CEREAL IMPROVEMENT PROGRAM

Annual Report for 1989

ICARDA

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

CONTENTS

1. Program Overview

Drought marked many areas of West Asia and North Africa (WANA) during the 1988/89 season, leading to large grain deficits in several countries of the region (e.g. Tunisia, Algeria, Syria, and Turkey). The use of drought tolerant cultivars with appropriate cultural practices is increasingly perceived by NARS as the sole means of sustaining reasonable agricultural production during dry years.

A significant event which marked the Program's activities was the signing in March 1989 of the new CIMMYT/ICARDA agreement specifying the terms of collaboration for the improvement of spring and facultative wheats in the WANA region. The agreement aims to achieve an efficient use of CGIAR resources to increase the benefits from both Centers to NARS. The agreement includes the posting of a CIMMYT wheat scientist at ICARDA and the implementation of a new system of germplasm distribution for WANA. Spring-type germplasm from ICARDA, Aleppo, and CIMMYT, Mexico, will be distributed from ICARDA as joint CIMMYT/ICARDA nurseries for testing in the major agroecological zones of WANA.

In line with the second External Program Review and ICARDA's recent strategic plan, both of which recognize the importance of barley in the dry areas, breeders are concentrating their efforts on developing genotypes with high and stable yield in terms of both grain and straw. Landraces and derived pure lines are successfully used in crossing programs to transfer drought tolerance into otherwise well adapted genotypes. The methodology of landrace exploitation is being transferred to NARS in Syria, Ethiopia and Nepal. Promising advanced barley lines were selected by NARS in several sites, including the lines Deir Alla 106/Strain 205, and Bal.16/Api//Deir Alla 106,in the low-rainfall areas and Cr 115/Por//Strain 205 and Comp. cross 229//As 46/Pro in the moderate-rainfall areas. Eight new barley varieties were released in 1989 and late 1988 (Table 1). Barley lines have been selected from ICARDA nurseries or proposed for release by NARS in WANA. Hull-less and early lines have been developed and included in nurseries for further testing and future distribution to NARS.

Durum and bread wheat breeders emphasized the development of improved germplasm for the low-rainfall areas of WANA. Multilocational testing was instrumental in characterizing wheat germplasm and designing targeted crosses for resistance to abiotic (drought, cold, and heat) and biotic (diseases and insect pests) stresses prevailing in the major agroecological zones of WANA. A 4-year testing of 11,000 durum wheat accessions has been completed and enabled a thorough evaluation for 25 traits. Durum wheat lines Omrabi 5, Belikh 2, and Lahn and bread wheat lines Nesser and Gv/Ald's' performed well and are candidates for release in WANA countries.

Drought and cold tolerant winter and facultative wheat germplasm has been identified through screening for drought at Tel Hadya and Breda and for cold at Sarghaya, Syria and Haymana, Turkey. Work on barley for highlands and continental areas has been enhanced following the CIMMYT/ICARDA agreement and the consequent appointment of a full-time barley breeder to this work.

Pathologists and entomologists worked in close association with breeders to develop resistant material with the goal of achieving sustainable cereal production under the farming systems prevailing in WANA. Germplasm pools for resistance to septoria, common bunt, wheat stem sawfly, aphids, and hessian fly have been assembled and furnished to collaborators. Facilities for controlled environments are now used to screen barley and wheat germplasm and carry in-depth studies on disease resistance and for aphid tolerance.

Physiological studies in barley and wheat indicate that specific combinations of desirable morphological and physiological traits for specific environments may be needed to improve selection efficiency for yield in dry areas. C_{13} discrimination was related to transpiration efficiency and appears to be a good indicator of superior barley performance under drought.

Doubled haploid (DH) plants of barley and wheat have been produced using anther culture and intergeneric or interspecific hybridization. Wheat cultivars having the 1B/1R translocation seem to be particularly suitable for DH production through anther culture. A wheat-maize crossing technique has been developed using an application of 2,4-D to wheat spikes following wheat pollination with maize. The technique was effective on 20 tested genotypes and is generally 50 times more effective than the Hordeum bulbosum technique.

In the area of germplasm exchange, more seed requests were made by NARS for finished material and trait-specific (e.g. drought, heat, etc.) nurseries than for segregating populations. This trend is being carefully monitored to further improve the targetting of wheat and barley germplasm to meet NARS needs.

Collaboration with NARS has been strengthened through exchange of visits, joint participation in travelling workshops in North Africa and Turkey, and planning meetings in the WANA countries. Training was diversified and an emphasis was placed on specialized and in-country courses. A total of 171 persons participated in training courses or workshops organized by the Cereal Program and 10 visiting scientists from the region spent time (2 weeks - 2 months) at ICARDA to exchange scientific information and become acquainted with the Program's research methodologies and findings.

Details on the various research and training activities are presented on the following pages.

Acknowledgements

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H. Ketata

Table 1. Cereal varieties released by national programs,as of Dec 1989.

Country	Year of release	Variety
Barley		
Algeria	1987	Harmal
Chile	1989	Leo/Inia/Ccu
China	1986	Gobernadora
	1989	V-24
Cyprus	1980	Kantara
	1989	(Mari/Aths*)
Ecuador	1989	Shyri
Ethiopia	1981	BSH 15
	1984	BSH 42
	1985	Ardu
Iran	1986	Aras
Jordan	1984	Rum (6-row)
Mexico	1986	Mona/Mzq/DL71
Morocco	1984	Asni
		Tamellalt
		Tissa
	1988	Tessaout
		Aglou
		Rihane
		Tiddas
Nepal	1987	Bonus
Pakistan	1985	Jau-83
	1987	Jau-87
	1987	Frontier 87
Peru	1987	Una 87
		Nana 87
Portugal	1982	Sereia
	1983	CE 8302
Qatar	1982	Gulf
	1983	Harmal
S. Arabia	1985	Gusto
Spain	1987	Rihane
Syria	1987	Furat 1113
Thailand	1987	Semangl IBON 48
	1987	Semeng2 IBON 42
Tunisia	1985	Taj
		Faiz
		Roho
	1987	Rihane
Vietnam	1989	Api/CM67/B1
Yemen AR	1986	Arafat
		Beecher

Table 1. (Cont'd)

Country	Year of release	Variety
Durum wheat		
Algeria	1986	Sahl
		Waha
	1982	ZB S FG'S'/LUKS GO
	1984	Timgad
Cyprus	1982	Mesoaria
	1984	Karpasia
Egypt	1979	Sohag 1
	1988	Sohag 2
		Beni Suef
Greece	1982	Selas
	1983	Sapfo
	1984	Skiti
	1985	Samos
	1985	Syros
Jordan	1988	Korifla=Petra
	1988	Cham1=Maru
	1988	N-432=Amra
	1988	Stork=ACSAD75
Lebanon	1987	Belikh 2
Libya	1985	Marjawi
		Ghuodwa
		Zorda
		Baraka
		Qara
		Fazan
Morocco	1984	Marzak
	1989	Sebou
		Oum Rabia
Pakistan	1985	Wadhanak
Portugal	1983	Celta
		Timpanas
	1984	Castico
	1985	Heluio
Saudi Arabia	1987	Cham 1
Spain	1983	Mexa
	1985	Nuna
Syria	1984	Cham 1
	1987	Cham 3
	1987	Bohouth 5
Tunisia	1987	Razzak
Turkey	1984	Susf bird
	1985	Balcili

Table 1. (Cont'd)

Country	Year of release	Variety
Bread wheat		
Algeria	1982	Setif 82
		HD 1220
Egypt	1982	Giza 160
	1988	Giza 162
		Giza 163
		Giza 164
		Sakha 92
Ethiopia	1984	Dashen
		Batu
		Gara
Greece	1983	Louros
		Pinios
		Arachthos
Iran	1986	Golestan
		Azadi
	1988	Darab
		Saludan
		Quds
Jordan	1988	NASMA=Jubeiha
	1988	L88=Rabba
Libya	1985	Zellaf
		Sheba
		Germa
Morocco	1984	Jouda
		Merchouche
	1989	Saba
		Kanz
Pakistan	1986	Sutlej 86
Portugal	1986	LIZ 1
		LIZ 2
Sudan	1985	Debeira
	1987	Wadi El Neel
Syria	1984	Cham 2
	1986	Cham 4
	1987	Bohouth 4
Tanzania	1983	T-VII-Veery'S'
		T-DUMA-D6811-Inrat
		69/BD Tunisia release.
Tunisia	1987	Byrsa
Yemena AR	1983	Marib 1
	1988	Mukhtar
	1988	Aziz
	1988	Dhumran
Yemen PDR	1983	Ahgaf
	1988	SW/83/2

2. GERMPLASM DEVELOPMENT

2.1. Barley Breeding

2.1.1. Introduction

The overall objective of the barley improvement project is to contribute towards bridging the gap between demand and production of barley. In the countries of WANA (West Asia and North Africa) the gap was 5 million metric tons in 1983 and is expected to raise to 11.3 million metric tons by the year 2000 (FAO, 1987. Agriculture: toward 2000). This poses a formidable challenge not only because of the size of the expected deficit to be bridged, but also because barley is typically grown in less favorable environments both from a climatic and an agronomic point of view, where genetic improvements of crop production have historically been more difficult to achieve.

ICARDA's strategy (Sustainable Agriculture for the Dry Lands, September 1989) recognizes this challenge both in its agroecological thrust ("ICARDA will increase its work in the highlands and the lower rainfall areas") as well as in its commodity thrust ("work on barley will be expanded in the WANA region in view of the crop's vital contribution to livestock production in its drier areas").

Precise statistics on barley deficits are not available outside WANA. However in the Andean Region of South America, in India, in the Himalyan countries, and in China barley is an important food crop, especially to the very poor.

To achieve its overall objective the research and training activities of the barley project are organized according to four main agroecological zones (Table 2). The specific objectives are related to the main yield-limiting factors in each agroecological zone.

This section deals with three agroecological zones: low rainfall, moderate rainfall and subtropical environments. Activities related to the highlands are covered in a separate chapter of this report.

Two approaches are followed in both research and training, namely

1) Development of germplasm
2) Development of breeding methodologies

Table 2. The barley improvement project: main objectives in relation to agroecological zones and division of responsibilities between ICARDA and CIMMYT

Agroecological zone	Main objectives	Main activities carried out from:
Low rainfall (250-350 mm)	Yield stability, straw quality	Aleppo
Moderate rainfall (> 350 mm)	Yield potential, pests, diseases and lodging resistance	Aleppo
Highlands in WANA	Yield stability, cold tolerance	Aleppo
Sub-tropical environments	Disease resistance	Mexico

Although complementary, in that methodologies are being developed within the context of the breeding activities, there is more emphasis on developing methodologies for the more difficult environments (low rainfall areas and highlands in WANA), and more emphasis on germplasm development for the climatically more favourable environments (moderate rainfall and subtropical environments). This difference in emphasis is associated with the lower research inputs and the poorer research infrastructure typical of the more difficult environments.

The size of the barley breeding project at Aleppo is illustrated in Table 3. Four main breeding methods are being used in the program:

- a bulk-pedigree method is used to manipulate segregating populations derived from crosses designed for low rainfall areas. With this method the F_2 populations are grown as 2 rows, 2.5 m long plots at Bouider (long term average rainfall = 212 mm) in an unreplicated design with systematic checks, and the best F_2's are identified. On the selected F_2's both bulk seed and between 15 and 40 heads are harvested. The bulk seed is evaluated for a minimum of three cropping seasons in the Initial, Preliminary and Advanced Yield Trials where selection between populations continues based on grain yield, earliness, cold tolerance, plant height etc. Single-head progenies of the selected bulks are evaluated at Tel Hadya for disease resistance and only resistant families of selected bulks are retained.

Table 3. Size of the barley breeding project at ICARDA in 1989.

Material		N. of entries	Locations (1)
New Crosses		1203*	
F_1's		2050	Tel Hadya
Segregating populations:	F_2	2300	Tel Hadya (normal and late(2) planting), Bouider
	F_3-F_n	20000	Tel Hadya, Bouider (F_3 with H. spontaneum)
Initial Yield Trials		1650	Tel Hadya, Bouider
Preliminary Yield Trials		760	Tel Hadya(2) Bouider, Breda, Athalassa(4)
Advanced Yield Trials		300	Tel Hadya 2,3, Breda, Bouider, Terbol, Athalassa (4)
Finished lines:	Crossing Blocks	84	Tel Hadya (5), Bouider, Athalassa (4), Terbol
	Observation Nurseries	271	Tel Hadya (5), Bouider, Athalassa (4), Terbol
	Regional Yield Trials	57	Tel Hadya (5), Bouider, Athalassa (4), Terbol

1) Excluding the locations where international nurseries are evaluated by national programs
2) Planting date: 21 April 1989
3) One set planted in a farmer field
4) Data collected by Dr. A. Hadjichristodoulou and staff at ARI, Nicosia, Cyprus
5) Three planting dates (October 15, 1988; December 12, 1988; February 15, 1989)
*) 457 for low rainfall, 406 for moderate rainfall, 340 for specific traits.

- a pedigree and a backcross method are used for moderate rainfall areas in WANA and for subtropical environments.
- During 1989-90 single seed descent will be used in the Aleppo-based project for a number of specific crosses for both low and moderate rainfall areas. This is already used in the Mexico-based project to advance specific crosses to homozygosity.

- Two generations a year are routinely produced in the Mexico-based project, and for most germplasm developed for moderate rainfall areas by the Aleppo-based project.

2.1.2 Major achievements during 1989

- During late 1988 and 1989 eight new barley varieties have been released in China (1), Vietnam (1), Chile (1), Ecuador (1) and Morocco (4) (Table 4). Although the release of a variety does not necessarily imply an impact at the production level, at least in the short term, it is a measure of acceptance of the type of germplasm being developed. In addition to the barley varieties already released, Rihane-03 has been recommended for release in Syria and Iraq, Roho/Mazurka is being multiplied for possible release in Iran, and Arabi Abiad is being considered for release in Pakistan. In China, four lines from the Regional Yield Trials for Moderate Rainfall Areas 1988-89 have been selected for further testing in 1990.

Table 4. Barley varieties released by national programs in 1988 and 1989.

Country	Year of Release	Variety Released
China	1989	V-24
Vietnam	1989	Api/CM67//B1
Chile	1989	Leo/Inia/Ccu
Ecuador	1989	Shyri
Morocco	1988	Tessaut
Morocco	1988	Aglou
Morocco	1988	Rihane
Morocco	1988	Tiddas

- Two national programs have become full partners in exploiting locally adapted germplasm: the Syrian national program has accepted to conduct the preliminary evaluation of pure-lines extracted from the two barley landraces grown in Syria, Arabi Abiad and Arabi Aswad (see section on low rainfall areas for more details). The Ethiopian national program began a program of selection within the Ethiopian barley landraces. In 1989 a preliminary evaluation of pure-lines selected within the best populations evaluated in 1988 was conducted at three locations in Ethiopia. A similar approach was discussed with Nepalese scientists and we plan to initiate a collaborative work on the evaluation of new collections of barley landraces in the near future.

- A collaboration with the national program of Nepal was started with a preliminary exchange of visits and germplasm. Although the first set of nurseries was sent with the sole purpose of identifying suitable germplasm for Nepal, seven lines were selected and promoted to the national yield trials for the next cropping season.
- Further progress was made in data analysis and information retrieval. The system used is linked to the yield trials so that a standard data file is prepared for the entries selected for the second and third year testing, containing both past years data and selection criteria used at each cycle of selection.
- To improve the targeting of new germplasm to the major agroecological zones, and to decrease the total number of lines distributed to each national program, the barley observation nursery for low rainfall areas (BOL) has been divided into two nurseries, one for low rainfall areas with mild winters (BOLW) and the second for low rainfall areas with cold winters (BOLC). This initiative is being implemented in the international nurseries distributed for the cropping season 1989-90. The major features of the various 1989-90 observation nurseries are summarized in Table 5. Average yield across nine environments was similar in the four nurseries (only the BOC was significantly lower than BOLW), yield under stress was significantly higher in the two BOL, while yield potential was higher for the BOM and BOLW. The genotypes in these two nurseries were also more erect, more cold susceptible and earlier than those in the BOC and in the BOLC. The

barley genotypes in the BOC were less productive under drought, less vigorous in the early stages of growth, more prostrate and late. Minor differences were found for kernel size. However, as 1000 kernel weight was recorded in 1989 (a very dry year), it was probably reduced to relatively low values in the majority of genotypes. When distributing germplasm through the international nurseries we try to consider the row type in relation to traditional preferences in different countries. As shown in Table 6 there is an overall prevalence of two-row genotypes, which are generally more tolerant to both drought and cold than six-row genotypes. However in the nursery designed for areas where earliness plays an important role as an escape mechanism, such as the low-rainfall areas with mild winter, there is a prevalence of six-row genotypes where higher levels of earliness are more frequent than in two-row genotypes.

Table 5. Targetting barley germplasm: average yield (9 environments), yield under stress (3 environments) yield potential (6 environments), growth habit GH (1 = erect; 5 = prostrate), days to heading DH, early growth vigour GV (1=good; 5=poor), 1000 kernel weight KW (g), and cold tolerance CT (1 = tolerant - 5 = susceptible) of the new ICARDA lines promoted to the 1989-90 observation nurseries.

Observation Nursery (Acronym)	Average yield (kg/ha)	Yield under stress (kg/ha)	Yield potential (kg/ha)	GH	DH	CT	GV	KW
Moderate rainfall (BOM)	2570ab	605b	5717a	2.8a	120.6b	3.6b	2.5ab	32.0
Low rainfall-mild (BOLW)	2650a	706a	5383a	2.8a	117.5a	3.2b	2.3a	33.1
Low rainfall-cold (BOLC)	2585ab	801a	4378b	3.5b	123.2c	1.7a	2.4a	33.5
High Elevation (BOC)	2477b	564b	4631b	3.8c	125.7d	1.5a	2.7b	32.2

Means followed by the same letter(s) are not significantly different (F-test) ($P < 0.05$).

One of the trait architectures expected to be associated with higher and more stable yields in environments with cold winters and both intermittent and terminal drought is a combination of prostrate growth habit and earliness (see Physiology/Agronomy).

Table 6. Frequency of two-row and six-row barley genotypes among new lines distributed in the international nurseries 1989/1990.

Nursery	Percent of 2 Row	Percent of 6 Row
Moderate rainfall (BOM)	64.3	35.7
Low rainfall-mild (BOLW)	32.1	67.9
Low rainfall-cold (BOLC)	100.0	0.0
High elevation (BOC)	90.0	10.0
Crossing block (BCB)	63.6	36.4
Total	65.6	34.4

During 1987/88 some early genotypes with prostrate growth habit and cold tolerance were identified (Annual Report 1988, pg 17). While those genotypes were used as parents in the crossing program to increase the frequency of this combination of traits, additional genotypes with the same combination of traits were identified in the 1988/89 cropping season (Table 7).

Table 7. New genotypes combining prostrate growth habit and earliness identified in 1989.

Trial/Material	No. of lines	%	Growth habit(1)	Days to heading(2)	Cold tolerance(3)
Preliminary Yield Trial	16	2.2	3.9	106.9	3.0
Initial Yield Trials	28	1.7	4.2	108.6	2.3
Harmal (early check)	-	-	2.7	109.4	2.8
A. Aswad (prostrate and cold tolerant check)	-	-	4.8	112.5	1.4

(1) 1 = erect; 5 = prostrate. (2) Days from emergence.
(3) 1 = tolerant, 5 = susceptible.

Although the total frequency of genotypes combining prostrate growth habit and early heading (1.8%) increased compared with the previous cropping season (0.5%), the level of cold tolerance of such genotypes (especially those in the preliminary yield trials) is not satisfactory. Using the two Syrian landraces (A. Aswad and A. Abiad) as sources of both prostrate growth habit and cold tolerance seems a more promising way to combine these two traits with early heading (Table 8).

Table 8. Barley genotypes with the best combination of prostrate growth habit, cold tolerance and early heading in the Initial Yield Trial 1989

Genotypes	Growth(1) habit	Days(2) to heading	Cold(3) tolerance
Arabi Aswad/Th. Unk.00	4.3	109.1	1.5
Arabi Aswad/Harmal-02	4.6	110.4	1.8
PI 386540/Arabi Abiad	3.9	106.3	1.6
Tron Sejet/Arabi Aswad	4.2	111.6	1.8
Harmal-02/Arabi Abiad/Api/CM67//Nacta	3.7	111.9	2.0

(1) 1 = erect; 5 = prostrate. (2) Days from emergence. (3) scale: 1 = tolerant, 5 = susceptible.

The development of specific plant types is an example of incorporating physiological concepts into barley breeding, and of the more general effort to develop breeding stocks with different plant types for different environments. This activity is conducted by applying different selection criteria during all stages of selection. The traits more frequently used as selection criteria (excluding disease and lodging resistance) are listed in Table 9. The use of different selection criteria has several advantages, such as maintaining genetic diversity, providing breeding stocks with specific traits to national programs and understanding the relationships between traits. Data such as those in Table 9 form the basis for the promotion of lines to international nurseries and for the preparation of the crossing program.

Table 9. Attributes of barley genotypes selected from the Advanced Yield Trials 1989 on the basis of different selection criteria (based on three years data).

Selection criteria	Attributes of selected genotypes								
	YP	YD	Y	DH	CT(1)	GH(2)	GV(3)	KW	PHD
Yield potential (YP)	6452	621	2646	119.8	3.4	2.9	2.5	32.3	26.3
Yield under drought (YD)	4891	960	2518	120.9	2.6	3.0	2.4	33.6	29.2
Earliness (DH)	5467	658	2467	115.3	3.5	2.7	2.3	32.2	29.7
Growth habit (GH)	4377	689	2364	124.1	1.9	3.9	2.8	32.2	24.4
Growth vigour (GV)	4937	710	2724	120.5	2.8	2.9	1.7	34.8	26.0
Plant height under drought (PHD)	5210	726	2580	119.9	3.3	2.9	2.5	32.4	34.4
Cold tolerance (CT)	4191	726	2443	124.8	1.4	3.7	2.6	32.5	23.7
1000 kernel weight (KW)	5002	743	2671	121.3	2.7	3.1	2.3	37.8	25.7
L.S.D.$_{(.05)}$	496	101	190	2.1	0.5	0.3	0.3	1.8	2.8

Y = grain yield (1) 1 = resistant; 5 = susceptible; (2) 1 = erect; 5 = prostrate; (3) 1 = good; 5 = poor;

The data of Table 9 confirm that:

- Selection based on yield potential alone is not an efficient strategy to maximize yield under drought.
- None of morphological traits used individually as selection criteria has an efficiency comparable with grain yield under drought

It is therefore obvious that to increase the precision of identifying superior genotypes under drought, alternative strategies need to be explored. The two main analytical tools used in barley breeding are (1) selection based on an architecture of traits and (2) selection based on physiological traits. Both analytical tools are illustrated in more detail in the chapter Physiology/Agronomy.

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2.1.3. Performance of barley lines in the region

The Regional Yield Trials are international nurseries where the lines selected by national program scientists from the observation nurseries are evaluated in replicated trials. Because of the large yield variability in different locations, we also used the average rank and the standard deviation of rank (Nachit and Ketata, 1986) to compare the different entries in addition to yield.

However, as expected, average yield and average rank were strongly correlated (r=-.98**) and therefore only average yields are presented.

Across a total of 14 locations the 19 lines tested in the Regional Yield Trials for High Altitude Areas yielded 175 kg/ha more than the average of the improved checks (yield = 2450 kg/ha). The 12 lines promoted to the regional yield trials in 1988 performed better (yield = 2691 kg/ha) than the 7 entries promoted in 1987 and tested for the second year (yield 2510 kg/ha), but are slightly less stable. The three best lines (shown at the bottom of Table 10), performed consistently well across the 14 locations. The low values of the standard deviations for the rank is an indication of the consistency of good performance. However this type of analysis does not necessarily

Table 10. Standard deviation of ranks (SR) and grain yield (kg/ha) in the Regional Yield Trials 1988-89 for High Altitude Areas (based on 14 locations).

Material	N. of lines	SR	Yield (kg/ha)
Lines evaluated for the second year	7	5.91	2510
Lines evaluated for the first year	12	6.45	2691
All lines	19	6.25	2625
Improved checks	4	6.13	2450
Best lines:			
Leb71/CBB37//Leb71/CBB29	-	3.74	2962
WI2291/3/SP(2h)//Cr.115/Por	-	8.64	2853
Rihane - 08	-	7.50	2869
Best check (Beecher)	-	6.27	2619

reveal those lines that perform well only in a particular country. Table 11 shows that among the lines outyielding the national check in different countries only one is in common with the best lines in terms of average performance.

In the case of the Regional Yield Trials for Moderate Rainfall Areas results are from the 26 locations for which data were received before writing this report.

The best improved check (Assala 04) ranked better than the national check in 15 out of the 26 locations. The second best improved check (ER/Apm) ranked better than the national check in 12 locations. One line, Cr. 115/Por//Strain 205 performed better than the national check in 17 locations. Another test line, N-Acc 4001-59-80 was on the average as good as Assala 04 and ranked better than the national check in 15 locations. Compared to the second best improved check (ER/Apm), in addition to the 2 cited lines, one line (Roho/Mazurka) was better and ranked better than the national check in 13 locations. Two lines (M69-77//Shi-r-kci No.87/4/Pro/TolI//Cer*2/TolI/3/5106 and Cm67/Apro//Sv.02109/Mari) were on the average as good as this check and ranked better than the national check in 12 locations. About 50% of the test lines (9 lines) ranked better than the national check in 10 or more locations.

Table 11. Lines in the 1988/89 Regional Yield Trials for High Altitude Areas outyielding significantly the national check in some selected countries.

Lines	Country	% over nat. check	Average rank
- Leb71/CBB37//Leb71/CBB29	Iran	162.9	5.08
	Tunisia	31.6	5.08
- Kenya/Research/Belle	Morocco	27.3	10.50
- WI2197/Arabische	Greece	23.7	12.00
- Jerusalem a barbes lisses/Bonus	Tunisia	56.9	12.75
- H272/Bgs/3/Mzq/Gva//PI002917	Korea	59.7	12.08
	Pakistan	15.8	11.71
- Di Jou 3-2-5	Pakistan	28.0	9.29

Compared to the best improved check in a given location (Assala 04, ER/Apm, Beecher, or WI2991), the national check ranked better in 8 out of the 26 locations. One test line (Cr.115/Por//Strain 205) also ranked better than the best improved check in 8 locations. Another test line (Com.Cr.229//As46/Pro) ranked better in 7 locations. One line (Th.Unk.7) ranked better in 6 locations, and 2 lines (WI2291/3/CI 03309/Attiki//Hja33 and N-Acc4001-59-80) ranked better in 5 locations. In summary, 8 lines seem to be promising for the region. The list of these lines is given Table 12.

With the exception of a few locations (data collected from 20 locations), all these entries were on the average earlier to head than the national check (with lines 6 and 8 being the earliest of all). With the exception of line 4, they were all more lodging resistant than the national check, with line 6 being the most resistant (data on lodging collected from 8 locations).

The reaction to powdery mildew (data collected from 7 locations) varied from location to location but with the exception of line number 5, all the entries had an acceptable level of resistance. Lines 2, 5, 6, 7, and 8 had also a good level of resistance to net blotch (data collected from 4 locations), with line 6 being the most resistant. For scald, all the lines except 2 and 3 showed a good level of resistance, with line 8 showing no reaction in any location (data collected from 4 locations). Except for lines 4 and 5, kernel weight was very high (3 locations only).

The locations from which data were analyzed were merged into 3 groups, with group 1 represented by 2 locations from Morocco, 2 from Tunisia, 1 from Spain, 1 from Portugal, and 1 from Italy, group 2 represented by 2 locations from Libya, 2 from Saudi Arabia, 1 from Qatar and 6 from Egypt, and group 3 represented by 3 locations from Syria, 1 from Lebanon, 1 from Cyprus, 2 from Iran, and 1 from Greece. By examining the different lines in each group of environments, the following conclusions were drawn: line number 1 in Table 12 was exceptionally good in group 3, line number 5 was good in group 1, line number 6 in both groups 2 and 3, line number 7 in group 3, and line number 8 in group 2. Line 6, besides being excellent in a wide range of environments, is also disease resistant, lodging resistant, and early.

Table 12. The most promising lines from the Regional Yield Trials for Moderate Rainfall Areas (1988/89).

Line	Number of locations with Rank 1	Rank 2	Rank 3
1. Th.Unk.7	1	1	3
2. Roho/Masurka	2	0	2
3. M69-77/Shi-r-Kci No.87/4/Pro/ TolI//Cer*2/TolI/3/5106	1	3	0
4. WI2291/3/CI 03309/Attiki/Hja33	2	2	1
5. CM67/Apro//Sv.02109/Mari	2	2	0
6. Cr. 115/Por//Strain 205	3	2	1
7. Comp.Cr. 229/As46/Pro	2	1	1
8. N-Acc 4001-59-80	1	2	1

In the Regional Yield Trials for Low Rainfall Areas a number of barley lines outyielded the national check for two consecutive years in the same country (Table 13).

Table 13. Number of barley lines (excluding the checks) in the Regional Yield Trials for Low Rainfall Areas which outyielded significantly the national check (8 lines tested in both 1986-87 and 1987-88; 6 lines in both 1987-88 and 1988-89).

Country	No. of lines 1986-87	1987-88	Both years
Iraq	0	2	0
Iran	3	5	2
Syria	6	8	6
Egypt	0	4	0
Italy	5	3	3
Pakistan	1	4	0
Country	1987-88	1988-89	Both years
Iraq	1	0	0
Iran	4	2	2
Syria	5	4	4
Egypt	2	6	2
Italy	1	3	1
Greece	0	1	0

The average yield for some of the best performing lines is shown in Table 14.

Table 14. Performance of barley lines in the Regional Yield Trials for Low Rainfall Areas 1986-87, 1987-88, 1988-89.

Line	Average yield*		
	1986-87	1987-88	1988-89
- WI 2197/Cam	4095	3885	-
- Deir Alla 106/Strain 205	4012	4048	-
- Pld10342//Cr.115/Por/3/Bahtim9/4/ Ds/Apro/5/WI2291	-	3778	2794
- Bal.16/Api//Deir Alla 106	-	4398	3142
- Long-term check (Beecher)	4045	3912	2938
- Average of all lines	3953	3627	2801

*22 locations in 1986-87; 29 in 1987-88 and 26 in 1988-89.

A number of lines outyielded the national check in other countries e.g. Morocco, Tunisia, Jordan, Portugal, Spain and China, but data were available only for one year.

Table 15 shows the performance (expressed as number of times that an entry outyielded the national check) of 6 barley lines evaluated in the Regional Yield Trials for Low Rainfall Areas in 29 locations in 1987-88 and 26 locations in 1988-89.

Table 15. Number of times that each entry outyielded the national check in 29 locations in 1987-88 and 26 locations in 1988-89.

Line	No. of times		
	1987-87	1988-89	Total
- Esp/1808-4L//WI2291	1	3	4
- Pld10342//Cr.115/Por/3/ Bahtim 9/4/Ds/Apro/5/WI2291	3	5	8
- WI 2197/CI 13520	1	3	4
- MPYT169-1Y	1	1	2
- Bal.16/Mzq/3/M67-18/M14// Ds/Apro/4/Iris	2	2	4
- Bal.16/Api//Deir Alla 106	7	5	12

S. Ceccarelli, A. Zahour, S. Grando

2.1.4. Barley breeding for moderate rainfall areas

The main objective of barley breeding for moderate rainfall areas is to develop suitable barley germplasm, with the cooperation of national programs, and for the national programs for areas where the barley yields range from 2 to 4 t/ha. The barley program deals with major constraints limiting barley production in WANA, namely diseases, low yield potential, lodging, straw quantity and quality, etc. Yield stability as affected mainly by short term fluctuations in the environment is also emphasized.

Germplasm development:

Four hundred six crosses were performed during the 1989 season (Table 3). Two hundred and two crosses were among 2 by 2-rowed genotypes, 142 crosses among 6 by 6-rowed genotypes, and 86 crosses among 2 by 6-rowed genotypes. The parents were selected based on their performance (disease resistance, lodging resistance, yield potential and stability, earliness, biomass, etc.) at different locations (mainly from the international nurseries and the advanced yield trials). The major diseases considered in making the crosses were powdery mildew, net blotch, scald, and BYDV. Even though specific crosses for other diseases (barley stripe, smuts, rusts, etc.) were not made for that particular purpose, plants or families showing susceptibility to any disease were eliminated from segregating populations or recycled in the program. Two lines identified by the entomology program as resistant to wheat stem sawfly were also included in the crossing program to introduce resistance to this pest. Parents were also selected based on their yielding ability, yield stability, lodging resistance, high biomass, and earliness.

All the segregating populations, besides being planted at the normal date at Tel Hadya for plant selection, were planted as short rows at Lattakia, and with the exception of the F2 generations were also planted as short rows at the disease nursery in the pathology field at Tel Hadya. F6, F7, and F8 generations were also planted in Terbol, Lebanon where they were selected for earliness, disease resistance, and good agronomic score.

During 1989, the segregating populations for moderate rainfall areas consisted of 280 F2 families, 435 F2 derived F4 families, 1477 F3 derived F5 families, 254 F4 derived F6 families 447 F5 derived F7 families, 1890 F6 derived F7 lines, 262 F6 derived F8 families and 1075 F7 derived F8 lines. All populations, with the exception of F8 were planted in the summer nursery in Terbol, Lebanon, for generation advance. The use of the summer nursery has permitted us to gain one generation per year during the last 3 years.

Despite the inoculation of segregating populations by scald in the disease nursery at Tel Hadya, infection was not uniform because of drought and cold temperature. Data on scald were not reliable and were considered only for blocks where the susceptible check was heavily attacked. On the other hand, the powdery mildew pressure was very high at Lattakia.

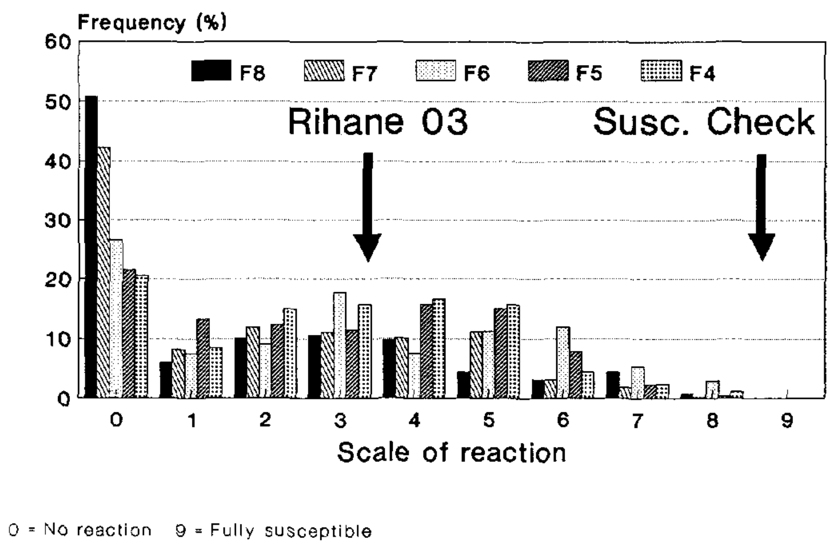


Fig. 1. Powdery mildew reaction (on a 0-9 scale) of segregating populations (F4, F5, F6, F7 and F8) at Lattakia.

Data on powdery mildew are reported in Figures 1, 2 and 3. Figure 1 shows the distribution on a 0 to 9 scale (with 0 meaning no reaction was recorded and 9 being fully susceptible) for F4, F5, F6, F7, and F8. As indicated by the reaction of the susceptible check, disease pressure was very intense. From Figure 1 we can see that over 50% of the F8 lines showed no infection with powdery mildew. A list of the most promising lines from F8 (also early, resistant to scald, and selected over 5 different environments) is given in Table 16. Figure 2 summarizes the powdery mildew reaction at Lattakia for the same populations.

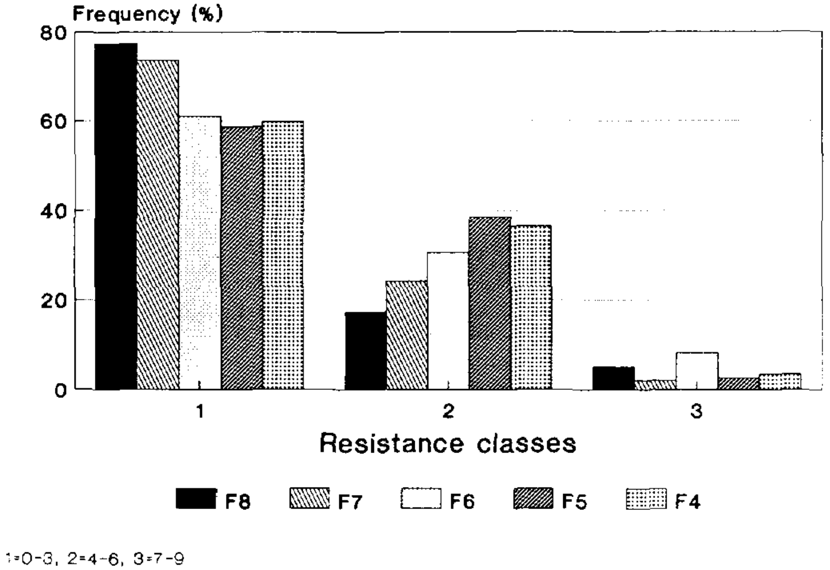


Fig. 2. Powdery mildew reaction (on a 0-9 scale) of barley populations (F4, F5, F6, F7 and F8) grouped into resistance/susceptibility classes.

The disease reaction was arranged in groups (group 1 ranging from 0 to 3 and classified as being resistant, group 2 ranging from 4 to 6, and

classified as being moderately resistant to moderately susceptible, and group 3 ranging from 7 to 9 and classified as being susceptible). The bulk of the populations was classified resistant.
This resulted from selection pressure applied to these populations in earlier generations. During selection, lines with a score of 3 or less were taken unless they presented other weaknesses such as lateness, susceptibility to other diseases, etc. Lines with scores from 4 to 6 were not selected unless they presented an exceptionally good performance for other characters such as resistance to a given disease. Lines with scores of 7 or above were always discarded, except for few lines from the advanced generations (mainly F8) which were recycled in the crossing program. Figure 3 shows the selection response for powdery mildew.

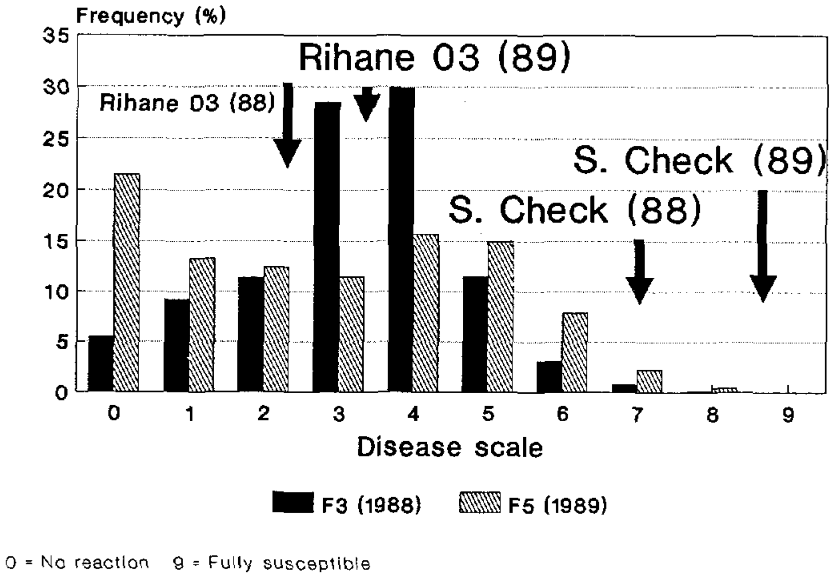
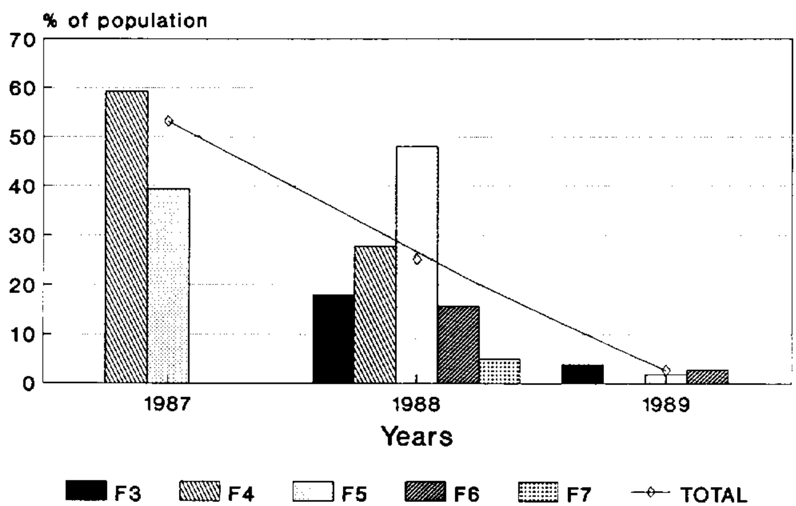


Fig. 3. Response to selection for powdery mildew resistance during 1988 and 1989 seasons.

It compares the reaction of F3 families at Tel Hadya in 1988 and the reaction at Lattakia in 1989 of the F5 families that were derived from these F3's after advancing the material by one generation at Terbol in the summer of 1988. The disease pressure at Lattakia in 1989 was higher than at Tel Hadya in 1988, as indicated by the reaction of Rihane 03 and the susceptible check (these 2 checks were planted every 20 rows), yet there was a shift in the F5 toward resistance as a result of selection of resistant genotypes in 1988.

