen.Cappelli	570	Sen.Cappelli	66
	M 1090	558	Baladia Hamra	59
	Cannizzara	485	Cannizzara	26
	LSD = 228		LSD = 75.5	
	C.V % = 15.9		C.V % = 29.0	

Table 59. Top and bottom ranked durum wheat genotypes in grain (GYM) and biological yield (BYM). Breda, 1990/91.

Rank	Genotype	GYM	Genotype	GYM
TOP				
	Hazar	341	Hazar	106
	Atsiki 3	333	M 20	95
	M 15	238	Omrabi 5	95
	Ain Arous	322	M 15	92
	Daki	309	M 1086	92
BOTTOM				
	Sajur	211	Akbash	7
	Sen.Cappelli	208	Sicilia Lutri	6
	Wakooma	206	Ethiopia IC(8373)	5
	Kishk	189	Cannizzara	4
	Local Iraklion	170	North Dakota	1
	LSD = 72.6		LSD = 27.7	
	C.V % = 14.3		C.V % = 23.8	

In comparison with previous seasons, (CIP Annual Reports 1989/90), the relative performance of some of the 81 genotypes changed across years and locations, suggesting genotype x environment interactions. We propose that a substantial part of the variation between the three seasons was due to temperature effects.

A. Dakheel, I. Naji and J.M. Peacock

3.2.4. The Role of Glaucousness as a Selection Criterion for Drought Tolerance in Durum Wheat

Assessment of individual traits can be improved when performed on isogenic lines. Among the traits which are simply inherited and have been found to correlate with drought tolerance is a waxy layer on vegetative parts of the plant, referred to as glaucousness in certain cereal crops.

A collection of seven pairs of isogenic lines differing in the wax layer, plus one pair of near isogenic lines was planted at Tel Hadya and Breda in 1990/91.

Table 60 shows biological and grain yield production of the 16 isogenic lines at Tel Hadya. In general, the glaucous lines outyielded the non-glaucous lines in both biological and grain yield. Glaucous lines yielded 30% more grain and had a 11% higher biomass than the non-glaucous lines. Among the top five dry matter producing genotypes, four were glaucous and only one was not (Isoline 8261-BN3) (Table 60). Similarly four out of the five top grain yielders were glaucous lines (Figure 19). Their average grain yield was 87 g/m^2, compared to 46 g/m^2 for their respectful non-glaucous isolines: the increase of 47% was highly significant (Table 60).

Table 60. Biological and grain yield of 8 glaucous and non-glaucous durum wheat isolines. Tel Hadya, 1990/91.

	BYM (g/m²)			GYM (g/m²)	
Entry	Glaucous	Non-glaucous	Entry	Glaucous	Non-glaucous
8261-BS3	796.0		8261-BS3	110.5	
8261-AC2	738.4		8262-AR3	86.7	
8261-AC4	734.0		8263-F3	84.5	
8261-BN3		727.8	8261-BN3		71.1
8262-AR3	720.4		8261-AC4	67.0	
AUS-2598	713.5		8261-AC2	63.1	
8263-F1	702.3		8263-F3		62.1
8261-AC2		669.5	8263-F1		61.4
8262-AR3		663.9	AUG 2598	60.4	
8263-F3	661.8		8261-BN3	50.5	
8263-F3		650.4	8263-F1	49.6	
8261-BS3		631.7	8261-AC4		46.7
8261-BN3	607.8		8261-BS3		45.7
AUS 2499		602.1	8261-AC2		44.9
8263-F1		577.2	AUS 2499		38.1
8261-AC4		543.6	8262-AR3		30.6
Mean =	709.3	633.3	Mean =	72	50.1
LSD =	103.6		LSD =	39	
C.V. % =	7.2		C.V. % =	28	

Contrary to expectations yields of the glaucous and non-glaucous lines were similar under more severe moisture at Breda, non-glaucous lines having a slight advantage. The top 4 glaucous and non-glaucous lines had similar biological yields (393 vs. 394g), and their average grain yield was identical (50g). The biological yield of the glaucous isolines was higher than the non-glaucous, in 3 out of 5 isolines. This interesting difference, associated with the severity of the stress, will be further investigated in 1991/92.

A. Dakheel and F. Makdis

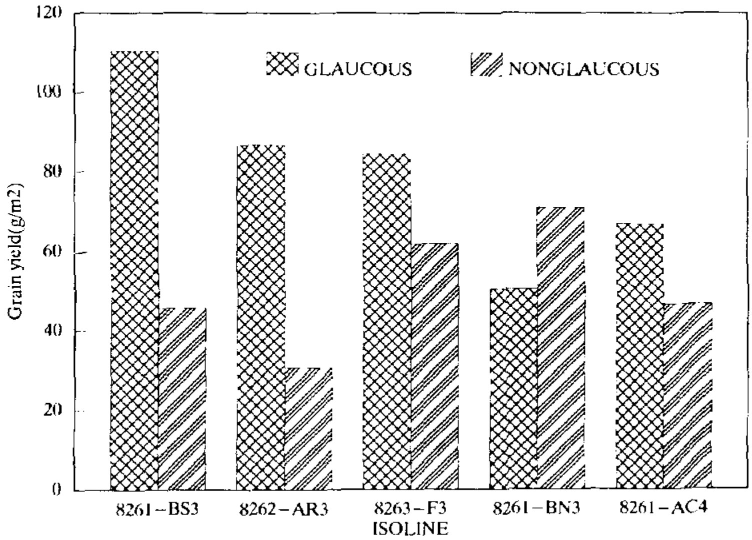

Fig. 19. Top grain yielding glaucous and non-glaucous durum wheat isolines. Tel Hadya, 1990/91.

3.2.5. Agronomy

Effect of Different Management Practices

The objective of this three year study was to determine the effect of row spacing, sowing date and sowing depth on survival, growth, development and yield of three selected improved durum wheat varieties.

Three row spacings (10, 20, 40 cm), sowing dates (early, medium, late) and depths of sowing (3, 7, 10 cm) were examined for each of three improved durum wheats differing in coleoptile length, Sebou (short), Korifla (medium), and Omrabi 17 (long).

The experiments were planted at Tel Hadya and Breda and complete details of materials and methods are given in the two earlier CIP annual reports (1989/90).

Results for 1991 were consistent with the two earlier seasons. They confirm that for durum wheat, grown in low to moderate rainfall Mediterranean environments, crop establishment and grain yield can be improved by using a narrow row spacing (10 cm), and planting as early as possible.

Sowing depth again had no significant effect, at either location, on ground cover, growth or subsequent yield. However deep sowing (7-10 cm) with early planting tends to be good agronomic practice in dry areas but these advantages usually disappear in higher rainfall areas.

I. Naji

3.3. PATHOLOGY

3.3.1. Durum Wheat Pathology

We report results on the performance of the durum wheat germplasm against major diseases in 1990/91, disease data from the Key Location Disease Nursery-90, crop loss assessment trials, and studies of the host-pathogen system in bread wheat and durum wheat. For the development of wheat diseases in our screening sites during the season 1990/91, see section on "Bread Wheat Pathology".

3.3.2. The Performance of Durum Wheat Germplasm Towards the Major Diseases, Season 1990/91

Durum wheat germplasm was assessed in different nurseries against five major diseases from a number of screening sites. The performance is based on the % resistant entries, checks excluded, in each nursery. The selection criteria were: for rusts ≤ 10MR; for

Septoria tritici blotch ≤ 6 on a 0-9 scale; and for common bunt ≤ 15% head infection (Figure 20). The nurseries evaluated were: Durum Aleppo Crossing Block (DACB), Durum Preliminary Disease Nursery (DPD) = Durum Wheat Preliminary Yield Trial, Preliminary Durum Screening Nursery (PDSN), Durum Key Location Disease Nursery (DKL) = Durum Advanced Yield Trial, as well as the special purpose disease nurseries, Durum Yellow Rust Nursery (DYR), Durum Leaf Rust Nursery (DLR), Durum Stem Rust Nursery (DSR), Durum Septoria Nursery (DST), and the Repeat Testing Bunt Nursery (RTB). For all diseases, except stem rust, the special purpose disease nurseries had relatively the best performance for the respective disease. For stem rust, the DACB had a higher percentage resistant entries, 63 %, as compared to the DSR (41%). For leaf rust, all nurseries had few resistant entries, the highest being DLR where only 7% of the entries were resistant. In the PDP and DACB none of the entries showed resistance to leaf rust.

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3.3.3. Summary of Disease Data from the Key Location Disease Nursery (DKL-90)

Disease recording of the multilocation DKL-90 were completed late in December 1990. Useful data on leaf rust were received from four locations, T. Hadya, Terbol summer planting, Elvas and Guelma/Algeria; on stem rust from two locations, T. Hadya and Terbol summer planting; on Septoria tritici blotch from two location, Lattakia and Elvas; and on yellow rust, barley yellow dwarf virus *

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* Data on barley yellow dwarf virus are furnished by Dr.K.M. Makkouk, Virology Lab./GRU.

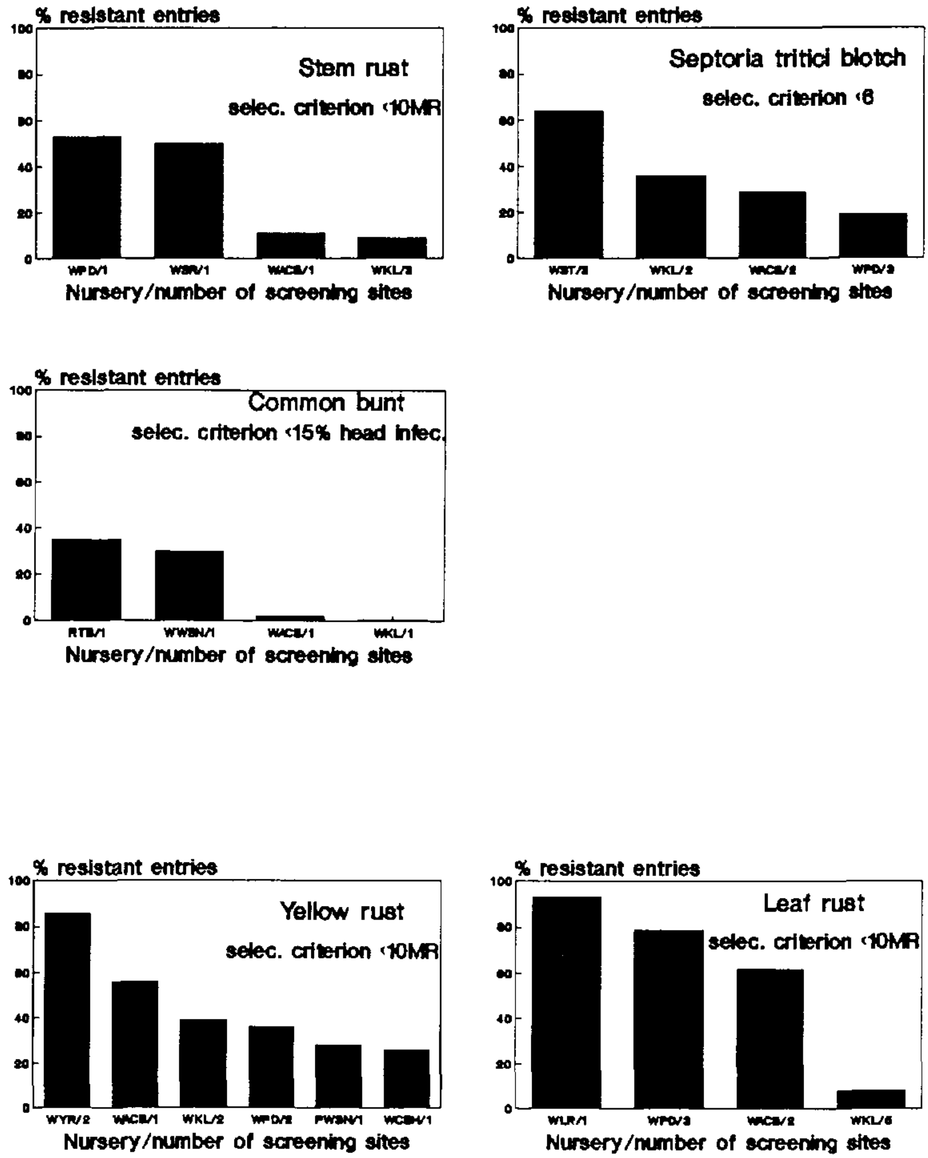

Figure 20. Percent resistant entries in the durum wheat germplasm to the different diseases.

and common bunt from one location, T. Hadya (Table 61). There were 70, 11, 104, 23, 32 and 49 resistant entries for yellow rust, leaf rust, stem rust, septoria blotch, barley yellow dwarf and common bunt respectively. Three lines, entry numbers 11, 26 and 121 (DKL-90) showed resistance to all three rusts. For the combination yellow rust and common bunt, 13 lines showed resistance, these were number 19, 27, 38, 55, 66, 121, 133, 136, 164, 215, 223, 231, and 236 of the DKL-90; whereas for septoria and barley yellow dwarf, 8 lines were resistant, (DKL-90 # 21, 22, 23, 24, 71, 72, 97 and 99). Entry number 121 showed resistance to four diseases, yellow rust, leaf rust, stem rust and common bunt. This entry, named Brachoua, is one of the most promising lines in Farmers Verification Trials.

Table 61. Number of durum wheat lines * resistant ** to one or more major diseases (DKL-90).

Disease	No. resistant lines	
	No.	%
Yellow rust	70	32
Leaf rust	11	5
Stem rust	104	48
Septoria blotch	23	11
Barley yellow	32	15
Common bunt	49	23
Yellow, leaf and stem rusts	3	1
Yellow rust and common bunt	13	6
Septoria blotch and barley yellow	8	4
Yellow, leaf and stem rusts and common bunt	1	0.5

* Total number tested 216, checks excluded.

** Selection criteria: CI 0.2 for yellow rust, ACI 2.0 for leaf rust and stem rust, 0-5 score on a 0-9 scale for septoria tritici blotch and barley yellow dwarf virus, 0-15% head infection for common bunt.

Its score against septoria blotch in several locations is relatively high (8) and it has a moderate resistance (6) to barley yellow dwarf, both on a 0-9 scale. The cross of this entry is:

Fg/3/Gs/Tc 60//Stk.

Omar F. Mamluk and Suzanne Khawatmi

3.3.4. Crop Loss Assessment Trials 1990/91

As in previous seasons, crop loss assessments trials were carried out at T. Hadya for yellow rust and at Lattakia for Septoria tritici blotch. These trials use 8 durum wheat cultivars from the Farmer Verification Trials conducted in Syria in collaboration with DSAR. Results on yellow rust are presented in Table 62. Bayfidan (fungicide I) was applied to all cultivars, whereas Daithane M45 and Sportak (fungicide II) was applied to three cultivars only. Results show that fungicide I suppressed the disease in all cultivars, except in Brachoua, in a more effective way than fungicide II. For all cultivars, applications of either fungicide I or II resulted in an increase in grain yield. The statistical analysis showed significant differences among treatments in Haurani for the variables ACI (LSD 11.983) and 1000KW (LSD 2.567). However, the 1000KW was reduced by both fungicides. Significant differences were also found in Omrabi 3 for ACI (LSD 4.965) and yield (LSD 266.276), i.e., Omrabi 3 with a yellow rust ACI of 10.0, or an infection of 12MS-S, lost 9.7% of its yield potential.

Table 62. Effect of yellow rust (Puccinia striiformis) on grain yield and yield components of durum wheat cultivars (Tel Hadya, Syria 1991)

Cultivar	Treatment	Yellow rust Score	/ ACI	Yield KG/ha	No.tillers per m	No.seeds per spike	1000KW (g)
Haurani 27	Infected	30 MS-S	26.0	1844	97	26	32.1
	Fungecide I	5 R-S	3.7	2156	87	27	28.4
	Fungecide II	5 MS	4.0	2022	97	27	28.2
Cham 1	Infected	2 R	0.5	2245	109	28	27.2
	Fungecide I	1 R	0.2	2478	120	27	26.6
	Fungecide II	2 R-MR	0.8	2856	134	26	29.3
Brachoua	Infected	1 R	0.2	2522	113	25	34.1
	Fungecide I	2 R	0.5	2744	112	26	31.4
	Fungecide II	—	—	—	—	—	—
Omguer 6	Infected	7 R-S	3.0	1889	107	20	35.0
	Fungecide I	5 R-MS	4.1	2389	121	19	34.6
	Fungecide II	—	—	—	—	—	—
Omrabi 3	Infected	12 MS-S	10.0	2589	97	29	32.2
	Fungecide I	1 R	0.2	2867	113	32	32.6
	Fungecide II	—	—	—	—	—	—
Stojocri 6	Infected	4 R	0.7	2167	101	20	37.9
	Fungecide I	1 R	0.2	2411	112	19	43.7
	Fungecide II	—	—	—	—	—	—
Stojocri 7	Infected	5 R-MR	1.7	2344	94	19	42.2
	Fungecide I	1 R	0.2	2456	96	17	45.6
	Fungecide II	—	—	—	—	—	—
Omlahn 3	Infected	7 R-MS	3.3	2467	106	25	35.2
	Fungecide I	2 R	0.5	3022	112	24	32.9
	Fungecide II	5 R-MS	4.1	3022	110	26	34.8

Figures = mean of 3 rep. each 6.3 m^2; harvested 3 m^2
Experiment design = split plot (treatment as main plot factor)
Infected = artificial inoculation applied three times
Fungecide I = Bayfidan, 0.5 l/ha, applied three times
Fungecide II = Daithane M45, 0.8 kg/ha, applied five times
Sportak, 1.2 l/ha, applied twice

Results on Septoria tritici blotch are summarized in Table 63. The two fungicides used were Bayfidan and Bravo, the latter applied to three cultivars. On Cham 1 and Omguer fungicide I did not reduce the vertical development of the disease (1st digit) but reduced severity (2nd digit). On Haurani, Cham 1 and Omlahn 3, fungicide II was as effective as fungicide I in suppressing the disease. Except for fungicide II on Haurani, both fungicides increased grain yield. Analysis showed significant differences among the treatments for vertical disease development in Haurani (LSD 3.298), Omrabi 3 (LSD 4.965), and Stojocri 6 (LSD 1.433). Significant differences were also found for disease severity in all cultivars, and for 1000KW in Cham 1 (LSD 3.758) and Omguer 6 (LSD 1.880).

Data from this season will be analyzed with data from pervious seasons, as several of these cultivars have been in crop loss assessment trials for 3 or 4 years.

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3.3.5. Studies on the Host-pathogen System

3.3.5.1. Host Preference in Septoria tritici Blotch

This study aimed at determining the relative preference of septoria blotch pathogen, M. graminicola, for either bread or durum wheat. A set of 35 cultivars of durum (14) and bread wheat (21) was used in pathogenicity tests in the field at Lattakia and T. Hadya for adult plant testing and in the greenhouse at T. Hadya for seedling tests. Three inocula were used, originating from bread wheat, durum wheat, or a mixture of both. Disease

Table 63. Effect of septoria tritici blotch (Mycosphaerella graminicola) on grain yield and yield components of different durum wheat cultivars (Lattakia, Syria 1991).

Cultivar	Treatment	Septoria score	Yield kg/ha	No.tillers per m	No.seed per/spike	1000KW (g)
Haurani 27	Infected	8/7	2358	87	31	44.4
	Fungicide I	5/2	2592	94	30	45.6
	Fungicide II	2/1	2158	106	28	46.0
Cham 1	Infected	9/7	3300	108	48	35.5
	Fungicide I	8/2	4350	125	43	39.8
	Fungicide II	5/1	3775	115	43	39.2
Brachoua	Infected	8/7	3050	93	41	44.9
	Fungicide I	6/1	4033	93	48	47.2
	Fungicide II	—	—	—	—	—
Omguer 6	Infected	8/6	3033	78	41	47.9
	Fungicide I	8/1	3900	114	41	50.3
	Fungicide II	—	—	—	—	—
Omrabi 3	Infected	8/7	3317	100	43	41.6
	Fungicide I	3/1	4083	122	45	43.4
	Fungicide II	—	—	—	—	—
Stojocri 6	Infected	8/5	3542	85	36	56.9
	Fungicide I	1/1	3633	88	38	57.6
	Fungicide II	—	—	—	—	—
Stojocri 7	Infected	8/5	3467	96	36	59.0
	Fungicide I	4/1	3900	109	35	59.6
	Fungicide II	—	—	—	—	—
Omlahn 3	Infected	8/7	3458	104	44	44.3
	Fungicide I	4/1	3908	103	42	45.9
	Fungicide II	4/1	4025	98	43	46.2

Figures = mean of 3 rep. each 8.4 m^2; harvested 4 m^2
Experiment design = split plot (treatment as main plot factor)
Infected = artificial inoculation applied four times
Fungicid I = Bayfidan, 0.5 l/ha, applied twice
Fungicid II = Bravo, 2 l/ha, applied twice

scoring was done on a two digit 0-9 scale. Results on adult plants showed that disease development on durum wheat cultivars was the same whether the inoculum originated from durum or bread wheat or from a mixture of both. On bread wheat the average disease score was 6/4 for inoculum from bread wheat, whereas it was 3/2 for inoculum from durum wheat. The mixture scored the same as the inoculum from bread wheat. In the seedling test, average necrosis formation on durum wheat and bread wheat cultivars was the same for the three sources of inoculum. However, pycnidial formation was quite different. In both durum and bread wheat cultivars, pycnidial formation was greatest when the source of the inoculum was from the host species.

3.3.5.2. Partial Spike Infection as an Indication of Partial Resistance to Common Bunt

The phenomenon that wheat spikes are some times partially infected by the common bunt pathogen is well established in nature and in artificially inoculated nurseries. If proven to be heritable and thus a kind of partial resistance, this characteristic would offer an alternative when breeding for resistance to common bunt. Partially infected spikes, 110 of durum and 70 bread wheat, were investigated. The first selection criterion was that spikes originated from entries in the Common Bunt-I nursery of 1989/90 with a rating of 0-50% head infection. The second criterion was that the spikes had 0-10% infected kernels by the common bunt. Healthy seeds of the partially infected spikes were surface disinfected and inoculated with spores of the pathogen. Seeds of each spike were planted as an entry in two replications.

Out of the 110 durum wheat entries tested, 109 (99%) entries had a general performance of 0-50% head infection and only one entry had 56% head infection. In regards to kernel infection within a spike, 33 (30%) entries had totally healthy spikes, 14 (13%) had all kernels infected, 21 (19%) had spikes with healthy and infected kernels (partially infected spike), and 42 (38%) had spikes with total as well as with partial infection.

Out of the 70 bread wheat entries tested, 69 (99%) entries had a general performance of 0-50% head infection and only one entry had 58%. The distribution of these entries in regards of kernel infection of the spike was: 10 (14%) entries had spikes with all kernels healthy, 9 (13%) had spikes with all kernels infected, 8 (11%) had spikes partially infected, and 43 (61%) had spikes with total as well as with partial infection.

The results indicate that the characteristic of spikes being partially infected is heritable. The heritability of this characteristic will be further studied.

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3.3.5.3. The Sexual Stage of Septoria tritici Blotch

To investigate the sexual stage of Mycosphaerella graminicola and its role in the epidemiology of the disease, 23 samples from T. Hadya (19) and Lattakia (4) were collected in the period Oct. 6, 1990 to March 10, 1991. These samples were oversummering on septoria infected bread and durum wheat plants at the two sites. A total of 207 isolates were obtained from the samples. Only samples collected between Nov. 4th and 18th 1990 yielded 5 colonies of the pathogen. However, we were not able to determine whether these colonies originated from pycnidiospores, the asexual organs of the pathogen or the ascospore, the sexual stage. This needs further investigation.

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

In 1988/89, 100 entries from 9 Aegilops species were screened in the field for septoria blotch, common bunt and yellow rust. In 1989/90, 189 entries from 16 Aegilops species were also screened for these diseases. A wide range of response to yellow rust was found in these collections, but none of the tested entries showed any susceptibility to septoria blotch and common bunt of wheat. In 1990/91 we tested 421 accessions of 20 Aegilops spp. for their reaction to yellow rust in the field and tested the immunity of the Aegilops genus to Septoria tritici blotch and common bunt. The yellow rust results are represented in the Annual Report of the Genetic Resources Unit, "1.5.3. Diversity for important wheat diseases in a selection of the ICARDA Aegilops collection".

To confirm the immunity of the Aegilops genera to septoria blotch, the 421 entries were tested in February-March 1991 in the greenhouse. The inoculum originated from several leaf samples collected in Syria and the isolates were adjusted to be in the ratio of 1:1 bread wheat and durum wheat, Mexipak and Gezira 17 were used as checks. The checks showed excellent disease development in the form of necrosis and pycnidial formation. Some of the Aegilops entries showed chlorosis but only one entry of the species, Ae. kotschyi (accession # 400799), showed typical necrosis with pycnidia. In the coming season other Aegilops species from ICARDA's collection will be tested to study the immunity of this genus to septoria blotch.

In screening for common bunt our routine inoculation method used for wheat was applied to Aegilops spp. Due to morphological differences between wheat and Aegilops seeds, it was essential to test the effectiveness of this method in order to confirm the immunity of the species to common bunt. In this test, ten species, Ae.biuncialis, caudata, columnaris, crassa, cylindrica, squarrosa, triaristata, triuncialis, ovata, and vavilovii, along with Mexipak were used to test the inoculation methods. Four different inoculation methods, plus the check (not inoculated) were tested:

1. soil method: the common bunt inoculum consisted of 800 g of soil and sand mixed with 2 g of common bunt teliospore, Syrian isolate for 1990. Seven g of this mixture was placed under each seed in open furrows.
2. vacuum methods: the seed was soaked in a concentrated spore suspension of 0.5 g spore/200 ml water and a vacuum applied then in a suspension of 1 g spores/200 ml water again under vacuum. This allowed spores to adhere better to the seed surface or to penetrate the hull.
3. routine wheat seed inoculation method: 10 g of Aegilops seeds were mixed with 0.144 g of spores in a flask and hand shaken for three minutes.
4. peat method: a paste was made with 0.2 g of spores mixed with 40 ml water and one bag of peat (50 g) to which some droplets of cellulose gum was added. This paste was mixed with the seed to provide complete coverage of the seed.

The check plants in all treatments (methods) remained uninfected. For Mexipak all four inoculation methods gave bunted spikes with 45, 41, 68 and 28% head infection respectively for soil, vacuum, routine, and peat methods. All *Aegilops* spp. independant of inoculation method remained healthy and were not infected by the common bunt. It is evident that the inoculation method had no effect on the susceptibility/resistance of the *Aegilops* spp. to common bunt. However, to further confirm the immunity of this genus, another 10-13 species will be tested next season using the routine wheat inoculation method.

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3.3.5.5. Disease Resistance of Durum and Bread Wheat Lines Derived from Crosses with *Triticum monococcum*

Results are presented in the Annual Report of the Genetic Resources Unit; Chapter 1.3.4.

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3.4. Entomology

Yield Loss due to Wheat Stem Sawflies

Results from caged yield loss trials reveal little about the impact of wheat stem sawflies but suggest the impropriety of using cages to measure sawfly-related losses (Table 64).

Table 64. Variables measured within and without cages in nothern Syria in 1990/91.

Tel Hadya	Cage 1	Cage 2	No cage	Saraqueb
No Plants	262.30 a	240.80 ab	211.20 b	82.90 c
Till/Plnt	2.09 a	1.99 a	1.96 a	2.41 b
Ads/Plnt	1.79 a	1.77 a	1.77 a	1.85 b
% Inf.	7.20 a	5.10 ab	3.70 b	3.60 b
Yield (g)	285.70 a	201.10 b	157.30 c	36.50 d

a) Means across rows followed by the same letter do not sigificantly differ at $P < 0.05$.

Cages were employed to keep sawflies from infesting wheat plants, whose grain yield would then be compared with that of uncaged plants subjected to natural sawfly infestation. However, severe winds in April destroyed the cages during the end of the sawfly flight season and allowed the caged plants to be infested. We observed that plants under cages were still green and succulent while plants outside were drying out, which resulted in these plants being immediately and severely infested when the cages were destroyed. Any yield loss comparisons using plants kept under cages during the sawfly flight season would therefore be highly influenced by the cages and not accurately reflect the impact of the sawflies themselves. We will not employ this experimental design in the future.

3.4.1. Screening for Greenbug

The objectives of greenbug (Schizaphis graminum) screening were to provide a backup test of material identified as greenbug resistant in the collaborative aphid resistance screening project conducted at ARC in Giza, Egypt, and to facilitate testing of some landrace material in ICARDA's collections against Syrian greenbug biotypes. For the past two years screening for greenbug was carried out in the plastic house. Each season three separate screenings of the same lines were performed. Laboratory reared greenbugs were placed on plants two weeks after germination in small pots under cages. Weekly plant damage ratings (Elenin et al., 1989) and aphid population density ratings (1990/91 season) were begun after 2 weeks. Arabi Aswad and Golan were used as susceptible barley and wheat checks. Fig. 21A-C summarizes the pooled results for both years. In 1989/90 a collection of barleys from the India national program were significantly more resistant than either check and the other lines tested. This was especially apparent late in the testing cycle when these lines successfully headed and produced seed while the other lines were killed. This, plus rapid development, large kernel size and adequate disease resistance lead these lines being included in barley crossing program, and additionally to be tested in Egypt and Sudan against laboratory and field aphid populations. Other lines tested at this time performed poorly and were ultimately killed. The collection of lines tested in 1990/91 revealed no striking sources of greenbug resistance, although tolerance was noted in the best lines selected. Differences in aphid population performance on these lines was negligible.

With the experience of these screenings, our testing procedure can be refined. First, there seems little advantage in evaluating lines for more than eight weeks after plant emergence. With the exception of the 1989/90 season noted above, differences in plant and aphid performance were apparent early in the tests and variation among lines decreased rapidly with time (Fig. 21C). A single screening is probably sufficient to identify resistant

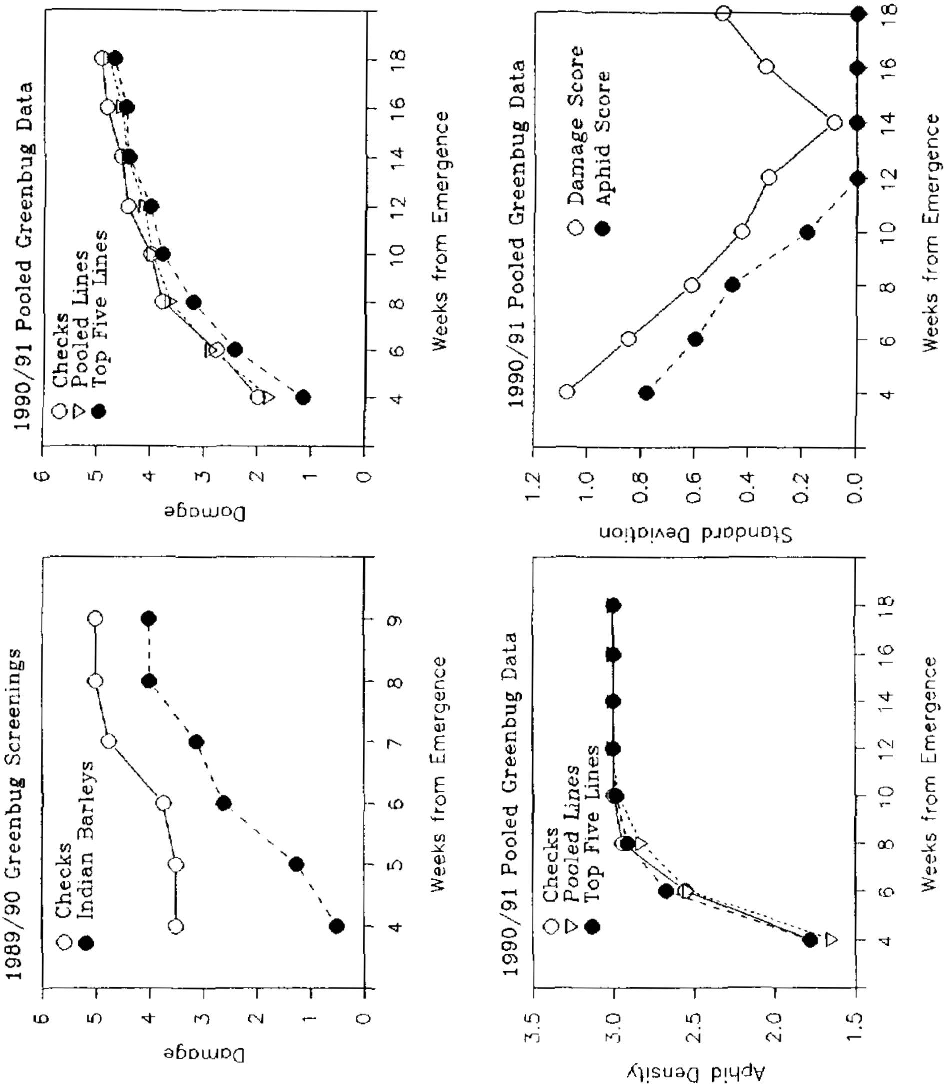

Fig. 21. Results from testing wheat and barley (means) against locally collected mixed biotypes of greenbug, Schizaphis graminum, in the plastic house in 1989/90 and 1990/91.

lines. These lines should be separately tested in two more laboratory tests, as is done in the aphid screening laboratory in Giza, before being included in the greenbug resistant germplasm pool. These lines should also be included in the International Aphid Screening Nursery now assembled annually by the Egyptian and Sudanese national programs and ICARDA for testing under severe field conditions in Egypt and Sudan.

3.4.2. Identification of Hessian Fly Biotypes in WANA

Budgetary and manpower considerations have caused us to limit ICARDA's Hessian fly biotype screening project in WANA. Data from past surveys of the Uniform Hessian Fly Nursery from various countries are being analyzed prior to deciding if and where this work should be continued. However, development of germplasm for Hessian fly will be done primarily by scientists from Morocco, with some backstopping from the Cereal Program. Additional information on Hessian Fly germplasm development is reported in the spring bread wheat breeding section of this report.

3.5. International Nurseries

Regional durum wheat nurseries assembled by the joint CIMMYT/ICARDA durum wheat project at ICARDA in 1991 are given in Table 65. The numbers of spring-type regular nurseries was unchanged. The CIMMYT and ICARDA agreement on spring wheat nursery preparation and distribution was implemented this season. For the first time, about half of the two observation nurseries included lines supplied from the CIMMYT base program in Mexico were multiplied at Tel Hadya. As agreed, distribution of the observation nurseries was restricted to the WANA region. The two germplasm pools for disease resistance, which had been made available for the last two consecutive seasons, were withdrawn as planned. New germplasm pools will be made available next season. The nursery containing winter-type segregating populations was discontinued.

Table 65. Durum wheat international nurseries for 1991.

Nursery	Abbre-viation	No. of entries	No. of sets distributed
Spring Types Regular Nurseries			
Crossing Block	DCB	83	31
Segregating Population	DSP	92	30
Observation Nurseries:			
- Low Rainfall Areas	DON-LRA	260	37
- Moderate Rainfall Areas	DON-MRA	204	50
Yield Trials:			
- Low Rainfall areas	DYT-LRA	24	46
- Moderate Rainfall Areas	DYT-MRA	24	64
Specific-trait Nurseries			
Drought & Heat Tolerance Obs. Nur.	DHTON	48	45
Drought & Cold Tolerance Obs. Nur.	DCTON	48	20
Sub-total			323
Winter and Facultative Types Regular Nurseries			
Observation Nursery	DON-HAA[1]	95	22
Yield Trial	DYT-HAA	24	12
Sub-total			34
Total			357

[1] HAA - High Altitude Areas

A total of 357 nursery sets were distributed in 1991. Since 1986, the year in which the record number of nursery sets (503) were sent, the numbers of nursery sets sent have been scrutinized more carefully and have been reduced gradually.

The distribution of nursery sets in 1986 versus 1991 is shown in Fig. 22. Requests for the regional nurseries were received from cereal scientists worldwide, except Oceania. In 1986 countries in West Asia received the largest share (39%) followed by North Africa. But in 1991 North Africa received the largest share (35%) followed by West Asia. In 1991, 67% of total nursery sets were sent to WANA (excluding Ethiopia, Sudan and Pakistan), compared to 60% in 1986. This trend is expected to continue following the CIMMYT and ICARDA agreement on nursery distribution.

S.K. Yau

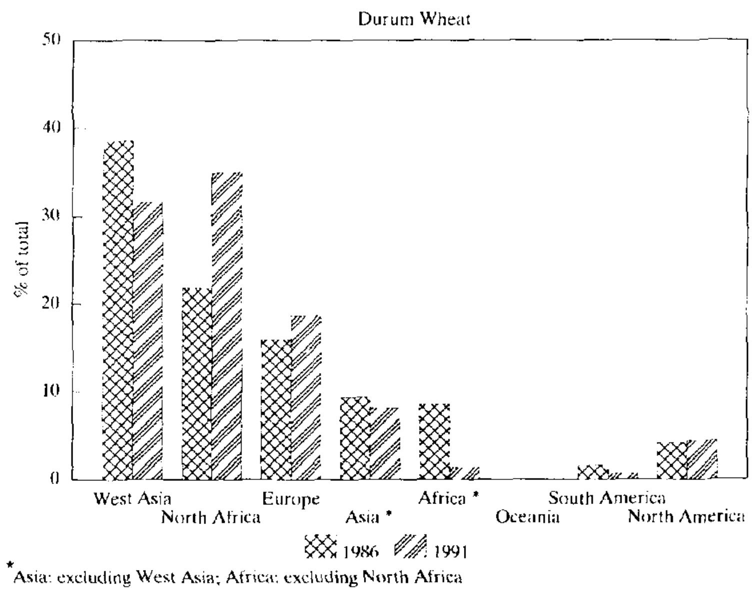

Fig. 22. Distribution of durum wheat nursery sets in 1986 and 1991.

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4. SPRING BREAD WHEAT IMPROVEMENT

4.1. Spring Bread Wheat Breeding

4.1.1. Introduction

During 1991, the CIMMYT/ICARDA spring bread wheat breeding project emphasized the development of improved, adapted germplasm for the variable and unpredictable environments of West Asia and North Africa (WANA), with special attention to rainfed areas particularly those areas receiving less than 400 mm annual rainfall.

Research was directed towards breeding and identifying parental material possessing high grain yield with stability through tolerance to abiotic stresses (terminal drought, cold and terminal heat), and to biotic stresses (yellow rust, septoria, common bunt, sawflies, Hessian fly, sunni bug and aphids).

The breeding strategies used in our project have been published elsewhere (Ortiz Ferrara, G. and Deghais, M., 1988, Ortiz Ferrara, G. et al., 1987, Ortiz Ferrara, G. et al., 1989). Multilocation testing, including multiple planting dates, which differentiate genotypes with different degrees of vernalization is a useful selection strategy. This, coupled with targeting, has resulted in germplasm being adopted increasingly by NARS, particularly for low-rainfall environments.

This report concentrates on presenting results from the driest testing sites in Syria and other dry locations in WANA. These activities are carried out jointly with National Programs and lead to identification and release of promising cultivars.

4.1.2. Germplasm development

Table 66 shows the number and type of crosses made during the last three years, 1989 to 1991. Approximately 1341 crosses are made yearly to cope with different agroclimatic regions.

Table 66. Number and type of crosses made for the last three years in the bread wheat crossing program.

Purpose of the cross	Number of crosses				% of total
	1989	1990	1991	Average	
Abiotic stress tolerance					34
Terminal drought	192	204	160	185	
Cold	146	230	120	165	
Terminal heat	139	105	70	105	
Biotic stress resistance					39
Yellow rust	125	106	120	117	
Leaf rust	42	152	55	83	
Stem rust	39	30	50	40	
Septoria leaf blotch	112	120	120	117	
Common bunt	54	45	70	56	
Wheat stem sawfly	86	75	110	90	
Hessian fly	-	-	90	30	
Bread making quality	98	102	110	103	8
Special purpose					19
Selected landraces	268	296	185	250	
Total	1301	1465	1260	1341	100

Special emphasis is placed on crosses for low-rainfall areas where abiotic stresses are most important. Biotic stresses are important in the moderate to high rainfall areas of WANA where they reduce yields. About one third of our crossing program is aimed at abiotic stresses, one third for biotic stresses and about 20% involve non-conventional material such as landraces (Table 66). The landraces used were extracted from collections made in the region. They were evaluated for two to three consecutive years under drought, cold and disease pressure before being promoted to crossing blocks.

4.1.3. Germplasm testing

The project follows the principle that stress tolerant material is difficult to identify unless selected under those stresses and multilocation testing is used further.