As a consequence of using the summer nursery in Terbol, Lebanon, the germplasm for the moderate rainfall areas was grouped into 2 pools. One with a vernalization requirement, and one without. The pool with a vernalization requirement formed a special nursery planted only at Tel Hadya and is meant to serve only specific regions. Figure 4 shows the evolution of the vernalization requirement of material that was planted in the summer nursery over the last 3 years. The evolution is linear over the three seasons.



1988: F3, F4, F5, F6, & F7 (4136 entrie)
1989: F3, F5, F6, & F7 (3480 entries)

Fig. 4. Evolution of vernalization requirement of the barley segregating populations as a response to selection in the summer nursery between 1987 and 1989.

Table 16. Barley lines (F8) combining powdery mildew resistance scald resistance, earliness, and good agronomic score.

Lines	RT	PM	SC	DH
1. Anthares/4/As/Dwgl-M2//M59-24/3/Api*2 ICB83-1509-1AP-1AP-2AP-0TR-1AP-0TR	6	R	MR	MEa
2. Harmal-02//WI2291/Bgs ICB83-1554-1AP-1AP-1AP-0TR-2AP-0TR	2	R	MR	Ea
3. Roho//WI2291/EH70-F3-AC ICB83-1575-5AP-1AP-1AP-0TR-1AP-0TR	2	R	R	Ma
4. Kv//Alger/Ceres,382-1-1/3/Arr/Esp/ /Alger/Ceres,362-1-1ICB84-0033-1AP-4AP -2AP-0TR-3AP-0TR	2	R	R	Ma
5. WI2291/EH70-F3-AC/Arr/Esp//Alger/Ceres, 362-1-1ICB83-0286-15AP-6AP-1AP-001TR-4AP-0TR	2	R	MR	MEa
6. Asse/Jaidor ICB83-1189-12AP-1AP-4AP-001TR-1AP-0TR	6	R	MR	Ea
7. Lignee 527/NK1272 ICB84-0323-4AP-1AP-2AP-001TR-1AP-0TR	6	R	MR	Ea
8. Lignee 527/Aths CYB-3191-0D-1AP-3AP-001TR-1AP-0TR	6	R	MR	MEa
9. Giza/Shiga Hakkoku//Ecpo'S' ICB84-0828-5AP-0TR-4AP-001TR-4AP-0TR	6	R	MR	MEa

RT: row type; PM = powdery mildew; SC = scald; DH = earliness; Ea = early; MEa = medium early.

Initial yield trials

Two out of 8 barley trials were targetted for moderate rainfall areas. In spite of the drought that prevailed at Tel Hadya during the growing season, yields over 4.5 t/ha were attained in these two experiments (Table 17). 3.3% of the lines in one experiment had a yield higher than the best check, Arabi Aswad (which yielded 3.9 t/ha), and 18.8% of the lines had a yield similar to Arabi Aswad. In the second experiment, 3.1% of the lines had a yield significantly higher than the yield of the best check, Arabi Abiad (4.1 t/ha) and 17.2% had a yield similar to this check.

Table 17. The highest yielding lines from the initial yield trials for moderate rainfall areas Tel Hadya, 1988/89.

Lines	Yield t/ha	RT	DH	PM	SC
ER/Apm/3/Arr/Esp//Alger/Ceres,362-1-1 ICB83-1467-7AP-5AP-4AP-001TR-3AP	4.7	2	Ea	R	S
Weeah 11/WI2291/Bgs ICB83-1826-1AP-6AP-4AP-001TR-4AP	4.6	2	Ea	R	MS
ER/Apm/3/Arr/Esp//Alger/Ceres,362-1-1 ICB-1467-7AP-5AP-2AP-1AP-0TR	4.7	2	Ea	R	-
ER/Apm/3/Arr/Esp//Alger/Ceres,362-1-1 ICB83-1467-7AP-5AP-2AP-2AP-0TR	4.6	2	Ea	R	-
Ore'S'//33-4/Bahtim10/3/Api/CM67//Mona ICB84-0677-4AP-3AP-0TR-1AP-0TR	4.5	6	Ea	MS	-
Bc//Aw WhiTR/Aths/3/WI2198/Emir ICB84-1455-2AP-5AP-0TR-1AP-0TR	4.9	6	Ea	R	-
Badia/5/Cr.115/Pro//Bc/3/Api/CM67/4/ Giza 120 ICB84-1072-3AP-2AP-001TR-3AP-0TR	4.5	6	Ea	R	R
Harmal-03/80-5013 ICB85-0462-1AP-4AP-3AP-0TR	4.5	6	MEa	R	MR
Harma-03/80-5013 ICB85-0462-1AP-4AP-5AP-0TR	4.7	6	MEa	R	MR

RT: row type, DH: earliness, Ea: early, MEa: medium early, PM: powdery mildew, SC: scald, R: resistant, S: susceptible, MR: moderately resistant, MS: moderately susceptible.

Among the lines tested in the advanced yield trials, nineteen (12 two-row and 7 six-row) lines outyielded Rihane-03 in the highest yielding environments during 1988 or 1989 (Tel Hadya, 1988, and Cyprus 1988 and 1989). The pedigree and grain yield for these lines are shown in Table 18.

Table 18. Advanced Barley Lines outyielding Rihane-03 in two or three high yielding environments*.

Cross	Average yield (kg/ha)	% over Rihane-03	Row type
ER/Apm//WI2198	6322 (3)	14.0	2
WI 2269//CI08887/CI05761	6583 (3)	18.7	2
Irania/Er/Apm	5961 (3)	7.5	2
Menuet/Arabi Abiad//WI2198	6095 (3)	9.9	2
Moroc 9-75/PmB	6121 (3)	10.4	2
Roho*2/Arabi Abiad	5880 (3)	6.0	2
Mazurka//Havila/Coracle Co65	6257 (2)	11.3	2
Mo. B1337/WI 2291	6770 (2)	20.4	2
CI 08887/CI05761//Cerise	6718 (2)	19.5	2
Esp/1808-4L//Er/Apm/3/Lignee 131//Er/Apm	6301 (2)	12.1	2
Dram/Emir//ER/Apm	6442 (2)	14.6	2
Harmal-02/Emir	6261 (2)	11.3	2
Rihane-03/3/Bc/Rihane//Ky63-1294	5709 (3)	3.0	6
Arar/3/1D/CM67//Ase/Nacta	6565 (2)	16.8	6
Lignee 527/Charan-01	6114 (2)	8.7	6
Deir Alla 106//DL70/Pitayo/ 3/RM 1508/4/Arizona 5908/ Ath//Avt/Attiki/3/Ager	6252 (2)	11.2	6
Lignee 527/NK 1272	6042 (2)	7.5	6
Lignee 527/Rihane	6093 (2)	8.4	6
Lignee 527/As45	5992 (2)	6.6	6

* Tel Hadya 1988 (average yield = 4388 kg/ha), Cyprus 1988 (average yield = 5008 kg/ha), Cyprus 1989 (average yield = 5824 kg/ha)
() = number of environments where the line outyielded Rihane 03.

A. Zahour

2.1.5. Barley breeding for low rainfall areas

The major objective of barley breeding for Low Rainfall Areas is greater yield stability, where stability is defined as a reduction in the frequency of crop failures.

In those areas drought is often associated with temperature stresses such as cold during winter and heat at grain filling period.

Furthermore, timing, duration and intensity of the drought stress are highly unpredictable.

To identify germplasm with higher and stable yield under dry conditions, bulk populations derived from the crossing program were tested in our driest experimental site (Bouider) for a minimum of three years in yield trials with two (Initial Yield Trials) or three replications (Preliminary and Advanced Yield Trials) using a lattice design. The same trials were also planted in more favorable conditions (Table 2) to assess their response to improved climatic and agronomic conditions.

During 1989 the average grain yield in the yield trials was 640 kg/ha at Bouider (184 mm rainfall) and 3000 kg/ha at Tel Hadya (234 mm rainfall). At Bouider (Table 19) the best check was the local landrace Arabi Aswad, but even using a relatively mild selection pressure (10%) a large number of lines were identified which outyielded A. Aswad. The average yield advantage of the best 10% of the lines was 19.1% in the initial yield trials, 24.8% in the Preliminary Yield Trials, and 16.4% in the Advanced Yield Trials. There is no evident trend in these figures but this could be associated with the different germplasm in the three types of trials. In both the Advanced and in the Preliminary Yield Trials, 21.3% and 26.2%, respectively, of the germplasm was comprised of pure lines selected from local landraces. These lines represent 83.3% and 78.9%, respectively of the top yielding lines. Pure lines selected from landraces were absent in the Initial Yield Trials because this type of germplasm is now evaluated in separate trials by the Syrian National Program. The adapted germplasm in the Initial Yield Trials was present in the form of crosses made in 1984 and 1985 between Tadmor and improved lines (1.4%, of the total) and crosses between either Arabi Aswad (7.8%) or Arabi Abiad (9.2%) and improved lines. Although the material derived from these three types of crosses was among the highest yielding material (the top yielding bulk, with 1651 kg/ha, was Moroc 9-75/Arabi Aswad), there was a relatively large number of low yielding crosses due to the lack of adaptation of the other parent.

Table 19. Grain yield (kg/ha) at Bouider (184 mm rainfall) of barley germplasm in the Initial, Preliminary and Advanced Yield Trials (1988/89).

Material	Initial (n = 1650)	Preliminary (n = 760)	Advanced (n = 300)
Grand mean	653	602	687
Best 10%	1137	1128	1191
max	1651	1394	1479
min	1018	1016	1069
Rihane -03	566	496	526
Kantara	772	622	683
Harmal	820	785	821
A. Aswad	955	904	1023
A. Abiad	872	752	931

At Tel Hadya (Table 20) the highest yielding check was again the local landrace grown in the area (Arabi Abiad), confirming that repeated selection under relatively favourable conditions maximizes

Table 20. Grain yield (kg/ha) at Tel Hadya (234 mm rainfall) of barley germplasm in the Initial, Preliminary and Advanced Yield Trials (1988/89).

Material	Initial (n = 1650)	Preliminary (n = 760)	Advanced (n = 300)
Grand mean	3086	3203	2667
Best 10%	4299	4072	3561
min	4019	3815	3348
max	4981	4913	4118
Rihane - 03	3148	3274	2631
Kantara	3470	3608	2845
Harmal	3440	3357	2774
A. Aswad	3106	3382	2802
A. Abiad	3531	3689	3203

yield potential at the expense of stability. With the exception of the Initial Yield Trials where the yield advantage of the best 10% of the lines over Arabi Abiad (21.8%) was slightly higher than the comparative figure in Bouider (19.1%), the yield advantage of the most productive lines in the Preliminary and Advanced Yield Trials were lower (10.4%

and 11.2%, respectively) than in Bouider. However, data from Advanced Yield Trials evaluated in Cyprus by the Agricultural Research Institute show no decline in yield potential. The average yield in Cyprus was 5824 kg/ha while the best 10% of the lines yielding an average of 7223 kg/ha, almost 1000 kg/ha more than the best check (Harmal = 6354 kg/ha).

Mixtures

Pure line selection within landraces has resulted in the identification of a number of promising lines for dry areas (Annual Reports 1986, 1987 and 1988) thus showing the power of this approach in the short term. If landraces, which are products of natural and artificial selection, are mixtures of genotypes, then stability of performance is likely associated with genetic heterogeneity.

To achieve a better understanding of the role of genetic heterogeneity in stabilizing yield in stress environments we evaluated three mixtures at different levels of complexity (4,8 and 16 lines) alongwith the single components for three years in a total of 11 locations (Table 21).

Table 21. Total rainfall (mm) and average yield at each location/year combination.

Location	Year	Rainfall mm	Average Yield kg/ha
Bouider	1986/87	176.2	61.2
Breda	1986/87	244.6	451.4
Tel Hadya	1986/87	357.9	1791.8
Bouider	1987/88	385.7	2826.7
Breda	1987/88	414.8	3379.7
Tel Hadya	1987/88	504.2	3743.8
Cyprus*	1987/88	321.0	4806.1
Bouider	1988/89	186.4	596.2
Breda	1988/89	193.8	1328.1
Tel Hadya	1988/89	234.4	3275.0
Hassake**	1988/89	184.5	1028.2

* data collected by Dr. A. Hadjichristodoulou and his staff at ARI, Nicosia, Cyprus. ** data collected by DASR, Hassake, Syria.

Two different techniques have been used to measure stability: the joint regression analysis and a nonparametric method proposed by Nachit and Ketata (1986).

Over 11 environments (Table 22) only the mixture of 4 lines had a better average rank (12.8) and a lower standard deviation of ranks (5.9) than A. Aswad (R = 13.5, SDR = 6.9).

Furthermore the mixture of 4 lines showed a better response (b = 0.90) and a higher intercept (a = 168.7) than A. Aswad (b = 0.85, a = 160.1).

Out of the three best lines (shown at bottom of Table 22) in terms of average rank, only two (SLB 42-64 and SLB 49-93) performed consistently well across the environments.

Table 22. Average grain yield GY (11 environments), regression coefficient (b), intercept (a), average rank (R), and standard deviation of ranks (SDR) of 3 mixtures and 3 lines.

	GY kg/ha	b	a	R	SDR
Mixture 4 lines (1)	2066.8	.90	168.7	12.8	5.9
Mixture 8 lines (2)	1937.7	.90	24.1	16.0	6.2
Mixture 16 lines (b)	2110.7	.99	15.4	11.7	7.8
SLB 42-64 (1-2-3)	2156.7	.99	64.0	9.0	6.8
SLB 45-93 (3)	2185.3	.96	146.5	8.8	4.3
SLB 45-58 (3)	2402.1	1.16	-44.1	8.5	7.4
A. Aswad	1955.3	.85	160.1	13.5	6.9

<u>Hordeum spontaneum</u>

In addition to landraces a second type of adapted germplasm that can be of great benefit to breeding programs for unfavorable environments are wild progenitors and/or relatives. <u>Hordeum spontaneum</u>, the wild progenitor of cultivated barley, might be expected to contribute useful genes in barley breeding for dry areas as suggested by its distribution in the driest areas of the Fertile Crescent. The species is extremely diverse. Different accessions need to be carefully evaluated under environmental conditions that allow the expression of useful traits before parents are selected for a crossing program. The activities on H. spontaneum began in 1984/85 with the evaluation of a large number of accessions at Bouider and the extraction of pure lines. In 1986/87, 59 lines were evaluated at Bouider (176.2 mm rainfall). Some were able to maintain open stomata, and thus some photosynthetic activity, at a very low leaf water potential. The local barley, well adapted to drought, had completely closed stomata (Acevedo, 1987). In addition they combined earliness with acceptable cold resistance, and they were able to maintain good plant height under drought (Table 23).

Table 23. Lines of H. spontaneum selected as parents for crosses. (Bouider, 1989).

Line/ variety	Cold damage*	Days to heading	Plant height (cm)	Peduncle extrusion (cm)
H. sp. 41-1	2.3	109	60.7	11.6
H. sp. 41-3	2.5	112	60.5	10.1
H. sp. 41-4	2.3	110	60.3	12.4
H. sp. 41-5	2.5	110	61.0	12.2
H. sp. 38-3	2.3	112	41.8	3.8
H. sp. 38-4	1.8	111	39.7	3.8
Harmal	2.5	114	29.3	-5.9
A. Aswad	1.0	116	29.8	-9.0
Tadmor	1.3	117	30.2	-6.1
Arta	1.8	113	22.7	-7.6

* Score: 1 = minimum damage, 5 = maximum damage.

The same lines were planted in Tel Hadya and were used in crosses with lines from landraces as well as with improved varieties.

In 1988-89, 1765 F3 families derived from crosses between selected accessions of H. spontaneum and cultivated barley were planted at Bouider along with the parents and a common check (Harmal).

The F3 families on average were earlier than Tadmor and Harmal, cold resistant and had medium growth vigour (Table 24).

Table 24. Cold damage, growth vigour and days to heading of F3 families from crosses H. spontaneum x H. vulgare (Bouider, 1989).

	n	Cold damage*	Growth vigor*	Days to heading
All F3	1765	2.0	2.8	116.6
F3 selected	475	1.8	2.1	114.2
Tadmor		1.6	2.3	117.6
Harmal		2.3	2.7	118.0

* Scale: 1-5 (1 = best, 5 = poorest).

S.Grando

2.1.6. ICARDA-CIMMYT Barley Project

The major objective of the Mexico-based project is the incorporation of disease resistance into ICARDA-CIMMYT barley germplasm with high yield potential.

Yield testing

In the 1988-89 winter season, 330 advanced lines were yield tested under irrigation in the Yaqui Valley in northwestern Mexico. The top yielding 139 lines were distributed in the 17th International Barley Observation Nursery (IBON) for observation under different conditions.

Selection for multiple disease resistance

Prior to yield testing, advanced lines were evaluated for their disease reaction simultaneously at three sites in central Mexico (Toluca, El Batan Experiment Station, and on a farmer's field in Lagunilla) during the summer of 1988. This scheme avoided interference and overlapping of disease symptoms caused by different pathogens. In Toluca, plants were exposed to scald (artificially inoculated) and stripe rust. In El Batan, the plants grew under heavy disease pressure, a combination of leaf rust (artificially inoculated) and stripe rust. In Lagunilla, the plants were screened for resistance to net blotch and stripe rust.

Only the 139 advanced lines resistant across the three locations with yields superior or equal to the best high yielding checks were chosen for international yield testing.

International yield testing

The top 12 high yielding lines with multiple disease resistance were entered in the International Barley Yield Trial (IBYT), a replicated yield trial sent around the world. Also included were the 12 most recently released varieties, mainly from countries with well developed barley breeding programs that submitted entries for international testing. In addition, each national cooperator included in the trial a check entry that generally is the most widely grown variety in that region.

Results of the 10th IBYT in 10 countries showed the ICARDA-CIMMYT lines to have a yield advantage over the local checks (Table 25). In all cases reported differences in yield were highly significant. Kenya and Pakistan used checks BIMA-84 and FRONTIER-87 and JAU-87 respectively. These varieties were released recently from selection made in previous IBYTs.

Table 25. Yield performance (t/ha) of the top ICARDA-CIMMYT advanced lines compared* to national checks during 1988.

Country	Yield of ICARDA-CIMMYT line	Local check	Yield
Kenya	3.9	Bima	2.8
Zimbabwe	7.4		3.1
Japan	5.1	Hoshimasari	3.9
Korea	5.3	Kangbori	4.1
Pakistan (WWFA)	6.5	Frontier-87	5.7
Pakistan (Punjab)	2.2	Jau-87	1.5
Pakistan (Sind)	2.4	Neelium	1.8
Italy (Macerata)	6.5	Arda	6.1
Saudi Arabia	7.0	Gustoe	4.5
Syria (Daraa)	5.7	Arabi Abiad	4.2
Turkey (Izmir)	6.0		4.7
Argentina	4.1	Quilmes Pampa	2.5
China (Heilongjiang)	3.2		1.1

* Yield differences were highly significant.

As shown in Table 25, the identification of new advanced barley lines with yields superior to BIMA, JAU and FRONTIER could indicate that gains in yield potential have been accomplished in recent years. More testing in additional locations is needed to confirm these results.

Breeding procedures

The ICARDA-CIMMYT Project depends on a large number of crosses to build up a relatively huge number of lines in early segregating generations. The number and type of crosses made during the growing breeding cycles is as follows:

Summer 1988	
El Batan	695 single crosses
Toluca	914 three-way crosses
Winter 1988-89	
Obregon	275 single crosses
Obregon	578 three-way crosses

The three-way cross has proven to be the most useful tool to combine multiple disease resistance in our breeding effort. In each three-way cross, 10 spikes are emasculated by clipping the green anthers. This emasculation procedure to avoid self-pollinization is fast, simple and reliable. Seed set ranges from 50 to 400 grains obtained from the 10 spikes. All seed is planted as an F2 population. The largest populations in both seasons were the F3 and F4. Numbers were reduced when both populations were subjected to disease pressure, as described earlier for the advanced lines. The only difference was that the F3 populations were planted only in one location (i.e. Toluca for screening for scald and stripe rust). The plants resistant to both diseases were grown as F4 in the Yaqui Valley, where they were selected for leaf rust and stem rust resistance. The F5 lines were screened for net blotch, scald and stripe rust at Lagunilla. Disease infection was used as a tool to reduce the size of the early segregating generations.

Multiple disease resistance does not imply that all germplasm produced will carry a uniform disease resistance. For example, germplasm destined for China is different from germplasm sent to South America. The Yangtze River Basin in China requires resistance to scab and barley yellow mosaic virus, coupled with high yield and earliness. Germplasm for China is the only material in which the bulk method is used for generation advance (it is not screened against the three rusts, scald or net blotch).

Germplasm pools are being developed to fit specific targets with a clear understanding of the major constraints in a particular area. The Narino Department in Southern Colombia is example of this strategy. A virus (BYDV) and a mycoplasma (dwarfing of Narino) are the two major diseases, followed by stripe rust and leaf rust on some 12,000 ha of barley in this region. In 1988, crosses were made to combine resistance to these diseases and early segregating populations were sent from Mexico for screening in Colombia. In the past, most germplasm sent to Narino was affected by the dwarfing of Narino and BYDV complex.

Hulless large grain

In the small Peruvian villages of the Andean Zone of South America, large grained durum wheat commands a high price. To determine if a large hulless barley grain would be accepted by farmers, specific crosses were made in 1984 to combine multiple disease resistance and large hulless grains. In the F2 generations grown in the Yaqui Valley a few plants resistant to leaf rust and stem rust were selected. 200 seeds from each selected F2 plant were planted in the greenhouse using the single seed descent method to shorten the time of variety development. The F3, F4 and F5 generations were grown in the greenhouse in a relatively short time, since each generation was obtained in 64 days.

During the 1988-89 winter season in the Yaqui Valley, 1165 F6 lines were screened for leaf rust and stem rust. Only 226 lines (19%) kept combined disease resistance and good agronomic type. These 226 F7 lines were planted in El Batan in 1989 for testing against leaf rust and stripe rust and 44% were retained. Resistant lines with 1000-kernel weight double that of the six-and two-row checks are listed in Table 26. A yield experiment has been sent to the Andean Region for planting in 1990. The same experiment will be conducted under irrigation in the Yaqui Valley to determine their maximum yield potential.

Table 26. Reaction to leaf rust and stripe rust and 1000-kernel weight of hulless barley lines developed through single seed descent.

Cultivar/line	1000-kernel weight (g)	Leaf rust	Stripe rust
Viringa "S" line 1	60.40	10 MS	R
Viringa "S" line 2	59.90	10 MS	tR
Viringa "S" line 3	59.45	10 MS	R
Viringa "S" line 4	59.15	30 MS	10MS
Viringa "S" line 5	59.05	tMS	R
Check (6 rows)	28.40	tR	80S
Check (2 rows)	29.00	80 S	90S

Early maturing lines

Barley lines with early maturity are being developed and have proven their value in China and Vietnam. In Southeast Asia, the short barley growing cycle allows farmers to plant two crops of rice and one of barley in a 12 month period. Earliness in the mountainous regions of South America could be a mechanism to escape frost, especially important when barley is planted at higher elevations. During the summer of 1989, several early lines were identified with multiple disease resistance, good plant height to permit hand harvesting, and a time to maturity of less than 100 days.

These lines are being sent to Latin America for yield testing and to Nepal for observation. In Mexico, yield results of an early line, Marco "S", planted at 10-cm row spacing reached 3.5 t/ha in farmers' fields, while in Colombia the same Marco "S" lines had a yield comparable to the best checks in yield trials conducted at the Tundama Experiment Station.

In central Mexico late barley planting is conducive to higher frost losses. An experiment was planted in Lagunilla, where the early Marco "S" lines were sown as late as July 15 (normal planting dates are May-June). Some Marco "S" lines performed well and reached 4.1 t/ha in plots where border effect was not accounted for.

Barley lines resistant to Russian wheat aphid

The Russian aphid Diuraphis noxia has been identified in Mexico, but so far has not caused severe damage in the Mexican barley producing area. Advanced lines and segregating populations were field tested in the winter of 1988-89 and during the summer 1989 under artificial aphid inoculation by Steven Calhoun, postdoctoral fellow in the Barley Project. Some of the lines consistently showed lower scores in both planting seasons compared to susceptible checks (Table 27).

Table 27. Symptom scores (1-6 scale) of selected barley lines in Diuraphis noxia Screening Nursery.

Cross	Scores*	
	Winter 1988-89	Summer 1989
Gloria/Come "S"	2.5	2.0
Rhodes"S"/ci 14100//Lignee 527	3.0	2.0
Mejorana "S"	3.5	2.0
SD729 Por/3/Apan//Aths/Gva/4/Ore"S"	3.5	2.5
Ase/2CM/B.7.6.B.B.	3.5	2.8
Laurel	5.0	4.3
Matico	4.0	4.3
K8755	5.5	5.3
Overall Mean	3.9	3.6
LSD .05	1.6	1.2

* 1= Little or not, 2= Minimal striping, 3= Distinct striping on several tillers, 4= As above plus leaf rolling, 5= As above plus leaf necrosis; 6= As above but severe necrosis.

H. Vivar

2.2. Durum Wheat Breeding

2.2.1. Introduction

The durum wheat (Triticum turgidum L. var durum) breeding project is a joint venture between CIMMYT and ICARDA for the Mediterranean drylands of West Asia and North Africa region (WANA). The main objective of the project is to assist WANA countries to enhance durum wheat production by developing drought, cold, frost and heat tolerant germplasm, development of efficient stress tolerance methodologies and upgrading manpower capabilities. Four major agroclimatic zones of the region with their abiotic and biotic constraints were identified (annual reports 1985/86 and 1986/87), and an improved durum wheat breeding methodology fitting the environmental conditions of WANA region was devised.

In the 1988/89 season severe intermittent drought combined with cold and terminal heat stress affected cereal production in the WANA region. Cold and drought during the vegetative stage were severe in the Middle East countries, particularly in Syria, Jordan, Turkey and Lebanon. These countries experienced dry and cold weather conditions in January and February, and hot and dry spells in April and May during the grain filling period. This affected yield components and particularly the number of tillers, number of kernels per spike and kernel size. Tunisia also experienced long dry periods during the growing season. In addition to abiotic stresses, wheat stem sawfly infestations were very high in Syria and Morocco, while Hessian fly, Septoria tritici, and leaf and stem rusts have affected several wheat growing areas in Morocco.

Progress in increasing dryland durum wheat yields was achieved by upgrading tolerances to the various abiotic and biotic stresses. This is reflected in the performance and release for commercial production of several durum wheat lines. Table 28 shows the number of durum wheat entries yielding higher than the checks in different environments for 1988/89 season.

Table 28. Number and percentage of durum wheat entries yielding higher than checks in different environments, 1988/89.

Environment	Checks			
	Haurani No. (%)	Cham 1 No. (%)	Stork No. (%)	All three checks No. (%)
Drought stress				
- Bouider	112 (53.3)	125 (59.5)	43 (20.0)	89 (42.0)
- Breda	109 (52.0)	48 (23.0)	86 (41.0)	80 (38.0)
- TH - Rainfed	88 (42.0)	118 (56.0)	94 (45.0)	82 (39.0)
Average	103 (49.1)	97 (46.2)	74 (35.3)	84 (39.7)
Heat/terminal stresses:				
- LP(1) - Rainfed	203 (97)	139 (66.0)	90 (43.0)	190 (90.0)
- LP - Til.irr.	210 (100)	129 (61.4)	141 (67.0)	187 (89.0)
- LP - Boo-irr.	202 (96)	164 (78.0)	134 (64.0)	168 (80.0)
- LP - Full-irr.	210 (100)	192 (91.4)	150 (71.4)	194 (92.0)
Average	206 (98.3)	156 (74.2)	129 (61.4)	185 (87.8)
Cold/frost stress:				
- EP(2)-suppl.irr.	227 (60.5)	115 (55.0)	134 (64.0)	126 (60.0)
High input:				
- Terbol	146 (69.5)	85 (40.5)	66 (31.4)	103 (49.0)

1. LP - Late planting; Til.irr. = one irrigation (40 mm) at tillering; Boo.irr=one irrigation (40 mm) at booting.
2. EP = early planting. Supp.irr. = two irrigations of 40 mm each.

The durum wheat lines Bicre, Belikh 2 and Brachoua were the best performing lines in the WANA region, particularly in West Asia. While in North Africa the lines Omrabi 5, Belikh 2 and Syrica 2 were the most stable yielding lines across the testing sites. Omrabi 5 is showing promising results in on-farm trials and large scale testing in Tunisia, Algeria, Morocco and Syria.

In high rainfall and irrigated areas the line Lahn has performed outstandingly in large scale testing and is now proposed for release in Syria, while Sebou, the early and terminal stress tolerant line has been released in Morocco and is promising in Saudi Arabia.

2.2.2. Breeding Methodology

Broadening the genetic base

The genetic base of durum wheat is narrow. However in the last 7 years crosses with landraces from the region and more recently crosses with wild relatives were undertaken.

a) Utilization of landraces

Crosses with landraces from the Maghreb/Iberia region were given high priority this season, 86 out of 100 crosses were conducted with this group.

b) Utilization of wild emmer

Seventy eight crosses were made between wild emmer (T. dicoccoides) and advanced durum wheat lines for improving quality, resistance to septoria leaf blotch and yellow rust. More than 90% of the crosses were backcrossed to durum wheats to eliminate the undesirable traits.

c) Utilization of wheat relatives

One hundred eighty one crosses with Triticum monococum were made to increase earliness, rusts resistance and early vigor in durum wheat, 124 out of 181 crosses were backcross combinations. Several crosses with T. aegilopoides and other wheat relatives were also made.

d) Recurrent selection

Three durum wheat populations were developed using recurrent selection method. They were composed of basic parental material that originated from landraces (Haurani for Middle East, Jennah Khetifa and Kyperounda for the Maghreb region) and advanced durum wheat lines with high and stable yield, multi-biotic and abiotic stress resistance.

Disease resistance

In 1989 the following targeted crosses for disease resistance were conducted; 84 crosses for Septoria tritici, 64 for common bunt, 28 for leaf rust, 16 for powdery mildew, 37 for BYDV and 18 with multiple disease resistant lines.

At Lattakia, segregating populations were screened for Septoria tritici resistance. In 1988/89 the segregating generations showed a high percentage of resistant populations compared with the 1986/87 and 1987/88 seasons. The most noticeable result in this season was that the early generations F_2 to F_7 exhibited a high percentage of resistant populations (Fig. 5). This resulted from the continuous upgrading of disease resistance through the incorporation of resistant material from landraces, particularly from the Maghreb/Iberia region and T. dicoccoides into advanced durum wheat germplasm.

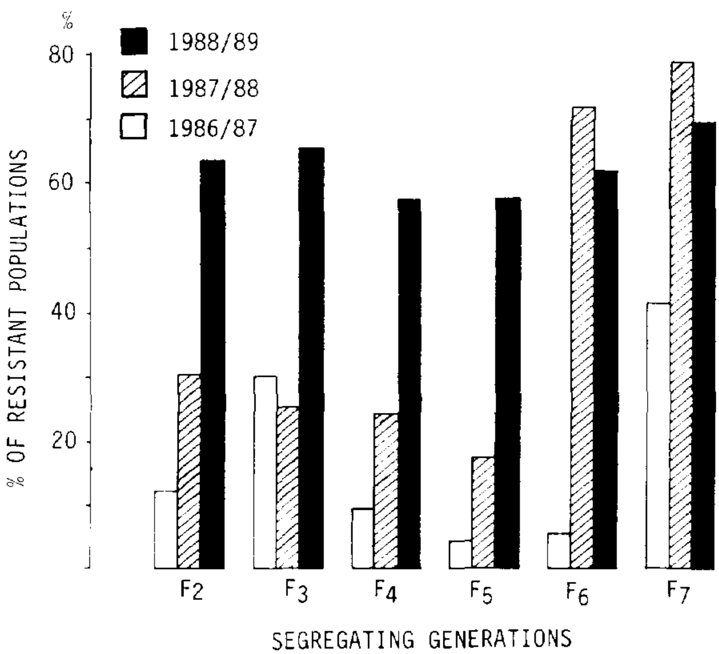


Fig. 5. Percentage of MR-R reaction to septoria leaf blotch in segregating populations during the years 1986, 1987 and 1988.

For multiple disease resistance, the segregating and advanced populations were screened at Terbol during the summer planting for leaf and stem rusts, at Tel Hadya/early planting for stripe rust, and at Lattakia for septoria leaf blotch. Fig. 6 shows the results achieved through this approach. More than 60% of the populations in F_6 carry multiple diseases resistance.

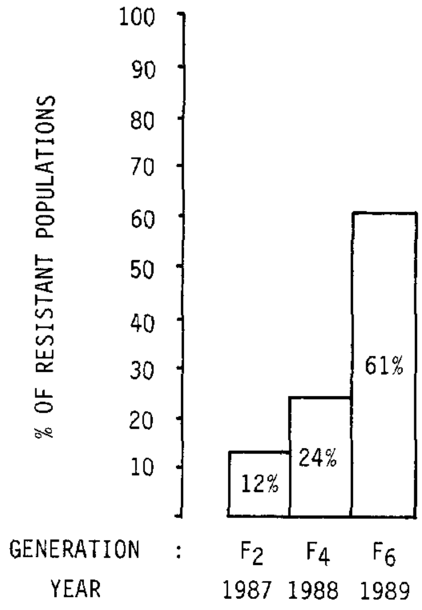


Fig. 6. Selection progress in septoria leaf blotch, yellow, leaf and stem rust resistance for 3 cycles.

Drought resistance

Drought was severe during the 1988/89 season in most durum wheat growing areas of WANA. In some countries such as Tunisia and Algeria severe drought has prevailed for two consecutive years.

In Syria the rainfall was only two-thirds of the annual long term average, with an abnormal temperature pattern; cold and dry during the vegetative stage and relatively warm and dry during the generative stage. Fig. 7 shows the distribution of rainfall, minimum and maximum temperatures for the 1988/89 season for the Tel Hadya station. Intermittent drought stress occurred and high evapotranspiration demand was observed near the end of April.

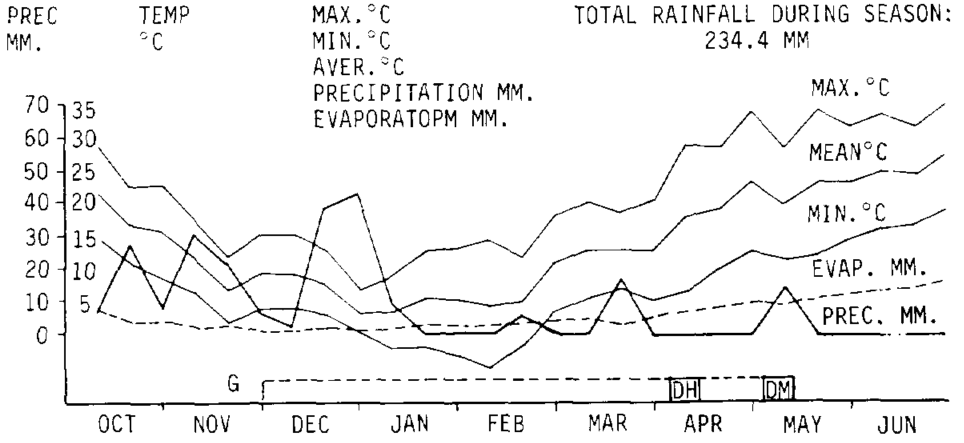


Fig. 7. Rainfall, evaporation, and temperature at Tel Hadya, 1988/89.

Mean grain yield at the dry sites Breda and Bouider was below the long term annual average, 758 and 653 kg/ha respectively. Table 29 shows average grain yields (kg/ha) and precipitations (mm) at Breda for 4 consecutive seasons. The average grain yields of the advanced yield trials at Tel Hadya, rainfed, was almost 50% below the long term average.

Table 29. Average grain yield (kg/ha) in advanced durum wheat yield trials (ADYT) at Breda for 4 years (1986, 1987, 1988 and 1989).

Season	Rainfall (mm)	Grain yield (kg/ha)		
		Mean	Max.	Haurani (Check)
1985/86	218	1224	1697	1014
1986/87	245	1127	2500	1066
1987/88	408	3608	4372	3066
1988/89	186	758	1237	505
Mean	264.3	1697.3	2451.5	1412.8

Drought resistance versus productivity

Table 30 shows the importance of combining moisture stress tolerance and responsiveness to favorable conditions in the case of Omrabi 17. In the 1987/88 season climatic conditions were favorable and yields were above-average, and Omrabi 17 outyielded Haurani. In the dry and cold 1988/89 season, Omrabi 17 performed well in comparison to Haurani, the stress tolerant local cultivar.

Table 30. Performance of Omrabi 17 and Haurani under dryland conditions in experimental stations and farmers' field verification trials (in Zone B*) in two seasons, 1987/88 and 1988/89.

Variety	1987/88			1988/89
	Bouider	Breda	FFVT**	FFVT**
Omrabi 17	2420	4372	3469	1118
Haurani	1521	3022	2828	981
Omrabi 17 / Haurani x 100	159.1	144.7	123.0	114.0
LSD (0.05)	628	539	160	113
CV	12.8	7.8	9.3	16.6
No. of sites	1	1	10	8

Zone B* = Low rainfall areas with less than 350 mm in 1987/88 and less than 250 mm in 1988/89.
**FFVT = Farmers' Field Verification Trials.

Trait association and heritabilities under dry conditions

Under Mediterranean continental dryland conditions the association between grain yield and morpho-physiological traits (Table 31) shows that grain yields are related to earliness, leaf rolling mechanisms, fertile tillers, peduncle length and number of spikelets/spike. These results corroborate earlier findings (Nachit and Jarrah, 1986). No correlations were found between grain yield and leaf temperature,

Table 31. Correlations between grain yield under dry conditions and some morphophysiological traits, Breda, 1988/89.

Trait	Correlation Coefficient
Plant vigor[1)]	+.51 ***
Days to head	-.53 ***
Leaf temperature	+.10 N.S
Days to mature	-.36 **
Fertile tillering[1)]	+.33 **
Peduncle length[1)]	+.27 *
Spikelet/spike[1)]	-.23 *
Florets/spikelet	+.01 N.S
1000 kernel weight(g)	+.01 N.S
Leaf rolling index[1)]	+.44 ***
Plant height (cm)	+.02 N.S

1) Scale 1-9, 1 = low; 9 = high, n = 210
N.S: Not Significant, *,**,*** Significant at .05, .01, and 0.001 levels, respectively.

number of florets/spikelet and kernel weight. However, morphophysiological traits of the highest and the lowest yielding lines (Table 32) differ significantly from each other. The highest yielding lines seem less sensitive to environmental changes, as shown by the multiple site selection where the highest yielding lines were selected in more sites than the lowest yielding lines. The leaf rolling index was also higher in the highest yielding group than in the lowest yielding group. Fertile tillering, number of spikelets/spike and florets/spikelet were larger in the highest yielding group than in the low yielding group. Earliness was an important trait and was more pronounced in the highest yielding lines. Plant vigor, leaf temperature, peduncle length and plant height were also associated with grain yield under dry conditions.

Grain yield variability was determined largely by the number of fertile tillers (Table 33). Peduncle length, plant height, number of florets per spikelet, number of spikelets per spike, date to anthesis, early plant vigor and leaf rolling were also good yield predictors under moisture-stress conditions.

Table 32. Performance and morphophysiological trait differences between the 5% highest (HYL) and 5% lowest (LYL) yielding durum wheat lines under dry conditions at Breda, 1988/89.

Trait	Yield Group HYL	Yield Group LYL	Difference
Grain Yield	1381.0	855.0	+526.0 ***
Plant vigor	5.5	5.1	+0.4 *
Days to heading	131.0	136.0	-5.0 **
Leaf temperature	32.5	33.1	-0.6 *
Fertile tillering	5.0	4.1	+0.9 **
Peduncle length	4.3	3.3	+1.0 **
Spikelets/spike	4.0	3.4	+0.6 *
Florets/spikelet	2.7	2.4	+0.3 *
Leaf rolling index	1.0	0.9	+3.1 ***
Multiple site selection	6.0	4.0	+2.0 **
Plant height	61.0	56.0	+5.0 *

*,**,*** Significant at the .05, .01, and 0.001 levels, respectively.

Table 33. Trait contribution (%) to grain yield under dry conditions Breda, 1988/89.

Trait	Contribution (%) 1987/88	Contribution (%) 1988/89
Fertile tillers	32.34	38.10
Peduncle length	6.63	0.72
Plant height	5.99	10.52
Grains/spikelet	5.27	1.37
Days to anthesis	4.26	1.50
Plant vigor	2.17	2.04
Days to maturity	1.48	2.28
Leaf rolling - AM	1.59	0.03
Leaf rolling - PM	1.07	0.00
Thousand kernel weight	0.94	0.02
Leaf temperature	0.78	0.01
Spikelets/spike	0.51	3.78
Total	63.03	60.28

Drought tolerance (Table 34) was the largest contributor to yield under dry conditions. The contribution of drought tolerance was 7 times higher than yield potential, and 12 times more than drought escape (earliness). These results demonstrate the importance of drought tolerance for yield in dryland conditions (Nachit and Ouassou, 1988).

Table 34. Contribution (%) and relationship of yield potential, drought tolerance and escape to grain yield under dry conditions, Breda, 1988/89.

	Yield potential	Drought tolerance	Drought escape
Contribution (%)	11.95	81.30	6.70
r	0.35***	0.94***	0.27**

r = correlation coefficient (n = 210)
, *, Significant at .01 and 0.001, respectively.

Table 35 shows the heritability and expected genetic advance for grain yield, drought tolerance, productivity, and some important morpho-physiological traits.

High values for heritability were found for days to heading (0.92), plant vigor (0.71), peduncle length (0.71) and productivity (0.71). Low values were found for leaf temperature (0.20) and number of florets per spikelet (0.24).

The highest expected genetic advance was recorded for peduncle length and fertile tillering ability. Number of spikelets per spike, leaf rolling, early plant vigor and drought tolerance were found to have medium to high expected genetic advance. The lowest values were found for leaf temperature and number of days to anthesis, although the latter had a high heritability value (0.92).

Table 35. Heritabilities and expected genetic advances (%) of some morpho-physiological traits under dry conditions, Breda, 1988/89.

	Heritability	Expected Genetic Advances (% of population means)
Plant vigor	.71	18.23
Days to heading	.92	5.17
Leaf temperature	.20	1.42
Fertile tillers	.64	31.08
Peduncle length	.71	56.23
Spikelet/spike	.52	21.78
Florets/spikelet	.24	9.96
Grain yield	.56	10.98
Leaf rolling index	.39	19.81
Plant height	.56	8.24
Drought tolerance	.60	16.59
Productivity	.71	12.59

Breeding for cold and frost resistance

The continental Mediterranean dryland and plateau areas of WANA are often subjected to cold at the vegetative growth stage and frost at anthesis. Cold and frost incidence increase with increased latitude and altitude (Annual Report 1986, 1987, 1988). The continental areas are also characterized by drought, and other terminal stresses. Evapotranspiration demand during the vegetative stage is low. However, during grain filling stage it quickly increases and soon exceeds precipitation.

Cold and frost damage on winter cereals were reported this season from several countries. Cold damage was evidenced in the field by the reduction of dry matter production and tillers per unit area, whereas frost damage impaired spike fertility.

In the gradient selection technique, use is made of early planting as a tool to test durum wheat breeding material for cold and frost tolerance. Although significant cold was experienced in 1988/89 only slight frost damage in the advanced durum wheat materials was recorded.

Trait association and heritability under cold conditions

Yields under cold conditions of the highest yielding lines and lowest yielding lines were significantly different (Table 36). The traits most associated with grain yields were fertile tillers, kernel weight and days to anthesis.

Table 36. Performance and morphophysiological trait differences between the 5% highest (HYL) and the 5% lowest (LYL) yielding durum wheat lines under cold conditions, (Tel Hadya), 1988/89.

	Yielding Group		
Trait	HYL	LYL	Difference
Grain yield (kg/ha)	5798.0	2304.0	+3494.0 ***
Plant vigor	5.9	6.3	-0.4 *
Days to anthesis	159.0	166.0	+7.0 **
Days to maturity	199.0	201.0	-2.0 *
Fertile tillers	6.4	5.2	+1.2 **
Spikelets/spike	6.2	6.1	+0.1 NS
Grains/spikelets	3.2	2.6	+0.6 *
Plant height	103.0	113.0	-10.0 *
Peduncle length	7.4	6.8	+0.6 *
1000 kernel weight	37.5	28.5	+9.0 ***

NS: Not significant, *, **, *** significant at the 5,1 and 0.1% levels, respectively.

The number of fertile tillers seemed to be the best indicator of grain yield and accounted for 44.12% of total variability (Table 37). The heritability and predicted genetic advances for grain yield were 0.92 and 87.43, respectively. For cold tolerance the heritability was 0.92 and the expected genetic advance over the population was 126.01 kg/ha. The predicted genetic advance for productivity under cold conditions was almost 5 times (27.06%) lower than for cold tolerance, although the heritability of productivity was high (Table 38). It appears that sufficient genetic variability is present in the advanced populations to provide substantial improvement by selection of superior genotypes for each trait studied.

Table 37. Contribution (%) to grain yield of some morpho-physiological traits under cold conditions, Tel Hadya, early planting.

Trait	1987/88	1988/89
Fertile tillers	44.12	24.27
Leaf rolling-PM	2.85	4.76
Thousand kernel weight	1.90	2.69
Grains/spikelet	0.88	0.93
Leaf rolling-AM	0.92	1.47
Spikelet/spike	0.46	4.92
Days to maturity	0.45	4.17
Plant height	0.15	0.03
Days to anthesis	0.20	3.13
Peduncle length	0.04	0.04
Plant vigor	0.02	1.38
Total	51.99	48.19

Table 38. Heritabilities and expected genetic advances (5%) of some morphophysiological traits under cold conditions, Tel Hadya, early planting, 1988/89.

	Heritability	EGA(5%)
Actual yield under cold conditions	.92	87.43
Cold tolerance	.92	126.01
Productivity	.88	27.06

Breeding for heat and terminal stresses

High temperature during the growing season and/or during grain filling frequently occurs in the Mediterranean dry areas of the region. Durum wheat grown in some areas of WANA this season were exposed to high temperature during the grain filling period, particularly in West Asia region. The effect of drought was confounded by high temperatures. Intermittent high temperature during the growing season also increased water stress. Wheat grown on light textured soils and/or without fallow was prone to moisture stress and high temperature. Under heat conditions the differences of grain yields of the highest and lowest yielding lines were significantly different (Table 39). The differences between the two yielding groups were also reflected in significant differences between their morpho-physiological traits. Early plant vigor, days to anthesis, fertile tillering ability, and performance across sites (multi-site selection). Plant height, fertile tillers and spike fertility were the best predictors of grain yield (Table 40). Together, they accounted for 65.9% in 1987/88 and 68.6% in 1988/89 of the variability in yield.

It also appears that sufficient genetic variability under warm conditions is available in the populations for selection of superior genotypes for these traits, in particular green leaf duration, plant height and fertile tillers (Table 41).

Table 39. Traits difference between the 5% highest yielding high and the 5% lowest yielding low durum wheat lines under heat and terminal stress conditions, Tel Hadya, late planting, 1988/89.

Trait	High	Low	Difference
Grain yield	1321.0	227.0	+1094.0 ***
Multi-site selection (kg/ha)	7.0	4.0	+3.0 ***
Early plant vigor	7.8	5.4	+2.4 ***
Leaf temperature	30.3	31.7	+1.4 *
Date to anthesis	54.0	87.0	-33.0 ***
Stay green	3.4	7.0	-3.6 *
Spikelets/spike	4.1	3.4	+0.7 *
Grains/spikelets	3.1	2.1	+1.0 *
Fertile tillers	4.2	2.0	+2.2 ***
Peduncle length	3.8	2.9	+0.9 **
Thousand kernel weight (g)	36.1	33.7	+2.4 *
Plant height	45.0	40.0	+5.0 *

*,**,***: Significant at the .05, .01 and 0.001% levels, respectively.

Table 40. Contribution (%) of some morphophysiological traits to grain yield under heat conditions, Tel Hadya, late planting.

Trait	Contribution (%) 1987/88	1988/89
Plant height	39.16	19.21
Fertile tillers	21.56	45.30
Spikelets/spike	5.13	4.11
Grains/spikelet	4.05	2.10
Leaf temperature	3.66	2.00
Days to anthesis	1.39	1.11
Peduncle length	0.19	3.16
Leaf rolling-AM	0.24	0.19
Leaf rolling-PM	0.18	0.71
Early plant vigor	0.05	7.06
Days to maturity	0.00	0.91
Total	75.62	85.87

Table 41. Estimates of heritability and expected genetic advance (EGA) of some traits under heat conditions, Tel Hadya, late planting, 1988/89.

	Heritability	EGA (5%)
Grain yield	.59	21.26
Fertile tillers	.75	30.15
Plant vigor	.76	19.07
Leaf temperature	.53	2.23
Green leaf duration	.94	88.03
Date to anthesis	.98	35.19
Plant height	.97	33.20
Heat tolerance	.53	14.07
Productivity	.75	14.53

Multiple abiotic stress tolerance

The estimated abiotic stress tolerances to drought, heat and cold showed significant positive correlations with most morpho-physiological traits included in the present investigation (Table 42). The most striking correlation was between fertile tillers and actual yield under the respective stress conditions. Days to anthesis showed a strong negative correlation with heat tolerance and a positive correlation with cold tolerance, while no correlation was found with drought tolerance. However, early lines with cold tolerance are found.

Table 42. Relationship between some morphophysiological traits and tolerances to drought, heat and cold.

Trait	Drought Tolerance	Heat Tolerance	Cold Tolerance
Days to anthesis	+0.029 NS	-0.514 ***	+0.537 ***
Plant vigor	+0.258 **	+0.522 ***	-0.076 NS
Plant height	+0.258 *	-0.158 NS	+0.354 **
Leaf temperature	+0.281 *	-0.301 *	+0.189 NS
Fertile tillers	+0.481 ***	+0.662 ***	+0.650 ***
Peduncle length	-0.196 NS	-0.150 NS	+0.346 **
Spikelet/spike	-0.190 NS	-0.191 NS	+0.262 *
Grain yield under stress	+0.929 ***	+0.962 ***	+0.797 ***
Grains/spikelet	+0.314 **	-0.210 NS	+0.758 ***
1000 Kernel weight	+0.197 NS	+0.112 NS	+0.010 NS

NS: Not significant, *, **, *** significant at the .05, .01 and 0.001 levels, respectively.

The drought susceptibility index was highly correlated ($r = -0.80$, $P < .001$) with drought tolerance, moderately correlated with cold tolerance ($r = -0.29$, $P < .05$), and not correlated with heat tolerance. Drought tolerance was highly associated with cold tolerance ($r = 0.35$, $P < .001$), while heat tolerance showed no significant relationship with either tolerance to drought or to cold.

Breeding for yield stability

Stable varieties are required to achieve reliable production in dry areas. Mediterranean dryland conditions are characterized by high year-to-year and site-to-site variations, particularly with respect to precipitation and temperature extremes (Nachit and Ketata, 1986). Development of varieties for the Mediterranean dryland should include selection for stress tolerance and responsiveness to environmentally favourable seasons.

Yield stability of a given genotype is defined as:

1) the ability to withstand stresses of moisture and temperature extremes, and
2) the ability to respond to favourable conditions when they occur.

Two techniques are used to estimate the stability of a genotype:

1) Regression of the grain yield of each genotype at each location on the location mean yield (mean of 23 genotypes). Stability of each genotype is then described by the mean yield over all locations, the regression coefficient (b), and the squared deviation from regression (sd2) according to the method of Eberhart and Russell.
2) Ranking of the genotypes at each location and computing a genotype rank average and standard deviation of rank across locations (Nachit and Ketata, 1986).

Table 43 shows the yield performance of the RDYT-LR for 1987/88. 5 lines were selected with the combination of high yield and yield stability. The lines Brachoua and Syrica 2 were the most promising. They possess a regression coefficient close to one and a low deviation from regression, both parameters are indicators of yield stability.

Table 43. Yield stability of durum wheat lines in WANA region, RDYT-LR, 1987/88.

No.	Entry	Mean performance (kg/ha)	Regression coefficient	Deviation from regression	Coefficient of determ.
3	Bicre	3892	1.122	227052	0.910
19	Belikh 2	3860	1.106	133010	0.934
12	Cham 1	3827	1.077	171175	0.920
27	Brachoua	3859	1.025	62613	0.948
20	Syrica 2	3803	1.090	58709	0.954

Yield stability under low rainfall areas was associated mainly with plant vigor, leaf rolling mechanism, number of fertile tillers, earliness, leaf temperature, peduncle length, plant height, spikelet per spike and grain yielding ability. These results indicate the importance of an analytical approach in selection of durum wheat for dry areas.

M. Nachit

2.3. Bread Wheat Breeding

2.3.1. Introduction

During 1989, the CIMMYT/ICARDA bread wheat breeding project emphasized the development of improved, adapted germplasm for the variable and unpredictable environments of West Asia and North Africa, with special attention to rainfed and low-rainfall areas (less than 400 mm annual rainfall).

Research this year was focussed to breeding and identifying parental material with tolerance to abiotic stresses such as terminal drought, cold and terminal heat stress and to biotic stresses such as yellow rust, septoria, common bunt, sawflies, Hessian fly, suni bugs and aphids. Targetted crosses were made between improved germplasm and selected landraces collected in the region. Genetic stocks were identified and distributed to NARS.

Attention was given to developing and verifying breeding methodologies, such as the modified bulk selection method (to enhance disease resistance and stability of performance). Multilocation testing, including the shifting of planting dates (spring and summer planting in order to differentiate genotypes with different degrees of vernalization) continued to be a useful selection strategy. These techniques, coupled with targetting, has resulted in germplasm being increasingly adopted by NARS, particularly in low rainfall environments.

In close collaboration with the physiologists and agronomists, special efforts were made yearly to identify agronomic traits associated with yield under the main abiotic stresses of this region. Cooperation also continued with other disciplines within the cereals program such as biotechnology, pathology, entomology, and grain quality. It is important to highlight that during 1989, the project continued close interaction with key NARS of West Asia and North Africa. This interaction included regional activities such as training, germplasm evaluation and selection, farmers field verification trials, consultancy and participation in program planning meetings.

2.3.2. Germplasm development

Targetting crosses is a fundamental strategy in the bread wheat breeding project. During the last six years approximately 1300 crosses have been made yearly to cope with the various agroclimatic conditions of the region. Special emphasis is placed on low-rainfall areas where abiotic stresses are most important. Careful consideration is also given to the biotic stresses important for reducing yields in the moderate to high rainfall areas of WANA.

Table 44 shows the number and type of crosses made during 1989. About one third of these crosses were aimed at abiotic stress resistance, one third for biotic stresses, and about 20% were crosses with selected landraces. The landraces used in the crossing program were selected from accessions collected in the Middle East. They were evaluated for two consecutive years under drought, cold and disease pressure.

Table 44. Number and type of crosses made in the 1988-89 bread wheat crossing program.

Purpose of the cross	No. of crosses	% of total
Abiotic stress tolerance		36.7
Terminal drought	192	
Cold	146	
Terminal heat	139	
Biotic stress resistance		35.2
Yellow rust	125	
Leaf rust	42	
Stem rust	39	
Septoria leaf blotch	112	
Common bunt	54	
Wheat stem sawfly	86	
Bread making quality	98	7.5
Special purpose		20.6
Selected landraces	268	
Total	**1301**	**100.0**

2.3.3. Germplasm Testing

Multilocation testing is also fundamental to our breeding approach. The project follows the principle that stress tolerant material is difficult to identify unless selected under those stresses.

The type of germplasm tested during 1988/89 at the Aleppo-based project is summarized in Table 45. This table also illustrates the size of the spring bread wheat breeding project at Aleppo.

Figure 8 shows the phenological development of bread wheat germplasm under terminal drought stress (normal planting, Breda), cold stress (early planting, Tel Hadya), and terminal heat stress (late planting, Tel Hadya). The long-term (1978-89) and last years' (1988-89) maximum/minimum temperatures as well as rainfall distribution are also shown. Segregating populations and advanced material are exposed to these stresses during critical stages of plant development.

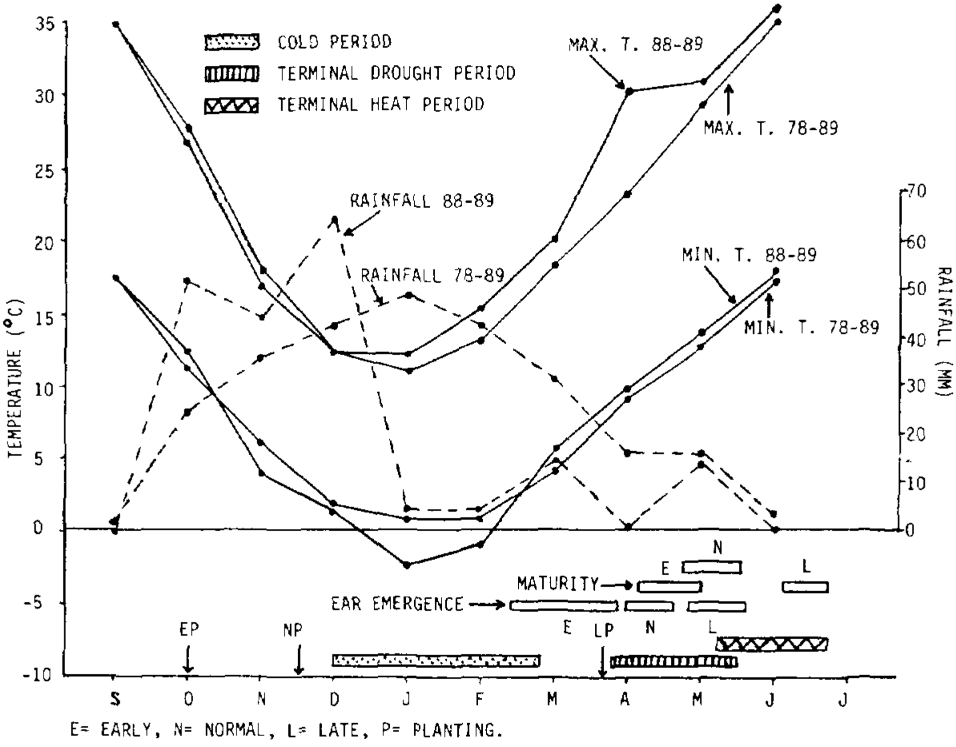


Fig. 8. Phenological development of bread wheat germplasm under three stress environments.

Table 45. Bread wheat breeding material evaluated during 1988/89.

Materials	No. of entries	Locations
F1s	1301	Tel Hadya, Terbol.
Segregating Populations (F2-Fn)	7251	Tel Hadya (*), Terbol, Breda, Lattakia.
Preliminary Yield Trials	504	Tel Hadya (*), Breda.
Advanced Yield Trials	240	Tel Hadya (**), Breda, Terbol, Merchouch, El Kef, Settat.
Crossing Blocks	380	Tel Hadya (**), Terbol (*)
Observation Nurseries	526	Tel Hadya (*), Terbol, Breda, Lattakia, 50 sites in WANA.
Regional Yield Trials	72	Tel Hadya (*), Terbol, Breda, Lattakia, 50 sites in WANA.

* Two planting dates, ** three planting dates.

Using these environments, plus the information from other two contrasting locations such as Bouider (driest site) and Terbol, Lebanon (irrigated), germplasm is selected and targetted according to where it is intended to be grown. For example, for the continental low-rainfall areas of WANA where drought and cold are the main abiotic stresses, emphasis is placed on germplasm performance in the drought-prone locations Breda and Bouider, as well as in the cold-prone environment of Tel Hadya-early planting. This germplasm is distributed to the low-rainfall areas of the region through the regional wheat yield trial for low rainfall areas (RWYT-LRA). Table 46 presents the rank of the 4 highest and the 4 lowest yielding entries in the RWYT-LRA grown in 35 dry locations in WANA during 1988. This table also shows the rankings of the same entries in the stress-prone environments described above during 1989. The highest ranking entries in WANA also ranked well in the dry and cold environments. Two entries (numbers 3 and 12) also ranked well in Tel Hadya-late planting, indicating good performance under drought, cold and terminal heat stress. The top ranking entries in WANA did not perform well in the optimum-irrigated environment of Terbol. This confirms that germplasm must be selected under the growing conditions for which the final product is intended.

Table 46. Rank of the highest and the lowest yielding entries in the 1988 RWYT-LRA (total of entries n=24) in different stress environments.

		Drought		Cold	Heat	Irrigated
Entry No.	WANA 1988	Bouider 1989	Breda 1989	TH-EP 1989	TH-LP 1989	Terbol 1989
3	1	2	4	2	5	21
12	2	1	2	6	1	18
7	3	4	3	5	19	23
22	4	6	7	1	17	15
10	20	15	6	18	24	9
2	21	21	12	14	23	4
6	22	13	24	22	11	7
20	23	18	20	19	22	10
N.Locs	35	1	1	1	1	1

WANA = West Asia and North Africa; LRA = Low rainfall areas; TH = Tel Hadya; EP = Early planting; LP = Late planting.

During 1989 efforts were made to identify agronomic traits associated with yield under terminal drought, cold and terminal heat stress. The environments and breeding techniques described in Figure 8 have served not only to develop germplasm with tolerance to those stresses but also to identify stress-related traits. Results from this type of testing show (Table 47) that increased leaf rolling, longer peduncle, increased plant height, early heading and maturity and possibly higher number of tillers/m^2 play an important role under terminal drought and heat stress. Conversely, with the exception of leaf temperature, all other characters responded differently under cold stress conditions.

Table 47. Correlation coefficients between grain yield and eleven agronomic characters under three stress environments, (data from 1989 Advanced Yield Trials).

Trait	TDS	THS	CS
Growth habit (GH)	0.05	-0.50**	0.29**
Seedling vigor (SV)	0.04	-0.38**	0.29**
Leaf rolling (LR)	0.25*	0.34**	0.20
Leaf temperature (LT)	-0.31**	-0.04	-0.40**
Leaf senescence (LS)	-0.03	-0.53**	0.54**
Peduncle length (PL)	0.37**	0.21	-0.20
Plant height (PH)	0.49**	0.36**	-0.02
Tiller number (TN)	0.11	0.15	0.15
1000 kernel weight (TKW)	0.18	-0.13	0.24*
Days to heading (DH)	-0.23*	-0.55**	0.37**
Days to maturity (DM)	-0.17	-0.65**	0.51**
Grain yield (GY)	1.00	1.00	1.00

N = 84, * = $P < 0.05$, ** = $P < 0.01$, TDS = Terminal drought stress, THS = Terminal heat stress, CS = Cold Stress.

The utility of particular traits as selection criteria in a breeding program depends on the ease and cost of screening, the reliability of observations and the genetic variability available for that trait. Table 48 shows the amount of genetic variability for the eleven traits under study in each of the three stress conditions. Sufficient variability within the 84 genotypes exists for the attributes suggested in Table 47 to explore them as selection tools.

To confirm these results we analyzed the 10% highest yielding lines (8 genotypes) and the 10% lowest yielding lines under the three stress conditions. Results shown in Table 49 confirm the importance of the characters suggested as selection criteria in Table 48. Using these characters, several lines which combine tolerance to one or more stresses have been developed and distributed to NARS in WANA.

Table 48. Genetic variability in twelve agronomic traits evaluated under terminal drought (TDS), terminal heat (THS) and cold stress (CS) conditions.

	TDS		THS		CS	
Trait	Mean (Range)	s.e.	Mean (Range)	s.e.	Mean (Range)	s.e.
GH	2.99 (1.0-5.0)	0.93	2.79 (1.0-5.0)	0.90	2.61 (1.0-5.0)	1.24
SV	3.89 (3.0-5.0)	0.50	3.01 (1.0-4.0)	0.61	2.97 (1.0-5.0)	1.28
LR	3.32 (1.0-5.0)	1.05	2.79 (1.5-5.0)	0.86	2.5 (1.0-4.5)	0.86
LT	39.8 (36.6-44.0)	1.78	29.4 (27-32.4)	1.43	23.0 (21.4-25)	0.72
LS	2.61 (1.0-5.0)	0.91	2.68 (1.0-5.0)	0.82	3.39 (1.0-5.0)	0.82
PL	16.1 (10-26.5)	3.17	18.7 (13-25.5)	2.71	28.7 (22-37.5)	3.37
PH	51.1 (42.5-62.5)	4.48	51.3 (42.5-60)	4.12	93.8 (80-117.5)	6.81
TN	132 (88-190)	24.9	168 (118-218)	22.9	364 (260-510)	44.6
TKW	25.7 (20.8-31.8)	2.27	24.5 (19.2-32)	2.42	35.4 (27.4-42.4)	3.07
DH	143.1 (136-155)	3.26	53.9 (29-64)	4.24	163 (145-177)	3.20
DM	172.5 (163-184)	3.55	85.0 (76-91)	3.06	203 (190-208)	2.87
GY	902 (458-1313)	181	1308 (521-2083)	398	4560 (1550-6033)	769

s.e. = Standard error

Table 49. Phenotypic attributes of the 10% highest and lowest yielding entries sorted according to their yields in three stress environments.

	GY	GH	SV	LR	LT	LS	PL	PH	TN	TKW	DH	DM
TDS												
H Y L 10%	1242	3.25	4.06	3.98	38.9	2.56	18.1	55.3	144	25.8	141.6	171.1
L Y L 10%	596	3.38	3.93	2.93	40.8	2.94	13.8	46.5	131	24.3	145.3	174.3
Difference	646	-0.13	0.13	1.05	-1.9	-0.38	4.3	8.8	13.0	1.5	-3.7	-3.2
	***	ns	ns	*	*	ns	**	***	ns	ns	**	ns
THS												
H Y L 10%	1960	2.12	2.62	3.75	29.3	2.12	19.7	54.7	172	24.6	50.2	81.2
L Y L 10%	631	4.06	3.75	2.56	29.9	3.63	17.4	49.0	133	25.2	59.0	88.1
Difference	1329	-1.94	-1.13	1.19	-0.6	-1.51	2.3	5.7	39.0	- 0.6	-8.8	-6.9
	***	***	***	*	ns	***	ns	**	ns	ns	***	***
CS												
H Y L 10%	5563	3.75	3.63	2.38	22.7	3.88	29.2	94.7	358	38.2	164.4	204.1
L Y L 10%	2900	2.56	2.37	1.81	23.9	2.50	30.4	96.6	349	34.9	159.9	197.9
Difference	2663	1.19	1.26	0.57	-1.2	1.38	-1.2	0.1	9.0	3.3	4.5	6.2
	***	*	*	ns	**	**	ns	ns	ns	*	**	**

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$, ns = $P > 0.05$. HYL = Highest yielding lines, LYL = Lowest yielding lines.
TDS = Terminal drought stress, THS = Terminal heat stress, CS = Cold Stress.

2.3.4. Germplasm distribution

The bread wheat breeding project continued close integration with other research projects in the cereal program, as well as with certain key national programs within the region. Plant pathologists contributed with disease inoculation and developing screening methodology for yellow rust, leaf rust, stem rust, septoria leaf blotch, and common bunt, and virologists screened for BYDV. Entomologists provided resistance screening for wheat stem sawfly and other insect pests. Cereal chemists assessed bread wheat quality parameters. Morpho-physiological studies help to identify genotypes with superior drought, cold or heat-associated traits. Results from this integration are presented in Table 50. Genetic stocks assembled as parental material for different desirable traits are distributed to national programs for use in their breeding programs.

Table 50. Number of bread wheat lines identified for desirable characteristics and distributed to national programs as genetic stocks.

Characteristics	Total number of lines	
	Identified	Distributed
High yield and stability:	58	23
Abiotic stress resistance:		
Terminal drought	54	27
Cold	28	18
Terminal heat	30	19
Biotic stress resistance:		
Yellow rust	31	14
Leaf rust	20	11
Stem rust	7	3
Septoria leaf blotch	23	13
Common bunt	18	9
Wheat stem sawfly	26	17
Selected landraces	16	16
Bread making quality	14	8
Total	**325**	**178**

2.3.5. Germplasm performance

The project's breeding strategy is to distribute germplasm to targeted areas in the region. Three major agroecological zones have been identified in West Asia and North Africa based on moisture availability and temperature regimes. These are:

a) areas of low rainfall associated with low temperature,

b) areas of moderate rainfall with moderate to high temperature, and

c) irrigated areas.

Special emphasis is placed by the breeding project to develop germplasm suitable to zone "a" and rely on CIMMYT, Mexico for zone "c". Table 51 shows the performance of bread wheat germplasm in 35 dry locations in WANA. Results of three years (1986 to 1988) from the international nurseries grown in those dry locations highlight the superior adaptation of bread wheat germplasm over triticale, durum and the national check varieties. This superiority is based on the number of times that each entry ranks fifth or less, or exceeds the national check in those dry locations.

Table 51. Number of the top yielding entries of bread wheat, triticale and durum wheat in the low rainfall areas of West Asia and North Africa. RDYT-LRA 1986-88.

	Top five				National check			
	86	87	88	Mean	86	87	88	Mean
Bread wheat	18	19	25	21	13	10	19	14
Triticale	15	21	11	16	13	15	9	12
Durum wheat	12	18	13	14	7	9	9	8
National check	6	12	6	8	0	0	0	0
No. of locations	30	42	32	35	30	42	32	35

* Based on total number of times that each entry ranks fifth or less or exceeds the national check (LSD test, P = 0.05, one sided test) in those locations.

Germplasm with cold and drought tolerance is also needed in the first agroecological zone. Results from the regional yield trials grown in the high elevation, cold-prone areas of WANA indicate (Table 52) that with our present breeding methodology it is possible to develop germplasm with the cold and terminal drought tolerance required in those areas.

Table 52. Performance of Cham 2 and Cham 4 (improved spring bread wheat cultivars) in the high altitude areas of West Asia and North Africa. RWYT-HAA 1987 and 1988.

Year	Cultivar	Yield (kg/ha)	N.L.	DHE	DMA
1987	Cham 2 (spring type check)	3594	9	151	196
1988	Cham 4 (spring type check)	3354	10	133	176
1987	* Zargoon	3538	9	151	198
1988	* SOTY/SUT//LER/4/2* RFN/3/FR.	3308	10	135	176
1987	Bezostaya (long term check)	2465	9	169	212
1988	Bezostaya (long term check)	2857	10	137	179
1987	National check	2466	9	173	217
1988	National Check	3282	10	134	176

N.L. = No. of locations; DHE = days to heading; DMA = days to maturity.
RWYT - HAA = Reg. Wheat Yield Trial for High Altitude Areas.
* Top yielding winter or facultative entries.

The emphasis placed on breeding for the dry areas of the region has resulted in material increasingly adapted to that particular zone. Table 53 presents data from seven dry locations throughout a large geographical area including North Africa, West Asia and Mexico. In six out of seven locations, the top performing bread wheat entry outyielded significantly the national check varieties.

Besides tolerance to terminal drought and cold stress, bread wheat germplasm grown in the dry areas should possess diseases and insects pests resistance which should enhance yield stability. Table 54 shows the yield and yield stability of four promising bread wheat lines in comparison to the improved durum wheat check in 35 low rainfall locations of WANA.

Using the spring and summer planting breeding techniques, we have been able to identify germplasm adapted to the second and third major agroecological zones described before. These zones are characterized by terminal heat stress (zone b) and early and terminal heat stress (zone c). In selecting germplasm for these zones, it is important to identify and eliminate material with strong vernalization requirements.

Table 53. Grain yield of bread wheat germplasm in low-rainfall areas of West Asia and North Africa. RWYT 87/88.

Country (location)	Yield (kg/ha) Best entry	National check	LSD 5 %	CV %
Tunisia (El Kef)	2881*	2416	322	13
Algeria (S.B.Abbes)	2700*	2195	301	13
Iraq (Telafer)	3520*	1453	610	21
Turkey (Diyarbakir)	2971*	2271	466	17
Lebanon (Tel Amara)	2717*	1978	547	22
Syria (Bouider)	2267	1983	370	17
Mexico (Ciano-RM)	3954*	3416	471	13

RWYT = Regional Wheat Yield Trial. RM = Reduced Moisture.
* significantly ($P < .05$) greater than national check yield.

Table 54. Yield and yield stability of bread wheat germplasm in the low rainfall (< 400 mm) areas of West Asia and North Africa. RWYT-LRA 87/88.

Line	Average yield (kg/ha)	Rank	b coef.	d^2	r^2
P 106.19//SOTY/JT*3	2850	1	1.042	154454	.922
Nesser (improved check)	2845	2	1.056	168662	.896
Maya 74/on/II60.147/3/Bb.	2831	3	1.118	91981	.937
Sanono	2819	4	1.062	82942	.935
Belikh (durum check)	2741	10	1.114	198422	.894
No. of locations	35		25	25	25

RWYT - LRA = Regional wheat yield trial for the low rainfall areas. b=regression coefficient, d^2=deviation mean square, r^2=coefficient of determination.

Foliar diseases as well as terminal heat stress are also important factors responsible for reduced yields in the costal-mediterranean environments of WANA. In these areas, moderate rainfall is usually associated with high temperatures especially at the end of the crop cycle. Table 55 shows the progress made in developing and identifying germplasm suitable for this agroecological zone. Average grain yields have been increased up to 5% over the improved national check varieties, and about 10% over the long-term local check Mexipak 65.

Table 55. Performance of the four top yielding bread wheat lines in the regional yield trials for moderate rainfall areas, 1985-86 to 1987-88.

Top yielding lines	Grain yield (kg/ha)				% NC	% LTC
	85-86	86-87	87-88	Average		
First	4302	3885	4304	4164	105	110
Second	4170	3877	4257	4101	103	108
Third	4146	3865	4179	4063	102	107
Fourth	4135	3812	4061	4003	101	106
N C	3946	3696	4285	3975	100	105
L T C	3643	3672	4060	3791	95	100
N L	53	53	53	53	-	-

N C = National checks; LTC = Long term check; N L = No. of locations.

The CIMMYT/ICARDA breeding project at Aleppo places little emphasis on irrigated areas because CIMMYT-Mexico germplasm is better suited for these areas. However, the national programs in those environments are increasingly interested in growing wheat under limited moisture and we have therefore developed germplasm combining heat and drought stress tolerance. Table 56 presents four promising bread wheat lines that perform well under reduced moisture conditions and early and terminal heat stress conditions typical of most irrigated areas. Results from selection under the spring and summer planting techniques are encouraging. However, the Aleppo project is reassessing its involvement in developing germplasm for this agroecological zone.

Table 56. Performance of bread wheat germplasm under heat stress conditions in Wad Medani, Sudan. Regional heat tolerance yield trial (RHYT) 1987-88.

Cross and pedigree	Yield (Kg/ha)	National Check (%)	DHE	DMA
Hi 669/Vee's' CM 62553-1AP-1AP-2AP-0AP	1458	114	49	93
Clement/Ald 's' SWM 09813-5Y-2Y-0Y-3AP-0AP	1433	112	56	86
TOW 'S'/PEW'S' CM59443-4AP-1AP-4AP-1AP-0AP	1383	108	53	92
VEE'S'/TSI 'S' CM 58943-1AP-1AP-2AP-0AP	1383	108	51	95
Genaro 81 (Improv. check)	1116	88	54	98
Debeira (National Check)	1275	100	49	93

2.3.6. Germplasm adoption

Realizing that improved cultivars must reach farmers before they can have any impact on cereal production, we have joined efforts with national programs in conducting research in on-farm trials in Syria, Algeria, Sudan, Lebanon, Morocco, Tunisia, Yemen AR, PDR Yemen, and Jordan. These activities reflect our concerns for germplasm adoption by farmers and the need to substitute the un-improved, low-yielding local varieties grown in WANA.

A number of bread wheat varieties have been released as a result of this close collaboration. A list of varieties released by these and other national programs is presented in Table 1. Many countries requested and obtained small amounts of newly bred cultivars registered in the region.

Table 57 shows the performance of the promising bread wheat line Nesser in Farmers Field Verification Trials in Syria. Three years data show that Nesser had an average yield advantage of 14% over check Mexipak 65 and of 22% over the widely grown durum variety Haurani, under low-rainfall conditions (250-350 mm). Similar results were obtained after large scale tests (3 ha, farmers' fields) under less than 300 mm rainfall. This promising line is a strong candidate for release in Syria. Seed has been requested and distributed to NARS in Syria, Jordan, Algeria, Morocco, Iraq and Lebanon.

Table 57. Performance of Nesser, a promising bread wheat line, under low-rainfall (250-350 mm) conditions in Syria. Farmer's Field Verification Trials 1985-86 to 1987-88.

	Grain yield (kg/ha)			%	% bw
Variety	1986	1987	1988	Average	Check
Nesser	2109	1834	3632	2525	114
Mexipak (bw check)	1795	1643	3229	2222	100
Haurani (dw check)	1933	1409	2828	2056	92
No. of locations	7	7	10	24	

bw= bread wheat; dw = durum wheat

The 1988-89 crop season was extremely dry and cold in Syria. Total precipitation received at Tel Hadya was 234 mm, and sixty days of subzero temperatures were also registered during the season. Many farmers in the area reported crop failures. Although the environmental conditions were harsh, results were obtained from five dry locations where on-farm verification trials were grown. The total precipitation received in these locations ranged from 190 to 280 mm. In addition to Nesser, another line, Saker (ICW77-0117-K-1AP-0AP-4AP-2AP-1AP-0AP) had an average yield of 963 kg/ha over 5 dry sites (200-300 mm) in Syria during 1988/89 as compared to 828 kg/ha for Mexipak 65 which is still widely grown in dry areas. Saker combines drought and cold tolerance as well as good bread making quality, making it highly acceptable to farmers and consumers in Syria.

Results of on-farm verification trials carried out in Algeria during the last three years are shown in Table 58. The bread wheat line Gv/Ald's' showed an average yield advantage of 13% over the widely grown local check variety Mahon Demias. These on-farm trials were carried out in the low-rainfall (200-350 mm) areas of the country. Based on these results Algeria decided to release it under the name of Zidane 89. Seed has been requested and distributed for multiplication.

Table 58. Performance of Gv/Ald (=Zidane 89), promising bread wheat line, under dry (200-350 mm) conditions in Algeria. Farmers field verification trials, 1986-87 to 1988-89.

Variety	Yield (kg/ha) 1987	1988	1989	Average	% Chk
Gv/Ald 's' L882-1AP-OAP-2AP-OAP	2141	2334	780	1752	113
Mahon Demias (local check)	1711	2226	730	1555	100
No. of locations	4	6	3	13	-

Chk = Local check.

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2.4. Cereal Improvement for High Elevation Areas

Among the cultivated crops in the highlands of WANA (Pakistan, Afghanistan, Iran, Iraq, Turkey, Algeria and Morocco) wheat covers 16.5 million ha and barley 5.4 million ha, i.e. about 54% of the total area devoted for their cultivation. However the contribution of this large area toward total national food production is very low (Ref. Sustainable Agriculture for the Dry Lands - ICARDA's strategy, 1989). Though the mean yield for the seven countries mentioned above is 1150 kg/ha this is distorted because Turkey obtains 1700 kg/ha while the average yields in the highlands of the remaining six countries range from 500-850 kg/ha. This low productivity is attributed to several adverse biotic and abiotic factors (ICARDA Annual Reports 1987-88). The Cereal Program has developed a research plan in cooperation with national programs to improve wheat and barley productivity in cold-winter areas of the region.

2.4.1. Germplasm development

The breeding work in this project aims to develop improved wheat and barley germplasm possessing genetic stability and tolerance to both biotic stress (yellow rust, common bunt, BYDV, tan spot, powdery mildew; and Hessian fly and sunn pest) as well as abiotic stress (cold, drought, and heat). In the 1988/89 season, 1218 lines/cultivars of wheat and 450 entries of barley were introduced from different areas of the world to expand the genetic base of winter and facultative cereals at ICARDA. The exceptionally dry and cold season provided a good environment to screen these materials for drought tolerance; 54 lines of wheat and 12 of barley were selected as parents for hybridization. A total of 369 crosses of bread wheat, 207 crosses of durum wheat and 324 of barley were made. These crosses involved locally adapted material and exotic germplasm. The segregating populations of bread wheat (3191), durum wheat (2335) and barley (282) were evaluated for drought and disease tolerance at Tel Hadya and the number of selections made in each crop species are given in Table 59.

Table 59. Number of cereal germplasm selections in bread wheat, durum wheat and barley for high altitude areas (Tel Hadya, 1988/89).

	Bread wheat		Durum wheat		Barley	
Nursery	Total	Sel.	Total	Sel.	Total	Sel.
F_0	369	-	207	-	324	-
F_1	556	520	248	229	225	205
F_2	471	313	411	230		
F_3	1110	503	690	217	-	-
F_4	482	230	358	195	57	20
F_5	460	344	538	450	-	-
F_6	112	27	90	57		
ON	150	115	150	92	188	55
PSN	378	290	231	140		
PYT	48	28	48	26		

To introduce alien gene(s) for desirable agronomic traits from *Aegilops* and wild *Triticum* species, 129 new crosses were made with *T. durum* or *T. aestivum*. From the advanced segregating populations of interspecific hybrids, 112 genetically homozygous lines were selected for evaluation.

Tel Hadya continued to serve as a site for germplasm generation, where facilities are available for crossing, detailed studies, disease and insect screening, and seed multiplication. This season, the exceptional drought (total rainfall of 234 mm) combined with cold (below freezing minimum temperature for 50 days) enabled a good germplasm screening for drought and cold tolerance. All components of the high altitude cereal germplasm (parental stocks, hybrid populations, observation nurseries, yield trials, etc.) have been grown at Tel Hadya. Advanced materials (observation nurseries and yield trials) were also tested at the drier (194 mm) site of Breda. However, a major emphasis was placed on screening the breeding material at two high altitude sites, i.e. Sarghaya in Syria and Haymana in Turkey.

In Sarghaya cold and drought were also major stresses. In addition there was a severe infection of BYDV which allowed an efficient screening for tolerance to this disease. The number of lines selected from the different nurseries on the basis of agronomic performance and resistance to BYDV are given in Table 65. More than 80% of durum wheat and barley lines were susceptible to BYDV. The selected lines showed an acceptable degree of tolerance. Observations at Colorado State University Research Farm by M. Tahir showed also a higher level of susceptibility of durum in comparison to bread wheat. Twelve durum wheat lines have been selected for future use in crossing at ICARDA.

Because Sarghaya has proved to be a good testing environment, more land will be acquired for testing more winter and facultative wheat and barley for the high altitudes of WANA.