The germplasm tested in 1990-91 is summarized in Table 67 which shows the size of the project. Two wheat cycles per year have been made for the last seven years using Tel Hadya for winter and Terbol, Lebanon for summer planting.

The yield levels of 216 advanced bread wheat lines tested for three consecutive years in three environments are shown in Table 68. All years were extremely dry at Breda (BR-less than 220 mm rainfall), a location used to screen germplasm for terminal drought resistance under low fertility conditions. Similarly, high temperatures and lack of moisture are stresses in the Tel Hadya Late Planting environment (TH-LP), an environment used to screen for terminal heat stress during the reproductive period. For both BR and TH-LP the grain yield of the highest yielding line (HYL), the average of the best ten lines (ABTL), and the average yield of all the lines (AAL) in the trials were substantially higher in 1991 while the average yield of the local checks (ALC) were only slightly higher than the previous years. Progress is being made in improving yield under terminal drought and heat stress.

Table 67. Bread wheat breeding material evaluated during 1990-91.

Materials	Season	No.of entries	Locations
F1's	Winter	751	TH.
	Summer	509	TH.
Segregating Populations (F2-Fn)	Winter	4593	TH(*), Lattakia, Breda, Terbol.
	Summer	8725	TH, Terbol.
PYT's	Winter	504	TH(*), Breda.
	Summer	-	
AYT's	Winter	264	TH(**), Breda, Terbol, Merchouch, El Kef, S.b. Abbes.
	Summer	96	TH.
Observation Nurseries	Winter	791	TH(*), Terbol, Breda, Lattakia, 50 sites in WANA.
	Summer	527	TH.
Regional Yield Trials	Winter	72	TH(*), Terbol, Breda, Lattakia, 50 sites in WANA.
	Summer	48	TH.
Crossing Blocks	Winter	377	TH(**), Terbol (*).
	Summer	-	

* = Two planting dates; ** = Three planting dates; TH = Tel Hadya.

The yield levels of the 216 lines evaluated in the cold-prone environment of Tel Hadya Early Planting (TH-EP), including the local checks, were substantially reduced in 1990 compared to 1989 and 1991 (Table 68). A severe winter was experienced in 1990 and it reduced yields.

Table 68. Trends in yield levels of 216 advanced bread wheat lines over three years and three environments: Terminal drought (BR); Terminal heat (TH-LP); and cold stress (TH-EP). Advanced wheat yield trials 1989 to 1991.

Testing site	Grain yield (kg/ha)		
	1989	1990	1991
BR:			
HYL	925	1983	1468
ABTL	855	1545	1404
AAL	585	682	1055
ALC	614	648	656
ML	186	179	220
TH-LP:			
HYL	1785	2100	2983
ABTL	1619	1843	2727
AAL	1044	1102	1757
ALC	1124	1146	1122
ML	300	320	310
TH-EP:			
HYL	5575	2166	5283
ABTL	5375	2080	4802
AAL	4243	1345	3343
ALC	4256	1417	2493
ML	480	350	405

BR = Breda (rainfed); TH-LP = Tel Hadya late planting (supplementary irrigation); TH-EP = Tel Hadya early planting (rainfed + supplementary irrigation); HYL = Highest yielding line; ABTL = Average of best ten lines; AAL = Average of all lines; ALC = Average of local check; ML = Moisture level (mm); LC = Local checks (BR = Mexipak, TH-LP = Ahgaf, TH-EP = Cham 4).

Several promising lines were identified with higher yields than local and improved checks. Table 69 presents the number and percentage of lines yielding more than the checks.

Table 69. Number and percentage of bread wheat lines yielding higher than the local and improved checks in different environments, AWYT'S 1990-91.

Environment	Checks						All three checks	
	Mexipak		Cham 4		Cham 6			
	No.	%	No.	%	No.	%	No.	%
Terminal drought - Breda:	122	46	130	49	30	11	15	6
Cold - TH-EP:	229	87	94	36	65	25	54	20
Terminal heat - TH-LP:	208	79	195	74	61	23	50	19
High input - Terbol:	93	35	97	37	159	60	58	22

N = 264; TH-EP = Tel Hadya early planting; TH-LP = Tel Hadya late planting

4.1.4. Germplasm distribution

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

Close integration between ICARDA scientists and key national program staff in WANA has resulted in a number of improved genetic stocks being identified. These stocks are assembled as parental material having desirable traits and are distributed yearly, upon request, to NARS for use in their breeding programs (Table 70). A total of 840 accessions have been distributed during the last five years.

Table 70. Number of bread wheat lines with desirable genetic traits distributed to national programs as genetic stocks during the last five years.

Characteristics	1987	1988	1989	1990	1991	Total
High yield and stability:	36	36	36	36	36	180
Abiotic stress resistance:						
Terminal drought	25	25	27	22	23	122
Cold	7	9	18	12	13	59
Terminal heat	5	18	19	12	13	67
Biotic stress resistance:						
Yellow rust	15	11	14	16	17	73
Leaf rust	12	5	11	8	9	45
Stem rust	6	5	3	2	3	19
Septoria leaf blotch	12	20	13	8	9	62
Common bunt	7	8	9	12	13	49
Wheat stem sawfly	13	15	17	16	17	78
Hessian fly	-	-	-	3	4	7
Selected landraces:	-	-	6	18	12	36
Bread making quality:	9	7	8	9	10	43
Total	147	159	181	174	179	840

In the 1991-92 season, CIMMYT and ICARDA, in consultation with national programs of the region, have implemented a new system of distributing improved bread and durum wheat germplasm to national programs in WANA. Figure 23 summarizes the strategy. Improved material developed at CIMMYT-Mexico and from the joint CIMMYT/ICARDA project at Aleppo is included in the nurseries, and duplicative testing in NARS is avoided.

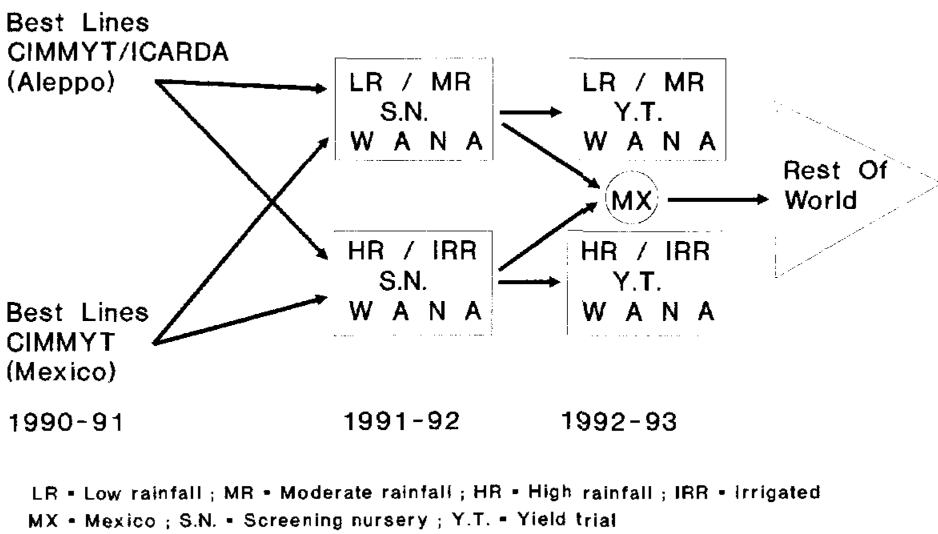

Figure 23. *Joint CIMMYT/ICARDA scheme for nursey distribution.*

4.1.5. Germplasm performance

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

Special emphasis is placed on developing germplasm suitable for zones 1 and 2, and we rely on CIMMYT-Mexico for zone 3. Grain yield and yield stability are the most important factors to consider in zones 1 and 2. Table 71 shows the stability of promising bread wheat

Table 71. 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 1990.

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

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.

germplasm in comparison with improved bread and durum wheat checks in at least 18 dryland locations in WANA for each of three years. The TYE entries were different in each year but the results indicate the mean stability over locations of the entries in comparison with the stable checks Cham 6 and Belikh.

Results for five years (1986 to 1990) of the international nurseries grown in more than 49 dry locations highlight the superior adaptation of bread wheat germplasm over the national checks varieties (Table 72). The first four top yielding entries in this table were different each year because the entries in the regional yield trials change annually.

Table 72. Performance of the four top yielding bread wheat lines in the regional yield trials for moderate rainfall areas, 1986 to 1990.

Top yielding lines	Grain yield (kg/ha)						% > N.C.
	1986	1987	1988	1989	1990	Mean	
First	4302	3885	4304	4259	4419	4234	107
Second	4170	3877	4257	4246	4293	4169	105
Third	4146	3865	4179	4220	4251	4132	104
Fourth	4135	3812	4061	4218	4171	4079	103
N.C.	3946	3696	4285	3912	3949	3958	100
N.L.	53	53	53	50	49	52	-

N.C. = National checks; N.L. = No. of locations.

Table 73 shows the importance of maturity and plant height for bread wheat germplasm grown in zone 2. Although this material was unreplicated, grain yield correlated well with the number of times that a line was visually selected.

These results indicate the value of visual selection in the observation nurseries.

The value of early maturity was less evident in zone 1 of the region (Table 74). Plant height was still important. This characteristic is important and several hundred crosses have been made with non-conventional material trying to incorporate this and other characteristic. Visual selection was again effective in detecting high yielding lines.

Table 73. Agronomic characteristics of bread wheat lines with the highest and lowest record of visual selection in the moderate, high rainfall and irrigated areas of West Asia and North Africa. WON-MRA 1989-90.

Entry No.	Sum Sel	Grain Yield (kg/ha)	DHE	DMA	PH	Diseases ACI YR	LR	SR
84	12	5078	104	147	93	0	0	63
19	12	4591	103	148	91	0	0	0
36	12	4516	110	152	89	0	7	6
88	12	4410	97	144	86	0	7	8
Mean		4649	103	147	90	0	3	19
57	0	3913	108	152	77	0	0	13
59	1	3484	114	155	75	0	0	3
62	1	3876	108	151	82	0	0	0
83	1	3911	109	152	82	0	0	33
Mean		3796	110	153	79	0	0	12
No. of sites	27	32	38	27	37	2	12	3

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

Disease resistance is important in the adaptation of germplasm to zones 2 and 3. The project emphasizes multilocation testing of early segregating material using a modified bulk method for disease resistance (Ortiz Ferrara, G. and Deghais, M., 1988). Further information is collected when selected lines are bulked for preliminary yield testing.

Table 74. Agronomic characteristics of bread wheat lines with the highest and lowest record of visual selection in the dry areas of West Asia and North Africa. WON-LRA 1989-90.

Entry No.	Sum Sel	Grain Yield (kg/ha)	DHE	DMA	PH	Diseases ACI YR	Diseases ACI LR
57	12	3602	117	163	74	0	4
85	12	3386	118	164	83	0	10
64	10	3530	115	164	79	0	0
59	10	3505	117	163	77	0	0
Mean		3506	117	164	78	0	3
36	1	2624	117	165	71	0	0
82	0	2828	122	166	65	0	19
97	0	2707	118	164	72	0	1
113	0	2376	114	162	73	0	10
Mean		2633	118	164	70	0	8
No. of sites	19	14	18	10	18	1	3

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

Table 75 shows the current level of resistance in the CIMMYT/ICARDA bread wheat observation nursery for moderate rainfall areas of WANA. Some progress has been made in raising the level of resistance to the three rusts but more work has to be done to incorporate additional sources of resistance to septoria leaf blotch. With pathology assistance, several hundred crosses have been made with exotic resistant gene pools, including germplasm from the Soviet Union, South America and elsewhere.

Table 75. % of lines in the CIMMYT/ICARDA wheat observation nursery for moderate rainfall areas (WON-MR) showing the levels of disease resistance during the last two years.

Class ACI	No of entries						Class		
	YR		LR		SR			ST	
	1989	1990	1989	1990	1989	1990		1989	1990
0 - 5	94	74	82	45	54	66	0	0	0
6 -10	2	7	7	36	21	16	1	0	0
11-15	0	9	5	8	7	7	2	0	7
16-20	2	7	1	5	7	4	3	9	38
21-25	0	2	4	3	4	4	4	45	37
26-30	0	0	0	2	0	1	5	36	15
31-35	0	0	1	0	1	1	6	10	4
36-40	0	0	0	2	2	2	7	0	1
> 40	2	3	0	1	4	1	8	0	0
							9	0	0
No. of locations	1	2	7	12	4	3		5	2

ACI = Average coefficient of infection. 0 = resistant. 100 = susceptible. YR, LR, SR = Yellow, leaf and stem rust respectively. ST = Septoria leaf blotch.

4.1.6. Germplasm adoption

Improved cultivars must be tested by farmers before they can be released. On-farm trials are run by National Programmes in Syria, Algeria, Sudan, Lebanon, Morocco, Tunisia, Yemen, and Jordan. These activities aim to substitute the un-improved, local varieties with improved varieties.

A number of bread wheat varieties have been released as a result (ICARDA, 1989). Many countries requested and obtained small amounts of newly bred cultivars registered in the region.

During 1991, the Syrian national program decided to release two bread wheat varieties: Bohouth 6 =(Crow 's') and Cham 6 =(Nesser). Bohouth 6 was released for the high rainfall and irrigated areas of the country, while Cham 6 for the low rainfall zones (200-350 mm rainfall). Table 76 presents results of five years testing of Cham 6 in farmer verification trials (FVT) and two years in large scale testing. Cham 6 yielded 12% higher than Mexipak 65 in FVT's and 26% higher in large scale testing. Data from the Syrian National Program indicates that approximately 450,000 ha of wheat are grown where rainfall is 350 mm or less. Approximately 200 ha of Cham 6 were planted for seed multiplication during 1991-92 (pers. comm., Mr. Abdel Bazet Sabagh, Head of Cereals, Seed Multiplication Organization).

Table 77 presents data from another promising bread wheat line Gomam. Over two years the average yield superiority over the national check was 11% and 7% above the improved check in farmers' fields of Syria. This line also performed better than the checks in 34 rainfed locations of WANA during 1989. Gomam was grown in the FVTs' in 1991-92 and will be considered for possible release next year. Seed of this cultivar is under multiplication by ICARDA's seed unit.

Table 76. Performance of Cham 6, commercial bread wheat variety released in 1991, under farmer's field verification trials and large scale testing in the dry areas (<350 mm) of Syria.

Year	F F V T' S					Large scale		
	Cham 6	Mxp	NL	LSD .05	CV (%)	Cham 6	Mxp	NL
1986	2109	1795	7	142	7	-	-	-
1987	1834	1643	7	117	11	-	-	-
1988	3632	3229	10	175	9	2083	1699	2
1990	1402	1224	9	42	11	-	-	-
1991	1557	1486	8	42	13	1127	840	2
Mean	2107	1875	-	-	-	1605	1270	-
% > Mxp	112	100	-	-	-	126	100	-

FFVT's = Farmer's field verification trials; NL = Number of locations; Mxp = Mexipak 65 (National check).

Table 77. Performance of Gomam, promising bread wheat line, in comparison to the local and improved checks in low-rainfall locations of WANA and Farmer's Field Verification Trials (FFVT) in Syria.

Cultivar	GRAIN YIELD (kg/ha)				
	1989 WANA	1990 FFVT	1991 FFVT	Mean FFVT	%> LC
Gomam	2527	3243	2816	3030	111
Cham 4 (IC)	-	3214	2630	2922	107
Mexipak 65 (LC)	2357	2951	2513	2732	100
No. of sites	34	8	9	-	-
All sites mean	2350	3132	2734	2933	-
LSD 5%	-	144	87	-	-
CV (%)	-	11	6	-	-

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

Results from farmer verification yield trials in 1991 in the low-rainfall (<400 mm) areas of West Algeria showed three CIMMYT/ICARDA bread wheat varieties yielding more than the local check variety Mahon Demias. These are: Cham 4 =(Flk/Hork), Zidane 89 =(Gv/Ald), and Cham 6 =(Nesser). On average these varieties yielded 97, 80, and 87% more than the local check at three dry locations (Table 78). There are approximately 200,000 ha of wheat in the dry areas of West Algeria (Sidi Bel Abbes). These varieties are currently under multiplication by the national program and ICARDA.

Table 78. Performance of three CIMMYT/ICARDA bread wheat varieties in on-farm demonstration trials planted in the low-rainfall (<400 mm) areas of West Algeria.

Site	M. Demias (LC)		Cham 4		Zidane 89		Cham 6	
	GY	(%)	GY	(%)	GY	(%)	GY	(%)
Tessala	1824	(100)	3660	(201)	3381	(185)	3380	(185)
Zidane	1192	(100)	1836	(154)	1953	(164)	1859	(156)
Telagh	514	(100)	1450	(282)	1029	(200)	1380	(268)
Site mean	1177	(100)	2315	(197)	2121	(180)	2206	(187)

LC = Local check; GY = Grain yield (kg/ha).

Cham 6 has also been reported to yield well under irrigation. Results from experiments carried out using supplementary irrigation and heat stress in Central and North Sudan show Cham 6 yielding 9% and 5% higher, respectively, than Debeira and Mexicani, the two main commercial varieties in the country (Table 79). Cham 6 has been included in the on-farm verification trials for 1991-92 (personal communication, Dr. Osman Ageeb national wheat research coordinator and DDG of the Agricultural Research Corporation, Sudan).

G. Ortiz Ferrara

Table 79. Grain yield (kg/ha) of Cham 6, CIMMYT/ICARDA bread wheat variety, under heat stress conditions in two regions of Sudan, 1990-91.

Cultivar	IHSGE Wad Medani	AYT Hudeiba	Mean	% > Debeira	DMA
Cham 6	4800	2590	3695	109	92
Mexicani	4550	2296	3423	101	86
Debeira	4380	2378	3379	100	95
Site mean	3984	2368	3176	-	88
S.E. ±	295	250	-	-	-

IHSGE = International heat stress genotype experiment; AYT = Advanced yield trial; DMA = Days to maturity.

4.1.7. Bread wheat grain quality

During 1991, the grain quality laboratory evaluated bread wheat germplasm to upgrade the nutritional and industrial quality of the germplasm distributed to National Programs in WANA.

Four quality tests were conducted in the preliminary (PWYT) and advanced (AWYT) yield trials. These were: hardness, protein content, 1000 kernel weight and seed color. Due to the very dry season in 1989-90 there was insufficient seed to measure other quality parameters such as milling, farinograph or baking characteristics.

Results show improved grain quality in most of the germplasm tested when compared to local checks (Figures 24 and 25). This

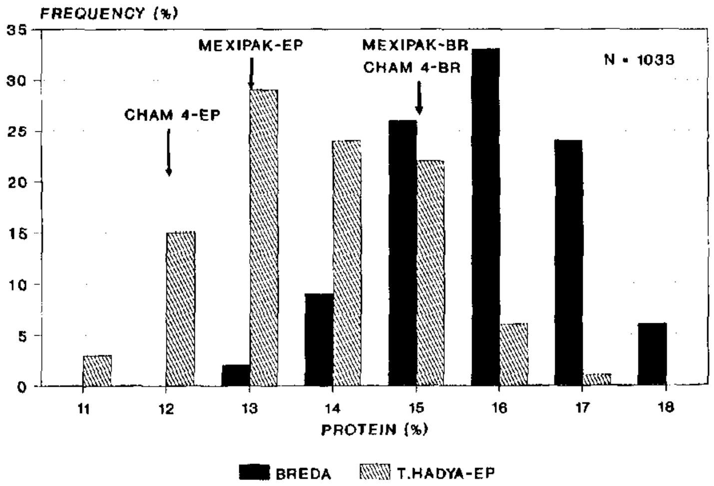

Figure 24. Protein distribution for PWYT's and AWYT's planted in two contrasting environments during 1989-90.

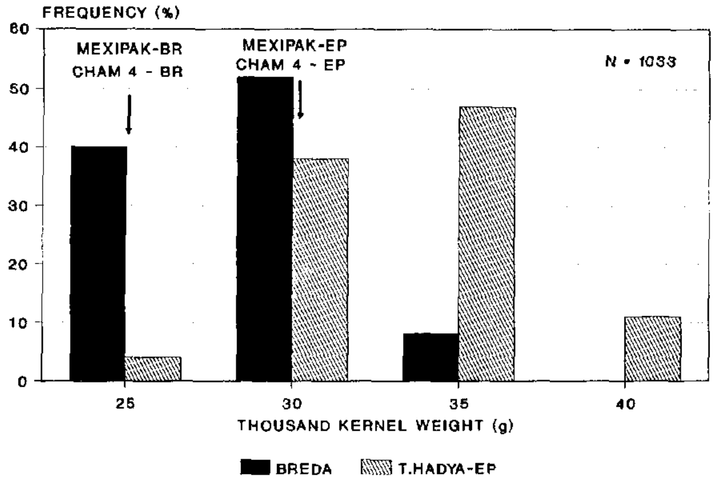

Figure 25. Thousand kernel weight distribution for PWYT & AWYT's planted in two contrasting environments during 1989-90.

information is used by the bread wheat breeding project when promoting promising material to NARS in WANA. Other lines were kept in crossing blocks for further recycling in the breeding project.