At Haymana, a relatively large number of wheat and barley populations were grown (in collaboration with Drs. B. Yilmaz and B.C. Curtis) and screened for tolerance to severe cold and drought. Disease pressure was minimal because of the dry season. Selection results (Table 60) clearly indicate that the barley germplasm in these nurseries lack cold tolerance, which is explained by the little work conducted so far on winter and facultative barley at ICARDA. This area will be strengthened starting the coming season.

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Table 60. Number of selections from facultative and winter cereal nurseries at Sarghaya, Syria or Haymana, Turkey, 1988/89.

Nursery	Bread wheat		Durum wheat		Barley	
	Total	Selected	Total	selected	Total	selected
Sarghaya						
F2	471	260	412	175 (30)	100	(13)
Obs. nursery	160	95	150	65 (24)	128	(22)
PSN	378	192	229	115 (35)	188	(19)
Int. Germplasm	340	70	44	8 (1)	-	-
Haymana						
F2	460	87	400	136	100	8
F6	112	21	86	13	128	33
PSN	322	111	225	38	300	12
Int. Germplasm	340	89	44	10	188	55

PSN = Preliminary Screening Nursery
( ) = Selected for BYDV resistance

2.4.2. Selection frequency of bread and durum wheat at high altitude sites

Bread Wheat

The average frequency of selection (%) of the Observation Nursery and F_2 segregating populations at high altitude sites of Quetta-Pakistan, Annaceur-Morocco, Setif-Algeria, Tehran-Iran and Ankara-Turkey, from 1980/81 to 1988/89, are presented in Fig. 9. This shows that most of the germplasm in the initial years was not well adapted to the high altitude areas of WANA. However the increase in the selection frequency of ICARDA generated germplasm at all sites from less than 1% to 25-30% shows that multi-location testing and selection of material at earlier generations in the target environment results in consistent progress despite the large environmental variability in high altitude areas.

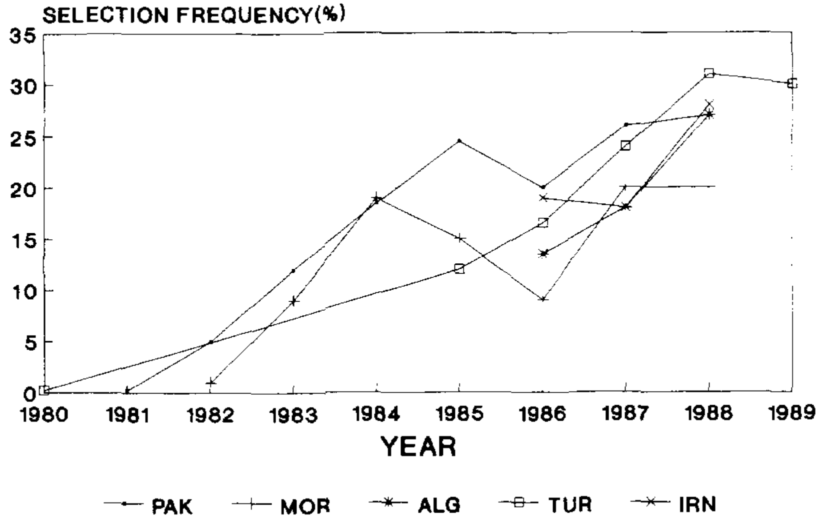

Fig. 9. Selection frequency (%) in bread wheat at high altitude sites.

Durum Wheat

Less progress has been achieved in selection frequency of durum wheat (Fig. 10) as compared to bread wheat which may be attributed to: 1) a narrow genetic base and lack of adaptability to stress conditions perhaps because of lower ploidy as compared to bread wheat, 2) a lower level of cold tolerance in durum wheat and 3) a lower research input for durum wheat improvement.

2.4.3. Adaptability and commonality of selected germplasm

The data for bread wheat germplasm selected at five high altitude sites were examined to identify lines performing well across sites. However the data presented in Fig. 11 show that lines selected from breeding nurseries at each site were different. The selection frequency (%) at individual sites was 25%, dropping to 8% of selected lines at two sites, and further down to 1% and .03% of commonly selected lines at three or four sites in the region. It is unlikely to identify widely adapted lines. These data indicate the agroclimatic specificity of each region and the need to develop germplasm with specific adaptability.

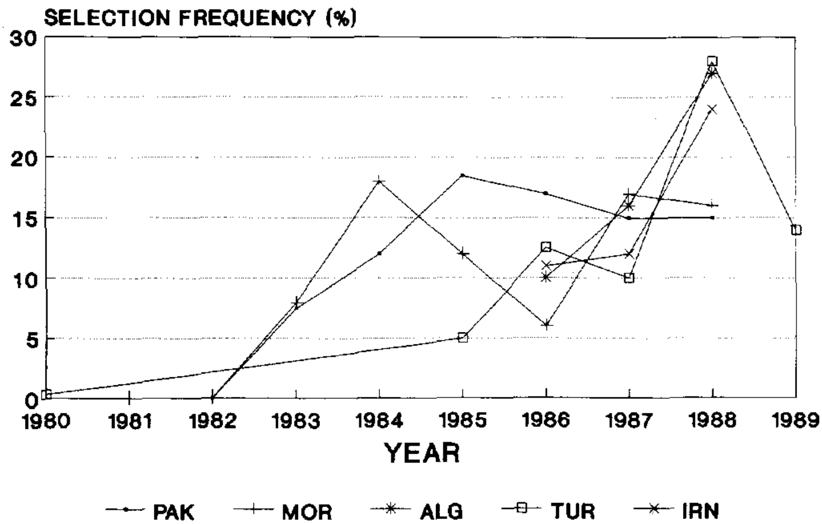

Fig. 10. Selection frequency (%) in durum wheat at high altitude areas.

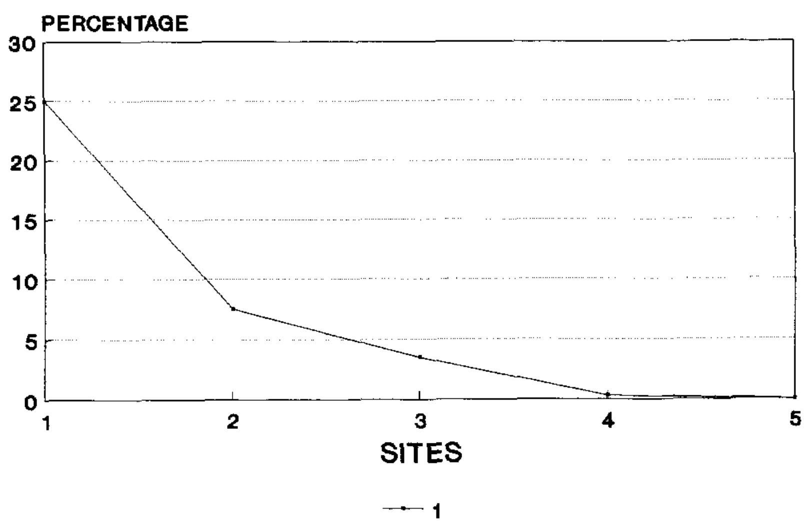

Fig. 11. Frequency of bread wheat lines selected at one or more highland sites in WANA.

2.4.4. Cold tolerance and response to photoperiod and vernalization in barley and wheat

The strategy to develop suitable cold tolerant barley and wheat germplasm for high altitude areas has been pursued by crossing cold tolerant parental lines and locally adapted germplasm of winter x spring or facultative X facultative types, and then subjecting the early generations to cold stress under field conditions. There is a wide gradation in growth habit ranging from early spring types to strong winter types among wheat and barley germplasm in high altitude areas, with facultative types predominating.

Barley

Three different nurseries, i.e. Barley Observation Nursery - High Altitude Areas (BON-HAA), Barley Observation Nursery - Low Rainfall Areas (BON-LRA) and Barley Observation Nursery - Moderate Rainfall Areas (BON-MRA) were tested by Dr. V. Shevtsov at Krasnodar (U.S.S.R) for cold tolerance under field conditions (Table 61). Twenty three percent of entries from BON-HAA, had 100% survival whereas none of the entries showed such a high level of survival in the other two nurseries. For survival under cold conditions BON-LRA ranked second, which suggests that there may be a correlation between cold tolerance and drought tolerance.

Table 61. Frequency of barley lines with different levels of survival in the Barley Observation Nurseries 1988-89 at Krasnodar (U.S.S.R).

Nursery	No. of Lines*	% Survival			
		100%	80 - 90	70 - 80	60 - 70
BON - HAA	124	22.6	-	29.8	31.5
BON - LRA	88	-	6.8	13.6	46.6
BON - MRA	81	-	-	8.6	28.4

* National check not included.

The fact that BON-HAA had the highest level of survival is due to testing and selection of early breeding generations at the cold prone site of Sarghaya-Syria, whereas the germplasm of the other two nurseries were primarily selected for severe to moderate moisture stress only.

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Wheat

The top yielding 19 breeding lines out of the Regional Wheat Yield Trials, and Observation Nursery for high altitude areas and 11 commercial varieties representing different growth habits were used to investigate their cold tolerance, and response to photoperiod and vernalization. To study the vernalization response, materials were kept for 6 weeks at 1-2° C. Photoperiod treatments were long day (24 hours continuous light) and short day (16/8 hours of day/night). Results are shown in Table 62. The Russian winter wheat variety Bezostaya 1 was the most winter hardy (LT 50 = -10.2°C) whereas the LT50 for the widely grown Turkish cultivar Bolal and a U.K. variety, Avalon, were - 8.1° and -7.2°C, respectively. The LT50 for the 19 breeding lines from ICARDA ranged from -5.7° to -9.3°C. The LT50 for the most widely cultivated spring type varieties, Mexipak was -4.9°C and for the other spring type cultivars, i.e., Zamindar, Zargoon and Cham 2, was only -4.6°C. The majority of new wheat lines showed much higher levels of cold tolerance. However, their response to vernalization and long day photoperiod revealed that only 5 (entries nos. 6, 23, 24, 26, and 28) were winter types carrying vernal genes. Two cold tolerant lines, i.e. entry nos. 24 and 28 seem to carry major photoperiod sensitivity gene(s). The remaining 14 breeding lines did not show any response to different day lengths and behaved as spring types once their minimum vernalization requirements were met. From these studies it is obvious that growth habit and cold tolerance are independent traits. Therefore it should be possible to transfer and combine earliness and cold tolerance without major vernal or photoperiod sensitivity genes.

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Table 62. Cold tolerance and response to photoperiod and vernalization in wheat.

Entry No.	Cultivar/line	LT50 (°C)	Vernalized		Non-vernalized	
			Long day+	Short day*	Long day*	Short day*
1	Bezostaya 1	-10.2	54	6	49	44
2	Kvz/Cut 75	-6.2	33	17	13	26
3	Bolal	-8.1	43	12	50	56
4	Vratza	-7.8	49	9	40	46
5	CA 8055	-8.9	48	8	27	-
6	Au/4/Cn53/N10B/3505/3/093.44/5/...	-8.0	60	5	47	39
7	Kavkaz	-8.4	46	12	51	-
8	Mexipak	-4.9	31	18	6	20
9	Katya Al	-7.4	37	14	11	26
10	Zaminder	-4.6	32	16	14	27
11	Avalon	-7.2	60	-	67	-
12	Zargoon	-4.6	33	18	11	29
13	Cham 2	-4.6	30	18	7	22
14	Au/Tob66/5/K338/Edch//Koudiat 17/...	-5.7	35	19	6	18
15	Tr.aest (Rom)//Tob's'/8156/3/Tx69A460-1/...	-6.0	34	19	4	22
16	Cllf/Pch//P101/...	-7.6	35	27	14	42
17	Au/3/Hork/Ymh//Kal/Bb	-7.6	-	-	-	-
18	F3.73/Nkt's'	-7.7	34	17	10	31
19	Tr.aest(R)//Tob's'/8156/3/Tx69Aa460...	-5.9	35	16	2	17
20	Lom10/3/2010/171-2//234-3819/4/...	-6.7	36	21	8	27
21	Chambord/5133//Mt/3/Kkc/4/Lfn//ND/..	-6.7	38	13	13	29
22	Dacia//Cofn/ND/3/Bez/Tob/;8156	-7.5	40	14	9	29
23	Bez//Tob/8156/4/On/3/6*Th/Kf//6*Lee/..	-7.5	48	9	57	-
24	Au//2*Yt54/N10b/3/Codr's'An//..	-7.4	45	10	47	79
25	Chambord/5133/Mt/3/.	-7.7	39	23	15	34
26	Lom11/Son65/4/..	-9.3	42	20	47	-
27	Chambord/5133//Mt/3/Kkc/4/Lfn/..	-6.6	34	24	13	39
28	Bez//Tob/8156/4/..	-8.0	47	11	42	82
29	T.aest (Rom)//Tob's'/8156/3/Tx69A460-1...	-6.6	37	11	0	21
30	Au//2*Yt54/N10B/5/...	-7.3	35	22	13	28
	L.S.D. (0.05):		5.85	5.69	7.14	6.43

All the data are in number of days to flag leaf emergence., *) Days to reach flag leaf emergence additional to long day-vernalized (+). LT50 = Lethal temperature of 50% of the plants.

2.4.5. Effect of alien cytoplasm on wheat anther culture

Haploid breeding of wheat is attractive to breeders to reduce the time required to reach homozygosity and to carry out genetic studies. One approach is altitude for anther culture. However due to low altitude for anther culture and genotype specificity, the use of this technique in wheat breeding has been restricted. To enhance anther culture and dihaploid production various methods such as the use of hormones, are under investigation. Studies were carried out to find out the influence of alien cytoplasms on wheat cv. Jones Fife for anther culturability. The anthers of Jones Fife carrying four different cytoplasms i.e. dicoccoides, squarrosa, kotschyi, speltoides and the euplasmic line were cultured; percentages of anthers producing embryoid callus in each alloplasmic line are given in Table 63.

Table 63. Effect of alien cytoplasm on anther culture in Triticum aestivum L.

Alloplasmic line	Plasma type	Backcross generation	% of anthers prod. embryoids
(dicoccoides) - JF	B	B14	10.7 a
(squarrosa) - JF	D	B13	8.7 ab
(aestivum) - JF	B	-	6.7 ab
(kotschyi) - JF	S^v	B14	6.6 ab
(speltoides) - JF	S	B12	4.7 b
LSD at 0.05			5.4

These data suggest that dicoccoides cytoplasm exerts a positive effect on anther culturability whereas speltoides cytoplasm, has a negative effect. No significant differences in anther culturability of alloplasmic lines with speltoides cytoplasm and the euplasmic line cv. Jones Fife were observed.

2.4.6. Heat tolerance

High temperature is a major abiotic stress which severely damages wheat and barley in WANA. Its effect is compounded in the presence of moisture stress after anthesis. It was therefore felt necessary to identify new sources of genetic resistance among wheat and barley germplasm and to study the interspecific differences for heat tolerance. Heat tolerance was studied as the thermostability of the cell membrane, estimated as the percent membrane injury (electrolyte leakage) (Blum and Ebercon, Crop Sci. Vol. 21: 43-47, 1981).

The heat tolerance of 234 bread wheat, 103 durum wheat and 10 barley lines/varieties, originating from WANA (Table 64) was studied along with a heat resistant check, Tam 107, and a susceptible check Nugains.

Table 64. Number of wheat and barley germplasm lines tested for heat tolerance.

Origin	Bread wheat	Durum wheat	Barley	Total
Afghanistan	54	12	-	66
Iran	35	12	-	47
Pakistan	19	3	-	22
Turkey	53	13	-	66
Syria	1	13	-	14
Morocco	6	10	-	16
Algeria	11	8	-	6
Ethiopia	11	10	-	21
ICARDA/CIMMYT	44	22	10	76
Total	234	103	10	347

Data on the heat tolerance of 337 wheat lines/varieties are presented in Fig. 12. Percentage injury was classified into four groups: 1) 0-20% injury = resistant; 2) 21-40% injury = moderately resistant; 3) 41-60% injury = moderately susceptible and 4) more than 60% injury as susceptible. Eighteen percent of the lines were highly resistant to heat and better than the resistant check Tam 107 (25% injury). A fairly large number (53%) of lines were found to be moderately resistant to heat. A critical analysis of the origin of heat tolerant lines revealed that most of those lines come from heat prone areas. The ICARDA/CIMMYT resistant lines were derived from selection under high temperature conditions.

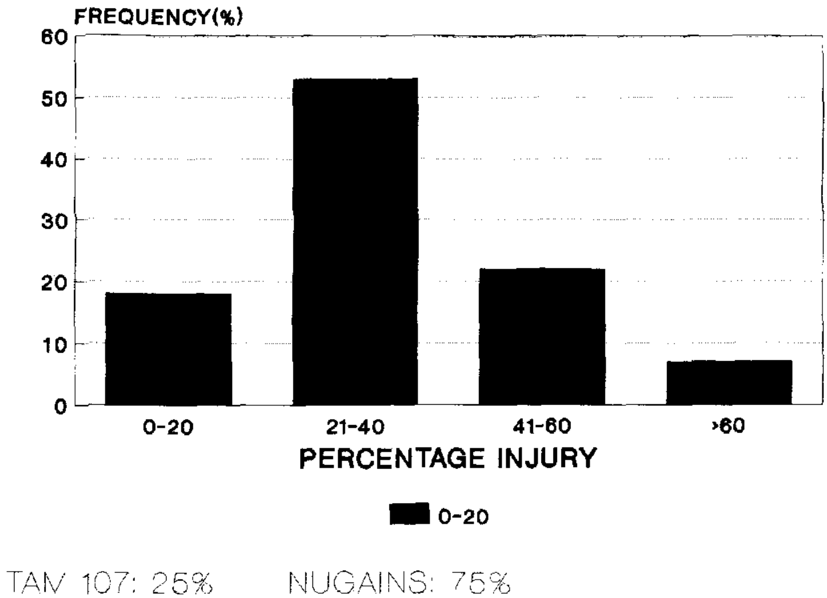

Fig. 12. Genetic diversity in wheat for heat tolerance.

No significant differences in heat tolerance between *Triticum aestivum* and *T. durum* lines were observed. Heat tolerance seems to be more related to the ecological origin and to selection pressure for heat tolerance. Barley lines were not as tolerant as some of the wheat lines. We suggest that early breeding generations should be subjected to high temperature under field conditions, and field selected material should be rated on the basis of percent membrane injury to remove any non-resistant lines or lines possessing avoidance mechanisms.

2.4.7. Regional yield trials

The best entries selected on the basis of yield and stress tolerance out of various nurseries in the region were provided to the cooperators in the high altitude areas of WANA as Regional Yield Trials. These trials were comprised of 24 entries including two check varieties, with three replications. However results from a few testing sites only have been received so far and are summarized in the following section.

Barley

Results from Tel Hadya, Syria in combination with frost tolerance data from Sarghaya, Syria are presented (Table 65). Tel Hadya this year was exceptionally dry whereas Sarghaya experienced severe cold (-24°C). Data on the top yielding four lines and two check varieties indicate that newly bred winter and facultative barley lines are superior to the spring improved check variety Rihane's' in cold tolerance. No significant yield differences were found.

Table 65. Regional Barley Yield Trial 1988-89 (High Altitude Areas), Tel Hadya, Syria.

Entry	Line/cross	Yield Kg/ha	Frost* Damage (%)	Rank
23	805021/V1701=Icbha 81-2254	3888	10	1
20	Tipper	3500	15	3
16	805066/Grt Ket Soros=Icbha81-2281	3388	15	4
11	Exa/Lignee 527=Icbha 81-0494	3333	20	5
1	Salmas - Check	3000	10	11
12	Rihane's' - Check	3611	65	2
	CV %	21.64		
	LSD (0.05)	996.96		

* Frost score is from Sarghaya.

Bread Wheat

In Diyarbakir (660 m.a.s.l.), Turkey eighteen lines outyielded the improved national check variety Malabadi during 1987/88. Data on yield and other important agronomic traits of the top yielding five lines and the two check varieties are given in Table 66. These lines were significantly higher yielders than the national check with improved tolerance to diseases (yellow rust, and common bunt) and frost. They did not differ significantly in days to heading (DH) and days to maturity (DM) but were relatively taller (PH), which is a desirable character for moisture stress conditions.

Table 66. Regional Wheat Yield Trial, 1987/88 (High Altitude Areas) Diyarbakir, Turkey

Entry No.	Name/cross	Yield kg/ha	Rank	DH	DM	P.H. (cm)
7	ICW-HA 81-2213	3919	1	131	162	90
9	ICW-HA 81-1337-3	3433	2	131	160	95
19	ICW-HA 81-1337-4	3069	3	137	163	95
20	ICW-HA 81-1369	3014	4	136	163	90
15	ICW-HA 81-1610	3000	5	131	163	90
1	Cham 4	2684	6	131	161	60
24	National check	2139	19	136	162	75
	CV%	19.0				
	LSD (0.05)	649.0				

DH= days to heading, DM = days to maturity, PH = plant height

Similarly, in Swat-Pakistan (1050 m.a.s.l.), eight lines outyielded the improved local check (2044 kg/ha) and 15 entries gave better yield than the spring variety Cham 4 (1789 kg/ha). Entry 4 (Bez // Tob / 81256 /4/ On /3/ 6* TH...) and one of its sister line (entry 5) gave significantly superior mean yield of 2502 kg/ha, as compared to local check.

In the Atlas mountains of Morocco the yield trial was planted at the Annaceur research station during 1988/89 and an improved breeding line (no. 1723) was included as a national check. Three lines, i.e. YKT406/Wren//Ve's' (No. 6), Tx 62A4793-7/CB 809//Vee's'(No. 3) and Tx 62A4793-7/CB809//Vee's'(No. 2) gave yields of 2120, 2106, and 2104 kg/ha, respectively as compared to 2080 kg/ha for the national check line No. 1723 and Bezostaya (1080 kg/ha). All lines giving higher yields are types developed through winter x spring crosses.

The results of the 5 top yielding lines at Karadj-Iran, and two check varieties are given in Table 67. Though only one line, Tx 62A4793-7/CB809/5/K338/Edch//Kaudiat 17/Ktv/3/WC/4/Cgn (No. 14) gave a significantly higher yield than the national check variety Azadi (4855 kg/ha), the other four high yielding lines also gave a 16-20% higher yield than the improved national check. Variety Azadi in Iran is considered cold tolerant and high yielding. The better yield performance of a number of lines in comparison to Azadi suggests that these lines have adequate cold tolerance and high yield. These lines have also been tested under controlled field conditions and found highly resistant two major diseases, yellow rust and common bunt.

Table 67. Regional Bread Wheat Yield trial 1988-89 (High Altitude Areas), Karaj, Iran.

Entry No.	Line/cross	Yield kg/ha	% of check
14	TXC62A4793-1/CB809/5/K338..= 14	6055	124
15	TX62A4793-1/CB809/5/K338..= 15	5838	120
13	AV/TOB.66/3/Cndr's'/Ana//Cndr's'/Mus's'	5777	118
10	Kanred/Funo/4/.../WWP4394	5766	118
12	Zargoon	5677	116
24	Azadi-National check	4855	100
1	Bezostaya-Long term check	5044	103
	CV	14.66	
	LSD (0.01)	1034.24	
	Overall mean	5144	

The data from yield trials and other nurseries at various locations in the high altitude areas shows the superior performance of a number of new lines/varieties. There is a need to test further such selected lines at the national level covering several locations. Therefore it will be highly desirable to develop a mechanism for systematic testing of such lines at national level for possible release to the farmers. This may become possible with the functioning of regional high altitude projects and networks. The work on winter and facultative cereals has been strengthened with the posting at ICARDA of a CIMMYT scientist, Dr. Byrd C. Curtis, who has taken post in August 1989, to work on breeding of winter and facultative bread wheat for the WANA region.

At most of the high altitude sites the resources, technical manpower and equipment to carry out large scale testing through on-farm trials, are not adequate. Therefore to reap the results of research this component needs strengthening.

M. Tahir

3. BREEDING-RELATED RESEARCH

3.1. Physiology/Agronomy.

In this season's report we concentrate on detailed studies of transpiration efficiency, root growth and partition of assimilates, development and yield of selected 2-row barley genotypes. We explore morphophysiological traits of adaptation of durum wheat to low rainfall Mediterranean environments using a wide genetic base nursery and present results of agronomic trials on this species. Finally, from the analysis of nine environments (year, locations) we propose potential sources of abiotic stress resistance for two and six row barleys, durum wheat and bread wheat.

3.1.1. Transpiration efficiency of barley genotypes.

A greenhouse experiment was conducted to assess differences in transpiration efficiency (TE) between barley genotypes. The literature is contradictory on this subject. Fischer and Turner concluded that variations in TE could be attributed largely to vapor pressure deficit and the primary carboxylating enzyme in photosynthesis (Ann. Rev. Plant Physiol 1978 29: 277-317). We have reported that barley genotypes grown under severe stress showed significant differences in ^{13}C discrimination C-13 D which is a measure of TE at the plant level (Cereal Annual Report 1987, pp: 100-116).

Ten two-row barley genotypes well adapted to Northern Syria were grown in six kg pots in a greenhouse. A mixture of 2 parts of soil and 1 part of sand was used as potting mix. The mixture was initially fertilized with 0.49 g of triple superphosphate and 1.20 g of ammonium sulphate, thereafter all irrigations were given with 1/10 strength Hoagland solution. The surface of the pots was sealed with aluminum foil to avoid direct soil evaporation. Irrigation was done throughout specially fitted hoses. Four germinated seeds were planted per pot to leave two uniform plants per pot when the first leave was fully emerged. Planting date was on December 19, 1988 and harvesting was done the first of June, 1989 when all the plants had reached maturity. Leaves were harvested as they senesced and at maturity the plants were split into grains, leaves including sheaths, stem (including chaff) and roots. Transpiration was recorded at each irrigation through the amount of water required by each pot to attain predetermined weights according to irrigation treatments.

The experimental design was a split-plot with varieties being the sub-plot and watering treatment the main plot. Four watering treatments were imposed: a) irrigation to field capacity (FC) throughout the season when half of the available water was transpired, b) irrigation to one half field capacity throughout the season, when the permanent wilting point was reached (1/2 FC), c) irrigation to FC through anthesis and 1/2 FC thereafter, d) irrigation to 1/2 FC through anthesis and FC thereafter. The mean temperature in the greenhouse was 15.5 ^{o}C with a maximum mean of 21.8 ^{o}C and a minimum mean of 9.1 ^{o}C. The target temperatures were 22^{o}C/5^{o}C (day/night) from planting to ear emergence and 25^{o}C/10^{o}C from ear emergence onwards. The mean relative humidity was 70.96 % and the mean vapour pressure deficit (vpd) through the growing cycle of 0.53 KPa.

Results indicated that there were differences between genotypes in total water transpired, transpiration efficiency, total biomass produced and grain weight across irrigation treatments (Table 68). The local barley landraces had a higher total biomass, higher grain weight, higher water transpired and lower transpiration efficiency. TE values were generally high due to the low VPD in the greenhouse (0.53 KPa). The relation between transpiration efficiency normalized by vpd and total biomass is depicted in Fig. 13. It can be seen that the landrace Tadmor has high transpiration efficiency and high total biomass production. In field measurements of gas exchange we observed that Tadmor also has high carboxylation efficiency.

The improved ICARDA genotype SBON 96, which has good grain yield at our driest sites (Cereal Annual Report 1987, p:123) has similar values (Table 68) as those found for landraces.

Table 68. Transpiration efficiency, yield and water transpired of barley genotypes. Means across irrigation treatments. I refers to improved genotypes, L are landraces.

Genotype	Type	Total biomass (g/pot)	Grain Weight (g/pot)	Water transpired (g/pot)	TE (mg DW/gH_2O)
Harmal	I	40.51	17.14	4713	8.66
WI 2198	I	43.39	19.09	5223	8.41
WI 2198/WI 2269	I	41.38	17.79	5095	8.24
Tadmor	L	50.56	21.53	6252	8.19
Roho	I	41.14	18.56	5192	8.10
SLB 8-6	L	44.88	21.03	5783	7.85
SBON 96	I	48.86	19.74	6414	7.69
SLB 62-99	L	46.52	20.76	6400	7.43
SLB 39-99	L	52.54	22.70	7245	7.35
SLB 62-35	L	46.97	21.66	6607	7.25

LSD .05 for total biomass means: 3.78
LSD .05 for grain weight means: 1.55
LSD .05 water transpired: 477
LSD .05 for TE means: 0.48

The values of transpiration efficiency reported were negatively correlated to C-13 discrimination (C-13 D) measured in the grain of the same genotypes grown in field experiments at Breda and Bouider in the 1985/86 season ($r = -0.68$, $P < 0.05$). This negative relation implies that genotypes with lower transpiration efficiency at low vapor pressure deficits in the greenhouse do well under dry rainfed Mediterranean environments of northern Syria. It is worth recalling (Cereal Program Annual Report 1987, p. 114) that grain yield at Breda and Bouider was strongly <u>positively</u> correlated ($P<0.01$) with C-13 discrimination and hence <u>negatively</u> related to transpiration efficiency. The data in Table 68 and Fig. 13 allow interpretation of these apparently contradictory results.

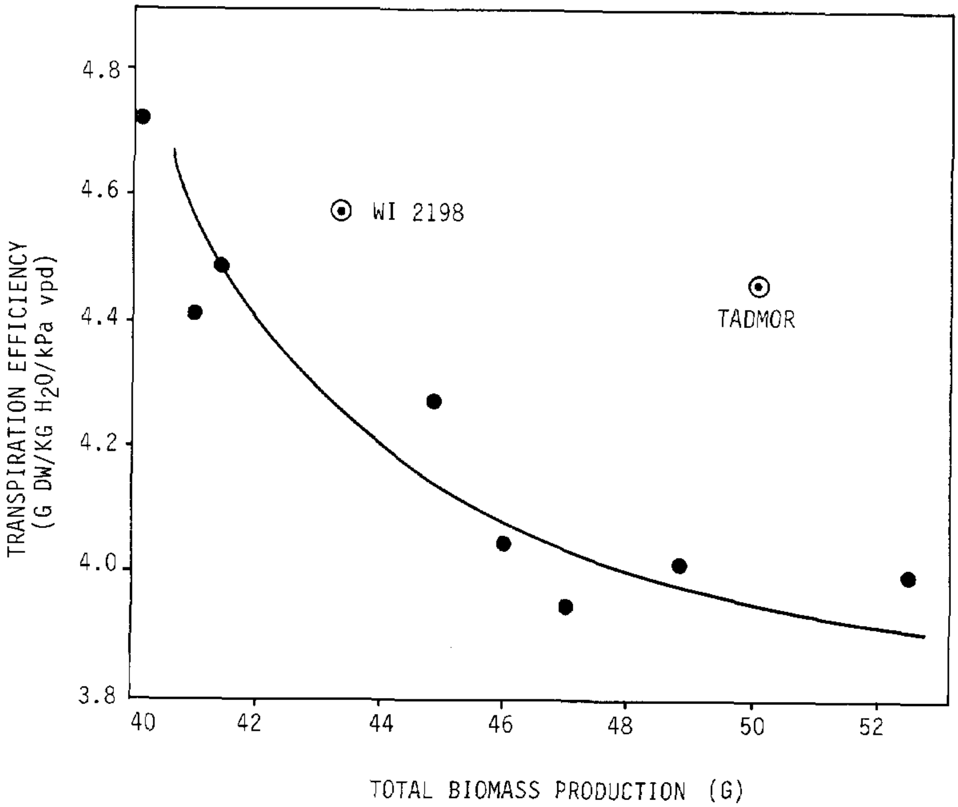

Fig. 13. Transpiration efficiency and total biomass production in barley genotypes. Greenhouse determinations (88/89).

There were no significant interactions between varieties and watering treatments in any of the parameters tested. The treatment means for irrigation are shown in Table 69.

Table 69. Irrigation treatment effects on transpiration efficiency. Means across varieties.

Treatment	TE (mg DW/g H_2O)
Field capacity (FC) through the growing cycle	7.20 a
FC through heading, 1/2 FC from heading to harvest	7.74 a
1/2 FC through the growing cycle	8.52 b
1/2 FC through heading, FC from heading to harvest	8.19 b

LSD.05 =.54. Numbers followed by a different letter differ at $P<0.05$.

The results in Table 69 clearly show that TE increased with drought stress, but only in those cases where drought stress occurred before heading. These results also match our measurements of C-13 D made in field grown plants. C-13 D decreased as drought stress increased and mean grain yield decreased across ten barley trials with 21 or 24 genotypes each, i.e. the transpiration efficiency was higher in the driest environments (Austin, Craufurd and Acevedo, unpublished). The field results also have shown that the within trial phenotypic correlation coefficient decreases linearly with decrease in drought stress (and increase in C-13 D), changing from highly positive to highly negative values (+0.8 to -0.7) shedding additional light for field C-13 D interpretations. A positive correlation can be interpreted as a dominant effect of stomata closure on discrimination while a negative correlation can be interpreted as a dominant effect of RUBISCO on C-13 discrimination. The first case would indicate variation in stress resistance, while the second would be indicative of variation in photosynthetic capacity. For further discussion on this topic see Cereal Program Annual Report 1987, pp: 100-116.

The greenhouse experiment also provided results on dry matter partitioning between genotypes. These are presented in Table 70 for the above ground biomass. Except for SLB 8-6 which is similar to the improved genotypes and Roho which is similar to the landraces, the landraces are characterized by a significantly higher investment of photosynthetic products into leaves. Except for Roho, the percentage of straw including chaff, is significantly lower in landraces. No significant variety x watering treatment interaction was found in above ground dry matter partitioning nor there were effects of the watering treatments on the allocation of assimilates in above ground biomass.

Table 70. Above ground dry matter distribution of 2-row barley genotypes. Plants grown in pots in a greenhouse. (I: improved barleys; L = landraces barleys).

Genotype	Type	Above ground biomass		
		Leaves %	Grains %	Straw %
Harmal	I	7.61	45.05	47.33
WI 2198	I	9.00	47.17	43.83
WI 2198/WI 2269	I	5.78	45.53	48.69
ROHO	I	10.80	47.66	41.57
SBON 96	I	7.68	43.89	48.43
Tadmor	L	12.56	44.93	42.51
SLB 62-99	L	13.93	49.34	36.73
SLB 39-99	L	13.18	47.50	39.32
SLB 62-35	L	14.37	49.18	36.45
SLB 8-6	L	9.49	50.43	40.08

3.1.2. Root growth

Four barley genotypes were grown in 1 m long 10.4 cm diameter PVC tubes in the greenhouse. The varieties were arranged in an RCB design with four replicates. A sandy soil mix (2 parts sand and 1 part soil) was used as rooting medium. A preplanting dose of fertilizers (N and P) was mixed with the soil as in the transpiration efficiency experiment. Two germinated seeds were planted per tube and one plant per tube was left after the 1st leaf fully emerged. The top of the tubes were sealed with aluminum foil allowing only for extrusion of the plants. A high mesh metal screen was installed at the bottom of the tube to avoid soil mix losses and allow eventual extrusion of roots. Irrigations were done when the soil mix reached 1/2 FC, adding 1/10 Hoagland solution to attain FC, the amount of irrigation solution was recorded. The area that each plant had was 84.75 cm^2 equivalent to 118 plants/m^2. Planting date was the 8 of December, 1988 and harvesting was done on the 15 of May, 1989 after all plants reached maturity. Above ground plant parts were harvested at maturity and root length density and weight was measured after washing out the soil mix.

The genotypes included in this trial were Tadmor, SLB 8-6, WI 2198 and a barley mutant with only two seminal roots. The plants grew well in the tubes. Relevant growth parameters are given in Table 71. The striking values of the table relate to the root/shoot ratio of Tadmor.

Table 71. Growth parameters of four barley genotypes grown in PVC tubes. Greenhouse experiment 88/89.

Genotype	Total dry wt (g/plant)	Grain (g/plant)	Root/Shoot (g/g)	HI (g/g)	TE (mg DW/gH_2O)
Tadmor	27.9	12.9	0.036	0.46	3.32
SLB 8-6	29.0	13.1	0.089	0.45	3.71
Mutant 8-7	30.8	5.5	0.084	0.18	4.97
WI 2198	32.3	14.1	0.109	0.44	4.63

This genotype invested only 3.6% of the photosynthates in root growth as compared to shoot growth whereas the other genotypes invested between 8.4 to 10.9%. The low number of seminal roots of the mutant were compensated by nodal root growth. Again, the transpiration efficiency of the landraces was lower than that of the other genotypes.

The root length density and weights are given in Table 72. Total root length/root weight ratios were higher in Tadmor than in the other genotypes, therefore the roots of Tadmor were thinner.

3.1.3. Barley development and yield.

It has been observed in previous seasons that grain number per unit area was drastically affected under severe stress. Earliness in flowering was associated to high yield under stress. It is our aim to analyze these two observations in more detail to obtain a better insight into the differences in grain yield between entries within sites.

Thirty six two-row barley entries including landraces, improved genotypes and crosses between landraces and improved genotypes were grown in 12 rows (20 cm apart), 5 m long plots at Tel Hadya and Breda.

Table 72. Root length density (Lv, cm root/cm^3 soil) and weight (g) of four barley genotypes.

Soil Depth	Genotype							
	Tadmor		SLB 8-6		Mutant 8-7		WI 2198	
(cm)	Lv	wt	Lv	wt	Lv	wt	Lv	wt
0-20	4.8	0.468	8.1	0.815	8.0	0.799	9.3	1.222
20-40	2.9	0.211	5.3	0.487	6.1	0.512	7.9	0.679
40-60	2.2	0.149	6.0	0.433	4.3	0.345	6.4	0.466
60-80	1.3	0.098	4.5	0.350	4.0	0.303	7.1	0.459

A simple lattice design was used at Tel Hadya while a triple lattice was used at Breda, the driest site. Ground cover, growth habit, leaf posture, growth vigour, leaf color and frost damage were scored in the field at two week intervals. These field observations have been shown to be correlated with yield under stress in previous years. In addition, every two weeks, samples (4 plants/plot) were taken to measure apex development, leaf number, leaf area and weight as well as main tiller number. Heading time and physiological maturity were scored in the field to complete growth and development observations. An additional four plants were tagged in the field for leaf number measurements and phyllochron period calculations. Grain number of the main tiller was assessed at three stages of development, as in the 87/88 season (Cereal Improvement Program Report. 1988, pp: 86-105): maximum number of primordia (potential kernel number, PKN), heading time (developed kernel number, DKN) and during grain filling (fertilized kernel number, FKN). Other observations made were plant height, peduncle length of the main shoot and awn length (fifth awn from the base of the spike). At harvest, the number of fertile spikes per unit area and the number of grains per 10 random spikes were counted.

3.1.4. Field observations

Results of field observations on growth habit and plant colour confirmed those reported in 1988. Barley landraces showed some variation in these traits but the general tendency was of being prostrate and dark colored early in the season changing to erect and pale green at stem extension. The Tadmor type (Tadmor, A. Abiad, A. Aswad, SLB 60-2, SLB 3-23) was the most prostrate with the darker plant color during winter. The SLB 62 type (SLB 62-68, SLB 62-99 and SLB 62-49) was medium dark during winter and the SLB 8 type (SLB 8-89, SLB 8-6, SLB 8-84 and SLB 8-10) had a dark plant colour only at the beginning of the season, changing slowly to pale green from 300 ^{o}CD to 800 ^{o}CD after emergence. Table 73 shows the time at which the change in plant colour started for the Tadmor type entries. This occurred just before stem extension.

Table 73. Time and thermal time (TT, ^{o}CD) at which the plant color of the Tadmor type group (n=5) became lighter.

Site	Color change Julian date	Color change TT ^{o}CD	TT to 50% heading	Apex development stage (Kirby, 1984)
Tel Hadya	43	550	1057	4.5
Breda	55	600	1129	5.1

During the dark colour period, a purple anthocyanic appearance was also observed, probably as a result of carbohydrate accumulation and, incorporation into anthocyanines. Arabi Aswad, Tadmor, SLB 62-49, SLB 3-23, SLB 39-99, Arta and SBON 96 had the highest visual scores for anthocyanic colour. On the contrary, Roho, Roho/Mazurka and Er/APM had light winter colour and were more frost susceptible. Crosses of Roho with A. Abiad (Tadmor type) were frost resistant while crosses with ER/APM were frost susceptible. A prostrate growth habit, darker plant colour in winter, anthocyanic symptoms and high frost resistance were in general associated. Table 74 shows a correlation matrix among these traits for Breda. Similar correlations were observed at Tel Hadya.

Table 74. Simple correlations between growth habit (GH), leaf posture (LP), winter plant color (PLCW), spring plant colour (PLCS) purple color leaves (PL) and frost damage (FRO). Breda, n = 35.

	GH	LP	PLCW	PLCS	PL	FRO
GH	1.000					
LP	0.942***	1.000				
PLCW	0.861***	0.784***	1.000			
PLCS	-0.143	-0.205	-0.261	1.000		
PL	0.662***	0.649***	0.693***	-0.466**	1.000	
FRO	-0.634***	-0.608***	-0.759***	0.220	-0.521**	1.000

Scoring: GH (1 =erect, 3 = prostrate); LP (1 = erect, 3 horizontal); PLC (1 light, 3 = dark); PL (1 = no symptoms, 3 = high symptom); FRO (1 = no damage, 5 = dead plant). ** ($P < 0.01$), *** ($P < 0.001$).