It is well documented in the literature that kernel hardness is a highly heritable trait. Little variation is expected in tests conducted with seed sources from different environments. Results of tests carried out in the PWYT's and AWYT's from Tel Hadya planted under supplementary irrigation show that over 80 percent of the bread wheat lines tested have optimum hardness (PSI = 45-55 %) for the local bread making industry (Figure 26).

G. Ortiz Ferrara and F. Jabi El-Haramein

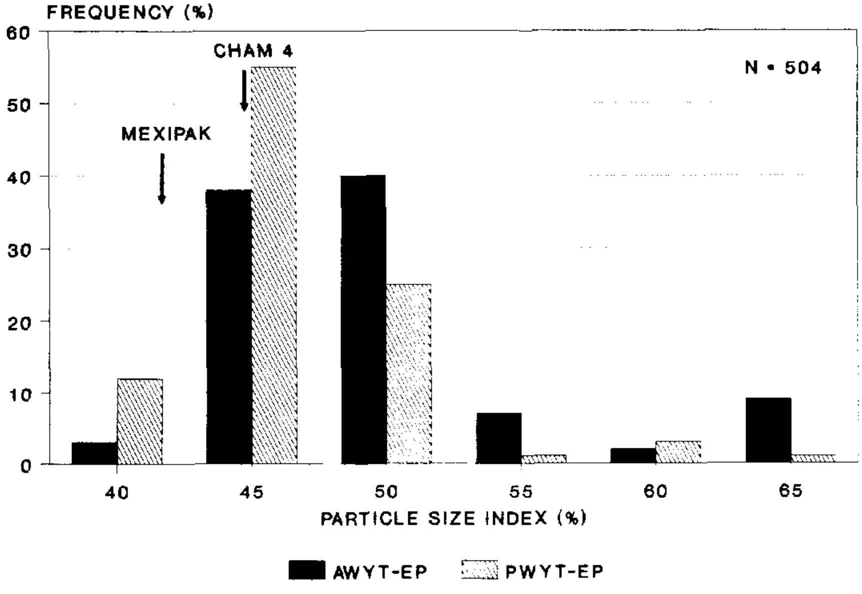

Figure 26. Hardness distribution for PWYT and AWYT's under supplementary irrigation 1989-90.

4.2. Physiology/Agronomy

4.2.1. Bread Wheat

4.2.1.1. Water Use efficiency, growth analysis and leaf energy balance of selected bread wheats

This research is part of a collaborative project with the Department of Plant Ecology and Evolutionary Biology, University of Utrecht, The Netherlands. Initial experiments were conducted on two varieties in growth rooms at Utrecht and on eight contrasting genotypes at Tel Hadya and Breda. Results from these experiments were used to select genotypes for 1991/92.

J.M. Peacock, A. Dakheel, E. Veneklaas and I. Naji

4.3. PATHOLOGY

4.3.1. Bread Wheat Pathology

The 1990/91 season was favourable for screening for resistance to yellow rust (Puccinia striiformis), leaf rust (P. recondita), stem rust (P. graminis), septoria tritici blotch (Mycosphaerella graminicola) and common bunt (Tilletia foetida and T. caries), at Tel Hadya and Lattakia (Syria) and Terbol (Lebanon). During the off-season in Terbol, the summer planting developed leaf rust and stem rust very well and yellow rust was present on a few susceptible lines. The main season was characterized by the occurrence of a severe leaf rust epidemic in Syria and Lebanon. This mainly affected the durum wheat cultivars in Syria but allowed us to identify susceptible material in the bread wheat nurseries.

Results reported here cover germplasm pools for sources of resistance distributed by the Program, the performance of the bread wheat germplasm against the major diseases in the season 1990/91, summary of data on the Key location Disease Nursery-90, and crop loss assessment trials. Results on studies of host-pathogen systems in bread and durum wheat are reported under "Durum Wheat Pathology".

4.3.1.1. Germplasm pools for sources of resistance to wheat diseases

Resistance screening to wheat diseases from the past five seasons (1986/87-1990/91) has produced four germplasm pools with sources of resistance to yellow rust, leaf rust, septoria tritici blotch and common bunt. The Program dispatched 49, 50, 29 and 27 sets of these pools respectively to collaborators in WANA and beyond. The pools contain good sources of resistance that could be used in crossing programs.

The germplasm pool for sources of resistance to yellow rust (WYRGP-91) has 65 entries including sister lines (Table 80). These lines are the end-product of our multilocation screening with the major site at Tel Hadya. Other sites were Terbol, Elvas/ Portugal and Gharakheil/Iran. Selection criterion for yellow rust was an average of 10MR over two seasons of testing. Data on the performance of these lines for other diseases are also included in the Table.

The germplasm pool for sources of resistance to leaf rust (WLRGP-91) includes 26 lines which were resistant to the disease for at least two season at T. Hadya (Table 81). Selection criterion was an average of 10MR. All lines in this pool performed well against yellow rust as well and some against stem rust and septoria tritici blotch.

Table 80. The performance[1] of selected bread wheat lines to yellos, <u>Pucinia striiformis</u>, and other diseases (WYRGP-91)

Ent.	Name or Cross	Screening year and Site[2] 1987 TH	1987 TE	1987 EL	1988 TH	1988 EL	1989 TH	1989 GH	1990 TH	1991 TH	Other diseases[3] LR	ST	PM	CB
1.	(K(ML) 7106) Bithoot/Veery	0	tR	tMR	5R	0	5R	5R	5R	tR	tMR	8	0	-
2.	71St2959/Crow	-	-	-	-	-	tR	tR	tR	tR	-	2	-	-
3.	71St2959/Crow	0	tR	0	5R	tR	tR	5R	tR	10R	tR	7	0	-
4.	71St2959/Crow	0	tR	tR	5R	5MR	tR	5R	tR	10R	tR	8	0	-
5.	71St2959/Crow	-	-	-	-	-	5R	20MR	5R	10MR	-	0	-	-
6.	Ald/Ska	-	-	-	-	-	5R	10MR	5R	tR	-	3	-	-
7.	Ao41/Emu	0	tR	tR	5R	0	5R	10R	tR	tR	tR	7	7	-
8.	Au//Kal/Bb/3/Bon/4/Bun	0	tR	0	5R	0	5R	20MR	tR	tR	0	8	-	-
9.	Au/Tob66/3/Gv/Az67/Mus	-	-	-	-	-	5R	20MR	tR	tR	-	0	-	-
10.	Bage/Hork//Aldan	0	-	-	5R	tR	tR	tR	5R	tR	-	8	-	12
11.	Bb/G11//Cj71/3/T.aest//Kal/Bb	-	-	-	-	-	tR	20MR	1MR	5R	-	0	-	-
12.	Bb/G11//Cj71/3/T.aest//Kal/Bb	-	-	-	-	-	10MR		5R	tR	10MR	-	0	—
13.	Bez//Tob/8156/4/On/3/6*Th/Kf//6*Lee	-	-	-	-	-	5R	20MR	5R	tR	10MR	1	-	-
14.	Bluebird II/T72-60/2/Kavkaz	5MR	tR	0	tR	tR	tR	5R	tR	tR	0	5	-	-
15.	Bow	-	-	-	-	-	tR	20MR	5R	tR	5MR	1	-	-
16.	Bow	tR	5MR	0	5R	5MR	5R	20MR	tR	tR	tMR	7	-	-
17.	Bow/Gh	-	-	-	-	-	5R	10MR	tR	tR	-	0	-	-
18.	Bow/Spt	-	-	-	-	-	5R	0	5MR	5R	-	0	-	-
19.	Clement/Ald	-	-	-	-	-	5MR	5R	tR	tR	-	0	-	-
20.	Dove/Ald	tR	tR	tR	tR	0	5R	5MR	tR	5R	tMR	8	7	-
21.	F3.71/Nkt	tR	-	-	5MR	0	tR	5R	5R	10MR	-	8	-	10
22.	F6-76/Nac	-	-	-	-	-	tR	5MS	tR	10R	-	0	-	-
23.	GH/Bow	-	-	-	-	-	5R	10MR	5R	5R	-	0	-	-

Table 80. (contd)

Ent.	Name or Cross	Screening year and Site[2) 1987 TH	1987 TE	1987 EL	1988 TH	1988 EL	1989 TH	1989 GH	1990 TH	1991 TH	Other diseases[3) LR	ST	PM	CB
24.	Golan//Mxc/Tob	0	tR	0	5MR	tR	tR	5R	tR	tR	5M	8	8	-
25.	HD2169/Bow	tR	tR	tR	5R	10MS	tR	5R	tR	tR	tR	8	3	-
26.	HYS/T2484-35T-2T-1T CB75-270	-	-	-	-	-	tR	5MR	tR	tR	-	0	-	-
27.	IAS58/IAS55//Ald/3/Mrng/4/Ald"	tR	-	-	5MR	0	tR	10R	tR	tR	-	5	-	13
28.	IAS63/Ald//Gto/LV/3/Ures	-	-	-	-	-	5R	5R	tR	tR	-	0	-	-
29.	Inia/RI4220//7C/3/Kal/Bb	0	tR	tR	15R	0	5R	10MR	5R	5R	tR	8	8	-
30.	Jup/Ald//Banks	-	-	-	-	-	tR	5MR	tR	tR	-	0	-	-
31.	Kvz/Cgn	tR	-	-	5MR	0	5MR	10R	tMR	10MR	-	7	-	11
32.	Maya/Sap	-	-	-	-	-	5R	5R	5R	tR	-	2	-	-
33.	Maya74/On/II60.147/3/Bb/G11/4/Chat	-	-	-	-	-	tR	10MR	5R	20MR	-	2	-	-
34.	Mon/Ald	-	-	-	-	-	tR	5R	5R	tR	-	2	-	-
35.	NP//Pob/8156/3/Kal/Bb	0	5R	0	5R	0	tR	10MR	tR	tR	tMR	8	-	-
36.	NS2699	0	-	-	10MR		tR	tR	5MR	tR	10R	20MR	7	-14
37.	NS732/Her	tR	tR	tR	5R	0	tR	5R	tR	tR	tR	8	0	-
38.	NS732/Her	0	tR	0	tR	0	tR	5R	5R	tR	0	8	3	47
39.	NS732/Her	-	-	-	-	-	5R	10MR	5R	tR	-	1	-	-
40.	NS732/Her	0	tR	0	tR	0	tR	tR	tR	tR	tR	8	0	-
41.	NS732/Her	0	tR	0	5MR	0	tR	10MR	tR	tR	tR	8	0	-
42.	Peq/6/Lfn/Mz/4/4777/3/Rei//Y/Kt"	-	-	-	-	-	5R	5R	5R	5R	5MR	0	-	-
43.	Prl/4/Kvz/3/Inia66/On//Inia66/Bb	-	-	-	-	-	5R	5R	5R	5MR	-	0	-	-
44.	Rbs/Anza/3/Kvz/Hys//Ymh/Tob/4/Bow	tMR	tR	0	5R	0	5R	10MR	tR	tR	5MR	6	-	-
45.	Rbs/Anza/3/Kvz/Hys//Ymh/Tob/4/Bow	0	tR	0	5R	0	tR	5R	5R	tR	10MR	8	4	70
46.	Rbs/Anza/3/Kvz/Hys//Ymh/Tob/4/Bow	tR	tR	0	tR	0	5R	5MR	tR	tR	tR	7	0	-

Table 80. (contd)

Ent.	Name or Cross	Screening year and Site[2)]									Other diseases[3)]			
		1987			1988		1989		1990	1991				
		TH	TE	EL	TH	EL	TH	GH	TH	TH	LR	ST	PM	CB
47.	Rbs/Anza/3/Kvz/Hys//Ymh/Tob/4/Bow	0	tR	tR	5R	tR	5R	5MR	tR	tR	tR	7	3	-
48.	Rbs/Anza/3/Kvz/Hys//Ymh/Tob/4/Bow	0	tR	0	10R	tMR	5R	5R	5R	tR	tMR	8	1	24
49.	Rbs/Anza/3/Kvz/Hys//Ymh/Tob/4/Bow	0	tR	0	0	0	tR	5R	5R	tR	tMR	7	2	62
50.	Rbs/Anza/3/Kvz/Hys//Ymh/Tob/4/Bow	-	-	-	-	-	tR	5MR	tM	tR	-	2	-	-
51.	S.Seafoan//Soty/Jn*3	-	-	-	-	-	tM	5MR	tR	10R	-	3	-	-
52.	SUDAN £7	-	-	-	-	-	5R	20MR	tR	tR	-	0	-	-
53.	Sannine/Ald	15MR		-	-	10MR	tMR	tR	5R	tR	tR	-	7	-12
54.	Shif4414/Crow	0	tR	tR	tR	tMS	5R	5MR	tR	tR	tMR	8	-	-
55.	Shif4414/Crow	-	-	-	-	-	tR	5MR	5R	tR	-	2	-	-
56.	Shif4414/Crow	-	-	-	-	-	5R	10R	tR	10R	-	1	-	-
57.	Shif4414/Crow	-	-	-	-	-	tR	5R	tR	5R	-	1	-	-
58.	Snb	-	-	-	-	-	tR	0	5R	tR	-	5	-	-
59.	TP114-65A/Monon/Aurora/448-1180	0	tR	0	tR	0	tR	10MR	tR	tR	0	6	-	-
60.	Tzpp*2/Ane//Inia/3/Cno/Jar//Kvz	-	-	-	-	-	tR	5MS	5R	tR	-	3	-	-
61.	Tzpp/Sn64A//Napo/3/Mn72131	0	-	-	5MR	0	5R	10R	5R	tR	-	8	-	12
62.	Van//Bb/Kal	0	tR	tR	15R	-	5R	5R	5R	5MR	tR	8	3	-
63.	Vee/Pvn	tR	tR	0	10R	10MR	5R	5R	tR	tR	tMS	8	1	57
64.	Wrm//Kal/Bb/3/Bow	-	-	-	-	-	5R	10MR	tR	tR	-	3	-	-
65.	Ww33/Vee	-	-	-	-	-	tR	5MR	5R	tR	-	0	-	-

1) Performance: % severity and reaction type; 2) screening site: TH = Tel Hadya/Syria; TE = Terbol/Lebanon; EL = Elvas/Portugal; GH = Gharakheil/Iran. 3) Other diseases: LR = leaf rust; ST = septoria tritici blotch, and PM = powdery mildew on 0-9 scale; CB = common bunt, % head infection.

Table 81. The performance[1] of selected bread wheat lines to leaf rust, <u>Puccinia recondita</u>, and other diseases (WLRGP-91)

Ent. Name or Cross	Screening year					Other diseases[2]				
	1987	1988	1989	1990	1991	YR	SR	PM	ST	CB
1. Ald/Ska	tR	tR	tR	tR	5R	tR	-	5	8	-
2. Lira	tR	tR	tR	tR	5R	5MR	-	5	8	-
3. NS732/Her	tR	5MR	tR	tR	tR	tR	-	-	8	-
4. Rbs/Anza/3/Kvz/Hys//Ymh/Tob/4/Bow	tR	5R	5R	tR	5R	tR	-	5	8	-
5. 12/1 (F7b2, SavaxPr)	tR	tR	7MR	tR	5R	tR	-	-	5	-
6. 33/1 (F7b2, S 143/73xPr)	tR	8R	5R	tR	5R	tR	-	5	4	-
7. 86/3 (F7b2, 82XSt.)	tR	tR	5R	tR	5R	5R	-	-	5	-
8. A041/Emu	tR	6MR	5R	tMR	3R	tR	tR	4	7	38
9. Van/5/Cno*2/Tob//Gll/3/Tob/Cc//Pato/4/Jar	-	tR	25MR	5R	5R	20MR	40S	5	8	-
10. Bos/5/Inia/R14220//7C/3/Yr/4/WI255/Wk*2/3/`	-	tR	tR	tR	5R	15MR	60S	-	7	-
11. Bb/Gll//cj71/3/T.aest//Kal/Bb	-	tR	5R	tR	5R	5MR	0	5	6	-
12. Bow/Dove	-	tR	5R	tR	tR	10MR	-	-	8	-
13. Bow/Gh	-	tR	5R	5R	5R	15R	-	-	6	-
14. Bb/Gll//Cj71/3/T.aest//Kal/Bb	-	tR	5R	5R	tR	tMR	-	-	7	82
15. HYS/T2484-35T-2T-1T CB75-270	-	5R	5R	tR	5R	tR	-	-	6	0
16. Mon/Ald	-	tR	5R	tR	5R	5R	-	-	7	80
17. Sannine/Ald	-	5R	5R	5R	tR	tR	-	-	8	78
18. IA78112	-	tR	tR	5R	5R	10MR	-	-	6	64
19. R16010/4*JUP73//CMH79.699	-	tR	tR	tR	3R	tR	-	-	8	-
20. BR 14.IAS 63/Alondra/2/Gaboto/Lagoa Vermelha	-	tR	tR	tR	tR	5R	-	-	3	-
21. Vee/Lira	-	-	tR	5R	5R	tR	tR	-	8	28
22. Dove/Bow	-	-	tR	tR	tR	5MR	tR	-	5	2
23. Rbs/Anza/3/Kvz//Ymh/Tob/4/Bow	-	-	tR	tR	5R	5MR	20M	-	8	4
24. Kvz//Cno67/Pj62/3/IA78112	-	-	5R	5R	tR	tR	5MR	-	8	-
25. Vee/SNB	-	-	tR	tR	5R	tR	15MR	-	8	-
26. Seri/Bow	-	-	5R	5R	tR	tR	10R	-	7	-

1) Performance : % severity and reaction type
2) Other diseases: YR and SR yellow and stem rust; PM = powdery mildew and ST = septoria tritici blotch on 0-9 scale;
CB = common bunt, % head infection.

The germplasm pool for sources of resistance to Septoria tritici blotch (WSTGP-91) included 25 lines which performed well against septoria for two seasons in two 'hot spots' (Table 82). The main screening site was Lattakia, others were T. Hadya, Gorgan/Iran, Beja/Tunisia and Elvas. The majority of lines performed well against the three rusts as well. Performance against powdery mildew was also good. The bread wheat germplasm pool for sources of resistance to common bunt (WCBGP-91) includes 13 lines which performed well, < 15% head infection, at T. Hadya (Table 83). All these lines have undergone at least three years of screening, one against ten different common bunt isolates from WANA. Lines in this pool have excellent performance against yellow rust.

Omar F. Mamluk and Mounzer Naimi

4.3.1.2. The performance of bread wheat germplasm against the major diseases, season 1990/91

The performance of wheat germplasm in our nurseries against five major diseases is based on the % resistant entries, checks excluded, in each nursery (Figure 27). Selection criterion over the screening sites was for rusts ≤ 10MR, for septoria tritici blotch ≤ 6 on a 0-9 scale, and for common bunt ≤ 15% head infection. The nurseries used were: Wheat Aleppo Crossing Block (WACB), Wheat Crossing Block for High Elevation (WCBH), Wheat Preliminary Disease Nursery (WPD) = Wheat Preliminary Yield Trial, Preliminary Wheat Screening Nursery (PWSN), Wheat Key Location Disease Nursery (WKL) = Wheat Advanced Yield Trial, as well as the special purpose disease nurseries: Wheat Yellow Rust Nursery (WYR), Wheat Leaf Rust Nursery (WLR), Wheat Stem Rust Nursery (WSR), Wheat Septoria Nursery (WST), and the Repeat Testing Bunt Nursery (RTB). For yellow rust, leaf rust, septoria

Table 82. The performance[1] of selected bread wheat lines to septoria tritici blotch, Mycospaerella graminicola, and other diseases (WSTGP-91).

Ent.	Name or Cross	Screening year and Site[2]													Other diseases[3]					
		1988					1989				1990	1991			YR	LR	SR	PM	CB	BY
		TH	IA	GO	BE	EL	TH	IA	GO	BE	IA	TH	IA	BE						
1.	KIME#23/4/CNO67/7C//KAL/BB/3/PCI/5/Bow	5	1	0	0	5	0	1	3	1	3	4	3	0	15MR	10S	25S	5	-	-
2.	Kvz//Cno67/Pj62/3/Tan	5	2	4	3	6	2	4	5	0	2	4	3	7	10MR	50R	0	4	68	5
3.	Dove/Bow	-	5	-	0	6	3	6	0	0	4	4	4	1	20MR	0	0	-	-	-
4.	Mir 264/Au	-	3	-	1	5	1	1	3	0	4	3	2	0	5R	10MS	-	4	-	-
5.	4777(2)//Fkn/Gb/3/Vee/4/Buc/Pvn	-	7	-	-	-	0	5	5	0	5	4	6	6	5MR	tR	-	1	48	-
6.	Bb/Gll//Cj71/3/T.aest//Kal/Bb	-	6	-	-	-	1	5	3	1	5	4	4	6	5MR	tR	-	0	82	-
7.	Sannine/Ald	-	6	-	-	-	0	1	3	0	2	4	6	1	tMS	5R	-	5	78	-
8.	Maya74/On//II60.147/3/Bb/Gll/4/Chat	5	-	-	-	-	2	6	5	0	4	4	6	4	10MR	0	-	0	78	4
9.	Rdl/P101*2//Torim	4	-	-	-	-	2	5	5	0	4	4	6	6	5R	30S	-	5	25	6
10.	Dove/Bow	-	-	-	-	-	3	1	-	2	2	4	4	6	5MR	10MR	tR	4	2	7
11.	Jup/Bjy//Ures	-	-	-	-	-	3	6	-	2	5	4	6	7	tR	5MS	tR	0	17	7
12.	Ald/Bow	-	-	-	-	-	3	3	-	2	3	4	4	7	tR	5R	tR	5	20	6
13.	Kvz//Cno67/Pj62/3/IA78112	-	-	-	-	-	2	3	-	1	5	4	4	7	5MR	tR	10MR	0	-	-
14.	Ures/3/Fury/Sln/Aldan	-	-	-	-	-	1	2	-	3	5	4	6	6	tMR	5R	15MR	0	-	-
15.	Kvz//Cno67/Pj62/3/SNV	-	-	-	-	-	2	4	-	0	3	4	4	8	tR	5R	5MR	0	-	-
16.	4777//Fkn/Bb/3/Vee/4/Buc/Pvn	-	-	-	-	-	0	5	-	-	4	2	5	5	10MR	tR	15MR	0	13	-
17.	Maya/Sap	-	-	-	-	-	1	4	-	-	3	4	6	6	5R	10MS	15MR	0	19	-
18.	Rbs/Anza/3/Kvz/Hys//Ymh/Tob/4/Bow	-	-	-	-	-	1	5	-	-	2	4	4	4	5R	5R	tR	4	22	-
19.	Rbs/Anza/3/Kvz/Hys//Ymh/Tob/4/Bow	-	-	-	-	-	5	2	-	-	2	5	4	1	5R	5R	10R	0	14	-
20.	Rbs/Anza/3/Kvz/Hys//Ymh/Tob/4/Bow	-	-	-	-	-	3	5	-	-	2	3	4	1	tR	tR	10R	0	16	-
21.	PF70354/MUS//GEN	-	-	-	-	-	-	-	-	-	4	2	4	4	tR	0	-	0	-	-
22.	IAS58/4/KAL/BB/CJ/3/ALD/5/BOW	-	-	-	-	-	-	-	-	-	2	4	4	6	tR	0	-	0	-	-
23.	PF72640/PF7326//PF7065/ALD/3/KLT	-	-	-	-	-	-	-	-	-	3	4	6	5	tR	0	-	0	-	-
24.	PAT24/ALD	-	-	-	-	-	-	-	-	-	4	2	5	4	10MR	0	-	0	-	-
25.	PVN/Bow	-	-	-	-	-	-	-	-	-	3	3	8	5	tR	0	-	0	-	-

1) Performance: 0-9 scale; screening site: TH = Tel Hadya and LA = Lattakia/Syria; GO = Gorgan/Iran; BE = Beja/Tunisia; EL = Elvas/Portugal. 3) Other diseases : Yr, LR and SR = Yellow, leaf and stem rust respectively (% severity and reaction type); PM = powdery mildew and BY = barley yellw dwarf virus on 0-9 scale; CB = common bunt, % head infection.

Table 83. The performance[1)] of selected bread wheat lines to common bunt, <u>Tilletia</u> <u>foetida</u> and <u>T.</u> <u>caris</u> (WCBGP-91)

Ent.	Name or Cross	Screening year 1986	1987	1988	1989	1990	Yellow[2)] rust
1.	71St2959/Crow	9	15	10*	-	-	tMR
2.	Wal/3/1154/45/Wal/Su92/4/Sol	1	1	1*	-	-	5MR
3.	4-22/skp35//C126-15/C74-6/5/Chambord~	8	7	5*	-	-	5R
4.	Tast/Torim	0	1	3*	-	-	5R
5.	5S1744/Mex67-1//2897/2800	0	4	1*	-	-	5R
6.	Lram/4/Mrs/Kal/Bb/3/Azt	-	3	2	1*	1*	tR
7.	Absolvent/4/Mrs//Kal/Bb/3/Azt	-	1	14	1*	2*	tR
8.	Hys//Drc*2/7C	-	0	15	1*	1*	5MR
9.	Dj/Bza//Woa	-	4	11	4*	-	tR
10.	Rbs/Anza/3/Kvz/Hys//Ymg/Tob	-	2	15	1*	1*	5R
11.	Las58/Las55//Ald/3/Mrng/4/Ald/Las58.103A//Ald	-	9	9	2*	2*	tMR
12.	RmnF3-71/Torim	-	0	2	1*	2*	tR
13.	Rbs/Anza/3/Kvz/Hys//Ymh/Tob/4/Bow	-	5	14	1*	2*	tR

1) Performance: % head infection; 2) Highest reading of % severity and reaction type.
* Average of ten isolates from Turkey (3), Iran (2) and one each from Pakistan, Syria, Lebanon, Tunisia and Morocco.

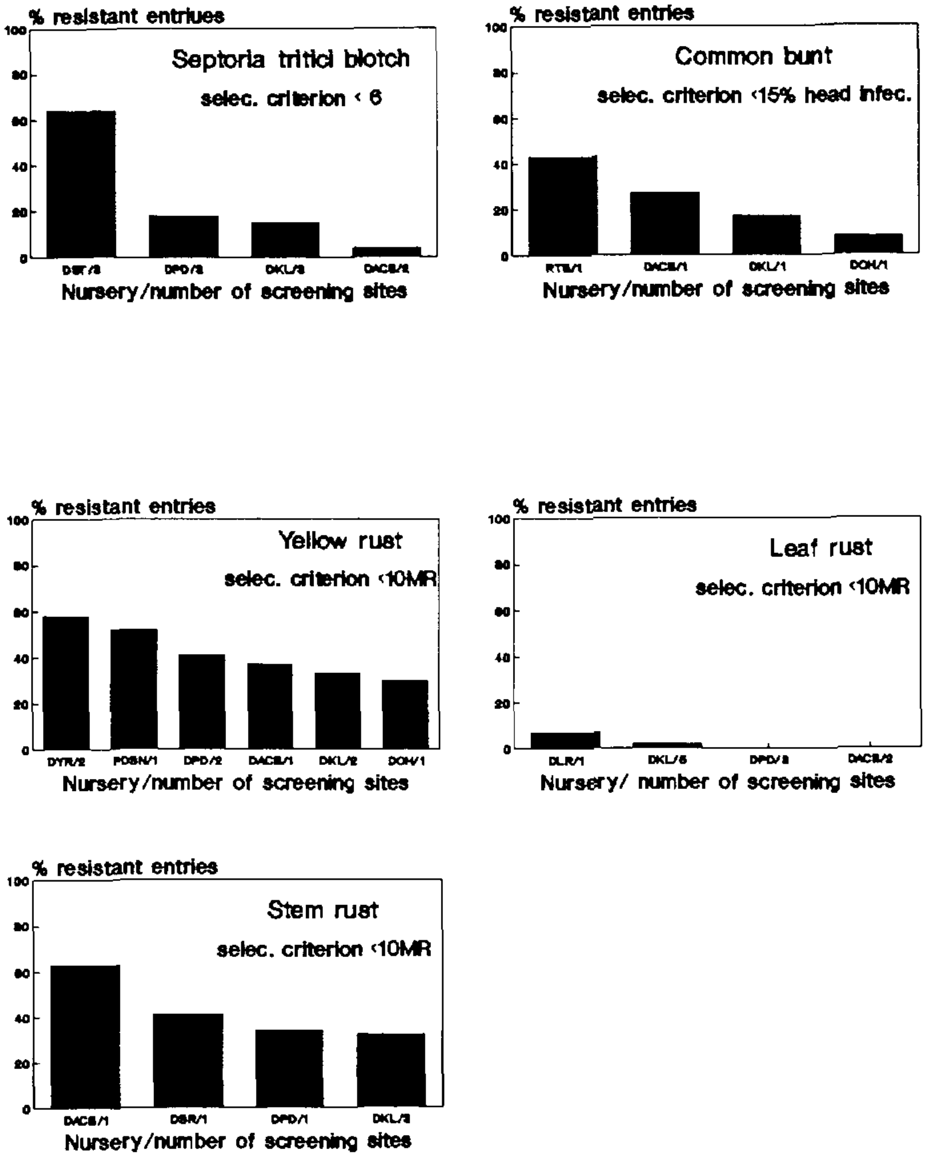

Figure 27. Percent resistant entries in the bread wheat germplasm to the different diseases.

blotch and common bunt, the special purpose disease nurseries had the best performance for their respective diseases. In WYR and in WLR, 86% and 93% of the entries respectively were resistant; in the WPD, 53% of the entries were resistant to stem rust, whereas in the WSR 50% were resistant. For septoria, the WST had 64% of the entries resistant and the lowest performance was 19% in the WPD. For common bunt, the highest performance of 35% was in the RTB and the lowest, 0.5% resistant entries, in the WKL.

Omar F. Mamluk and Alaa Yaljarouka

4.3.1.3. Summary of disease data of the Key Location Disease Nursery (WKL-90)

Disease data from our multilocation screening on the WKL-90 were completed in January 1991. Useful data on leaf rust were received from four locations, T. Hadya, Sakha and Gemeisa/Egypt, and Elvas; on stem rust from three locations, T. Hadya, Sakha, and Terbol (summer planting); on septoria from two locations, Lattakia and Elvas; and on yellow rust, barley yellow dwarf virus*, and common bunt from one location, T. Hadya (Table 84). There were 9, 75, 46, 17, 20 and 18 lines with resistance to yellow rust, leaf rust, stem rust, septoria blotch, barley yellow and common bunt respectively. Lines showing resistance to all three rusts totaled 18 (WKL-90 # 21, 43, 63, 64, 84, 89, 95, 109, 115, 122, 163, 164, 167, 176, 177, 178, 179, 184). Six lines

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* Data on barley yellow dwarf virus are furnished by Dr. K.M. Makkouk, Virology Lab./GRU

Table 84. Number of bread wheat lines * resistant ** to one or more major diseases (WKL-90).

Disease	No. and % resistant lines	
	No.	%
Yellow rust	79	46
Leaf rust	75	44
Stem rust	46	27
Septoria blotch	17	10
Barley yellow	20	12
Common bunt	18	11
Yellow, leaf and stem rusts	18	11
Yellow rust and common bunt	6	4
Septoria blotch and barley yellow	2	1
Yellow, leaf and stem rusts; septoria blotch; barley yellow; and common bunt	1	0.6

* Total number tested 171, checks excluded.

** Selection criteria: CI 0.2 for yellow rust, ACI 2.0 for leaf and stem rusts, 0-5 score on a 0-9 scale for septoria tritici blotch and barley yellow dwarf virus, 0-15 % head infection for common bunt.

showed resistance to yellow rust and common bunt (WKL-90 # 7, 25, 67, 77, 159, 184) and two lines to septoria and barley yellow (WKL-90 # 74, 184). One line, entry # 184, showed resistance to all six diseases; its cross/pedigree is:

Tob'S'/8156/Y50E/Kal(3)/4/MRS//Lak/BB/3Az

ICW82383-023AP-300AP-4AP-300L-3AP-300L-0AP

Omar F. Mamluk and Suzanne Khawatmi

4.3.1.4. Crop loss assessment trials, season 1990/91

Crop loss assessment trials aim at estimating the actual losses to a particular disease. Seven bread wheat cultivars were included in this season's trials to estimate the losses due to yellow rust and septoria tritici blotch. These cultivars are from the Farmer Verification Trials conducted in Syria in collaboration with DSAR. The trial on yellow rust was at T. Hadya, whereas that on septoria blotch was at Lattakia. Results on the yellow rust trial are summarized in Table (85). Bayfidan, fungicide I, was applied to all cultivars, whereas fungicide II, Daithane M45 and Sportak, was applied to two cultivars only. Fungicide I suppressed the disease substantially in the susceptible cultivars Mexipak and Hazega and caused an increase in grain yield in cultivars Mexipak, Zarzour, Baz, and Douri. Statistical analysis showed significant differences among the treatments (infected, fungicide I and II) in Mexipak for the variable ACI only (LSD 38.252). Also significant differences among treatments for number of tillers occurred in the cultivars Baz (LSD 9.4) and Hazega (LSD 5.165).

Results on septoria blotch are summarized in Table (86). Fungicide II, Bravo, suppressed the disease in Douri and to a lesser extend in Mexipak (the only varieties having this treatment). Fungicide I, Bayfidan reduced disease substantially on all cultivars, except Mexipak. In all cases, fungicide I and II increased grain yield, notably in Mexipak. The statistical

Table 85. Effect of yellow rust (<u>Puccinia striiformis</u>) on grain yield and yield components of bread wheat cultivars (Tel Hadya, Syria 1991)

Cultivar	Treatment	Yellow rust Score	/ ACI	Yield KG/ha	No.tillers per m	No.seeds per spike	1000KW (g)
Mexipak 65	Infected	93 S	93.3	1578	132	20	22.6
	Fungecide I	43 R-S	35.3	1700	111	20	28.9
	Fungecide II	80 MS-S	69.3	1456	115	16	24.5
Zarzour	Infected	5 R-MR	1.3	2144	125	21	27.8
	Fungecide I	1 R	0.2	3011	138	24	28.4
	Fungecide II	—	—	—	—	—	—
Baz	Infected	4 R	0.7	2567	117	21	29.0
	Fungecide I	1 R	0.2	2644	133	22	30.5
	Fungecide II	—	—	—	—	—	—
Douri	Infected	2 R	0.5	1556	112	16	30.6
	Fungecide I	1 R	0.2	1611	112	17	29.7
	Fungecide II	4 R	0.7	1322	120	13	30.7
Bau	Infected	4 R	0.8	1733	131	15	28.1
	Fungecide I	2 R	0.5	1633	127	16	27.1
	Fungecide II	—	—	—	—	—	—
Ghurab	Infected	4 R-MS	1.7	2544	113	24	28.5
	Fungecide I	2 R-S	1.8	1845	121	23	27.5
	Fungecide II	—	—	—	—	—	—
Hazega 1	Infected	73 S	73.3	1989	132	20	24.6
	Fungecide I	27 R-S	26.7	1922	114	21	28.8
	Fungecide II	—	—	—	—	—	—

Figures = mean of 3 rep. each 6.3 m^2; harvested 3 m^2
Experiment design = split plot (treatment as main plot factor)
Infected = artificial inoculation applied three times
Fungecide I = Bayfidan, 0.5 l/ha, applied three times
Fungecide II = Daithane M45, 0.8 kg/ha, applied five times
Sportak, 1.2 l/ha, applied twice

Table 86. Effect of septoria tritici blotch (Mycosphaerella graminicola) on grain yield and yield components of different braed wheat cultivars (Lattakia, Syria 1991).

Cultivar	Treatment	Septoria score	Yield kg/ha	No.tillers per m	No.seed per/spike	1000KW (g)
Mexipak 65	Infected	9/7	2925	102	47	32.8
	Fungicide I	8/2	4467	102	48	36.1
	Fungicide II	8/2	3808	119	42	37.6
Zarzour	Infected	8/3	3508	124	31	45.4
	Fungicide I	1/1	3633	95	40	45.2
	Fungicide II	—	—	—	—	—
Baz	Infected	8/5	3317	118	33	44.3
	Fungicide I	1/1	4317	135	38	44.0
	Fungicide II	—	—	—	—	—
Douri	Infected	8/5	3508	112	39	45.9
	Fungicide I	1/1	3821	128	39	42.1
	Fungicide II	1/1	4058	99	41	47.6
Bau	Infected	8/3	4108	124	41	45.2
	Fungicide I	2/1	4525	132	40	45.1
	Fungicide II	—	—	—	—	—
Ghurab	Infected	8/4	4025	114	39	42.0
	Fungicide I	2/1	4183	118	42	42.7
	Fungicide II	—	—	—	—	—
Hazega 1	Infected	8/7	3208	108	40	38.4
	Fungicide I	6/1	4050	117	40	41.4
	Fungicide II	—	—	—	—	—

Figures = mean of 3 rep. each 8.4 m^2; harvested 4 m^2
Experiment design = split plot (treatment as main plot factor)
Infected = artificial inoculation applied four times
Fungicid I = Bayfidan, 0.5 l/ha, applied twice
Fungicid II = Bravo, 2 l/ha, applied twice

analysis showed significant differences among treatments for Mexipak (LSD 0.0*), Zarzour (LSD 0.0*), Baz (LSD 1.433), Douri (LSD 0.0*), Bau (LSD 2.867), and Ghurab.

Omar F. Mamluk, Mounzer Naimi and Suzanne Khawatmi

4.4. International Nurseries

Regional bread wheat nurseries assembled by the joint CIMMYT/ICARDA bread wheat project at ICARDA in 1991 are given in Table 87. The numbers of spring-type nurseries remained unchanged from last year. The CIMMYT/ICARDA agreement on spring wheat nursery preparation and distribution was implemented this season. For the first time, about half of the two regular observation nurseries included lines supplied from the base program in Mexico with seed multiplied at Tel Hadya. Distribution of the observation nurseries was restricted to the WANA region as agreed.

The germplasm pool for Septoria tritici resistance, which was available for the last two seasons, was replaced by four new disease resistant germplasm pools. The segregating populations and observation nursery for high altitude areas containing winter and facultative types were not prepared this season as a result of re-organization of the CIMMYT/ICARDA winter wheat project. The observation nursery for high altitude areas was combined with the

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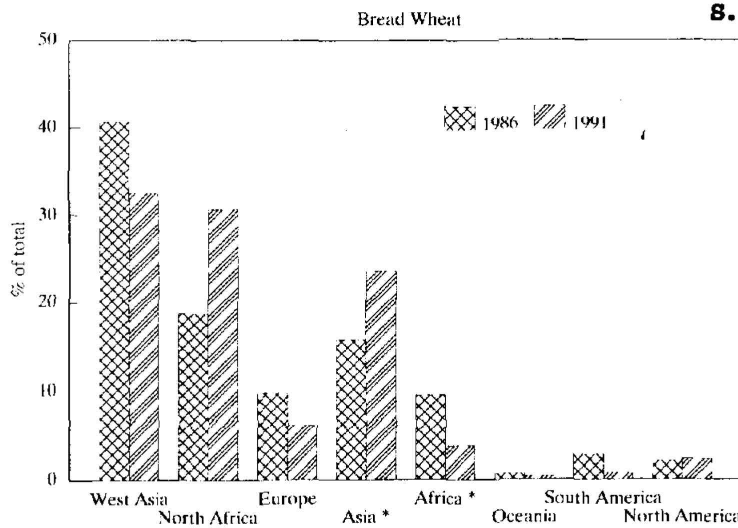
* Due to consistnent response over reps. and low variability (LSD 4.3) for vertical disease development and in all cultivars for disease severity. There were differences between treatments for yield in Mexipak (LSD 0.0*) and for number of tillers/m (LSD 23.464) and number of seed/spike (LSD 1.433) in Zarzour.

International Winter Wheat Screening Nursery and distributed from Ankara, Turkey, where the CIMMYT/ICARDA facultative wheat project is based.