3.1.5. Apex development.

Results on apex development studies confirmed that the two-row barley landraces are characterized by a longer vegetative phase (emergence to double ridges) and a shorter generative phase or ear initiation period (double ridges to maximum number of primordia) when compared to improved two-row genotypes. Among the landraces, the Tadmor type had the highest ratio between the two phases (1.15-1.17) followed by the SLB 62 group (0.99-0.84) and the SLB 39 group (0.80-0.78). The WI type had a ratio of 0.68-0.70. Under conditions of low winter temperature a long vegetative phase might protect the apex from frost damage. At the beginning of stem extension with the apex in its generative phase, frost may have a damaging effect. Early heading is strongly correlated with grain yield under terminal drought stress, i.e. a short season crop is necessary. A compromise between slow early apical development (providing frost resistance) and early heading implies a shorter ear initiation period. Entries in our nursery unadapted to the Mediterranean environments with cold winters showed a long vegetative period coupled with long ear initiation and ear growth periods. General values for leaf initiation rates and kernel initiation rates coming out of these data and environments are: leaf initiation rate (total leaf number/^{o}CD vegetative period) of 0.032 and kernel initiation rate (potential kernel number/^{o}CD ear initiation period) of 0.086.

Apex development, leaf number in the main shoot and maximum number of tillers per plant were also found to be correlated (Table 80).

Table 75 indicates a strong correlation between leaf number and heading time. A longer vegetative period was associated to more leaves in the main shoot and a later heading date. More leaves in the main shoot imply more potential sites for tillers leading to a positive association between these two variable.

Contrary to expectations, the ear initiation period (EIP) was not correlated to the potential kernel number (PKN). Since the length of the EIP is related to the duration of the vegetative period, EIP values independent of the vegetative period (VP) were generated by taking the residual values of EIP after regression on the independent thermal time to double ridges.

Table 75. Simple correlations between apex development and final leaf number in the main shoot (n = 35). DR = double ridges. MNP = maximum number of primorida and EIP = ear initiation period.

		Thermal time to			EIP	Max.tillers/ plant
		DR	MNP	Heading		
Final leaf No.	TH	0.737***	0.644***	0.601***	-0.205	0.697***
	Br.	0.604***	0.766***	0.565***	0.065	0.539***

* (P < 0.05); *** (P < 0.001).

The correlation of the residuals was only weakly significant (r = 0.392, P < 0.05) at Breda, and was non significant at Tel Hadya. The calculated broad sense heritabilities for PKN were also low (0.58 at Breda and 0.30 at Tel Hadya), indicating that the environment plays a major role in the determination of potential kernel number and that the phenomena is complex. No relation was found between PKN and leaf area index within sites when results of the 87/88 and 88/89 season were examined. The specific leaf area (area of leaves/weight of leaves, SLA) was however significantly (P < 0.05) correlated with PKN within site at the end of the EIP (entries with thinner leaves initiated more kernels). The SLA at maximum number of primordia stage explained 20% of the variation in PKN at Breda. If the EIP adjusted for VP was added to the regression, the reduction in sum of squares increased to 35% with a multiple r = 0.59 (P < 0.01). The overall differences in kernel number of the main shoot appeared to be established at the maximum number of the primordia stage.

There were no overall differences in the percent kernel loss between Breda and Tel Hadya. Furthermore, the percent grain loss after the PKN was realised in a dry season like 88/89 compared well with a wet season (87/88) (Table 76).

Table 76. Potential (PKN), developed (DKN) and fertilized (FKN) kernels in the main shoot expressed as % of potential values.

Season	n	Rainfall (mm)	PKN %	DKN %	FKN %	PKN Relative Values
TH1988	25	499	100	65.8	60.3	1.00
BR1988	25	408	100	62.0	58.5	0.92
TH1989	35	234	100	62.6	58.6	0.90
BR1989	35	180	100	63.4	59.1	0.67

The percent kernel loss in the main shoot appeared relatively independent of drought. While rainfall decreased to a 36.2% the relative PKN decreased only to a 67%. This indicates that in the conformation of grain yield there must be compensatory effects of other yield components. A stepwise regression analysis showed that the number of fertile spikes per unit area of soil explained 58% of the variation in grain yield. A negative correlation was found at both sites between potential, developed, fertilized kernel number and the number of fertile spikes per unit area. Though kernel number was positively correlated to grain number per unit area, it was negatively related ($P < 0.05$) to grain yield due in part to a decrease in kernel weight and in part by the fact that plants with lower number of tillers had higher number of grains per ear ($P < 0.05$ at Breda and $P < 0.01$ at Tel Hadya).

3.1.6. Field observations, phenology and yield

The previous results indicated a relation between plant architecture and apex development. Table 77 shows this association. Similar correlations were obtained for Tel Hadya and Breda.

The results of Table 77 indicate that by selecting for a given plant architecture (visual scores) there is a high probability of selection for a given apex development pattern. None of the traits listed in Table 77 were correlated with the thermal time to heading except for a dark plant color in spring (PLCS) which indicated later heading (P < 0.01) at the driest site only. All the visual traits were also associated with shorter grain filling period, except for frost damage which prolonged grain filling and PLCS which was not correlated. When grain yield was adjusted to a common heading date, a horizontal leaf posture before stem extension and dark color in winter as well as a high difference in plant color between winter and spring were correlated to yield at Breda (P<0.05).

Frost damage was the dominant effect in yield at Tel Hadya (P<0.01), an effect negatively correlated to dark winter color (P<0.001) and positively related to SLA in winter (P<0.01). The data strongly support previous findings for the plant architecture required for dry Mediterranean environments with cold winters. We conclude that a prostrate growth habit, horizontal leaf posture, dark winter plant colour, light spring plant colour, a big change in winter to spring plant colour from dark to light, a long VP, short EIP and a high number of fertile spikes conform a plant architecture adapted to dry, cold Mediterranean environments in two-row barleys. Furthermore, this architecture is not necessarily conducive to an increased number of days to heading and, in the nursery under study, is associated with a short grain filling period (P<0.01 at Tel Hadya and P<0.05 at Breda) and higher grain yield at the drier site.

Table 77. Association between plant architecture and apex development. Breda 88/89.

	Vegetative period (°CD)	Ear initiation period (°CD)
GH	0.579***	-0.425*
LP	0.492***	-0.338*
PLCW	0.488***	-0.505**
PLCS	-0.050	0.458**
DPLC[1)]	0.392*	-0.605***
FRO	-0.335*	0.461**

[1)] DPLC = PLCW - PLCS
* (P < 0.05); ** (P < 0.01); *** (P < 0.001)

Flag leaf length and width were strongly positively correlated ($P<0.01$) to grain yield adjusted to a common heading date at Breda. The correlation was negative with peduncle length and plant height though non significant. At Tel Hadya, no relation of flag leaf parameters with grain yield was observed. Longer awns increased the grain filling period and decreased grain yield at the driest site.

3.1.7. Yield and yield components

Independent measurements of the yield components allowed assessment of their contribution to yield under stress. Table 78 shows the results of a stepwise regression analysis.

The site effect on grain yield components is shown in Table 79. The major effects on yield decreases at Breda are seen to occur due to decreased head number/m^2 and grain number, previously shown to be a result of decreased potential kernel number.

Table 78. Percentage of the variance in grain yield and adjusted grain yield by heading date accounted for by independent measurements of yield components: head number/m^2 (HNM), kernel weight (TKW) and grain number per ear (GN).

Site	Component	Grain yield	Adjusted grain yield
TH	HNM	57.4	58.1
	TKW	6.8	1.5
	GN	0.4	0.0
	Total	64.6	59.6
BR.	HNM	58.1	37.1
	TKW	18.1	10.1
	GN	10.4	0.8
	Total	86.6	48.0

A major step forward in yield under stress can be done by selecting genotypes with high number of fertile spikes as previously indicated (see Cereal Program Annual Report 1986). In turn, high number of fertile spikes is associated to the "landraces syndrome of traits" discussed here and in previous reports.

Table 79. Average values for yield and yield components at Tel Hadya and Breda (n = 35).

	Tel Hadya (TH)	Breda (BR)	BR/TH
Grain yield (g/m^2)	253.5	125.2	0.49
HNM	505.4	123.7	0.64
GN	21.2	16.7	0.79
TKW	35.1	32.9	0.94

Conclusions

a. The relation between early heading and grain yield was confirmed once more. For cold, dry Mediterranean environments as those in northern Syria, earliness per se is not enough, it has to be qualified involving a long vegetative period and a short ear initiation period. Short grain filling is a desirable attribute in 2-row barleys with terminal drought. This pattern is associated to a syndrome of morphological traits easily screened visually.

b. Within a site no major gain in grain yield may be expected by increasing the kernel number per ear under stress. Increased kernel number is compensated by a decreased number of fertile spikes per unit area, the yield component which explains the major part of the variance in grain yield.

3.1.8. Durum Wheat Physiology/Agronomy - Genotype characterization.

A joint regression analysis performed on the durum wheat physiology nursery assembled in the 85/86 season showed that the range in variety mean yield was low and that most of the genotypes in the nursery had below average stability (ICARDA 1987, Cereal Improvement Program Report pp: 117-126). A nursery with a wider genetic background was assembled in 1988 comprising 81 genotypes contrasting in their adaptation to the environments of North Africa and West Asia. Several landraces were included in this nursery together with the 20 genotypes of the original nursery hoping to find better sources of stress resistance and a wider range in morphophysiological traits.

The newly assembled nursery was planted at Tel Hadya and Breda in northern Syria, as well as at Montpellier in France with the collaboration of Dr. Philippe Monneveux. At Montpellier the nursery was grown under irrigation and rainfed conditions. Four environments per season were thus created. A common field design at the four environments a 9 x 9 simple lattice is being used. Due to the limited quantity of seed available, plot size was kept during the first season at 6 rows 2.5 m long and 20 cm apart instead of 12 rows, 5 m long regularly used in our physiology studies. In northern Syria crop husbandry was as described elsewhere (ICARDA, 1986. Cereal Improvement Program Report pp: 107-121) with a sowing rate equivalent to 120 kg/ha. Planting dates, emergence date and harvesting were the following for tne Tel Hadya and Breda sites:

	Tel Hadya	Breda
Planting	November, 13, 1988	November, 2, 1988
Emergence	November, 26, 1988	November, 13, 1989
Harvest	May, 29, 1989	May, 20, 1989

In Syria observations were limited to visually scored morphological traits and yield, while at Montpellier more detailed studies on chlorophyll fluorescence, water potential and components are also being conducted. We report here on the results of northern Syria. Tables 80 and 81 summarize those attributes which were correlated with

Table 80. Durum wheat physiology nursery 88/89. Simple correlations between plant and crop attributes and grain yield (81 genotypes, Breda (194 mm).

Crop Attribute (Zadoks)	Score	Mean (range)	Phenotypic standard deviation	Correlation coefficient
Grain yield		85.1 (34.4 - 178.5)	22.7	
Ground cover	(1-10)			
(22)		3.8 (2.0 - 6.0)	0.7	0.25**
(30)		7.1 (6.7 - 8.0)	0.3	0.27**
(60)		7.6 (7.0 - 8.3)	0.3	0.30**
Growth vigour	(1-5)			
(22)		2.3 (1.5 - 3.3)	0.4	0.30**
(30)		3.1 (2.5 - 3.8)	0.3	0.30**
(60)		3.8 (3.3 - 4.5)	0.3	0.40**
Tiller number				
(22)		1.7 (1.0 - 3.0)	0.5	-0.06
(30)		2.4 (1.5 - 4.0)	0.5	0.03
(36)		2.2 (1.5 - 4.0)	0.5	0.23**
Flag leaf main shoot				
Length		15.1 (12.3 - 22.9)	1.9	-0.03
Width		1.2 (1.0 - 1.5)	0.1	0.22*
Peduncle length		25.2 (16.0 - 36.3)	4.4	0.19*
Plant height at maturity		56.6 (42.5 - 75.5)	6.0	0.18*
Days to heading		142.9 (134.5 - 153.0)	3.7	-0.34**
Days to maturity		175.9 (171.0 - 181.5)	2.5	-0.37***
Spikes/m^2		86.7 (102.1 - 412.5)	44.2	0.37***
Straw yield		147.9 (96.0 - 269.1)	30.9	0.47***

Harvest index		0.29 (0.16 - 0.37)	0.04	0.70***
Wilting score	(1-5)			
(22)		1.6 (1.0 - 2.8)	0.5	-0.17*
Glaucousness				
Stem	(1-3)	2.8 (1.0 - 3.0)	0.5	-0.21*
Leaves	(1-3)	1.9 (1.0 - 3.0)	0.8	-0.01
Leaf colour				
(30)	(1-3)	2.2 (1.0 - 3.0)	0.6	-0.05
(60)	(1-3)	2.2 (1.0 - 3.0)	0.6	-0.01
Frost damage				
(22)	(1-5)	1.2 (1.0 - 1.8)	0.2	-0.11
Above ground biomass		294.7 (172.6 - 497.4)	54.8	0.83*

* P < 0.05, ** P < 0.01, *** P < 0.001

Table 81. Durum wheat physiology nursery 88/89. Simple correlations between plant and crop attributes and grain yield (81 genotypes). Tel Hadya (234 mm rainfall plus 50 mm irrigation).

Crop Attribute (Zadoks)	Score	Mean (range)	Phenotypic standard deviation	Correlation coefficient
Grain yield		172.8 (70.0-305.0)	48.6	-
Ground Cover	(1-10)			
(22)		4.3 (2.3 - 6.0)	0.7	0.02
(32)		6.8 (6.3 - 7.5)	0.3	0.18*
(50)		8.1 (6.5 - 9.5)	0.7	0.18*
Growth vigor	(1-5)			
(22)		2.4 (1.5 - 3.0)	0.4	0.10
(24)		2.9 (2.3 - 3.8)	0.3	0.17*

Tiller number				
(22)		2.5 (2.0 - 3.0)	0.4	0.16*
(24)		3.9 (2.0 - 5.0)	0.6	0.20*
Flag leaf main shoot				
Length		15.3 (12.2 - 19.9)	1.7	0.10
Width		1.3 (1.0 - 1.7)	0.1	0.25*
Peduncle length		26.2 (19.0 - 46.2)	4.9	0.39***
Plant height at maturity		66.5 (52.5 - 98.0)	9.2	0.24**
Days to heading		132.5 (129.0 - 138.5)	2.4	-0.25**
Days to maturity		169.8 (165.0 - 178.5)	3.3	0.02
Spikes/m^2		253.7 (143.7 - 404.2)	47.1	0.49***
Straw yield		399.4 (247.1 - 685.8)	91.1	0.66***
Wilting score				
(22)	(1-5)	2.5 (1.0 - 4.3)	0.9	-0.14
Glaucousness	(1-3)	2.9 (1.0 - 3.0)	0.4	-0.08
Leaves	(1-3)	2.6 (1.0 - 3.0)	0.5	-0.11
Leaf Colour				
(24)	(1-3)	2.0 (1.0 - 3.0)	0.6	0.21**
(50)	(1-3)	2.2 (1.0 - 3.0)	0.8	0.22**
Frost damage	(1-5)			
(23)		2.0 (1.5 - 3.5)	0.5	-0.25**
Above ground biomass		572.1 (343.8 - 916.7)	126.0	0.84***
Harvest index		0.30 (0.15 - 0.41)	0.06	

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

grain yield at one or both sites. The attributes are similar to those reported earlier for barley (ICARDA 1987. Cereal Improvement Program Annual Report pp. 117-126). Winter ground cover (Zadoks 20 to 30), which is an important parameter in terms of radiation interception, and water use efficiency, was also found to be related to a higher number of leaves in the main shoot, a horizontal leaf posture and a darker winter leaf colour. These traits have been suggested as having a positive effect on the growth and yield of two row barleys in northern Syria (ICARDA. 1988. Cereal Improvement Program Annual Report. pp. 86-113). The data show that the nursery assembled has enough variability to warrant detailed studies and eventually provide solid information on stress resistance traits to the durum wheat breeding project.

Table 82 summarizes easily scored traits which, in the interim, may be used to aid in selections of durum wheat for stressed Mediterranean environments.

3.1.9. Potential sources of stress resistance.

Analysis over nine environments (years and locations) of the barley, durum wheat and bread wheat physiology nurseries using the residual yield index (RYI) proposed by Bidinger et al. (Aust. J. Agric. Res. 1987. 38: 48-59) allowed the identification of genotypes performing well under stress intensities greater that 0.5 (stress intensity calculated as 1- Y_D/Y_P) after eliminating yield potential (Y_P) and phenology (days to heading) effects. These genotypes are potential sources of stress resistance for the Mediterranean type of environments of South West Asia. They are given in Table 83. Note the predominance of landraces in the 2-row barley genotypes.

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Table 82. Durum wheat attributes correlated with high grain yield at Tel Hadya and Breda (81 genotypes). 88/89 Season.

- High winter ground cover
- Good early (winter) vigour
- High tiller number
- Wide flag leaf in the main shoot
- Long peduncles
- Tall plants
- Early heading
- Short crop duration (Breda only)
- High number of fertile spikes
- High straw yield
- Low canopy temperature

Table 83. Potential sources of stress resistance for Mediterranean environments of West Asia. RYI significantly greater than 0 for stress intensity greater than 0.5.

2-row barley	6-row barley	durum wheat	bread wheat
Roho/Masurka	Assala-06	Om Rabi 14	FLK's/Hork's
Roho*	Badia	Daki	Golan
SLB 39-99	Athenais*	Haurani	HD2206/Hork
SLB 62-35	C 63	Belikh 2	Ures 81*
SLB 45-38	Deir Alla 106	Cham 1*	Katya A-1
SLB 8-6	BAT 414		
SLB 60-2*			
SLB 39-43			
SLB 45-65			

* Genotypes with the highest RYI.

3.1.10. Agronomy

Durum and bread wheat have a slow growth early in the season, such that the ratio of transpiration (T) to evapotranspiration (ET) is very unfavorable when compared to barley during the months of January and February (Table 84). Increasing the early ground cover by agronomical means leads to a more favourable ratio of T/ET and a higher radiation interception, both conducive to a better use of limited resources and hence an increased yield. Increased winter ground cover can be achieved by early planting and narrow row spacing as reported for barley (Cereal Improvement Program Report 1986, pp: 62-75). Three durum wheat varieties of similar phenology were planted in a 3^4 unreplicated factorial experiment at Tel Hadya and Breda. The effects of row spacing and planting date on ground cover, number of fertile spikes per unit area and yield are presented in Table 85, 86 and 87. Planting dates were around 15 October (early), 15 November (medium) and 15 December (late). The results show that early planting and narrow (10 cm) row spacing with a constant sowing rate of 120 kg/ha increased ground cover, number of fertile spikes, total above ground biomass and grain yield significantly. No varietal effects on grain yield were observed.

Table 84. Percent difference between barley (B) and wheat (W) in ground cover and in the ratio of transpiration to evapotranspiration. The values are for the winter months of January and February, 40 to 80 days after emergence (approximate Zadoks scores 13 to 24).

Days after emergence	Ground cover (B-W)/B %	T/ET[1] (B-W)/B %
40	16	63
50	17	52
60	12	46
70	10	20
80	9	14

1) Mean of six barley and four wheat genotypes. Transpiration (T) obtained as in Cooper et al. (1983).

Table 85. Winter ground cover. Main effects of variety, row spacing and planting date. Durum wheat, 3 to 6 leaf stage according to planting date. 1988/89 season.

Factor	Ground cover (%)	
	Tel Hadya	Breda
Variety		
Om Rabi 14	35**b	24**b
Sebou	34 b	23 b
Korifla	40 a	28 a
Row spacing		
10 cm	43**a	32**a
20 cm	38 b	25 b
40 cm	28 c	19 c
Planting date		
Early	52**a	45**a
Medium	38 b	25 b
Late	19 c	5 c

N = 27; * P < .05; ** P < .01; different letters in the same column for a given factor indicate significant differences.

Table 86. Effect of variety, row spacing and planting date on number of fertile spikes per unit area. Durum wheat, 88/89 season. Rainfall: Tel Hadya 239 mm + 50 mm irrigation. Breda: 194 mm.

Factor	No. of fertile spikes/ m^2	
	Tel Hadya	Breda
Variety		
Om Rabi 14	203* b	107**b
Sebou	206 b	122 ab
Korifla	234 a	141 a
Row spacing		
10 cm	225**a	133* a
20 cm	222 a	126 a
40 cm	196 b	111 b
Planting date		
Early	236**a	194**a
Medium	202 b	166 b
Late	205 b	10 c

N = 27; * P < 0.05; ** P < 0.01; Numbers followed by a different letter in a column for a given factor differ significantly.

Table 87. Main effects of variety, row spacing and planting date on total above ground biomass (BIOY) and grain yield (GWT). Durum wheat. 1988/89 season rainfall: Tel Hadya 239 mm + 50 mm irrigation. Breda: 194 mm.

Factor	Tel Hadya BIOY (t/ha)	Tel Hadya GWT (t/ha)	Breda BIOY (t/ha)	Breda GWT (t/ha)
Variety				
Om Rabi 14	4.8* b	1.6 a	1.6 a	0.4 a
Sebou	5.3 a	1.9 a	1.7 a	0.4 a
Korifla	5.1 ab	1.7 a	1.8 a	0.5 a
Row spacing				
10 cm	5.7**a	2.5**a	2.1**a	0.6**a
20 cm	5.0 b	2.3 a	1.6 b	0.4 b
40 cm	4.6 c	2.0 b	1.4 b	0.3 b
Planting date				
Early	6.7**a	2.4**a	3.9**a	0.7**a
Medium	4.3 b	1.5 b	1.9 b	0.5 b
Late	4.4 b	1.3 b	0.3 c	0.0 c

N = 27; * $P < 0.05$; ** $P < 0.01$; Numbers followed by a different letter in a column for a given factor differ significantly.

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3.2. Pathology

3.2.1. Wheat pathology

Screening for disease resistance

The local screening conducted in the 1988/89 season at T. Hadya and Lattakia covered five major wheat diseases : 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). However, additional information on the above diseases and on the disease powdery mildew (Erysiphe graminis) were obtained through the multilocation testing system.

Results of the Key Location Disease Nursery (KLDN) in 1987/88 are summarized in Tables 88 and 89. Disease data on the particular diseases were obtained from :

Pakistan	:	leaf rust
Iran	:	leaf rust
Turkey	:	leaf and stem rusts; powdery mildew
Syria	:	leaf and yellow rusts; septoria blotch; common bunt; barley yellow dwarf virus.
Lebanon	:	yellow rust
Jordan	:	leaf rust; powdery mildew
Yemen	:	stem rust
Ethiopia	:	stem rust
Tunisia	:	septoria blotch
Morocco	:	leaf rust; septoria blotch
Portugal	:	leaf rust; septoria blotch
Mexico	:	leaf rust.

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* Data from the ICARDA Virology Unit

Together there were 8 sites for leaf rust, 3 for stem rust, 2 for yellow rust, 4 for septoria, 2 for powdery mildew and 1 each for common bunt and barley yellow dwarf virus*.

Tables 88 and 89 show the number of entries exhibiting resistance to a group of diseases, as they are relevant in the agro-ecological areas of the WANA region. In the Durum-KLDN, 9 entries were resistant to the three rusts, (Table 88). Resistance to powdery mildew, septoria and barley yellow dwarf virus was shown in 22 entries; whereas 9 entries showed resistance to yellow rust and common bunt. In addition, some of these entries showed resistance to the two groups of diseases.

Table 88. Number* of durum wheat lines with multiple resistance** to major groups of wheat diseases (KLDN-88)

Disease group	No. Entries	Entry No.
Leaf, stem and yellow rust	9	71, 109, 163, 169, 173, 183, 185, 194, 199
Powdery mildew, septoria blotch and barley yellow dwarf	22	18, 35, 44, 54, 62, 66, 74, 76, 86, 87, 108, 109, 117, 118, 131, 133, 164, 172, 181, 185, 192,199
Common bunt and yellow rust	9	41, 44, 91, 155, 178 181, 178, 194, 197

* Total number tested 180, checks excluded
** Selection criteria - Leaf rust, ACI 10; stem and yellow rust, ACI 2
- Powdery mildew, septoria blotch and barley yellow dwarf, 0-5 on 0-9 scale
- Common bunt 0-15% head infection

Three durum wheat entries (nos. 109, 185 and 199) were resistant to three rusts and the powdery mildew-septoria-barley yellow dwarf group. Entry 44 was resistant to powdery mildew, septoria, yellow dwarf and the yellow rust-common bunt group. Entry 194 was resistant to the rusts and to the yellow rust-common bunt group. Names and source of these entries are as follows:

KLDN 88	Name or Cross
109	Gta/D21563/AA/3/Stk/5/Fg/4/Jo/61-130//61-115/3/Gll
185	Lahn-SH
199	Qfn/Memo/3/Oyca//Ruff/Fg
44	Brachoua
194	Swan//Dack/Rabi

In the bread wheat KLDN, 31 entries showed resistance to the rust group and 48 to the powdery mildew, septoria and barley yellow dwarf group. None of the entries tested showed combined resistance to yellow rust and common bunt (Table 89). However, some of these entries showed resistance to both groups: rusts, powdery mildew, septoria, and barley yellow dwarf. These are :

KLDN 88	Name or Cross
55	Hohm//R 16010/Ska(3)
56	Crow/Vee
78	Ww 33/Vee
85	Rbs/Anza/3/Kvz/Mys//Ymh/Tob/4/Bow
179	Sd468.5/8156/3/Chr//Sn64/Kl.Rend/4/Cc/5/Iwp19
182	Ns 732/Her
212	Bb/G11//Cj71/3/T.aest.//Kal/Bb

Table 89. Number* of bread wheat lines with multiple resistance** to major groups of wheat diseases (KLDN-88)

Disease group	No. Entries	Entry No.
Leaf, stem and yellow rust	31	3, 6, 17, 18, 51, 52, 53, 54, 55, 56, 67, 78, 85, 93, 97, 122, 125, 128, 129, 131, 132, 139, 142, 159, 161, 162, 174, 179, 182, 187, 212
Powdery mildew, septoria blotch and barley yellow dwarf	48	1, 4, 5, 6, 12, 15, 17, 18, 21, 24, 25, 33, 38, 39, 41, 55, 56, 68, 72, 78, 85, 86, 94, 95, 118, 145, 154, 155, 156, 157, 158, 163, 166, 169, 172, 176, 179, 182, 186, 199, 202, 205, 207, 211, 212, 213, 214, 216

* Total number tested 198, checks excluded
** Selection criteria- Leaf rust, ACI 10; stem and yellow rust, ACI 2
- Powdery mildew, septoria blotch and barley yellow dwarf, 0-5 on 0-9 scale
- Common bunt 0-15% head infection

Germplasm pools for sources of resistance

Lines showing resistance in the local and multilocational screening are assembled in special-purpose disease nursery and retested for 2-4 years in different locations. During this retesting, lines are selected for acceptable agronomic traits and for reasonable resistance to a targetted disease. In the 3rd phase, lines with resistance to a disease are pooled together, increased and distributed to NARs. For the season 1989/90 three new germplasm pools for resistance were developed and 39 sets of these were furnished to collaborators in the region and abroad. The pools are for septoria blotch in durum and bread wheat and for common bunt and yellow rust in durum wheat (Tables 90, 91, and 92). Resistance to septoria was confirmed by a seedling test carried out in growth chambers with a combination of different pathogen isolates from Syria.

Lines in these pools are the end-products of our screening for septoria and yellow rust, and for common bunt and yellow rust.

There are 19 lines in the durum wheat germplasm pool for septoria resistance. Mean score of the disease ranged from 0-6 in field tests but did not exceed the mean score of Gezira 17 (Table 90). Mean necrosis in the seedling test was higher than that of the check in two lines (No. 12 and 18). Pycnidial formation was always less than the check. Almost all lines had good resistance to yellow rust. Earliness of these lines ranged from 133 to 156 days to heading and were with the exception of three lines (No. 5, 11 and 19), 2-15 days earlier than the check. Ten out of the 19 lines in this pool are extensively used by the breeder to up-grade the resistance level to septoria in the durum wheat project. The most selected crosses in advanced segregating generations (F5 - F7) are those from the parents Shwa/Bittern (13%), Pin/Gre//Trob (5%) and Crosby (3%). Some lines in this pool combine earliness, septoria resistance, and high yield potential. For example Lahn, a cross between Schearwater and Bittern, showed an increase in yield by 16% as compared to Gezira 17 and 4% as compared to Cham 1, a newly released variety (Table 91).

Table 90. The performance of selected durum wheat lines to septoria tritici blotch, Mycosphaerella graminicola and yellow rust, Puccinia striiformis (DSTGP 87)

	Mean score[1)]				Seedling test[2)]		
Year	1984	1985	1986	1987	Necrosis	Pycnidia	Yellow
No. screening sites	4	2	4	3			rust[3)]
Name or Cross:							
1. Shwa/Bit	3	6	4	6	4	+	20MR
2. Shwa/Bit	4	5	4	-	5	+	tR
3. Shwa/Goo	4	4	4	-	6	++	5MR
4. Fg/Rabi	5	3	3	5	7	+	tMR
5. PI 298547	3	4	4	4	7	+	5R
6. (ACC 3040*Lang)Leeds	2	6	4	5	6	+	tR
7. Pin/Gre//Cit/Fg	-	4	4	6	6	+	tR
8. Pin/ Gre//Cit/Fg	-	4	3	5	6	+	0
9. Pin/Gre//Cit/Fg	3	5	6	-	7	++	5MR
10. Badri//Gta/Fg	6	5	4	-	5	+	10MR
11. Berillo	6	4	6	-	7	+	0
12. Grosby	5	6	4	-	8	++	0
13. Br/ZB/4/G11/3/ BYE*2/Tc//213W	3	6	5	-	7	+	0
14. Memo/Goo	-	6	4	5	6	+	10MR
15. Uveyik126/61-130// Kohak2916/Lds/3/Ibis	0	6	5	-	6	++	5MR
16. D/T/3/D 21563/AA//Fg	6	4	3	6	6	+	25MR
17. Cr/4/21563/61-130// Lds/5/Cameltooth/6/ Gs/Cr//Shwa	1	6	5	-	6	+	5MR
18. MT/S1K//Ch67/ 21563/3/Waha	4	6	5	-	8	+	5MR
19. P9/3/GU//T.dic.v. vern/GU	4	6	4	6	6	+	10MR
Gezira 17 (Check)	-	8	6	7	7	+++	

1) Septoria Scale 0-9.
2) Septoria Necrosis (0-9)= mean score on 30 leaves 21 days after inoculation.
Pycnidia formation: +light; ++ moderate;+++ abundant.
3) Yellow rust; highest reading of severity and reaction type.

Table 91. Performance (kg/ha) of three durum wheat varieties in on-farm trials under irrigated conditions; Raqqa/Syria.

Variety	Season 1985/86	1986/87	1987/88	Mean	%-increase over Gezira
Gezira 17	8906	9310	7281	8499	-
Cham 1	10332	9295	8677	9435	11
Lahn (Shwa/Bit)	9341	10473	9708	9841	16

Table 92. The performance of selected bread wheat lines to septoria tritici blotch, Mycosphaerella graminicola and yellow rust, Puccinia striiformis

	Mean Score1)				Seedling test2)		
Year	1984	1985	1986	1987	Necr.	Pycn.	Yellow rust3)
No. screening sites	2	3	4	3			
Name or Cross							
1. Vee	3	4	1	5	4	+	5M
2. Vee	4	4	2	7	6	+	5R
3. Snb	2	2	2	3	5	+	5R
4. Snb	1	2	2	4	2	0	5R
5. Barbet/Manatial	4	4	3	6	4	0	5R
6. Bb/Cno//CI 12703/3/Bow	-	4	4	6	5	+	10MR
7. Pj/Hn4//Gll	-	3	2	4	5	+	5R
8. Pj/Hn4//Gll	-	1	3	4	5	+	5R
9. Bb/Kal//TJB791-12765	-	1	3	3	6	+	5R
10. 4777(2)//Fkn/Gb/3/Vee /4/Buc/Pvn	-	5	2	6	4	+	10MR
11. Vee/Snb	-	3	2	7	6	+	5R
12. IAS58/IAS55//Ald/3/Mrng /4/Ald/IAS58.103A//Ald	-	0	4	6	5	+	5R
13. Bow	-	0	3	4	6	0	35MS
14. Pvn/Sprw	4	2	3	7	5	+	5R
15. Pvn/Sprw.	-	2	7	4	5	+	5R
16. C182.24/C168.3/3/ Cno*2/7C//Cc/Tob	-	4	2	5	5	+	5R
Mexipak (check)	8	9	8	9	7	+	

1) Septoria-Scale 0-9. 2) Septoria-Necrosis (0-9)= mean score on 30 leaves 21 days after inoculation. Pycnidia formation: +light; ++ moderate;+++ abundant. 3) highest reading of severity and reaction type.

Sixteen lines were found in the bread wheat germplasm pool for sources of resistance to septoria blotch (Table 92). Mean score of the disease in each of the testing years ranged from 0 to 6 except for four lines (No. 2, 11, 14 and 15) which received the highest score of 7 in one year. Mean necrosis in the seedling test ranged from 2 to 6 and the pycnidial formation on any of the lines was equal to the check or less. In general, all lines in adult and seedling stage testing showed better resistance than the check. All lines except one (No. 13) had good resistance to yellow rust. Eight lines (No. 1, 2, 3, 4, 6, 10, 11 and 13) out of the sixteen lines in this pool carry the 1B/1R translocation. The earliness level (days to heading) is quite acceptable. It ranges from 130 - 147 days under the conditions of northeastern Syria, and 11 lines are 2-13 days earlier than the check. However, some lines in this pool appear not to yield well under rainfed conditions.

Table 93 summarizes the performance of the 19 durum wheat lines in the germplasm pool for sources of resistance to common bunt and yellow rust (DCBYRGP 88). Lines in this pool have undergone at least one year of testing using ten common bunt isolates from the region. Percentage head infection ranged from 0-19%. The resistance to the non-targeted disease, yellow rust was acceptable.

Table 93. Performance of selected durum wheat lines to common bunt, Tilletia foetida and T. caries; and yellow rust, Puccinia striiformis (DCBYRGP 88).

Screening year	Common bunt[1] 1984	1985	1986	1987	1988	Yellow[2] rust
Ent. Name or Cross						
Senatore Cappelli	-	0	3	4*	-	35MR
Kabir 1 = Ovi/Cp/Fg	-	6	10*	13*	-	5M
Cr/3/Jo//61-130/Lds/4/Ente	5	4*	14*	-	-	15MR
Gediz 75 / Bit	-	3*	-	-	16*	5MR
Fa/Cando	5	1*	-	-	4*	10MR
Gdovz 469/Plc//Jo	5	4*	-	-	-	5MR
Cit/Gdovz 579	5	1*	-	-	7*	20MR
Snipe/F. 9-3	-	3	9	4*	-	5MS
CDK = Candeal//Cappelli/ Candeal	-	0	8	12*	-	20MS
Capeiti Mut.=Eiti 6- Cappelli	-	4	9	8*	-	20M
MG 5927, cv Montferrier	-	0	5	5*	-	10MR
61-130/414//44/3/AA	-	0	4	15*	-	5R
Tafna 1 = Swan//Dack/Rabi	-	0	5*	-	-	5R
Tafna 2 = Swan//Dack/Rabi	-	0	5*	-	-	5MR
Daki = Dack/Gd//USA 575	-	-	8*	-	19	20M
Syrica 1 = Shwa/Ptl	5	5*	9*	-	-	5MR
Tigris = Fg/Pales//Mexi/ 3/Ruff/Fg	-	5	6*	-	-	15MR
Oronte 1=Cit 71/Mexi//Shwa	0*	3*	2*	-	-	0
Barika =Jo/Cr//USA 01679/ 3/Jo/Gr	-	5	9*	-	-	0

1. Common bunt=%infected heads using composite isolates from Syria; (*) Average of 10 different isolates from the region (3 Syria, 2 Turkey, one each Pakistan, Iran, Lebanon, Tunisia and Morocco) 2.Yellow rust=highest reading of severity and infection type over two years.

O.F. Mamluk

Combined tolerance to septoria leaf blotch, powdery mildew and barley yellow dwarf virus in bread and durum wheat.

Cereals are affected by a number of fungal and viral diseases which lead to reduction in yield. In areas characterized by moderate rainfall (400-600 mm), such as North Africa, powdery mildew (Erysiphe graminis fs. tritici), Septoria tritici blotch (Mycosphaerella graminicola) and barley yellow dwarf virus (BYDV) are economically important diseases. Bread and durum wheat entries from the Key Location Disease Nurseries were evaluated for their reaction to these three diseases in multilocation testing at "hot spots" under high disease pressure. Powdery mildew data were obtained from natural infection at Deir Alla/Jordan and Sakarya/Turkey. Data on septoria were obtained from Tel Hadya/Syria, from Guich and Merchouch/Morocco, from Beja/Tunisia, and from artificial inoculation with isolates of the pathogen prevailing in each country.

A PAV isolate of BYDV was inoculated by using the aphid vector Rhopalsiphum padi during the tillering stage at Tel Hadya, Syria. Disease symptoms were scored 8 weeks after BYDV inoculation.

Disease score for all three diseases was based on a 0-9 scale, (0= no symptoms and 9 very severe symptoms where plants are almost killed). Bread and durum wheat lines which had an average disease score of 5 or less in two replications for all three diseases are summarized in Table 94. These lines produced grain yield above average after inoculation with BYDV.

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Table 94. Reaction of bread and durum wheat lines to septoria leaf blotch, powdery mildew, and barley yellow dwarf virus (BYDV) in multilocation testing (KLDN 1987/88).

Entry No.	Name or cross	Disease reaction (0-9 scale)			Yield and Earliness			
					Tel Hadya Supplementary irrig.		Breda (rainfed)	
		Powdery Mildew	Septoria	BYDV	Grain yield (kg/ha)	Days to heading	Grain yield (kg/ha)	Days to heading
1	Gen8/Yaco	4	4	4	5250	153	3694	131
2	Vee/3/R37/Gh1121/Kal/Bb	5	5	5	5183	153	3944	126
3	Kvz/Cj/Mad	0	5	4	5050	153	3594	128
4	A041/Emu	4	4	5	4333	153	3716	131
5	Vee/Nac	1	5	5	6391	161	4000	133
6	Fln/Acc/Ana/3/Prl	2	5	4	4233	166	3361	132
7	Fln/Acc/Ana/3/Prl	0	5	4	2850	167	3472	131
8	Vee/Nac	2	5	5	5783	161	3666	133
9	Rbs/Anza/3/Kvz/Mys//Ymh/Tob/4/BOW	3	5	5	5125	164	3350	132
10	Ttr/Jun	4	4	5	6033	153	3772	128
11	Prl/Pew	2	5	5	4550	155	3816	130
12	Maya/Sap	4	4	5	4800	155	3855	132
13	Pfau/Banks/BOW	3	5	4	4416	161	3638	133
14	Sd648.5/8156/3Chr//Sn64/Kl.Rend/4/Cc/5/Iwp19	2	5	5	3783	158	3283	129
15	Tr380-16-3A614/Chat	4	5	5	5508	155	-	-
16	Dga/4/Napo/Tob/8156/3/Kal/Bb	0	5	5	4958	153	-	-
17	2Ca542C/Skorospelka//Neuzucht/3/Nac76	0	5	4	5433	160	-	-
18	MA-12	1	5	4	4666	166	4916	149
19	Scar/Gdovz579/3/Gdovz471/Br//Pg	4	5	5	4316	174	5450	151
20	Ente/Mario//Cando	4	4	5	4283	173	4811	151
21	Gta//D2563//AA/3/Stk/5/Fg/4/Jo/61-130-115/3/G11	1	5	5	5058	159	5366	144
22	Loukos 3	4	5	5	3558	163	3855	145
23	Akrache 1	5	5	4	4525	163	4516	147
24	Hui/Yav	4	5	5	4083	161	4338	143
25	Stk/Gediz/3/Pt1/S15/Cr/4/Yav79	4	5	4	3400	163	4394	144
26	Marrout	5	5	5	5688	167	6177	144

3.2.2. Barley pathology

Introduction

To avoid losses due to barley diseases, methodologies to control pathogens have to be developed that fit the farming systems of the WANA region. Most barley is grown in low-input systems, either in drier regions, or in shallow soils in areas with a higher rainfall. As the demand for cereals is growing, inputs are continuously increased with farmers abandoning fallow and using barley as a break crop in land that was previously devoted only to wheat. It is difficult to identify a single major disease in a given area because of the large variation between years in rainfall and temperature, and because of the large influence agronomic practices play in disease development. High moisture levels are needed for most leaf pathogens, but although a disease like barley scald (Rhynchosporium secalis) needs free water to sporulate and infect new leaves, its ability to develop at relatively low temperatures and the presence of initial inoculum on seed or stubble, enables epidemic development during winter rainy periods, even in the drier regions. Seed-borne diseases such as smuts and bunts, depend less on the climatological conditions and more on the quality of the seed the farmer uses.

Strategies to control diseases can be based on cultural methods, on chemical control by fungicides, or on resistance. The use of fungicides is not economical in areas with low yields. An exception might be the use of seed dressings with systemic fungicides that not only protect the crop from its seed-borne pathogens, like smuts or barley leaf stripe, but also have a protective effect against diseases that are transmitted by seed or affect the crop in an early stage through inoculum that over summers on the residue of the previous season. Cultural practices can be used to control a number of diseases, but these often conflict with prevailing agronomic methods:

i.e. mono-culture, earlier and deeper sowing, application of fertilizer or supplementary irrigation all favour the development of diseases by extending the growth period, by promoting dense plant stands and by providing better opportunities for the pathogens to survive crop-free periods.

Among the different aspects of modern farming systems, the replacement of old landraces by improved germplasm has the largest influence on the status of plant diseases. So far the introduction of improved germplasm has led to genetic homogeneity of the host plant populations, which can lead to destructive epidemics by highly virulent pathogen strains, unwittingly selected for. Furthermore, introduced germplasm is often unsufficiently tested in its target environment. After a few years of commercial cultivation it may prove susceptible to diseases, of previously minor importance.