A total of 319 nursery sets, excluding the germplasm pools, were distributed in 1991. Since 1986, the year in which the record number of nursery sets (454) were sent, the numbers of nursery sets sent has been scrutinized more carefully and the number reduced gradually.

The distribution of nursery sets in 1986 versus 1991 is shown in Fig. 28. Requests for the regional nurseries were received from cereal scientists worldwide. In 1986 West Asia received about twice the number of sets as North Africa. But in 1991 North Africa received nearly the same as West Asia. In 1991, 64% of total nursery sets were sent to WANA (excluding Ethiopia, Sudan and Pakistan), compared to 60% in 1986. This trend is expected to continue following the agreement between CIMMYT and ICARDA on nursery distribution.

S.K. Yau



*Asia: excluding West Asia; Africa: excluding North Africa

Fig. 28. Distribution of bread wheat nursery sets in 1986 and 1991.

Table 87. Bread wheat regional nurseries for 1991.

Nursery	Abbre-viation	No. of entries	No. of sets distributed
Spring Types			
Regular Nurseries			
Crossing Block	WCB	181	40
Segregating Populations	WSP	122	30
Observation Nurseries:			
- Low Rainfall Areas	WON-LRA	270	20
- Moderate Rainfall Areas	WON-MRA	267	30
Yield Trials:			
- Low Rainfall areas	WYT-LRA	24	63
- Moderate Rainfall Areas	WYT-MRA	24	81
Specific-trait Nurseries			
Heat Tolerance Obs. Nur.	HTON	60	55
Sub-total			319
Germplasm Pools for Sources of Disease Resistance			
Yellow Rust	WYRGP	65	49
Leaf Rust	WLRGP	26	50
Common Bunt	WCBGP	13	27
Septoria Tritici Blotch	WSTGP	25	29
Sub-total			155
Total			474

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5. WINTER AND FACULTATIVE BARLEY IMPROVEMENT

5.1. Breeding Winter and Facultative Barley

Introduction

Winter and Facultative (W & F) barley is grown in areas with continental climates. In WANA region W & F barley covers approximately 6 million hectares in high altitude areas where yields average less than one ton/ha. This is due to several biotic and abiotic stresses (see earlier annual reports). The objective of this project (in collaboration with NARS) is to increase facultative and winter barley production of WANA countries by minimizing the effects of stresses increase yield potential and by strengthening the technical manpower of the national programs.

Germplasm Development

The strategy adopted is to analyze the germplasm, especially of WANA countries, for various traits. Crosses involve the use of locally adapted germplasm, and use winter x winter, winter x spring, and facultative x facultative hybrization. The F_2 is evaluated at a number of locations in WANA to target germplasm for the different environments. The material evaluated at various sites during 1990-91 is listed in Table 88.

Table 88. Winter and facultative barley germplasm evaluated during 1990-91.

Generation	Entries	Selected	Location
F_0	960		
F_1	279	279	Tel Hadya
F_{2*}	599	4500	Tel Hadya, Maadar, Turkey
F_3	1777	3500	Tel Hadya, Maadar
F_4	1412	2000	Tel Hadya
F_5	1070	2325	Tel Hadya
WBSN	504	472	Tel Hadya, Breda, Maadar, Ankara
WB Germplasm	504	170	Tel Hadya, Maadar, Ankara
Exotic Germp.	252	125	Tel Hadya
Hulles Barley	102	102	Tel Hadya
ABYT	48	32	Tel Hadya, Maadar, Ankara
PBYT	48	29	Tel Hadya, Breda, Maadar, Ankara
RWBYT	24	13	Internationally
WBCB	200	180	Tel Hadya, Breda, Maadar, Ankara
IWFBON	150	65	Internationally, Tel Hadya, Breda

*) Out of F_2 Seg. Pops 150 entries were supplied to NARS in WANA.
WBSN: Winter Barley Screening Nursery; WB: Winter Barley;
ABYT: Advanced Barley Yield Trial; PBYT: Preliminary Barley Yield Trial;
RWBYT: Reional Winter Barley yield Trial;
WBCB: Winter Barley Crossing Block;
IWFBON: International Winter Barley Observation Nursery.

Expansion of Genetic Base

The success of a breeding program depends on the available genetic variability. New variability is obtained from many sources, particularly from environments with similar problems.

Two hundred and fifty two entries of W & F barley from WANA (Nepal, Pakistan, Afghanistan, Turkey, Morocco, Algeria, Ethiopia) and 252 from the USSR were evaluated for agronomic score, growth habit, maturity, disease tolerance, and lodging resistance in the 1990/91 season.

Variability for growth habit and maturity was large. The evaluation of the germplasm from WANA showed a gradation in growth habit from spring to pure winter types and a wide range of maturity types. Growth habit show that more than eighty percent of the barley germplasm from WANA and USSR was of the winter or facultative type and only 17 & 19 % respectively was of spring type (Fig. 29a).

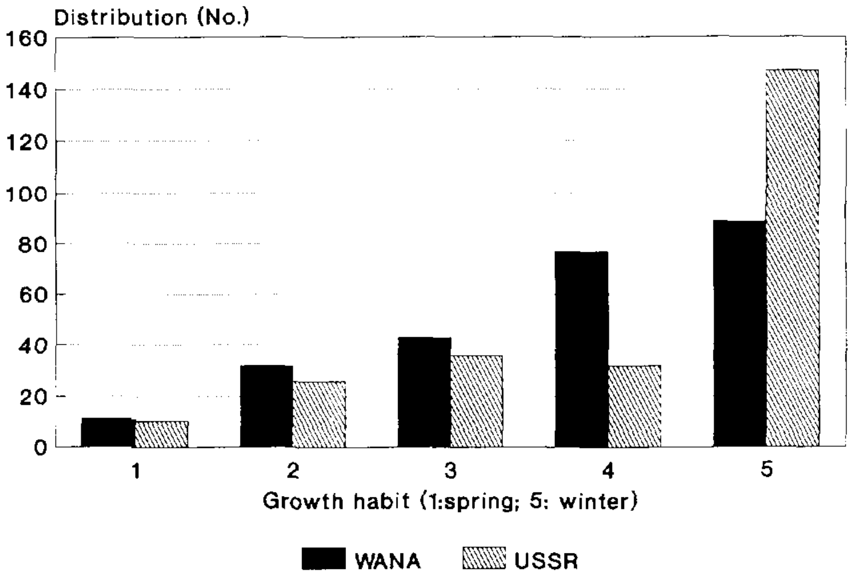

Fig. 29a. Variation in growth habit of W & F barley germplasm.

The Genetic variation for plant height was greater in germplasm from WANA and ranged from 50 cm to 120 cm whereas USSR material ranged only from 60-110 cm (Fig. 29b). In low rainfall areas, tall and stable plant height is a desirable trait which is associated with yield stability. On the basis of disease tolerance, agronomic score and lodging resistance, 170 lines were selected for further evaluation.

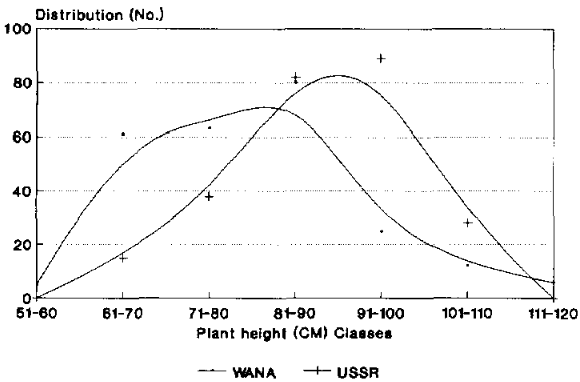

Fig. 29b. Genetic variation in plant height.

Further 252 lines from China and USA were evaluated at Tel Hadya, and 125 were selected on their overall performance.

Crossing Program

The crossing program was planned to incorporate disease resistance and create variability for growth habit and maturity to cater for the diverse environments of high altitude areas of WANA in particular and other winter barley growing areas. In total 960 single, double and top crosses were made.

Breeding of Hulless Barley

Hulless barley is primarily consumed as bread and soup in the high altitude areas of WANA. Therefore 102 elite hulless barley lines were obtained from the ICARDA/CIMMYT barley project in Mexico. These lines were spring types. All the lines have been retained for further evaluation and testing. The hulless gene is being transferred into a wider genetic background to develop cold tolerant, winter type hulless improved germplasm for the high altitude areas of WANA and elsewhere.

Segregating Populations

Segregating populations, (F_2 to F_5 (Table 88) were obtained using accelerated generation enhancement (Annual Report 1990). These populations were evaluated in the field for agronomic score, growth habit, lodging and disease tolerance. Heavily diseasesd populations were discarded. Single plant selections were made and 1777 F_3 and 1412 F_4 populations were classified into five groups on the basis of growth habit (1 = spring type to 5 = strong winter type).

The populations originated primarily from winter x spring crosses and data show that a majority were of intermediate (facultative) types (Fig. 30). However, F_3 populations had a higher proportion of winter and facultative types (82%) compared to the F_4, where the frequency of spring types were higher (33%). Variation in growth habit caters for the diverse needs of the region. An effort will be made to select cold tolerant, very early spring types out of these populations which can be *spring* planted for areas where the winter is too severe to permit fall planting.

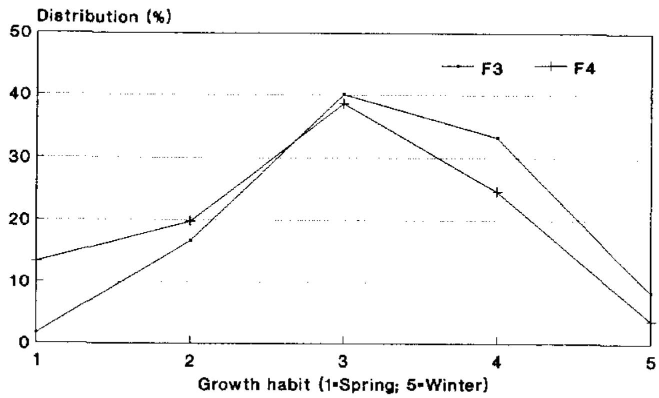

Fig. 30. Growth habit of F_3 and F_4 segregating populations.

Growth Habit of IWFBON and WBCB

Growth habit and maturity in barley is influenced by temperature, photoperiod and genotype. There are three genes which determine growth habit. Winter habit is expressed also by 3 genes, and only when the genotype is $\underline{Sh}$ $\underline{Sh}$, $\underline{sh_2}$ $\underline{sh_2}$, $\underline{sh_3}$ $\underline{sh_3}$. Any other combination of genes produces spring types. The winter habit requires vernalization.

Preliminary studies of growth habit were carried out on IWFBON (International Winter and Facultative Barley Observation Nursery) and WBCB (Winter Barley Crossing Block) by planting them in late spring i.e. May 1, 1991.

The temperature never went below 8°C and day length in June-July-August was over 15 hours. Percentage heading was recorded in late August. The material was subjected to long days and high temperature and the gene(s) controlling photoperiod were assumed not to interfere with heading.

Heading data allowed classification into different growth habit groups (Table 89). Further studies will be carried out to identify spring, facultative and winter habit lines carrying photoperiod gene(s) which were masked in these studies by long daylengths.

Table 89. Heading data of barley lines in the 1991 summer planting.

Heading %	Nurseries		Growth habit classification
	IWFBON	WBCB	
71 - 100	27	10	Spring type, no vernalization needed.
41 - 70	36	20	Facultative, Moderate vernalization requirement.
1 - 40	44	37	Facultative to winter type, high vernalization requirement.
0	36	115	Winter types, need very high vernalization.

Breeding for Drought Tolerance

Breeding for drought tolerance is complicated. Four nurseries (Winter Barley Crossing Block (WBCB), Preliminary Winter Barley Yield Trial (PWBYT), International Winter and Facultative Barley Observation Nursery (IWFBON), and Preliminary Winter Barley Screening Nursery (PWBSN)) were planted at Breda, a moisture stress site.

The agronomic score, heading date, plant height and drought tolerance (scored 1 = susceptible and 9 = resistant) were recorded. Heading date classified the material into two broad categories late and early (Table 90). Most late material was of the winter type, in some cases with a photoperiod response and most of the material did not head or was discarded before maturity. Scoring drought tolerance was carried out taking account of growth habit, irrespective of maturity, yield etc. and four following distinct classes were observed:

1. Early, drought susceptible:	Low agronomic score, plant desiccated.
2. Early, drought tolerant:	High agronomic score, no desiccation.
3. Late, drought susceptible:	Low agronomic score and plants desiccated.
4. Late, drought tolerant:	High agronomic score, no desiccation.

The lines falling into class 1 and 3 were discarded. A few lines from class 2 were retained for breeding purpose and all the lines falling in class 4 were selected for further testing (Table 90).

Table 90. Number of barley lines selected at Breda for drought tolerance, 1990-91.

		No. selected			
Nursery	Total	Total	Early	Late	% Selected
WBCB	181	35	10	25	19.3
PBYT	48	19	6	13	39.6
IWFBON	150	54	11	43	36.0
PBSN	504	210	64	146	41.7

WBCB: Winter Barley Crossing Block.
PBYT: Preliminary Barley Yield Trial.
PBSN: Preliminary Barley Screening Nursery.
IWFBON: International Winter and Facultative Barley Observation Nursery.

M. Tahir

Breeding for Cold Tolerance

W & F barley was evaluated for cold tolerance in the field at Ankara-Turkey and Maadar-Syria; and in controlled conditions (freezing chambers) at Krasnodar-USSR. The results of field screening are summarized in Table 91. Cold damage at Maadar was less and screening was not very effective due to relatively mild temperature. At Ankara cold susceptible lines were damaged significantly. Out of a total of 1891 lines/cultivars, 944 (50% Ankara) and 1191 (63% Maadar) lines were selected for further testing (Table 91).

Table 91. Breeding for cold tolerance at Ankara and Maadar.

Nursery	Total at	Selected at Ankara-Turkey	Selected at Maadar-Syria
BSP-F_2	280	165	189
BSP-F_3	75	45	65
RBYT-1	24	10	11
PBYT-2	24	13	16
PBSN-1	252	127	161
PBSN-2	252	98	149
BG-USSR	252	163	130
BG-China	252	41	160
IWBEL	150		104
WBCB	180	134	131
IWFBON	150	67	75

The studies on genetic variation for cold tolerance were carried out at Ankara on 252-Elite lines, 252 lines from WANA and 252 lines of Chinese origin. The data indicate that more than 50%

of Elite lines and selected WANA germplasm were tolerant to cold (damage range 0-25% Fig. 31). A majority of Chinese material was cold susceptible. Most of the Chinese material was early and of spring type. However, 70 Chinese lines were not damaged and 41 were selected on the basis of agronomic score for further testing and utilization. The Chinese barley germplasm was interesting because of its earliness, a highly desirable trait when combined with cold tolerance.

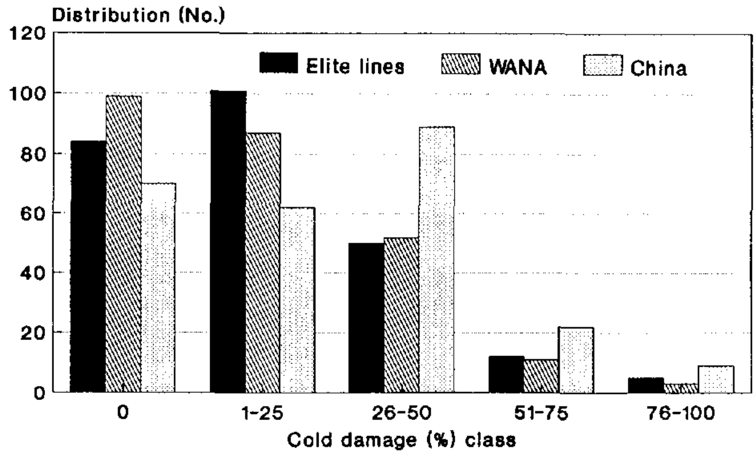

Fig. 31. Genetic variation for cold tolerance-damage percentage.

In collaboration with the Agricultural Research Institute, Krasnodar-USSR, two barley nurseries (Regional Barley Yield Trial for High Altitude - RBYT-HA) 24 entries and Barley Observation Nursery for High Altitude (BON-HA 83 entries) were used for a critical evaluation for cold tolerance. These nurseries were tested at the seedling stage in freezing chambers at two temperatures treatments (-8°C and -10°C). The data on survival percentage and relative frequency at those two temperatures is presented in Fig. 32.

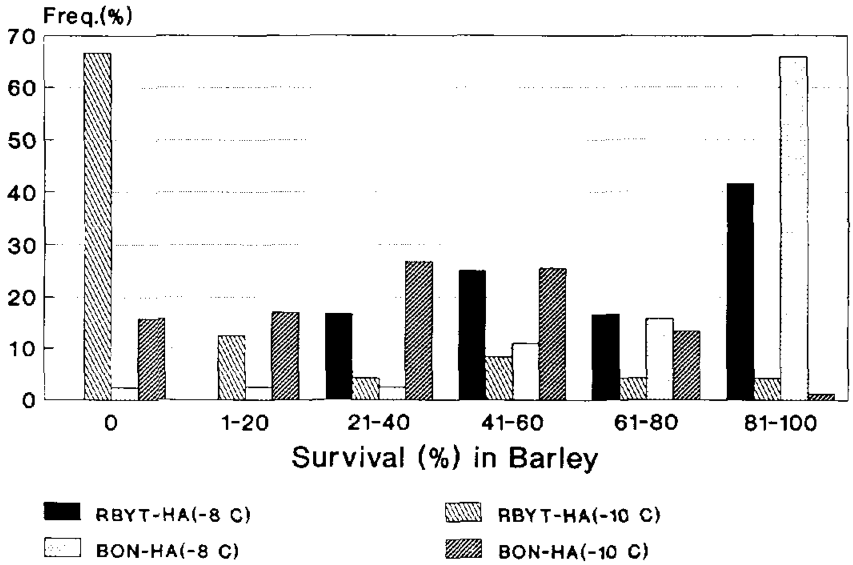

Fig. 32. Cold resistance of barley lines at Krasnodar-USSR.

In the RBYT-HA no line was killed at -8°C where as at -10°C about 67% lines were killed and only 4.2% lines were not damaged. BON-HA had greater variability for cold tolerance. Though 2.2% lines were killed completely at -8°C, 66% of the entries were not damaged at all. At -10°C about 1.2% lines survived undamaged and 13.4% had less than 20% damage. It seems that -8°C temperature treatment is too mild for effective cold screening and a minimum of -10°C treatment should be employed to better separate resistant and susceptible material.

M. Tahir

Characteristics of Barley Landraces from Iran

Barley yield in the dryland area of Iran averages only 729 kg/ha. Low yields are due to several factors. Studies were carried out to understand agronomic and stress tolerance characteristics of landraces.

Twenty four landraces, five improved cultivars and three exotic varieties were studied (Table 92). Four cultivars (Gouhar Jou, Erm, Kavir and Mahli Shehr Kurd) were highly resistant to high temperature (Tahir and Banisadr, 1991). The majority of Iranian lines were not cold tolerant, except Mahlishahr Kurd a local line and the variety Star which is an introduction.

The data on agronomic characteristics are given in Table 92. The majority of these lines were spring types (1 = spring and 5 = winter type), 8 were facultative and only three were winter types. However, some lines had slow primordial development due to their facultative habit followed by rapid development in spring. This strategy minimizes the risks of both frost damage and late moisture stress.

The data on tiller number/plant and percent productive tillers/plant (% PT) show that most landraces, as well as the newly released cultivars (Walfajr, Rihane, Gurgon 4, Star, and Atlas 64) had high tiller numbers per plant. However the % productive tillers/plant at maturity was much higher in improved cultivars and the exotic varieties (Steptoe and Radical) than in the landraces. The capacity to produce large numbers of rudimentary tillers in the vegetative stage when the plant has to pass through uncertain climatic conditions (low temperature, high or low rainfall) buffers the old varieties against stress in harsh unpredictable environments compared to new improved cultivars. Farmers therefore prefer these old adapted varieties to ensure stable production.

Table 92. Agronomic characteristics of barley from Iran.

S. No.	Var/line	GH	Pri. Stage	P.H (cm)	Culm L. (mm)	Till/P	Spike L. (mm)	% PT
1	Walfajr	3.5	V	34.0	5.7	13.3	1.6	80
2	Rihane	2.0	VII	32.7	8.3	14.0	2.0	73
3	Binam	2.5	VIII	35.7	14.0	14.0	2.5	57
4	Gouhar	3.5	V	30.0	7.7	15.3	2.4	50
5	Zar Jau	3.0	VIII	37.0	22.3	13.7	2.4	63
6	Erm	4.5	VII	33.3	8.0	16.7	1.8	67
7	Gurgon 4	2.5	VIII	41.0	33.3	14.7	2.9	71
8	Star	3.0	V	27.3	7.0	18.3	1.4	72
9	Kavir	2.0	X	43.7	30.0	12.7	3.0	61
10	Aras	1.0	X	36.0	35.0	15.3	3.0	48
11	Karoon	4.0	VI	25.3	6.7	15.3	1.3	50
12	ShehrKurd	2.5	IXL	36.0	15.7	14.3	3.0	47
13	Baluch-L	2.5	VII	36.3	10.7	14.0	2.1	70
14	Mughan-L	1.0	VIIe	32.7	9.7	12.0	1.8	46
15	Atlas-46	1.0	X	35.0	15.0	11.3	3.3	71
16	121438	1.0	IXL	34.3	12.7	14.3	3.0	44
17	121440	1.0	IX	34.7	13.7	10.3	2.5	52
18	121307	3.0	IX	40.7	24.7	10.3	2.5	55
19	121430	3.0	VII	30.0	10.0	19.0	2.0	36
20	121439	1.0	IX	41.3	33.3	7.7	2.4	42
21	121435	4.0	VIII	40.3	11.0	14.3	1.9	47
22	121387	2.0	VIIe	39.0	10.3	8.3	2.0	59
23	121441	1.0	IX	46.0	35.0	8.7	3.6	71
24	121256	3.0	X	32.3	12.0	15.7	2.6	69
25	121348	1.0	X	40.3	15.0	11.3	3.3	64
26	121431	2.5	VI	32.3	7.0	19.0	1.5	55
27	121429	3.5	VII	35.0	10.7	9.7	1.5	48
28	121266	2.5	VII	33.3	10.3	12.7	2.0	59
29	121256	1.0	XL	42.7	57.3	22.3	5.2	62
30	Tokak	4.0	V	21.0	4.7	12.7	1.3	54
31	Steptoe	4.0	VI	45.7	7.7	7.7	1.5	71
32	Radical	5.0	V	20.0	8.0	6.3	1.1	81
	LSD (0.05)	0.5	0.5	1.7	1.6	1.7	0.4	
	CV	12.0	3.9	3.0	6.2	7.8	10.7	
CORRELATION COEFFICIENTS								
Primordia		0.56**						
Plant height		-0.24	0.18					
Culm length		-0.27	0.19	0.60**				
Tiller/Plant		-0.04	0.06	-0.16	0.12			
Spike length		-0.49*	0.15	0.56**	0.79**	0.21		
Freez. Surv.(%)		0.28	0.16	-0.38*	0.37*	0.01	-0.43*	-0.35*

The correlation coefficients were positive correlation (r = 0.56**) between primordia development and growth habit and negative correlations between freezing survival and plant height, and between culm length and spike length. Growth habit and freezing survival (%) were not correlated significantly. Cold tolerance was also found in spring types (Tahir and Banisadr, 1991) and this tolerance is useful in developing cold tolerant, early maturing germplasm.

M. Tahir and N. Banisadr

Breeding for Better Quality

One thousand and forty five lines ranging from segregating populations (F_6) to advanced lines/cultivars (RBYT) were evaluated for protein content (%) and thousand kernel weight (gms); the two most important quality characteristics.

Thousand Kernel Weight (gm)

The frequency distribution (%) of Thousand Kernel Weight (TKW) of WBCB (Winter Barley Crossing Block), BONH (Barley Observation Nursery - High Altitude), PBSN (Preliminary Barley Screening Nursery), WBF_6 (Winter Barley Segregating Population - F_6) and RBYT (Regional Barley Yield Trial) are presented in Fig. 33. TKW in these nurseries ranged from 15 gm to 50 gms. However, over 60% of lines in the WBCB, BONH, PBSN, RBYT had TKW less than 35 gms. This is most probably due to a lower selection pressure for high TKW. Also most of the lines were winter or facultative types and late maturiing. These suffered moisture stress and high temperatures during grain filling. The TKW of check varieties, Tokak, Salmas and Rihane was 32.6, 36.3, and 22.3 gms, respectively. However, 32 lines having a high TKW, ranging from 45.5 - 55.4 gm, were selected.

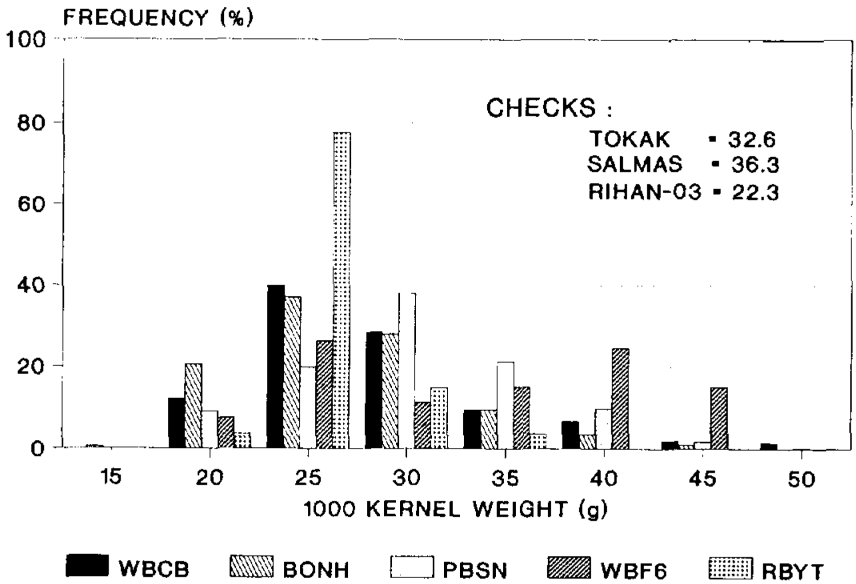

Fig. 33. Thousand kernel weight (TKW) distribution in winter barley breeding material 1990-91.

Protein Content (%)

The distribution (%) of protein content in the same nurseries is illustrated in Fig. 34. Few lines had less than 13% protein. With the exception of the BONH, more than 80% of lines had protein contents (%) between 13-20%. In general high protein content is related to low TKW. The average protein content of the check varieties, Tokak, Salmas, and Rihane was 14.6, 12.5 and 13.8%, respectively. Sixteen lines with a protein content between every 17.1 and 20% were selected for further testing.

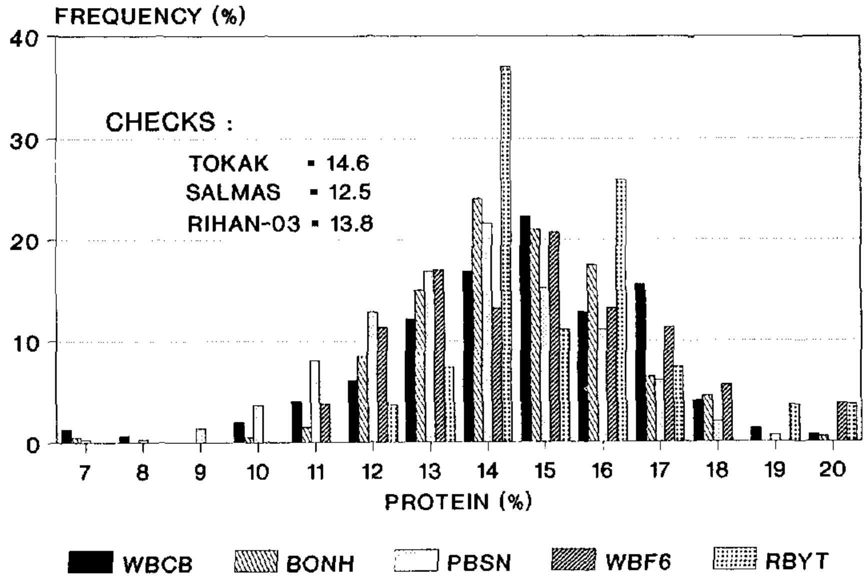

Fig. 34. Protein distribution in winter barley breeding material, 1990-91.

Sixteen lines (Table 93) with a protein content between 13.1 to 17.9 and TKW between 36 to 44 gms, respectively were identified. These lines were not affected adversely by moisture stress and high temperature at grain filling. They will be used in breeding to develop better quality and stress tolerant material.

F. J. El Haramein and M. Tahir

Table 93. Lines of winter barley with high TKW and high protein.

SNo.	Line/Cross	S. Source		TKW	Protein (%)
1	H. def. ICB 101301	PBSN3-	30	36.0	13.6
2	Atem/3/Arr/Esp//Alger/Ceres	PBSN3-	43	36.3	15.3
3	H. dist. Icb 101243	PBSN3-	51	42.1	13.2
4	EBC (A)	PBSN4-	247	40.2	17.7
5	H. def. ICB 101287	PBSN4-	25	38.2	17.0
6	53TH/105//Klein W/Benerst Piok	IWBON-	11	36.0	17.9
7	Salmas*2/3/V/Julia//ZY	WBF6 -	46	36.3	13.4
8	P1000505/Alfa	WBF6 -	61	36.0	17.5
9	P1000505//W12197/CI13520	WBF6 -	63	37.1	15.2
10	P1000505//W12197/CI 13520≈2	WBF6 -	67	39.5	14.7
11	ICB 85-1463	WBF6 -	68	41.3	16.2
12	ICB 85-1498	WBF6 -	69	42.8	13.2
13	Th. Unk. 48//Roho/Delisa	WBF6 -	73	36.1	13.1
14	Rabur/J-126//OWB753431D/SL3	INBON-	38	38.3	14.4
15	Alfa/Durra=OR 1861164	INBON-	47	36.3	13.9
16	Alfa/Quinn=ICBH81-2190	INBON-	54	44.1	14.5

Barley Observation Nursery - High Altitude (BON-HA), 1989-90

On the basis of agronomic performance at different locations, a number of lines were selected by the NARS. The agronomic characteristics of 14 lines selected 2 or more times by the NARS are presented in Table 94. Average grain yield ranged from 4036 to 5973 kg/ha. All the lines except entry nos. 81 and 61 were resistant to lodging. Average plant height ranged from 68 to 86 cm. Tall plants (> 60 cm) under moisture stress are desirable and associated with yield stability as well as faciliting mechanical harvesting.

The cold tolerance was evaluated in the freezing chambers at Krasnodar - USSR. Most lines, except check varieties, Matnan - 01 (0%) and Salmas (54%), and entry No. 64 (50%), had more than

Table 94. Characteristics of the entries selected 2 or more times at 5 location out of BON-HA, 1989-90.

Ent. No.	Name/Cross	Sum Sel.	GH	Grain yield (kg/ha)	Head Days	Mat. Days	Plnt Hght (cm)	Lodg-ing %	PM	Survival % at -8°	Survival % at -10°C
33	Lignee 131/Quinn	4	4	5147	138	178	76	0	4	88	64
19	Lignee 131/Sul/Nacta	4	3.5	4036	141	178	79	0	3	100	58
30	Salmas	3	2.5	4438	138	178	77	0	5	54	20
25	MV46/Mazurka	3	2.5	5623	144	177	80	0	5	83	10
77	Tok/4857	2	5	5973	151	175	84	2	4	100	43
71	2537-TA/Tok	2	5	4718	163	175	86	0	5	78	18
81	Denmark 57	2	5	5116	148	175	82	20	4	89	14
67	364 TH//3869 Vtg/Gzk II	2	5	5764	149	175	83	15	4	84	56
11	Lignee 131/Arabi Abiad	2	4	4591	138	184	75	0	5	84	56
10	Matnan-01	2	3.5	4496	144	171	68	0	4	0	0
64	392 TH/3896 Vtg/Gzk	2	5	5147	150	176	84	0	5	50	25
62	682/3887 Swan-28//3892/zk	2	5	5244	147	175	80	0	4	86	71
14	ER/Apm//Lignee 131	2	3.5	4485	139	174	75	0	4	100	23
24	GK 58	2	5	4862	147	183	82	0	4	78	56

75% survival at -8°C. However, at -10°C only five lines (Entry Nos. 33, 19, 11, 62, and 24) had more than 50% survival. There is a need to improve the cold tolerance of winter barley as the present level of tolerance is inadequate.

Regional Barley Yield Trial - High Altitude (RBYT-HA), 1989-90

Although widely distributed, only the data from the high elevation sites of Pakistan, Morocco and Algeria is reported.

The yield of the top five lines is presented in Table 95. At Setif 17 entries out yielded the national check variety Tichedrett (2580 kg/ha). At Tiaret-Algeria 16 entries had significantly higher yields than the check (ACSAD 176). The

Table 95. Yield performance (kg/ha) of top five lines of the Regional Barley Yield Trials (High Altitude), 1989-90.

Country	Mean Yield		Max.yield	Local Check		
	Expt.	Av.of 5 top lines		Yield	Rank	Name
Algeria (Setif)	2887	3090	3552	2580	17	Tichedrett
Algeria (Tiaret)	2728	3275	4244	2322	16	ACSAD 176
Morocco (Fez)	3541	4556	5556	4000	4	ASNI
Morocco (Annoceur)	1581	2001	2133	1828	6	-
Pakistan (Quetta)	2580	3396	3762	2392	17	Local Barley

mean yields of 2887 kg and 2728 kg at both sites were greater than the national check's yield. This indicates that these trials contained good lines which were adapted to the high altitude sites of Algeria.

At Fez (Morocco) only 3 lines out yielded the check variety ASNI (4000 kg/ha). A site mean yield of 3541 kg and the yield of best line of 5556 kg/ha shows that this was a very high production zone in 1991. Some lines in this experiment, which are especially adapted to moisture stressed areas, may not be suitable to this region. At Annoceur (Morocco) five lines had higher yields (ranging from 2001 to 2133 kg/ha) than the check variety 1826 kg.

Under the harsh environment of Quetta (Pakistan) the national check yielded 2392 kg/ha and ranked 17th. The mean yield of 2580 kg of the site was greater than the national check. Interestingly, entry No. 10 (WI2291/3/SP(2h)//Cr 115/Por) which was highest yielding at Setif and Tiaret-Algeria, ranked 3rd in Fez and 2nd, at Quetta indicating its wide adaptability and high yield potential in different environments. The detailed results of each site will be published in the Annual Barley Nursery Report of 1989-90.

However there is an urgent need in the high altitude areas of WANA to strengthen on-farm trials and accelerate the process of dissemination of research results to the farmers.

Strengthening of National Technical Competence

The national programs of Pakistan, Iran, and Turkey were assisted in identify better germplasm. For the training activities see the section on Training.

M. Tahir

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6. WINTER AND FACULTATIVE BREAD WHEAT IMPROVEMENT

6.1. Winter and Facultative Bread Wheat Breeding

Personel

Dr. Byrd C. Curtis retired in mid-1991 after nearly four decades of involvement in cereal research. Dr. Curtis joined CIMMYT in 1981 as leader of the Wheat Program. During his tenure in Mexico, he provided leadership to a cadre of international scientists engaged in international germplasm development and testing to improve bread wheat, durum wheat, and triticale. Since 1988, Dr. Curtis served as the CIMMYT/ICARDA Regional Coordinator based in Ankara, Turkey and Aleppo, Syria. While in Aleppo, he was also responsible for Facultative (High Altitude) Wheat Breeding. Dr. Curtis now resides in Ft. Collins, Colorado.

Dr. Thomas S. Payne, CIMMYT Wheat Breeder based in Ankara, Turkey, has filled the Facultative Wheat position. Dr. Payne has earned advanced degrees at the Universities of Nebraska and Minnesota, and has worked in post-doctoral positions with Dr. Katarina Borojevic in Novi Sad, Yugoslavia, and Dr. Sanjaya Rajaram CIMMYT/Mexico.

Reorganization/Reunification

Facultative germplasm may be of considerable importance within the WANA region and ICARDA's headquarters at Tel Hadya will be utilized to screen for this type of germplasm. However, Tel Hadya is not a suitable environment to develop winter wheat germplasm. Therefore, primary facultative and winter wheat germplasm development activities will be executed in Turkey which offers a diversity of facultative and winter wheat environments. Tel Hadya will be used for its excellent support facilities for germplasm improvement (e.g., greenhouse facilities, vernal and photoperiod screening, disease screening, entomology, milling, baking and nutritional quality analysis, virology, etc.). Multi-location early generation germplasm field screening will occur in Turkey, Syria, Iran and Mexico.

International Nurseries

The Facultative and Winter Wheat Observation Nursery (FAWWON) is organized by the National Wheat Improvement Program of Turkey, the International Maize and Wheat Improvement Center (CIMMYT) and the International Center for Agricultural Research in Dry Areas (ICARDA). The FAWWON replaces the International Winter Wheat Screening Nursery (IWWSN) formerly distributed by the National Wheat Improvement Program of Turkey and CIMMYT, and the Wheat Observation Nursery High Altitude Areas (WON-HAA) formerly distributed by ICARDA.

The FAWWON contains a collection of advanced lines and cultivars from diverse facultative and winter wheat breeding programs. The 1st FAWWON, distributed in August 1991, contains 140 entries distributed to 120 cooperators in 48 countries.

Activities

Vernal response of endemic northern-Syrian and Turkish bread wheat landraces indicates that moderate vernalization requirement was typical. Today, however, the area of north Syria is sown primarily with improved spring bread wheat germplasm. Might adapted facultative and winter wheat cultivars be more appropriate for this area? An alpha-lattice replicated yield trial comparing the response of winter, facultative and spring bread wheat will be conducted in 1991-1992. This trial will be planted at Tel Hadya, Hasakeh, Kamishly, Idlib, Azaz, and Maadar, Syria.

About 5000 years BP, T. aestivum cultigens replaced einkorn and emmer landrace cultivation in mesopotamian Turkey and Syria. Contemporary turkish farmers (Black Sea region) continue to cultivate einkorn and emmer due to culinary (bulgar) desirability, and stem rust resistance, but complain that these species are not as responsive to nitrogen inputs as are T. aestivum landrace cultigens. Perhaps the historical switch from the prevailent cultigens to T. aestivum was related to increased nitrogen (in the form of manure) application. Response of einkorn, emmer, durum and aestivum landraces to nitrogen will be determined in 1992-1993 in collaboration with Mr. Mark Nesbitt (Archaeobotanist, British Institute of Archaeology, Ankara).

Thomas S. Payne

7. COLLABORATIVE RESEARCH

MAGHREB REGION PROGRAM REPORT

Introduction

The Cereals Improvement Program in collaboration with national programmes in the Maghreb countries assists wheat and barley scientists in planning and implementing research on production constraints to improve output and reduce imports. ICARDA is increasing its interaction with the Maghreb NARS to move closer to this goal. Additional support came from the IFAD project on technology transfer and the UNDP project on disease monitoring, surveillance and germplasm enhancement. In addition, the ICARDA cereal scientist in North Africa plays a role in developing working relationships among national research and education institutions to build a unified, complementary regional network.

The activities reported here are by countries, and have been carried out primarily by the national program staff. Their efforts have been supported by ICARDA North Africa scientists, with backstopping from ICARDA base program.

Collaborative research activities were many. Maghreb scientists jointly carried out wheat and barley disease and insect surveys as well as joint training of junior staff. Germplasm was exchanged through the Maghreb Cereal Observation Nursery (POM). The Cereal Disease Monitoring Nursery (CDMN) was grown at high disease pressure sites to monitor changes in virulence of major cereal pathogens in the region. A travelling workshop in Tunisia was well attended by a large number of maghreb scientists and research coordinators visited ICARDA at selection time. Maghreb scientists are determined to work together and ICARDA will assist in establishing effective and viable networks of cereal researchers in the region.

MOROCCO

Production situation

Weather conditions in Morocco were good. The 1990-91 season was characterized by above average rainfall although there was a period of drought in January. Low temperatures favored the development of yellow rust and Septoria as well as insect populations, particularly aphids.

Production exceeded 8.2 million tonnes, a record. Durum wheat area is increasing in the north, and barley is moving further south. Bread and durum wheats covered 1.4 million hectares each, while barley acreage exceeded 2.4 million hectares. Arig 8 barley; Kyperounda, Cocorit, Marzak and Karim durum wheats; and Nesma, Merchouch 8, and Jouda bread wheats have been the most popular new cultivars for the second consecutive season. Seed quantities of the newest wheat varieties is increasing and they are having an impact on the nation's output. The bulk of the barley crop is still produced from varieties released in the early 80's, but newer barley varieties are rapidly increasing in area. Morocco's access to Maghreb markets for barley exports continues to improve. Morocco today supplies most of Libya's needs for certified seed.