Our research in barley pathology centers on the identification and utilization of genes that will provide durable resistance, thereby providing the farmers with the most economical way of controlling diseases both in traditional and in improved farming systems. To evaluate potential sources for resistance it is essential to study the variability within the pathogen population. Virulence studies on major barley pathogens are therefore made both in our own program and in collaboration with colleagues from other institutions.

A relatively new activity within the project are studies on the losses caused by diseases and the interaction of disease development and losses with drought. These studies will help to assess the importance of different pathogens in different environments and can therefore assist in the targeting of germplasm within the breeding program.

International screening for resistance to powdery mildew

Powdery mildew (Erysiphe graminis) is an obligate parasite which occurs wherever barley is grown. Within the WANA region it is especially severe in areas with a relatively high temperature and adequate moisture. However, yield losses of up to 10% have been measured at ICARDA's research station at Tel Hadya on susceptible varieties, even though disease development is only severe during the early growth stages of the crop. The pathogen is highly variable and although many resistance genes are known, single genes have rarely given durable protection to plants in areas with high disease pressure. To incorporate adequate resistance into ICARDA's germplasm and to detect lines that might be used as donors for broad-based resistance, we use a selection strategy based on multi-location field testing in a wide range of environments in collaboration with scientists of NARS both within and outside WANA. Table 95 shows the locations and the average disease pressure during two years testing of entries in the Advanced Barley Yield Trials.

Table 95. Screening of ICARDA's advanced barley yield trials for resistance to powdery mildew, during 1987-88 (360 entries) and 1988-89 (324 entries). Testing sites, average disease score (0-9 scale) and average correlation coefficient with other testing sites.

Location	Average disease score		Average correlation	
	1987-88	1988-89	1987-88	1988-89
Tel Hadya, greenhouse	3.8	6.3	0.38	0.25
Tel Hadya, field	0.7	-	0.23	-
Cyprus, Athalassa	3.7	-	0.34	-
Egypt, Giza	-	1.2	-	0.05
Tunis, Beja	1.3	5.0	0.11	0.13
Morocco, Rabat	6.6	7.4	0.15	0.21
Morocco, Merchouch	3.4	5.4	0.32	0.13
Morocco, Tessaout	3.8	-	0.21	-
Italy, Perugia	6.9	5.7	0.10	0.18
Italy, Bologna	-	7.0	-	0.22
Iran, Gorgan	4.8	3.6	0.19	0.23

Although the entries change from one year to another, large differences in disease pressure are observed between years and between testing sites (Table 95). Listed also are the average correlation coefficients of readings of a specific site with the other sites. Sites that show a stronger correlation of results with the other sites are more useful for the screening.

The results show that the screening of adult plants in the greenhouse at Tel-Hadya, where a favourable environment exists for the development of the pathogen, are relatively well correlated with the readings in the other locations. The relatively poor correlation of the readings in Tunisia and in Perugia might be caused by a different virulence pattern of the pathogen population. The results also indicate that a heavy disease pressure is not necessarily the most efficient for screening, as the distinction between moderately resistant lines and susceptible lines becomes vague. For example mild disease pressure existed during the 1987-88 season in Merchouch, but the readings showed a good correlation with other locations during this season, while the higher readings during the next season were poorly correlated. The same happened for screenings in the greenhouse in Tel Hadya.

Within the collaborative network on barley diseases with pathologists in the region, Dr Emil Ghobrial et al. in Egypt studied the virulence of and resistance to Erysiphe graminis. As part of their work, germplasm of ICARDA and NARS is screened in the seedling stage against virulent mildew isolates. The testing of the 1988-89 Advanced Barley Yield Trials showed a relatively low average (r=0.15) correlation with the eight locations where the same entries were tested in the adult stage (Table 95). A low correlation between seedling tests and field tests of adult plants may be expected as certain resistance genes only express themselves in the adult plant. However, a number of entries showed resistance both in seedling and in field tests (Table 96). As seedling resistance is more easily detected in a hybridization program than adult plant resistance, those entries that express resistance at both stages can be of greater use as parental material.

New sources of resistance were identified by screening pure line extractions of Syrian and Jordanian landraces. A set of 17 lines selected in previous screening in Tel-Hadya, was tested in Denmark by Dr J.H. Joergensen of the Risoe National Laboratory. All lines showed resistance during field tests with highly virulent isolates. It is planned to extend our activities in the work with local material and with the wild progenitor of barley (Hordeum spontaneum) to broaden the genetic basis of powdery mildew resistance in ICARDA's germplasm.

Table 96. Lines in Advanced Barley Yield Trials 1988-89, showing resistance in seedling tests to several powdery mildew isolates in Giza, Egypt and having a average score below 3 in multi-location (8 sites) field testing.

Name and pedigree	Average score (on a 0-9 scale)
Roho/Arabi Abiad//5056/1605 ICB82-0355-2AP-0AP	3.0
11012-2/Impala//Birence/3/Lignee 131 ICB81-1128-7AP-0AP-0AP	3.0
CI 08887/CI 05761//Cerise ICB82-0825-3AP-2AP-0AP	2.8
11012-2/Impala//Birence/3/Arabi Abiad/Iris/CI 01507 ICB82-0591-22AP-0AP	2.8
Emir*2/Arabi Abiad ICB82-1017-5AP-0AP	2.6
Roho/Julia ICB77-0177-1AP-2AP-2AP-7AP-1AP-0AP	2.8
Harmal//Kv/Mazurka ICB83-1705-8AP-0TE-0AP	3.0

Studies on Pyrenophora graminea (barley leaf stripe)

Multi-location testing, which has proved to be efficient in the detection of broad-based resistance to leaf diseases such as scald and powdery mildew, can not be used for seed-borne diseases such as Pyrenophora graminea. The epidemiology of this pathogen stretches over two seasons. The leaves of striped plants produce conidia that affect seed of neighboring healthy plants, in which the fungus over-summers as dormant mycelia. Depending on the environmental conditions during the seed germination in the next season, the mycelia may penetrate the seedling and infect the plant. Losses due to this disease are high as the affected plant is dwarfed and produces few seeds. The disease occurs throughout the region but is especially severe in areas with higher rainfall and in areas with cooler temperatures, such as Turkey or the high elevations of Ethiopia and Nepal.

The detection of highly susceptibile lines in our germplasm lead us to initiate a screening program for resistance, partly in collaboration with other pathologists in the region. In last year's Annual Report a number of lines were reported to be resistant to local isolates in Syria as well as in Morocco. Results from these and other tests suggested a form of physiological specialization there may be in the pathogen population within the WANA region.

To assess the variability within the pathogen population, a screening technique for barley leaf stripe has been developed that enables the testing of foreign isolates in a controlled environment. Table 97 shows results of a test involving isolates originating from Syria and from Nepal. The test was part of a larger experiment in which the resistance of Nepalese germplasm was compared with lines of known reaction to barley leaf stripe. The experiment was initiated during the visit of a Nepalese scientist, Dr Kishore Sherchand, to the Barley Pathology project. Analysis of the data showed significant differences among isolates and genotypes. The isolate from Syria, 8710C, was the most aggressive strain on most lines, including those originating from Nepal. Lines identified previously as resistant to this strain (less than 25% striped plants) showed resistance to the other isolates as well. The high level of aggressiveness of this Syrian isolate is also demonstrated by the susceptibility of lines described in the literature as highly resistant (CI 6306 and CI 0920).

Table 97. Response of barley lines to artificial inoculation with two Syrian and two Nepalese strains of Pyrenophora graminea (averaged over two experiments with four replicates each). Data show the Percentage of seed giving striped plants, 20 days after planting, computed per pot with five seeds planted.

Variety name	Syria			Nepal			grand mean
	8710C	8708A	mean	8901A	8902B	mean	
Group I: Nepalese germplasm lines							
Nepal N 92A/2	40	33	36	5	5	5	21
Nepal C 72A/3	48	25	36	23	25	24	30
Nepal C 83A/3	75	38	56	60	40	50	53
Nepal C 49A/1	80	40	60	50	50	50	55
Nepal C 17A/1	80	43	61	75	70	73	67
Group II: Lines reported to have a high resistance							
CI 2202 (USSR)	15	8	11	8	3	5	8
Betzes (USA)	8	10	9	8	10	9	9
Vada (Netherlands)	23	23	23	23	15	19	21
CI 3694 (Egypt)	23	30	26	23	10	16	21
CI 6306 (Uruguay)	48	33	40	18	15	16	28
CI 0920 (China)	73	18	45	30	20	25	35
Group III: Lines previously identified as resistant to Syrian strains							
Tokak 157/37 (Turkey)	18	13	15	13	5	9	12
Tadmor (Syria)	23	38	30	0	0	0	15
Group IV: Lines previously identified as susceptible to Syrian strains							
ER/APM (ICARDA)	60	15	38	5	15	10	24
SLB 39-60 (Syria)	45	40	43	20	10	15	29
CI 6944 (Afghanistan)	98	28	63	0	0	0	31
Atlas 46 (USA)	90	43	66	3	8	5	36

Although the analysis showed a significant interaction between isolates and genotypes, no definite conclusion can be drawn about the presence of physiological specialization within the plant-pathosystem. No combination of isolates and host plants could be found that shows the complete reversal of reaction typical for a gene-for-gene relationship. The statistical interaction may be caused by inconsistent differences among isolates for a number of varieties. However there may be an indication of a physiological specialization as the Nepalese isolates did not affect lines that were thought to be universally susceptible, such as CI 6944 (reported by Danish workers to be the 'most susceptible line ever seen') and Atlas 46.

We are currently testing a large number of strains from different origins. Preliminary results confirm that considerable differences exist between and within countries.

Losses caused by dry-land root rot

With the emphasis placed by ICARDA's barley improvement project on the drier and more marginal areas, special attention is given to those diseases that are of particular importance in these zones. The development of dry-land root rot, caused by Cochliobolus sativus or Fusarium sp. is favoured by dry conditions, most probably because of lower competitive activity of other soil organisms. Little is known about losses caused by this disease in West Asia, or about differences in resistance among barley varieties. In last year's annual report results were presented from a survey on the occurrence of dry-land root rot in barley yield trials. Discoloration of sub-crown internodes was strongly related to the presence of Cochliobolus sativus. Differences among varieties in severity of symptoms were present, but before initiating a screening program for resistance more information was needed on the losses caused by this disease.

An experiment was planted in 1988/89, at Tel Hadya (moderate rainfall) and Bouider (low rainfall) in which the response to root rot of eight varieties was measured. Varieties were chosen, showing a contrast in severity of root-rot symptoms during last year's survey. To measure the effect of the root-rot on yield parameters an artificial inoculation with Cochliobolus sativus was carried out. The inoculation was made by growing the fungus on sterilized oat kernels and distributing these kernels in the furrows before planting. Two different check treatments were included. One consisted of non-inoculated sterilized oat kernels placed in the furrows and the other without oat kernels. Sowing depth was included as treatment, as longer sub-crown internodes are expected to become more severely affected. The experiment was planted as a split-split plot with four replicates, the two different sowing depths considered as main treatments, inoculation vs checks as sub treatments and varieties in the sub-sub plots. Each plot consisted of six rows 3 m long. At maturity the centre four rows were harvested, while the border rows were uprooted and the discoloration of the sub-crown internodes was scored using a 0-4 scale (0 = white, 4 = completely discoloured). A significant increase of symptoms in the inoculated plots was observed in Bouider (Table 98), but not in Tel Hadya. Apart from the effect of the inoculation, the analysis of variance showed a difference in the score between lines and a significant interaction between lines and treatments, indicating differential reaciton among lines. However, actual differences in score were rather small (Table 98) and ranking of the cultivars was not similar to the one in previous year's survey.

Both seasons were distinct in the amount of rainfall, the 1987/88 season was unusually wet while 1988/89 was extremely dry, which is reflected in the low yields in this experiment (Table 99). Deeper sowing resulted in a significantly higher yield, and the average yield in the inoculated plots was over 10% less than in the checks; but this difference was not significant perhaps because of the large variability within the experiment. The study will be repeated for another season before definite conclusions can be drawn.

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Table 98. Average discoloration score* of sub-crown internode of 8 barley lines, inoculated with Cochliobolus sativus versus checks, sown at two depths in Bouider 1988/89.

Name	Inoculated			Oats only			Check			Ave.
	Shal.	Deep	Ave.	Shal.	Deep	Ave.	Shal.	Deep	Ave	
Arabi Abiad	2.5	1.9	2.2	1.8	1.8	1.8	2.2	1.7	2.0	2.0
Arabi Aswad	2.6	2.2	2.4	2.4	2.1	2.2	2.2	1.8	2.0	2.2
Tadmor	2.4	2.3	2.3	2.3	1.9	2.1	2.3	2.4	2.3	2.2
JLB 6-38	2.7	2.5	2.6	2.0	2.0	2.0	2.0	1.6	1.8	2.1
Kervana/Mazurka	2. 9	2.5	2.7	2.1	2.5	2.3	2.4	1.9	2.1	2.4
WI2291	2.5	2.5	2.5	2.0	2.0	2.0	2.1	2.1	2.1	2.2
Arta	3.2	2.7	3.0	2.4	2.2	2.3	1.9	1.9	1.9	2.4
Furat 653	2.6	1.9	2.3	1.9	1.8	1.9	1.8	1.6	1.7	2.0
mean	2.7	2.3	2.5	2.1	2.0	2.1	2.1	1.9	2.0	2.2

Scale: 0-4 (0 = white; 4 = complete discoloration)

Table 99. Yield (t/ha) of 8 barley lines, inoculated with Cochliobolus sativus versus checks, sown at two depths in Bouider, 1988/89.

Name	Inoculated			Oats only			Check			Ave.
	S	D	A	S	D	A	S	D	A	
Arabi Abiad	0.49	0.81	0.65	0.58	0.94	0.76	0.83	0.81	0.82	0.74
Arabi Aswad	0.69	0.87	0.78	0.65	0.91	0.78	0.98	0.94	0.96	0.84
Tadmor	0.66	0.87	0.76	0.80	0.76	0.78	0.84	0.72	0.78	0.77
JLB 6-38	0.55	0.88	0.72	0.62	1.00	0.81	0.79	0.81	0.80	0.78
Kervana/Mazurka	0.07	0.11	0.09	0.09	0.09	0.09	0.14	0.08	0.11	0.10
WI2291	0.38	0.77	0.58	0.65	0.72	0.68	0.64	0.75	0.70	0.65
Arta	0.65	0.93	0.79	0.76	1.02	0.89	0.85	1.03	0.94	0.87
Furat 653	0.42	0.57	0.50	0.35	0.58	0.47	0.48	0.61	0.55	0.50
Mean	**0.49**	**0.73**	**0.61**	**0.56**	**0.75**	**0.66**	**0.69**	**0.72**	**0.71**	**0.66**

S = shallow, D = deep, A = average

3.3 Entomology

3.3.1. Introduction

The Cereal Program Entomology Project sets to develop the research capabilities of national program entomologists, conducts research beyond the current capabilities of the national programs, and trains technicians, scientists and students. A summary of projects undertaken in 1988/89 is shown in Table 100.

Table 100. Cereal Program Entomology Projects, 1988/89.

Project/Description	Location
Wheat Stem Sawfly	
1. Resistance screening-to identify resistant germplasm for breeders	Tel Hadya, SYRIA
2. Factors affecting sawfly resistance in wheat(with Tischrin University, last year of project)	Tel Hadya, SYRIA
3. Chemical analysis of WSS resistant plants(with Canadian Grain Commission)	Tel Hadya, SYRIA
4. Field trials of resistant lines	MOROCCO
Sunn Pest	
1. Resistance screening-to identify sources of resistance in wheat	Azaz, SYRIA
Hessian Fly	
1. Resistance screening-to identify and verify sources of HF resistance in wheat and barley (with INRA/MIAC)	MOROCCO
2. Biotype identification using differential screening nursery	MOROCCO, ALGERIA, TUNISIA, SYRIA, TURKEY, LEBANON
Aphids	
1. Resistance screening-to identify and verify sources of aphid resistance in wheat and barley	EGYPT, SUDAN ETHIOPIA
Wheat Ground Beetle (*Zabrus tenebrioides*)	
1. Summary of data collected by national program on infestation levels	SYRIA
Ground Pearls (*Porphyrophora tritici*)	
1. Effects of crop rotation on *P. tritici* biology (with FRMP, last year of study)	SYRIA

3.3.2. Summary of projects

The 1988/89 growing season was distinguished by a marked lack of rainfall during the winter and spring. While this did not adversely affect insect populations, which had expanded considerably during the previous favorable season, plant growth was retarded in plots at Tel Hadya, Breda, and Bouider. As a result, there appeared to be a more distinct differentiation in the expression of insect resistance in 1988/89 than in previous seasons.

Wheat stem sawfly

Lines selected in wheat stem sawfly screening trials are shown in Table 101. These lines have been selected for three consecutive years and form the core of resistant germplasm pools being developed at ICARDA for use in sawfly infested regions. In general a 10% infestation level (approximately the mean infestation of all lines + 1 SD) was the cutoff for retaining a line for subsequent testing. As found previously (ICARDA Cereal Program Report 1987-1988), stem solidness was important in imparting sawfly resistance to bread wheat and durum wheat, and not important for barley. A number of Moroccan solid stemmed durum landraces were also screened this year (Table 102). Variation in the expression of stem solidness was apparent as were differences in sawfly infestation, even in completely solid stemmed lines. Other exotic lines showed varying degrees of resistance and selected lines (%inf>10%) are also shown (Table 102).

Trap data (yellow water traps) on sawflies and sawfly parasites at Tel Hadya are shown in Fig. 14. In general, *Cephus pygmaeus* was the most abundant sawfly collected followed by a *Trachelus* species, most probably *T. judaicus*. More sawflies were trapped in durum fields than in bread wheat or barley fields. Females greatly outnumbered males. *Cephus* appeared earlier than *Trachelus* and few sawflies were trapped after Julian day 110. Adult parasite populations in wheat, consisting primarily of the ichneumonid *Collyria* spp. and the braconid *Terebrella* usually appeared around Julian day 80, remained at low levels until late in the season, and then rose rapidly. Populations of adult parasites in barley were consistently very low.

Results from this years spacing study, where the effect of seeding rate on sawfly infestation, stem solidness, and yield were examined, generally corroborate those of 1988/89. Closely spaced plants were more highly infested with sawflies, had hollower stems, and matured more rapidly than wide spaced plants. Sawfly resistance was best expressed in widely spaced plants which had previously been identified as resistant. Nonresistant, closely spaced plants were the most highly infested and had the hollowest stems. Overall yield was affected by the seeding rate as well as sawfly resistance. Optimum seeding rate and row spacing for maximum yield and maximum resistance will be examined in 1989/90.

Aphids

Russian wheat aphid, Diuraphis noxia, was observed in late planted wheat and barley maintained under partial irrigation at Tel Hadya in March, April and May. Parasites were collected and sent to Peter Stary of Czechoslovakia who identified them as Aphidius colmani, Diaeretiella rapae and Praon sp. Mummified aphids were sent to the USDA European Parasite Laboratory, Paris, France for retrieval of parasites. Plastic house cultures of D. noxia and parasites were established for future study.

Results from this years aphid resistance screenings in Egypt are presented in Table 103. A few lines were rated as moderately tolerant to Rhopalosiphum padi. Plants derived from crosses with Bushland-Amigo lines continue as the most promising for Schizaphis graminum resistance in Egypt and Sudan. Field observations of this years heavy aphid infestations in upper Egypt also suggest that early varieties possessing moderate tolerance may escape significant yield losses. Controlled yield loss studies by the Egyptian national program indicate aphid losses in bread wheat to range from 14% to 38%.

Table 101. Promising bread wheat, durum wheat and barley lines for wheat stem sawfly resistance.

Name	Pedigree	Source	No.	%Inf87	%Inf.88	%Inf.89
Bread Wheat						
Fta/W71//Imuris	CMH80A-276-1B-2Y-1B-2Y-2B-0Y	WCB87	71	.83	5.42	1.70
Y50E/Kal*3//Rg's'/Soty/3/Sx/We/4/Hork	CM39867-2S-1AP-0AP-3AP-2AP-2AP-0AP	WCB87	159	5.41	7.50	6.68
Fta/W71//Imuris	CMH80A-276-1B-2Y-1B-1Y-1B-0Y	WCB87	72	2.91	5.00	7.10
Bol's'/Pvn's'	CM 58696-5AP-2AP-1AP-1AP-0AP	WOM87	42	2.91	10.00	7.50
Rbs/Ti Resel	SWM4781-2S-3AP-0AP-1AP-0AP	WCB87	43	5.00	8.75	7.90
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
Rmn F12-71/Jup//S	SWM76 584-01H-1H-1S-05	WOL86	89	4.58	7.08	9.18
Durum Wheat						
Gezira 17/Scaup	ICD-HA81-1917-3AP-1AP-1AP-0AP	DCB87	37	0.83	5.00	3.35
Bit/Creso	CD 34346-2TR-2AP-1AP-0AP	DCB87	11	1.25	7.92	5.83
A63040/Sty//Lds/3/Win/4/Erp/Ruso	CD 35072-C-5Y-1M-0Y	DCB87	123	0.83	8.33	5.83
Can2101/Magh//Stk/3/Wlls/65150	CD 15111-3S-2AP-2AP-3AP-0AP	DCB87	19	0.83	8.75	6.25
Bit/Creso	CD 34346-2TR-2AP-1AP-0AP	DBB87	20	0.83	9.85	7.05
D-2/Bit	CD 20796-4AP-6AP-2AP-0AP	DAT87	116	1.66	9.58	4.58
Barley						
FB73-075	-	BAB85	14	0.83	2.08	2.03
Ager//Api/CM67/3/Cel/WI2269//Ore	ICB81-1275-0SH-1AP-0AP-0AP	BAT88	405	-	7.50	5.03

Table 102. Exotic lines screened at Tel Hadya for sawfly resistance.

Name	Source	No.	%Infest	%SS
Moroccan landraces				
16189	SOLIDST	75	4.60	100.00
19895	SOLIDST	1	3.35	100.00
8207	SOLIDST	11	3.78	100.00
11087	SOLIDST	41	2.93	100.00
8854	SOLIDST	22	2.35	100.00
19922	SOLIDST	25	7.08	100.00
19927	SOLIDST	29	4.43	100.00
11894	SOLIDST	44	2.93	75.75
37746	SOLIDST	79	4.96	70.00
11778	SOLIDST	43	3.78	58.55
19944	SOLIDST	45	5.43	51.85
13623	SOLIDST	49	5.40	45.35
16176	SOLIDST	74	5.45	44.10
16401	SOLIDST	77	8.33	43.05
16142	SOLIDST	71	6.25	41.55
13569	SOLIDST	48	2.23	40.70
8392	SOLIDST	12	3.73	39.80
10723	SOLIDST	35	4.25	37.85
16394	SOLIDST	76	2.93	33.35
19925	SOLIDST	27	5.85	32.00
8182	SOLIDST	9	4.58	31.55
19904	SOLIDST	10	5.40	30.45
19901	SOLIDST	7	3.75	26.80
16094	SOLIDST	64	4.18	25.40
USSR				
Spektr-5	USSR	1	5.00	
Spektr	USSR	2	9.18	
Canada				
BW 607	Canada	607	0.58	
Lancer	Canada	1	5.83	
BW 608	Canada	608	5.85	
BW 610	Canada	610	6.65	
BW 611	Canada	611	6.65	

%SS = percent straw solidness

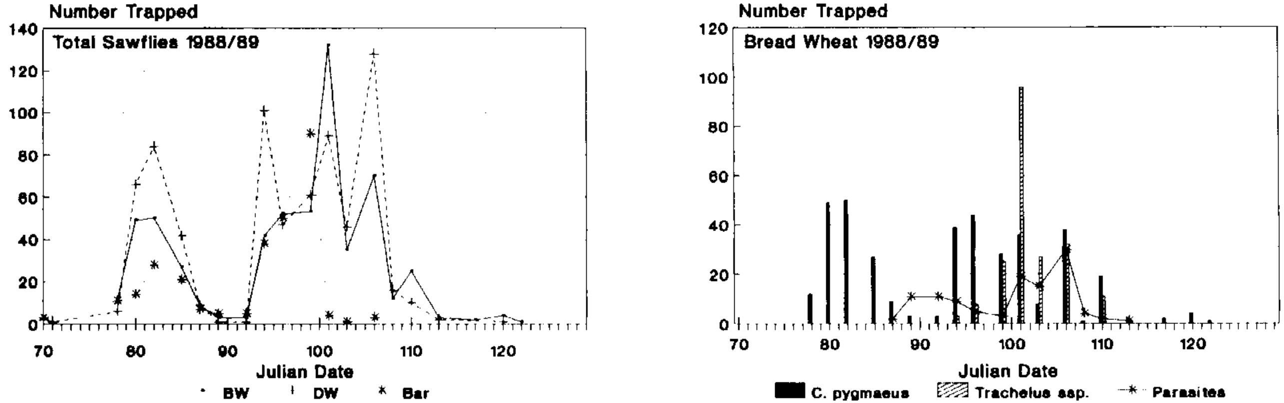
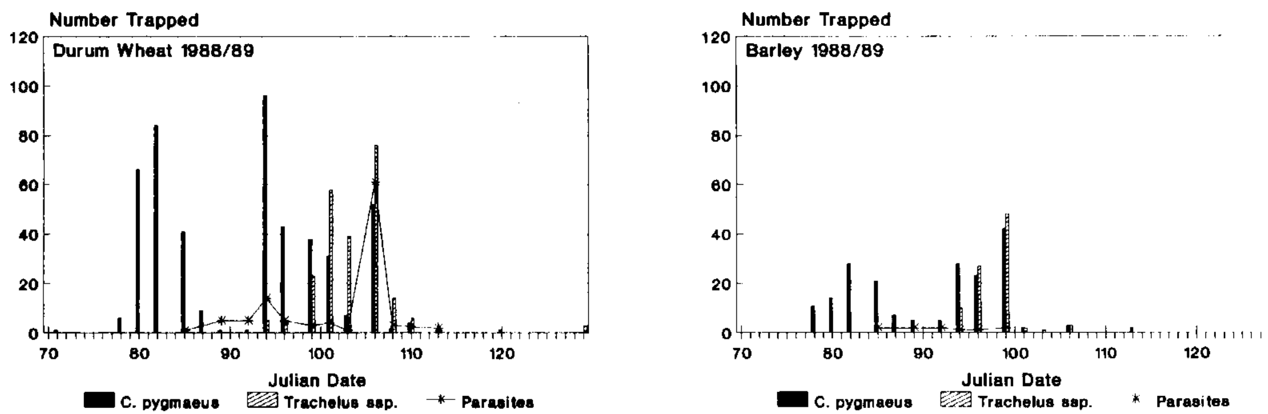


Fig. 14. Trap catches of C. pygmaeus and Trachelus spp. in wheat and barley at Tel Hadya in spring 1989.



Hessian fly

The Uniform Hessian Fly Nursery was planted near Lattakia, Syria and in Turkey (Erzerum). While the material froze in Turkey, results from the Lattakia site suggest that the H5 gene contained in SD 8036 may be effective against Hessian fly in West Asia. SD 8036 was not infested at all while plants having all other gene combinations suffered varying degrees of infestation. A survey of Hessian fly in North Africa, conducted in conjunction with a INRA/USAID/MIAC/ICARDA sponsored Hessian fly workshop, revealed Morocco, Tunisia, and Algeria to have Hessian fly infestations in wheat and barley. Barley was generally infested more than wheat, though damage to barley was less. Hessian fly infestations in Morocco were much higher than those observed in the other two countries.

Sunn pest

Sunn pest resistance trials were inadvertantly sprayed in the course of Syria's aerial spray program for sunn pest. This setback underscores the difficulty of field screening for resistance to sunn pest, and has caused us to search for alternatives to the traditional field trials. Workers at Montana State University (USA) have suggested another approach where seeds are screened for the presence of protease inhibitors which deactivate the trypsin-like enzymes injected into the kernel by feeding sunn pests. A simple protocol for the assay has been developed and is currently being tested.

Wheat ground beetle

A joint study on the wheat ground beetle, Zabrus tenebrioides, was conducted by ICARDA and the Syrian national program. Data from various research stations were collected and summarized (Fig. 15), and an attempt was made to correlate autumn rainfall with the area infested by the beetle that was chemically treated by national program staff.

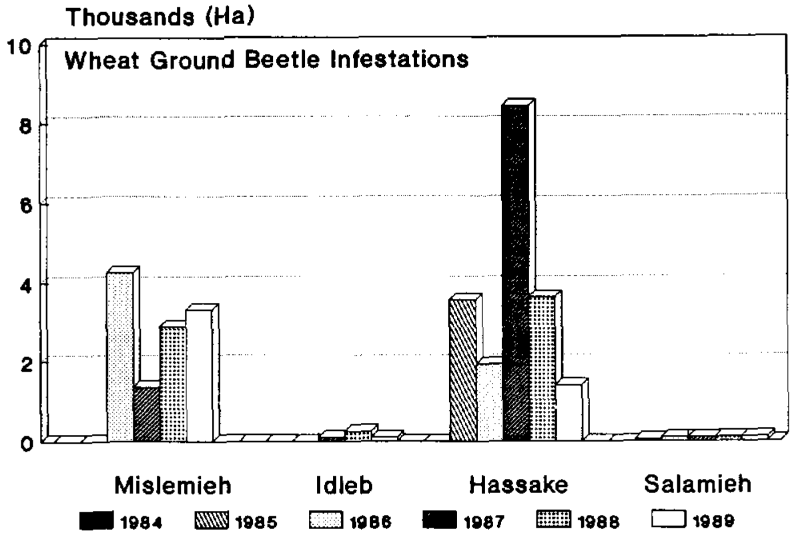


Fig. 15. Area chemically treated to control Z. tenebrioides by Syrian national program in northern Syria.

Correlation were generally non significant probably due to variation in data collected by pest control staff over the years. Controlled experiments were set up in selected fields in northern Syria which will be monitored by ICARDA and national program staff in 1989/90 to test the effects of crop rotation (or lack of it) and rainfall and temperature on beetle development.

Ross H. Miller

Table 103. Wheat and barley lines showing moderate resistance/tolerance to aphids.

Field Results 1989 - R. padi Resistance

Cross	Number of Lines
Bushland-Amigo T101* X Sakha 69	11
Bushland-Amigo T101* X Sakha 61	7
Bushland-Amigo T105* X Giza 157	5
Bushland-Amigo T105* X Sakha 69	44

Laboratory Results 1989 - Greenbug Resistance

Bread wheat entry numbers	Durum wheat entry numbers
8,25,74,82	44,46,47,48,507,622,715,716,719
85,91,181,182	720,721,723,801,803,804,810,814

Barley - Greenbug Resistance

Hordeum vulgare

81-CG-7431-36 Sel-309
Beecher x (B225 x B106)
Tequila x Arimar-2763 CMB 78A-100
Harma-02//11012-2/CM67 ICB79-0556-3AP-0AP

Hordeum spontaneum

Entry	Characterization
28	high resistance
3,4,5,7,13 20,26,27,30 42,43,44,47	moderate resistance
5,7,13,27, 30,42,43,44,47	moderate resistance (after 1 retest)

*Translocation lines developed for greenbug resistance using rye genes.

3.4. Cereal Grain Quality

The cereal quality laboratory provides quality information for several thousand new lines before each planting season (Table 104). Further quality evaluations of advanced lines include millability, farinograph tests, and baking and diastatic power (barley).

Table 104. Number of tests(1) carried out in the ICARDA cereal quality laboratory, 1988/89, for different projects(2).

Test / Project	ELEC	TKW	VKC	PSI	SDS	YP	GC	FM	FAR	KSD	DP	PROT	LYS	Total
Barley	-	7632	-	-	-	-	-	-	-	375	340	5168	4912	18427
BW	-	2606	-	1454	-	-	1454	270	270	-	-	1454	-	7508
DW	216	2469	2469	-	687	1829	-	48	48	-	-	3257	-	11023
DG	-	2979	2421	-	656	-	2421	-	-	-	-	2979	-	11456
HE	-	2373	745	-	745	745	-	-	-	-	-	2373	-	6981
FFVT	-337	125	112	125	125	-	-	-	-	-	337	100	1261	
Other	-	834	640	771	-	-	-	-	-	451	-	4571	-	7357
Total	216	19230	6400	2337	2213	2699	3875	318	318	916	340	20139	5012	64013

(1) ELEC=Electrophoresis, TKW=thousand kernel weight, VKC=vitreous kernel count, PSI=particle size index, SDS=sodium dodecyl sulphate sedimentation, YP=yellow pigment, GC=grain colour, FM=flour milling, FAR=farinograph, KSD=kernel size distribution, DP=diastatic potential, PROT=protein, LYS=lysine.

(2) BW=bread wheat, DW=durum wheat, DG=durum germplasm evaluation, HE=high elevation, FFVT=farmer's field verification trials, Other=other ICARDA programs.

F. J. El Haramein and A. Sayegh

3.4.1. Advanced bread wheat lines

Because of the increased demand for bread-based foods in WANA, the cereal quality laboratory focuses its efforts on selecting medium and strong bread wheat types. A total of 216 advanced bread wheat lines (from AWYT-Tel Hadya, rainfed 1987-88) were evaluated for milling and baking quality. Over 40% of the lines included in the AWYT combined all desirable quality parameters (Table 105). The promising lines have, generally, medium-to-hard kernels, medium protein level, medium kernel size, good test weight and flour yield, and medium-to-strong flour strength.

Table 105. Quality characteristics of advanced bread wheat lines (n=87) desirable for milling and baking industries (Tel Hadya, 1987-88).

Test	Average	High	Low
Kernel hardness (%)	47.1	55.0	39.0
Protein content (%)	12.2	13.5	10.7
1000-kernel weight (g)	34.6	43.7	30.3
Test weight (kg/hl)	76	80	70
Flour yield (%)	72	76	68
F.S.T.* (min)	7.0	14.5	4.0
F.M.T.* (Brabender U.)	64	100	15
F.W.A. (%)	61.1	65.5	56.5

- F.S.T.=Farinograph stability time.
- F.M.T.=Farinograph mixing tolerance.
- F.W.A.= Farinograph water absorption.

Table 106 shows the progress made in the improvement of wheat germplasm for bread making quality. In a period of five years (1982-83 to 1987-88) the number of good quality genotypes in the international wheat yield trials has increased three fold.

Table 106. Selection progress in bread making quality (Tel Hadya, rainfed).

Grain quality Classification	Frequency*	
	RWYT 1982-83	RWYT 1987-88
Excellent	3	9
Acceptable	11	7
Poor	7	5

* Number of entries within each category in the international wheat yield trials.

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3.4.2. Selection for kernel size in barley.

The combination of good kernel size with high protein and lysine content is essential for nutrition. Some advanced barley lines with their characteristics are listed in Table 107. Neither selection for yield under drought conditions nor selection for yield potential appeared to affect seed quality characteristics (Table 108 and 109).

Table 107. Barley lines combining large kernel size and high protein content (advanced yield trials 1988-89).

Line	Row Type	Protein Content (%)	1000 KW (g)
CI 07117-9/Deir Alla 106//Badia/3/Arar	2	14.3	38.3
Roho/Arabi Abiad	2	14.5	37.9
ER/Apm//Lignee 131	2	14.3	37.5

Table 108. Best 10% of advanced barley lines for 1000 kernel weight, protein and lysine content (1988/89 season).

	1000 K.W. (g)	Protein (%)	Lysine (%)	YD* (3 sites)	YP* (6 sites)
1000 KW	37.8	13.5	0.54	743	5002
Protein content	32.3	14.6	0.57	507	5250
Lysine content	32.7	14.5	0.58	587	5326
Mean	32.6	13.6	0.54	617	5216
Best for YD	33.6	13.4	0.54	960	4891
Best for YP	32.3	13.6	0.54	621	6452

* Based on data from 3 seasons (1987-1989)
YD = yield under drought conditions.
YP = yield potential.

Table 109. Mean of 1000 kernel weight (g), protein and lysine content (%) of five barley varieties used as checks in the yield trials (1988/89 season).

Variety	1000 kernel weight	Protein	Lysine
Rihane-03	32.0	13.51	0.54
Kantara	37.9	13.58	0.54
Harmal	35.9	13.31	0.53
A. Aswad	30.4	13.30	0.54
A. Abiad	36.0	13.72	0.55

Last season's data show that selection for kernel size does not necessarily reduce protein and lysine content, as compared with either the checks or the population mean. Kernel size appears to be positively correlated to yield under drought.

S. Ceccarelli and F. J. El-Haramein

3.4.3. Grain quality in durum wheat

Durum wheat quality was studied with respect to environmental fluctuations. The environments of "early planting" and "zero nitrogen" application drastically affected sedimentation test values in 1988/89 while all other environments were similar in their effect. The "early planting" and "zero-nitrogen" environments allowed the selection of lines with stable and high protein content (Fig. 16). Similar results were found for sedimentation values and vitreousness. The reverse was noticed for kernel size (Fig. 17) but no major differences between the environments were detected for carotene content. To upgrade the quality parameters in durum wheat grain, 90 crosses were made between lines having high quality values and _T_. _dicoccoides_.

M. Nachit and A. Sayegh

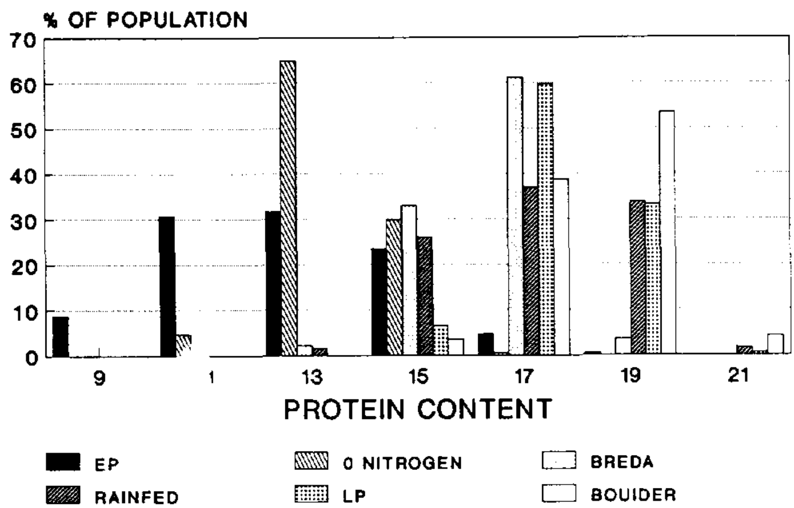

Fig. 16. Protein content at Tel Hadya (early planting; rainfed; late planting, or "0" N), Breda, and Bouider.

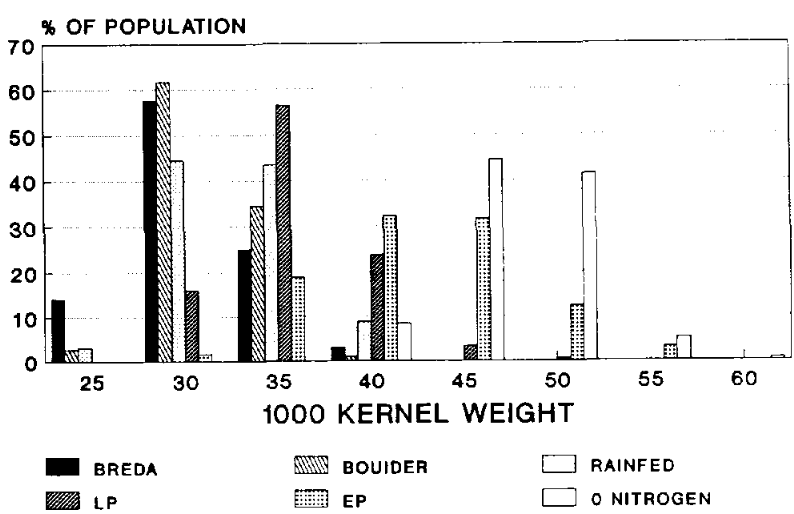

Fig. 17. 1000 Kernel weight at Tel Hadya (early planting, normal planting, late planting, and "0" N), Breda and Bouider.

3.5. Applied Biotechnology

3.5.1. Introduction

This project aims at developing and adapting techniques and methodologies that would accelerate and improve the efficiency of cereal breeding. At this stage, activities are focused on the production of doubled haploid (DH) lines of barley and wheat using two different methods: anther culture and intergeneric crosses. At a second priority level, other technologies including the use of molecular markers will be investigated in view of their possible use and adaptation.

3.5.2. Anther culture

The use of anther culture allows the development of genetically stable plants (DH) in a short period of time and therefore will contribute to faster breeding of improved varieties. The objective in the 1988/89 season was to develop in association with breeders techniques for large-scale production of DH at ICARDA. A large number of haploid plants were produced in bread wheat and barley and the first DH lines will be tested under field conditions during the 1989/90 season.

Barley

Different genotypes, including two European check varieties (Dissa and Sabarlis) known to be well responsive, landraces (Tadmor, Harmal), lines of H. spontaneum (3-4 and 41-3) and improved germplasm, were evaluated for their suitability for anther culture. Although considerable variation between the different genotypes was observed (Table 110), the general aptitude of the material tested was promising. Yields as high as 100 embryoids per 100 anthers cultured were obtained. This technique is not restricted to improved barley germplasm and may be applied to landraces as well as to wild progenitors. However, two major problems limit the effective application of the technique: low frequency of plant regeneration (11% of embryoids), and high proportion of albino plants (91%). To overcome this limitation, experiments such as the use of sucrose-free medium and modification of the growth conditions for the donor plants were carried out. The following conditions appeared important to produce a large number of green plants :

- growth of the donor plants in relatively cool temperatures
- a culture medium with relatively low ammonium and relatively high glutamine as a source for reduced nitrogen
- relatively low auxin to prevent development of unorganized structures
- high osmotic pressure and low sucrose concentration.

In view of this preliminary experimentation, haploid production via microspores culture appears a promising tool for barley breeding.

Table 110. Performance in anther culture of different genotypes of barley using a sucrose-free medium*.

Genotype	No. of cultured anthers	% responding anthers	No. embryoids/ calli per 100 anthers	No.of plants per 100 anthers
Dissa	682	53.5	267.5	26.8
Sabarlis	310	17.7	89.4	10.6
WI 2291	655	20.0	101.3	15.0
Rihane-03	261	6.5	32.5	3.5
ICB 88-0106	636	21.7	109.3	13.6
ICB 88-0396	851	6.8	34.7	2.1
Tadmor	480	19.4	97.0	10.2
H. Sp. 3-4	490	11.2	56.0	4.9
H. Sp. 3-4 x Tadmor	746	22.3	111.5	13.4

* Medium composition: modified MS-nutrient + Maltose 90 g/l + Glutamine 750 mg/l + Myo-Inositol 100 mg/l + Ag No_3 5 mg/l + BAP 0.5 mg/l + IAA 0.5 mg/l, solidified and filter sterilized.

Wheat

Production of DH lines from targetted crosses of bread wheat was undertaken using anther culture. More than one thousand haploid plants were produced and the first DH lines will be tested under field conditions next season. Objectives of this project were to examine the response level of wheat material adapted to the dry areas of WANA and the effect of others variables in anther culture technique.

Although considerable variation in haploid production was observed between different genotypes, the results (Table 111) indicate an acceptable efficiency. The average green plant production (5.4 green plants per 100 anthers cultured) is high in comparison with those usually reported. The hybrids involving the line Kavkaz as a parent or cultivars derived from it such as Veery"S" (Seri 82, Genaro 81 or Hodhod) show a good embryo induction rate as well as embryo regeneration ability. All these cultivars carry the 1B/1R translocation.

Table 111. Performance in anther culture[1)] of 8 bread wheat hybrids.

Targeted cross	No. of embryoid per 100 anthers*		Plant frequency % (embryoids)	No. of plants per 100 anthers	
				Total	Green*
Seri 82//Veery/Sunbird	28.0	(286)	80.0	22.4	22.4 a
Hodhod / Sudan	24.5	(576)	49.4	12.1	11.9 b
Sunbird / Genaro 81	12.4	(370)	43.5	5.4	5.4 c
Kavkaz/Ciguena//Chilero	6.4	(1009)	21.9	1.4	1.4 d
Egvd 14/Roshan	6.1	(1203)	16.4	1.0	0.9 de
Sunbird//Clement/Alondra	7.2	(446)	9.7	0.7	0.7 de
Cham 4/76529A5-3	3.7	(933)	8.1	0.3	0.3 e
Parula/Sonalika	5.6	(648)	5.4	0.3	0.3 e

* Percentages followed by the same letter are not significantly different at the 0.05 probability level, as determined by "t" test of arcsin transformed values.

1) Medium composition: modified MS-nutrient + Sucrose 85.5 g/l + Glutamine 750 mg/l + Myo-Inositol 100 mg/l + $AgNO_3$ 10 mg/l + 2,4-D 2mg/l, solidified and filter-sterilized.

The use of Veery "S" in crossing programs, could be a means toincrease the efficiency of microspore culture. Experiments to study the possibility and importance of genes favoring microspore culture linked to the 1B/1R translocated chromosome of Kavkaz will be carried out next season.

A comparison was made between sucrose and maltose media for plant production from anther culture (Table 112). The sucrose-free medium appears favorable for genotypes with low aptitude to anther culture by a strong increase in the plantlet regeneration frequency.

Analysis of variance for embryoids and green plant production frequencies from data including four genotypes, two donor plant growth environments ($20^oC \pm 3$ and $15^oC \pm 3$) and three replications also revealed a significant interaction between genotypes and environmental conditions. These results indicate that improvement can be made in the androgenesis efficiency, but the possibility of genotype-culture environment interaction must be considered.

Table 112. Effect of sucrose-free medium (SF) on embryoid production and plantlet development in bread wheat*.

Genotype	Medium	No. of embryoid** per 100 anther	Plant regeneration** (% embryoids)	Green** plants per 100 anthers
Seri 82//Veery/Sunbird	BM	28.0 a	80.0 a	22.4 a
	SF	18.7 b	82.9 a	13.6 b
Hodhod/Sudan	BM	24.5 a	49.6 a	11.9 a
	SF	10.2 b	44.8 a	4.2 b
Sunbird	BM	8.4 a	43.9 a	2.1 a
	SF	2.5 b	32.0 a	0.7 b
Egvd 14/Roshan	BM	6.1 a	16.4 a	0.9 a
	SF	4.7 a	26.0 a	1.0 a
Sunbird//clement/Alondra	BM	7.2 a	9.4 a	0.7 a
	SF	5.1 a	54.2 b	2.5 b
Cham 4/76529A5-3	BM	3.7 a	8.6 a	0.3 a
	SF	6.9 b	32.6 b	2.2 b

* SF medium composition: basal medium (BM) with 0.25 M maltose in place of 0.25 M sucrose. ** Percentages from the same genotype followed by the same letter are not significantly different at the 0.05 probability level, as determined by "t" test of arcsin transformed data.

Ph. Lashermes

3.5.3. Intergeneric crosses

The objective of the project on cereal haploid production through intergeneric crosses is to develop the breeding methods that can accelerate development of new varieties, as complementary tools for conventional breeding programs. The haploid production project in barley has been started this season using breeders' materials. Products from this project will be fed back to breeders for selection, and also utilized for genetical analyses of agronomic characters that are not amenable to be studied in segregating generations.

For wheat haploid production, cross-incompatibility with Hordeum bulbosum was successfully overcome by use of maize pollen and exogenous plant hormone. This method will be applied for double haploid production from F_1 or F_2 wheat crosses during next season.

Wheat

During 1987/88, crossabilities of bread wheat varieties with tetraploid H. bulbosum were investigated. Unfortunately, most wheat genotypes were not crossable with H. bulbosum, and did not result in the production of haploid plants. This fact suggests that cross-incompatibility gene(s) predominate among the wheat varieties examined (Ann. Rep. 1988, p. 149-151). In order to reduce the cross-incompatibility barrier of wheat, the use of alternative pollen of maize and the application of plant hormone were attempted this season.

Four check varieties of bread wheat i.e., Norin 61, Chinese Spring, Mexipak 65 and Highbury were used as female parents. Pollen parents were four clones of tetraploid H. bulbosum and eight genotypes of maize. On each of two consecutive days after pollination, wheat culms with pollinated spikes were needle-injected with a 100 ppm solution of 2,4-dichlorophenoxyacetic acid (2,4-D). In each crossing treatment, five to six wheat spikes with approximately 125 to 150 florets were used. After 14-16 days of pollination, immature embryos were cut out and transferred onto B_5 medium to regenerate to plants.

Table 113 shows the frequencies of embryo formation in four wheat varieties crossed with H. bulbosum or maize. In the crosses with H. bulbosum, two wheat varieties, Norin 61 and Chinese Spring, produced embryos at frequencies of 23.6% and 16.9%, respectively. These frequencies increased with the 2,4-D treatment. Without the 2,4-D treatment, the crosses of wheat with maize produced no embryos, but, with the 2,4-D treatment, all wheat varieties produced embryos and the frequencies of embryo formation ranged from 8.3% to 21.1% among the wheat varieties.

Immature embryos ca. 1.0 mm size obtained from crosses with H. bulbosum and maize were successfully regenerated to green plants within three weeks after incubation, at a frequency of 43.1%. All the regenerated plants examined cytologically were euhaploids having a complement of twenty-one chromosomes.

Table 113. Effect of 2,4-D treatment on the embryo formation frequencies (%) in bread wheat varieties crossed with H. bulbosum and maize

Pollen source	2,4-D treatment	Wheat variety			
		Norin 61	Chinese Spring	Mexipak 65	Highbury
None	-	0.0	0.0	0.0	0.0
None	+	0.0	0.0	0.0	0.0
H. bulbosum	-	23.6	16.9	0.0	0.0
H. bulbosum	+	38.5	25.0	0.0	0.0
Maize	-	0.0	0.0	0.0	0.0
Maize	+	17.5	21.1	18.9	8.3

Table 114 gives a comparison of two methods of haploid production using H. bulbosum and maize pollen in twenty bread wheat varieties from West Asia and North Africa. Only three wheat varieties were crossable with H. bulbosum, but, with very low frequencies. On the other hand, all the wheat varieties examined were highly crossable with maize with frequencies ranging from 12.0% to 35.6%. Overall frequencies of haploid production were 0.2% through the H. bulbosum cross, and 9.5% for the maize cross, indicating that the maize cross is more efficient than the H. bulbosum cross, and suggesting that the haploid production method via the maize cross can be applied as an additional approach to conventional breeding programs. Nevertheless, the maize technique requires further development and improvement because the frequency of haploid production is still less than 10% of wheat florets pollinated.

Table 114. Frequencies of haploid production in twenty bread wheat varieties through intergeneric crosses with H. bulbosum and maize

Pollen Source	No. of florets pollinated	No. of embryos obtained (%)	No. of plants regenerated (%)
H. bulbosum	2296	7(0.3)	5(0.2)
Maize	1128	245(21.7)	107(9.5)

This work clearly demonstrated that maize pollination with subsequent 2,4-D treatment onto wheat florets resulted in the production of wheat embryos capable of regenerating haploid plants, even for wheat genotypes not crossable with H. bulbosum.

Barley

All the H. bulbosum clones collected from Syria are tetraploids, and will result in the production of triploid hybrids when pollinated to barley. Therefore, three diploid lines/clones of H. bulbosum were obtained from Canada and U.K. last season. Haploid production in barley through the bulbosum cross has been commenced this season. Target barley materials were fifteen F_1 crosses provided by cereal breeders. Fresh pollen collected from three clones of H. bulbosum was mixed and used as pollinator.

Table 115 shows the frequencies of seed setting, embryo formation and plant regeneration in fifteen F_1 barley crossed with H. bulbosum.

From 7975 florets pollinated, 3150 seeds and 2479 embryos were obtained at a frequencies of 39.5% and 31.1%, respectively. However, only 317 green plants were regenerated from the embryos incubated on B_5 medium, at frequency of 12.8%. This was remarkably lower than those in previous publications. It may be attributed to the heterogeneous development of embryos even in the same spike. The efficiency of haploid production was 4.0% of the florets pollinated, that is, 0.7 plants per spike, including a few number of hybrid plants. Improvement of the culture medium and incubation technique are particularly required for increasing haploid production efficiency in barley.

Table 115. Haploid production from fifteen barley F_1s through interspecific crosses with H. bulbosum

	Spikes used	Florets pollinated	Seeds set	Embryos obtained	Plants regenerated
Total number	448	7975	3150	2479	317
Per cent	-	100.0	39.5	31.1	4.0
Genotypic range (%)	-	-	13.7-75.6	6.3-64.9	1.1-15.8

M.N. Inagaki.

3.6. Evaluation of Wild Relatives and Primitive Forms of Wheat.

Wild species and primitive forms may harbor genetic variability useful in wheat breeding. In the past, the principal use of wild relatives of wheat has been the transfer of genes for disease resistance. In recent reports, variability in Aegilops species was reported by Dhaliwal et al (1986) and Waines et al (1987) whereas previous studies emphasized the evaluation of T. dicoccoides Korn. (Lowrence et al 1958, Avivi, 1979) the progenitor of modern wheats. However, the exploitation of wild forms in wheat breeding for tolerance to stresses occurring in unfavorable environemnts has been insufficient and hardly any report exists.

3.6.1. Evaluation of Aegilops

Three hundred and nineteen pure lines isolated from 662 accessions (see CP Annual Report, 1988) planted in the previous season (1987-88) were sown at Tel Hadya and Breda, ICARDA's moderate (330 mm long-term average) and low (275 mm) rainfall sites (Table 116). However during this season (1988-89) these locations received only 234 and 194 mm of rain, respectively.

Table 116. Pure lines isolated from population samples of Aegilops species grown in 1988.

Species	No.	Species	No.
Ae. biuncialis	37	Ae. peregrina	6
Ae. caudata	2	Ae. speltoides	23
Ae. columnaris	5	Ae. speltaeformis	1
Ae. comosa	2	Ae. squarrosa	21
Ae. crassa	2	Ae. triaristata	19
Ae. cylindrica	1	Ae. triuncialis	92
Ae. kotschyi	1	Ae. umbellulata	92
Ae. longissima	3	Ae. uniaristata	4
Ae. lorentii	2	Ae. ventricosa	7
Ae. mutica	3		
Ae. ovata	77	Total	319

The low rainfall resulted in suppression of yellow rust manifestation not only in the field but also in the nurseries and no susceptible ones could be detected among the Aegilops accessions.

The low rainfall and cold weather at Breda (night temperatures below 0°C for 50 days during January and February) permitted screening for tolerance to drought and frost. The number of lines found to be tolerant to drought and cold at Breda are given in Table 117 and these are available on request from the program.

These lines will be replanted at Tel Hadya and Breda in the next season in two replicates. The disease nurseries will also be repeated in collaboration with Dr. O.F. Mamluk, Wheat Pathologist. We also plan to make several crosses of Aegilops spp. with T. durum. Genetic stocks will be offered to breeders and other scientists in the national programs.

Table 117. Aegilops spp. tolerant to drought and cold, Breda, 1989.

Species	No. of lines	Ploidy
Ae. biuncialis	16	4x
Ae. columnaris	2	4x
Ae. kotschyi	1	4x
Ae. lorentii	2	4x
Ae. ovata	52	4x
Ae. peregrina	1	4x
Ae. squarrosa	13	2x
Ae. triaristata	7	4x
Ae. triuncialis	45	4x
Total	139	

3.6.2. Evaluation of T. dicoccoides.

Three hundred and forty-four accessions of T. dicoccoides were planted at Tel Hadya and Breda in single rows of 2.5 m each. This collection originated mainly from Jordan and Turkey. The following observations were made at both locations: frost tolerance, early growth vigor, total number of tillers per plant, peduncle length, days to heading, days to maturity, plant height, number of fertile tillers per plant and in the cereal grain quality laboratory observations on 1000-Kw and protein content were also recorded. The preliminary results are interesting and show T. dicoccoides as an extremely valuable genetic resource (Tables 118 and 119). Cham 3, Cham 4, Om Rabi 9, Nesser and Haurani were used as checks.

Table 118. Preliminary results of screening a selected collection of T. dicoccoides for economically important traits.

Trait	Tel Hadya		Breda	
	No. accs.	Range	No.accs.	Range
Frost tolerance	83	(0-1)	58	(0-1)
Early heading	165	(133-140)	90	(143-150)
Early maturing	192	(156-163)	129	(169-176)
1000 - Kw (g)	62	(25-40)	-	-
Protein (%)	132	(22-25)	-	-

Checks	Fr. tol.	Days to heading	Days to maturity	1000-Kw* (%)	Protein (%)
Cham 3	R (0)	145	176	39	14
Cham 4	MR (1)	140	176	28	12
Om Rabi	R (0)	140	175	41	12
Nesser	R (0)	148	178	30	12
Mexipak	MR (1)	149	177	35	11
Haurani	R (0)	144	176	37	15

*Check data for 1000-Kw and protein % from Annual Report of Regional Durum and Bread Wheat nurseries 1987-88 for Tel Hadya (rainfall=503 mm).

3.6.3. Evaluation of T. dicoccum

The primitive wheat Triticum dicoccum Schubler (Syn. T. dicoccon Schank.) is an intermediate form between the wild T. dicoccoides Korn. and the cultivated T. durum L. This species had almost become extinct in Europe (Perrino and Hammer, 1982) and is under threat of extinction in some countries of the WANA region where it is still grown. However, it is again being cultivated at least in Italy where it is becoming popular as a health food.

Table 119. Simple statistics for 344 accessions of T. dicoccoides evaluated at Tel Hadya (TH) and Breda (BR) during 1988-89.

Trait	Site	Mean	Max	Min	C.V. (%)
Total no. tillers	TH	10	23	6	24.5
	BR	6	18	2	32.2
Peduncle length (cm)	TH	11	18	5	19.2
	BR	14	25	7	21.6
Days to heading	TH	141	165	133	2.5
	BR	153	177	143	2.6
Days to maturity	TH	164	189	152	2.5
	BR	177	204	169	2.4
Plant height (cm)	TH	39	51	26	12.9
	BR	39	74	26	15.7
No. fertile tillers	TH	3	6	1	27.9
	BR	4	9	1	34.1
1000-Kw (g)	TH	22	37	12	16.7
Protein (%)	TH	22	24	18	5.3

There were 17 accessions of T. dicoccum in the primitive wheat collection planted at both locations. The simple statistics are given in Table 120. It can be seen that T. dicoccum is also very tolerant to low rainfall conditions i.e. plant height and peduncle length at Breda are both significantly higher than at Tel Hadya. In the coming season, 46 pure lines isolated from the above collection will be tested for resistance to common bunt with the collaboration of pathologists.

3.6.4. Evaluation and utilization of Aegilops species for disease resistance at University of Tuscia, Viterbo, Italy.

The screening of ICARDA's Aegilops and primitive forms of cultivated wheat is being carried out in the Department of Agrobiology and Agrochemistry at the University of Tuscia, Viterbo, Italy under the supervision of Professor E. Porceddu and Dr. Carla Ceoloni.

Table 120. Simple statistics for 17 accessions of T. dicoccum evaluated at Tel Hadya (TH) and Breda (BR) during 1988-89.

Trait	Site	Mean	Max	Min	C.V. %
Total tillers	TH	9	15	6	25.1
per plant	BR	5	11	3	38.5
Peduncle length (cm)	TH	9	15	6	24.3
	BR	13	23	9	23.1
Days to heading	TH	138	153	136	2.4
	BR	158	164	142	3.1
Days to maturity	TH	177	182	168	2.4
	BR	184	190	173	2.5
Plant height (cm)	TH	43	47	34	8.9
	BR	47	56	39	9.0
1000-Kw	TH	36	42	24	12.4
Protein (%)	TH	15	19	14	8.7

The evaluation of about 450 Aegilops accessions from ICARDA's collection was continued for another season until several pure lines for disease resistance were confirmed. Out of the 10 diploid species (genomes S, D, U, C, M, Mt) only two had a sufficiently high number of representative accessions, i.e. Ae. squarrosa (D genome, 110 accs.) and Ae. speltoides (S genome, 19 accs.). Both species had 60% of the accessions resistant to powdery mildew (Erysiphe graminis f. sp. tritici) and leaf rust (Puccinia recondita).

On the other hand, in the case of polyploids (i.e. Ae. biuncialis, columnaris, ovata and triaristata with the UM genomes; kotschyi and variabilis with US genomes; triuncialis with UC; cylindrica with CD; and vavilovi with DMS), 70% of the accessions were resistant to powdery mildew. However, 23 accessions of Ae. biuncialis from Syria and Turkey were all resistant to powdery mildew infection. In the case of reaction to leaf rust the situation was more variable, as all species have resistant, intermediate and susceptible accessions. The percentage of resistant ones were 31 and 45% when the two strains (from Rome and Puglia region) were inoculated on to the species, showing that the former strain was more virulent. Some of the polyploid accessions had combined resistance to both diseases and these could be used as donors in crosses.

3.6.5. Utilization

The exploitation of the rich gene pool of wild wheat relatives such as Aegilops is hindered by a complex system of genes whose effect in a cross is to suppress homeologous chromosomes from pairing. Manipulations of the wheat pairing control mechanisms are therefore necessary to achieve homeologous gene transfer. Wheat mutants at the two major loci controlling this phenomenon viz ph1 and ph2, which permit homeologous pairing have become available during the last few years and have been used extensively and successfully at several research facilities including the laboratory of Dr. C. Ceoloni at Viterbo.

A possible 'super high-pairing' situation (combination of ph1 and a ph2 mutation) and an intermediate pairing one (ph2 mutation with an extra dose for a promoting wheat chromosome pairing) have been produced at Viterbo by Dr. C. Ceoloni. These are being tested for their effect in hydrids with Aegilops from the ICARDA collection. So far, crosses have been made utilizing accessions of Ae. biuncialis, kotschyi, ovata and variabilis which posses combination of resistances to more than one fungal pathogen.

F_1 hybrid seeds so produced are highly variable in structure and considerable amount of shrivelling is observed. In such case an embryo rescue will be performed and the in vitro rescued plantlets will subsequently be transferred to controlled environment conditions for assessment of the meiotic pairing behaviour. Backcrosses with pollen of selected bread and durum wheat varieties will be made to overcome the sterility problems of the F_1 plants.

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3.7. Evaluation of Durum Wheat Landraces and Germplasm Development.

The collaborative project between Italian institutions and ICARDA on "Evaluation and Documentation of Durum Wheat Germplasm" has completed the fourth year of field work and the following objectives of the project have been achieved: 1) multi-location screening for 25 characters of about 18,000 accessions which included bread wheat, primitive forms and duplicates from the ICARDA collection; 2) repatriation of 350 g. each of 8,000 accessions received for evaluation and multiplication to the Germplasm Institute, Bari, Italy; 3) creation of separate data-bases of passport and evaluation data for durum landraces, bread wheat landraces and primitive forms, as well as elimination of duplicate and redundant accessions from the collection; 4) short-listing of 1,987 accessions selected over four seasons for economically desirable traits (report available from Cereal Improvement Program); and 5) analysis of data matrix using statistical computer software packages for in-depth study of genetic diversity and drift in the collection as well as frequency of characters in ten groups of countries in the world.

During the 1988-89 season an intensive analysis of data assembled during previous three years was undertaken with collaboration of Dr. S. Jana from the Department of Crop Science and Plant Ecology of the University of Saskatchewan, Canada. The relative frequency of the economically important characters i.e. early heading, short or tall stature, high kernel weight, high protein content, good agronomic performance, yellow rust resistance and common bunt resistance were studied by sub-dividing 6,936 accessions on which collection site data was available in the world collection into ten groups based on country of origin. Ethiopia was considered a unique region in itself (Table 121) with most of the entries being single spike progenies. For ease of interpretation of multilocation and multi-season data the quantitative measurements of characters were reduced to 8-class scores.

Table 121. Origin of accessions and number of entries for ten groups.

Origin	No. of entries	Origin	No. of entries	Origin	No. of entries
India	73	Bulgaria	55	Portugal	535
Pakistan	5	Hungary	51	Spain	117
		Poland	16		
South Asia	**78**	Romania	29	**SW Europe**	**652**
		U.S.S.R.	460		
Afghanistan	44	Yugoslavia	34	Canada	11
Iran	72			U.S.A.	101
Turkey	1033	**East Europe**	645		
Iraq	32			**N. America**	**112**
Jordan	216				
Lebanon	15	France	65	Argentina	19
Syria	118	Germany F.R.	6	Bolivia	1
		Germany D.R.	39	Chile	48
SW Asia	**1530**	Switzerland	42	Ecuador	4
				Peru	8
Algeria	34	**Central Europe**	**152**	Uruguay	4
Morocco	210				
Egypt	38	Cyprus	29	**South America**	**84**
Libya	1	Greece	562		
Tunisia	149	Italy	263		
		Malta	4		
N. Africa	**432**				
		S. Europe	**858**	**Total**	**6936**
Ethiopia	**2393**				

It became apparent that there are geographic zones where certain attributes occur at a higher frequency than expected in the germplasm. A summary of Chi-square test carried out on the frequencies of selected accessions for the most desirable characteristics of eight traits is given in Table 122. The above information could assist breeders and other scientists to search for material useful to their crossing programs. It could also facilitate genetic resources collectors in planning their exploration missions. For instance, accessions from North Africa, particularly Tunisia, had a high frequency for 1000-kernel weight i.e. over 48 g, combined with high protein content (over 15%). Tunisia also excels in accessions with high SDS-index (over

2.5). The SDS-index is a ratio of SDS-volume (ml) over protein content and is considered an indicator of gluten strength. Accessions with desirable quality characteristics are listed in Table 123.

Table 122. Summary of a chi-square test on the frequency of selected accessions for eight traits.

Trait	Higher frequency than expected	Lower frequency than expected
Earliness (heading)	Greece, Morocco, India	Turkey
Short plants	Syria, Italy	Ethiopia, Turkey, USSR, Portugal
Tall plants	USSR, Portugal, Italy, Tunisia.	
High kernel weight	Morocco, Tunisia, Italy	Ethiopia, USSR
High protein content	Tunisia	USSR
High agronomic score	Jordan, Greece, Syria, Iran, Morocco	Ethiopia, Portugal
Yellow rust resistance	Portugal, Spain, Greece, Italy.	Turkey, USSR
Common bunt resistance	Portugal, Italy, Spain, Tunisia, Iran.	Ethiopia, Morocco

Table 123. Accessions selected for desirable quality characteristics.

Acc. with high 1000 KW and protein content from Tunisia.		Acc. with high SDS-index (> = 2.5) at Tel Hadya and Breda.	
Acc. No.		Acc. No.	Origin
6822	6883	20064	Morocco
6833	6884	7589	Italy
6836	6885	7770	Italy
6837	6887	12795	Unknown
6839	6891	17726	Tunisia
6842	6892	17729	Tunisia
6844	6918	17815	Tunisia
6879	6922	18004	Tunisia
6880	6957	18076	Tunisia
6881	7018	18249	Tunisia

3.7.1. Efficiency of a visual agronomic score

During the last three seasons a number of accessions were selected on the basis of a good agronomic score at Breda and promoted for further tests in replicated nurseries. The agronomic score is normally recorded just prior to physiological maturity and indicates agronomic potential of an accession based on earliness, growth vigour, tillering, plant height, grain filling period, waxiness and 1000-kw. In order to test the efficiency of this procedure, an experiment was set up at Tel Hadya and Breda comparing 139 selected accessions and 131 chosen at random from the entire collection. The experiments were planted next to each other in two 12 x 12 simple lattices with common checks. During 1988-89 there was only 234 and 194 mm of rainfall at Tel Hadya and Breda, respectively which is considerably below the long-term average for both locations.

Table 124. T-test values for agronomic score (1-9) and grain yield (g/plot) of selected (n = 139) vs random (n = 131) groups at Breda and Tel Hadya, 1988/89.

Group	Agronomic score				Grain yield			
	Breda		Tel Hadya		Breda		Tel Hadya	
	Mean	s.e.	Mean	s.e.	Mean	s.e.	Mean	s.e.
Selected	5.44 a	0.09	5.52 a	0.11	185.0 a	5.35	345.5 a	13.40
Random	4.08 b	0.08	4.36 b	0.08	106.1 b	5.39	179.0 b	10.23

Out of 139 selected accessions 19 had retained the high agronomic score at Breda and 30 at Tel Hadya and eight accessions had a high agronomic score at both locations. On the other hand there was only one accession at each site from the randomly chosen 131 accessions having a high agronomic score. Five accessions of the selected group and none of the random chosen group had a grian yield of 1 t/ha or more at Breda. Similarly, at Tel Hadya 12 accessions of the selected group and none of the random group had a yield of 2 t/ha or more. Thus, it is more efficient to work on germplasm which has already been screened by evaluators based on a visual score than with non-screened material. The t-test given in Table 124 confirms the superiority of the selected group. The correlation coefficients between the agronomic performance and the grain yield were highly significant regardless of material or location (Table 125).

Table 125. Correlation coefficients between agronomic score and grain yield.

	Selected germplasm	
	Breda	Tel Hadya
Simple correlation	0.72	0.88
Spearman rank correlation	0.70	0.89
	Random germplasm	
	Breda	Tel Hadya
Simple correlation	0.80	0.81
Spearman rank correlation	0.81	0.82

3.7.2. Report on selected germplasm for economically useful traits

A short-list of 1,987 accessions for economically useful traits, especially those which are important for biotic and abiotic stresses in the drylands of WANA, has been prepared and is available in the program. The list of characters and number of accessions is given below. Some accessions may be included in more than one category.

Character	Accs.
- Early heading at Breda	146
- Early heading at Tel Hadya	70
- Long grain-filling period at Breda	128
- Early heading and long grain-filling period at Breda	61

-	Good overall agronomic score at Breda	187
-	Good overall agronomic score at Breda and high grain yield at Tel Hadya	60
-	Resistance to yellow rust	190
-	Resistance to common bunt	193
-	Resistance to septoria	147
-	Resistance to septoria & common bunt	40
-	Tolerance to cold in vegetative phase	185
-	Tolerance to salinity soil	126
-	Early heading, long grain filling period, high tillering and tall plants at Breda	148
-	Early heading, long grain filling period, high tillering at Tel Hadya	227
-	Early heading, high 1000-Kw, high tillering and high number of seeds per spike at Tel Hadya	79
	Total	1987

3.7.3. Evaluation for salinity tolerance

Certain accessions which were previously selected in the field at Hegla for salinity tolerance were supplied to Dr. P. Monneveux of the Ecole Nationale Superieure Agronomique (ENSA) at INRA, Montpellier, France, for assessing chlorophyll fluresœnce as a screening tool for salt tolerance. It was found that IC 14789 and 15596 confirmed their resistance to salinity and this technique proved useful as a predictive test for this trait (see Rachis 8(2), 1989). The chlorophyll fluorescence technique which can also be useful for screening bread wheat and barley as well as wild relatives will be used in the program to confirm results emanating from hydroponics or sand culture experiments. Sand culture in a plastic house for salinity tolerance will be used during 1989-90 as it eliminates the problem of high variability of salinity in field experiments, and allows a greater control of the environment.

3.7.4. Computerized data-base for durum wheat germplasm.

The evaluation data on 11,782 actual durum wheat samples out of a total of 18,000 evaluated accessions from multi-location testing during the last 4 seasons has been entered in a computerized data-base in collaboration with ICARDA's Genetic Resources Unit (GRU) and a catalog will be produced. The data-base can be queried and passport as well as evaluation data for regional networks is available. The information on the selected germplasm is available in a report under preparation as well as from the data-base. For instance accessions can be listed by countries of origin, by donor institutions by individual collector and by single or combination of traits. The data files are stored on magnetic tapes which will also be duplicated and stored at a separate location for security. In keeping with the principle of free exchange and duplication for safety, some data have already been sent to the University of Saskatchewan, Canada and CIMMYT, Mexico which also use a compatible VAX/VMS computer system. The data will be analyzed further using advanced statistical packages at the University of Saskatchewan.

3.7.5. International symposium on evaluation and utilization of genetic resources in wheat improvement.

An International Symposium on "Evaluation and Utilization of Genetic Resources in Wheat Improvement" was held at ICARDA from 18-22 May, 1989. This meeting was sponsored by the University of Tuscia, Viterbo and Cereal Improvement Program, ICARDA. The purpose of the symposium was to bring together genetic resources scientists, gene-bank managers, germplasm evaluators and breeders in order to stimulate discussion at an international forum. During this symposium the results and achievements of the collaborative project (between advanced Italian institutions and ICARDA) on "Evaluation and Documentation of Durum Wheat Germplasm", were also presented and discussed.

Speakers at the Symposium emphasized factors which reduce productivity such as drought, temperature extremes, salinity, low soil nutrients as well as diseases and pests which are common in the WANA region. Other scientists demonstrated in their presentations how landraces, wild progenitors and primitive forms could be used in reconstituting gene pools of genetic stocks useful for improving tolerance to stresses and minimizing losses in years of severe drought. The symposium highlighted possible imbalance between theoretical studies and experimental verification and identified areas of future research on genetic resources of wheat. During group discussions, the most effective and desirable link between evaluation and germplasm enhancement was sought. The conclusions and recommendations are included in the proceedings (in press).

3.7.6. Electrophoretic evaluation of durum wheat germplasm.

Polyacrylamide gel electrophoresis (PAGE) of the durum wheat collection have revealed interesting results at the Department of Agrobiology and Agrochemicals at the University of Tuscia, Viterbo, Italy, where the work is being carried out by Dr. D. Lafiandra assisted by two junior scientists under the overall supervision of Professor E. Porceddu.

In cultivated durum wheat varieties the chromosome 1B is considered to be responsible for differences in industrial quality. Cultivars possessing a gliadin (storage protein) component designated band Rm-45 in the gamma zone of the polyacrylamide gel at pH 3.1 have been found to possess superior cooking quality when compared with cultivars which possess band Rm-42 instead. The two components have been found to be coded by two co-dominant alleles of a single gene on the short arm of chromosome 1B. More recently it has been shown that low molecular weight (LMW) glutenin subunits are actually responsible for the qualitative differences and that bands Rm-45 and Rm-42 are their genetic markers.

Electrophoretic analysis carried out at Viterbo on ICARDA's world collection of durum wheat have revealed the existence of gliadin components that are alternative to band Rm-45 and Rm-42. The highest numbers of these forms were discovered in accessions originating from Ethiopia (see Dominici et al. 1988, Rachis 7, 34-36). Germplasm was also analyzed for variability in LMW glutenin subunits by electrophoresis in presence of sodium dodecyl sulphate (SDS-PAGE). A collection comprising 145 accessions of durum wheat from Ethiopia was analyzed in greater detail and variability at the Gli-B1 locus revealed the presence of ten new forms for LMW glutenins which were not reported before.

The chemotype form provisionally designated LMW-3 was most frequent in 84% of accessions and all accessions possessing these subunits also exhibited the same gliadin component, with a greater mobility than band Rm-45. It is possible, therefore, to hypothesize that there exists an association of this new gliadin component and LMW-3 as there exists for gamma Rm-42 and LMW-1, as well as gamma Rm-45 and LMW-2.

Relationships between these new forms of LMW glutenins and qualitative characters were assessed using the SDS-Sedimentation test. High values of SDS volume in the sedimentation test were found to be associated with materials possessing LMW glutenin subunits and these accessions are being utilized in crosses with recently released Italian durum wheat cultivars to improve pasta quality and further enlarge the present narrow genetic base of this crop.

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4. International Cooperation

Research and training activities were carried out in all WANA countries, in line with ICARDA's strategy to strengthen outreach activities through ICARDA's Regional Programs. Cooperation has also been extended outside WANA, particularly in the area of barley improvement.

4.1. Cooperation with NARS

Maghreb Regional Program

The Cereal Improvement Program assisted NARS of the Maghreb countries in training and germplasm evaluation and played an effective catalytic role in coordination of research efforts within countries and collaboration among countries. Regional activities have been enhanced through discipline-oriented networks focussed on breeding, pathology, entomology, and physiology. Examples of network components include: a) the Pepinère d' Observation Maghrebine (POM) which groups germplasm from the Maghreb countries grown and tested by researchers in different agroecologies of each country, b) the Cereal Disease Monitoring Nursery (CDMN) designed to monitor the virulences of virus and disease pathogens in the Region (including Portugal and Spain), and c) the Cereal Travelling Workshop (CTW) which takes place in one or two countries during selection time and offers the opportunity for breeders and pathologists to jointly visit sites, evaluate germplasm and discuss research methodologies. The increased capability in certain research areas of some NARS has benefited other programs. For example, durum wheat germplasm from Tunisia was tested for resistance to root rot by Dr. Lyamani of Morocco; barley germplasm from Algeria was screened for scald and net blotch by Dr. Harrabi of Tunisia; and barley international nurseries were screened for barley stripe resistance by Dr. Boulif of Morocco who also trained a Tunisian researcher on barley stripe screening techniques.

The activities reported hereafter (by M.S. Mekni) have been carried out by national program staff in each of the Maghreb countries, with support by ICARDA outreach and headquarters scientists including CIMMYT scientists posted at ICARDA.

Algeria

Drought conditions prevailed throughout Algeria for the second consecutive season and decreased cereal production significantly. Total 1989 output is not expected to exceed 3.0 million tons. Though double the previous year's harvest, it is well below local requirements. In Sidi Bel Abbes province, average rainfall was around 200 mm in drier central and south arid zones (Zones 2, 3 and 4) and around 300 mm throughout the northern higher rainfall areas (Zone 1). Rainfall distribution was also poor as December and January were dry. The drought permitted the identification or confirmation of drought tolerant germplasm.

1988/89 was the third year for the collaborative project between the Institut Technique des Grandes Cultures (ITGC), Algeria, ICARDA and LECSA/INRA, France, to improve research, production and transfer of technology for winter cereals, food legumes and forages in the Wilaya of Sidi Bel Abbes. Off-station testing was conducted on 6 durum varieties, 5 bread wheats, and 8 barleys in locations representing the three different agroecological zones of Sidi Bel Abbes. Demonstration plots incorporating improved varieties and production technologies were conducted in unreplicated 1/2 ha plots in all 4 zones. They included one improved durum variety, Waha; one bread wheat, Flk-Hork's; and one barley, Rihane-03. Each variety was planted in at least two sites in each of the four zones. The highlights of the season's work were:

- The bread wheat line Gv/Ald"s" confirmed its good adaptation to drought and was recommended for seed multiplication and use as the improved check in on-farm (level III) research work during 1989/90 season. The name of Zidane 89 was tentatively selected for this line.

- Omrabia 9 durum significantly outyielded the local check Oued Zenati.
- Rihane, Harmal, and ACSAD 176 barleys were superior to the local cultivar Saida and were multiplied in the 1988/89 season.
- Yield levels at Zidene (Zone 3) and Telagh (Zone 4) research sites were similar to those obtained at the weed infested, high rainfall Tessala experimental farm (Zone I). Weeds remained the major constraint to cereal production throughout the region.
- Two consecutive years of drought highlighted the difficulties of generating farmer's interest when yield levels are severely reduced.
- Barley germplasm was introduced and tested in the southernmost site of Saida.
- Algerian technicians and researchers participated in various ICARDA cereal activities, including training courses, workshops and surveys.
- ICARDA outreach and headquarters staff visited Sidi Bel Abbes as well as other stations throughout Algeria. This particularly helped in planting the off-station trials at Sidi Bel Abbes, and note taking at Sidi Bel Abbes, Tiaret, El Khroub, Setif and Guelma stations.

Libya

Libya annually devotes 663,000 hectares to cereals. Cereals are grown primarily under rainfed conditions, but irrigated production projects in the southern region contribute significantly to national output. Cereal improvement research has been hindered during the past decade by a continuous reshuffling of research staff and organizational changes.

The first cereal coordination meeting between the Agricultural Research Center (ARC-Tripoli) and ICARDA was held in Tripoli, 3-5 October 1989. Experimental work of previous years was reviewed and research needs discussed. For the 1989-90 season, it is planned: a) to conduct on-farm research work in the Benghazi area, b) to train junior researchers in breeding and related disciplines, and c) to encourage participation of Libyan scientists in the cereal travelling workshop and disease surveys in the Maghreb.

Morocco

Morocco enjoyed favorable weather conditions for the second consecutive year, and harvested a near record small grains crop and consolidated Morocco's access to other Maghreb countries markets for barley exports. Production exceeded 28 millions quintals of barley, 24 million quintals of durum wheat and 16 million quintals of bread wheat. Bread wheat growing continued to expand rapidly to all regions of Morocco and replaced durum wheat in the north and barley in the south. Bread wheat covered 1.46 million hectares, while barley and durum wheat covered 2.4 and 1.17 million hectares, respectively. Arig barley, Kyperounda, Cocorit, Marzak and Karim durum wheats, and Nasma, Merchouch 8, and Jouda bread wheats were the most popular new cultivars. Seed of the newest varieties was available only in small quantities, and their impact on the nation's total output was not assessed. The total rainfall received was high but its distribution favored only late maturing varieties. Barley and early wheats could not take advantage of abundant April and May rainfall.

A harmonious partnership between several Moroccan institutions resulted in a unified national program. A team approach permitted workplans to be carried out by several researchers from various institutes. There were 11, 9 and 11 projects for bread wheat, durum wheat and barley, respectively. Major highlights for the season were:

- Registration of five durum cultivars, 4 bread wheat cultivars and four barley cultivars.
- Training of 30 extension workers in on-farm research methodologies (Mahdia, September 8-15, 1988).
- Consolidation of summer nursery research programs and screening for cold tolerance at Annaceur station.
- Evaluation and selection of promising lines from specific international nurseries for priority diseases and stresses in Morocco.

- Participation of Moroccan scientists in carrying surveys and selection work in Tunisia and Algeria.
- Presentation of 2 papers on stresses in semi-arid Mediterranean environments by Moroccan scientists in Montpellier, France, July 1989.

Tunisia

For the second consecutive season rainfall deficit was serious in most cereal growing areas. This season's severe weather conditions followed the 1987-88 drought, which was the most severe drought recorded in the century. Total cereal production this year was about 0.6 million tons, or about 30% of an average crop. Seed filling was impaired by heat and drought and seed quality was poor.

In spite of the severe drought, most research was completed. The drought highlighted the importance of drought tolerance research. The national program will therefore give more attention to semi-arid areas and conduct more research at the El Kef dry site in addition to the Beja station. The main observations of this season were:

- The newly-released Byrsa bread wheat was more adapted to higher rainfall areas, while Salambo confirmed its good performance and wider adaptation under drought.
- The newly-released *durum* wheat Razzak outyielded all commercial varieties. It also proved responsive to higher fertility conditions. Razzak is expected to become the leading durum wheat variety in Tunisia.
- Omrabia 5 and Omrabia 3 durum wheat lines having shown good adaptation to drought for two consecutive years, were recommended for seed multiplication starting 1989-90 season.
- In addition to its wide adaptation, tall stature and row type, Rihane barley proved also excellent under drought. The extent of its cultivation was limited only by low seed availability.
- Due to good resistance to net blotch and high yielding ability, the new barley line Deir Alla 106/D.L. 71//Strain 205, was recommended

for seed multiplication in 1989-90 season.