The team approach permitted workplans to be carried out by several researchers from various institutions. All major objectives were conducted in separate research projects and implemented by researchers from various organizations.

The efforts of the cereal group have increased yields substantially. Production records were achieved for the third consecutive year. Demand by farmers for certified seed also increased and seed is produced on nearly 50.000 hectares in Morocco with production of 100000 tonnes annually.

Major highlights of the season were:

- Registration of 2 durum, 2 bread wheat and 2 barley cultivars.
- Initiation of a breeding program for the mountain region.
- Screening for cold tolerance at the Annaceur Middle Atlas mountain station of a large number of nurseries from all Maghreb countries and the use of this site to advance germplasm over summer.
- Introduction and screening of hulless barley collections.
- Evaluation and selection of promising lines from selected international and Maghreb nurseries for priority diseases and stresses in Morocco.
- Participation by Morocco scientists in disease and insect surveys in Algeria and Libya, a Hessian fly Survey in Algeria was coupled with junior staff training.
- Participation of a scientist from Morocco in a regional course on breeding techniques.
- Organization of the 6th all-Morocco cereal workers coordination meeting, October 1-2, 1991.
- Participation of one Morocco scientist in inoculum preservation and multiplication at the School of Agriculture, Le Kef, Tunisia.
- Participation of five Moroccan scientists in Cereal Travelling Workshop in Tunisia, attended by 37 scientists from Tunisia, Algeria, Libya, Egypt, Sudan, Morocco, as well as ICARDA and CIMMYT.

- Five genes for resistance to Hessian fly derived from Aegilops squarrosa, in addition to the genes H5 and H11 have been incorporated into promising breeding lines. Two new lines tolerant to Hessian fly have been registered for pre-release. These have much higher yield and significantly superior seed quality than the only resistant cultivar Saada. They are also resistant to the rusts and Septoria.
- Morphophysiological characterization for salt tolerance of newly released and most widely grown cultivars.
- Selection of 2 dual-purpose barley genotypes.
- Screening and identification of sources of resistance to BYDV.
- Characterization of the IFAD project zone and publication of reports on the production systems and a monograph on the physical environment (climate and soil).
- Implementation of diagnostic and verification trials using registered and pre-released cultivars.
- Development of "best-bet" agronomic packages for semi-arid areas.

ALGERIA

Algeria harvested a crop of over 3.6 million tons; also a record that covers half the country's needs.

The 1990/91 season was fairly good. From September to mid November, rainfall was low in all cereal zones. This was followed by milder rainy weather which favored seedbed preparation and seedling emergence. Rainfall occurred mainly in winter and spring. The season was mild, although winter and spring frosts occurred and some damage was observed at Setif and Tiaret in the high plateau areas. Hot winds (SIROCCO) occurred in March and April at Medea, Sidi Bel Abbes and Setif caused shriveled grain in early varieties and reduced production.

The 1990-91 season was the fifth year of a collaborative project between the Institut Technique des Grandes Cultures (ITGC), Algeria, ICARDA and LECSA/INRA, France. The project seeks to develop improved varieties and production technology, to test and verify results in farmer's fields and demonstrate research findings to farmers in the various agro-ecological zones of the Wilaya, and to evaluate the impact of this technology in the Wilaya of Sidi Bel Abbes.

On-station research was directed towards evaluating germplasm collections assembled during the past 5 years and establishing national crossing programs at Khroub for durum, Sidi Bel Abbes for bread wheat and Setif for barley.

At Sidi Bel Abbes, demonstration plots using improved varieties and production technology were grown. They included two improved durum varieties: Waha and Om-Rabia 9, 2 bread wheats: Zidane 89 and Nesser and 2 barleys: Rihane-03, and Badia. Each variety was planted at least two sites in each of four production zones. The trials demonstrate that cereals production in the Wilaya can be increased easily.

Highlights were:

1.) Breeding:

- Initiation of a crossing program (214 crosses for all species)
- Selection of about 100 lines from observation nurseries and trials for further testing in national collaborative trials.
- Establishment of the following advanced lines and varieties for final year testing prior to release.

<u>Durum</u>

Mrb 9 and Mrb 17

Chen'S'/Altar 84

904'S'/Loghs'S'

CI9225/Trobs

Kebir

Gallareta

Fg/Palestinia

Karim

Chen'S'

<u>Bread wheat</u>

F.134.71/Crow'S'

Ut.157/23

Neelkant

Tx621A47937/CB-309

Pls 70-03-P-4/Pv//Anza

Alondra

Zergoon

Tanit

<u>Barley</u>

Mo.B.1937/WI 2291

Kantara (Roho)

WI 2291

Rihane-03

Roho/Masurka

Roho/Delisa

Begoha

2.) Pathology:

- A disease survey was carried out in cooperation with ICARDA and three Moroccan scientists, and was coupled with on-the-job training of five junior staff. Priority diseases for resistance breeding were identified in each region.
- Most breeding material was tested for disease resistance using artificial inoculation.

3.) Others:

- Evaluation of lines in advanced stages of testing for grain quality.
- Confirmation of the potential of Zidane 89 and Nesser bread wheats, Waha and O. Rabia 9 durums, and Badia and Rihane barleys and continuation of seed increase.
- Use of Saida research station for barley testing against cold stress.
- Survey of Hessian fly and Russian Wheat Aphid incidence and severity of attack throughout the cereal growing regions.

LIBYA

In 1990-91 wheat and barley covered 80.000 hectares under irrigation and 565.000 hectares under rainfed condition in Libya. Rainfed areas are located mainly in the coastal belt, while full irrigation characterizes cereal production in the desert strategic production projects. In 1990-91 26.00 tonnes of good quality barley seed and 39.00 tonnes of wheat seed were produced.

The high frequency of dry years during the past decade had two important consequences:

- Barley acreage has increased in traditionally wheat growing areas.
- Farmers have adopted the strategy of harvesting barley as forage crop.

The seven research sites in western Libya: Azizia, Zahra, Hira, Tajourah, Janduba, Misurata and Khoms; in addition to three sites in eastern Libya: Benghazi, Marj, and Fataeh; and Sebha research station in the south constitute a network that covers all agro-ecological zones of the country. Research is also carried out in the irrigated projects in the desert.

1.) 1990-1991 research work:

- 114 nurseries and trials were evaluated throughout Libya 42 in eastern Benghazi region, 54 in western Tripoli region and 18 in the south.
- Identification of MisourataII bread wheat, YAVAROS durum and Libya 4 barley as promising genotypes for on-farm research next season.
- Evaluation of wheat and barley nurseries from Tunisia and Morocco.
- Organization of a training course on cereal breeding techniques for the benefit of 36 trainees from Libya, Algeria and Morocco.
- Two disease surveys were conducted in the major cereal growing regions of Libya.
- Initiation of on-farm research on:

1.) Verification trials using promising cultivars at the Khoms and Barjouj agriculture projects, where all cultivars of bread wheat, durum, and barley from Libya are planted.

2.) Barley on-farm trials in Benghazi and Derna region (Fataeh station, IFAD project).

TUNISIA

Cereals covered 1.66 million hectares, and because of favorable weather conditions a record crop was harvested (2.55 million tonnes).

In all 98 percent of the area planted was harvested also a record. Average wheat yields in northern Tunisia exceeded 2 t/h. Very high barley yields were also obtained in several parts of Tunisia and yields of 7.0 to 9.0 t/ha were harvested in the Kef region. The weather conditions were also favorable for diseases. Surveys carried out throughout the season confirmed the results of previous years:

- Septoria and yellow rust were most damaging to wheat cultivars.
- BYDV, mildew and net blotch were the most prevalent diseases on barley.
- Helminthosporium gramineum and Fusarium culmorum attacks were present at all growth stages and on all plant parts including the spike.
- Loss estimate trials using fungicides showed that Septoria on wheat and net blotch on barley cause high economic losses.
- Plant protection strategies against mildew and fusarium using fungicides were not economic.

- Resistant lines were identified for inclusion in breeding programs.
- A new durum wheat, Chen/Altar, gave good results in high yielding environments, it will probably be registered next year.
- 2 ICARDA lines, Om Rabi 3 and 5 were high yielding on the high plateau areas of the Kef as they were in the preceeding drier years. They will be used on a small scale by some farmers. They are being multiplied for release next year.
- Several bread wheat lines exceeded check varieties by 5 to 20% and release will depend on their disease reaction as this trait, a limiting factor for high yields, is receiving a greater attention.
- In the barley program, progress was made for resistance to several diseases. Promising lines were identified by INAT, ESAK and INRAT and their resistance to diseases was confirmed.
- Several barley lines were higher yielding than the check Rihane in the favorable regions; others, originating from the ESAK program had excellent yields in central and southern Tunisia. Some will be registered next year.
- On-farm research supported by ICARDA/IFAD/Maghreb project and by Office des Cereales demonstrated cultivar, seed rates, row spacing and weed control aspects of the recommended technology package.

INRA-MAGHREB COOPERATION

The ICARDA cereal scientist in North Africa has assisted in strengthening intra-regional cooperation by helping initiate discipline orientied networks and other communication bridges. The networks have benefitted from resources from special projects and have contributed to improved research quality in the Maghreb region. These networks established several regional workshops and survey as well as developing germplasm and information delivery systems.

This has:

- Facilitated the exchange of germplasm and information between and within national programs.
- Allowed better exploitation of national researchers expertise and developed procedures for mutual research support across institutes and countries.
- Favored the consolidation of routine regional activities in the areas of training, disease and insect surveillance, exchange of elite germplasm and its subsequent observation, scoring and screening.
- Brought about a Regional coordination meeting between scientists from different countries.

Components of the Maghreb Networks:

1.) Pepiniere d'Observation Maghrebine (POM):

The POM groups elite germplasm from Morocco, Tunisia and Algeria for regional testings. Libya's participation commenced in 1989-90. The POM is grown annually at 8 sites across Maghreb and is an efficient system for exposing national germplasm to a wide range of environments across North Africa. It allows access to elite germplasm from each program across the region.

2.) **<u>Cereal Disease Monitoring Nursery (CDMN)</u>:**

This nursery monitors virulence changes in pathogen populations of priority wheat and barley diseases in the region. It was grown at 15 locations in Tunisia, 7 in Algeria, 5 in Morocco during the main season, 2 in Libya and one additional set was planted in the off-season site at Annaceur. Two sets were also grown in both Spain and Portugal as well as one at Tel Hadya, Syria.

3.) **<u>Cereal Travelling Workshop</u>:**

Scientists form 6 countries (Algeria, Egypt, Libya, Morocco, Sudan, Tunisia) and CIMMYT and ICARDA staff participated in the 1991 cereals travelling workshop held in Tunisia, May 6-10, 1991. Participants selected material at Beja, Le Kef, and Mornag research stations and held a meeting in Tunis to discuss research priorities and the region's annual scientific events.

WORKPLANS

The actions needed to consolidate inter-relationships within the Maghreb were grouped as follows:

1.) **<u>Cereals Travelling Workshop (CTW)</u>:**

The CTW takes place in one of the region's countries during selection time. The region's cereal breeders and pathologists look at the nurseries, trials and populations together. Group discussions occur on the strengths and weaknesses of programs, and decisions to be taken on promotion of germplasm. The 1991-92 season CTW will take place in Algeria.

2.) <u>Training</u>:

The scientific expertise of some national programs in the region can benefit weaker NARS and help them in training and disease and insect screening, inoculum preservation, note taking and data collection.

3.) <u>Germplasm exchange</u>:

In addition to the POM, national programs will exchange material resistant to diseases and insects. This is traditionally provided directly as well as through the Cereal Disease Monitoring Nursery (CDMN).

4.) <u>Breeding strategies</u>:

The need for a Maghreb strategy in breeding for semi arid environments was strongly felt. 1991-92 work will seek to identify:

- Selection criteria for drought tolerance in each region.
- Stress tolerance studies to back up selection work.
- Additional technologies to improve selection in stress environments include:
  - Biotechnology
  - Development of plant populations
  - Shuttle breeding

M.S. Mekni

8. TRAINING AND VISITS

In 1991 many cereal training courses were collaborative, with other ICARDA Programs and/or other institutions. Because of the Gulf War enrollment in early courses was relatively low but was normal thereafter. Specialized training and scientific visits in response to evolving needs of NARS was emphasized.

Long-term course

The long-term course continues to meet the need of certain WANA countries for training in barley or wheat breeding. The course (3 March - 18 June 1991) was attended by 11 researchers from 7 countries (Iran, Jordan, Lebanon, Libya, Morocco, Sudan and Syria).

Classroom sessions were a small portion of the schedule, leaving about 80% of the time for more individual training. Participants were involved in research under the supervision of senior scientists within a research area of relevance to their countries. Each participant submitted a final report on his training and evaluated the course. Trainees benefitted from both classroom and lab/field activities and rated the organization and implementation of training highly.

Short Courses

Cereal disease methodologies

This recurrent course reflects continuing requests from NARS. Ten researchers from 8 countries (Cyprus, Egypt, Lebanon, Libya, Morocco, Syria, Tunisia and Turkey) attended the course (19 March -

4 April, Tel Hadya). The course covered aspects of disease inoculation, diagnosis, scoring, epidemiology and control, with emphasis on resistance. Evaluation indicated that trainees benefitted to various degrees depending on the level and background of the trainee. Therefore it has been decided to offer two alternating versions of the course, one emphasizing pathology and disease methodologies, and the other limited to practical field diagnosis and scoring.

Insect control in legumes and cereal crops

As in the previous two seasons this course was conducted jointly by the Cereal and Legume Programs. This year, 13 trainees from 10 countries (Algeria, Ethiopia, Iran, Jordan, Libya, Morocco, Syria, Tunisia, Turkey and Yemen) participated in the course (21 April - 2 May at Tel Hadya). Trainees participated in classroom and practical sessions covering the biology of major insect pests in legumes and cereals, control measures, seed health, and integrated pest management, and gave brief presentations on insect problems in their countries.

DNA molecular marker techniques for germplasm evaluation and crop improvement

The course, jointly conducted (22 September - 3 October) by the Cereal and the Legume Programs, is supported by a United Nations Development Program project on biotechnology and the Government of France. There were 11 participants from 10 countries (Algeria, Iran, Lebanon, Libya, Morocco, Pakistan, Saudi Arabia, Syria, Tunisia and Turkey) and 6 instructors from Germany, USA, France and ICARDA. The course included lectures and practical lab sessions on molecular genetics, molecular marker techniques (e.g. RFLP, PCR) and the application of these techniques for germplasm identification, evaluation and improvement. The participants, most of whom have a good scientific background, expressed their satisfaction with the course.

In-country and regional courses

Techniques of cereal germplasm development and evaluation

The course was jointly conducted by the Libyan Agricultural Research Center and ICARDA. Trainees included 19 research workers from Libya, four from Algeria and two from Morocco. Instructors were scientists from, Libya, Algeria Morocco and ICARDA.

The course focussed on applied techniques in cereal breeding, diseases and insect control, and on-farm research. The trainees attended classroom lectures, participated in field activities (hybridization, disease and insect identification and scoring, etc.) and visited wheat and barley fields at other Agricultural Projects in southern Libya.

New biometrical tools for plant variety evaluation

A regional course was jointly organized by CIHEAM, CIMMYT and ICARDA on 16-27 September 1991 at the Mediterranean Agronomic Institute, Zaragoza (IAMZ), Spain. There were 40 participants, 33 trainees from 18 countries (mostly from the Mediterranean region) and 7 instructors from Australia, CIMMYT, ICARDA, Spain and the UK. The course covered aspects of field plot techniques, experimental design, data analysis, and on-farm testing. A major emphasis was placed on methods of handling field variability in variety evaluation through experimental design and data analysis. Incomplete block designs and spatial analysis methods were dominant topics. Lectures were complemented by computer applications. The course was well organized by IAMZ and well received by the participants most of whom were experienced in breeding or agronomy.

Breeding strategies for cereal improvement in dry areas

The course was jointly organized on 18-29 November 1991 at Montpellier by INRA (France) and ICARDA for 15 French speaking cereal researchers from 7 countries: Alegeria (7), Chile (1), China (1), France (1), Lebanon (1), Morocco (2) and Tunisia (2). The trainees attended classroom presentations, and participated in discussions and lab visits.

The course focussed on breeding methodologies and strategies but related topics were also covered including physiology, pathology, cereal quality and biotechnology. Although the audience was relatively heterogeneous, most participants had some knowledge or experience in plant breeding and benefitted from most sessions.

Individual training

Training in specific areas was provided to 11 researchers from 4 countries (Egypt, Lebanon, Syria, and Tunisia) who spent periods of 2 weeks to 4 months in wheat or barley breeding, biotechnology, cereal diseases or insects, and grain quality. Individual training is most suitable for persons who undertake some research work for a reasonable period of time.

Graduate research training

Four Ph.D students finished their research in 1991 while two MSc. students started work in the Cereal Improvement Program (Table 96). Two senior-level students from Aleppo University were trained on tissue culture as part of their graduation project. One Ir. (ingenieur degree) student from Wageningen University, the Netherlands, spent 6 months as a trainee in barley breeding.

Table 96. Students supported by the Cereal Improvement Program, 1991

Name[1]	Degree	Research Area	Country	ICARDA support
Mohamed S. Hakim	PhD	Wheat breeding	Syria	Financial/Technical
Peter Stefany	PhD	Wheat breeding	USA	Technical
Michael Mayer	PhD	Barley breeding	Germany	Technical
Erik van Oosterom	PhD	Barley breeding	Netherlands	Technical
Joop van de Wege	Ir	Barley breeding	Netherlands	Technical
Suha Ismail	MSc	Wheat pathology	Syria	Financial/Technical
Adnan Al Yassin	MSc	Barley breeding	Jordan	Financial/Technical
Ghassan Naassa	MSc	Wheat breeding	Syria	Technical
Fareed Maqdees	MSc	Wheat physiology	Syria	Technical

(1) The first 5 candidates finished their research work in 1991.

Visits

Visits between the Cereal Program and NARS is an effective tool for transferring scientific information and research experience. In 1991, eleven scientists from 7 countries (Table 97) visited the Program to undertake research and/or learn about cereal research at ICARDA. Many other scientists visited for short periods to discuss joint projects, select germplasm, lecture in training courses, discuss graduate students research, or gather information on Cereal Program activities and results. In addition, around 210 students from Aleppo University and Tichreen University came to the Program on a one-day study visit.

Table 97. Visiting scientists to the Cereal Improvement Program, 1991.

Scientist's name	Country	Duration of visit	Research interest
Mrs. Hajer Amara	Tunisia	2 weeks	Biotechnology
Mr. Nasser Beni Sadr	Iran	3 months	Cereal breeding
Mr. Kiflemariam Mengistu	Ethiopia	3 weeks	Barley breeding/pathology
Mr. Brehane Lakew	Ethiopia	3 weeks	Barley breeding/pathology
Mr. Roberto Papa	Italy	2 1/2 months	Barley breeding
Dr. Nicolay Dukharev	USSR	2 1/2 months	Cereal breeding
Dr. Chandra Karki	Nepal	1 month	Barley pathology
Dr. Mahrous A. Mahrous	Egypt	1 1/2 month	Wheat breeding
Dr. Ahmed Sabry Jamal	Egypt	2 weeks	Barley breeding
Dr. Dalvir Singh	India	2 weeks	Barley breeding
Dr. Jyoti Singh	India	2 weeks	Barley pathology

Meeting and Workshops

Cereal Program and NARS scientists participated in travelling workshops in North Africa, Pakistan, Turkey and Syria, and attended coordination meetings through out the WANA region. A consultation meeting in Tunis, sponsored by FAO, ICARDA and CIMMYT, brought together representatives of 11 countries from the region to discuss cereal research networks in the region. The meeting recommended that existing ICARDA networks be strengthened and new networks may be initiated in specific research areas as necessary through the collaboration of FAO and research centers.

Cereal Program staff also participated in the VI Barley Genetics Symposium at Helsinborg, Sweden; as well as sponsoring regional scientists.

H. Ketata

9. PUBLICATIONS

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10. STAFF LIST

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[1]) Left the Program, July, 1991
[2]) Left the Program, June, 1991
[3]) Returned from sabbatical, August, 1991
[4]) Joined the Program as research fellow, Dec. 1, 1991

المركز الدولي للبحوث الزراعية في المناطق الجافة

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