- The transfer of research findings to farmers needs to be consolidated and supported adequately. Several on-farm verification and demonstration trials conducted by DAP of l'Office des Céréales were lost to drought. On-farm trials were conducted for variety performance assessment, response to fertilizer, seed rate and weed control and limited results were obtained. They confirmed the superiority of both improved practices, and of cultivars Karim and Razzak (durum wheats), Salambo (bread wheat) and Rihane and Roho (barleys).
- Kernel weight, test weight, vitreousness and protein content remained important quality characteristics and selection criteria for durum wheat screening. Due to drought, all variables decreased except protein content but early maturing lines had higher kernel weight than later lines.
- Diseases were important even in this dry season. Pathology research allowed the evaluation of the barley, bread wheat, durum wheat germplasms for priority diseases, and the identification of valuable sources of resistance.

Nile Valley Regional Program

The Nile Valley countries (Egypt, Ethiopia, and Sudan) share similar environments and production constraints. Outside funds were secured to assist NARS carry out some of the essential on-farm and on-station testing and to provide training to NARS researchers. The NVRP has enhanced the exchange of wheat and barley germplasm, scientific expertise (e.g. virulence analysis for specific diseases, and testing for aphid resistance) and visits among scientists of the collaborating countries. A NVRP Steering Committee meeting was held in Cairo 16-17 Nov 1989 to discuss and approve the 1989-90 plan of work for the 3 countries.

Egypt

Egyptian scientists have concentrated their research on wheat in Upper Egypt and on barley in the Northwest Coast, within the framework of the EEC-funded NVRP component on "Strengthening research for sustained production of wheat, barley, and cool-season legumes in Egypt".

Results of wheat pilot production plots showed grain yield increases of 18-59% in Upper Egypt resulting from the adoption of an improved production technology that included: optimum land preparation, timely sowing, improved cultivars, adequate irrigation, use of fertilizers, herbicides, insecticides against aphids, and early harvesting. Promising breeding material has been identified in researcher-managed trials including the bread wheat cultivars Giza 160, Giza 164, and Vee"s" and the durum wheats Sohag 1 and Sohag 2. Other new material has been identified as resistant or tolerant to diseases and aphids. The cultivars Sakha 69, Sakha 8 and Giza 155 seem to perform well in the Northwest Costal Area.

Barley is grown on 63,000 ha in the Northwest Coast under rainfed conditions (120-190 mm of annual rainfall). Another 55,000 ha is grown under irrigation in the Nile Valley. Barley is used mainly as animal feed, and to a lesser extent as human food in remote areas of the country. Preliminary on-farm testing showed grain yield increases of 75-250% resulting from the use of improved cultivars Giza 123, Giza 124 and CC89. The researchers have identified drought tolerant germplasm , and breeding lines with adequate resistance to leaf rust, powdery mildew, and net blotch. Details can be found in the NVRP - Egypt-Annual Report, 1989.

Five junior researchers have attended training courses at Aleppo and three senior scientists have visited ICARDA for germplasm evaluation and acquaintance with ICARDA's work in cereal improvement. ICARDA and CIMMYT scientists have also visited Egypt during the season and at the annual coordination meeting (8-12 September 1989).

Ethiopia

The Ethiopian Component of the NVRP (financed by SAREC) is limited to barley and concentrates on training and education. However, collaboration in research has been supported from core sources and continued in the area of barley improvement and pathology with an emphasis on the exploitation of landraces. Three scientists from IAR, Ethiopia visited ICARDA for 2 weeks to work on the analysis and interpretation of their research results. Two ICARDA scientists visited Ethiopia during the season to evaluate barley germplasm and discuss the on-going collaborative research. Five junior researchers from Ethiopia participated in cereal training courses at ICARDA.

Sudan

Improved cultivars and production technology were tested under farmers' conditions of the Gezira Scheme within the framework of the OPEC funded project. Other wheat-related activities of the NVRP were financed by the Dutch Government (project recently approved). Improved production practices including recommendations on land preparation, fertilizer application, planting date, wheat cultivar, and irrigation interval significantly increased yield over that in farmers' fields not using the package. Yields in package farms in the Gezira and New Halfa schemes were 4.20 t/ha and 1.22 t/ha, respectively, as opposed to 2.50 t/ha and 0.74 t/ha in neighboring farms where the package was not used. Yields in the Northern Region were 2.28 - 3.10 t/ha versus 1.48 - 2.00 t/ha. It is indicated that improved wheat cultivation in the Sudan is economically profitable and could lead to filling the wheat deficit in the country if proper technology and marketing are adopted. Back-up research was conducted on crop improvement, cultural practices, diseases and insects, but some of the projects planned for the 1988-89 season were not fully implemented due to lack of funds during the cropping season; they will be conducted in the 1989-90 season. Three junior researchers participated in ICARDA training courses at Tel

Hadya, Aleppo, Syria. The annual coordination meeting (4-7 September 1989, Wad Medani) was attended by a large number of scientists from the Sudan and by ICARDA and CIMMYT scientists. During the meeting, research results were presented and discussed; and research/training plans for 1989-90 were prepared.

Arabian Peninsula Regional Program

The Cereal Program maintained collaboration with all countries of the Arabian Peninsula (Yemen AR, PDR Yemen, Saudi Arabia, Oman, Kuwait, United Arab Emirates, Qatar and Bahrain) by sending wheat and barley germplasm for testing under heat and salinity stresses. Germplasm was received from YAR and PDRY for inclusion and testing in ICARDA's nurseries. Two researchers from YAR were trained on barley breeding and seed multiplication for 4 months at ICARDA.

West Asia Lowland Regional Program

Cereal Program scientists were involved in the formulation of an UNDP/AFESD-funded project on "increased productivity of barley, pastures and sheep in the critical rainfall zones". The project aims to improve the production of rainfed barley, forages, pastures and sheep in the 200-300 mm annual rainfall zones of Syria, Iraq, and Jordan through transfer of available technology and implementation of necessary research.

Barley germplasm and related information were provided to NARS staff involved in the project who initiated on-farm testing and demonstration plots in the three countries. Other areas of collaboration with individual countries of the West Asia Lowland Regional Program are listed below.

Syria

The growing conditions during the 1988-89 season were unfavorable both with respect to temperature and rainfall. The amount of rainfall was lower than the long-term average and the distribution was inadequate with long rainless periods at critical plant development stages. This was aggravated by low temperature in the winter and relatively warm spring in many areas of the country. These harsh conditions made efficient the selection of barley and wheat for drought and cold tolerance.

Advanced lines of barley, durum wheat and bread wheat have been tested by NARS under various agroecological conditions for yield performance and disease resistance in field verification trials or large-scale testing plots. Researchers from the Directorate of Agricultural Scientific Research (DASR) and ICARDA participated in an in-country travelling workshop (25 April - 3 May) during which they observed wheat and barley grown in the on-farm trials. Some farmers' fields have been grazed due to poor plant development. Promising lines included: the durum wheats Omrabia 3 and Omrabia 5 under low rainfall and Lahn under irrigation, the bread wheats Nesser, Douma 9457, and Douma 6419, under rainfed low-moisture conditions, and the barleys Furat 654 under low rainfall and Arta in drier areas.

Training and visits continued to form the backbone of ICARDA collaboration with Syrian institutions. Twenty four researchers from DASR have participated in long or short-term training courses at ICARDA. Five students pursued their post-graduate research at ICARDA and two scientists from DASR have participate in the cereal travelling workshop in Turkey.

Jordan

Collaboration with Jordanian institutes (NCARTT, UOJ and JUST) covered the exchange of barley and wheat germplasm, post-graduate training, and mutual visits. Specific areas of collaboration in cereal improvement were discussed during the visit of a Jordanian delegation to ICARDA in April 1989 and a workplan for 1989-90 was prepared during the annual coordination meeting in August 1989 at Amman. The ICARDA cereal physiologist visited Jordan, through an IAEA-Jordan contract, to organize a national conference on water use efficiency in wheat. A report has been submitted determining the constraints and solutions to increase yield of wheat under moisture stress in Jordan.

Cyprus

Within the framework of the collaborative ICARDA-ARI project on cereal improvement for dy areas, barley and durum wheat observation nurseries and yield trials from ICARDA have been grown at Cyprus and assessed by ARI researchers for earliness, disease resistance, and other agronomic traits. Crosses involving early parents have been made and sent to Aleppo for further evaluation. The results are encouraging particularly in the area of earliness and adaptation to mild winters. Several barley lines involving the newly released cultivar Mari/Ath*2 have shown promise in yield tests at ICARDA. ARI scientists have participated in cereal meetings at ICARDA.

Lebanon

The Program used the Terbol station for germplasm evaluation during the winter season and for generation advance and testing of vernalization and photoperiod requirements during the summer. Breeder's seed was provided for promising cultivars to enable seed multiplication and distribution to farmers. The cultivars Rihane (barley), Sebou (durum) and Seri (bread wheat) have performed particularly well during the season.

Highland Regional Program

Iran

In addition to provision of wheat and barley germplasm, there was an increased exchange of scientific visits between ICARDA and Iran.

Four ICARDA and CIMMYT scientists have discussed cereal breeding strategies, disease resistance and winter wheat improvement at a National Cereal Research Seminar held at Karaj, January 1989. Three senior scientists from Iran visited ICARDA to review and update the biannual plan of work for 1989-1990. Four junior researchers participated in cereal training courses and one scientist participated in the "Symposium on evaluation of genetic resources" at ICARDA. Five cereal scientists from ICARDA lectured in a joint in-country training course on "cereal research techniques and methodologies", held in Iran in collaborative with the national research institutions. ICARDA scientists visited Iran to review the collaborative work and discuss future opportunities for collaboration in research and training. ICARDA's assistance was sought for the improvement of agricultural research in the rainfed areas of Iran.

Turkey

Within the framework of the ICARDA-Turkey agreement, germplasm of bread wheat, durum wheat and barley have been evaluated under the agroclimatic conditions of Turkey and a number of lines were selected for further evaluation. Similarly, bread wheat and barley lines from Turkey were evaluated at ICARDA. Some breeding lines selected from the Turkish material have been included in international nurseries for wider testing. A travelling workshop has been organized in collaboration with the Ministry of Agriculture, FAO, and CIMMYT. Invited participants from 9 countries visited various research institutes and farmers' fields during the workshop and discussed problems related to cereal research and production in the rainfed areas. Young researchers from Turkey were trained in anther and embryo culture, cereal pathology and entomology. A coordination meeting was held at Adana during November 1989 to review past activities and develop a plan of work for 1989-90.

Nepal

A training workshop was organized in Nepal to discuss the improvement of barley research and production in the country (please refer to chapter 6 of this report). A visiting scientist spent two months at ICARDA and worked in breeding, pathology, germplasm characterization, and computer-assisted data analysis. As a result of the exchange of visits and research data, better targeted barley germplasm will be sent to Nepal.

China

The Program continued the exchange of barley and wheat germplasm and related information with China. Some of the ICARDA material has been selected for its good performance in arid areas of China. An ICARDA delegation, including a cereal scientist, visited China in November 1989. A biannual (1990-1991) plan of work has been signed for joint collaboration in research and training with an emphasis on barley improvement.

4.2. Cooperation with other Institutions

A number of projects are carried out in collaboration with institutions of several industrialized countries to complement research at ICARDA and NARS. While a comprehensive list of these projects has been presented in the 1988 Cereal Program Report, the major 1989 results pertaining to these projects have been included in the relevant sections of the present report.

A new project on barley genetics and improvement has been initiated in 1989 in collaboration with the Department of Breeding and Population Genetics of Hohenheim University, FRG. The objective of the project is to gain information on the relative merits and limitations of double haploids in conjunction with the improvement of barley for dry areas. The collaboration includes joint supervision of a Ph.D.

student from Hohenheim University, who started thesis research at ICARDA.

Collaboration with USSR was strengthened in 1989 following the visit of a delegation from USSR to ICARDA and the signing in May 1989 of a protocol of collaboration between VASKhNIL and ICARDA. A delegation from ICARDA, including two cereal scientists visited USSR institutions in November 1989 and drew up a joint plan of work for collaborative activities in 1990 and 1991. The plan includes the exchange of barley and wheat germplasm (with an emphasis on tolerance to abiotic and biotic stresses), the exchange of visits and scientific information and the participation in joint conferences. A durum wheat breeder from Saratov, USSR, has joined the Cereal Program in mid October 1989 for 6 months as a visiting scientist to become acquainted with CIMMYT/ICARDA durum wheat activities and exchange experience in durum wheat improvement for harsh environments.

4.3. Conferences and Workshops

The Cereal Program has organized the following workshops and symposia in collaboration with NARS and other institutions:

- North Africa Cereal Travelling Workshop: Breeders and pathologists from Algeria, Morocco, Tunisia, Spain, Portugal, ICARDA and CIMMYT travelled together and carried out selection of wheat and barley at 3 sites in Tunisia (Beja, Kef, Mornag) and 6 sites in Algeria (Khroub, Guelma, Setif, Skikda, Tiaret and Sidi Bel Abbas).
- Cereal Disease Survey: A cereal disease survey was carried out in selected areas of Tunisia, Algeria and Morocco to assess the intensity and spread of major wheat and barley diseases.
- Cereal Insect Survey: A Hessian fly survey in the 3 Maghreb countries was conducted in March 1989 by scientists from these countries in conjunction with an entomology training workshop held in Morocco for cereal workers of the region.

- Travelling Workshop in Turkey: A cereal travelling workshop was organized in Turkey during 11-16 June in collaboration with the Turkish Ministry of Agriculture, FAO, and CIMMYT. Invited scientists from 9 countries (Morocco, Algeria, Tunisia, Libya, Egypt, Jordan, Iraq, Syria, and Pakistan) and scientists from Turkey, FAO, CIMMYT and ICARDA toured research sites and production farms to become acquainted with and discuss successful agricultural technology for rainfed cereal production in highland and lowland areas.
- International Symposium on "Evaluation of Genetic Resources in Wheat Improvement: 18-22 May 1989, ICARDA, Aleppo. The Symposium was attended by 47 scientists from within and outside the region (for details, please refer to section 3.7.5. of this report).
- International Symposium on "Physiology/Breeding of Winter Cereals for Stresses of the Mediterranean Environments": 3-6 July, ENSA-INRA, Montpellier. The participants discussed the integration of physiology and breeding to improve selection of cereal gentoypes adapted to abiotic stresses.

H. Ketata

5. International Nurseries

The international nursery system has three objectives:

1. To distribute improved barley and wheat germplasm to and among national programs.
2. To provide a channel for national scientists to evaluate their elite materials under multi-location testing.
3. To collect, analyze, summarize and report results of the international nurseries for the use of all national program scientists and ICARDA.

5.1. Demand in Regular International Nurseries from 1978 to 1988

The international nursery system has functioned since the establishment of ICARDA. To better serve the national programs, we need to know what types of breeding materials are preferred by them. One way to obtain such information is to determine the trend, if any, in the demand of ICARDA and ICARDA/CIMMYT international nurseries by national programs in WANA over the last ten years.

Average demand for the regular international nurseries in 1978/79 and 1979/80 was compared with that of 1987/88 and 1988/89. Written requests from national programs were used as a measure of actual demand. The WANA region was considered to include Pakistan, Sudan and Ethiopia. Four main types of regular nurseries have been assembled at ICARDA since 1978/79, but the number of nurseries within each type, except the crossing block, gradually increased from 1979/80 to 1987/88 as a result of targetting the germplasm to three macro-environments within WANA. In order to allow a fair comparison among the nursery types and between the two periods studied, requests were adjusted to three nurseries within each type, i.e. one nursery for each crop. Requests for high altitude areas nurseries in 1987/88 and 1988/89 were not included, because they were not available in the previous period.

The adjusted total nursery demand within the WANA region increased by 97% between the periods studied (Table 126). This showed clearly that there was a true increase in nursery demand not caused by a concurrent increase in the number of nurseries.

During the 1978/79 to 1979/80 period, the most popular nurseries were observation nurseries and yield trials, followed by crossing blocks and segregating populations (Table 126). In the period from 1978/88 to 1988/89, the proportion of yield trials increased to 36% while there was a 2% decrease in the other three types of nurseries. Over the last 9 or 10 years, requests for yield trials experienced the highest rate of increase (131%). This contradicts the idea that as national programs improve, the demand for advanced lines decreases and the demand for segregating populations and basic parental material increases.

Although the increase in demand for regular observation nurseries was less than that for yield trials over the years, the demand for trait-specific observation nurseries has been high. The Heat Tolerance Observation Nursery, which was the first trait-specific nursery to be assembled, was launched in 1987. In 1988 the Durum Wheat Drought and Heat Tolerance Observation Nursery and three germplasm pools for disease resistance were also assembled, and a total of 156 sets were requested. The demand for trait-specific nurseries is high and it is planned to develop more of these nurseries to satisfy the need.

5.2. Types, Numbers and Distribution of Nurseries

The regular nurseries distributed in 1989 remained the same as in the two previous seasons and are given in Table 127. There were 5 specific-trait nurseries. The Heat Tolerance Observation Nursery and the Drought and Heat Tolerance Observation Nursery remained, but the previous three germplasm pools for disease resistance were substituted with new ones.

1988/89 was the third season that national programs were invited to nominate their best lines for testing in the international nursery system. In the observation nurseries distributed in 1989 there was a substantial increase in the number of entries submitted by national scientists, from 26 last year to 103 this year.

Table 126. Averaged requests from West Asia and North Africa (adjusted to 3 nurseries within each type) for the 4 different types of regular nurseries in 1987/79 to 1979/80 and 1987/88 to 1988/89. (The percentage of each type of nurseries given in parenthesis)

Period	Total	Yield Trial	Observation Nursery	Crossing Block	Segregating Population
First	224	68 (30)	69 (31)	49 (22)	38 (17)
Second	434	157 (36)	125 (29)	86 (20)	66 (15)
Increase (%)	96	131	81	76	74

In 1989, 1098 sets of regular nurseries and 165 sets of specific trait nurseries were distributed from Aleppo to 87 co-operators in 48 countries upon request. Compared with last season, there was a 18% reduction in the number of sets of regular nurseries sent. This was due to a seed shortage, mainly in the barley and high elevation projects, caused by the unusual cold and dry conditions of the season. Wheat nurseries were developed through the joint CIMMYT/ICARDA wheat project at ICARDA. Barley nurseries sent from Mexico through the joint ICARDA/CIMMYT project at CIMMYT are reported by CIMMYT. Approximately 74% of all the nursery sets were distributed from Aleppo to countries within the ICARDA region. The number of sets distributed for barley, durum wheat and bread wheat represented 34%, 29% and 37% of the overall total, respectively. Detailed information on distribution of nurseries for 89/90 can be found in the booklet "International Cereal Nurseries, List of Cooperators and Nursery Distribution, 1989/90" available from the Cereal Improvement Program.

In addition to the regular and specific trait nurseries reported here, key location disease screening nurseries, aphid tolerance screening nurseries and other special germplasm were provided to national scientists on specific requests and agreement.

Table 127. Cereal international nurseries distributed in 1989.

Nursery	Barley	Durum wheat	Bread wheat
Regular Nursery			
Crossing Block	*	*	*
Segregating Populations			
- Low rainfall areas (LRA)[1]	*	-	-
- Moderate rainfall areas (MRA)[1]	*	-	-
- High altitude areas (HAA)	*	*	*
- Lowland	-	*	*
Observation Nursery			
- Low rainfall areas (LRA)[1]	*	*	*
- Moderate rainfall areas (MRA)[1]	*	*	*
- High altitude areas (HAA)	*	*	*
Yield Trial			
- Low rainfall areas (LRA)[1]	*	*	*
- Moderate rainfall areas (MRA)[1]	*	*	*
- High altitude areas (HAA)	*	*	*
Specific-Trait Nursery			
Bread Wheat Heat Tolerance Observation Nursery			
Durum Wheat Drought and Heat Tolerance Observation Nursery			
Germplasm Pools for Disease Resistance			
- Durum Wheat Septoria Tritici			
- Bread Wheat Septoria Tritici			
- Durum Wheat Common Bunt and Yellow Rust			

[1] LRA & MRA are for lowlands

5.3. Data Analysis and Report

As in the previous three seasons, upon receipt of the yield trial field books from cooperators data were analyzed and results in the form of computer print-outs were returned to allow cooperators make a more decision regarding germplasm. Annual nursery reports for the 1987/88 barley, durum wheat and bread wheat international nurseries were distributed to cooperators in May-August, 1989. The reports retained the features of previous years, but results on the crossing blocks and segregating populations were included for the first time.

5.4. Cluster Analysis of Genotypes

Investigation was conducted to determine an appropriate procedure for genotype clustering using data received on the international yield trials. It was found that raw yield data are usually not suitable for genotype clustering because using them unduly gives more weight to genotype performance in environments having large within-environment ranges or standard deviations. Since within-environment range or standard deviation tends to be positively correlated with environmental mean yield, this means that more weight is usually given to performance in high yielding environments as well. This bias is undesirable in plant breeding. Scale transformation of data is needed to give equal weight to performance in each environment. However standardization of yield within genotypes as used by some researchers is inappropriate and ineffective. Range transformation or standardization should be conducted within each environment, not within each genotype.

5.5. RCB Design with Nearest Neighbour Analysis Versus Lattice Design

The randomized complete block design (RCB) has been continuously used in our international yield trials. The design is simple and is well handled by national programs. But the assumption of homogeneity within each block is not fulfilled in most situations, and there is compelling evidence that the incomplete block lattice design is more efficient. It has been suggested that the lattice design be adopted in our yield trials. The lattice design has been used by some breeding projects at ICARDA. However nearest neighbour analysis (NNA) has attracted much attention recently. The NNA can be applied to nearly any kind of experimental design with replications. It has been shown in simulation studies to be more efficient than RCB and lattice analyses. Before deciding whether to change the RCB design of our yield trials, it is desirable that field data comparing the different analyses be obtained.

In cooperation with the barley, durum wheat and bread wheat improvement projects, international yield trials with lattice design (5x5) and RCB design (n=24) were planted side by side at Tel Hadya, Breda and Bouider. A total of 8 trials were harvested. Only grain yield was compared using the different analyses. The NNA was conducted with the ANOFT program.

In three trials, lattice analysis was not superior to the RCB analysis. The CV was lower after NNA analysis than by lattice or RCB analyses, except in one trial at Breda. This preliminary result suggests that our international yield trials need not be changed to the lattice design, but NNA should be conducted to get a more accurate genotype ranking. The experiments will be continued next season.

S.K. Yau

6. Cereal Training

Emphasis on specialized training continued in 1989 where 4 short specialized courses were conducted in addition to residential, individual, and in-country courses. A total of 171 persons (including 24 females, but excluding visiting scientists) participated in Cereal Improvement Program training activities (Table 128). Although most of training was imparted by Cereal Program scientists, other instructors from ICARDA and NARS contributed to various activities.

Table 128. Number of participants in various training courses 1979-89.

Year	Type of training				
	Residential	Individual		Short*	In-country*
		Non-degree	Degree		
1979	19	3	-	25 (1)	-
1980	16	-	-	-	-
1981	12	2	-	16 (1)	-
1982	10	2	-	35 (2)	24 (1)
1983	18	3	-	-	-
1984	8	7	2	36 (2)	20 (1)
1985	15	8	4	49 (2)	47 (1)
1986	18	14	4	15 (1)	44 (2)
1987	12	18	8	29 (2)	88 (3)
1988	18	18	14	41 (4)	57 (2)
1989	18	19	12	31 (4)	91 (3)

* Number of courses in parentheses

6.1. On-station Short Group-Training

Based on NARS requests and the Cereal Program's strategy for training on specific topics, four specialized courses were conducted at Tel Hadya on applied cereal physiology, on cereal diseases with an emphasis on cereal rusts, on physiological trait assessment for cereal improvement, and on insect control in cereal crops and food legumes.

Applied aspects of cereal physiology

Upon request from Syrian NARS, the Cereal Improvement Program conducted a specialized short training course on applied cereal physiology attended by five BS-level research workers of the Directorate of Agricultural Scientific Research, at ICARDA from 15 - 19 January 1989. The course provided information and training on cereal growth and development, with special reference to the environmental conditions prevailing in the cereal growing areas of Syria. Topics covered were: measurement of soil water, soil-plant water relations, growth stages-Zadok's scale, growth analysis, water use efficiency and relevant agronomic practices.

Cereal disease methodologies with emphasis on cereal rusts

Given the importance of diseases in the region, a specialized training course on pathology has been offered once a year at ICARDA during the last few years. In 1989, this course was held at Tel Hadya from 21 March to 4 April and was attended by 12 participants from 8 countries (Algeria, Egypt, Ethiopia, Morocco, Sudan, Syria, Tunisia and Turkey). Prof. Ronald W. Stubbs from IPO, the Netherlands, was invited to lecture on cereal rusts. Other instructors were from ICARDA. The following topics were covered: collection, isolation, preservation and multiplication of inoculum; inoculation procedures for rusts and other pathogens, disease identification and scoring, disease nurseries, data analysis and interpretation. Trainees attended classroom lectures, and participated in laboratory exercises and field sessions (at Tel Hadya and Lattakia) to learn techniques for identification and scoring of wheat and barley diseases and screening of germplasm for genetic resistance.

Training workshop on methodologies of physiological trait assessment for cereal improvement

This training workshop was held at ICARDA, Aleppo, Syria from 5-19 April 1989 to discuss the incorporation and use of physiological concepts in cereal breeding for stress environments. Seven researchers from 6 countries (Table 129) participated in the workshop. The topics addressed were: resistance to abiotic stress, development and measurement of ideotypic traits for defined environments, water balance and water use efficiency in Mediterranean environments, heat tolerance, computer modeling for trait assessment, and quantitative data analysis. The course combined lectures, laboratory sessions and field activities. Some of the participants gave presentations in the above topics and discussed them with ICARDA scientists and other participants.

Insect control in food legumes and cereal crops

Fourteen trainees (Table 130) attended a 2-week course on insect control in food legumes and cereal crops at ICARDA's main station in Tel Hadya-Aleppo, Syria, from 16-29 April 1989. The course included lectures on the biology of major insects in lentil, chickpea, faba bean, barley and wheat; insect-plant interactions; breeding for insect resistance; integrated pest management; and seed health and quarantine. The practical laboratory and field sessions covered insect identification, assessment of insect infestation and damage, sampling and monitoring of insect populations, screening for host plant resistance, use of pesticides, and design, implementation and evaluation of experiments.

Table 129. Participants in the training workshop on methodologies of physiological-trait assessment for cereal improvement, ICARDA 1989.

Name	Institutions/Country
Dr. Ahmed Bamouh (Ph.D)	IAV, Rabat, Morocco
Dr. Abdullah Al Dakhil (Ph.D)	Univ. Aleppo, Deir Ezzor, Syria
Mr. Meziani Larbi (MS.)	ITGC, Constantine, Algeria
Mr. Negusie Tesfa Michael (MS)	IAR, Addis Ababa, Ethiopia
Mr. Amir Yezdansepas (MS)	SPII, Karaj, Iran
Ms. Bahija Kabelma (BS)	CRRA, Settat, Morocco
Mr. Mohamed Salah Gharbi (BS)	INRAT, Tunis, Tunisia

Table 130. Participants in the specialized course on insect control in food legumes and cereal crops, ICARDA, 1989.

Name	Crop/Program	Institution/Country
Ezzedin Abderrahman M. El Said	Cereals	ARC, Giza, Egypt
Bayeh Mulatu Aregay	Cereals	IAR, Holetta, Ethiopia
Kamel Ali	Cereals	IAR, Kulumsa, Ethiopia
Valiollah Ghadiri	Cereals	PPDRI, Tehran, Iran
Imad Bayoun	Food legumes	AUB, Beirut, Lebanon
Rabah Mahdi	Cereals	INRA, Settat, Morocco
Amir Abdullahi Youssif	Cereals	ARC, Wad Medani, Sudan
Haytham Waqaf	Food legumes	DASR, Tartous, Syria
Mounir Youssif	Food legumes	DASR, Kamishly, Syria
Yagoub Azzar	Food legumes	DASR, Aleppo, Syria
Chebbi Zine El Abidine	Food legumes	Office of Cereals, Tunis, Tunisia
Hassine Ben Salah	Food legumes	INRAT, Tunis, Tunisia
Mohamed Kharrat	Food legumes	INRAT, Tunis, Tunisia
Nilgun Yasar Akinci	Cereals	ZMAEH,Diyarbakir,Turkey

6.2. In-country Training

Nepal

A training workshop on "techniques of barley improvement" was jointly organized by National Agricultural Research Service Center (Nepal), ICARDA and IDRC on 24 Feb-2 March 1989 at Khatmandu, Nepal. Twenty three researchers participated in classroom, field and laboratory activities. Participants also visited different research stations to observe field and research facilities. Workshop topics included barley ecologies in Nepal, breeding techniques and strategies, diseases and insects, genetic resources, and agronomy. Recommendations made by the participants emphasized the need to better characterize the barley growing environments in Nepal and to develop appropriate breeding methodologies including the initiation of a crossing program, testing local and exotic material for disease and insect resistance, and evaluation of hull-less barley for human consumption. The training workshop provided an opportunity for Nepalese researchers to discuss further improvement in barley research in Nepal with ICARDA and MSU scientists.

Maghreb

A regional training workshop on Hessian fly was jointly organized by INRA (Morocco), MIAC, and ICARDA during 21-30 March 1989. Participants included 3 researchers each from Algeria and Tunisia, and 9 from Morocco, in addition to lecturers/instructors from Morocco, MIAC and ICARDA. The workshop agenda included classroom presentations as well as laboratory and field activities. The presentations, made at INRA, Settat, covered the biology of the Hessian fly (Mayetiola destructor Say) and the development and use of varietal resistance. The practical sessions dealt with insect rearing and germplasm screening (diagnosis and scoring) followed by a 2-day field survey of Hessian fly. Following the course work, which took place in Morocco, field surveys were conducted by Algerian and Tunisian participants, in Algeria and Tunisia respectively, in company with one Moroccan instructor for each country. The workshop was seen as a unique and effective method for combining training and practical field experience using NARS expertise, and for further strengthening intra-Maghreb collaboration in cereal research.

Iran

An in-country training course on cereal research techniques and methodologies was jointly organized by ANRRO (Agricultural and Natural Resources Research Organization) and ICARDA during 27 May - 4 June 1989 at the Seed and Plant Improvement Institute, Karaj, Iran. A total of fifty three trainees participated in the course, distributed as follows: 33 from the Seed and Plant Improvement Institute, 10 from the Water and Soil Research Institute and 10 from the Plant Pest and Disease Research Institute. Classroom presentations covered cereal genetics, breeding, genotype x environment interaction, diseases and insect pests, agronomy and on-farm testing. Presentations were either given in Farsi or translated from English to Farsi. One day was spent in the field to screen germplasm at Karaj, and two days were devoted to field visits at 4 research stations in northern Iran.

6.3. Individual Training

Nineteen participants from 7 countries were trained in barley or wheat breeding and related topics for periods ranging from 1 week up to 3 months and a half, totaling 14 person-months (Table 131). Six persons who were trained for short periods also attended other courses.

Table 131. Specialized individual non-degree training at the Cereal Improvement Program, ICARDA, 1989.

Subject	No. of participants	Duration	Country
Breeding	1	2 weeks*	Algeria
	1	2 weeks	Algeria
	1	2 weeks*	Morocco
	1	9 days*	Tunisia
Computer applic. (breeding)	2	10 days	Syria
Pathology	1	1 month*	Ethiopia
	2	1 week*	Syria
Entomology	1	1 week	Syria
Grain quality	1	2 weeks	Morocco
	1	2 weeks	Syria
	1	2 weeks	Tunisia
Physiology	1	1 week	Algeria
Data Analysis	1	2 weeks	Morocco
	2	2 weeks	Syria
Biotechnology	2	3 1/2 months	Turkey

* Also attended a short course.

6.4. Residential Course

Eighteen trainees form 9 countries (Table 132) attended the residential training course held at ICARDA, Tel Hadya, Syria, 1 March-

30 June 1989. As in previous seasons, the focus was on breeding barley and wheat for rainfed areas; but supporting disciplines were also well covered, in particular: pathology, entomology, grain quality, physiology/agronomy, seed production, on-farm testing, experimental design, and data analysis and interpretation.

Practical activities comprised a major part of the training period and trainees had the opportunity to visit and work with the research staff at off-station research sites in Breda, Bouider and Lattakia. They also visited a number of on-farm testing sites in Syria. For the first time in ICARDA's training, a special award for "Outstanding Trainee of the Year" was established. Mr. Ali Reza Abbas Mohamadi, from Iran, received the Cereal Program award.

Table 132. List of trainees in the cereal residential training course, 1 March - 30 June 1989.

Name	Country	Topic
Mr Zerargui Hocine	Algeria	Cereal breeding for high elevation areas
Mr Djennadi Mohamed Rachid	Algeria	Durum wheat breeding
Mr Xu Hengyong	China	Cereal physiology/agronomy
Mr Mohamed Fahmi Saad	Egypt	Barley breeding
Mr Abdel Karim Abdel Karim	Egypt	Bread wheat breeding
Mr Asefa Yelma Sabura	Ethiopia	Barley breeding
Ms Messeret Kassa Kebede	Ethiopia	Barley breeding/pathology
Mr Rahim Rezza Baghai Keya	Iran	Cereal breeding for high elevation areas
Mr Ali Rezza Abbas Mohammadi	Iran	Cereal breeding for high elevation areas
Mr Chaoui Mohamed	Morocco	Barley breeding
Mr Bouzerkaoui Moulay Driss	Morocco	Barley breeding
Mr Nasserdin Mustafa Abdel Salem	Sudan	Cereal pathology
Mr Yehia Abu Mejanah	Syria	Durum wheat breeding
Mr Mahmoud Mozaal	Syria	Durum wheat breeding
Mr Ahmed Fateh Al Kadri	Syria	Bread wheat breeding
Mr Mohamed Ali Kataya	Syria	Seed production/cereal improvement
Mr Salah Ahmed Sholan	Yemen AR	Barley Breeding
Mr Saeed Mokbel Dahhan	Yemen AR	Seed production/cereal improvement

6.5. Graduate Research Training

The Cereal Program continued to support degree-seeking trainees from within and outside the region. During the 1988-89 season, seven ICARDA-supported students completed their thesis research or graduated, while two new students started thesis research work at ICARDA (Table 133). In addition to support for graduate studies, training was also imparted to 6 senior-level students from the University of Aleppo as part of their graduation project on cereal entomology. Groups of third and fourth year students from the University of Aleppo, visited ICARDA to gain scientific knowledge in cereal research at the Center.

Table 133. Graduate students* supported by the Cereal Improvement Program, 1988-89.

Name	Degree	Research area	Country	Date of completion*
Mr Mahmoud Deghaies	Ph.D.	Wheat breeding	Tunisia	(June 1990)
Mr M. S. El Khatem	MSc	Wheat physiology	Sudan	20.2.89
Mr Pedro Perez Marco	Ph.D.	Cereal physiology	Spain	30.10.89
Mr Hani Ghoshe	MSc.	Wheat breeding	Jordan	6.1.89
Mr Erik van Oosterom	Ph.D.	Barley physiology/ breeding	Netherlands	(July 1991)
Mr Peter Stefany	Ph.D.	Wheat breeding	FR Germany	(July 1990)
Mr Haytham Al Sayed	MSc.	Wild species	Syria	(Mar. 1990)
Mr Mohamed S. Hakim	Ph.D.	Wheat pathology	Syria	(Dec. 1990)
Ms Samia El Masri	MSc.	Cereal entomology	Syria	(Jan. 1990)
Ms Suha Ismail	MSc.	Wheat pathology	Syria	(July 1990)
Ms Sawsan Hakim	MSc.	Wheat germplasm	Syria	(Dec. 1990)
Mr Michael Mayer	Ph.D.	Barley breeding	FR Germany	(July 1991)

* Four other students have completed their research and graduated in 1988 (please refer the CP Annual report, 1988, Table 123). For those still continuing research, expected date of completion is indicated between parentheses. The last two students on the list started research in 1989.

6.6. Visiting Scientists

In addition to the large number of scientists who visited the Cereal Improvement Program for short periods, the following NARS scientists spent relatively longer periods at ICARDA to become acquainted with the program's research methodologies and findings:

- two wheat breeders from Egypt for two weeks
- a pathologist from Egypt for 2 weeks
- two barley breeders and a pathologist from Ethiopia for two weeks
- a barley breeder from Nepal for 2 months
- a barley breeder from Syria for 2 months
- a durum wheat breeder from Iran for 2 weeks
- two wheat breeders from Afghanistan for one month.

During their stay, these visiting scientists were involved in ICARDA's on-going work and contributed to the Program's planned research and training activities.

H. Ketata

7. Publications

Journal Articles

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8. Staff List of Cereal Improvement Program (1989)

Dr. Jitendra P. Srivastava	Program Leader
Dr. Edmundo Acevedo	Cereal Physiologist/Agronomist
Dr. Salvatore Ceccarelli	Barley Breeder
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Dr. Ardeshir B. Damania	Wheat Germplasm Specialist
Dr. Guillermo Ortiz Ferrara	Bread Wheat Breeder (CIMMYT/ICARDA)
Dr. Masanori Inagaki[2]	Senior Researcher (Japan)
Dr. Habib Ketata	Senior Training Scientist
Dr. Philippe Lashermes[3]	Biotechnologist
Ir. Joop van Leur	Barley Pathologist
Dr. Omar F. Mamluk[4]	Cereal Pathologist
Dr. Mohamed S. Mekni	Cereal Scientist (Morocco)
Dr. Ross H. Miller	Entomologist
Dr. Miloudi Nachit	Durum Wheat Breeder (CIMMYT/ICARDA)
Dr. Mohamed Tahir[5]	Cereal Breeder
Dr. Hugo Vivar	Barley Breeder (ICARDA/CIMMYT)
Dr. Stefania Grando	Research Scientist (Barley)
Mr. Issam Naji	Agronomist
Dr. Sui K. Yau	International Nurseries Scientist
Dr. Ahmed Zahour	Visiting Scientist (Barley)
Mr. Mohamed Assad Mousa	Research Associate
Mr. Luciano Pecetti	Research Associate
Mr. Abdul Jawad Sabouni	Training Assistant
Mr. Michael Michael	Research Assistant

Mr. Nicolas Rbeiz	Research Assistant (Terbol)
Mr. Rizkallah Abed	Research Assistant
Mr. Antoine Pierre Asbati	Research Assistant
Mr. Fuad Jabi El-Haramein	Research Assistant
Mr. Mazen Jarrah	Research Assistant
Mr. Adonis Kourieh	Research Assistant
Mr. Mohamed Mushref	Research Assistant
Mr. Munzer El-Naimi	Research Assistant
Mr. Henry Pashayani	Research Assistant
Mr. Riad Sakkal	Research Assistant
Mrs. Anette Sayegh	Research Assistant
Mr. George Kashour	Research Assistant
Mr. Haitham Kayali	Research Assistant
Mr. Mohamed Ziad Alamdar	Senior Research Technician
Mr. Haitham Altunji	Senior Research Technician
Mr. Mohamed Azrak	Senior Research Technician
Mr. Zuhair Murad	Senior Research Technician
Ms. Sonia Sultan	Senior Technician
Mr. Mufid Ajami	Research Technician
Mr. Adnan Ayyan	Research Technician
Mr. Mohamed Izzat Ghannoum	Research Technician
Mrs. Suzan Khawatmi	Research Technician
Mrs. Therese Kibbe	Research Technician
Mr. Amir Makki	Research Technician
Mr. Omar Muhandess	Research Technician
Mr. Ahmed Obaji	Research Technician
Mr. Bassam Shammo	Research Technician
Mr. Mohamed Tarakji	Research Technician
Mr. Abdul Rahman Touma	Research Technician
Mr. Zuhair Haj Younes	Research Technician

Mr. Joseph Aziz	Research Technician (Terbol)
Mr. Salem Farrouh	Research Technician
Ms. Wafa Haj Juma'a	Research Technician
Mr. Riad Lutfi	Research Technician
Mr. Mohamed Mosbahi	Research Technician
Mr. Fahd Rahmani	Research Technician
Mr. Mohamed Charrab	Driver (Morocco)
Mr. Abdalla Steif Abdalla	Assistant Technician
Ms. Gisele Dadour	Assistant Research Technician
Mr. Asaad Ahmed Jasem	Labour Foreman
Mr. Hasan El-Khatib	General Worker (Terbol)
Mr. Michael Abu Naked	General Worker (Terbol)
Mr. Obeid El-Jasem	Farm Labourer
Ms. Rita Nalbandian	Program Secretary
Ms. Magda Khawam[6]	Secretary
Ms. Samira Maksoud	Secretary
Ms. Dia Mufti[6]	Secretary
Ms. Nahed Sammani	Secretary
Ms. Najla Nakeshbandi	Secretary

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Mr. Renato D'Ovidio	Durum Wheat (Viterbo)
Mr. Rudi Petti	Barley (Perugia)
Ms. Antonella Grillo	Barley (Perugia)
Ms. Stefania Maria Mascia	Wild Wheat (Viterbo)
Ms. Laura Ercoli	Wild Wheat (Viterbo)
Ms. Aatika Mihamou	Biotechnology (Paris)

[1] Joined the Program, August 1989

[2] Seconded by TARC, Japan.

[3] Seconded by Government of France, GIS-Moulon

[4] Left for sabbatical, October 1989

5 Returned from sabbatical, July 1989.

[6] Left the Program, March 1989

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